POINT BEACH

May 13, 2010

NRC 2010-0039
10 CFR 50.90

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555

Point Beach Nuclear Plant, Units 1 and 2
Dockets 50-266 and 50-301
Renewed License Nos. DPR-24 and DPR-27

License Amendment Request 261
Extended Power Uprate
Response to Request for Additional Information

References:
(1) FPL Energy Point Beach, LLC letter to NRC, dated April 7, 2009, License Amendment Request 261, Extended Power Uprate (ML091250564)
(2) NRC letter to NextEra Energy Point Beach, LLC, dated April 9, 2010, Point Beach Nuclear Plant, Units 1 and 2 – Request for Additional Information from Environmental Branch RE: Extended Power Uprate (TAC Nos. ME1044 and ME1045) (ML100820217)

NextEra Energy Point Beach, LLC (NextEra) submitted License Amendment Request (LAR) 261 (Reference 1) to the NRC pursuant to 10 CFR 50.90. The proposed license amendment would increase each unit's licensed thermal power level from 1540 megawatts thermal (MWt) to 1800 MWt, and revise the Technical Specifications to support operation at the increased thermal power level.

Via Reference (2), the NRC staff determined that additional information was required to enable the staff's continued review of the request. Enclosure 1 provides the NextEra response to the NRC staff's request for additional information. Enclosure 2 provides an update on site terrestrial activities.

This letter contains no new Regulatory Commitments and no revisions to existing Regulatory Commitments.

The information contained in this letter does not alter the no significant hazards consideration contained in Reference (1) and continues to satisfy the criteria of 10 CFR 51.22 for categorical exclusion from the requirements of an environmental assessment.

NextEra Energy Point Beach, LLC, 6610 Nuclear Road, Two Rivers, WI 54241

In accordance with 10 CFR 50.91, a copy of this letter is being provided to the designated Wisconsin Official.

I declare under penalty of perjury that the foregoing is true and correct.
Executed on May 13, 2010.

Very truly yours,

NextEra Energy Point Beach, LLC

Larry Meyer
Site Vice President

Enclosures

cc: Administrator, Region III, USNRC
Project Manager, Point Beach Nuclear Plant, USNRC
Resident Inspector, Point Beach Nuclear Plant, USNRC
PSCW

ENCLOSURE 1

NEXTERA ENERGY POINT BEACH, LLC
POINT BEACH NUCLEAR PLANT, UNITS 1 AND 2

LICENSE AMENDMENT REQUEST 261
EXTENDED POWER UPRATE
RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

The NRC staff determined that additional information was required (Reference 1) to enable the Environmental Branch to complete its review of License Amendment Request (LAR) 261, Extended Power Uprate (EPU) (Reference 2). The following information is provided by NextEra Energy Point Beach, LLC (NextEra) in response to the NRC staff's request.

RERB RAI-1

It is expected that there will be temporary short-term air quality impacts resulting from construction/plant modification activities and vehicle emissions related to traveling of the workforce and truck deliveries required to complete extended power uprate (EPU) modifications. What is the estimated number of equipment and material (truck) deliveries needed to support EPU-related plant modifications during the 2010 and 2011 refueling outages? Provide the approximate estimated duration of the planned refueling outages for Unit 1 in Spring 2010 and Unit 2 in Spring 2011 and the associated percent increase in air emissions (i.e. relative to normal outage without EPU modifications).

NextEra Response

The EPU-implementation outages (i.e., Unit 2 in spring 2011, Unit 1 in fall 2011) are planned for approximately 68 days duration. For the purpose of this estimate of percent increase in EPU-related air emissions, 68-day outages are assumed.

Approximately 1,200 additional personnel are expected in addition to the 700 supplemental workers required for a typical refueling outage for both the spring 2011 and fall 2011 EPU-implementation outages. The estimated number of additional truck deliveries to support the implementation of the EPU modifications is 727 for the spring 2011 outage and 888 for the fall 2011 outage in addition to the more typical refueling outage deliveries of 774.

The temporary, short-term percent increase in air emissions during these outages resulting from construction/plant modification activities and vehicle emissions related to traveling of the workforce and truck deliveries have been estimated relative to the air emissions associated with a typical refueling outage based on the following assumptions:

- Similar equipment and vehicles are used for the typical refueling outage and EPU modifications, such that air emissions are directly proportional to the equipment/vehicle usage.
- The typical refueling outage requires 35 days and 700 staff to complete.

- The EPU and refueling outage together are expected to require 68 days.
- The EPU outage requires an additional 1,200 staff compared to that of a normal refueling outage.
- Each of the 1,200 additional EPU workers drives their own vehicle to work in the same proportion as the normal refueling outage workers.

Based on the above assumptions, the percent increase in air emissions relative to a normal outage is determined as follows:

Incremental EPU air emissions increase due to workforce and duration =

$$\frac{\text{(EPU outage work force) x (EPU outage duration)}}{\text{(Refueling outage workforce) x (Refueling outage duration)}}$$

$$\frac{\text{(1,200 + 700 workers) x (68 days)}}{\text{(700 workers x 35 days)}} = \text{5.27 times or 527\% of a typical refueling outage}$$

Air emissions will increase due to truck traffic by approximately a factor of 2. A typical refueling outage at PBNP requires approximately 774 truck deliveries and the EPU outages (spring 2011 and fall 2011) will average approximately 808 additional truck deliveries.

To provide a perspective on these two estimates of relative emissions increase, the EPU-related increase in worker vehicle traffic (i.e., 1,200 round trips per day) and extra truck traffic (808 round trips per 68 days or approximately 12 round trips per day) should be compared to annual average daily traffic (AADT) count data provided by the Wisconsin Department of Transportation (WDOT) for the Year 2008. The total EPU additional trips per day is approximately 2,424 (1,200 worker trips plus 12 truck trips times 2 for round trip adjustment). For Highway 42, the local north-south road just to the west of the Point Beach Nuclear Plant (PBNP), WDOT estimates an AADT of 3,200 vehicle trips every day. For Interstate Highway 43, slightly further to the west, the AADT is approximately 17,700 vehicle trips every day. The additional temporary EPU-related trip traffic is a small (approximately 14%) portion of the AADT of the nearest single interstate highway. The above response is based on best estimate data at the time of this submittal.

RERB RAI-2

In Appendix D, Section 7.1, Florida Power and Light Energy (FPLE) indicated that the American Transmission Company (ATC) prepared an Interconnection System Impact Study for the PBNP uprate, indicating that a number of system upgrades may be needed. Please provide the identified environmental impacts of any such upgrades that are needed directly related to the PBNP uprate.

NextEra Response

American Transmission Company (ATC) takes the responsibility for scheduling, permitting, and constructing the transmission system upgrades. In addition, the implementation of these changes and the schedule of implementation are in part related to other generation, transmission, and load center changes. ATC plans work to meet all of its transmission responsibilities, not just the PBNP EPU project impacts. With regard to the environmental impacts of the near-term modifications, ATC informed NextEra that the appropriate process for making modifications is described in the Public Service Commission of Wisconsin (PSCW) website, specifically, the application filing requirements.

The PSCW makes final determination by evaluating the concerns of routing, siting, and environmental impact. Furthermore, ATC indicated none of the transmission upgrades, which are to be completed in 2010 in support of the EPU, require federal or state permits. The environmental impacts of the long-term upgrades which have not yet been determined by ATC will be processed in accordance with the PSCW protocol referenced above.

RERB RAI-3

Appendix D, Section 7.2, mentions "recent studies of thermal effects ....", but does not provide the reports or the references for these studies. Please provide a copy of the FPLE study to model the effects of the thermal discharge plume under EPU conditions, as referenced in Section 7.2, paragraphs 5-6 of the environmental report (ER). Further in the same section, other "studies" are mentioned -- please provide references or a copy of other studies that FPLE has performed directly related to the uprate that supports the conclusion that there are minimal impacts to the aquatic environment.

NextEra Response

Attachments 1 and 2 were used to prepare Licensing Report Appendix D, Environmental Report, Section 7.2, Aquatic Impacts, and to support the conclusion that there are minimal impacts to the aquatic environment from EPU. These documents have been submitted to the Wisconsin Department of Natural Resources (WDNR) in support of the renewal of the Wisconsin Pollutant Discharge Elimination System (WPDES) permit for PBNP.

RERB RAI-4

As referenced in paragraph 3 of Section 7.3 of the ER, the WPDES permit sets limits for plant discharges. FPLE states that no impact on the environment is anticipated as the discharges regulated under the WPDES permit are not expected to significantly change under the proposed action. Provide the basis for this determination of "no impact". (e.g. the discharges under the proposed action fall within the limits of the current WPDES permit).

NextEra Response

The basis of this statement is contained in the application material used for the renewal of the WPDES permit and as listed in the NextEra response to RERB RAI-3 above.

RERB RAI-5

In Appendix D, PBNP indicated that their Wisconsin Pollution Discharge Elimination System Permit (WPDES) will expire on June 30, 2009, and that the licensee applied for renewal of the WPDES and Water Quality Certification (WQC) in December 2008 to reflect likewise their planned increase in power production. Please provide copies of the new WPDES permit (or the application for it, if the permit has yet to be received) and WQC that would indicate State concurrence on this proposed action. If the current permit/certification is unavailable, please provide State applications.

NextEra Response

The application materials for the WPDES permit are supplied in the NextEra response to RERB RAI-3. The renewed WPDES permit has not yet been issued, however, the expired permit is administratively continued in accordance with state regulations until issuance of the renewed permit.

RERB RAI-6

Has FPLE provided a Coastal Zone Consistency Certification or received a waiver from the State of Wisconsin for Coastal Zone Consistency for the proposed power uprate? Most recently, this was discussed with FPLE during a conference call on December 16, 2009. If the State has determined that one is required, what is the status of the Consistency Certification?

NextEra Response

The State of Wisconsin Coastal Zone Consistency is determined as a part of the comprehensive process of the renewal of the WPDES permit. Attachment 3 requests a decision from the Wisconsin Department of Administration that either the EPU project was consistent with the Wisconsin Coastal Zone Management Plan or that a Consistency Certification is not required. Attachment 4 provides a letter stating that Wisconsin Coastal Management will not pursue a Coastal Zone Consistency review for the proposed EPU.

RERB RAI-7

No information was provided in the ER on the number of EPU modification workers needed during the Spring 2011 refueling outage. What is the approximate number (i.e. relative to the number of workers normally needed for the outage) of EPU modification workers planned for the Spring 2011 Unit 2 refueling outage?

NextEra Response

Approximately 1,200 additional personnel are estimated to be required over the typical 700 workers required for each EPU-implementation refueling outage for the Unit 2 spring 2011 and Unit 1 fall 2011 outages.

References

(1) NRC letter to NextEra Energy Point Beach, LLC, dated April 9, 2010, Point Beach Nuclear Plant, Units 1 and 2 – Request for Additional Information from Environmental Branch RE: Extended Power Uprate (TAC Nos. ME1044 and ME1045) (ML100820217)

(2) FPL Energy Point Beach, LLC letter to NRC, dated April 7, 2009, License Amendment Request 261, Extended Power Uprate (ML091250564)

ATTACHMENT 1

NEXTERA ENERGY POINT BEACH, LLC
POINT BEACH NUCLEAR PLANT, UNITS 1 AND 2

LICENSE AMENDMENT REQUEST 261
EXTENDED POWER UPRATE
RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

PBNP APPLICATION FOR REISSUANCE OF WPDES PERMIT

99 pages follow

THE SIGMA GROUP
Single Source. Sound Solutions.

December 30, 2008 — Project Reference #11196

Mr. Paul Luebke, P.H.
Wisconsin Department of Natural Resources
101 South Webster Street
Madison, Wisconsin 53707-7921

Re: Application for Reissuance of WPDES Permit Number: 0000957-07-1
FPL Energy Point Beach, LLC – Point Beach Nuclear Plant

Dear Mr. Luebke:

Enclosed please find a completed application for the reissuance of the above referenced WPDES Permit for the FPL Energy Point Beach, LLC Point Beach Nuclear Plant located at 6610 Nuclear Road, Two Rivers, Wisconsin.

In accordance with the May 29, 2008 WDNR permit renewal letter, monitoring has been conducted over the past several months at Outfall 002 and Outfall 105. Monitoring results for Outfall 002 are believed to be representative of the water quality of water discharged via Outfall 001.

The Point Beach Nuclear Plant no longer intends to land apply wastewater sludge. Therefore, application forms for Outfall 005 have not been completed.

Please contact us at 414/643-4200 or Mark Schanke of FPL Energy Point Beach at 920/755-6270 if you have any questions or require additional information.

Sincerely,

SIGMA ENVIRONMENTAL SERVICES, INC.

Kristi L. Linsmeier, P.E., CHMM
Senior Engineer

Thomas Koeppen, Jr, P.E.
Senior Engineer

Enclosure

cc: Mark Schanke – FPL Energy Point Beach

Application for Reissuance of a Wisconsin Pollutant Discharge Elimination System (WPDES) Industrial Wastewater Discharge Permit

Form 3400-178

WPDES Permit Number	Permit Expiration Date
WI-0000957-07-1	*June 30, 2009*
FID # *436034500*	Date Received (leave blank - DNR use only)

Completion of this application is required pursuant to ss. 283.37 and 283.53, Stats., and ch. NR 200, Wis. Adm. Code. Failure to provide the requested information may result in fines, forfeitures or other penalties pursuant to ss. 283.89 and 283.91, Stats. Personally identifiable information is not likely to be used by the Department for any purpose other than the reasons stated in the form or for the purpose the form is being submitted.

You must complete and return this application at least 180 days prior to the expiration of your current permit. Your application will not be considered complete unless you answer every question on this form. Many items require you to place a check mark in one or more boxes. If an item does not apply to you, enter "NA" (for "not applicable") to show that you considered the question. The Department may request additional information which is not already specifically requested in this application.

Please type or print the requested information. Do not feel constrained by the space available for answers. If insufficient space is available to address any item, you may continue your answers on an attached sheet of paper, properly noting the item you are addressing. If you are unsure of how to answer a question, refer to the attached instructions. Mail the completed application to the following address:

Department of Natural Resources
Regional Office (see web site for details)

I. GENERAL INFORMATION

A. FACILITY INFORMATION

1. Facility Name — *FPL Energy Point Beach, LLC - Point Beach Nuclear Plant*

   Facility Mailing Address

   P.O. Box, Street Address or Route — *6610 Nuclear Road*

   City or Village, State and Zip Code — *Two Rivers, Wisconsin 54241-9516*

2. Facility Location Address — *Same as Facility Mailing Address*

   Street Address, Route, Legal description or other location description:

   City

   State

   Zip Code

   County

3. Responsible Party (person, parent company or organization with direct control over the facility - see instructions for complete definition). If appropriate, enter "same as facility name" or "same as owner". **(This question is for industrial permittees only. Municipal permittees, continue to question 4.)**

   Entity Name *Same as Facility Name*

   Contact Person *Mark Schanke*

   Telephone Number *(920) 755-6270*

4. Other environmental permits or approvals

   Has the facility received or applied for coverage under any general WPDES permit or any other environmental permits, such as for management of hazardous wastes, emission of air pollutants or underground injection?

   ☐ No

   ☒ Yes If yes, give the permit number(s) and briefly describe the discharge(s)

Permit Number	Description of Discharge
WI-0000957-07-1	*WPDES*
WI-SO-67857-2	*NR216 Stormwater General Permit (Site No. 7336)*
436034500-P10	*Air Pollution Control Operations Permit*

5. Native American Lands

   a. ☐ Yes ☒ No Is any portion of the facility located on Native American lands?

   b. ☐ Yes ☒ No Does the receiving stream flow through Native American lands after it receives discharge from the treatment facility?

   c. ☐ Yes ☒ No Are biosolids stored on, disposed of, or land applied on Native American lands?

   If yes, to any of the above, please identify those portions of the facility or wastewaters located on Native American lands.

6. Site Map	***See Figure 1, Figure 2, and Figure 3***

Attach to this application a detailed site map, such as a USGS topographic map, showing the area extending to at least one (1) mile beyond property boundaries. This map must show the outline of the facility, the locations of incoming wastewater, including hauled waste receiving stations, the locations of all surface water discharge points (e.g., to rivers, lakes, streams etc) and all land treatment sites (e.g., seepage cells). For surface water discharges, estimate the approximate distance from the plant to the receiving waters. For groundwater discharges, include all groundwater monitoring wells, nearby residences and all potable wells within 1,000 feet of all land treatment sites. Number all discharge points and sampling points on the map. Include the map scale and a meridian arrow showing north.

B. CONTACT INFORMATION

1. Please list all facility contacts

SLUDGE CONTACT	Name	Rob Grossheim	Title	Chemistry Supervisor
	Address	6610 Nuclear Road		
		Two Rivers, WI 54241	Phone	920/755 – 6793
	Email	Robert.grossheim@fpl.com	FAX	920/755 - 6086
AUTHORIZED REPRESENTATIVE	Name	Daniel Frey	Title	Chemistry Manager
	Address	6610 Nuclear Road		
		Two Rivers, Wisconsin, 54241	Phone	920/ 755 – 6987
	Email	Daniel.frey@fpl.com	FAX	920/755-6086
DISCHARGE MONITORING CONTACT	Name	Rob Grossheim	Title	Chemistry Supervisor
	Address	6610 Nuclear Road		
		Two Rivers, WI 54241	Phone	920/755 – 6793
	Email	Robert.grossheim@fpl.com	FAX	920/755 - 6086
STORMWATER CONTACT ON SITE	Name	Kjell Johansen	Title	Senior Chemist
	Address	6610 Nuclear Rd		
		Two Rivers, Wisconsin 53201	Phone	920/ 755-6869
	EMail	Kjell.johansen@fpl.com	FAX	920/ 755-6086
OWNER OF FACILITY	Name	FPL Energy Point Beach, LLC	Title	
	Address	6610 Nuclear Rd		
		Two Rivers, WI 54241	Phone	
	EMail		FAX	
FACILITY OPERATOR/PLANT MANAGER	Name	John Bjorseth	Title	Plant Manager
	Address	6610 Nuclear Road		
		Two Rivers, Wisconsin, 54241	Phone	920/ 755 - 6826
	EMail	John.bjorseth@fpl.com	FAX	319/851 - 7986

II. WASTEWATER CHARACTERIZATION, TREATMENT, and DISPOSAL

A. DESCRIPTION OF INDUSTRIAL ACTIVITY (see instructions)

1. Nature of Business - Provide a brief description of the facility's operations.

Point Beach Nuclear Plant is a nuclear-fueled stream electric power generating plant. It consists of two nuclear powered stream supply systems, which drive two turbine generators. Each unit has an electrical output of 540 megawatts.

2. Change in Operations

a. Since the issuance of your current WPDES permit, have any changes in the operations of the facility or modifications of the facility's wastewater treatment system affected either the quantity or quality of the discharges from the facility?

☒ No (continue to b)
☐ Yes If yes, attach a brief summary of the changes and modifications, and continue to b.
New sewage treatment plant improved effluent quality, vacuum fabric filter system replaced retention pond function

b. In the next five years, do you intend to expand or change the operations of the facility or modify the facility's wastewater treatment system to an extent that the quantity or quality of the discharge will be affected?

☒ No (continue to 3)
☐ Yes If yes, attach a brief summary of the planned changes.

3. Days of Operation *24* Hours per Day, *7* Days per Week, and *12* Months per Year

4. Number of Employees Normal *1300*, and Maximum *2500 (during outage)*

Approximately 800 utility employees and 500 contractors, plus 1200 more during an outage.

5. Sanitary Wastes - Where are sanitary wastes (wastewaters from lavatories, washrooms, lunch/break room sinks, showers, etc.) discharged?

☐ In a septic tank system and/or subsurface absorption system

☒ In a privately owned treatment system owned by you or others. Identify others: ____________

☐ In a publicly owned treatment system operated by ____________

☐ Other (specify) ____________

6. Water Supply - What are the facility's sources of water?

	Name of Source	Average Volume or Flow Rate (include units)
Municipal Supply		
Surface Water Intake	*Lake Michigan*	*780.4 MGD*
Private Well	*PBNP Water Supply Well*	*0.006 MGD (sewer treatment, Outfall 104)*
Other (specify)		
Other (specify)		

7. Flow Diagram - Attach a line drawing showing the water flow through the facility. Indicate sources of intake water, operations contributing wastewater to the effluent, and treatment units. Construct a water balance on the line drawing by showing average flows between intakes, operations, treatment units, and outfalls.

See Figure 4 – Flow Diagram

Complete this section for ***each*** surface water outfall excluding those that discharge only storm water.

II. WASTEWATER CHARACTERIZATION, TREATMENT, and DISPOSAL

B. SPECIFIC OUTFALL INFORMATION

Surface Water Outfall Information for OUTFALLS 001 and 002 – Condenser Cooling Water

1. Receiving Water

Lake Michigan

2. Outfall Location Description (for example, east bank of Wisconsin River one-quarter mile down stream of Second Street bridge)

Outfall 001 at Lake Michigan shoreline: 44 deg. 16 min. 50 sec. latitude 87 deg. 32 min. 00 sec. longitude
Outfall 002 at Lake Michigan shoreline: 44 deg. 16 min. 50 sec. latitude 87 deg. 32 min. 10 sec. longitude

3. Wetlands - Does this outfall discharge to a wetland?

☒ No. (continue to 4)

☐ Yes. If yes, are you requesting increased (less restrictive) effluent limitations for this outfall or will the discharge from this outfall increase over the next 5 years?
- ☐ No. (continue to 4)
- ☐ Yes. If yes, you may be required to submit a wetland evaluation with this application. See the instructions for more information.

4. Seasonal or Intermittent Discharges (check only one of the boxes and provide information requested)

☒ Discharge is year round.

☐ Discharge is seasonal (specify) From: ________ Through: ________.

From: ________ Through: ________.

☐ Discharge is intermittent (attach a description of the frequency, duration and flow rate of each discharge occurrence, except for storm water runoff and spillage or leaks)

5. Type of Wastewater Discharged (check all that apply to this outfall)

	Average Flow (specify units)
☒ Noncontact Cooling Water *(Outfalls 001 & 002)*	*780.4 MGD*
☐ Contact Cooling Water	
☒ Sanitary Wastes *(Sample Point 104)*	*0.006 MGD*
☒ Process Wastewater	*0.127 MGD*
☐ Storm Water	
☒ Boiler Blowdown	*0.228 MGD*
☐ Cooling Tower Blowdown	
☒ Neutralization Tank *(Sample Point 101)*	*0.035 MGD*
☒ Water Treatment RO Reject *(Sample Point 106)*	*0.069 MGD*
☒ Microfiltration Unit Backwash *(Sample Point 107)*	*0.052 MGD*

6. Discharge Flow Rates - Specify in gallons per day (gpd) or million gallons per day (MGD) the maximum discharge flow rates that have occurred during the term of the current permit. ***Note: Maximums provided are theoretical; the maximums for each individual outfall were added together, but never occurred simultaneously.***

	Flow (specify units)	Time Period when flow occurred
Maximum Day	*1008 MGD*	*May 2008 for Outfall 001 and November 2008 for Outfall 002*
Maximum 7-day Average	--	--
Maximum 30-day Average	*994.7 MGD*	*November 2006 for Outfall 001 and April 2004 for Outfall 002*
Maximum Annual Average	*840.6 MGD*	*2006 for Outfall 001 and 2007 for Outfall 002*

B. SPECIFIC OUTFALL INFORMATION

Surface Water Outfall Information for OUTFALLS 001 and 002 – Condenser Cooling Water

7. Process Streams Contributing to the Outfall Discharge - Identify and provide the Standard Industrial Classification (SIC) code for each production process that contributes wastewaters to this outfall discharge. If a technology-based effluent standard is applicable to the process wastewater, provide the production rate for the process.

Process Name (if applicable) *Steam Electric* Process SIC Code *4 9 1 1*

Description and production rates: ***Condenser Cooling, Water Screen Backwash, Fire Protection, Misc. Equipment Cooling, Steam Generator Blowdown, Primary Coolant Letdown, Reverse Osmosis, Neutralization Tank***

Process Name (if applicable) ______ Process SIC Code ___ ___ ___ ___

Description and production rates

Process Name (if applicable) ______ Process SIC Code ___ ___ ___ ___

Description and production rates

Process Name (if applicable) ______ Process SIC Code ___ ___ ___ ___

Description and production rates

8. Treatment System Description - Describe any treatment given to wastewaters prior to discharge from this outfall.

See Appendix A – Additional Treatment Information

9. Schematic Diagram of Treatment System - Attach to this application a schematic diagram of your wastewater treatment system for this outfall. Show all bypasses, sample locations and treatment units and processes.

See Figure 5 – Wastewater Flow Diagram

10. Effluent Flow Monitoring and sampling

Flow Monitoring Type & Age *No flowmeter; Use pump capacities, # pumps running, and pump run times to determine flow*

Flow Monitoring Location ______

Effluent Composite Sample Location *Outfall 002*

Effluent Grab Sample Location *Outfall 002*

11. Sludge Disposal - Does your wastewater treatment system produce a sludge?

☐ No. (continue to next question)
☒ Yes. If yes, where do you dispose your wastewater treatment system sludge?

☐ Land Application
☒ Landfill
☐ Haul to or by Other Permitted Facility

Facility Name

WPDES Permit No. WI- ___ ___ ___ ___ ___ ___ ___

☐ Other

B. SPECIFIC OUTFALL INFORMATION

Surface Water Outfall Information for OUTFALLS 001 and 002 – Condenser Cooling Water

12. Additives - Provide the number of biocides, water quality conditioners and process additives that you add to the waters discharged from this outfall.

Note: Per instructions, Table B-5 has not been completed since the discharge includes "other process wastewater" in addition to cooling water.

2 Biocides (chlorine and other halogens, fungicides, algicides, herbicides, bacterial control chemicals, etc.)

15 Water Quality Conditioners (water and wastewater treatment chemicals including scale and corrosion inhibitors, chemical conditioning agents, pH adjustment chemicals, dechlorination chemicals, alum, ferric chloride, ferrous sulfate or chloride (pickle liquor) polymers, ammonia, phosphorus, defoamers, etc.)

____ Process Additives (limited to dyes and surfactant-based detergents)

1 How many of the biocides are used less frequently than once in any four day period?

5 How many of the water quality conditioners and process additives are used less frequently than once in any four day period?

13. Biological Toxicity Data - In the last five years, have any biological tests for acute or chronic toxicity been made on the discharge from this outfall or on the receiving water in relation to the discharge from this outfall?

☐ No. (continue to the next section of the application)
☒ Yes. If yes, provide all test dates and types below and attach to this application test results **for those tests not previously submitted to the Department**.

Dates	Type or Test
June 5-12, 2007	*Whole Effluent Toxicity (WETOX)*
Sept 13-20, 2005	*Whole Effluent Toxicity (WETOX)*
Apr 8-15, 2003	*Whole Effluent Toxicity (WETOX)*
Oct 10 -17, 2000	*Whole Effluent Toxicity (WETOX)*
Sept 14 -21, 1999	*Whole Effluent Toxicity (WETOX)*

14. Alternative Phosphorus Effluent Limitation - If your current permit contains a 1 mg/L total phosphorus effluent limitation and you wish to request an alternative effluent limitation for phosphorus, or if your current permit already contains an alternative effluent limitation for phosphorus and you would like retain or modify the alternative limit in the reissued permit, you must demonstrate that the 1 mg/L total phosphorus effluent standard is not achievable and provide information that is necessary for the Department to establish an alternative limit. The demonstration and alternative limit information must be submitted with this application even though you may already have an alternative phosphorus limit in your current permit. Use the Alternative Phosphorus Effluent Limitation Information Request discussed in the Contents of Your Application part of the instructions.

II. WASTEWATER CHARACTERIZATION, TREATMENT, and DISPOSAL

B. SPECIFIC OUTFALL INFORMATION

EFFLUENT MONTORING REQUIREMENT – PRIMARY INDUSTRY PROCESS WASTEWATER

You are required to complete part C-1 through C-4 for each surface water outfall that discharges **process wastewaters, other than noncontact cooling water, from a primary industry**. You must sample the discharge and test for the parameters listed in Table C-1 under the headings "Common Pollutants" and "Metals, Cyanide, Hardness & Phenols." You are also required to test for the parameters under each of the remaining headings as specified for your industrial category in Table 4 of the instructions. If you have more than one discharge of primary industry process wastewater, you should have received a copy of this form for each outfall. (See the instructions if two or more outfalls discharge identical wastewaters.) If you test any parameter more frequently than required by Table C-1, use Table C-2 to report the results. **For testing not performed as part of routine, permit-required monitoring, please also attach laboratory reports.**

C-1. EFFLUENT MONITORING FORM for Outfall 001 and 002 – Condenser Cooling Water (see instructions)

From Table 4 of the instructions, list below the industrial category or categories that contribute process wastewaters to the discharge from this outfall and place a check mark in the box of each pollutant group that you must test.

Industrial Category: ***Steam Electric Power Plants***

☐ Volatile Organics ☐ Acid Extractable Compounds ***Pollutants monitored per the May 29, 2008 WDNR permit renewal letter.***

☐ Base/Neutral Compounds ☐ Pesticides ☐ Dioxins and Furans

Were all effluent samples properly preserved and handled, and are they representative of normal operating conditions?

☒ Yes ☐ No. If no, please collect and test another discharge sample.

Parameter Code	Parameter Name (CAS No.)	Sample Result	QC Flags (explain below)	Units	Detection Limit (LOD)	LOQ	Analytical Method	Confirmed Organics (Y/N)	Sample Collection Date	Extraction Date	Analysis Date	Lab ID Number	Sample Type (Co/Gr)	DMR (✓)
	COMMON POLLUTANTS													
321	Ammonia Nitrogen (Submit a minimum of 4 sample results collected at least 1 month apart)	<0.10		mg/L as N	0.10	0.33	SM 4500NHH		9/23/08		10/07/08	128053530	Co	
		<0.10		mg/L as N	0.10	0.33	SM 4500HH		10/21/08		10/29/08	128053530	Co	
		<0.10		mg/L as N	0.10	0.33	SM 4500NHH		11/25/08		12/2/08	128053530	Co	
		<0.10		mg/L as N	0.10	0.33	SM 4500NHH		12/18/08		12/29/08	128053530	Co	
66	BOD_5 (5-day Biochemical Oxygen Demand)	<2.0		mg/L	2.0	6.7	SM 5210		9/23/08		9/24/08	128053530	Co	

C-1 (continued). **EFFLUENT MONITORING REPORT FORM for Outfall 001 and 002 – Condenser Cooling Water (see instructions)**

Parameter Code	Parameter Name (CAS No.)	Sample Result	QC Flags (explain below)	Units	Detection Limit (LOD)	LOQ	Analytical Method	Confirmed Organics (Y/N)	Sample Collection Date	Extraction Date	Analysis Date	Lab ID Number	Sample Type (Co/Gr)	DMR (✓)
140	COD (Chemical Oxygen Demand)	6.2	J	mg/L	5.7	19	EPA 410.4		9/23/08		9/24/08	128053530	Co	
105	Chlorides, Total	10		mg/L	1.0	3.3	EPA 325.2		9/23/08		9/26/08	128053530	Co	
112	Chlorine, Total Residual	<0.016	A-01	mg/L	0.016	0.053	SM4500C1 G		9/23/08		9/23/08	128053530	Gr	
342	Oil and Grease	<0.82		mg/L	0.82	2.7	EPA 1664		9/23/08		9/26/08	128053530	Gr	
377	pH	6.80		s.u.			EPA 150.1		9/23/08		9/23/08	Field	Gr	
		6.9		s.u.			EPA 150.1		11/25/08		10/21/08	Field	Gr	
388	Phosphorus, Total (7723-14-0) (Submit a minimum of 4 sample results collected at least 1 month apart)	<0.10		mg/L as P	0.10	0.33	EPA 365.1		9/23/08		9/30/08	128053530	Co	
		<0.10		mg/L as P	0.10	0.33	EPA 365.1		10/21/08		10/27/08	128053530	Co	
		<0.10		mg/L as P	0.10	0.33	EPA 365.1		11/25/08		12/3/08	128053530	Co	
		<0.10		mg/L as P	0.10	0.33	EPA 365.1		12/18/08		12/24/08	128053530	Co	
457	Suspended Solids, Total	8.0		mg/L	1.0	3.3	EPA 160.2		9/23/08		9/25/08	128053530	Co	
488	Temperature (winter)			°F										✓
487	Temperature (summer)			°F										✓
	METALS, CYANIDE, HARDNESS & PHENOLS													
31	Antimony, Total Recoverable (7440-36-0)	0.31	J	μg/L	0.12	0.40	SW 6020A		9/23/08		9/25/08	128053530	Co	
34	Arsenic, Total Recoverable (7440-38-2)	1.0		μg/L	0.12	0.40	SW 6020A		9/23/08		9/25/08	128053530	Co	
50	Beryllium, Total Recoverable (7440-41-7)	<0.12		μg/L	0.12	0.40	SW 6020A		9/23/08		9/25/08	128053530	Co	
88	Cadmium, Total Recoverable (7440-38-2)	<0.12		μg/L	0.12	0.40	SW 6020A		9/23/08		9/25/08	128053530	Co	
131	Chromium, Hexavalent	<0.0025		mg/L	0.0025	0.0083	SM 3500CrD		9/23/08		9/24/08	128053530	Gr	

C-1 (continued). **EFFLUENT MONITORING REPORT FORM for Outfall 001 and 002 – Condenser Cooling Water (see instructions)**															
Parameter Code	Parameter Name (CAS No.)	Sample Result	QC Flags (explain below)	Units	Detection Limit (LOD)	LOQ	Analytical Method	Confirmed Organics (Y/N)	Sample Collection Date	Extraction Date	Analysis Date	Lab ID Number	Sample Type (Co/Gr)	DMR (✓)
133	Chromium, Total Recoverable (7440-47-3)	0.17	J	µg/L	0.12	0.40	SW 6020A		9/23/08		9/25/08	128053530	Co	
147	Copper, Total Recoverable (7440-50-8) (Submit a minimum of 4 sample results collected at least 3 days apart)	<6.0		µg/L	6.0	20	SW 6020A		9/23/08		9/25/08	128053530	Co	
		<6.0		µg/L	6.0	20	SW 6020A		10/21/08		10/27/08	128053530	Co	
		<6.0		µg/L	6.0	20	SW 6020A		11/25/08		12/6/08	128053530	Co	
		<6.0		µg/L	6.0	20	SW 6020A		12/18/08		12/24/08	128053530	Co	
155	Cyanide, Total (57-12-5)	<0.017	C	mg/L	0.017	0.057	EPA 335.4		9/23/08		9/25/08	128053530	Gr	
152	Cyanide, Amenable to Chlorination	<0.017		mg/L	0.017	0.007	EPA 335.4		9/23/08		9/25/08	128053530	Gr	
264	Lead, Total Recoverable (7439-92-1)	<0.12		µg/L	0.12	0.40	SW 6020A		9/23/08		9/25/08	128053530	Co	
280	Mercury, Total Recoverable (7439-97-6) (Submit a minimum of 3 sample results collected at least 3 days apart)	<0.14		ng/L	0.14	0.47	EPA 1631E		9/23/08		9/25/08	128053530	Gr	
		2.5		ng/L	0.14	0.47	EPA 1631E		10/21/08		10/24/08	128053530	Gr	
		1.2		ng/L	0.14	0.47	EPA 1631E		11/25/08		12/05/08	128053530	Gr	
315	Nickel, Total Recoverable (7440-02-0)	<6.0		µg/L	6.0	20	SW 6020A		9/23/08		9/25/08	128053530	Co	
423	Selenium, Total Recoverable (7782-49-2)	0.64	B	µg/L	0.12	0.40	SW 6020A		9/23/08		9/25/08	128053530	Co	
430	Silver, Total Recoverable (7440-22-4)	<0.12		µg/L	0.12	0.40	SW 6020A		9/23/08		9/25/08	128053530	Co	
494	Thallium, Total Recoverable (7440-28-0)	<0.12		µg/L	0.12	0.40	SW 6020A		9/23/08		9/25/08	128053530	Co	
553	Zinc, Total Recoverable (7440-66-6)	<6.0		µg/L	6.0	20	SW 6020A		9/23/08		9/25/08	128053530	Co	
231	Hardness (as $CaCO_3$) (Submit a minimum of 4 sample results collected at least 3 days apart)	210		mg/L	4.0	13	EPA 130.2		9/23/08		9/26/08	128053530	Co	
		160		mg/L	4.0	13	EPA 130.2		10/21/08		10/24/08	128053530	Co	
		170		mg/L	4.0	13	EPA 130.2		11/25/08		12/4/08	128053530	Co	
		170		mg/L	4.0	13	EPA 130.2		12/18/08		12/27/08	128053530	Co	
382	Phenols, Total	<0.00126		mg/L	0.00126	0.00420	EPA 420.4		9/23/08		10/01/08	9999917270	Co	

Explain QC flags here:

A-01 – No Detect
B – Analyte was detected in the associated Method Blank
C – Calibration Verification recovery was above the method control limit for this analyte. Analyte not detected, data not impacted
J – Results reported between the MDL and LOQ are less certain than results at or above the LOQ

C-2. ADDITIONAL MONITORING FORM for OUTFALLS 001 and 002 – Condenser Cooling Water (see instructions)

If you know or have reason to believe that any parameter listed in Tables 1 and 2 of the instructions is present in the discharge from this outfall at a concentration greater than 10µg/L AND you have not already provided a sample result in Table C-1, you must list the parameter below in Table C-2 and either provide at least one sample result for the parameter, check the "Intake" column if you expect the parameter is present in the discharge solely as a result of its presence in your intake water, OR check the "DMR" column if you have provided a sample result for the parameter in a recent Discharge Monitoring Report. Check the following box to indicate that you have evaluated the potential for these parameters being present in the discharge.

☒ Excluding those parameters that I have reported in either Table C-1 or Table C-2 below, I believe the parameters listed in Tables 1 and 2 of the instructions are either absent from this outfall's discharge or are present at concentrations less than 10 µg/L.

Table C-2 may also be used to report test results for any parameter that is tested more frequently than required by Table C-1.

Were all effluent samples properly preserved and handled, and are they representative of normal operating conditions?

☐ Yes ☐ No. If no, collect and test another discharge sample.

Parameter Code	Parameter Name (CAS No.)	Sample Result	QC Flags (explain below)	Units	Detection Limit (LOD)	LOQ	Analytical Method	Confirmed Organics (Y/N)	Sample Collection Date	Extraction Date	Analysis Date	Lab ID Number	Sample Type (Co/Gr)	DMR (✓)	Intake (✓)

Explain QC flags here:

C-3. HAZARDOUS SUBSTANCES FORM for OUTFALLS 001 and 002 – Condenser Cooling Water (see instructions)

If you know or have reason to believe that any substance listed in Table 3 of the instructions is present in the discharge from this outfall, you must list the substance below in Table C-3, provide any monitoring data that you may have, check the "Intake" column if you expect the parameter is present in the discharge solely as a result of its presence in your intake water, check the "DMR" column if you have provided a sample result for the substance in a recent Discharge Monitoring Report and explain why you believe the substance is present in the discharge. (NOTE: No analytical testing is required for Table 3 substances.) Check one of the following.

☒ I believe all substances in Table 3 of the instructions are absent from the discharge.

☐ I believe all substances in Table 3 of the instructions are absent from the discharge with the exception of those that I have listed below in Table C-3.

Parameter Code	Parameter Name	Sample Result	Units	DMR (✓)	Intake (✓)	Explanation of Presence in Discharge

Comments:

C-4. DISCHARGE MONITORING REPORT (DMR) INFORMATION for OUTFALLS 001 and 002 – Condenser Cooling Water (see instructions)

Check one or more of the following statements and provide the requested information to identify the Discharge Monitoring Report (DMR) data that best represents the current discharge from this outfall. At least one of the first two statements must be checked. Checking the third is optional.

☒ I believe that Discharge Monitoring Report data for the last 36 months are representative of the current effluent quality from this outfall.

☐ I believe that Discharge Monitoring Report data covering the period from ____________________ (day/month/year) to ____________________ (day/month/year) are representative of the current effluent quality from this outfall. The reason for my belief is as follows:

☐ Certain of the data previously submitted on Discharge Monitoring Reports are not representative of the current effluent quality from this outfall.

The data and the reasons for them not being representative are as follows:

Complete this section for ***each*** surface water outfall excluding those that discharge only storm water.

II. WASTEWATER CHARACTERIZATION, TREATMENT, and DISPOSAL

B. SPECIFIC OUTFALL INFORMATION

Surface Water Outfall Information for OUTFALL 105 – Low Volume Wastewater In-plant Location

1. Receiving Water
   Lake Michigan

2. Outfall Location Description (for example, east bank of Wisconsin River one-quarter mile down stream of Second Street bridge)

Sampling point 105 routes to Outfalls 001/002 at Lake Michigan at shoreline; 44 deg. 16 min. 50 sec. latitude 87 deg. 32 min. 00 sec. longitude

3. Wetlands - Does this outfall discharge to a wetland?

☒ No. (continue to 4)

☐ Yes. If yes, are you requesting increased (less restrictive) effluent limitations for this outfall or will the discharge from this outfall increase over the next 5 years?

☐ No. (continue to 4)

☐ Yes. If yes, you may be required to submit a wetland evaluation with this application. See the instructions for more information.

4. Seasonal or Intermittent Discharges (check only one of the boxes and provide information requested)

☒ Discharge is year round.

☐ Discharge is seasonal (specify) From: ______ Through: ______.

From: ______ Through: ______.

☐ Discharge is intermittent (attach a description of the frequency, duration and flow rate of each discharge occurrence, except for storm water runoff and spillage or leaks)

5. Type of Wastewater Discharged (check all that apply to this outfall)

	Average Flow (specify units)
☐ Noncontact Cooling Water	
☐ Contact Cooling Water	
☒ Sanitary Wastes *(Sample Point 104*	*0.006 MGD*
☒ Process Wastewater	*0.127 MGD*
☐ Storm Water	
☐ Boiler Blowdown	
☐ Cooling Tower Blowdown	
☒ Water Treatment RO Reject *(Sample Point 106)*	*0.069 MGD*
☒ Microfiltration Unit Backwash *(Sample Point 107)*	*0.052 MGD*

6. Discharge Flow Rates - Specify in gallons per day (gpd) or million gallons per day (MGD) the maximum discharge flow rates that have occurred during the term of the current permit.

	Flow (specify units)	Time Period when flow occurred
Maximum Day	*317,000 gpd*	*November 24, 2005*
Maximum 7-day Average	--	--
Maximum 30-day Average	*181,000 gpd*	*November 2005*
Maximum Annual Average	*142,660 gpd*	*2004*

B. SPECIFIC OUTFALL INFORMATION

Surface Water Outfall Information for OUTFALL 105 – Low Volume Wastewater In-plant Location

7. Process Streams Contributing to the Outfall Discharge - Identify and provide the Standard Industrial Classification (SIC) code for each production process that contributes wastewaters to this outfall discharge. If a technology-based effluent standard is applicable to the process wastewater, provide the production rate for the process.

Process Name (if applicable) *Steam Electric* Process SIC Code 4 9 1 1

Description and production rates

Process Name (if applicable) ______ Process SIC Code ___ ___ ___ ___

Description and production rates

Process Name (if applicable) ______ Process SIC Code ___ ___ ___ ___

Description and production rates

Process Name (if applicable) ______ Process SIC Code ___ ___ ___ ___

Description and production rates

8. Treatment System Description - Describe any treatment given to wastewaters prior to discharge from this outfall.

See Appendix A

9. Schematic Diagram of Treatment System - Attach to this application a schematic diagram of your wastewater treatment system for this outfall. Show all bypasses, sample locations and treatment units and processes. *See Figure 5 – Wastewater Flow Diagram*

10. Effluent Flow Monitoring and sampling

Flow Monitoring Type & Age *Rosemount Vortex flowmeter; Ages: 2000 and 2003 Manufacture dates; Flowmeter is calibrated at the factory annually, new meter was installed in March 2003 when old meter sent out for calibration*

Flow Monitoring Location *Downstream of all inputs from vacuum filters and effluent Sump. Inputs consisting of sanitary wastewater effluent, turbine hall sumps and floor drains, façade sumps, water treatment plant backwash wastewell, heating steam condensate and potable water treatment system filter backwash and RO reject water*

Effluent Composite Sample Location *Outfall 105*

Effluent Grab Sample Location *Outfall 105*

11. Sludge Disposal - Does your wastewater treatment system produce a sludge?

☐ No. (continue to next question)
☒ Yes. If yes, where do you dispose your wastewater treatment system sludge?

☐ Land Application
☐ Landfill
☒ Haul to or by Other Permitted Facility

Facility Name *Green Bay Metro WWTF*

WPDES Permit No. WI- 0020991-6

Facility Name *City of Manitowoc WWTF*

WPDES Permit No. WI - 0024601

☐ Other

B. SPECIFIC OUTFALL INFORMATION

Surface Water Outfall Information for OUTFALL 105 – Low Volume Wastewater In-plant Location

12. Additives - Provide the number of biocides, water quality conditioners and process additives that you add to the waters discharged from this outfall.

Note: Per instructions, Table B-5 has not been completed since the discharge includes "other process wastewater".

__1__ Biocides (chlorine and other halogens, fungicides, algicides, herbicides, bacterial control chemicals, etc.)

__7__ Water Quality Conditioners (water and wastewater treatment chemicals including scale and corrosion inhibitors, chemical conditioning agents, pH adjustment chemicals, dechlorination chemicals, alum, ferric chloride, ferrous sulfate or chloride (pickle liquor) polymers, ammonia, phosphorus, defoamers, etc.)

____ Process Additives (limited to dyes and surfactant-based detergents)

__1__ How many of the biocides are used less frequently than once in any four day period?

__4__ How many of the water quality conditioners and process additives are used less frequently than once in any four day period?

13. Biological Toxicity Data - In the last five years, have any biological tests for acute or chronic toxicity been made on the discharge from this outfall or on the receiving water in relation to the discharge from this outfall?

☐ No. (continue to the next section of the application)
☒ Yes. If yes, provide all test dates and types below and attach to this application test results **for those tests not previously submitted to the Department.**

Dates	Type or Test

WETOX testing is performed at Outfalls 001/002; Outfall 105 discharges to Outfalls 001/002. Test dates provided in application section for 001/002.

14. Alternative Phosphorus Effluent Limitation - If your current permit contains a 1 mg/L total phosphorus effluent limitation and you wish to request an alternative effluent limitation for phosphorus, or if your current permit already contains an alternative effluent limitation for phosphorus and you would like retain or modify the alternative limit in the reissued permit, you must demonstrate that the 1 mg/L total phosphorus effluent standard is not achievable and provide information that is necessary for the Department to establish an alternative limit. The demonstration and alternative limit information must be submitted with this application even though you may already have an alternative phosphorus limit in your current permit. Use the Alternative Phosphorus Effluent Limitation Information Request discussed in the Contents of Your Application part of the instructions.

II. WASTEWATER CHARACTERIZATION, TREATMENT, and DISPOSAL

C. SPECIFIC OUTFALL INFORMATION

EFFLUENT MONTORING REQUIREMENT – PRIMARY INDUSTRY PROCESS WASTEWATER

You are required to complete part C-1 through C-4 for each surface water outfall that discharges **process wastewaters, other than noncontact cooling water, from a primary industry**. You must sample the discharge and test for the parameters listed in Table C-1 under the headings "Common Pollutants" and "Metals, Cyanide, Hardness & Phenols." You are also required to test for the parameters under each of the remaining headings as specified for your industrial category in Table 4 of the instructions. If you have more than one discharge of primary industry process wastewater, you should have received a copy of this form for each outfall. (See the instructions if two or more outfalls discharge identical wastewaters.) If you test any parameter more frequently than required by Table C-1, use Table C-2 to report the results. **For testing not performed as part of routine, permit-required monitoring, please also attach laboratory reports.**

C-1. EFFLUENT MONITORING FORM for Outfall 105 *(see instructions)*

From Table 4 of the instructions, list below the industrial category or categories that contribute process wastewaters to the discharge from this outfall and place a check mark in the box of each pollutant group that you must test.

Industrial Category: Steam Electric

"Common Pollutants", "Metals, Cyanide, Hardness & Phenols", "Volatile Organics", and "Acid Extractable Compound" (Monitoring is not required for the "Base/Neutral Compounds", "Pesticides", and "Dioxins & Furans").

☒ Volatile Organics ☒ Acid Extractable Compounds

☐ Base/Neutral Compounds ☐ Pesticides ☐ Dioxins and Furans

Were all effluent samples properly preserved and handled, and are they representative of normal operating conditions?

☒ Yes ☐ No. If no, please collect and test another discharge sample.

Parameter Code	Parameter Name (CAS No.)	Sample Result	QC Flags (explain below)	Units	Detection Limit (LOD)	LOQ	Analytical Method	Confirmed Organics (Y/N)	Sample Collection Date	Extraction Date	Analysis Date	Lab ID Number	Sample Type (Co/Gr)	DMR (✓)
	COMMON POLLUTANTS													
321	Ammonia Nitrogen (Submit a minimum of 4 sample results collected at least 1 month apart)	2.0		mg/L as N	0.10	0.33	SM 4500NHH		9/23/08		10/07/08	128053530	Co	
		0.73		mg/L as N	0.20	0.67	SM 4500NHH		10/21/08		10/29/08	128053530	Co	
		0.36		mg/L as N	0.10	0.33	SM 4500NHH		11/25/08		12/2/08	128053530	Co	
		0.32	J	mg/L as N	0.10	0.33	SM 4500NHH		12/18/08		12/29/08	128053530	Co	
66	BOD_5 (5-day Biochemical Oxygen Demand)	4.4	J	mg/L	2.0	6.7	SM 5210		9/23/08		9/24/08	128053530	Co	

C-1 (continued). **EFFLUENT MONITORING REPORT FORM for Outfall ___105__ (see instructions)**														
Parameter Code	Parameter Name (CAS No.)	Sample Result	QC Flags (explain below)	Units	Detection Limit (LOD)	LOQ	Analytical Method	Confirmed Organics (Y/N)	Sample Collection Date	Extraction Date	Analysis Date	Lab ID Number	Sample Type (Co/Gr)	DMR (✓)
140	COD (Chemical Oxygen Demand)	<5.7		mg/L	5.7	19	EPA 410.4		9/23/08		9/24/08	128053530	Co	
105	Chlorides, Total	9.4		mg/L	1.0	3.3	EPA 325.2		9/23/08		9/26/08	128053530	Co	
112	Chlorine, Total Residual	<0.016	**A-01**	μg/L	0.016	0.053	SM45000Cl G		9/23/08		9/23/08	128053530	Gr	
342	Oil and Grease	<0.78		mg/L	0.78	2.6	EPA 1664		9/23/08		9/26/08	128053530	Gr	
377	pH	7.20		s.u.			EPA 150.1		9/23/08		9/23/08	Field	Gr	
		8.30		s.u.			EPA 150.1		10/21/08		10/21/08	Field	Gr	
388	Phosphorus, Total (723-14-00) (Submit a minimum of 4 sample results collected at least 1 month apart)	1.1		mg/L as P	0.10	0.33	EPA 365.1		9/23/08		9/30/08	128053530	Co	
		1.7		mg/L as P	0.10	0.33	EPA 365.1		10/21/08		10/27/08	128053530	Co	
		0.27	**J**	mg/L as P	0.10	0.33	EPA 365.1		11/25/08		12/03/08	128053530	Co	
		0.14	**J**	mg/L as P	0.10	0.33	EPA 365.1		12/18/08		12/24/08	128053530	Co	
457	*Suspended Solids, Total*	12		mg/L	1.0	3.3	EPA 160.2		9/23/08		9/25/08	128053530	Co	
487	Temperature (summer)			°F										✓
488	Temperature (winter)			°F										✓
METALS, CYANIDE, HARDNESS & PHENOLS														
31	Antimony, Total Recoverable (7440-36-0)	0.12	**J**	μg/L	0.12	0.40	SW 6020A		9/23/08		9/25/08	128053530	Co	
35	Arsenic, Total Recoverable (7440-38-2)	<0.12		μg/L	0.12	0.40	SW 6020A		9/23/08		9/25/08	128053530	Co	
50	Beryllium, Total Recoverable (7440-41-7)	<0.12		μg/L	0.12	0.40	SW 6020A		9/23/08		9/25/08	128053530	Co	
87	Cadmium, Total Recoverable (7440-43-9)	<0.12		μg/L	0.12	0.40	SW 6020A		9/23/08		9/25/08	128053530	Co	
131	Chromium, Hexavalent	<0.0025		mg/L	0.0025	0.0083	SM 3500CrD		9/23/08		9/24/08	128053530	Gr	
133	Chromium, Total Recoverable (7440-47-3)	<0.12		μg/L	0.12	0.40	SW 6020A		9/23/08		9/25/08	128053530	Co	

C-1 (continued). EFFLUENT MONITORING REPORT FORM for Outfall __105__ (see instructions)

Parameter Code	Parameter Name (CAS No.)	Sample Result	QC Flags (explain below)	Units	Detection Limit (LOD)	LOQ	Analytical Method	Confirmed Organics (Y/N)	Sample Collection Date	Extraction Date	Analysis Date	Lab ID Number	Sample Type (Co/Gr)	DMR (✓)
147	Copper, Total Recoverable (7440-50-8) (Submit a minimum of 4 sample results collected at least 3 days apart)	7.4	J	µg/L	6.0	20	SW 6020A		9/23/08		9/25/08	128053530	Co	
		12	J	µg/L	6.0	20	SW 6020A		10/21/08		10/27/08	128053530	Co	
		<6.0		µg/L	6.0	20	SW 6020A		11/25/08		12/6/08	128053530	Co	
		<6.0		µg/L	6.0	20	SW 6020A		12/18/08		12/24/08	128053530	Co	
155	Cyanide, Total (57-12-5)	<0.017	C	mg/L	0.017	0.057	EPA 335.4		9/23/08		9/25/08	128053530	Gr	
152	Cyanide, Amenable to Chlorination	<0.017		mg/L	0.017	0.057	EPA 335.4		9/23/08		9/25/08	128053530	Gr	
264	Lead, Total Recoverable (7439-92-1)	1.8		µg/L	0.12	0.40	SW 6020A		9/23/08		9/25/08	128053530	Co	
280	Mercury, Total Recoverable (7439-97-6) (Submit a minimum of 3 sample results collected at least 3 days apart)	14		ng/L	0.14	0.47	EPA 1631E		9/23/08		9/25/08	128053530	Gr	
		17		ng/L	1.4	4.7	EPA 1631E		10/21/08		10/24/08	128053530	Gr	
		4.0		ng/L	0.14	0.47	EPA 1631E		11/25/08		12/5/08	128053530	Gr	
315	Nickel, Total Recoverable (7440-02-0)	<6.0		µg/L	6.0	20	SW 6020A		9/23/08		9/25/08	128053530	Co	
423	Selenium, Total Recoverable (7782-49-2)	0.19	J, B	µg/L	0.12	20	SW 6020A		9/23/08		9/25/08	128053530	Co	
430	Silver, Total Recoverable (7440-22-4)	<0.12		µg/L	0.12	0.40	SW 6020A		9/23/08		9/25/08	128053530	Co	
494	Thallium, Total Recoverable (7440-28-0)	<0.12		µg/L	0.12	0.40	SW 6020A		9/23/08		9/25/08	128053530	Co	
553	Zinc, Total Recoverable (7440-66-6)	12	J	µg/L	6.0	20	SW 6020A		9/23/08		9/25/08	128053530	Co	
231	Hardness (as $CaCO_3$) (Submit a minimum of 4 sample results collected at least 3 days apart)	180		mg/L	4.0	13	EPA 130.2		9/23/08		9/26/08	128053530	Co	
		230		mg/L	4.0	13	EPA 130.2		10/21/08		10/24/08	128053530	Co	
		190		mg/L	4.0	13	EPA 130.2		11/25/08		12/2/08	128053530	Co	
		150		mg/L	4.0	13	EPA 130.2		12/18/08		12/27/08	128053530	Co	
382	Phenols, Total	<0.00113		mg/L	0.00113	0.00378	EPA 420.4		9/23/08		10/01/08	999917270	Co	

C-1 (continued). **EFFLUENT MONITORING REPORT FORM for Outfall ___105__ (see instructions)**

Parameter Code	Parameter Name (CAS No.)	Sample Result	QC Flags (explain below)	Units	Detection Limit (LOD)	LOQ	Analytical Method	Confirmed Organics (Y/N)	Sample Collection Date	Extraction Date	Analysis Date	Lab ID Number	Sample Type (Co/Gr)	DMR (✓)
VOLATILE ORGANICS														
6	Acrolein (107-02-8)	<5.0		µg/L	5.0	17	SW8260B		9/23/08		9/26/08	128053530	Gr	
8	Acrylonitrile (107-13-1)	<5.0		µg/L	5.0	17	SW8260B		9/23/08		9/26/08	128053530	Gr	
40	Benzene (71-43-2)	<0.20		µg/L	0.20	0.67	SW8260B		9/23/08		9/26/08	128053530	Gr	
79	Bromodichloro-methane (dichlorobromo-methane) (75-27-4)	<0.20		µg/L	0.20	0.67	SW8260B		9/23/08		9/26/08	128053530	Gr	
80	Bromoform (75-25-2)	<0.20		µg/L	0.20	0.67	SW8260B		9/23/08		9/26/08	128053530	Gr	
93	Carbon Tetrachloride (56-23-5)	<0.50		µg/L	0.50	1.7	SW8260B		9/23/08		9/26/08	128053530	Gr	
113	Chlorobenzene (108-90-7)	<0.20		µg/L	0.20	0.67	SW8260B		9/23/08		9/26/08	128053530	Gr	
115	Chlorodibromo-methane (124-48-1)	<0.20		µg/L	0.20	0.67	SW8260B		9/23/08		9/26/08	128053530	Gr	
117	Chloroethane (75-00-3)	<1.0		µg/L	1.0	3.3	SW8260B		9/23/08		9/26/08	128053530	Gr	
118	Chloroform (67-66-3)	<0.20		µg/L	0.20	0.67	SW8260B		9/23/08		9/26/08	128053530	Gr	
568	1,2-Dichloro-benzene (95-50-1)	<0.20		µg/L	0.20	0.67	SW8260B		9/23/08		9/26/08	128053530	Gr	
581	1,3-Dichloro-benzene (541-73-1)	<0.20		µg/L	0.20	0.67	SW8260B		9/23/08		9/26/08	128053530	Gr	
587	1,4-Dichloro-benzene (106-46-7)	<0.50		µg/L	0.50	1.7	SW8260B		9/23/08		9/26/08	128053530	Gr	
556	1,1-Dichloroethane (75-34-3)	<0.50		µg/L	0.50	1.7	SW8260B		9/23/08		9/26/08	128053530	Gr	
570	1,2-Dichloroethane (107-06-2)	<0.50		µg/L	0.50	1.7	SW8260B		9/23/08		9/26/08	128053530	Gr	
558	1,1-Dichloro-ethene (75-35-4)	<0.50		µg/L	0.50	1.7	SW8260B		9/23/08		9/26/08	128053530	Gr	
567	*cis*-1,2-Dichloro-ethene	<0.50		µg/L	0.50	1.7	SW8260B		9/23/08		9/26/08	128053530	Gr	

C-1 (continued). EFFLUENT MONITORING REPORT FORM for Outfall ___105__ (see instructions)

Parameter Code	Parameter Name (CAS No.)	Sample Result	QC Flags (explain below)	Units	Detection Limit (LOD)	LOQ	Analytical Method	Confirmed Organics (Y/N)	Sample Collection Date	Extraction Date	Analysis Date	Lab ID Number	Sample Type (Co/Gr)	DMR (✓)
	(159-59-2)													
576	*trans*-1,2-Dichloroethene (156-60-5)	<0.50		µg/L	0.50	1.7	SW8260B		9/23/08		9/26/08	128053530	Gr	
573	1,2-Dichloro-propane (78-87-5)	<0.50		µg/L	0.50	1.7	SW8260B		9/23/08		9/26/08	128053530	Gr	
583	1,3-Dichloro-propane (142-28-9)	<0.25		µg/L	0.25	0.83	SW8260B		9/23/08		9/26/08	128053530	Gr	
560	1,1-Dichloro-propene (563-58-6)	<0.50		µg/L	0.50	1.7	SW8260B		9/23/08		9/26/08	128053530	Gr	
580	*cis*-1,3-Dichloro-propene (10061-01-5)	<0.20		µg/L	0.20	0.67	SW8260B		9/23/08		9/26/08	128053530	Gr	
585	*trans*-1,3-Dichloropropene (10061-02-6)	<0.20		µg/L	0.20	0.67	SW8260B		9/23/08		9/26/08	128053530	Gr	
598	2,3-Dichloro-propylene (78-88-6)	<0.25		µg/L	0.25	0.83	SW8260B		9/23/08		9/26/08	128053530	Gr	
200	Ethylbenzene (100-41-4)	<0.50		µg/L	0.50	1.7	SW8260B		9/23/08		9/26/08	128053530	Gr	
82	Methyl Bromide (bromomethane) (74-83-9)	<0.50		µg/L	0.50	1.7	SW8260B		9/23/08		9/26/08	128053530	Gr	
120	Methyl Chloride (chloromethane) (74-87-3)	<0.30		µg/L	0.30	1.0	SW8260B		9/23/08		9/26/08	128053530	Gr	
285	Methylene Chloride (dichloromethane) (75-09-2)	<1.0		µg/L	1.0	3.3	SW8260B		9/23/08		9/26/08	128053530	Gr	
565	1,1,2,2-Tetra-chloroethane (79-34-5)	<0.20		µg/L	0.20	0.67	SW8260B		9/23/08		9/26/08	128053530	Gr	
490	Tetrachloro-ethene (127-18-4)	<0.50		µg/L	0.50	1.7	SW8260B		9/23/08		9/26/08	128053530	Gr	
500	Toluene (108-88-2)	<0.50		µg/L	0.50	1.7	SW8260B		9/23/08		9/26/08	128053530	Gr	
561	1,1,1-Trichloro-ethane (71-55-6)	<0.50		µg/L	0.50	1.7	SW8260B		9/23/08		9/26/08	128053530	Gr	
563	1,1,2-Trichloro-ethane (79-00-5)	<0.25		µg/L	0.25	0.83	SW8260B		9/23/08		9/26/08	128053530	Gr	
508	Trichloroethene	<0.20		µg/L	0.20	0.67	SW8260B		9/23/08		9/26/08	128053530	Gr	

C-1 (continued). **EFFLUENT MONITORING REPORT FORM for Outfall ___105__ (see instructions)**															
Parameter Code	Parameter Name (CAS No.)	Sample Result	QC Flags (explain below)	Units	Detection Limit (LOD)	LOQ	Analytical Method	Confirmed Organics (Y/N)	Sample Collection Date	Extraction Date	Analysis Date	Lab ID Number	Sample Type (Co/Gr)	DMR (✓)
	(79-01-6)													
517	Vinyl Chloride (75-01-4)	<0.20		µg/L	0.20	0.67	SW8260B		9/23/08		9/26/08	128053530	Gr	
	ACID EXTRACTABLE COMPOUNDS (Phenols)													
592	2-Chlorophenol (95-57-8)	<0.770		µg/L	0.770	2.56	SW8270C		9/23/08		9/26/08	999917270	Co	
614	3-Chlorophenol (108-43-0)	Absent		µg/L	0.0050	0.0166	SW8270C		9/23/08		9/26/08	999917270	Co	
623	4-Chlorophenol (106-48-9)	Absent		µg/L	0.0050	0.0166	SW8270C		9/23/08		9/26/08	999917270	Co	
616	2-Chloro-5-methylphenol (615-74-7)	Absent		µg/L	0.0050	0.0166	SW8270C		9/23/08		9/26/08	999917270	Co	
597	2,3-Dichloro-phenol (576-24-9)	Absent		µg/L	0.0050	0.0166	SW8270C		9/23/08		9/26/08	999917270	Co	
603	2,4-Dichloro-phenol (120-83-2)	<0.770		µg/L	0.770	2.56	SW8270C		9/23/08		9/26/08	999917270	Co	
610	2,5-Dichloro-phenol (583-78-8)	Absent		µg/L	0.0050	0.0166	SW8270C		9/23/08		9/26/08	999917270	Co	
611	2,6-Dichloro-phenol (87-65-0)	Absent		µg/L	0.0050	0.0166	SW8270C		9/23/08		9/26/08	999917270	Co	
620	3,4-Dichloro-phenol (95-77-2)	Absent		µg/L	0.0050	0.0166	SW8270C		9/23/08		9/26/08	999917270	Co	
604	2,4-Dimethyl-phenol (105-67-9)	<7.90		µg/L	7.90	26.3	SW8270C		9/23/08		9/26/08	999917270	Co	
605	2,4-Dinitrophenol (51-28-5)	<0.490		µg/L	0.490	1.63	SW8270C		9/23/08		9/26/08	999917270	Co	
609	2,5-Dinitrophenol (329-71-5)	<0.390		µg/L	0.390	1.30	SW8270C		9/23/08		9/26/08	999917270	Co	
594	2-Methyl-4-chlorophenol (1570-64-5)	Absent		µg/L	0.0050	0.0166	SW8270C		9/23/08		9/26/08	999917270	Co	
615	3-Methyl-4-chloro-phenol (*para*-chloro-*meta*-cresol) (59-50-7)	<0.510		µg/L	0.510	1.70	SW8270C		9/23/08		9/26/08	999917270	Co	
593	2-Methyl-4,6-dinitrophenol (4,6-dinitro-*ortho*-cresol) (534-52-1)	<0.420		µg/L	0.420	1.40	SW8270C		9/23/08		9/26/08	999917270	Co	
596	2-Nitrophenol (88-75-5)	<0.720		µg/L	0.720	2.40	SW8270C		9/23/08		9/26/08	999917270	Co	
624	4-Nitrophenol (100-02-7)	<0.360		µg/L	0.360	1.20	SW8270C		9/23/08		9/26/08	999917270	Co	
368	Pentachlorophenol (87-86-5)	<0.770		µg/L	0.770	2.56	SW8270C		9/23/08		9/26/08	999917270	Co	
	Phenol (108-95-2)	<0.390		µg/L	0.390	1.30	SW8270C		9/23/08		9/26/08	999917270	Co	
600	2,3,4,6-Tetra-chlorophenol (58-90-2)	Absent		µg/L	0.0050	0.0166	SW8270C		9/23/08		9/26/08	999917270	Co	

C-1 (continued). **EFFLUENT MONITORING REPORT FORM for Outfall __105__ (see instructions)**														
Parameter Code	Parameter Name (CAS No.)	Sample Result	QC Flags (explain below)	Units	Detection Limit (LOD)	LOQ	Analytical Method	Confirmed Organics (Y/N)	Sample Collection Date	Extraction Date	Analysis Date	Lab ID Number	Sample Type (Co/Gr)	DMR (✓)
607	2,4,5-Trichloro-phenol (95-95-4)	<0.670		µg/L	0.670	2.23	SW8270C		9/23/08		9/26/08	999917270	Co	
608	2,4,6-Trichloro phenol (88-06-2)	<0.690		µg/L	0.690	2.30	SW8270C		9/23/08		9/26/08	999917270	Co	

Explain QC flags here:

A-01: No Detect.
B: Analyte was detected in the associated Method Blank
C: Calibration Verification recovery was above the method control limit for this analyte. Analyte not detected, data not impacted.
J: Results reported between the MDL and LOQ are less certain than results at or above the LOQ.

C-2. ADDITIONAL MONITORING FORM for OUTFALL 105 (see instructions)

If you know or have reason to believe that any parameter listed in Tables 1 and 2 of the instructions is present in the discharge from this outfall at a concentration greater than 10µg/L AND you have not already provided a sample result in Table C-1, you must list the parameter below in Table C-2 and either provide at least one sample result for the parameter, check the "Intake" column if you expect the parameter is present in the discharge solely as a result of its presence in your intake water, OR check the "DMR" column if you have provided a sample result for the parameter in a recent Discharge Monitoring Report. Check the following box to indicate that you have evaluated the potential for these parameters being present in the discharge.

☒ Excluding those parameters that I have reported in either Table C-1 or Table C-2 below, I believe the parameters listed in Tables 1 and 2 of the instructions are either absent from this outfall's discharge or are present at concentrations less than 10 µg/L.

Table C-2 may also be used to report test results for any parameter that is tested more frequently than required by Table C-1.

Were all effluent samples properly preserved and handled, and are they representative of normal operating conditions?

☐ Yes ☐ No. If no, collect and test another discharge sample.

Parameter Code	Parameter Name (CAS No.)	Sample Result	QC Flags (explain below)	Units	Detection Limit (LOD)	LOQ	Analytical Method	Confirmed Organics (Y/N)	Sample Collection Date	Extraction Date	Analysis Date	Lab ID Number	Sample Type (Co/Gr)	DMR (✓)	Intake (✓)

Explain QC flags here:

C-3. HAZARDOUS SUBSTANCES FORM for OUTFALL 105 (see instructions)

If you know or have reason to believe that any substance listed in Table 3 of the instructions is present in the discharge from this outfall, you must list the substance below in Table C-3, provide any monitoring data that you may have, check the "Intake" column if you expect the parameter is present in the discharge solely as a result of its presence in your intake water, check the "DMR" column if you have provided a sample result for the substance in a recent Discharge Monitoring Report and explain why you believe the substance is present in the discharge. (NOTE: No analytical testing is required for Table 3 substances.) Check one of the following.

☒ I believe all substances in Table 3 of the instructions are absent from the discharge.

☐ I believe all substances in Table 3 of the instructions are absent from the discharge with the exception of those that I have listed below in Table C-3.

Parameter Code	Parameter Name	Sample Result	Units	DMR (✓)	Intake (✓)	Explanation of Presence in Discharge

Comments:

C-4. DISCHARGE MONITORING REPORT (DMR) INFORMATION for OUTFALL _105____ (see instructions)

Check one or more of the following statements and provide the requested information to identify the Discharge Monitoring Report (DMR) data that best represents the current discharge from this outfall. At least one of the first two statements must be checked. Checking the third is optional.

☒ I believe that Discharge Monitoring Report data for the last 36 months are representative of the current effluent quality from this outfall.

☐ I believe that Discharge Monitoring Report data covering the period from
____________________ (day/month/year) to ____________________ (day/month/year)
are representative of the current effluent quality from this outfall. The reason for my belief is as follows:

☐ Certain of the data previously submitted on Discharge Monitoring Reports are not representative of the current effluent quality from this outfall.
The data and the reasons for them not being representative are as follows:

Complete this section for ***each*** land treatment outfall at the facility.

II. WASTEWATER CHARACTERIZATION, TREATMENT, and DISPOSAL

B. SPECIFIC OUTFALL INFORMATION

Land Treatment System Discharge Information --- *This Outfall will not be renewed.*

1. Type of Land Treatment System

This Outfall will not be renewed.

2. Location of Land Treatment System

Quarter-quarter Section _______, Quarter Section _______, Section _______, Township _______, Range _______

3. Seasonal or Intermittent Discharges

☐ Discharge is year round.

☐ Discharge is seasonal (specify)

From: ______________ Through: ______________.
From: ______________ Through: ______________.

☐ Discharge is intermittent (Describe the frequency, duration and flow rate of each discharge occurrence, except for storm water runoff and spillage or leaks)

4. Size of Land Treatment System ______________ Acres

5. Type of Wastewater Discharged (check all that apply)

	Average Flow (specify units)
☒ Noncontact Cooling	______________
☐ Contact Cooling	______________
☒ Sanitary Wastewater	______________
☒ Process Wastewater	______________
☐ Storm Water	______________
☒ Boiler Blowdown	______________
☐ Cooling Tower Blowdown	______________
☒ ______________	______________
☐ ______________	______________

6. Schematic Diagram of Land Treatment System - Attach a schematic diagram of the land treatment system and indicate the predominant soil type present. Provide a description of any pretreatment units or storage.

7. Effluent Flow Monitoring

Flow Monitoring Type & Age ______________

Flow Monitoring Location ______________

Effluent Composite Sample Location ______________

Effluent Grab Sample Location ______________

B. SPECIFIC OUTFALL INFORMATION

Land Treatment System Discharge Information --- *This Outfall will not be renewed.*

8. Management Plan - Do you have an approved management plan for the operation of the land treatment system?

☐ No. (continue to the next section of the application)

☐ Yes. If yes, provide the information requested below.

When did the Department approve the management plan?

Have any changes occurred in your land treatment system or in the operation of the system since the management plan was approved?

☐ No. (continue to the next section of the application)

☐ Yes. If yes, describe the changes below.

9. Provide at least one test result for each of the following parameters. Samples must have been collected within the last 5 years and must be representative of the current discharge.

Parameter	Result(s)		Units
	Maximum Value	Average	
BOD_5 (5-day biochemical oxygen demand)			mg/L
Suspended Solids, Total			mg/L
Total Kjeldahl Nitrogen (as N)			mg/L (as N)
Ammonia			mg/L (as N)
Nitrate plus nitrite			mg/L (as N)
Phosphorus, Total			mg/L (as P)
Chloride			mg/L
pH			Standard units

Name of laboratory performing analyses ______________________

Certification ID number ______________

Complete this section for ***each*** land application outfall at the facility.

II. WASTEWATER CHARACTERIZATION, TREATMENT, and DISPOSAL

B. SPECIFIC OUTFALL INFORMATION ***This Outfall will not be renewed.***

Land Application Discharge Information for Outfall _____ (see instructions)

1. Type of Land Application System

☐ Liquid Wastes (continue to 2) ☐ By-product Solids (continue to 3) ☐ Sludge (continue to 3)

2. Manure Storage Facilities - Will liquid wastes or sludge be stored in a manure storage facility prior to land application?

☐ No. (continue to 3)
☐ Yes. If yes, provide the information requested below for *each* storage facility. (List any additional manure storage facilities on a separate sheet of paper and attach it to this application.)

Location:
Quarter-quarter Section ______, Quarter Section ______, Section ______, Township ______, Range ______.

Owner's Name

Owner's Address
P.O. Box, Street Address or Route

City or Village, State and Zip Code

Volume of manure storage facility ________________________ gallons

Volume of liquid waste stored in storage facility ________________________ gallons

Does the manure storage facility meet Soil Conservation Service design requirements? ☐ Yes ☐ No

3. Waste Sources - What is the source of liquid wastes, by-product solids or sludge?

4. Waste Volume - How much liquid wastes, by-product solids or sludge is land applied in an average year?

________________________ gallons per year of liquid wastes

________________________ tons (dry weight basis) per year of by-product solids

________________________ tons (dry weight basis) per year of sludge

5. Application Frequency - How often will liquid wastes, by-product solids or sludge be land applied in an average year?

__________ days per year

6. Site Identification - Do all of your land application sites have Department ID numbers?

☐ Yes. (continue to 7)
☐ No. If no, for each approved site that lacks a Department ID number submit a copy of the Landspreading Approval Form for Land Application, Form 3400-122. For each site that the Department has not approved, complete and submit a Landspreading Site Evaluation Form, Form 3400-53.

7. Waste Storage - How is liquid wastes, by-product solids or sludge storage provided?

☐ On-site	Type of storage structure	________________
☐ Off-site (owned by permittee)	Type of storage	________________
	Storage Location	________________
☐ Off-site (contracted)	Type of storage structure	________________
	Storage Location	________________
	Owner	________________

8. Waste Hauler - Who hauls the liquid wastes, by-products solids or sludge to the land application site?

- ☐ Plant Personnel
- ☐ Contract Hauler
  - Name ____________________
  - Company ____________________
- ☐ Other (specify)
  - Name ____________________
  - Address ____________________

9. Management Plan - Do you have an approved management plan for land application of the liquid wastes, by-product solids or sludge?

- ☐ No. (continue to the next section of the application)
- ☐ Yes. If yes:

When was the management plan approved by the Department?
Have any changes occurred in the waste or in the land application operation since the management plan was approved?

- ☐ No. (continue to the next section of the application)
- ☐ Yes. If yes, describe the changes below.

10. Provide at least one test result for each of the following parameters. Samples must have been collected within the last 5 years and must be representative of the current discharge.

Parameter	Result(s)		Units
	Maximum Value	Average	
BOD_5 (5-day biochemical oxygen demand) **(liquid wastes only)**			mg/L
Suspended Solids, Total **(liquid wastes only)**			mg/L
Percent Solids **(by-product solids or sludge only)**			%
Total Kjeldahl Nitrogen (as N)			mg/L (as N)
Ammonia			mg/L (as N)
Nitrate plus nitrite **(liquid wastes only)**			mg/L (as N)
Phosphorus, Total			mg/L (as P)
Chloride			mg/L
pH			Standard units
Cadmium **(for sludge only)**			mg/Kg as dry weight
Copper **(for sludge only)**			mg/Kg as dry weight
Lead **(for sludge only)**			mg/Kg as dry weight
Nickel **(for sludge only)**			mg/Kg as dry weight
Zinc **(for sludge only)**			mg/Kg as dry weight

Name of laboratory performing analyses ____________________
Certification ID number ____________________

II. WASTEWATER CHARACTERIZATION, TREATMENT AND DISPOSAL

B. SPECIFIC OUTFALL INFORMATION

BY-PRODUCT SOLIDS and SILAGE STACKS for Outfall _____ (see instructions) Complete this section for ***each*** by-product stack.

Not Applicable.

1. Type of By-product Solids ☐ Sweet Corn Silage, or ☐ Other

2. Location of By-products Solids Stack

   Quarter-quarter Section _______, Quarter Section _______, Section _______, Township _______, Range _______

3. Maximum Size of By-products Solids Stack _______________ Tons

4. Anticipated Volume of Leachate _______________ gallons per _______________ (day, week or month)

5. Location and Size of Leachate Disposal Sites

	Name	Acres	Quarter-quarter Section	Quarter Section	Section	Township	Range
First Site							
Second Site							
Third Site							
Fourth Site							

(Please list any additional leachate disposal sites on a separate sheet of paper and attach it to this application.)

6. Stack Owner or Operator

   ☐ Same as Owner or Responsible Party as provided in Part I, B

   ☐ Other (specify) Name _______________

   Third-party Operator (if any) _______________

II. WASTEWATER CHARACTERIZATION, TREATMENT, and DISPOSAL

B. SPECIFIC OUTFALL INFORMATION

GROUNDWATER MONITORING INFORMATION (see instructions)

1. Groundwater Monitoring - Does your current WPDES permit contain groundwater monitoring requirements?

☒ No. If no, you do not have to provide the information that is requested below and may proceed to the next section of the application.

☐ Yes. If yes, are the Turn-Around Documents (Form 3400-73) issued by the Department during the term of your current WPDES permit consistent with the groundwater monitoring requirements of the current WPDES permit?

☐ Yes. (continue to 2)
☐ No. If no, please note the inconsistencies below.

2. Land Use Changes - Have there been any land use changes on your facility's property and/or land treatment site(s) during the term of the current WPDES permit?

☐ No. (continue to 3)
☐ Yes. If yes, please describe the land use changes below and provide a map showing the relation of the new land uses to the groundwater monitoring

3. Other Existing Wells - Are there any operable groundwater monitoring wells on your facility's property and/or land treatment site(s) that are <u>not</u> required to be monitored by your current WPDES permit?

☐ No. (continue to 4)
☐ Yes. If yes, does another Department program or another state agency require you to monitor the wells?

☐ Yes. If yes, identify the program(s) or agency

☐ No. If no, complete the table below and explain why the well(s) have not been abandoned.

Well No.	Treatment Site the Well Monitors	Quarter-quarter Section	Quarter Section	Section	Township,	Range	Range Dir

Explain why the well(s) have not been abandoned.

B. SPECIFIC OUTFALL INFORMATION

GROUNDWATER MONITORING INFORMATION (see instructions)

4. Wells - During the term of your current WPDES permit, have you abandoned any groundwater monitoring wells on your facility's property and/or land treatment site(s) and not submitted Well/Drillhole/Borehole Abandonment Form 3300-5B for each abandoned well?

☐ No. (continue to 5)
☐ Yes. If yes, complete the table below and attach Well/Drillhole/Borehole Abandonment Form 3300-5B for each well that has been abandoned.

Well No.	Treatment Site the Well Monitors	Quarter-quarter Section	Quarter Section	Section	Township,	Range	Range Dir

5. New Wells - During the term of your current WPDES permit, have you installed any new wells on your facility's property and/or land treatment site(s) and not submitted Monitoring Well Construction Form 4400-113A, Well Development Form 4400-113B and Soil Boring Log Information Form 4400-122 for each new well?

☐ No. (continue to the next section of the application)
☐ Yes. If yes, complete the table below and attach Monitoring Well Construction Form 4400-113A, Well Development Form 4400-113B and Soil Boring Log Information Form 4400-122 for each new well, and a site map showing well locations.

Well No.	Treatment Site the Well Monitors	Quarter-quarter Section	Quarter Section	Section	Township,	Range	Range Dir

II. WASTEWATER CHARACTERIZATION, TREATMENT, and DISPOSAL

B. SPECIFIC OUTFALL INFORMATION

STORM WATER

1. APPLICABILITY

Please check the appropriate box or boxes:

☒ The storm water from this facility is covered by a WPDES discharge permit. (Identify which permit below)

- ☐ Tier 1 WPDES Storm Water Discharge Permit (WI-S067849).
- ☒ Tier 2 WPDES Storm Water Discharge Permit (WI-S067857).
- ☐ Tier 3 WPDES Storm Water Discharge Permit (WI-S049158)
- ☐ The WPDES discharge permit addressed by this application.

☐ The storm water from this facility is not covered by a WPDES discharge permit.

If you checked the last box, please provide the information that is requested below. If you checked the first box, you do not have to provide the information that is requested below and may proceed to the next section of the application unless changes have occurred at your facility that may have impacted the storm water discharge.

2. FACILITY IDENTIFICATION INFORMATION

a. Facility Location

(1). Quarter-quarter Section _______, Quarter Section _______, Section _______, Township _______, Range _______

(2). Is the site wholly contained in the above quarter-quarter section? ☐ No ☐ Yes

b. Is your facility a transportation facility?

☐ No. (continue to 3)
☐ Yes. If yes, does your facility have a vehicle maintenance shop, equipment cleaning operations, including vehicle washing, or airport de-icing operations? (Vehicle maintenance includes rehabilitation, mechanical repairs, painting, fueling and lubrication.)

☐ No. (continue to 3)
☐ Yes. If yes, please explain in the space provided below.

3. STORM WATER DISCHARGE INFORMATION

a. Has storm water runoff from your facility been analyzed for the presence of any pollutants?

☐ No. (continue to b)
☐ Yes. If yes, please attach copies of any collected data.

b. Any known adverse impact on receiving waters from your storm water discharges?

☐ No ☐ Yes

c. Have any leaks or similar instances of storm water contamination occurred at your facility within the last 3 years?

☐ No. (continue to d)
☐ Yes. If yes, please answer the following questions:

Did spill occur in an earthen area?	☐ No	☐ Yes
Did the spill occur on a paved surface?	☐ No	☐ Yes
Was action taken to clean up the spill?	☐ No	☐ Yes

d. Are any material handling equipment or activities, raw materials, intermediate products, final products, waste materials, by-products or industrial machinery located in areas exposed to rainfall, storm water or snow melt water?

☐ No ☐ Yes

III. ADDITIONAL COMMENTS AND SIGNATURE (see instructions)

A. Additional Comments (attach additional sheets, if necessary)

B. Signature of Authorized Representative

This application MUST be signed by an Authorized Representative who is:

For a corporation - The owner, the proprietor for a sole proprietorship, a senior member or manager of a limited liability company, a general partner for a partnership, a principal executive officer of at least the level of vice-president or their authorized representative responsible for the overall operation of the facility.

For a publicly owned treatment works - A principal executive officer, ranking elected official or other duly authorized employee.

I certify that the information contained in this document and all attachments was gathered and prepared under my supervision and based on inquiry of the people directly under my supervision that, to the best of my knowledge, the information is true, accurate and complete.

1. Signature [signature]

2. Date 12-19-08

3. Typed/Printed Name Daniel Frey

Title Chemistry Manager

Telephone Numbers (920) 755 - 6987, FAX (920) 755 - 6086

4. Mailing Address

☐ Facility Mailing Address, ☐ Facility Location Address ☐ Owner or Responsible Party Mailing Address, or ☐ Other (provide below)

Company Name FPL Energy Point Beach, LLC

P.O. Box, Number and Street or Route 6610 Nuclear Road

City or Village, State and Zip Code Two Rivers, WI 54241

5. Preparer's Name (if different than authorized representative) Mark Schanke

Appendix A – Additional Treatment Information

Point Beach Nuclear Plant
Additional Treatment Information

Condenser Cooling Water (Outfalls 001 and 002)
As stated in the previous permit application, the Intake Crib was redesigned in 2002 such that cooling water for both condenser units is withdrawn through a submerged intake crib located 1,750 feet offshore in about 22 feet of water.

Water flows from the intake structure to the pumphouse forebay through two 14 foot diameter, corrugated, galvanized, structural plate pipes buried to a minimum depth of three feet below the lake bed. Water depth in the forebay is approximately 28 feet. The intake water passes through vertical bar racks consisting of 3/8-inch by 4-inch bars, spaced with 2¼- inch gaps. One 59-foot wide rack is provided for each unit. Water then flows through the eight traveling water screens (3/8-inch square mesh) in the pumphouse, each of which is approximately 11 feet wide. The screen wash (80 psi) is filtered through a collection basket with 3-inch square openings, and returned to the lake via a 24-inch diameter steel pipe with an outlet in the Unit 2 discharge flume, approximately 80 feet from the collection basket. The eight traveling water screens are operated intermittently with a minimum rinsing three times a day, or once each eight hour shift. The duration of each rinse is 30 minutes. Rinsing is performed more often when debris accumulates.

Deicing is performed by reversing flow in one of the intake pipes to return warm discharge water to the intake crib. Part or all of the cooling water discharge of one unit can be redirected to the crib. The other intake pipe then supplies the water to both units. Deicing is performed during the winter months. From March or April until November, the plant usually operates on four circulating water pumps, with a maximum design flow of about 750,000 gpm. During the remainder of the year, two pumps are used for a design flow rate of about 430,000 gpm. Maximum recirculation flow to the intake crib is approximately 200,000 gpm. It should be noted that recirculated water does not discharge directly to the lake, but only to the intake crib.

The condenser cooling water system is routinely chlorinated for bio-fouling problems. The system utilizes liquid sodium hypochlorite fed at the rate of 3 to 5 gpm per unit.

Zebra Mussel Control Program
Sodium hypochlorite is applied for one hour per day. The number of times per week depends on lake temperature and is as follows:

- 3 days per week when below 45 °F,
- 5 days when between 45 °F and 55 °F, and
- 7 days per week when above 55 °F.

The main benefit is control of the slime layer that zebra mussels prefer to attack.

EVAC (cocoamine salt of endothall) is applied roughly once per year at 4 ppm active amines into service water. The aim is for 24 hours over one weekend. The treatment is normally secured mid-way in order to replenish our pure water inventory and restarted the next day. Circulation water temperature is raised to 65 degrees if necessary along with these treatments for efficacy.

Chlorination has been used during the warmest months of the year to control zebra mussels in the intake structure and pipelines which extend about 1800 feet off-shore. The final cooling water, including service water, discharge is dechlorinated using sodium bisulfite fed at a rate of 1.5 to 3 gpm per unit prior to discharge to Lake Michigan via outfalls 001 and/or 002.

Sewage Treatment Plant

Sanitary wastes from the plant and administration building are treated in a package extended aeration, activated sludge plant. The raw sewage pump station contains a macerator to grind large solids in the waste into small particles. The raw sewage is pumped to an equalization basin located at the influent end of the package extended aeration activated sludge unit in the sewage treatment building. The equalization basin uses variable speed feed pumps to reduce surges in flow to the activated sludge plant.

The aeration basin has an approximate capacity of 20,000 gallons and a detention time of about 27 hours at 17,500 gpd flow. Aeration is provided through 12 diffusers. Air to the diffusers is provided by three rotary positive displacement blowers. Effluent from the aeration basin flows by gravity to a final clarifier in the sewage treatment building. An air ejector pump transports the sludge collected in the clarifier to the influent end of the aeration basin as Returned Activated Sludge (RAS). Waste Activated Sludge (WAS) from the clarifier is pumped to the waste sludge storage basin using timed operation wasting pumps.

Effluent from the final clarifier flows by gravity into a channel beneath the floor of the sewage treatment building. Water level in the channel is maintained with a 11½-degree V-notch weir. An ultrasonic level probe is installed in the channel to continuously measure the flow over the weir. An automatic flow proportional sampler is provided for the clarifier effluent. Positive displacement chemical feed pumps are provided for feeding the following:

1. Liquid polymer to the final clarifier influent for improved solids settling.
2. Caustic soda to the aeration basin for pH control.

The treated effluent flows by gravity to the effluent sump pump station immediately north of the lift stations. This sump also collects water from the power plant's potable RO reject and Iron/Carbon filter with final discharge to the cooling water discharge via wastewater effluent point 105.

Waste sludge is continuously aerated. A local licensed septage hauler periodically removes the sludge off site for ultimate disposal.

Microfiltration System

The Point Beach Makeup Water system starts with Lake Michigan water from the service water system and processes it into high quality demineralized water for use in plant systems. Pretreatment uses a microfiltration system which uses a mechanical filtration membrane to remove all solids greater than ~0.2 microns from the water prior to processing through the reverse osmosis units, cation/ion demineralizers, degassifiers, and finally the mixed bed demineralizer for final polishing. The microfiltration system consists of three independent units that can each supply 250 gpm of product water for a total capacity of 750 gpm. The accumulated solids are routinely removed (approximately every 20 to 30 minutes) through a backwash system. The microfilter membranes are periodically cleaned (approximately monthly) chemically to remove hardened filtered solids that normal backwashing can not remove. Sulfuric acid, sodium hypochlorite, and sodium bisulfite are used for the chemical cleaning process. Both the backwash and chemical cleaning processes discharge to the wastewell which eventually enters the circulating water system for discharge to Lake Michigan.

Appendix B – Laboratory Reports

TestAmerica
THE LEADER IN ENVIRONMENTAL TESTING
602 Commerce Drive Watertown, WI 53094 * 800-833-7036 * Fax 920-261-8120

October 07, 2008

Client:	SIGMA ENVIRONMENTAL (WW) 1300 West Canal Street Milwaukee, WI 53233	Work Order: Project Name: Project Number:	WRI0797 Point Beach Power Plant 11196
Attn:	Mr. Tom Koeppen	Date Received:	09/23/08

An executed copy of the chain of custody is also included as an addendum to this report.

If you have any questions relating to this analytical report, please contact your Laboratory Project Manager at 1-800-833-7036

SAMPLE IDENTIFICATION	LAB NUMBER	COLLECTION DATE AND TIME
002 FPC 9/22-23	WRI0797-01	09/23/08 10:30
002 Grab	WRI0797-02	09/23/08 10:30
LL Hg Blank	WRI0797-03	09/23/08

EPA 420.4 analysis performed at Lab ID: 999917270

Samples were received into laboratory at a temperature of 12 °C.

Wisconsin Certification Number: 128053530

The Chain(s) of Custody, 2 pages, are included and are an integral part of this report.

Unless subcontracted, volatiles analyses (including VOC, PVOC, GRO, BTEX, and TPH gasoline) performed by TestAmerica Watertown at 1101 Industrial Drive, Units 9&10. All other analyses performed at the address shown in the heading of this report.

Approved By:

Michael M Miller

TestAmerica Watertown
Mike Miller For Warren L. Topel
Project Manager

TestAmerica
THE LEADER IN ENVIRONMENTAL TESTING

602 Commerce Drive Watertown, WI 53094 * 800-833-7036 * Fax 920-261-8120

SIGMA ENVIRONMENTAL (WW)
1300 West Canal Street
Milwaukee, WI 53233
Mr. Tom Koeppen

Work Order: WRI0797
Project: Point Beach Power Plant
Project Number: 11196

Received: 09/23/08
Reported: 10/07/08 11:13

ANALYTICAL REPORT

Analyte	Sample Result	Data Qualifiers	Units	MDL	LOQ	Dilution Factor	Date Analyzed	Analyst	Seq/ Batch	Method
Sample ID: WRI0797-01 (002 FPC 9/22-23 - Waste Water)							**Sampled: 09/23/08 10:30**			
General Chemistry Parameters										
Ammonia as N	<0.10		mg/L	0.10	0.33	1	10/07/08 09:30	tdc	8100056	SM 4500NHH
BOD - 5 Day	<2.0		mg/L	2.0	6.7	1	09/24/08 14:33	shf	8090634	SM 5210
Chemical Oxygen Demand	**6.2**	J	mg/L	5.7	19	1	09/24/08 13:11	kls	8090630	EPA 410.4
Chloride	**10**		mg/L	1.0	3.3	1	09/26/08 15:52	pxm	8090715	EPA 325.2
Hardness	**210**		mg/L	4.0	13	1	09/26/08 11:50	shf	8090722	EPA 130.2
Phosphorus, Total (as P)	<0.10		mg/L	0.10	0.33	1	09/30/08 12:42	pxm	8090740	EPA 365.1
Total Suspended Solids	**8.0**		mg/L	1.0	3.3	1	09/25/08 15:47	lcr	8090681	EPA 160.2
Metals										
Antimony	**0.31**	J	ug/L	0.12	0.40	1	09/25/08 12:07	gaf	8090598	SW 6020A
Arsenic	**1.0**		ug/L	0.12	0.40	1	09/25/08 12:07	gaf	8090598	SW 6020A
Beryllium	<0.12		ug/L	0.12	0.40	1	09/25/08 12:07	gaf	8090598	SW 6020A
Cadmium	<0.12		ug/L	0.12	0.40	1	09/25/08 12:07	gaf	8090598	SW 6020A
Chromium	**0.17**	J	ug/L	0.12	0.40	1	09/25/08 12:07	gaf	8090598	SW 6020A
Copper	<6.0		ug/L	6.0	20	1	09/25/08 12:07	gaf	8090598	SW 6020A
Lead	<0.12		ug/L	0.12	0.40	1	09/25/08 12:07	gaf	8090598	SW 6020A
Nickel	<6.0		ug/L	6.0	20	1	09/25/08 12:07	gaf	8090598	SW 6020A
Selenium	**0.64**	B	ug/L	0.12	0.40	1	09/25/08 12:07	gaf	8090598	SW 6020A
Silver	<0.12		ug/L	0.12	0.40	1	09/25/08 12:07	gaf	8090598	SW 6020A
Thallium	<0.12		ug/L	0.12	0.40	1	09/25/08 12:07	gaf	8090598	SW 6020A
Zinc	<6.0		ug/L	6.0	20	1	09/25/08 12:07	gaf	8090598	SW 6020A
General Chemistry Parameters										
Phenol	<0.00126		mg/L	0.00126	0.00420	0.96	10/01/08 12:24	kmc	8091248	EPA 420.4
Sample ID: WRI0797-02 (002 Grab - Waste Water)							**Sampled: 09/23/08 10:30**			
General Chemistry Parameters										
Chromium, Hexavalent	<0.0025		mg/L	0.0025	0.0083	1	09/24/08 08:25	kls	8090602	SM 3500CrD
Cyanide (amenable)	<0.017		mg/L	0.017	0.057	1	09/25/08 10:31	pxm	8090663	EPA 335.4
Cyanide (total)	<0.017	C	mg/L	0.017	0.057	1	09/25/08 10:26	pxm	8090638	EPA 335.4
Oil & Grease (HEM)	<0.82		mg/L	0.82	2.7	1.136364	09/26/08 00:00	JEJ	8090675	EPA 1664
Metals										
Mercury	<0.14		ng/L	0.14	0.47	1	09/25/08 16:34	jej	8090648	EPA 1631E
Field Sampling Parameters										
pH	**6.80**		pH Units	NA		1	09/23/08 10:30	pam	8090738	EPA 150.1
Temperature	**24.0**		°C	NA		1	09/23/08 10:30	pam	8090738	EPA 170.1
Chlorine, Field	<0.016	A-01	mg/L	0.016	0.053	1	09/23/08 10:30	pam	8090738	SM4500Cl G
Sample ID: WRI0797-03 (LL Hg Blank - Waste Water)							**Sampled: 09/23/08**			
Metals										
Mercury	<0.14		ng/L	0.14	0.47	1	09/25/08 16:34	jej	8090648	EPA 1631E

TestAmerica Watertown
Mike Miller For Warren L. Topel
Project Manager

TestAmerica
THE LEADER IN ENVIRONMENTAL TESTING

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SIGMA ENVIRONMENTAL (WW)
1300 West Canal Street
Milwaukee, WI 53233
Mr. Tom Koeppen

Work Order: WRI0797
Project: Point Beach Power Plant
Project Number: 11196

Received: 09/23/08
Reported: 10/07/08 11:13

LABORATORY BLANK QC DATA

Analyte	Seq/ Batch	Source Result	Spike Level	Units	MDL	MRL	Result	Dup Result	% REC	Dup %REC	% REC Limits	RPD	RPD Limit	Q
General Chemistry Parameters														
Chromium, Hexavalent	8090602			mg/L	0.0025	0.0088	<0.0025							
Chromium, Hexavalent	8090602			mg/L	0.0025	0.0088	<0.0025							
Chemical Oxygen Demand	8090630			mg/L	5.7	20	<5.7							
Chemical Oxygen Demand	8090630			mg/L	5.7	20	<5.7							
BOD - 5 Day	8090634			mg/L	2.0	6.7	<2.0							
Cyanide (total)	8090638			mg/L	0.017	0.058	<0.017							C
Oil & Grease (HEM)	8090675			mg/L	0.72	2.6	<0.72							
Chloride	8090715			mg/L	1.0	3.3	<1.0							
Hardness	8090722			mg/L	4.0	12	<4.0							
Phosphorus, Total (as P)	8090740			mg/L	0.10	0.33	<0.10							
Ammonia as N	8100056			mg/L	0.10	0.33	<0.10							
Metals														
Antimony	8090598			ug/L	0.12	0.40	0.130							J
Arsenic	8090598			ug/L	0.12	0.40	<0.12							
Beryllium	8090598			ug/L	0.12	0.40	<0.12							
Cadmium	8090598			ug/L	0.12	0.40	<0.12							
Chromium	8090598			ug/L	0.12	0.40	<0.12							
Copper	8090598			ug/L	6.0	20	<6.0							
Lead	8090598			ug/L	0.12	0.40	<0.12							
Nickel	8090598			ug/L	6.0	20	<6.0							
Selenium	8090598			ug/L	0.12	0.40	0.290							J
Silver	8090598			ug/L	0.12	0.40	<0.12							
Thallium	8090598			ug/L	0.12	0.40	<0.12							
Zinc	8090598			ug/L	6.0	20	<6.0							
Mercury	8090648			ng/L	0.14	0.50	<0.14							
Mercury	8090648			ng/L	0.14	0.50	<0.14							
General Chemistry Parameters														
Phenol	8091248			mg/L	0.00126	0.0200	<0.00126							

TestAmerica Watertown
Mike Miller For Warren L. Topel
Project Manager

SIGMA ENVIRONMENTAL (WW)
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Project: Point Beach Power Plant
Project Number: 11196

Received: 09/23/08
Reported: 10/07/08 11:13

CCV QC DATA

Analyte	Seq/ Batch	Source Result	Spike Level	Units	MDL	MRL	Result	Dup Result	% REC	Dup %REC	% REC Limits	RPD	RPD Limit	Q
General Chemistry Parameters														
Chromium, Hexavalent	8090602		0.5000 0	mg/L	N/A	N/A	0.529		106		90-110			
Chromium, Hexavalent	8090602		0.5000 0	mg/L	N/A	N/A	0.528		106		90-110			
Chemical Oxygen Demand	8090630		100.00	mg/L	N/A	N/A	95.0		95		90-110			
Chemical Oxygen Demand	8090630		100.00	mg/L	N/A	N/A	94.4		94		90-110			
BOD - 5 Day	8090634		200.00	mg/L	N/A	N/A	220		110		84.6-115.4			
Cyanide (total)	8090638		0.2000 0	mg/L	N/A	N/A	0.214		107		90-110			C
Cyanide (total)	8090638		0.2000 0	mg/L	N/A	N/A	0.241		120		90-110			C
Oil & Grease (HEM)	8090675		40.000	mg/L	N/A	N/A	39.8		100		86-114			
Chloride	8090715		20.000	mg/L	N/A	N/A	19.6		98		90-110			
Chloride	8090715		40.000	mg/L	N/A	N/A	40.7		102		90-110			
Chloride	8090715		20.000	mg/L	N/A	N/A	19.4		97		90-110			
Chloride	8090715		40.000	mg/L	N/A	N/A	41.2		103		90-110			
Hardness	8090722		44.000	mg/L	N/A	N/A	48.0		109		90-110			
Hardness	8090722		80.000	mg/L	N/A	N/A	80.0		100		90-110			
Hardness	8090722		80.000	mg/L	N/A	N/A	84.0		105		90-110			
Phosphorus, Total (as P)	8090740		10.000	mg/L	N/A	N/A	9.90		99		90-110			
Phosphorus, Total (as P)	8090740		10.000	mg/L	N/A	N/A	9.86		99		90-110			
Ammonia as N	8100056		10.000	mg/L	N/A	N/A	10.1		101		90-110			
Ammonia as N	8100056		10.000	mg/L	N/A	N/A	9.82		98		90-110			
Metals														
Mercury	8090648		5.0000	ng/L	N/A	N/A	4.68		94		77-123			

TestAmerica Watertown
Mike Miller For Warren L. Topel
Project Manager

602 Commerce Drive Watertown, WI 53094 * 800-833-7036 * Fax 920-261-8120

SIGMA ENVIRONMENTAL (WW)
1300 West Canal Street
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Mr. Tom Koeppen

Work Order: WRI0797
Project: Point Beach Power Plant
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Received: 09/23/08
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CCV QC DATA

Analyte	Seq/ Batch	Source Result	Spike Level	Units	MDL	MRL	Result	Dup Result	% REC	Dup %REC	% REC Limits	RPD	RPD Limit	Q
Metals														
Mercury	8090648		5.0000	ng/L	N/A	N/A	4.08		82		77-123			
Mercury	8090648		5.0000	ng/L	N/A	N/A	4.16		83		77-123			
Mercury	8090648		5.0000	ng/L	N/A	N/A	4.58		92		77-123			

SIGMA ENVIRONMENTAL (WW)
1300 West Canal Street
Milwaukee, WI 53233
Mr. Tom Koeppen

Work Order: WRI0797
Project: Point Beach Power Plant
Project Number: 11196

Received: 09/23/08
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LABORATORY DUPLICATE QC DATA

Analyte	Seq/ Batch	Source Result	Spike Level	Units	MDL	MRL	Result	% REC	Dup %REC	% REC Limits	RPD	RPD Limit	Q
General Chemistry Parameters													
QC Source Sample: WRI0797-02													
Chromium, Hexavalent	8090602	<0.0025		mg/L	0.0025	0.0088	<0.0025					8	
QC Source Sample: WRI0787-04													
BOD - 5 Day	8090634	149		mg/L	2.0	6.7	162				8	26	
QC Source Sample: WRI0799-01													
BOD - 5 Day	8090634	200		mg/L	2.0	6.7	175				13	26	
QC Source Sample: WRI0802-01													
Total Suspended Solids	8090681	86.0		mg/L	1.0	3.3	87.0				1	26	
QC Source Sample: WRI0799-01													
Total Suspended Solids	8090681	226		mg/L	1.0	3.3	218				4	26	

TestAmerica
THE LEADER IN ENVIRONMENTAL TESTING
602 Commerce Drive Watertown, WI 53094 * 800-833-7036 * Fax 920-261-8120

SIGMA ENVIRONMENTAL (WW)
1300 West Canal Street
Milwaukee, WI 53233
Mr. Tom Koeppen

Work Order: WRI0797
Project: Point Beach Power Plant
Project Number: 11196

Received: 09/23/08
Reported: 10/07/08 11:13

LCS/LCS DUPLICATE QC DATA

Analyte	Seq/ Batch	Source Result	Spike Level	Units	MDL	MRL	Result	Dup Result	% REC	Dup %REC	% REC Limits	RPD	RPD Limit	Q
General Chemistry Parameters														
Cyanide (total)	8090638		0.2000 0	mg/L	N/A	N/A	0.218		109		90-110			C
Phosphorus, Total (as P)	8090740		10.000	mg/L	0.10	0.33	9.67		97		90-110			
Ammonia as N	8100056		10.000	mg/L	0.10	0.33	9.86		99		90-110			
Metals														
Antimony	8090598		50.000	ug/L	0.12	0.40	43.8		88		85-115			
Arsenic	8090598		50.000	ug/L	0.12	0.40	50.6		101		85-115			
Beryllium	8090598		50.000	ug/L	0.12	0.40	50.8		102		80-112			
Cadmium	8090598		50.000	ug/L	0.12	0.40	51.7		103		83-109			
Chromium	8090598		50.000	ug/L	0.12	0.40	50.7		101		80-120			
Copper	8090598		50.000	ug/L	6.0	20	51.7		103		84-111			
Lead	8090598		50.000	ug/L	0.12	0.40	49.4		99		85-115			
Nickel	8090598		50.000	ug/L	6.0	20	52.6		105		83-108			
Selenium	8090598		50.000	ug/L	0.12	0.40	47.7		95		84-110			B
Silver	8090598		50.000	ug/L	0.12	0.40	51.7		103		80-123			
Thallium	8090598		50.000	ug/L	0.12	0.40	52.2		104		80-120			
Zinc	8090598		50.000	ug/L	6.0	20	57.0		114		82-111			L1
Mercury	8090648		5.0000	ng/L	0.14	0.50	4.73		95		75-125			
Mercury	8090648		5.0000	ng/L	0.14	0.50	4.39		88		75-125			
General Chemistry Parameters														
Phenol	8091248		0.100	mg/L	0.00113	0.0180	0.0924		92		90-110			

TestAmerica Watertown
Mike Miller For Warren L. Topel
Project Manager

TestAmerica
THE LEADER IN ENVIRONMENTAL TESTING

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SIGMA ENVIRONMENTAL (WW)
1300 West Canal Street
Milwaukee, WI 53233
Mr. Tom Koeppen

Work Order: WRI0797
Project: Point Beach Power Plant
Project Number: 11196

Received: 09/23/08
Reported: 10/07/08 11:13

MATRIX SPIKE/MATRIX SPIKE DUPLICATE QC DATA

Analyte	Seq/ Batch	Source Result	Spike Level	Units	MDL	MRL	Result	Dup Result	% REC	Dup %REC	% REC Limits	RPD	RPD Limit	Q
General Chemistry Parameters														
QC Source Sample: WRI0667-02														
Cyanide (total)	8090638	<0.017	0.33333	mg/L	0.017	0.058	0.306	0.296	92	89	57-138	3	21	C
QC Source Sample: WRI0845-02														
Chloride	8090715	28.5	200.00	mg/L	10	33	222	226	97	99	64-132	2	19	
QC Source Sample: WRI0843-01														
Hardness	8090722	330	200.00	mg/L	4.0	12	500	510	85	90	76-126	2	15	
QC Source Sample: WRI0779-01														
Phosphorus, Total (as P)	8090740	0.410	10.000	mg/L	0.10	0.33	9.89	9.91	95	95	64-136	0	23	
QC Source Sample: WRI0796-01														
Ammonia as N	8100056	2.01	10.000	mg/L	0.10	0.33	12.0	11.8	100	98	60-136	2	22	
Metals														
QC Source Sample: WRI0796-01														
Antimony	8090598	0.120	50.000	ug/L	0.12	0.40	40.7	54.4	81	109	75-125	29	20	R2
Arsenic	8090598	<0.12	50.000	ug/L	0.12	0.40	50.9	53.6	102	107	75-125	5	20	
Beryllium	8090598	<0.12	50.000	ug/L	0.12	0.40	54.5	53.8	109	108	56-131	1	25	
Cadmium	8090598	<0.12	50.000	ug/L	0.12	0.40	52.3	52.3	105	105	65-118	0	18	
Chromium	8090598	<0.12	50.000	ug/L	0.12	0.40	48.6	48.3	97	97	75-125	1	20	
Copper	8090598	7.45	50.000	ug/L	6.0	20	56.0	56.5	97	98	69-123	1	25	
Lead	8090598	1.81	50.000	ug/L	0.12	0.40	49.8	49.5	96	95	75-125	1	20	
Nickel	8090598	<6.0	50.000	ug/L	6.0	20	52.9	53.2	106	106	63-117	1	21	
Selenium	8090598	0.190	50.000	ug/L	0.12	0.40	47.6	52.9	95	105	70-123	11	20	B
Silver	8090598	<0.12	50.000	ug/L	0.12	0.40	50.2	49.9	100	100	70-124	1	20	
Thallium	8090598	<0.12	50.000	ug/L	0.12	0.40	51.4	50.8	103	102	75-125	1	20	
Zinc	8090598	12.0	50.000	ug/L	6.0	20	66.3	65.6	109	107	63-125	1	30	
QC Source Sample: WRI0689-01														
Mercury	8090648	<0.14	5.0000	ng/L	0.14	0.50	3.35	3.49	67	70	71-125	4	24	M8
QC Source Sample: WRI0797-02														
Mercury	8090648	<0.14	5.0000	ng/L	0.14	0.50	4.68	4.08	94	82	71-125	14	24	
QC Source Sample: WRI0805-02														
Mercury	8090648	<0.14	5.0000	ng/L	0.14	0.50	4.04	4.14	81	83	71-125	2	24	
General Chemistry Parameters														
QC Source Sample: CRI1150-01														
Phenol	8091248	<0.0013	0.100	mg/L	0.00126	0.0200	0.0940	0.0978	94	98	90-110	4	15	

TestAmerica Watertown
Mike Miller For Warren L. Topel
Project Manager

TestAmerica

THE LEADER IN ENVIRONMENTAL TESTING

602 Commerce Drive Watertown, WI 53094 * 800-833-7036 * Fax 920-261-8120

SIGMA ENVIRONMENTAL (WW)	Work Order:	WRI0797	Received:	09/23/08
1300 West Canal Street	Project:	Point Beach Power Plant	Reported:	10/07/08 11:13
Milwaukee, WI 53233	Project Number:	11196		
Mr. Tom Koeppen				

CERTIFICATION SUMMARY

TestAmerica Watertown

Method	Matrix	Nelac	Wisconsin
EPA 130.2	Water - NonPotable	X	X
EPA 150.1	Water - NonPotable	X	N/A
EPA 160.2	Water - NonPotable	X	X
EPA 1631E	Water - NonPotable		X
EPA 1664	Water - NonPotable	X	X
EPA 170.1	Water - NonPotable		
EPA 325.2	Water - NonPotable	X	X
EPA 335.4	Water - NonPotable	X	X
EPA 365.1	Water - NonPotable	X	X
EPA 410.4	Water - NonPotable		X
SM 3500CrD	Water - NonPotable		X
SM 4500NHH	Water - NonPotable	X	X
SM 5210	Water - NonPotable	X	X
SM4500Cl G	Water - NonPotable		
SW 6020A	Water - NonPotable		X

Subcontracted Laboratories

TestAmerica Analytical - Cedar Falls NELAC Cert #000668, Wisconsin Cert #999917270, Illinois Cert #000668, Minnesota Cert #019-999-319, Iowa Cert #007, North Dakota Cert #R-186
704 Enterprise Drive - Cedar Falls, IA 50613

Method Performed: EPA 420.4
Samples: WRI0797-01

DATA QUALIFIERS AND DEFINITIONS

A-01	No Detect.
B	Analyte was detected in the associated Method Blank.
C	Calibration Verification recovery was above the method control limit for this analyte. Analyte not detected, data not impacted.
J	Results reported between the Method Detection Limit (MDL) and Limit of Quantitation (LOQ) are less certain than results at or above the LOQ.
L1	Laboratory Control Sample and/or Laboratory Control Sample Duplicate recovery was above acceptance limits.
M8	The MS and/or MSD were below the acceptance limits. See Blank Spike (LCS).
R2	The RPD exceeded the acceptance limit.

ADDITIONAL COMMENTS

TestAmerica Watertown
Mike Miller For Warren L. Topel
Project Manager

WRI0797

TestAmerica
THE LEADER IN ENVIRONMENTAL TESTING

Watertown Division
602 Commerce Drive
Watertown, WI 53094

Phone 920-261-1660 or 800-833-7036
Fax 920-261-8120

To assist us in using the proper analytical methods, is this work being conducted for regulatory purposes?
Compliance Monitoring ____

Client Name: Sigma   Client #: ____
Address: ____
City/State/Zip Code: Milw
Project Manager: Tom Koeppen
Telephone Number: 414 643 4138   Fax: 414 643 4210
Sampler Name: (Print Name) D. Kuhtz
Sampler Signature: [signature]
E-mail address: ____

Project Name: Point Beach Nuclear Power Plant
Project #: 11196
Site/Location ID: Two Rivers   State: WI
Report To: Tom Koeppen
Invoice To: ____
Quote #: ____   PO#: ____

TAT
___ Standard
___ Rush (surcharges may apply)

Date Needed: ____

Fax Results: Y N

E-mail: Y N

	SAMPLE ID	Date Sampled	Time Sampled	G = Grab, C = Composite	Field Filtered	Matrix (SL - Sludge DW - Drinking Water, GW - Groundwater S - Soil/Solid, WW - Wastewater Specify Other)	HNO_3	HCl	NaOH	H_2SO_4	Methanol	None	Other (Specify)	Analyze For:	REMARKS
-01	#002 (TC) 9/22-9/23	9/23/08	10:30	C		WW	2			3		2		SEE Attached	pH = 6.8
-02	#002 (Grab)	↓	↓	G		↓			1	1		1	1		Temp = 24°C
-03	LL Hg Blank												1		Res. Chlorine = No Detect.

QC Deliverables
___ None
___ Level 2 *(Batch QC)*
___ Level 3
___ Level 4
Other: ____

Special Instructions:

Relinquished By	Date	Time	Received By	Date	Time
[signature]	9-23	2:15	[signature]	9-23	2:15
[signature]	9-23	3:15	[signature]	9/23/08	1518

LABORATORY COMMENTS:
Init Lab Temp: 12
Rec Lab Temp: 10 Ice
Custody Seals: Y (N) N/A
Bottles Supplied by TestAmerica: (Y) N
Method of Shipment: Client

TAL-0020 (1207)

R 9/23/08

TestAmerica
THE LEADER IN ENVIRONMENTAL TESTING
602 Commerce Drive Watertown, WI 53094 * 800-833-7036 * Fax 920-261-8120

October 07, 2008

Client:	SIGMA ENVIRONMENTAL (WW) 1300 West Canal Street Milwaukee, WI 53233	Work Order: Project Name: Project Number:	WRI0796 Point Beach Power Plant 11196
Attn:	Mr. Tom Koeppen	Date Received:	09/23/08

An executed copy of the chain of custody is also included as an addendum to this report.

If you have any questions relating to this analytical report, please contact your Laboratory Project Manager at 1-800-833-7036

SAMPLE IDENTIFICATION	LAB NUMBER	COLLECTION DATE AND TIME
105 FPC 9/22-23	WRI0796-01	09/23/08 11:15
105 Grab	WRI0796-02	09/23/08 11:15
LL Hg Blank	WRI0796-03	09/23/08

SW 8270C, EPA 420.4 analysis performed at Lab ID: 999917270

Samples were received into laboratory at a temperature of 8 °C.

Wisconsin Certification Number: 128053530

The Chain(s) of Custody, 4 pages, are included and are an integral part of this report.

Unless subcontracted, volatiles analyses (including VOC, PVOC, GRO, BTEX, and TPH gasoline) performed by TestAmerica Watertown at 1101 Industrial Drive, Units 9&10. All other analyses performed at the address shown in the heading of this report.

Approved By:

Brian DeJong

TestAmerica Watertown
Brian DeJong For Warren L. Topel
Project Manager

TestAmerica
THE LEADER IN ENVIRONMENTAL TESTING

602 Commerce Drive Watertown, WI 53094 * 800-833-7036 * Fax 920-261-8120

SIGMA ENVIRONMENTAL (WW)
1300 West Canal Street
Milwaukee, WI 53233
Mr. Tom Koeppen

Work Order: WRI0796
Project: Point Beach Power Plant
Project Number: 11196

Received: 09/23/08
Reported: 10/07/08 11:34

ANALYTICAL REPORT

Analyte	Sample Result	Data Qualifiers	Units	MDL	LOQ	Dilution Factor	Date Analyzed	Analyst	Seq/ Batch	Method
Sample ID: WRI0796-01 (105 FPC 9/22-23 - Waste Water)							**Sampled: 09/23/08 11:15**			
General Chemistry Parameters										
Ammonia as N	**2.0**		mg/L	0.10	0.33	1	10/07/08 09:29	tdc	8100056	SM 4500NHH
BOD - 5 Day	**4.4**	J	mg/L	2.0	6.7	1	09/24/08 14:33	shf	8090634	SM 5210
Chemical Oxygen Demand	<5.7		mg/L	5.7	19	1	09/24/08 13:11	kls	8090630	EPA 410.4
Chloride	**9.4**		mg/L	1.0	3.3	1	09/26/08 15:52	pxm	8090715	EPA 325.2
Hardness	**180**		mg/L	4.0	13	1	09/26/08 11:53	shf	8090723	EPA 130.2
Phosphorus, Total (as P)	**1.1**		mg/L	0.10	0.33	1	09/30/08 12:42	pxm	8090740	EPA 365.1
Total Suspended Solids	**12**		mg/L	1.0	3.3	1	09/25/08 15:47	lcr	8090681	EPA 160.2
Metals										
Antimony	**0.12**	J	ug/L	0.12	0.40	1	09/25/08 12:07	gaf	8090598	SW 6020A
Arsenic	<0.12		ug/L	0.12	0.40	1	09/25/08 12:07	gaf	8090598	SW 6020A
Beryllium	<0.12		ug/L	0.12	0.40	1	09/25/08 12:07	gaf	8090598	SW 6020A
Cadmium	<0.12		ug/L	0.12	0.40	1	09/25/08 12:07	gaf	8090598	SW 6020A
Chromium	<0.12		ug/L	0.12	0.40	1	09/25/08 12:07	gaf	8090598	SW 6020A
Copper	**7.4**	J	ug/L	6.0	20	1	09/25/08 12:07	gaf	8090598	SW 6020A
Lead	**1.8**		ug/L	0.12	0.40	1	09/25/08 12:07	gaf	8090598	SW 6020A
Nickel	<6.0		ug/L	6.0	20	1	09/25/08 12:07	gaf	8090598	SW 6020A
Selenium	**0.19**	J, B	ug/L	0.12	0.40	1	09/25/08 12:07	gaf	8090598	SW 6020A
Silver	<0.12		ug/L	0.12	0.40	1	09/25/08 12:07	gaf	8090598	SW 6020A
Thallium	<0.12		ug/L	0.12	0.40	1	09/25/08 12:07	gaf	8090598	SW 6020A
Zinc	**12**	J	ug/L	6.0	20	1	09/25/08 12:07	gaf	8090598	SW 6020A
Field Sampling Parameters										
Flow	**105133**		Gal/Day	NA		1	09/23/08 11:15	pam	8090738	NA
General Chemistry Parameters										
Phenol	<0.00113		mg/L	0.00113	0.00378	0.9	10/01/08 12:23	kmc	8091248	EPA 420.4
Semivolatile Organics by GC/MS										
4-Chloro-3-methylphenol	<0.510		ug/L	0.510	1.70	1.02	09/26/08 17:07	DMD	8091072	SW 8270C
2-Chlorophenol	<0.770		ug/L	0.770	2.56	1.02	09/26/08 17:07	DMD	8091072	SW 8270C
2,4-Dichlorophenol	<0.770		ug/L	0.770	2.56	1.02	09/26/08 17:07	DMD	8091072	SW 8270C
2,4-Dimethylphenol	<7.90		ug/L	7.90	26.3	1.02	09/26/08 17:07	DMD	8091072	SW 8270C
2,4-Dinitrophenol	<0.490		ug/L	0.490	1.63	1.02	09/26/08 17:07	DMD	8091072	SW 8270C
4,6-Dinitro-2-methylphenol	<0.420		ug/L	0.420	1.40	1.02	09/26/08 17:07	DMD	8091072	SW 8270C
2-Nitrophenol	<0.720		ug/L	0.720	2.40	1.02	09/26/08 17:07	DMD	8091072	SW 8270C
4-Nitrophenol	<0.360		ug/L	0.360	1.20	1.02	09/26/08 17:07	DMD	8091072	SW 8270C
2,5-Dinitrophenol	<0.390		ug/L	0.390	1.30	1.02	09/26/08 17:07	DMD	8091072	SW 8270C
Pentachlorophenol	<0.770		ug/L	0.770	2.56	1.02	09/26/08 17:07	DMD	8091072	SW 8270C
Phenol	<0.390		ug/L	0.390	1.30	1.02	09/26/08 17:07	DMD	8091072	SW 8270C
2,4,5-Trichlorophenol	<0.670		ug/L	0.670	2.23	1.02	09/26/08 17:07	DMD	8091072	SW 8270C
2,4,6-Trichlorophenol	<0.690		ug/L	0.690	2.30	1.02	09/26/08 17:07	DMD	8091072	SW 8270C
Surr: Phenol-d6 (8-64%)	*22 %*									
Surr: 2-Fluorophenol (15-85%)	*35 %*									
Surr: 2,4,6-Tribromophenol (33-148%)	*67 %*									
Mass Spec Library Seach by 8270C										
3-Chlorophenol	Absent		Present/Absent	0.00500	0.0166	1.02	09/26/08 17:07	DMD	8091072	SW 8270C
4-Chlorophenol	Absent		Present/Absent	0.00500	0.0166	1.02	09/26/08 17:07	DMD	8091072	SW 8270C
2,3-Dichlorophenol	Absent		Present/Absent	0.00500	0.0166	1.02	09/26/08 17:07	DMD	8091072	SW 8270C
3,4-Dichlorophenol	Absent		Present/Absent	0.00500	0.0166	1.02	09/26/08 17:07	DMD	8091072	SW 8270C
2,5-Dichlorophenol	Absent		Present/Absent	0.00500	0.0166	1.02	09/26/08 17:07	DMD	8091072	SW 8270C
2,6-Dichlorophenol	Absent		Present/Absent	0.00500	0.0166	1.02	09/26/08 17:07	DMD	8091072	SW 8270C
4-Chloro-2-methylphenol	Absent		Present/Absent	0.00500	0.0166	1.02	09/26/08 17:07	DMD	8091072	SW 8270C

TestAmerica Watertown
Brian DeJong For Warren L. Topel
Project Manager

602 Commerce Drive Watertown, WI 53094 * 800-833-7036 * Fax 920-261-8120

SIGMA ENVIRONMENTAL (WW)
1300 West Canal Street
Milwaukee, WI 53233
Mr. Tom Koeppen

Work Order: WRI0796
Project: Point Beach Power Plant
Project Number: 11196

Received: 09/23/08
Reported: 10/07/08 11:34

Analyte	Sample Result	Data Qualifiers	Units	MDL	LOQ	Dilution Factor	Date Analyzed	Analyst	Seq/ Batch	Method
Sample ID: WRI0796-01 (105 FPC 9/22-23 - Waste Water) - cont.							**Sampled: 09/23/08 11:15**			
Mass Spec Library Seach by 8270C - cont.										
2-Chloro-5-methylphenol	Absent		Present/Absent	0.00500	0.0166	1.02	09/26/08 17:07	DMD	8091072	SW 8270C
2,3,4,6-Tetrachlorophenol	Absent		Present/Absent	0.00500	0.0166	1.02	09/26/08 17:07	DMD	8091072	SW 8270C
Sample ID: WRI0796-02 (105 Grab - Waste Water)							**Sampled: 09/23/08 11:15**			
General Chemistry Parameters										
Chromium, Hexavalent	<0.0025		mg/L	0.0025	0.0083	1	09/24/08 08:25	kls	8090602	SM 3500CrD
Cyanide (amenable)	<0.017		mg/L	0.017	0.057	1	09/25/08 10:31	pxm	8090663	EPA 335.4
Cyanide (total)	<0.017	C	mg/L	0.017	0.057	1	09/25/08 10:26	pxm	8090638	EPA 335.4
Oil & Grease (HEM)	<0.78		mg/L	0.78	2.6	1.086957	09/26/08 00:00	JEJ	8090675	EPA 1664
Metals										
Mercury	**14**		ng/L	0.14	0.47	1	09/25/08 16:34	jej	8090648	EPA 1631E
VOCs by SW8260B										
Acrolein	<5.0		ug/L	5.0	17	1	09/26/08 11:03	MAE	8090688	SW 8260B
Acrylonitrile	<5.0		ug/L	5.0	17	1	09/26/08 11:03	MAE	8090688	SW 8260B
Benzene	<0.20		ug/L	0.20	0.67	1	09/26/08 11:03	MAE	8090688	SW 8260B
Bromodichloromethane	<0.20		ug/L	0.20	0.67	1	09/26/08 11:03	MAE	8090688	SW 8260B
Bromoform	<0.20		ug/L	0.20	0.67	1	09/26/08 11:03	MAE	8090688	SW 8260B
Bromomethane	<0.50		ug/L	0.50	1.7	1	09/26/08 11:03	MAE	8090688	SW 8260B
Carbon Tetrachloride	<0.50		ug/L	0.50	1.7	1	09/26/08 11:03	MAE	8090688	SW 8260B
Chlorobenzene	<0.20		ug/L	0.20	0.67	1	09/26/08 11:03	MAE	8090688	SW 8260B
Chlorodibromomethane	<0.20		ug/L	0.20	0.67	1	09/26/08 11:03	MAE	8090688	SW 8260B
Chloroethane	<1.0		ug/L	1.0	3.3	1	09/26/08 11:03	MAE	8090688	SW 8260B
Chloroform	<0.20		ug/L	0.20	0.67	1	09/26/08 11:03	MAE	8090688	SW 8260B
Chloromethane	<0.30		ug/L	0.30	1.0	1	09/26/08 11:03	MAE	8090688	SW 8260B
1,2-Dichlorobenzene	<0.20		ug/L	0.20	0.67	1	09/26/08 11:03	MAE	8090688	SW 8260B
1,3-Dichlorobenzene	<0.20		ug/L	0.20	0.67	1	09/26/08 11:03	MAE	8090688	SW 8260B
1,4-Dichlorobenzene	<0.50		ug/L	0.50	1.7	1	09/26/08 11:03	MAE	8090688	SW 8260B
1,1-Dichloroethane	<0.50		ug/L	0.50	1.7	1	09/26/08 11:03	MAE	8090688	SW 8260B
1,2-Dichloroethane	<0.50		ug/L	0.50	1.7	1	09/26/08 11:03	MAE	8090688	SW 8260B
1,1-Dichloroethene	<0.50		ug/L	0.50	1.7	1	09/26/08 11:03	MAE	8090688	SW 8260B
cis-1,2-Dichloroethene	<0.50		ug/L	0.50	1.7	1	09/26/08 11:03	MAE	8090688	SW 8260B
trans-1,2-Dichloroethene	<0.50		ug/L	0.50	1.7	1	09/26/08 11:03	MAE	8090688	SW 8260B
1,2-Dichloropropane	<0.50		ug/L	0.50	1.7	1	09/26/08 11:03	MAE	8090688	SW 8260B
1,3-Dichloropropane	<0.25		ug/L	0.25	0.83	1	09/26/08 11:03	MAE	8090688	SW 8260B
1,1-Dichloropropene	<0.50		ug/L	0.50	1.7	1	09/26/08 11:03	MAE	8090688	SW 8260B
cis-1,3-Dichloropropene	<0.20		ug/L	0.20	0.67	1	09/26/08 11:03	MAE	8090688	SW 8260B
trans-1,3-Dichloropropene	<0.20		ug/L	0.20	0.67	1	09/26/08 11:03	MAE	8090688	SW 8260B
2,3-Dichloropropene	<0.25		ug/L	0.25	0.83	1	09/26/08 11:03	MAE	8090688	SW 8260B
Ethylbenzene	<0.50		ug/L	0.50	1.7	1	09/26/08 11:03	MAE	8090688	SW 8260B
Methylene Chloride	<1.0		ug/L	1.0	3.3	1	09/26/08 11:03	MAE	8090688	SW 8260B
1,1,2,2-Tetrachloroethane	<0.20		ug/L	0.20	0.67	1	09/26/08 11:03	MAE	8090688	SW 8260B
Tetrachloroethene	<0.50		ug/L	0.50	1.7	1	09/26/08 11:03	MAE	8090688	SW 8260B
Toluene	<0.50		ug/L	0.50	1.7	1	09/26/08 11:03	MAE	8090688	SW 8260B
1,1,1-Trichloroethane	<0.50		ug/L	0.50	1.7	1	09/26/08 11:03	MAE	8090688	SW 8260B
1,1,2-Trichloroethane	<0.25		ug/L	0.25	0.83	1	09/26/08 11:03	MAE	8090688	SW 8260B
Trichloroethene	<0.20		ug/L	0.20	0.67	1	09/26/08 11:03	MAE	8090688	SW 8260B
Vinyl chloride	<0.20		ug/L	0.20	0.67	1	09/26/08 11:03	MAE	8090688	SW 8260B
Surr: Dibromofluoromethane (89-119%)	*102 %*									
Surr: Toluene-d8 (91-109%)	*92 %*									
Surr: 4-Bromofluorobenzene (89-114%)	*102 %*									
Field Sampling Parameters										
pH	**7.20**		pH Units	NA		1	09/23/08 11:15	pam	8090738	EPA 150.1

TestAmerica Watertown
Brian DeJong For Warren L. Topel
Project Manager

602 Commerce Drive Watertown, WI 53094 * 800-833-7036 * Fax 920-261-8120

SIGMA ENVIRONMENTAL (WW)
1300 West Canal Street
Milwaukee, WI 53233
Mr. Tom Koeppen

Work Order: WRI0796
Project: Point Beach Power Plant
Project Number: 11196

Received: 09/23/08
Reported: 10/07/08 11:34

Analyte	Sample Result	Data Qualifiers	Units	MDL	LOQ	Dilution Factor	Date Analyzed	Analyst	Seq/ Batch	Method
Sample ID: WRI0796-02 (105 Grab - Waste Water) - cont.							**Sampled: 09/23/08 11:15**			
Field Sampling Parameters - cont.										
Temperature	**24.0**		°C	NA		1	09/23/08 11:15	pam	8090738	EPA 170.1
Chlorine, Field	<0.016	A-01	mg/L	0.016	0.053	1	09/23/08 11:15	pam	8090738	SM4500Cl G
Sample ID: WRI0796-03 (LL Hg Blank - Waste Water)							**Sampled: 09/23/08**			
Metals										
Mercury	<0.14		ng/L	0.14	0.47	1	09/25/08 16:34	jej	8090648	EPA 1631E

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SIGMA ENVIRONMENTAL (WW)	Work Order:	WRI0796	Received:	09/23/08
1300 West Canal Street	Project:	Point Beach Power Plant	Reported:	10/07/08 11:34
Milwaukee, WI 53233	Project Number:	11196		
Mr. Tom Koeppen				

SAMPLE EXTRACTION DATA

Parameter	Batch	Lab Number	Wt/Vol Extracted	Extracted Vol	Date	Analyst	Extraction Method
Mass Spec Library Seach by 8270C							
SW 8270C	8091072	WRI0796-01	980	1	09/25/08 13:16	MH	SW 3510C_MS
Semivolatile Organics by GC/MS							
SW 8270C	8091072	WRI0796-01	980	1	09/25/08 13:16	MH	SW 3510C_MS

SIGMA ENVIRONMENTAL (WW)
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Mr. Tom Koeppen

Work Order: WRI0796
Project: Point Beach Power Plant
Project Number: 11196

Received: 09/23/08
Reported: 10/07/08 11:34

LABORATORY BLANK QC DATA

Analyte	Seq/ Batch	Source Result	Spike Level	Units	MDL	MRL	Result	Dup Result	% REC	Dup %REC	% REC Limits	RPD	RPD Limit	Q
General Chemistry Parameters														
Chromium, Hexavalent	8090602			mg/L	0.0025	0.0088	<0.0025							
Chromium, Hexavalent	8090602			mg/L	0.0025	0.0088	<0.0025							
Chemical Oxygen Demand	8090630			mg/L	5.7	20	<5.7							
Chemical Oxygen Demand	8090630			mg/L	5.7	20	<5.7							
BOD - 5 Day	8090634			mg/L	2.0	6.7	<2.0							
Cyanide (total)	8090638			mg/L	0.017	0.058	<0.017							C
Oil & Grease (HEM)	8090675			mg/L	0.72	2.6	<0.72							
Chloride	8090715			mg/L	1.0	3.3	<1.0							
Hardness	8090723			mg/L	4.0	12	<4.0							
Phosphorus, Total (as P)	8090740			mg/L	0.10	0.33	<0.10							
Ammonia as N	8100056			mg/L	0.10	0.33	<0.10							
Metals														
Antimony	8090598			ug/L	0.12	0.40	0.130							J
Arsenic	8090598			ug/L	0.12	0.40	<0.12							
Beryllium	8090598			ug/L	0.12	0.40	<0.12							
Cadmium	8090598			ug/L	0.12	0.40	<0.12							
Chromium	8090598			ug/L	0.12	0.40	<0.12							
Copper	8090598			ug/L	6.0	20	<6.0							
Lead	8090598			ug/L	0.12	0.40	<0.12							
Nickel	8090598			ug/L	6.0	20	<6.0							
Selenium	8090598			ug/L	0.12	0.40	0.290							J
Silver	8090598			ug/L	0.12	0.40	<0.12							
Thallium	8090598			ug/L	0.12	0.40	<0.12							
Zinc	8090598			ug/L	6.0	20	<6.0							
Mercury	8090648			ng/L	0.14	0.50	<0.14							
Mercury	8090648			ng/L	0.14	0.50	<0.14							
VOCs by SW8260B														
Acrolein	8090688			ug/L	5.0	17	<5.0							
Acrylonitrile	8090688			ug/L	5.0	17	<5.0							
Benzene	8090688			ug/L	0.20	0.67	<0.20							
Bromodichloromethane	8090688			ug/L	0.20	0.67	<0.20							
Bromoform	8090688			ug/L	0.20	0.67	<0.20							
Bromomethane	8090688			ug/L	0.50	1.7	<0.50							
Carbon Tetrachloride	8090688			ug/L	0.50	1.7	<0.50							
Chlorobenzene	8090688			ug/L	0.20	0.67	<0.20							
Chlorodibromomethane	8090688			ug/L	0.20	0.67	<0.20							
Chloroethane	8090688			ug/L	1.0	3.3	<1.0							

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Reported: 10/07/08 11:34

LABORATORY BLANK QC DATA

Analyte	Seq/ Batch	Source Result	Spike Level	Units	MDL	MRL	Result	Dup Result	% REC	Dup %REC	% REC Limits	RPD	RPD Limit	Q
VOCs by SW8260B														
Chloroform	8090688			ug/L	0.20	0.67	<0.20							
Chloromethane	8090688			ug/L	0.30	1.0	<0.30							
1,2-Dichlorobenzene	8090688			ug/L	0.20	0.67	<0.20							
1,3-Dichlorobenzene	8090688			ug/L	0.20	0.67	<0.20							
1,4-Dichlorobenzene	8090688			ug/L	0.50	1.7	<0.50							
1,1-Dichloroethane	8090688			ug/L	0.50	1.7	<0.50							
1,2-Dichloroethane	8090688			ug/L	0.50	1.7	<0.50							
1,1-Dichloroethene	8090688			ug/L	0.50	1.7	<0.50							
cis-1,2-Dichloroethene	8090688			ug/L	0.50	1.7	<0.50							
trans-1,2-Dichloroethene	8090688			ug/L	0.50	1.7	<0.50							
1,2-Dichloropropane	8090688			ug/L	0.50	1.7	<0.50							
1,3-Dichloropropane	8090688			ug/L	0.25	0.83	<0.25							
1,1-Dichloropropene	8090688			ug/L	0.50	1.7	<0.50							
cis-1,3-Dichloropropene	8090688			ug/L	0.20	0.67	<0.20							
trans-1,3-Dichloropropene	8090688			ug/L	0.20	0.67	<0.20							
2,3-Dichloropropene	8090688			ug/L	0.25	0.83	<0.25							
Ethylbenzene	8090688			ug/L	0.50	1.7	<0.50							
Methylene Chloride	8090688			ug/L	1.0	3.3	<1.0							
1,1,2,2-Tetrachloroethane	8090688			ug/L	0.20	0.67	<0.20							
Tetrachloroethene	8090688			ug/L	0.50	1.7	<0.50							
Toluene	8090688			ug/L	0.50	1.7	<0.50							
1,1,1-Trichloroethane	8090688			ug/L	0.50	1.7	<0.50							
1,1,2-Trichloroethane	8090688			ug/L	0.25	0.83	<0.25							
Trichloroethene	8090688			ug/L	0.20	0.67	<0.20							
Vinyl chloride	8090688			ug/L	0.20	0.67	<0.20							
Surrogate: Dibromofluoromethane	*8090688*			ug/L					*102*		*89-119*			
Surrogate: Toluene-d8	*8090688*			ug/L					*93*		*91-109*			
Surrogate: 4-Bromofluorobenzene	*8090688*			ug/L					*104*		*89-114*			
General Chemistry Parameters														
Phenol	8091248			mg/L	0.00126	0.0200	<0.00126							
Semivolatile Organics by GC/MS														
4-Chloro-3-methylphenol	8091072			ug/L	0.510	10.0	<0.510							
2-Chlorophenol	8091072			ug/L	0.770	10.0	<0.770							
2,4-Dichlorophenol	8091072			ug/L	0.770	10.0	<0.770							
2,4-Dimethylphenol	8091072			ug/L	0.899	10.0	<0.899							
2,4-Dinitrophenol	8091072			ug/L	0.490	20.0	<0.490							
4,6-Dinitro-2-methylphenol	8091072			ug/L	0.420	10.0	<0.420							
2-Nitrophenol	8091072			ug/L	0.720	10.0	<0.720							
4-Nitrophenol	8091072			ug/L	0.360	10.0	<0.360							
2,5-Dinitrophenol	8091072			ug/L	0.390	10.0	<0.390							
Pentachlorophenol	8091072			ug/L	0.770	10.0	<0.770							
Phenol	8091072			ug/L	0.390	10.0	<0.390							
2,4,5-Trichlorophenol	8091072			ug/L	0.670	10.0	<0.670							
2,4,6-Trichlorophenol	8091072			ug/L	0.690	10.0	<0.690							

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SIGMA ENVIRONMENTAL (WW)
1300 West Canal Street
Milwaukee, WI 53233
Mr. Tom Koeppen

Work Order: WRI0796
Project: Point Beach Power Plant
Project Number: 11196

Received: 09/23/08
Reported: 10/07/08 11:34

LABORATORY BLANK QC DATA

Analyte	Seq/ Batch	Source Result	Spike Level	Units	MDL	MRL	Result	Dup Result	% REC	Dup %REC	% REC Limits	RPD	RPD Limit	Q
Semivolatile Organics by GC/MS														
Surrogate: Phenol-d6	*8091072*			ug/L					*27*		*10-64*			
Surrogate: 2-Fluorophenol	*8091072*			ug/L					*44*		*15-85*			
Surrogate: 2,4,6-Tribromophenol	*8091072*			ug/L					*64*		*35-130*			
Mass Spec Library Seach by 8270C														
3-Chlorophenol	8091072			P/A	0.00500	0.00500	Absent							
4-Chlorophenol	8091072			P/A	0.00500	0.00500	Absent							
2,3-Dichlorophenol	8091072			P/A	0.00500	0.00500	Absent							
3,4-Dichlorophenol	8091072			P/A	0.00500	0.00500	Absent							
2,5-Dichlorophenol	8091072			P/A	0.00500	0.00500	Absent							
2,6-Dichlorophenol	8091072			P/A	0.00500	0.00500	Absent							
4-Chloro-2-methylphenol	8091072			P/A	0.00500	0.00500	Absent							
2-Chloro-5-methylphenol	8091072			P/A	0.00500	0.00500	Absent							
2,3,4,6-Tetrachlorophenol	8091072			P/A	0.00500	0.0100	Absent							

TestAmerica Watertown
Brian DeJong For Warren L. Topel
Project Manager

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SIGMA ENVIRONMENTAL (WW)
1300 West Canal Street
Milwaukee, WI 53233
Mr. Tom Koeppen

Work Order: WRI0796
Project: Point Beach Power Plant
Project Number: 11196

Received: 09/23/08
Reported: 10/07/08 11:34

CCV QC DATA

Analyte	Seq/ Batch	Source Result	Spike Level	Units	MDL	MRL	Result	Dup Result	% REC	Dup %REC	% REC Limits	RPD	RPD Limit	Q
VOCs by SW8260B														
Acrolein	8I26002		50.000	ug/L	N/A	N/A	51.3		103		80-120			
Acrylonitrile	8I26002		50.000	ug/L	N/A	N/A	54.1		108		80-120			
Benzene	8I26002		50.000	ug/L	N/A	N/A	54.9		110		80-120			
Bromodichloromethane	8I26002		50.000	ug/L	N/A	N/A	52.6		105		80-120			
Bromoform	8I26002		50.000	ug/L	N/A	N/A	54.4		109		80-120			
Bromomethane	8I26002		50.000	ug/L	N/A	N/A	46.8		94		80-120			
Carbon Tetrachloride	8I26002		50.000	ug/L	N/A	N/A	56.1		112		80-120			
Chlorobenzene	8I26002		50.000	ug/L	N/A	N/A	50.4		101		80-120			
Chlorodibromomethane	8I26002		50.000	ug/L	N/A	N/A	55.6		111		80-120			
Chloroethane	8I26002		50.000	ug/L	N/A	N/A	54.1		108		80-120			
Chloroform	8I26002		50.000	ug/L	N/A	N/A	54.6		109		80-120			
Chloromethane	8I26002		50.000	ug/L	N/A	N/A	53.6		107		80-120			
1,2-Dichlorobenzene	8I26002		50.000	ug/L	N/A	N/A	47.8		96		80-120			
1,3-Dichlorobenzene	8I26002		50.000	ug/L	N/A	N/A	47.8		96		80-120			
1,4-Dichlorobenzene	8I26002		50.000	ug/L	N/A	N/A	47.6		95		80-120			
1,1-Dichloroethane	8I26002		50.000	ug/L	N/A	N/A	54.9		110		80-120			
1,2-Dichloroethane	8I26002		50.000	ug/L	N/A	N/A	51.9		104		80-120			
1,1-Dichloroethene	8I26002		50.000	ug/L	N/A	N/A	55.0		110		80-120			
cis-1,2-Dichloroethene	8I26002		50.000	ug/L	N/A	N/A	56.0		112		80-120			
trans-1,2-Dichloroethene	8I26002		50.000	ug/L	N/A	N/A	56.2		112		80-120			
1,2-Dichloropropane	8I26002		50.000	ug/L	N/A	N/A	51.1		102		80-120			
1,3-Dichloropropane	8I26002		50.000	ug/L	N/A	N/A	52.6		105		80-120			
1,1-Dichloropropene	8I26002		50.000	ug/L	N/A	N/A	53.7		107		80-120			
cis-1,3-Dichloropropene	8I26002		50.000	ug/L	N/A	N/A	51.9		104		80-120			
trans-1,3-Dichloropropene	8I26002		50.000	ug/L	N/A	N/A	51.3		103		80-120			
2,3-Dichloropropene	8I26002		50.000	ug/L	N/A	N/A	53.0		106		80-120			
Ethylbenzene	8I26002		50.000	ug/L	N/A	N/A	50.4		101		80-120			
Methylene Chloride	8I26002		50.000	ug/L	N/A	N/A	56.7		113		80-120			
1,1,2,2-Tetrachloroethane	8I26002		50.000	ug/L	N/A	N/A	49.2		98		80-120			
Tetrachloroethene	8I26002		50.000	ug/L	N/A	N/A	52.6		105		80-120			
Toluene	8I26002		50.000	ug/L	N/A	N/A	49.6		99		80-120			
1,1,1-Trichloroethane	8I26002		50.000	ug/L	N/A	N/A	54.8		110		80-120			
1,1,2-Trichloroethane	8I26002		50.000	ug/L	N/A	N/A	53.8		108		80-120			
Trichloroethene	8I26002		50.000	ug/L	N/A	N/A	55.6		111		80-120			
Vinyl chloride	8I26002		50.000	ug/L	N/A	N/A	56.3		113		80-120			
Surrogate: Dibromofluoromethane	*8I26002*			ug/L					*103*		*80-120*			
Surrogate: Toluene-d8	*8I26002*			ug/L					*92*		*80-120*			
Surrogate: 4-Bromofluorobenzene	*8I26002*			ug/L					*103*		*80-120*			

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SIGMA ENVIRONMENTAL (WW)
1300 West Canal Street
Milwaukee, WI 53233
Mr. Tom Koeppen

Work Order: WRI0796
Project: Point Beach Power Plant
Project Number: 11196

Received: 09/23/08
Reported: 10/07/08 11:34

LABORATORY DUPLICATE QC DATA

Analyte	Seq/ Batch	Source Result	Spike Level	Units	MDL	MRL	Result	% REC	Dup %REC	% REC Limits	RPD	RPD Limit	Q
General Chemistry Parameters													
QC Source Sample: WRI0797-02													
Chromium, Hexavalent	8090602	<0.0025		mg/L	0.0025	0.0088	<0.0025					8	
QC Source Sample: WRI0787-04													
BOD - 5 Day	8090634	149		mg/L	2.0	6.7	162				8	26	
QC Source Sample: WRI0799-01													
BOD - 5 Day	8090634	200		mg/L	2.0	6.7	175				13	26	
QC Source Sample: WRI0802-01													
Total Suspended Solids	8090681	86.0		mg/L	1.0	3.3	87.0				1	26	
QC Source Sample: WRI0799-01													
Total Suspended Solids	8090681	226		mg/L	1.0	3.3	218				4	26	

TestAmerica Watertown
Brian DeJong For Warren L. Topel
Project Manager

SIGMA ENVIRONMENTAL (WW)	Work Order: WRI0796	Received:	09/23/08
1300 West Canal Street	Project: Point Beach Power Plant	Reported:	10/07/08 11:34
Milwaukee, WI 53233	Project Number: 11196		
Mr. Tom Koeppen			

LCS/LCS DUPLICATE QC DATA

Analyte	Seq/ Batch	Source Result	Spike Level	Units	MDL	MRL	Result	Dup Result	% REC	Dup %REC	% REC Limits	RPD	RPD Limit	Q
General Chemistry Parameters														
Cyanide (total)	8090638		0.2000 0	mg/L	N/A	N/A	0.218		109		90-110			C
Phosphorus, Total (as P)	8090740		10.000	mg/L	0.10	0.33	9.67		97		90-110			
Ammonia as N	8100056		10.000	mg/L	0.10	0.33	9.86		99		90-110			
Metals														
Antimony	8090598		50.000	ug/L	0.12	0.40	43.8		88		85-115			
Arsenic	8090598		50.000	ug/L	0.12	0.40	50.6		101		85-115			
Beryllium	8090598		50.000	ug/L	0.12	0.40	50.8		102		80-112			
Cadmium	8090598		50.000	ug/L	0.12	0.40	51.7		103		83-109			
Chromium	8090598		50.000	ug/L	0.12	0.40	50.7		101		80-120			
Copper	8090598		50.000	ug/L	6.0	20	51.7		103		84-111			
Lead	8090598		50.000	ug/L	0.12	0.40	49.4		99		85-115			
Nickel	8090598		50.000	ug/L	6.0	20	52.6		105		83-108			
Selenium	8090598		50.000	ug/L	0.12	0.40	47.7		95		84-110			B
Silver	8090598		50.000	ug/L	0.12	0.40	51.7		103		80-123			
Thallium	8090598		50.000	ug/L	0.12	0.40	52.2		104		80-120			
Zinc	8090598		50.000	ug/L	6.0	20	57.0		114		82-111			L1
Mercury	8090648		5.0000	ng/L	0.14	0.50	4.73		95		75-125			
Mercury	8090648		5.0000	ng/L	0.14	0.50	4.39		88		75-125			
General Chemistry Parameters														
Phenol	8091248		0.100	mg/L	0.00113	0.0180	0.0924		92		90-110			
Semivolatile Organics by GC/MS														
4-Chloro-3-methylphenol	8091072		100	ug/L	1.45	10.0	72.6	73.5	73	74	40-115	1	20	
2-Chlorophenol	8091072		100	ug/L	1.38	10.0	67.6	68.8	68	69	40-100	2	20	
2,4-Dichlorophenol	8091072		100	ug/L	1.72	10.0	71.8	73.8	72	74	40-105	3	20	
2,4-Dimethylphenol	8091072		100	ug/L	0.899	10.0	68.6	70.2	69	70	20-95	2	20	
2,4-Dinitrophenol	8091072		100	ug/L	1.25	20.0	56.2	60.5	56	60	25-110	7	20	
4,6-Dinitro-2-methylphenol	8091072		100	ug/L	1.64	10.0	79.0	78.0	79	78	40-120	1	20	
2-Nitrophenol	8091072		100	ug/L	1.65	10.0	73.9	76.4	74	76	45-110	3	20	
4-Nitrophenol	8091072		100	ug/L	0.834	10.0	29.0	29.8	29	30	15-65	3	20	
2,5-Dinitrophenol	8091072		100	ug/L	1.44	20.0	72.7	70.6	73	71	30-120	3	20	
Pentachlorophenol	8091072		100	ug/L	1.22	10.0	57.5	57.8	57	58	35-125	1	20	
Phenol	8091072		100	ug/L	0.730	10.0	30.0	30.7	30	31	15-50	2	20	
2,4,5-Trichlorophenol	8091072		100	ug/L	1.78	10.0	73.0	75.1	73	75	50-120	3	20	
2,4,6-Trichlorophenol	8091072		100	ug/L	1.84	10.0	74.3	75.1	74	75	45-120	1	20	
Surrogate: Phenol-d6	*8091072*			ug/L					*28*	*29*	*10-60*			
Surrogate: 2-Fluorophenol	*8091072*			ug/L					*44*	*45*	*20-65*			
Surrogate: 2,4,6-Tribromophenol	*8091072*			ug/L					*76*	*76*	*45-130*			

602 Commerce Drive Watertown, WI 53094 * 800-833-7036 * Fax 920-261-8120

SIGMA ENVIRONMENTAL (WW)
1300 West Canal Street
Milwaukee, WI 53233
Mr. Tom Koeppen

Work Order: WRI0796
Project: Point Beach Power Plant
Project Number: 11196

Received: 09/23/08
Reported: 10/07/08 11:34

MATRIX SPIKE/MATRIX SPIKE DUPLICATE QC DATA

Analyte	Seq/ Batch	Source Result	Spike Level	Units	MDL	MRL	Result	Dup Result	% REC	Dup %REC	% REC Limits	RPD	RPD Limit	Q
General Chemistry Parameters														
QC Source Sample: WRI0667-02														
Cyanide (total)	8090638	<0.017	0.3333 3	mg/L	0.017	0.058	0.306	0.296	92	89	57-138	3	21	C
QC Source Sample: WRI0845-02														
Chloride	8090715	28.5	200.00	mg/L	10	33	222	226	97	99	64-132	2	19	
QC Source Sample: WRI0779-01														
Phosphorus, Total (as P)	8090740	0.410	10.000	mg/L	0.10	0.33	9.89	9.91	95	95	64-136	0	23	
QC Source Sample: WRI0796-01														
Ammonia as N	8100056	2.01	10.000	mg/L	0.10	0.33	12.0	11.8	100	98	60-136	2	22	
Metals														
QC Source Sample: WRI0796-01														
Antimony	8090598	0.120	50.000	ug/L	0.12	0.40	40.7	54.4	81	109	75-125	29	20	R2
Arsenic	8090598	<0.12	50.000	ug/L	0.12	0.40	50.9	53.6	102	107	75-125	5	20	
Beryllium	8090598	<0.12	50.000	ug/L	0.12	0.40	54.5	53.8	109	108	56-131	1	25	
Cadmium	8090598	<0.12	50.000	ug/L	0.12	0.40	52.3	52.3	105	105	65-118	0	18	
Chromium	8090598	<0.12	50.000	ug/L	0.12	0.40	48.6	48.3	97	97	75-125	1	20	
Copper	8090598	7.45	50.000	ug/L	6.0	20	56.0	56.5	97	98	69-123	1	25	
Lead	8090598	1.81	50.000	ug/L	0.12	0.40	49.8	49.5	96	95	75-125	1	20	
Nickel	8090598	<6.0	50.000	ug/L	6.0	20	52.9	53.2	106	106	63-117	1	21	
Selenium	8090598	0.190	50.000	ug/L	0.12	0.40	47.6	52.9	95	105	70-123	11	20	B
Silver	8090598	<0.12	50.000	ug/L	0.12	0.40	50.2	49.9	100	100	70-124	1	20	
Thallium	8090598	<0.12	50.000	ug/L	0.12	0.40	51.4	50.8	103	102	75-125	1	20	
Zinc	8090598	12.0	50.000	ug/L	6.0	20	66.3	65.6	109	107	63-125	1	30	
QC Source Sample: WRI0689-01														
Mercury	8090648	<0.14	5.0000	ng/L	0.14	0.50	3.35	3.49	67	70	71-125	4	24	M8
QC Source Sample: WRI0797-02														
Mercury	8090648	<0.14	5.0000	ng/L	0.14	0.50	4.68	4.08	94	82	71-125	14	24	
QC Source Sample: WRI0805-02														
Mercury	8090648	<0.14	5.0000	ng/L	0.14	0.50	4.04	4.14	81	83	71-125	2	24	
VOCs by SW8260B														
QC Source Sample: WRI0865-01														
Benzene	8090688	<0.20	50.000	ug/L	0.20	0.67	55.5	56.4	111	113	80-121	2	11	
Bromodichloromethane	8090688	<0.20	50.000	ug/L	0.20	0.67	52.2	53.6	104	107	70-130	3	20	
Bromoform	8090688	<0.20	50.000	ug/L	0.20	0.67	53.2	55.7	106	111	70-130	4	20	
Bromomethane	8090688	<0.50	50.000	ug/L	0.50	1.7	54.9	58.7	110	117	70-130	7	20	
Carbon Tetrachloride	8090688	<0.50	50.000	ug/L	0.50	1.7	61.0	60.1	122	120	70-130	2	20	
Chlorobenzene	8090688	<0.20	50.000	ug/L	0.20	0.67	50.8	51.7	102	103	85-116	2	9	
Chlorodibromomethane	8090688	<0.20	50.000	ug/L	0.20	0.67	54.7	55.5	109	111	70-130	2	20	
Chloroethane	8090688	<1.0	50.000	ug/L	1.0	3.3	58.8	56.0	118	112	70-130	5	20	
Chloroform	8090688	<0.20	50.000	ug/L	0.20	0.67	54.5	54.7	109	109	70-130	0	20	
Chloromethane	8090688	<0.30	50.000	ug/L	0.30	1.0	54.0	51.7	108	103	70-130	4	20	
1,2-Dichlorobenzene	8090688	<0.20	50.000	ug/L	0.20	0.67	46.4	47.3	93	95	70-130	2	20	
1,3-Dichlorobenzene	8090688	<0.20	50.000	ug/L	0.20	0.67	46.8	47.9	94	96	70-130	2	20	
1,4-Dichlorobenzene	8090688	<0.50	50.000	ug/L	0.50	1.7	46.8	47.7	94	95	70-130	2	20	
1,1-Dichloroethane	8090688	<0.50	50.000	ug/L	0.50	1.7	56.0	55.5	112	111	70-130	1	20	
1,2-Dichloroethane	8090688	<0.50	50.000	ug/L	0.50	1.7	51.4	51.8	103	104	70-130	1	20	
1,1-Dichloroethene	8090688	0.910	50.000	ug/L	0.50	1.7	62.7	58.6	124	115	72-131	7	17	
cis-1,2-Dichloroethene	8090688	46.7	50.000	ug/L	0.50	1.7	100	99.2	107	105	70-130	1	20	
trans-1,2-Dichloroethene	8090688	1.36	50.000	ug/L	0.50	1.7	61.4	59.9	120	117	70-130	3	20	

TestAmerica Watertown
Brian DeJong For Warren L. Topel
Project Manager

TestAmerica
THE LEADER IN ENVIRONMENTAL TESTING

602 Commerce Drive Watertown, WI 53094 * 800-833-7036 * Fax 920-261-8120

SIGMA ENVIRONMENTAL (WW)
1300 West Canal Street
Milwaukee, WI 53233
Mr. Tom Koeppen

Work Order: WRI0796
Project: Point Beach Power Plant
Project Number: 11196

Received: 09/23/08
Reported: 10/07/08 11:34

MATRIX SPIKE/MATRIX SPIKE DUPLICATE QC DATA

Analyte	Seq/ Batch	Source Result	Spike Level	Units	MDL	MRL	Result	Dup Result	% REC	Dup %REC	% REC Limits	RPD	RPD Limit	Q
VOCs by SW8260B														
QC Source Sample: WRI0865-01														
1,2-Dichloropropane	8090688	<0.50	50.000	ug/L	0.50	1.7	51.3	52.5	103	105	70-130	2	20	
1,3-Dichloropropane	8090688	<0.25	50.000	ug/L	0.25	0.83	51.8	53.2	104	106	70-130	3	20	
1,1-Dichloropropene	8090688	<0.50	50.000	ug/L	0.50	1.7	57.6	56.2	115	112	70-130	2	20	
cis-1,3-Dichloropropene	8090688	<0.20	50.000	ug/L	0.20	0.67	52.0	52.9	104	106	70-130	2	20	
trans-1,3-Dichloropropene	8090688	<0.20	50.000	ug/L	0.20	0.67	51.1	52.3	102	105	70-130	2	20	
Ethylbenzene	8090688	<0.50	50.000	ug/L	0.50	1.7	51.3	51.1	103	102	83-118	0	13	
Methylene Chloride	8090688	<1.0	50.000	ug/L	1.0	3.3	55.0	55.3	110	111	70-130	1	20	
1,1,2,2-Tetrachloroethane	8090688	<0.20	50.000	ug/L	0.20	0.67	47.1	49.9	94	100	70-130	6	20	
Tetrachloroethene	8090688	67.1	50.000	ug/L	0.50	1.7	124	122	114	111	70-130	1	20	
Toluene	8090688	<0.50	50.000	ug/L	0.50	1.7	51.9	52.1	104	104	82-116	1	11	
1,1,1-Trichloroethane	8090688	<0.50	50.000	ug/L	0.50	1.7	58.7	58.5	117	117	70-130	0	20	
1,1,2-Trichloroethane	8090688	<0.25	50.000	ug/L	0.25	0.83	52.5	53.8	105	108	70-130	3	20	
Trichloroethene	8090688	49.7	50.000	ug/L	0.20	0.67	107	107	115	115	80-117	0	13	
Vinyl chloride	8090688	2.24	50.000	ug/L	0.20	0.67	59.0	53.7	114	103	70-130	9	20	
Surrogate: Dibromofluoromethane	*8090688*			ug/L					*103*	*101*	*89-119*			
Surrogate: Toluene-d8	*8090688*			ug/L					*93*	*93*	*91-109*			
Surrogate: 4-Bromofluorobenzene	*8090688*			ug/L					*103*	*104*	*89-114*			
General Chemistry Parameters														
QC Source Sample: CRI1150-01														
Phenol	8091248	<0.0013	0.100	mg/L	0.00126	0.0200	0.0940	0.0978	94	98	90-110	4	15	

TestAmerica Watertown
Brian DeJong For Warren L. Topel
Project Manager

TestAmerica
THE LEADER IN ENVIRONMENTAL TESTING

602 Commerce Drive Watertown, WI 53094 * 800-833-7036 * Fax 920-261-8120

SIGMA ENVIRONMENTAL (WW)	Work Order:	WRI0796	Received:	09/23/08
1300 West Canal Street	Project:	Point Beach Power Plant	Reported:	10/07/08 11:34
Milwaukee, WI 53233	Project Number:	11196		
Mr. Tom Koeppen				

CERTIFICATION SUMMARY

TestAmerica Watertown

Method	Matrix	Nelac	Wisconsin
EPA 130.2	Water - NonPotable	X	X
EPA 150.1	Water - NonPotable	X	N/A
EPA 160.2	Water - NonPotable	X	X
EPA 1631E	Water - NonPotable		X
EPA 1664	Water - NonPotable	X	X
EPA 170.1	Water - NonPotable		
EPA 325.2	Water - NonPotable	X	X
EPA 335.4	Water - NonPotable	X	X
EPA 365.1	Water - NonPotable	X	X
EPA 410.4	Water - NonPotable		X
NA	Water - NonPotable		
SM 3500CrD	Water - NonPotable		X
SM 4500NHH	Water - NonPotable	X	X
SM 5210	Water - NonPotable	X	X
SM4500Cl G	Water - NonPotable		
SW 6020A	Water - NonPotable		X
SW 8260B	Water - NonPotable	X	X

Subcontracted Laboratories

TestAmerica Analytical - Cedar Falls NELAC Cert #000668, Wisconsin Cert #999917270, Illinois Cert #000668, Minnesota Cert #019-999-319, Iowa Cert #007, North Dakota Cert #R-186
704 Enterprise Drive - Cedar Falls, IA 50613

Method Performed: EPA 420.4
Samples: WRI0796-01

Method Performed: SW 8270C
Samples: WRI0796-01

DATA QUALIFIERS AND DEFINITIONS

A-01	No Detect.
B	Analyte was detected in the associated Method Blank.
C	Calibration Verification recovery was above the method control limit for this analyte. Analyte not detected, data not impacted.
J	Results reported between the Method Detection Limit (MDL) and Limit of Quantitation (LOQ) are less certain than results at or above the LOQ.
L1	Laboratory Control Sample and/or Laboratory Control Sample Duplicate recovery was above acceptance limits.
M8	The MS and/or MSD were below the acceptance limits. See Blank Spike (LCS).
R2	The RPD exceeded the acceptance limit.

ADDITIONAL COMMENTS

TestAmerica Watertown
Brian DeJong For Warren L. Topel
Project Manager

WR I0796

TestAmerica
THE LEADER IN ENVIRONMENTAL TESTING

Watertown Division
602 Commerce Drive
Watertown, WI 53094

Phone 920-261-1660 or 800-833-7036
Fax 920-261-8120

To assist us in using the proper analytical methods, is this work being conducted for regulatory purposes?
Compliance Monitoring ______

Client Name: Sigma
Client #: ______
Address: ______
City/State/Zip Code: Milw.
Project Manager: Tom Koeppen
Telephone Number: 414 643 4138
Fax: 414 643 4210
Sampler Name: (Print Name) D. Kurtz
Sampler Signature: [signature]
E-mail address: ______

Project Name: Point Beach Nuclear Power Plant
Project #: 11196
Site/Location ID: Two Rivers
State: WI
Report To: Tom Koeppen
Invoice To: ______
Quote #: ______ PO#: ______

TAT
___ Standard
___ Rush (surcharges may apply)

Date Needed: ______

Fax Results: Y N
E-mail: Y N

Matrix: SL - Sludge, DW - Drinking Water, GW - Groundwater, S - Soil/Solid, WW - Wastewater, Specify Other

Analyze For: SEE Attached

QC Deliverables
___ None
___ Level 2 *(Batch QC)*
___ Level 3
___ Level 4
Other: ______

	SAMPLE ID	Date Sampled	Time Sampled	G = Grab, C = Composite	Field Filtered	Matrix	HNO_3	HCl	NaOH	H_2SO_4	Methanol	None	Other (Specify) LL Mercury	REMARKS
-01	#105 (FPC) 9/22-9/23	9/23/08	11:15A	C		WW	2			3		5	1	Flow = 105,133 gpd
-02	#105 Grab	↓	↓	G		WW		4	1	1		1		
-03	LL Hg Blank												1	Temp = 24°C pH = 7.2
														Res. Chlorine = No Detect

Special Instructions:

Relinquished By:	Date:	Time:	Received By:	Date:	Time:
[signature]	9-23	2:15	[signature]	9-23	2:15
[signature]	9-23	3:15	[signature]	9/23/08	1517

LABORATORY COMMENTS:
Init Lab Temp: 8, no Ice
Rec Lab Temp:
Custody Seals: Y (N) N/A
Bottles Supplied by TestAmerica: (Y) N
Method of Shipment: Client

TAL-0020 (1207)

TestAmerica
THE LEADER IN ENVIRONMENTAL TESTING
602 Commerce Drive Watertown, WI 53094 * 800-833-7036 * Fax 920-261-8120

October 29, 2008

Client:	SIGMA ENVIRONMENTAL (WW) 1300 West Canal Street Milwaukee, WI 53233	Work Order: Project Name: Project Number:	WRJ0812 Point Beach Power Plant 11196
Attn:	Mr. Tom Koeppen	Date Received:	10/22/08

An executed copy of the chain of custody is also included as an addendum to this report.

If you have any questions relating to this analytical report, please contact your Laboratory Project Manager at 1-800-833-7036

SAMPLE IDENTIFICATION	LAB NUMBER	COLLECTION DATE AND TIME
105 FPC 10/20-21	WRJ0812-01	10/21/08 13:30
105 Grab	WRJ0812-02	10/21/08 13:30
002 TC 10/20-21	WRJ0812-03	10/21/08 14:00
002 Grab	WRJ0812-04	10/21/08 14:00
LL Hg Blank	WRJ0812-05	10/21/08

Samples were received into laboratory at a temperature of 4 °C.

Wisconsin Certification Number: 128053530

The Chain of Custody, 1 page, is included and is an integral part of this report.

Unless subcontracted, volatiles analyses (including VOC, PVOC, GRO, BTEX, and TPH gasoline) performed by TestAmerica Watertown at 1101 Industrial Drive, Units 9&10. All other analyses performed at the address shown in the heading of this report.

Approved By:

Michael M Miller

TestAmerica Watertown
Mike Miller For Warren L. Topel
Project Manager

TestAmerica

THE LEADER IN ENVIRONMENTAL TESTING

602 Commerce Drive Watertown, WI 53094 * 800-833-7036 * Fax 920-261-8120

SIGMA ENVIRONMENTAL (WW)
1300 West Canal Street
Milwaukee, WI 53233
Mr. Tom Koeppen

Work Order: WRJ0812
Project: Point Beach Power Plant
Project Number: 11196

Received: 10/22/08
Reported: 10/29/08 14:23

ANALYTICAL REPORT

Analyte	Sample Result	Data Qualifiers	Units	MDL	LOQ	Dilution Factor	Date Analyzed	Analyst	Seq/ Batch	Method
Sample ID: WRJ0812-01 (105 FPC 10/20-21 - Waste Water)							**Sampled: 10/21/08 13:30**			
General Chemistry Parameters										
Ammonia as N	**0.73**		mg/L	0.20	0.67	2	10/29/08 12:35	tdc	8100702	SM 4500NHH
Hardness	**230**		mg/L	4.0	13	1	10/24/08 12:07	shf	8100635	EPA 130.2
Phosphorus, Total (as P)	**1.7**		mg/L	0.10	0.33	1	10/27/08 13:16	pxm	8100658	EPA 365.1
Metals										
Copper	**12**	J	ug/L	6.0	20	1	10/27/08 10:42	gaf	8100621	SW 6020A
Field Sampling Parameters										
Flow	**103693**		Gal/Day	NA		1	10/21/08 13:30	pam	8100643	NA
Sample ID: WRJ0812-02 (105 Grab - Waste Water)							**Sampled: 10/21/08 13:30**			
Metals										
Mercury	**17**		ng/L	1.4	4.7	10	10/24/08 14:55	jcj	8100610	EPA 1631E
Field Sampling Parameters										
pH	**8.30**		pH Units	NA		1	10/21/08 13:30	pam	8100643	EPA 150.1
Temperature	**19.0**		°C	NA		1	10/21/08 13:30	pam	8100643	EPA 170.1
Sample ID: WRJ0812-03 (002 TC 10/20-21 - Waste Water)							**Sampled: 10/21/08 14:00**			
General Chemistry Parameters										
Ammonia as N	<0.10		mg/L	0.10	0.33	1	10/29/08 12:36	tdc	8100702	SM 4500NHH
Hardness	**160**		mg/L	4.0	13	1	10/24/08 12:07	shf	8100635	EPA 130.2
Phosphorus, Total (as P)	<0.10		mg/L	0.10	0.33	1	10/27/08 13:17	pxm	8100658	EPA 365.1
Metals										
Copper	<6.0		ug/L	6.0	20	1	10/27/08 10:42	gaf	8100621	SW 6020A
Sample ID: WRJ0812-04 (002 Grab - Waste Water)							**Sampled: 10/21/08 14:00**			
Metals										
Mercury	**2.5**		ng/L	0.14	0.47	1	10/24/08 14:55	jcj	8100610	EPA 1631E
Field Sampling Parameters										
pH	**7.00**		pH Units	NA		1	10/21/08 14:00	pam	8100643	EPA 150.1
Temperature	**20.0**		°C	NA		1	10/21/08 14:00	pam	8100643	EPA 170.1
Sample ID: WRJ0812-05 (LL Hg Blank - Waste Water)							**Sampled: 10/21/08**			
Metals										
Mercury	<0.14		ng/L	0.14	0.47	1	10/24/08 14:55	jcj	8100610	EPA 1631E

TestAmerica Watertown
Mike Miller For Warren L. Topel
Project Manager

602 Commerce Drive Watertown, WI 53094 * 800-833-7036 * Fax 920-261-8120

SIGMA ENVIRONMENTAL (WW)
1300 West Canal Street
Milwaukee, WI 53233
Mr. Tom Koeppen

Work Order: WRJ0812
Project: Point Beach Power Plant
Project Number: 11196

Received: 10/22/08
Reported: 10/29/08 14:23

LABORATORY BLANK QC DATA

Analyte	Seq/ Batch	Source Result	Spike Level	Units	MDL	MRL	Result	Dup Result	% REC	Dup %REC	% REC Limits	RPD	RPD Limit	Q
General Chemistry Parameters														
Hardness	8100635			mg/L	4.0	12	<4.0							
Phosphorus, Total (as P)	8100658			mg/L	0.10	0.33	<0.10							
Ammonia as N	8100702			mg/L	0.10	0.33	<0.10							
Metals														
Mercury	8100610			ng/L	0.14	0.50	<0.14							
Mercury	8100610			ng/L	0.14	0.50	<0.14							
Copper	8100621			ug/L	6.0	20	<6.0							

602 Commerce Drive Watertown, WI 53094 * 800-833-7036 * Fax 920-261-8120

SIGMA ENVIRONMENTAL (WW)
1300 West Canal Street
Milwaukee, WI 53233
Mr. Tom Koeppen

Work Order: WRJ0812
Project: Point Beach Power Plant
Project Number: 11196

Received: 10/22/08
Reported: 10/29/08 14:23

CCV QC DATA

Analyte	Seq/ Batch	Source Result	Spike Level	Units	MDL	MRL	Result	Dup Result	% REC	Dup %REC	% REC Limits	RPD	RPD Limit	Q
General Chemistry Parameters														
Hardness	8100635		44.000	mg/L	N/A	N/A	44.0		100		90-110			
Hardness	8100635		80.000	mg/L	N/A	N/A	80.0		100		90-110			
Hardness	8100635		80.000	mg/L	N/A	N/A	80.0		100		90-110			
Phosphorus, Total (as P)	8100658		10.000	mg/L	N/A	N/A	10.3		103		90-110			
Phosphorus, Total (as P)	8100658		10.000	mg/L	N/A	N/A	10.3		103		90-110			
Ammonia as N	8100702		10.000	mg/L	N/A	N/A	10.0		100		90-110			
Ammonia as N	8100702		10.000	mg/L	N/A	N/A	10.2		102		90-110			
Metals														
Mercury	8100610		5.0000	ng/L	N/A	N/A	5.12		102		77-123			
Mercury	8100610		5.0000	ng/L	N/A	N/A	4.82		96		77-123			
Mercury	8100610		5.0000	ng/L	N/A	N/A	4.99		100		77-123			
Mercury	8100610		5.0000	ng/L	N/A	N/A	5.09		102		77-123			

602 Commerce Drive Watertown, WI 53094 * 800-833-7036 * Fax 920-261-8120

SIGMA ENVIRONMENTAL (WW)
1300 West Canal Street
Milwaukee, WI 53233
Mr. Tom Koeppen

Work Order: WRJ0812
Project: Point Beach Power Plant
Project Number: 11196

Received: 10/22/08
Reported: 10/29/08 14:23

LCS/LCS DUPLICATE QC DATA

Analyte	Seq/ Batch	Source Result	Spike Level	Units	MDL	MRL	Result	Dup Result	% REC	Dup %REC	% REC Limits	RPD	RPD Limit	Q
General Chemistry Parameters														
Phosphorus, Total (as P)	8100658		10.000	mg/L	0.10	0.33	10.6		106		90-110			
Ammonia as N	8100702		10.000	mg/L	0.10	0.33	10.2		102		90-110			
Metals														
Mercury	8100610		5.0000	ng/L	0.14	0.50	5.31		106		75-125			
Mercury	8100610		5.0000	ng/L	0.14	0.50	4.91		98		75-125			
Copper	8100621		50.000	ug/L	6.0	20	51.1		102		84-111			

TestAmerica Watertown
Mike Miller For Warren L. Topel
Project Manager

SIGMA ENVIRONMENTAL (WW)
1300 West Canal Street
Milwaukee, WI 53233
Mr. Tom Koeppen

Work Order: WRJ0812
Project: Point Beach Power Plant
Project Number: 11196

Received: 10/22/08
Reported: 10/29/08 14:23

MATRIX SPIKE/MATRIX SPIKE DUPLICATE QC DATA

Analyte	Seq/ Batch	Source Result	Spike Level	Units	MDL	MRL	Result	Dup Result	% REC	Dup %REC	% REC Limits	RPD	RPD Limit	Q
General Chemistry Parameters														
QC Source Sample: WRJ0812-01														
Hardness	8100635	230	200.00	mg/L	4.0	12	410	410	90	90	76-126	0	15	
QC Source Sample: WRJ0806-07														
Phosphorus, Total (as P)	8100658	0.333	10.000	mg/L	0.10	0.33	10.7	10.6	104	103	64-136	1	23	
QC Source Sample: WRJ0812-01														
Ammonia as N	8100702	0.730	20.000	mg/L	0.20	0.66	21.0	20.8	101	100	60-136	1	22	
Metals														
QC Source Sample: WRJ0730-02														
Mercury	8100610	0.763	5.0000	ng/L	0.14	0.50	5.13	5.15	87	88	71-125	0	24	
QC Source Sample: WRJ0781-02														
Mercury	8100610	1.15	5.0000	ng/L	0.14	0.50	5.62	5.62	89	89	71-125	0	24	
QC Source Sample: WRJ0812-04														
Mercury	8100610	2.49	5.0000	ng/L	0.14	0.50	6.26	6.22	75	75	71-125	1	24	
QC Source Sample: WRJ0781-01														
Copper	8100621	18.8	50.000	ug/L	6.0	20	63.5	63.8	89	90	69-123	0	25	

TestAmerica
THE LEADER IN ENVIRONMENTAL TESTING
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SIGMA ENVIRONMENTAL (WW)	Work Order:	WRJ0812	Received:	10/22/08
1300 West Canal Street	Project:	Point Beach Power Plant	Reported:	10/29/08 14:23
Milwaukee, WI 53233	Project Number:	11196		
Mr. Tom Koeppen				

CERTIFICATION SUMMARY

TestAmerica Watertown

Method	Matrix	Nelac	Wisconsin
EPA 130.2	Water - NonPotable	X	X
EPA 150.1	Water - NonPotable	X	N/A
EPA 1631E	Water - NonPotable		X
EPA 170.1	Water - NonPotable		
EPA 365.1	Water - NonPotable	X	X
NA	Water - NonPotable		
SM 4500NHH	Water - NonPotable	X	X
SW 6020A	Water - NonPotable		X

DATA QUALIFIERS AND DEFINITIONS

J Results reported between the Method Detection Limit (MDL) and Limit of Quantitation (LOQ) are less certain than results at or above the LOQ.

ADDITIONAL COMMENTS

TestAmerica Watertown
Mike Miller For Warren L. Topel
Project Manager

WR J0812

TestAmerica

THE LEADER IN ENVIRONMENTAL TESTING

Watertown Division
602 Commerce Drive
Watertown, WI 53094

Phone 920-261-1660 or 800-833-7036
Fax 920-261-8120

To assist us in using the proper analytical methods, is this work being conducted for regulatory purposes?
Compliance Monitoring ______

Client Name: S. Gma   Client #: ______
Address: ______
City/State/Zip Code: Mil W
Project Manager: Tom Koeppen
Telephone Number: 414 643 4138   Fax: 414 643 4210
Sampler Name: (Print Name) D. Kurtz
Sampler Signature: [signature]
E-mail address: ______

Project Name: Point Beach Nuclear Power Plant
Project #: 11196
Site/Location ID: Two Rivers   State: WI
Report To: Tom Koeppen
Invoice To: ______
Quote #: ______   PO#: ______

TAT
___ Standard
___ Rush (surcharges may apply)
Date Needed: ______
Fax Results: Y N
E-mail: Y N

QC Deliverables
___ None
___ Level 2 (Batch QC)
___ Level 3
___ Level 4
Other: ______

	SAMPLE ID	Date Sampled	Time Sampled	G = Grab, C = Composite	Field Filtered	Matrix (SL - Sludge DW - Drinking Water GW - Groundwater S - Soil/Solid WW - Wastewater Specify Other)	HNO_3	HCl	NaOH	H_2SO_4	Methanol	None	Other (Specify) (HCl VO Vials)	A. Nitrogen	Phosphorous	Cu Total Rec.	Hardness	Lo Level Hg	REMARKS
-01	#105 (FPC) 10/20-10/21	10/21/08	1:30	C		WW	1			1				X	X	X	X		#105 →
-02	#105 (Grab)	⊥	⊥	G		⊥							4					X	FLOW = 103,693 gpd
																			Temp = 19°C
-03	#002 (TC) 10/20-10/21	10/21/08	2:00	C		WW	1			1				X	X	X	X		pH = 8.3
-04	#002 (Grab)	⊥	⊥	G		⊥							4					X	
																			#002 →
-05	Lo Level Hg Field Blanks	10/21/08	—										2					X	Temp = 20°C
																			pH = 7.0

Special Instructions:

Relinquished By:	Date:	Time:	Received By:	Date:	Time:
[signature]			Roy Wolff	10/22/08	1015
Roy Wolff	10/22	1335	T Spancle	10/22/08	1352

LABORATORY COMMENTS:
Init Lab Temp: 4°C
Rec Lab Temp:
Custody Seals: Y N N/A
Bottles Supplied by TestAmerica: Y N
Method of Shipment:

TAL-0020 (1207)

R 10/22/08

TestAmerica
THE LEADER IN ENVIRONMENTAL TESTING
602 Commerce Drive Watertown, WI 53094 * 800-833-7036 * Fax 920-261-8120

December 08, 2008

Client:	SIGMA ENVIRONMENTAL (WW) 1300 West Canal Street Milwaukee, WI 53233	Work Order: Project Name: Project Number:	WRK0875 Point Beach Power Plant 11196
Attn:	Mr. Tom Koeppen	Date Received:	11/26/08

An executed copy of the chain of custody is also included as an addendum to this report.

If you have any questions relating to this analytical report, please contact your Laboratory Project Manager at 1-800-833-7036

SAMPLE IDENTIFICATION	LAB NUMBER	COLLECTION DATE AND TIME
002 TC 11/24-25	WRK0875-01	11/25/08 11:30
002 Grab	WRK0875-02	11/25/08 11:30
105 FPC 11/24-25	WRK0875-03	11/25/08 12:00
105 Grab	WRK0875-04	11/25/08 12:00
002 LL Hg Blank	WRK0875-05	11/25/08 11:30
105 LL Hg Blank	WRK0875-06	11/25/08 12:00

Samples were received into laboratory at a temperature of 3 °C.

Wisconsin Certification Number: 128053530

The Chain of Custody, 1 page, is included and is an integral part of this report.

Unless subcontracted, volatiles analyses (including VOC, PVOC, GRO, BTEX, and TPH gasoline) performed by TestAmerica Watertown at 1101 Industrial Drive, Units 9&10. All other analyses performed at the address shown in the heading of this report.

Approved By:

Michael M Miller

TestAmerica Watertown
Mike Miller For Warren L. Topel
Project Manager

SIGMA ENVIRONMENTAL (WW)
1300 West Canal Street
Milwaukee, WI 53233
Mr. Tom Koeppen

Work Order: WRK0875
Project: Point Beach Power Plant
Project Number: 11196

Received: 11/26/08
Reported: 12/08/08 09:03

ANALYTICAL REPORT

Analyte	Sample Result	Data Qualifiers	Units	MDL	LOQ	Dilution Factor	Date Analyzed	Analyst	Seq/ Batch	Method
Sample ID: WRK0875-01 (002 TC 11/24-25 - Waste Water)							**Sampled: 11/25/08 11:30**			
General Chemistry Parameters										
Ammonia as N	<0.10		mg/L	0.10	0.33	1	12/02/08 12:31	tdc	8120047	SM 4500NHH
Hardness	**170**		mg/L	4.0	13	1	12/04/08 11:12	shf	8120128	EPA 130.2
Phosphorus, Total (as P)	<0.10		mg/L	0.10	0.33	1	12/03/08 14:51	pxm	8120100	EPA 365.1
Metals										
Copper	<6.0		ug/L	6.0	20	1	12/06/08 11:42	gaf	8120005	SW 6020A
Sample ID: WRK0875-02 (002 Grab - Waste Water)							**Sampled: 11/25/08 11:30**			
Metals										
Mercury	**1.2**		ng/L	0.14	0.47	1	12/05/08 14:21	jej	8120143	EPA 1631E
Field Sampling Parameters										
pH	**6.90**		pH Units	NA		1	11/25/08 11:30	pam	8120054	EPA 150.1
Temperature	**12.0**		°C	NA		1	11/25/08 11:30	pam	8120054	EPA 170.1
Sample ID: WRK0875-03 (105 FPC 11/24-25 - Waste Water)							**Sampled: 11/25/08 12:00**			
General Chemistry Parameters										
Ammonia as N	**0.36**		mg/L	0.10	0.33	1	12/02/08 12:32	tdc	8120047	SM 4500NHH
Hardness	**190**		mg/L	4.0	13	1	12/04/08 11:12	shf	8120128	EPA 130.2
Phosphorus, Total (as P)	**0.27**	J	mg/L	0.10	0.33	1	12/03/08 14:51	pxm	8120100	EPA 365.1
Metals										
Copper	<6.0		ug/L	6.0	20	1	12/06/08 11:42	gaf	8120005	SW 6020A
Sample ID: WRK0875-04 (105 Grab - Waste Water)							**Sampled: 11/25/08 12:00**			
Metals										
Mercury	**4.0**		ng/L	0.14	0.47	1	12/05/08 14:21	jej	8120143	EPA 1631E
Field Sampling Parameters										
pH	**6.70**		pH Units	NA		1	11/25/08 12:00	pam	8120054	EPA 150.1
Temperature	**12.0**		°C	NA		1	11/25/08 12:00	pam	8120054	EPA 170.1
Sample ID: WRK0875-05 (002 LL Hg Blank - Waste Water)							**Sampled: 11/25/08 11:30**			
Metals										
Mercury	<0.14		ng/L	0.14	0.47	1	12/05/08 14:21	jej	8120143	EPA 1631E
Sample ID: WRK0875-06 (105 LL Hg Blank - Waste Water)							**Sampled: 11/25/08 12:00**			
Metals										
Mercury	<0.14		ng/L	0.14	0.47	1	12/05/08 14:21	jej	8120143	EPA 1631E

TestAmerica Watertown
Mike Miller For Warren L. Topel
Project Manager

SIGMA ENVIRONMENTAL (WW)
1300 West Canal Street
Milwaukee, WI 53233
Mr. Tom Koeppen

Work Order: WRK0875
Project: Point Beach Power Plant
Project Number: 11196

Received: 11/26/08
Reported: 12/08/08 09:03

LABORATORY BLANK QC DATA

Analyte	Seq/ Batch	Source Result	Spike Level	Units	MDL	MRL	Result	Dup Result	% REC	Dup %REC	% REC Limits	RPD	RPD Limit	Q
General Chemistry Parameters														
Ammonia as N	8120047			mg/L	0.10	0.33	<0.10							
Phosphorus, Total (as P)	8120100			mg/L	0.10	0.33	<0.10							
Hardness	8120128			mg/L	4.0	12	<4.0							
Metals														
Copper	8120005			ug/L	6.0	20	<6.0							
Mercury	8120143			ng/L	0.14	0.50	<0.14							

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SIGMA ENVIRONMENTAL (WW)
1300 West Canal Street
Milwaukee, WI 53233
Mr. Tom Koeppen

Work Order: WRK0875
Project: Point Beach Power Plant
Project Number: 11196

Received: 11/26/08
Reported: 12/08/08 09:03

CCV QC DATA

Analyte	Seq/ Batch	Source Result	Spike Level	Units	MDL	MRL	Result	Dup Result	% REC	Dup %REC	% REC Limits	RPD	RPD Limit	Q
General Chemistry Parameters														
Ammonia as N	8120047		10.000	mg/L	N/A	N/A	9.94		99		90-110			
Ammonia as N	8120047		10.000	mg/L	N/A	N/A	10.4		104		90-110			
Phosphorus, Total (as P)	8120100		10.000	mg/L	N/A	N/A	10.6		106		90-110			
Phosphorus, Total (as P)	8120100		10.000	mg/L	N/A	N/A	10.6		106		90-110			
Hardness	8120128		40.000	mg/L	N/A	N/A	40.0		100		90-110			
Hardness	8120128		80.000	mg/L	N/A	N/A	80.0		100		90-110			
Hardness	8120128		80.000	mg/L	N/A	N/A	80.0		100		90-110			
Metals														
Mercury	8120143		5.0000	ng/L	N/A	N/A	4.98		100		77-123			
Mercury	8120143		5.0000	ng/L	N/A	N/A	4.78		96		77-123			
Mercury	8120143		5.0000	ng/L	N/A	N/A	4.89		98		77-123			
Mercury	8120143		5.0000	ng/L	N/A	N/A	4.76		95		77-123			

TestAmerica Watertown
Mike Miller For Warren L. Topel
Project Manager

602 Commerce Drive Watertown, WI 53094 * 800-833-7036 * Fax 920-261-8120

SIGMA ENVIRONMENTAL (WW)
1300 West Canal Street
Milwaukee, WI 53233
Mr. Tom Koeppen

Work Order: WRK0875
Project: Point Beach Power Plant
Project Number: 11196

Received: 11/26/08
Reported: 12/08/08 09:03

LCS/LCS DUPLICATE QC DATA

Analyte	Seq/ Batch	Source Result	Spike Level	Units	MDL	MRL	Result	Dup Result	% REC	Dup %REC	% REC Limits	RPD	RPD Limit	Q
General Chemistry Parameters														
Ammonia as N	8120047		10.000	mg/L	0.10	0.33	9.79		98		90-110			
Phosphorus, Total (as P)	8120100		10.000	mg/L	0.10	0.33	10.5		105		90-110			
Metals														
Copper	8120005		50.000	ug/L	6.0	20	50.4		101		84-111			
Mercury	8120143		5.0000	ng/L	0.14	0.50	5.00		100		75-125			

TestAmerica Watertown
Mike Miller For Warren L. Topel
Project Manager

602 Commerce Drive Watertown, WI 53094 * 800-833-7036 * Fax 920-261-8120

SIGMA ENVIRONMENTAL (WW)	Work Order: WRK0875	Received:	11/26/08
1300 West Canal Street	Project: Point Beach Power Plant	Reported:	12/08/08 09:03
Milwaukee, WI 53233	Project Number: 11196		
Mr. Tom Koeppen			

MATRIX SPIKE/MATRIX SPIKE DUPLICATE QC DATA

Analyte	Seq/ Batch	Source Result	Spike Level	Units	MDL	MRL	Result	Dup Result	% REC	Dup %REC	% REC Limits	RPD	RPD Limit	Q
General Chemistry Parameters														
QC Source Sample: WRK0868-02														
Ammonia as N	8120047	<0.10	20.000	mg/L	0.20	0.66	18.6		93		60-136			
QC Source Sample: WRK0851-01														
Phosphorus, Total (as P)	8120100	0.250	10.000	mg/L	0.10	0.33	10.7	10.7	104	104	64-136	0	23	
QC Source Sample: WRK0875-01														
Hardness	8120128	170	200.00	mg/L	4.0	12	350	350	90	90	76-126	0	15	
Metals														
QC Source Sample: WRK0865-01														
Copper	8120005	82.0	50.000	ug/L	6.0	20	129	131	95	98	69-123	1	25	
QC Source Sample: WRK0755-02														
Mercury	8120143	1.54	5.0000	ng/L	0.14	0.50	5.28	5.10	75	71	71-125	3	24	
QC Source Sample: WRK0875-02														
Mercury	8120143	1.18	5.0000	ng/L	0.14	0.50	5.49	5.62	86	89	71-125	2	24	
QC Source Sample: WRL0148-04														
Mercury	8120143	0.613	10.000	ng/L	0.14	0.50	9.62	9.51	90	89	71-125	1	24	
QC Source Sample: WRL0148-05														
Mercury	8120143	<0.14	10.000	ng/L	0.14	0.50	9.52	9.71	95	97	71-125	2	24	

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SIGMA ENVIRONMENTAL (WW)
1300 West Canal Street
Milwaukee, WI 53233
Mr. Tom Koeppen

Work Order: WRK0875
Project: Point Beach Power Plant
Project Number: 11196

Received: 11/26/08
Reported: 12/08/08 09:03

CERTIFICATION SUMMARY

TestAmerica Watertown

Method	Matrix	Nelac	Wisconsin
EPA 130.2	Water - NonPotable	X	X
EPA 150.1	Water - NonPotable	X	N/A
EPA 1631E	Water - NonPotable	X	X
EPA 170.1	Water - NonPotable		
EPA 365.1	Water - NonPotable	X	X
SM 4500NHH	Water - NonPotable	X	X
SW 6020A	Water - NonPotable		X

TestAmerica Watertown
Mike Miller For Warren L. Topel
Project Manager

SIGMA ENVIRONMENTAL (WW)	Work Order:	WRK0875		Received:	11/26/08
1300 West Canal Street	Project:	Point Beach Power Plant		Reported:	12/08/08 09:03
Milwaukee, WI 53233	Project Number:	11196			
Mr. Tom Koeppen					

DATA QUALIFIERS AND DEFINITIONS

J Results reported between the Method Detection Limit (MDL) and Limit of Quantitation (LOQ) are less certain than results at or above the LOQ.

ADDITIONAL COMMENTS

TestAmerica Watertown
Mike Miller For Warren L. Topel
Project Manager

WRK0875

TestAmerica
THE LEADER IN ENVIRONMENTAL TESTING

Watertown Division
602 Commerce Drive
Watertown, WI 53094

Phone 920-261-1660 or 800-833-7036
Fax 920-261-8120

To assist us in using the proper analytical methods, is this work being conducted for regulatory purposes?
Compliance Monitoring ______

Client Name: S.Guig
Client #: ______
Address: ______
City/State/Zip Code: Milw.
Project Manager: Tom Koeppen
Telephone Number: 414 643 4138
Fax: 414 643 4210
Sampler Name: (Print Name) D. Kyhtz
Sampler Signature: [signature]
E-mail address: ______

Project Name: Point Beach Nuclear Power Plant
Project #: 11196
Site/Location ID: Two Rivers
State: WI
Report To: Tom Koeppen
Invoice To: ______
Quote #: ______
PO#: ______

TAT
___ Standard
___ Rush (surcharges may apply)

Date Needed: ______

Fax Results: Y N

E-mail: Y N

QC Deliverables
___ None
___ Level 2 *(Batch QC)*
___ Level 3
___ Level 4
Other: ______

	SAMPLE ID	Date Sampled	Time Sampled	G = Grab, C = Composite	Field Filtered	Matrix: SL - Sludge DW - Drinking Water GW - Groundwater S - Soil/Solid WW - Wastewater Specify Other	HNO_3	HCl	NaOH	H_2SO_4	Methanol	None	Other (Specify) glass vials	A. Nitrogen	Phosphorous	Cu / Total Rec.	Hardness	Lo Level Hg	REMARKS
-01	#002 (TC) 11/24-11/25	11/25/08	11:30	C		WW	1			1				X	X	X	X		#002 →
-02	#002 (Grab)	⊥	⊥	G		⊥							4					X	Temp = 12°C pH = 6.9
-03	#105 (FPC) 11/24-11/25	11/25/08	12:00	C		WW	1			1				X	X	X	X		
-04	#105 (Grab)	⊥	⊥	G		⊥							4					X	#105 → Temp = 12°C pH = 6.7
-05	#002 Lo Level Hg Blank	11/25/08	11:30	–									2					X	
-06	#105 Lo Level Hg Blank	11/25/08	12:00	–									2					X	

Special Instructions:

	Date	Time		Date	Time
Relinquished By: [signature]			Received By: [signature]	11/26/08	12:20
Relinquished By: [signature]	11/26/08	16:15	Received By: [signature]	11/26/08	1632
Relinquished By:			Received By:		

LABORATORY COMMENTS:
Init Lab Temp: 3°C
Rec Lab Temp:
Custody Seals: Y N N/A
Bottles Supplied by TestAmerica: (Y) N
Method of Shipment: HD

TAL-0020 (1207)

[initials] 11/26/08

TestAmerica
THE LEADER IN ENVIRONMENTAL TESTING

602 Commerce Drive Watertown, WI 53094 * 800-833-7036 * Fax 920-261-8120

December 29, 2008

Client:	SIGMA ENVIRONMENTAL (WW) 1300 West Canal Street Milwaukee, WI 53233	Work Order: Project Name: Project Number:	WRL0603 Point Beach Power Plant 11196
Attn:	Mr. Tom Koeppen	Date Received:	12/22/08

An executed copy of the chain of custody is also included as an addendum to this report.

If you have any questions relating to this analytical report, please contact your Laboratory Project Manager at 1-800-833-7036

SAMPLE IDENTIFICATION	LAB NUMBER	COLLECTION DATE AND TIME
002 TC 12/17-18	WRL0603-01	12/18/08 12:00
105 FPC 12/17-18	WRL0603-02	12/18/08 12:30

Samples were received on ice into laboratory at a temperature of 0 °C.

Wisconsin Certification Number: 128053530

The Chain of Custody, 1 page, is included and is an integral part of this report.

Unless subcontracted, volatiles analyses (including VOC, PVOC, GRO, BTEX, and TPH gasoline) performed by TestAmerica Watertown at 1101 Industrial Drive, Units 9&10. All other analyses performed at the address shown in the heading of this report.

Approved By:

Michael M Miller

TestAmerica Watertown
Mike Miller For Warren L. Topel
Project Manager

TestAmerica
THE LEADER IN ENVIRONMENTAL TESTING
602 Commerce Drive Watertown, WI 53094 * 800-833-7036 * Fax 920-261-8120

SIGMA ENVIRONMENTAL (WW)
1300 West Canal Street
Milwaukee, WI 53233
Mr. Tom Koeppen

Work Order: WRL0603
Project: Point Beach Power Plant
Project Number: 11196

Received: 12/22/08
Reported: 12/29/08 14:59

ANALYTICAL REPORT

Analyte	Sample Result	Data Qualifiers	Units	MDL	LOQ	Dilution Factor	Date Analyzed	Analyst	Seq/ Batch	Method
Sample ID: WRL0603-01 (002 TC 12/17-18 - Waste Water)							**Sampled: 12/18/08 12:00**			
General Chemistry Parameters										
Ammonia as N	<0.10		mg/L	0.10	0.33	1	12/29/08 13:38	pxm	8120549	SM 4500NHH
Hardness	**170**		mg/L	4.0	13	1	12/27/08 15:54	shf	8120610	EPA 130.2
Phosphorus, Total (as P)	<0.10		mg/L	0.10	0.33	1	12/24/08 13:17	pxm	8120573	EPA 365.1
Metals										
Copper	<6.0		ug/L	6.0	20	1	12/24/08 11:20	gaf	8120536	SW 6020A
Sample ID: WRL0603-02 (105 FPC 12/17-18 - Waste Water)							**Sampled: 12/18/08 12:30**			
General Chemistry Parameters										
Ammonia as N	**0.32**	J	mg/L	0.10	0.33	1	12/29/08 13:38	pxm	8120549	SM 4500NHH
Hardness	**150**		mg/L	4.0	13	1	12/27/08 15:54	shf	8120610	EPA 130.2
Phosphorus, Total (as P)	**0.14**	J	mg/L	0.10	0.33	1	12/24/08 13:18	pxm	8120573	EPA 365.1
Metals										
Copper	<6.0		ug/L	6.0	20	1	12/24/08 11:20	gaf	8120536	SW 6020A

TestAmerica Watertown
Mike Miller For Warren L. Topel
Project Manager

TestAmerica
THE LEADER IN ENVIRONMENTAL TESTING

602 Commerce Drive Watertown, WI 53094 * 800-833-7036 * Fax 920-261-8120

SIGMA ENVIRONMENTAL (WW)
1300 West Canal Street
Milwaukee, WI 53233
Mr. Tom Koeppen

Work Order: WRL0603
Project: Point Beach Power Plant
Project Number: 11196

Received: 12/22/08
Reported: 12/29/08 14:59

LABORATORY BLANK QC DATA

Analyte	Seq/ Batch	Source Result	Spike Level	Units	MDL	MRL	Result	Dup Result	% REC	Dup %REC	% REC Limits	RPD	RPD Limit	Q
General Chemistry Parameters														
Ammonia as N	8120549			mg/L	0.10	0.33	<0.10							
Phosphorus, Total (as P)	8120573			mg/L	0.10	0.33	<0.10							
Hardness	8120610			mg/L	4.0	12	<4.0							
Metals														
Copper	8120536			ug/L	6.0	20	<6.0							

TestAmerica Watertown
Mike Miller For Warren L. Topel
Project Manager

SIGMA ENVIRONMENTAL (WW)
1300 West Canal Street
Milwaukee, WI 53233
Mr. Tom Koeppen

Work Order: WRL0603
Project: Point Beach Power Plant
Project Number: 11196

Received: 12/22/08
Reported: 12/29/08 14:59

CCV QC DATA

Analyte	Seq/ Batch	Source Result	Spike Level	Units	MDL	MRL	Result	Dup Result	% REC	Dup %REC	% REC Limits	RPD	RPD Limit	Q
General Chemistry Parameters														
Ammonia as N	8120549		10.000	mg/L	N/A	N/A	9.82		98		90-110			
Ammonia as N	8120549		10.000	mg/L	N/A	N/A	9.58		96		90-110			
Phosphorus, Total (as P)	8120573		10.000	mg/L	N/A	N/A	10.8		108		90-110			
Phosphorus, Total (as P)	8120573		10.000	mg/L	N/A	N/A	10.6		106		90-110			
Hardness	8120610		40.000	mg/L	N/A	N/A	40.0		100		90-110			
Hardness	8120610		80.000	mg/L	N/A	N/A	80.0		100		90-110			
Hardness	8120610		80.000	mg/L	N/A	N/A	80.0		100		90-110			

TestAmerica Watertown
Mike Miller For Warren L. Topel
Project Manager

602 Commerce Drive Watertown, WI 53094 * 800-833-7036 * Fax 920-261-8120

SIGMA ENVIRONMENTAL (WW)
1300 West Canal Street
Milwaukee, WI 53233
Mr. Tom Koeppen

Work Order: WRL0603
Project: Point Beach Power Plant
Project Number: 11196

Received: 12/22/08
Reported: 12/29/08 14:59

LCS/LCS DUPLICATE QC DATA

Analyte	Seq/ Batch	Source Result	Spike Level	Units	MDL	MRL	Result	Dup Result	% REC	Dup %REC	% REC Limits	RPD	RPD Limit	Q
General Chemistry Parameters														
Ammonia as N	8120549		10.000	mg/L	0.10	0.33	9.60		96		90-110			
Phosphorus, Total (as P)	8120573		10.000	mg/L	0.10	0.33	10.8		108		90-110			
Metals														
Copper	8120536		50.000	ug/L	6.0	20	50.5		101		84-111			

TestAmerica Watertown
Mike Miller For Warren L. Topel
Project Manager

602 Commerce Drive Watertown, WI 53094 * 800-833-7036 * Fax 920-261-8120

SIGMA ENVIRONMENTAL (WW)
1300 West Canal Street
Milwaukee, WI 53233
Mr. Tom Koeppen

Work Order: WRL0603
Project: Point Beach Power Plant
Project Number: 11196

Received: 12/22/08
Reported: 12/29/08 14:59

MATRIX SPIKE/MATRIX SPIKE DUPLICATE QC DATA

Analyte	Seq/ Batch	Source Result	Spike Level	Units	MDL	MRL	Result	Dup Result	% REC	Dup %REC	% REC Limits	RPD	RPD Limit	Q
General Chemistry Parameters														
QC Source Sample: WRL0520-01														
Ammonia as N	8120549	<0.10	20.000	mg/L	0.20	0.66	19.3	19.3	97	96	60-136	0	22	
QC Source Sample: WRL0563-04														
Phosphorus, Total (as P)	8120573	0.469	10.000	mg/L	0.10	0.33	11.5	11.3	110	108	64-136	2	23	
QC Source Sample: WRL0603-01														
Hardness	8120610	170	200.00	mg/L	4.0	12	350	350	90	90	76-126	0	15	
Metals														
QC Source Sample: WRL0646-01														
Copper	8120536	<6.0	50.000	ug/L	6.0	20	46.6	47.2	93	94	69-123	1	25	

TestAmerica Watertown
Mike Miller For Warren L. Topel
Project Manager

602 Commerce Drive Watertown, WI 53094 * 800-833-7036 * Fax 920-261-8120

SIGMA ENVIRONMENTAL (WW)	Work Order: WRL0603	Received:	12/22/08
1300 West Canal Street	Project: Point Beach Power Plant	Reported:	12/29/08 14:59
Milwaukee, WI 53233	Project Number: 11196		
Mr. Tom Koeppen			

CERTIFICATION SUMMARY

TestAmerica Watertown

Method	Matrix	Nelac	Wisconsin
EPA 130.2	Water - NonPotable	X	X
EPA 365.1	Water - NonPotable	X	X
SM 4500NHH	Water - NonPotable	X	X
SW 6020A	Water - NonPotable		X

TestAmerica Watertown
Mike Miller For Warren L. Topel
Project Manager

SIGMA ENVIRONMENTAL (WW)	Work Order:	WRL0603	Received:	12/22/08
1300 West Canal Street	Project:	Point Beach Power Plant	Reported:	12/29/08 14:59
Milwaukee, WI 53233	Project Number:	11196		
Mr. Tom Koeppen				

DATA QUALIFIERS AND DEFINITIONS

J Results reported between the Method Detection Limit (MDL) and Limit of Quantitation (LOQ) are less certain than results at or above the LOQ.

ADDITIONAL COMMENTS

WRL0603

TestAmerica
THE LEADER IN ENVIRONMENTAL TESTING

Watertown Division
602 Commerce Drive
Watertown, WI 53094

Phone 920-261-1660 or 800-833-7036
Fax 920-261-8120

To assist us in using the proper analytical methods, is this work being conducted for regulatory purposes?
Compliance Monitoring ______

Client Name: Sigma
Client #: ______
Address: ______
City/State/Zip Code: Milw.
Project Manager: Kristi Linsmeier / Tom Koeppen
Telephone Number: 414 643 4141
Fax: 414 643 4210
Sampler Name: (Print Name) D. Kuhtz
Sampler Signature: [signature]
E-mail address: ______

Project Name: Point Beach Nuclear Power Plant
Project #: 11196
Site/Location ID: Two Rivers
State: WI
Report To: Tom Koeppen
Invoice To: ______
Quote #: ______
PO#: ______

TAT
___ Standard
___ Rush (surcharges may apply)

Date Needed: ______

Fax Results: Y N

E-mail: Y N

QC Deliverables
___ None
___ Level 2 *(Batch QC)*
___ Level 3
___ Level 4
Other: ______

Matrix: SL - Sludge, DW - Drinking Water, GW - Groundwater, S - Soil/Solid, WW - Wastewater, Specify Other

Preservation & # of Containers

Analyze For:

	SAMPLE ID	Date Sampled	Time Sampled	G = Grab, C = Composite	Field Filtered	Matrix	HNO_3	HCl	NaOH	H_2SO_4	Methanol	None	Other (Specify)	A. Nitrogen	Phosphorous	Cu, Total Recoverable	Hardness, as CaCO3	REMARKS
-01	#002(TC) 12/17-12/18	12/18/08	12:00A	C		WW	1			1				X	X	X	X	
-02	#105(FPC) 12/17-12/18	12/18/08	12:30P	C		⊥	1			1				X	X	X	X	

Special Instructions:

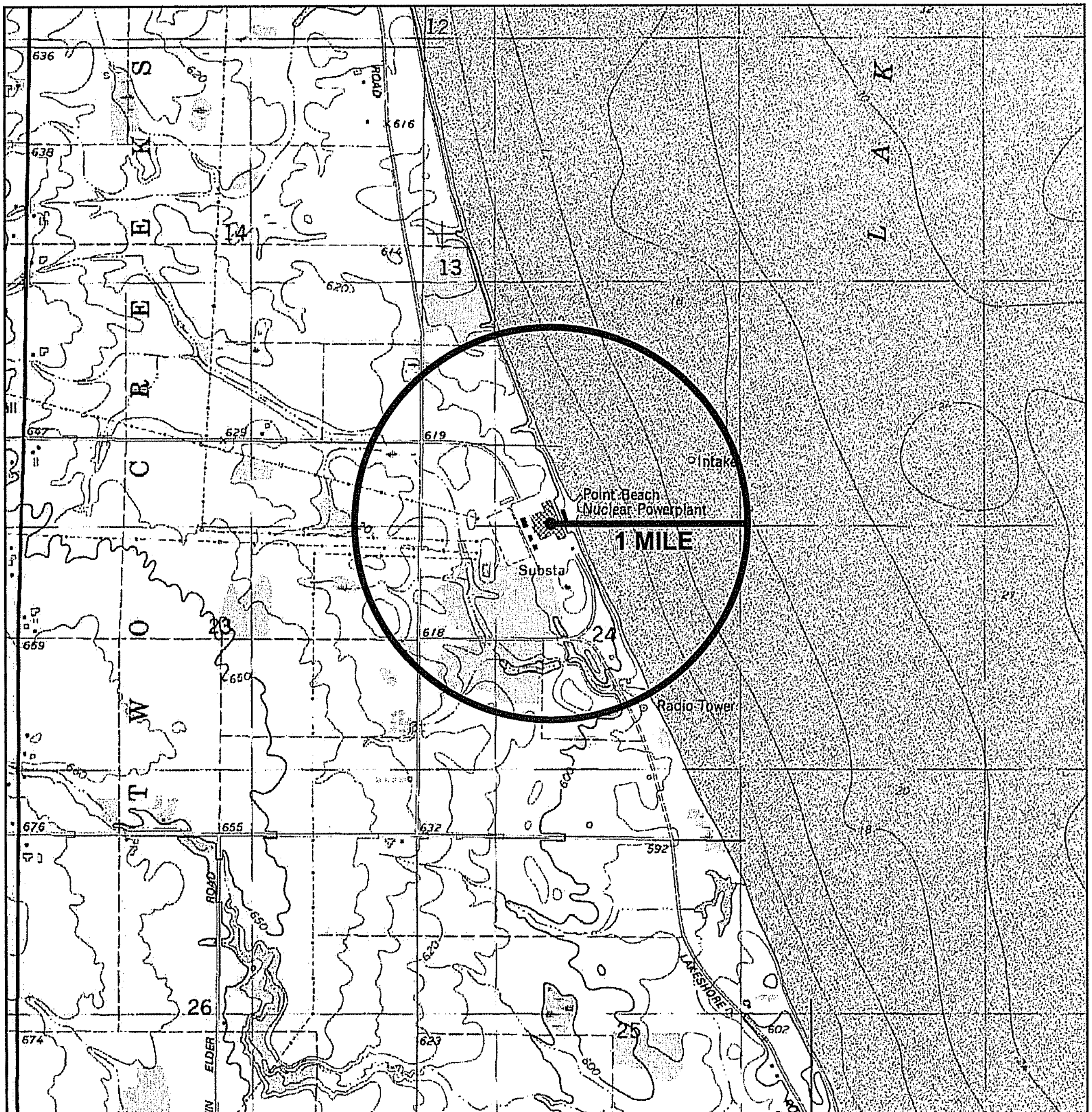
Relinquished By	Date	Time	Received By	Date	Time
[signature]			Seeger	12/20/08	1335
			Nieto	12/22/08	837

LABORATORY COMMENTS:
Init Lab Temp: on ice
Rec Lab Temp:
Custody Seals: Y N (N/A)
Bottles Supplied by TestAmerica: (Y) N
Method of Shipment: Dunham

TAL-0020 (1207)

R 12/22/08

Figures



N

Scale 1 : 24,000
1 Inch = 2,000 feet

Located in the NW 1/4 of Section 24, T21N, R24E
USGS Two Creeks Quadrangle (1978)
7.5 minute, 1 : 24,000 Topographic Map Collection

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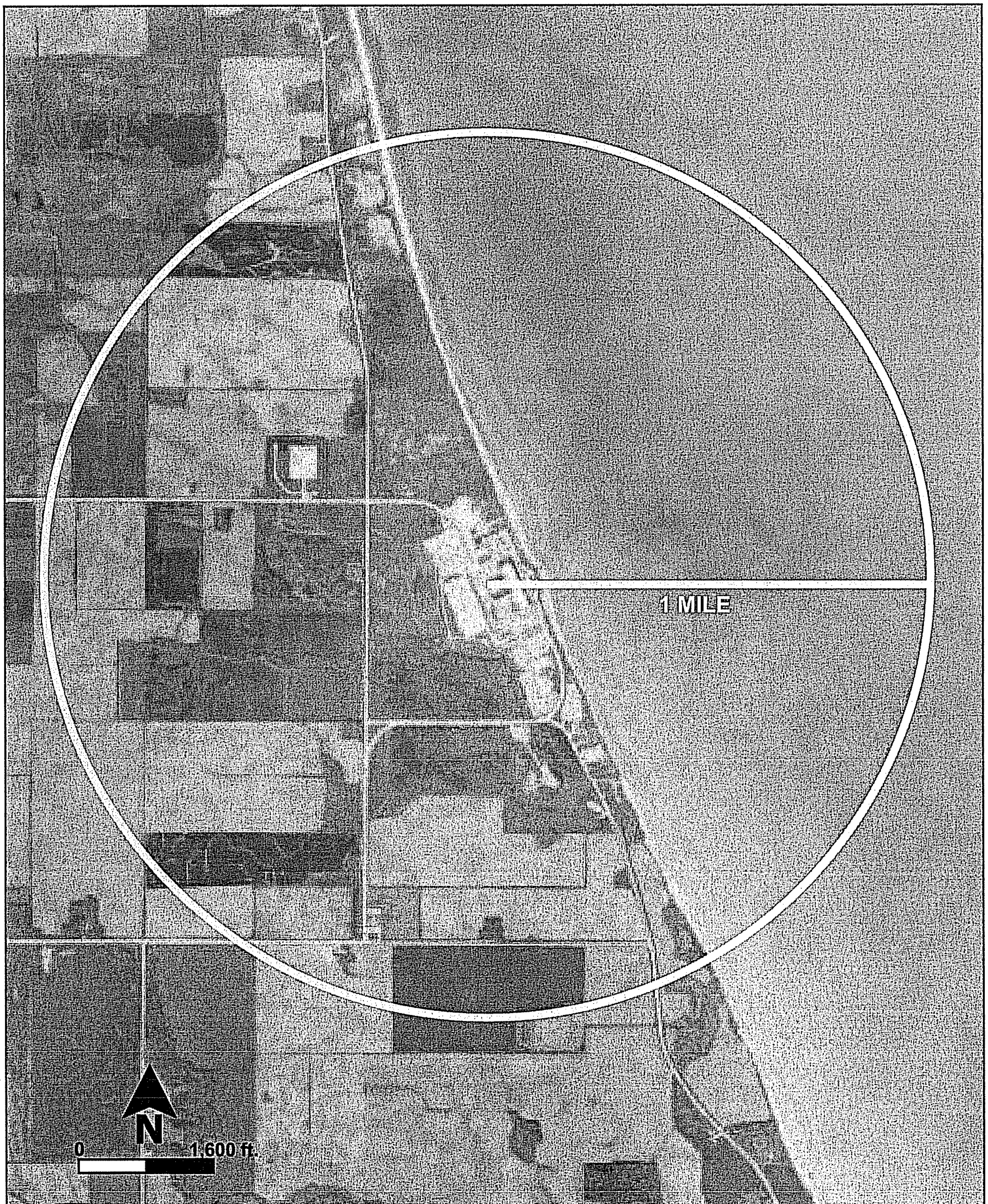
SITE LOCATION MAP

POINT BEACH NUCLEAR POWER PLANT
6610 NUCLEAR ROAD
TWO RIVERS, WISCONSIN

FIGURE

1

Project : 11196 | Directory: GRAPHICS | Filename: F1_Site Location Map.ai | Created By: ERO | Date: 12/08/2008



Project : 11196 | Directory: GRAPHICS | Filename: F2_Site Location Map_Aerial.ai | Created By: ERO | Date: 12/009/2008

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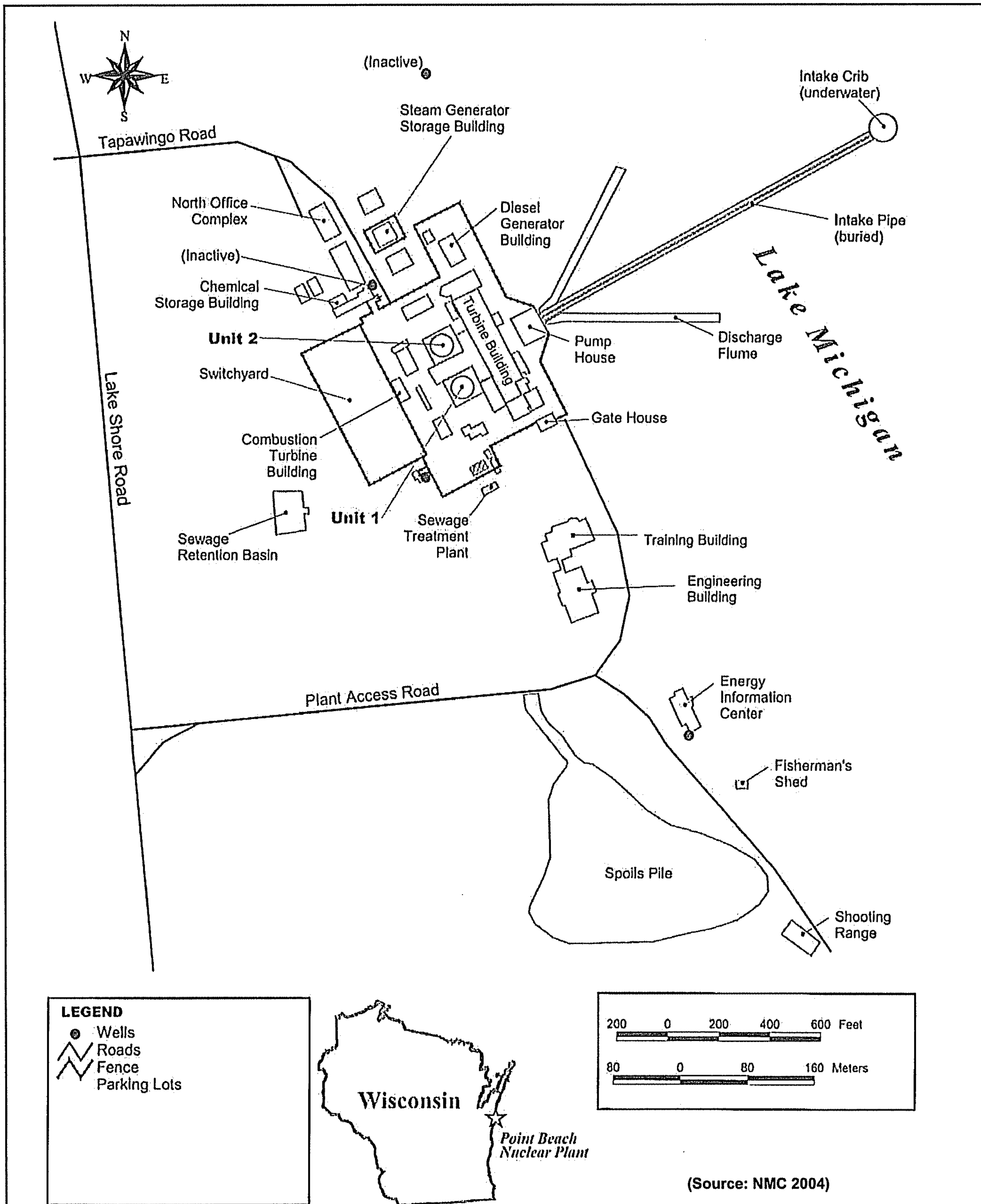
SITE LOCATION MAP - AERIAL

POINT BEACH NUCLEAR POWER PLANT
6610 NUCLEAR ROAD
TWO RIVERS, WISCONSIN

FIGURE
2



(Source: NMC 2004)

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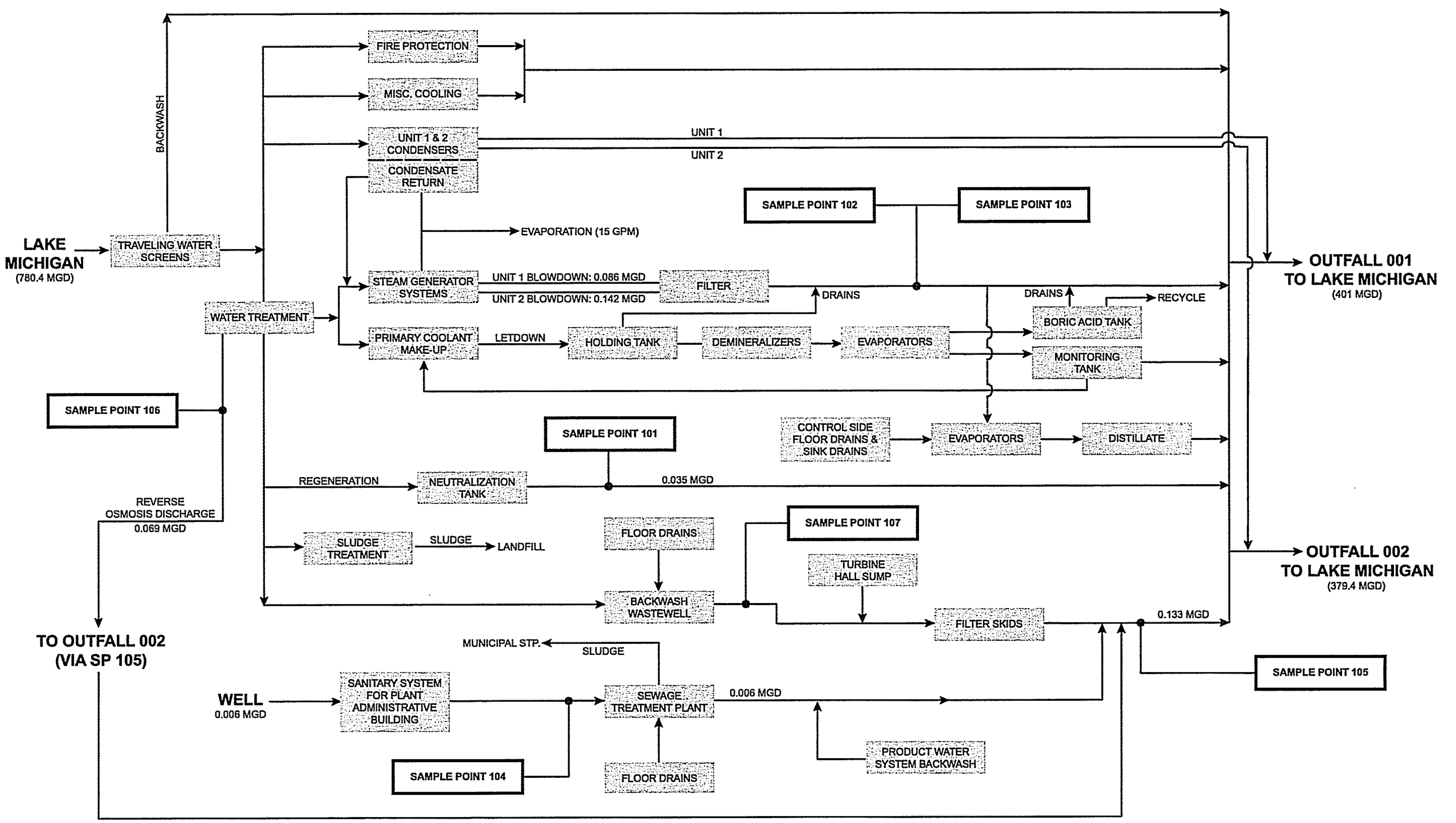
SITE LAYOUT MAP

POINT BEACH NUCLEAR POWER PLANT
6610 NUCLEAR ROAD
TWO RIVERS, WISCONSIN

FIGURE

3

Project: 11196 | Directory: | Filename: F3_Site Layout Map.ai | Created By: ERS | Date: 12/30/2008



NOTES:

1) FLOW DIAGRAM BASED ON INFORMATION PROVIDED BY FPL.

2) FLOWS ARE ESTIMATED BASED ON NOVEMBER 2007 TO OCTOBER 2008 DATA.

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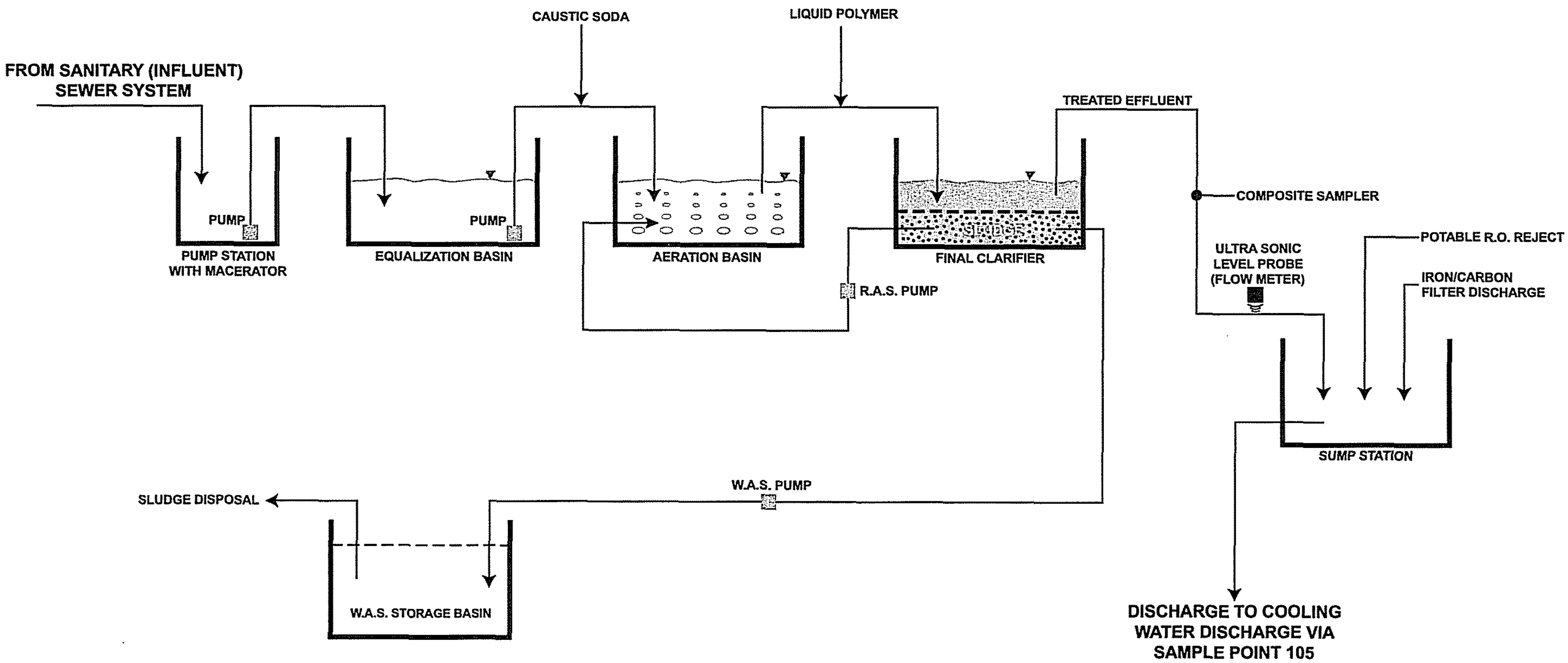
FLOW DIAGRAM - DECEMBER 2008

POINT BEACH NUCLEAR PLANT
6610 NUCLEAR ROAD
TWO RIVERS, WISCONSIN

FIGURE
4

Project: 11196 | Directory: GRAPHICS | Filename: 11196_flowdiagram.ai | Created By: ERO | Date: 12/24/2008



NOTES:

1) FLOW DIAGRAM BASED ON INFORMATION PROVIDED BY FPL.

2) DIAGRAM REVISED DECEMBER 2008.

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Single Source. Sound Solutions.

WASTEWATER FLOW DIAGRAM

POINT BEACH NUCLEAR PLANT
6610 NUCLEAR ROAD
TWO RIVERS, WISCONSIN

FIGURE **5**

ATTACHMENT 2

NEXTERA ENERGY POINT BEACH, LLC
POINT BEACH NUCLEAR PLANT, UNITS 1 AND 2

LICENSE AMENDMENT REQUEST 261
EXTENDED POWER UPRATE
RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

WPDES PERMIT RENEWAL APPLICATION
SUPPLEMENTAL DOCUMENTATION

212 pages follow

May 8, 2009

NPL 2009-0120
Wis. Stats 283.31

Paul Luebke, P.H.
Wastewater Specialist
Wisconsin Department of Natural Resources
101 South Webster Street - WT/3
Madison, WI 53703

NextEra Energy Point Beach, LLC
Point Beach Nuclear Plant, Units 1 and 2
WPDES Permit No. WI-0000957-07-1

WPDES Permit Renewal Application – Supplemental Documentation

References: (1) Application for Reissuance of Wisconsin Pollutant Discharge Elimination System (WPDES) Industrial Wastewater Discharge Permit, electronic submittal dated December 19, 2008

(2) FPL Energy Point Beach, LLC Letter Dated December 28, 2007, Cooling Water Intake Structures 283.31(6) Report

(3) FPL Energy Point Beach, LLC Letter Dated July 30, 2008, Notice of Planned Changes

On December 19, 2008, NextEra Energy Point Beach, LLC, (formerly FPL Energy Point Beach, LLC) submitted an application to the Wisconsin Department of Natural Resources (WDNR) to renew Point Beach Nuclear Plant (PBNP) Wisconsin Pollutant Discharge Elimination System (WPDES) Permit, WI-0000957-07-1 (Reference 1). The purpose of this letter is to provide supplemental information for the WPDES permit renewal application.

Enclosure 1 contains Amendment to Permit Renewal Application for WPDES Permit No. WI-0000957-07; Supplemental 283.31(6) Report. The enclosure is a revision of the report previously provided via Reference 2, and is submitted in response to concerns expressed by the WDNR during a May 13, 2008, meeting held at the Mishicot Field Office regarding the impingement of alewives by PBNP and the perceived "cost" associated with the impingement. The revised report presents a more detailed estimate and evaluation of wire screens at the PBNP intake, an economic evaluation of impinged alewives using EPA Guidance and a statement regarding the overall impact of the impingement of alewives at PBNP in the overall context of the Lake Michigan ecosystem.

Enclosure 2 contains "Point Beach Nuclear Plant – Evaluation of the Thermal Effects Due to a Planned Extended Power Uprate". This enclosure provides a description of the thermal impacts of the existing once-through cooling water discharge for PBNP and predicts, using modeling, the impact on the discharge temperature and various fish and shellfish populations following the planned extended power uprate (Reference 3).

Two copies of Enclosures 1 and 2 along with electronic diskettes are provided.

If you have any questions or need additional information, please contact Mr. Brian Vander Velde at 920/755-6987.

Very truly yours,

NextEra Energy Point Beach, LLC

Larry Meyer
Site Vice President

Enclosures

cc: David Gerdman, Wisconsin Department of Natural Resources

Supplemental §283.31(6) Report
Point Beach Nuclear Plant

WPDES Permit Number WI-0000957-07

FPL Energy Point Beach, LLC

6610 Nuclear Road
Two Rivers, WI 54241

Prepared by:

AKRF, Inc.

March 2009

TABLE OF CONTENTS

LIST OF ACRONYMS AND DEFINED TERMS

2009 Guidance	DNR issued additional guidance on February 10, 2009 on implementing
AEI	adverse environmental impact
ADS	acoustic deterrent system
BPJ	best professional judgment
BTA	best technology available
Company	FPL Energy Point Beach, LLC
Crib	intake crib
CWIS	cooling water intake structures
CWS	cooling water system
DNR	Wisconsin Department of Natural Resources
DNR Guidance	DNR guidance issued in November of 2007 in response to the suspension by the USEPA of the Phase II §316(b) Rule in March 2007
ERGS	Elm Road Generating Station
EPU	extended power uprate
FPL Energy	FPL Energy Point Beach, LLC
ft	feet
gpm	gallons per minute
Lake	Lake Michigan
MBTU/hr	Million British Thermal Units per hour
MGD	million gallons per day
NJDEP	New Jersey Department of Environmental Protection
O&M	operation and maintenance
OCPP	Oak Creek Power Plant
OTCW	once-through cooling water
PBNP	Point Beach Nuclear Plant
Phase II Rule	§316(b) regulations applicable to the design and operation of CWISs at existing steam electric generating stations that draw at least 50 million gallons per day of cooling water from waters of the United States
PWPP	Port Washington Power Plant
Riverkeeper II	Riverkeeper, *et al.* v. USEPA, 475 F.3d 83 (2d Cir. 2007)
VPP	Valley Power Plant
WPDES Permit	WPDES Permit No. WI-0000957-07-0
USEPA	United States Environmental Protection Agency
Wis. Stats.	Wisconsin Statutes

I. INTRODUCTION

FPL Energy Point Beach, LLC ("FPL Energy" or the "Company") owns and operates the Point Beach Nuclear Plant ("PBNP"). PBNP is located on the western shore of Lake Michigan ("Lake") near Two Rivers, Manitowoc County, Wisconsin. The Company operates PBNP pursuant to Wisconsin Pollutant Discharge Elimination System Permit No. WI-0000957-07-0 ("WPDES Permit") issued by the Wisconsin Department of Natural Resources ("DNR") (2004). The Company is submitting this amendment to its December 30, 2008 WPDES permit renewal application in response to DNR's preliminary comments to FPL Energy's §283.31(6) Report for PBNP (WEPCO and AKRF 2007).

A. Regulatory Background

In December 2007, the Company submitted a §283.31(6) Report for PBNP pursuant to the revised November 7, 2007 DNR guidance ("DNR Guidance") issued in response to the suspension (USEPA 2007a) by the United States Environmental Protection Agency ("USEPA") of the Phase II §316(b) Rule (USEPA 2004) in March 2007. The DNR Guidance (2007) addresses the collection of data and information to assess the impacts of cooling water intake structures ("CWIS") on the environment, as required under the Wisconsin Statutes ("Wis. Stats.") §283.31(6) as well as the analogous federal provision, §316(b) of the Federal Water Pollution Control Act of 1972 ("CWA").

The §283.31(6) Report tracked the requirements of the DNR Guidance. The §283.31(6) Report provided a description of the source water physical data, the CWIS and the cooling water system ("CWS"), the baseline biological characterization, and the CWIS technologies in place to minimize environmental impacts. The §283.31(6) Report also provided a preliminary assessment of potential alternatives for further reducing environmental impacts.

On May 9, 2008, David A. Gerdman of DNR sent comments in an email to Mr. Ron Hix of FPL Energy expressing DNR's preliminary comments regarding PBNP's §283.31(6) Report. DNR's preliminary comments focus on the impingement of alewife and its economic impact on the salmon fishery. DNR also raised questions about the potential for the thermal plume to affect impingement. Mr. Gerdman indicated that DNR was considering requiring FPL Energy to install 1.75-mm wedgewire screens to address:

> (1) significant damage to the local fish community [that] appears to be occurring from an economic perspective; and (2) much of the impingement seems to be due to the thermal plume being discharged at the outfalls and then withdrawn by the CWIS.

This Supplemental §283.31(6) Report addresses DNR's preliminary comments on the §283.31(6) Report, which focused on alewife impingement and its impact on the salmon fishery as well as the potential impact of PBNP's thermal plume on impingement. This supplemental report, including its appendices, provides additional information that supports the conclusions that: (1) the existing CWIS does not cause an adverse impact on the ecosystem of Lake Michigan; (2) 1.75-mm wedgewire screens have not been demonstrated to be an available technology for use at PBNP and; (3) that these screens could not be installed at PBNP at a reasonable cost.

B. USEPA's Regulatory Standards

In July 2004, USEPA promulgated final §316(b) regulations applicable to the design and operation of CWISs at existing steam electric generating stations that draw at least 50 million gallons per day of cooling water from waters of the United States ("Phase II Rule") (USEPA 2004).

In January 2007, the United States Court of Appeals for the Second Circuit decided Riverkeeper, *et al.* v. USEPA, 475 F.3d 83 (2d Cir. 2007) ("Riverkeeper II"), which found key aspects of the Phase II Rule inconsistent with the requirements of the Clean Water Act and remanded major portions of the rule to USEPA for reconsideration.[1] In response to the Riverkeeper II decision, USEPA suspended the Phase II Rule in March 2007 in its entirety and directed that, on an interim basis, §316(b)'s best technology available ("BTA") standard would be implemented based on best professional judgment ("BPJ") (USEPA 2007a). On July 9, 2007, USEPA issued a notice in the Federal Register formally confirming its prior notice of the Phase II Rule's suspension and again directed that permitting agencies make BTA determinations on the basis of best professional judgment (USEPA 2007b). USEPA specifically stated:

> As noted, the Second Circuit's decision found key provisions of the Phase II rule to be inconsistent with the Clean Water Act and remanded most of the rule to the Agency. As a result, under the decision, EPA is precluded from applying the rule unless and until it takes further action to address the decision.[2]

DNR regulates CWISs through the provisions of Wis. Stat. §283.31(6), which provide:

> Any permit issued by the department under this chapter which by its terms limits the discharge of one or more pollutants into the waters of the state may require that the location, design, construction and capacity of water intake structures reflect the best technology available for minimizing adverse environmental impact.

In suspending the Phase II Rule, USEPA (2007a, 2007b) directed that §316(b) determinations be made on a case-by-case basis using BPJ. USEPA's initial §316(b) regulations adopted a case-by-case approach for regulating CWISs under §316(b). Although these

[1] On November 2, 2007 a number of interested parties filed petitions with the Supreme Court of the United States asking the Court to review Riverkeeper II. The Court heard arguments on the role of cost-benefit analysis on December 2, 2008. A decision is expected over the next several months.

[2] USEPA 2007b, 72 Fed. Reg. at 37108, column 3.

regulations were overturned in 1977, USEPA continued to implement §316(b) on a BPJ BTA basis, following various guidance documents (USEPA 1975, 1976, and 1977a), until the Phase II Rule was promulgated in 2004. As noted above, USEPA has again directed delegated states to apply this guidance in regulating CWISs.

In summary, this guidance directs permit writers to assess the effects of the CWIS, determine if those effects are causing an adverse environmental impact ("AEI"), and then if there is an AEI, to identify the technologies that can be successfully installed and operated at a cost that is not wholly disproportionate to the value of the benefits.

1. AEI

USEPA provided guidance as to the meaning of AEI. USEPA's 1975 guidance stated:

> Adverse environmental impacts occur when the ecological function of the organism(s) of concern is impaired or reduced to a level which precludes maintenance of existing populations; a reduction in optimum sustained yield to sport and/or commercial fisheries results; threatened or endangered species of aquatic life are directly or indirectly involved; the magnitude of the existing or proposed damage constitutes an unmitigable loss to the aquatic system.

USEPA's (1976) Development Document also followed a community or population-level focus for AEI determinations. However, USEPA recognized that it was not practical to require an assessment of all species. USEPA (1977a) authorized the use of representative important species ("RIS"). Under the RIS approach, the evaluation of AEI should focus on a small number of species that are both representative of other species in a waterbody and important in that they have special human use or ecological value. Pursuant to USEPA's (1977a) guidance, certain species would be selected as representative of various categories of species evaluated.

USEPA (1977a) indicated that the magnitude of an AEI to biota should also be estimated both in terms of short-term and long-term impact. Finally, USEPA (1977a) indicated that an impact assessment should be performed. This assessment could include biostatistical analyses of data or an evaluation of community response parameters, such as changes in structure.[3]

USEPA (1976) also made it clear that AEI was not limited to impacts to RIS. Terrestrial impacts, air emissions, aesthetics, noise, consumptive water use, and loss of habitat were specifically identified as factors that should be considered in assessing AEI for a BPJ determination under §316(b).

[3] Community is defined as the populations of all species in a given area or volume.

2. Determination of BTA

USEPA's guidance documents also address an approach for assessing technologies, which includes a consideration of costs. USEPA (1976) recommended determining whether less intrusive and less costly technologies would sufficiently minimize AEI before more intrusive and costly technologies, including retrofitting to closed-cycle cooling, would be required and interpreted BTA to mean "best technology commercially available at an economically practicable cost."

3. Judicial and Administrative Precedent

Using the factors identified in the guidance documents, USEPA and state permitting agencies have made BPJ BTA determinations for minimizing AEI at a wide variety of power plants. USEPA Regional Administrators and state agencies, including DNR, have made BPJ BTA decisions over the years using this guidance. DNR can look to these as guidance in making this BPJ BTA determination.

Administrative and judicial decisions relating to Seabrook Nuclear Station were decided relatively soon after §316(b) was enacted. In connection with determining AEI, USEPA made clear that population-level impact was the relevant standard, and that large entrainment losses of individual organisms causing relatively localized effects were not an adequate basis for requiring costly retrofits, especially given the operation of compensatory mechanisms in fish populations.[4]

In another early contested permit proceeding, USEPA (1977b) found the Pilgrim Generating Station's existing once-through cooling water ("OTCW") to be BTA and declined to require any modifications to the intake. Pilgrim Unit 1 had been operating and Unit 2 was under construction when USEPA Region 1 made its initial BTA determination for both units. USEPA's decision was based on determinations by the Pilgrim Technical Advisory Committee that the intake was not adversely impacting populations of RIS, even though it was causing substantial losses of individual organisms.

In its 1988 Crystal River Power Plant determination, USEPA (1988) stressed that the relevant adverse impact consideration was an impact at the community level and not at the individual organism level. In its BTA determination, USEPA found that fine-mesh screens were not BTA at Crystal River because they would not be technically feasible.

In both 1994 and 2001, the New Jersey Department of Environmental Protection ("NJDEP"), reached its proposed BTA determination and renewed the permit for Salem Generating Station. NJDEP determined that the existing CWIS, in conjunction with screen modifications, improved fish bucket design, a cooling water intake flow limitation and a sound

[4]Density-dependent processes such as growth, survival, reproduction, and movement are compensatory if their rates change in response to variation in population density (or numbers) such that they result in a slowed population growth rate at high densities and promote a numerical increase of the population at low densities. Compensatory density dependence is important to fisheries management because it operates to offset the losses of individuals. Rose *et al.* 2001.

deterrent feasibility study satisfied the BTA requirement for minimizing AEI (NJDEP 1993, 1994, 2000, 2001).

DNR issued BPJ BTA determinations for several power plants throughout Wisconsin including Port Washington Power Plant ("PWPP"), Valley Power Plant ("VPP"), PBNP, and Oak Creek Power Plant ("OCPP"). On July 12, 1977, DNR determined that the location and operation of the CWIS at PWPP would have minimal AEI and therefore no modifications to the CWIS would be required. For VPP, DNR determined, on September 23, 1977, that the location and operation of the CWIS under present water quality conditions would have minimal AEI and therefore no modifications to the CWIS would be required. A similar determination was made for PBNP on February 8, 1978 due to what were deemed to be insignificant total entrainment and impingement losses. In May 2008, DNR (2008a) issued a Draft Permit for a major modification to the OCPP and Elm Road Generating Station ("ERGS") WPDES Permit. In the Fact Sheet for the Draft Permit, DNR explained its rationale for proposing its BPJ BTA determination applicable to the OCPP units; DNR relied upon USEPA's (2007b) guidance after the suspension of the Phase II Rule, as described in this Section I.B. DNR also proposed a BTA determination applicable to the ERGS units based on the Alternative Requirements provisions of the USEPA Phase I Rule. In July 2008, DNR issued a final major modification to the WPDES Permit for OCPP and ERGS consistent with the Draft Permit (DNR 2008b).

C. DNR's Recent Regulatory Guidance

While AKRF was in the process of finalizing this supplemental report, DNR (2009) issued additional guidance on February 2, 2009 on implementing §316(b) and §283.31(6) based on BPJ ("2009 Guidance"). This 2009 Guidance references USEPA's direction upon the suspension of the Phase II Rule discussed above, USEPA's general guidance on making BPJ determinations at 40 CFR §125.3 and DNR's 2007 guidance on the information required to be submitted in lieu of a CDS under the Phase II Rule.

The 2009 Guidance recognizes that different regulatory approaches are appropriate for new and existing facilities, noting on page 4 of the 2009 Guidance that for existing plants, DNR staff:

> will need to determine when the intake was installed, whether the intake technologies chosen where appropriate at the time of construction, and whether those technologies continue to minimize adverse environmental impact (impingement/entrainment) at the current location.

In addition, with respect to existing facilities, the 2009 Guidance states that under a BPJ analysis, DNR will have to evaluate site-specific information for the facility. DNR (2009) goes on to note that decisions for some facilities may be clear-cut while others may be complex. FPL Energy believes that the information presented below is adequate to allow DNR to respond to DNR's preliminary comments on the §283.31(6) Report and to support a BPJ determination that the existing CWIS is BTA. Therefore, this supplemental report addresses both DNR's comments and DNR's 2009 Guidance, following USEPA's §316(b) guidance and state and federal administrative decisions, discussed above in Section I.B.

D. Description of PBNP's Cooling System

PBNP's CWIS includes an intake crib ("Crib"), an acoustic deterrent system ("ADS"), an intake pipe, conventional traveling screens, a fish and debris return system, and pumps.[5] The Crib is located 1,750 feet ("ft") offshore of Lake Michigan in approximately 22 ft of water and covered with bar grating to prevent debris and large fish from entering the intake system.

Water flows from the Crib to the pumphouse through two 14-ft diameter pipes buried beneath the Lake bed. The OTCW then passes through vertical bar racks in the forebay and eight traveling screens at the pumphouse. The traveling screens use an 80 pounds per square inch screen wash to collect small debris and trapped fish into filter baskets. The fish and debris are removed and disposed of at an appropriate off-site location, consistent with the requirements of PBNP's WPDES permit.

PBNP Units 1 and 2 are designed to operate continuously as base-load electrical generating units. PBNP currently withdraws cooling water at a peak rate of about 489.6 million gallons per day ("MGD") (40,000 gallons per minute ["gpm"]) per unit (combined total of 979.2 MGD [680,000 gpm]). The vast majority of water withdrawn via the CWIS is used in the CWS. Cooling water withdrawn by the CWIS is also used to cool nuclear-safety related systems. The OTCW system discharges the non-contact OTCW to Lake Michigan via its own outfall approximately 200 ft from the shoreline. During the winter months, normally mid-December through March, the circulating water flow rate is reduced. Two pumps (one pump per unit) are used to provide a flow rate of 619.2 MGD (430,000 gpm) as compared to the 979.2 MGD during other seasons. In addition, a portion of the OTCW discharge is recirculated to prevent frazil ice from forming at the offshore Crib. The deicing operation during cold weather months is performed by throttling the discharge valve between the seal well and the discharge flume, which allows a maximum of 288 MGD (200,000 gpm) from one of the units to be recirculated to the Crib through one of the two intake pipes.

Prior to 2001, the CWIS's offshore Crib emerged from the water with a top elevation of 8 ft above standard water level. Cooling water was withdrawn from the entire water column through the diameter of the emergent Crib. The Crib design was re-evaluated due to episodes of cormorant and alewife impingement. Since the top of the CWIS rock Crib was originally designed to rise above lake surface level, emerging from the water, cormorants would occasionally fall into the center of the rock enclosure and be drawn into the Station's pumphouse. Also, large number of alewives would be attracted to the area, resulting in significant impingement events, when PBNP's thermal plume, which floats on the lake surface, would be present in the area of the emergent Crib. To address both issues, the emergent Crib was cut down so that it is approximately 8 ft from the lake bottom.

The CWIS has also been outfitted with a high frequency ADS in order to reduce alewife impingement. The deterrence system is deployed only during the warmer months (May to October) in order to prevent ice damage to the electronic equipment. This deployment corresponds to the period during which the vast majority of alewife impingement has historically

[5] Engineering drawings and other supporting information has been provided to DNR in the 2007 §283.31(6) Report (WEPCO and AKRF 2007).

occurred. The sound frequency has been shown to be very effective at deterring alewife at other facilities including a power plant on Lake Ontario that has a similar offshore intake structure.

1. Planned Extended Power Uprate (EPU) Operation

FPL Energy is in the process of applying to the United States Nuclear Regulatory Commission for an increase in the Plant's maximum power rate, or an extended power uprate ("EPU"). The Plant currently discharges up to 680,000 gpm of water with a maximum temperature increase of 20.7°F and a maximum heat load of 7,048 Million British Thermal Units per hour ("MBTU/hr") (EA 2008). The Company has notified DNR of its EPU application. The EPU is expected to increase the existing plant output by approximately 17% to 8,273 MBTU/hr. The EPU does not include any changes to the CWS pumping capacity.

II. THE EXISTING CWIS DOES NOT CAUSE AN ADVERSE IMPACT ON THE ECOSYSTEM OF LAKE MICHIGAN

As presented in the sections below, the PBNP CWIS is not causing an adverse impact to the ecosystem of Lake Michigan. FPL Energy has sponsored multiple studies to quantify the impingement at PBNP. Fisheries biologists at AKRF have translated these losses into commercially and recreationally valuable species. Finally, Dr. James Kitchell, a professor at the University of Wisconsin, has evaluated these losses in the context of the larger ecosystem of Lake Michigan and determined that the impacts of PBNPs CWIS are, at most, minimal.

A. PBNP Impingement of Alewife

As DNR is aware, studies to estimate impingement at PBNP have been conducted and the results of those studies have been analyzed. Reports have been submitted to DNR. The summaries that follow focus on alewife impingement, the focus of DNR's comments and this supplemental Report.

1. 1975-1976 Study Summary

Studies were conducted from March 1975 through February 1976 to evaluate the impacts of the CWIS (WEPCO 1976). In 1975-1976, during 88 impingement sampling events, 265,644 alewife were collected, which represented 84.8% of the total number of fish collected. The biomass of the alewife collected was 17,892 pounds, which represented 94.1% of the total biomass of the fish collected. After reviewing the WEPCO report, DNR concluded that the location and operation of the intake structure had minimal environmental impact and no modifications to the intake structure were required (EA 2008).

2. 2005-2006 Study Summary

Studies were conducted from December 7-8, 2005 through November 29-30, 2006 to evaluate the impact of the CWIS (EA 2007). In 2005-2006 during 80 impingement sampling events, 1,595,015 alewife were collected, which represented 99.1% of the total number of fish collected. The biomass of the alewife collected was 12,572 pounds, which represented 93% of the total biomass of the fish collected. Ninety-one percent of the alewives collected were 60-109 mm in length. An estimated 8.624 million alewife weighing 66,687 pounds were impinged, based on using the actual plant flows during the study period.

The lower biomass of the alewife collected in the impingement samples in 2005-2006 compared to 1975-1976 appears to be consistent with the lake-wide USGS trawl data (Bunnell *et al.* 2007) and data from other sources (Lyons *et al.* 2000) which shows alewife biomass in Lake Michigan has decreased roughly three-fold compared to the early 1970s (EA 2008).

B. Effect of PBNP Impingement on Commercially and Recreationally Important Species

Consistent with USEPA's guidance, AKRF has translated the alewife impinged at PBNP into commercial and recreationally important species, as summarized below and described more fully in Appendix A. This analysis supported both the ecosystem level analysis conducted by

Dr. Kitchell which is fully described in Appendix B and summarized in Section II.C and the economic analysis conducted by NERA which is fully described in Appendix C and summarized in Section III.

In order to assess the effects of alewife impingement at PBNP on the commercial and recreational fishery in the Lakes, AKRF estimated the loss of biomass (Appendix A). Estimates of potential lost fishery yield due to alewife impingement at PBNP were calculated using impingement data collected at PBNP from 4 December 2005 through 2 December 2006 (EA 2007). The method of estimation had three steps: 1) estimation of annual lost production (biomass) by alewife due to impingement at PBNP, 2) estimation of the corresponding total lost yield (in pounds) to the Lake Michigan fisheries, and 3) allocation of that total lost yield to the commercial and sport fisheries.

Annual impingement of alewife at PBNP has the potential to reduce the annual sport fishery harvest by 1,159 salmonids, and to reduce the annual commercial fishery harvest by 241 pounds. These losses represent extremely small fractions of the populations of these recreationally and commercially important fish and will not cause an adverse impact to the ecosystem of Lake Michigan or a significant decline in the number of salmonids available for commercial and sport fisheries.

C. Ecosystem Level Assessment

As presented in Appendix B, Dr. Kitchell states that the Lake Michigan ecosystem is a highly managed system, heavily impacted by invasive and introduced species. Non-native species, such as Chinook salmon (*Oncorhynchus tshawytscha*), rainbow trout (*Oncorhynchus mykiss*), and alewife (*Alosà pseudoharengus*), dominate the top and middle trophic levels. Invasive species, such as zebra mussels (*Dreissena polymorpha*) and quagga mussels (*Dreissena bugensis*), dominate the lower levels of the food web. As development of mussel beds continue to extend and new invasive species appear and gain a foothold in the Lake, Dr. Kitchell predicts that changes to the ecosystem and fisheries will continue in ways not yet known.

Dr. Kitchell's report further explains that the observed changes in Lake Michigan fisheries are primarily due to ecological interactions and stocking policies and that power plant effects are minor, at most. He believes that ecological interactions and their outcomes are the dominant control of fish population dynamics. That is especially true for alewife. Both salmon and alewife are broadly distributed and highly migratory, which require assessing their interactions and ecological effects at the ecosystem scale. Dr. Kitchell believes that local mortality effects, such as those related to a power plant, are very small parts of a much bigger picture. They are relatively inconsequential given the lake-wide fishery management policies, compensatory responses by fishes, and the continuing ecological changes wrought by invasive species. Dr. Kitchell concurs with the earlier findings of Spigarelli *et al.* (1981) that on a lake-wide scale, the cumulative effects of all Lake Michigan power plants are a very small part of the bigger picture.

Evidence and arguments presented by Dr. Kitchell (Appendix B) portray a positive and alternative interpretation of the ecological effects of power plant plumes that have not yet been tested. Regardless of the outcome of any studies to test his hypothesis, Dr. Kitchell concludes that the plume habitat and its analogous river mouth habitats represent a very small fraction (<1%) of total nearshore habitat area (Höök *et al.* 2008). Therefore, any increase in impingement due to thermal attraction would have an inconsequential impact on the alewife population in the lake.

III. 1.75-MM SCREENS HAVE NOT BEEN DEMONSTRATED TO BE AN AVAILABLE TECHNOLOGY AND CANNOT BE INSTALLED AT A REASONABLE COST

1.75-mm wedgewire screens have been identified as the proposed BTA for PBNP both by USEPA (2004) and DNR (2008b). However, the use of 1.75-mm wedgewire screens has not been demonstrated to be an available technology for a CWIS on Lake Michigan. Wedgewire screens are installed at two large power plants in the Great Lakes: James H. Campbell Power Plant (WEPCO and AKRF 2006) and Oak Creek Power Plant/Elm Road Generating Station (DNR 2005, 2008b). Both of these facilities employ 9.5-mm screens as opposed to 1.75-mm screens, which were deemed unsuitable at these locations. Prior to committing to the installation of 1.75-mm wedgewire screens at PBNP, FPL Energy would require extensive pilot testing under a wide variety of conditions to ensure that the CWIS would not experience unplanned outages due to clogging or icing so that the 1.75-mm screens would meet the operational requirements of PBNP.

The CWIS at PBNP supplies cooling water not just to the condensers, but to the nuclear-safety related system as well. If the potential for clogging of 1.75-mm wedgewire screens can not be resolved successfully then this technology would not be deemed an available technology for use at PBNP. Alden (2007) identifies other potential concerns which are discussed below.

Approach velocities to the screens would be equal to the ambient lake currents. The design *through-screen* velocity for wedgewire screens would be 0.5 ft/sec with clean screens. Head losses through the screens should not exceed 1.0 ft (assuming biofouling is not a substantial problem). Due to recent low water levels in the lake, this 1.0 ft of additional head loss might result in cavitation of the pumps. This concern would need to be evaluated thoroughly if wedgewire screens were to be considered further at PBNP (Alden 2007).

Deicing of the screens during the winter would also need to be evaluated in more detail. It may be that the existing warm water recirculation could be extended to deice the screens. However, before these wedgewire screens could be deemed available for use at PBNP, an assessment of the ability to deice a large array of fine mesh wedgewire screens would be required, including an evaluation of the amount of heat recirculation that would be sufficient for this purpose. Use of an on-shore back-up intake also might be required to ensure that interruption of the cooling water supply does not occur. As the specific requirements for ice prevention are not known at this time, the cost for warm water or electrical deicing has not been included in the costs (Alden 2007).

Dr. Kitchell (Appendix B) noted increases in *Cladophora* loadings in the Lake. As mussel beds improve water clarity in Lake Michigan, growth of this filamentous green algae is promoted. Decomposing *Cladophora* poses a potential clogging risk to the screens. Alden (2007) assumed that the screens could be maintained with periodic manual cleanings by divers; and, therefore, did not include costs for an automatic cleaning system would be required prior to implementation of wedgewire screens. A more detailed assessment of *Cladophora* loadings and the need for an air burst or other (e.g., brushes) cleaning system would have to be assessed during the pilot study. Neither capital nor operation and maintenance ("O&M") costs for a mechanical cleaning system are included in the cost estimates used in this report.

A. Costs Far Exceed the Economic Value of the Impinged Alewife

As presented in Appendix C, NERA analyzed the costs and benefits of installing 1.75-mm wedgewire screens to reduce impingement of alewife at PBNP. NERA utilizes standard economic methods, and converts the biological estimates developed by AKRF (Appendix A) into monetized social costs and benefits.

1. Cost of Wedgewire Screens

NERA determined that the net present value of the cost of installing and operating (in 2006 dollars) 1.75-mm wedgewire screens is about $43 million and that the equivalent annualized value is about $4.1 million. They developed these costs based on a methodology that measures costs to society as a whole. This methodology is consistent with USEPA guidelines. NERA considered costs associated with installing and maintaining wedgewire screens, including any studies required prior to construction, up-front capital costs to design and build the screens and supporting structures, the cost of providing replacement power if PBNP were required to be offline for construction/installation, and O&M costs. NERA did not consider the costs associated with a deicing system or with an air burst or other mechanical cleaning system. NERA also did not include all societal costs (*e.g.*, costs associated with increases in carbon dioxide and fine particulates emissions).

2. Economic Value of Impinged Alewife

There is no commercial or recreational fishery for alewife. Alewife is, however, a forage fish for various predator species, including various types of salmon and trout. Following USEPA's guidance on §316(b) (USEPA 2000) and the Office of Management and Budget's guidance on cost-benefit analysis (OMB 2003), NERA evaluated the economic impact of alewife impingement at PBNP on Lake Michigan's recreational fishery for trout and salmon. NERA conservatively used the estimate from Appendix A that the impact of alewife impingement on predator species is about 18,640 pounds per year. This estimate is conservative because it assumes that: (1) all impinged alewife would have been consumed by predator fish with high economic value; and (2) all of these predator fish would have been caught by recreational fisherman.

NERA estimated that the annualized benefits achieved by installing wedgewire screens at PBNP under their base case assumptions would be $63,000. Expressed as present value over 20 years at 7%, this benefit is $671,000. There are a variety of values that NERA could have selected from the literature to represent the marginal value of fish caught recreationally. If they had selected different values, the annualized benefit could have fallen within the range of $14,600 to $135,000. This range, expressed as present value, is $155,000 to $1,400,000.

a. Comparison

NERA compared estimated costs of 1.75-mm wedgewire screens and benefits achieved by their implementation on both a present-value and an annualized-value basis. As discussed in Section IV.A of Appendix C, they found that the costs ($42,953,000 present value) are roughly 60 times as great as the value of the benefits ($671,000 present value), resulting in large positive net costs on both present-value and amortized-value bases. As noted above, NERA's estimate of costs may be conservative because it did not include the capital and O&M costs for a cleaning system for the screens. NERA noted in their report that while there were omitted categories of benefits in their analysis, they were believed to unlikely be significant relative to the large gap between quantified costs and benefits. They further noted that there were a number of conservative assumptions that were likely to overstate the actual benefits quantified.

b. Sensitivity Analysis

Given the considerable uncertainty in the estimates of many components of NERA's analysis, NERA conducted an analysis to test the sensitivity of the results to alternative assumptions. The results of this analysis reinforced their basic conclusion that the cost of requiring screens would far exceed the benefits.

IV. CONCLUSIONS

The CWIS at PBNP, as designed and currently implemented, represents BTA. FPL Energy has demonstrated that the loss of alewife to impingement at PBNP is not having a significant impact on the ecology of Lake Michigan or on commercial or recreational fisheries in the Lake. 1.75 mm wedgewire screens have not been demonstrated to be an available technology for use at Lake Michigan. Moreover, the costs, which exceed the value of the benefits by a factor of 60, are clearly wholly disproportionate. As the information in this summary report and its attachments demonstrates, FPL Energy has met its burden under Wisconsin Statute §283.31(6) and §316(b) USEPA's guidance.

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Supplement to §283.31(6) Report
WPDES Permit Number WI-0000957-07

APPENDIX A

ESTIMATES OF POTENTIAL LOST FISHERY YIELD DUE TO IMPINGEMENT OF ALEWIFE AT POINT BEACH NUCLEAR POWER PLANT

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SUMMARY AND APPROACH

Annual impingement of alewife at Point Beach Nuclear Plant ("PBNP") has the potential to reduce the annual sport fishery harvest by 1,159 salmonids, and to reduce the annual commercial fishery harvest by 241 pounds.

Estimates of potential lost fishery yield due to alewife impingement at PBNP were calculated using impingement data collected at PBNP from 4 December 2005 through 2 December 2006 (EA 2007). The method of estimation had three steps: 1) estimation of annual lost production (biomass) by alewife due to impingement at PBNP, 2) estimation of the corresponding total lost yield (in pounds) to the Lake Michigan fisheries, and 3) allocation of that total lost yield to the commercial and sport fisheries.

A. PRODUCTION LOST DUE TO ALEWIFE IMPINGEMENT

The annual production of alewife biomass lost due to impingement at PBNP was estimated to be 84,630 kg (186,410 pounds). Total production lost due to alewife impingement was estimated as the sum of the alewife biomass impinged and the lifetime production foregone for alewife beginning at the age at which they were impinged. The biomass of alewife (alewife plus alewife type) impinged in 2006 was reported to be 30,268 kg (from Table 4-5, EA 2007)

Production foregone of impinged alewife was estimated to be 54,362 kg, based on the following formulation (Rago 1984, USEPA 2006):

$$PF = N\sum_{s=0}^{6}\left(\prod_{i=1}^{s-1} e^{-z_i}\right)\frac{G_s \times W_s \times \left(e^{G_s - Z_s} - 1\right)}{G_s - Z_s} \quad ,$$

where the summation is over all lifestages, s, beginning with the juvenile stage (s=0) and

N = number of alewife impinged

PF = lifetime production foregone for alewife from the date of impingement

G_s = instantaneous rate of increase in weight for lifestage s alewife

W_s = weight of alewife at the beginning of lifestage, s

Z_s = instantaneous rate of mortality for lifestage s alewife

The reported number of alewife (alewife plus alewife type) impinged, N, in 2006 was 8,630,719 (Table 4-5, EA 2007). Estimates of the instantaneous mortality rates, Z_s, were from USEPA (2006).

Estimates of growth rates were derived from average, lifestage-specific weight estimates, $\overline{W}_s$, from USEPA (2006):

$$G_s = \ln\left(\frac{\frac{(\overline{W}_{s+1} + \overline{W}_s)}{2}}{\frac{(\overline{W}_s + \overline{W}_{s-1})}{2}}\right)$$

For the juvenile lifestage, the instantaneous rates and initial weight were adjusted to reflect only the period from the date of impingement to age 1. The date of impingement, expressed in terms of the fraction of the juvenile lifestage duration (t^*), was estimated from the average weight of impinged alewife, W_0^*:

$$t^* = \frac{\ln\left(\frac{W_0^*}{W_0}\right)}{G_0}$$

The reported average weight per alewife impinged, W_0^*, was 3.51 gm (from Table 4-5, EA 2007). The mortality rate from the date of impingement to age 1 was estimated as:

$$Z_0^* = (1 - t^*)Z_0$$

B. FISHERY YIELD LOST

The estimated annual lost yield to the Lake Michigan fisheries is 10,625 pounds. This estimate was based on: 1) the estimate of alewife production lost due to impingement, 2) trophic conversion efficiency from alewife to piscivores, and 3) the fraction of the resulting production of piscivores that would be harvested.

The trophic efficiency from alewife to piscivore was assumed to be 10% (USEPA 2006, Pauly and Christensen 1995, Jennings and Mackison, 2003; and Jennings *et al.* 2002). Therefore, the total lost piscivore production was estimated to be 8,463 kg (0.10 x 84,630 kg) (18,658 pounds).

The approach for translating total annual piscivore production lost due to alewife impingement into lost fishery yield was based on the Great Lakes Fisheries Commission ("GLFC") method for defining sustainable harvest levels for salmonids in Lake Michigan. Sustainable harvest levels of salmonids from Lake Michigan (GLFC 2007) were defined in a GLFC special publication, titled "Fish-Community Objectives for Lake Michigan (Eshenroder *et al.* 1995). Eshenroder et al computed upper bounds for fishery yields of salmonids in Lake Michigan based on: 1) an estimate of annual production by large piscivores (from Sprules et al. 1991, and Leach et al. 1987), and 2) an estimate of the optimal fishing mortality rate (from Leach et al. 1987 and Deriso 1987).

Using the methods described by Deriso (1987), Leach et al (1987) estimated that the optimum sustained yield of large harvestable fish in Lake Michigan would be 57% of their annual production. Assuming that all lost alewife production affected only large harvestable piscivores and using the optimal exploitation rate from Leach et al, the estimated annual lost fishery yield is 4,824 kg (0.57 x 8,463 kg), or 10,625 pounds. The reported total Lake Michigan harvest of large piscivores (i.e., chinook salmon, coho salmon, lake trout, brown trout, brook trout, rainbow trout, walleye, burbot, and pike[1]) was 10,029,961 pounds (GLFC 2007). All other species reported harvested were non-piscivores and therefore would not be directly affected by the loss of alewife as forage.

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[1] Reported as pike and panfish.

C. SPORT AND COMMERCIAL YIELD LOST

The estimated lost yield to the commercial fishery is 241 pounds, and the estimated lost yield to the sport fishery is 10,385 pounds (Table 1). The total lost fishery yield was allocated to individual species and to the sport and commercial fishery based on the 2006 reported harvest (GLFC 2007) by species and fishery (Table 2).

For lost yield to the sport fishery, pounds of lost yield were translated into numbers of fish based on reported average weight per fish (Table 3), by species, harvested by the Wisconsin sport fishery in Lake Michigan in 2006 (Peterson and Eggold 2008). An average weight per fish harvested by the Wisconsin sport fishery was reported for the five dominant salmonid species (i.e., chinook salmon, coho salmon, lake trout, brown trout and rainbow trout) which accounted for 10,192 pounds of lost yield. The estimated annual lost yield to the sport fishery for the five dominant salmonid species is 1,138 fish (Table 1).

An average weight per fish was not reported for brook trout, walleye, burbot and pike. Collectively these species had an estimated annual lost yield to the sport fishery of 193 pounds. Assuming the same average weight per harvested fish for these species as for the five dominant salmonids (i.e., 9.39 lbs per fish), an additional 21 fish would have been lost to the sport fishery. In this case, the total annual lost yield to the sport fishery would be 1,159 fish.

Table 1. Estimated lost yield by species and fishery.

Species	Commercial Fishery	Sport Fishery	
	(lbs)	(lbs)	(numbers)
chinook salmon	4	8,742	853
coho salmon	0	520	138
lake trout	221	197	37
brook trout	0	0	
brown trout	0	176	28
rainbow trout	0	556	82
walleye	2	112	
burbot	14	18	
pike and panfish	0	63	
total	241	10,385	1,138

Table 2. Reported 2006 Lake Michigan fish harvest (GLFC 2007).

Species	Commercial fishery		Sport fishery	
	(lbs)	(%)	(lbs)	(%)
chinook salmon	3,774	0.04%	8,443,200	82.27%
coho salmon	7	0.00%	502,070	4.89%
lake trout	213,070	2.08%	190,610	1.86%
brook trout	0	0.00%	51	0.00%
brown trout	0	0.00%	170,320	1.66%
rainbow trout	0	0.00%	537,120	5.23%
walleye	2,385	0.02%	108,360	1.06%
burbot	13,316	0.13%	17,000	0.17%
pike and panfish	0	0.00%	61,230	0.60%
total	232,552	2.27%	10,029,961	97.74%

Table 3. Reported average weight per fish harvested in the 2006 Lake Michigan sport fishery in Wisconsin (Peterson and Eggold, 2008).

Species	Average weight per fish (lbs)
chinook salmon	10.25
coho salmon	3.76
lake trout	5.36
brown trout	6.31
rainbow trout	6.79

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Supplement to §283.31(6) Report
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APPENDIX B

ASSESSMENT OF ALEWIFE IMPINGEMENT IMPACT AT POINT BEACH NUCLEAR PLANT (PBNP) ON LAKE MICHIGAN FISHERIES

Prepared by

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March 2009

ASSESSMENT OF ALEWIFE IMPINGEMENT IMPACT AT POINT BEACH NUCLEAR PLANT (PBNP) ON LAKE MICHIGAN FISHERIES

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I. INTRODUCTION

This document provides an assessment of impacts to alewife related to operation of the offshore cooling water intake structure at Point Beach Nuclear Plant (PBNP). PBNP is located on the western shore of Lake Michigan at Two Rivers, Manitowoc County, Wisconsin, which is owned and operated by FPL. PBNP consists of two nuclear powered steam electric generating units. The current peak cooling water flow rate is about 489.6 million gallons per day (340,000 gallons per minute) through each condenser, and is 979.2 million gallons per day (680,000 gallons per minute) through both condensers, combined. The cooling water is withdrawn from, and discharged back to, Lake Michigan. The intake, which has been modified over the years, is located 1,750 feet from the shoreline at approximately the 22-foot depth contour. The discharge outfall is located approximately 200 feet from the shoreline southwest of the intake. During the winter, the cooling water discharge from one of the units can be discharged via a deicing line to the offshore intake to prevent the formation of frazil ice.

The Wisconsin Department of Natural Resources (DNR) has conducted an initial review of the PBNP §283.21(6) Report submitted in 2007 (WEPCO and AKRF 2007). DNR (2008) raised some issues regarding the intake's effect on the aquatic resources of Lake Michigan and indicated that DNR was considering requiring that FPL install wedgewire screens to address:

(1) Significant damage to the local fish community [that] appears to be occurring from an economic perspective; and

(2) Much of the impingement seems to be due to the thermal plume being discharged at the outfalls and then withdrawn by the CWIS.

This assessment responds to the issues DNR raised by placing the losses due to the intake at PBNP into the context of the Lake Michigan ecosystem, how this ecosystem has changed, and how it is likely to continue changing due a myriad of effects.

This assessment, consistent with DNR's comments, focuses on the impacts of alewife impingement at PBNP on the Lake Michigan fisheries. I consider both the impingement estimates developed by EA Engineering, Science, and Technology, Inc. (EA 2007) (WEPCO and AKRF 2007) and the analysis conducted by AKRF presented in Appendix A to AKRF's 2009 Supplemental §283.31(6) Report. This assessment also considers the potential for the thermal plume to impact alewife impingement, based on knowledge of the Lake Michigan fisheries and EA's recent biothermal assessment (EA 2008).

II. LAKE MICHIGAN ECOLOGY

A. Historical Perspective

Rapid influx of European immigrants brought major ecological changes to the Laurentian Great Lakes. Implements of change included the axe, the plow, the hook, and the net. As the region's forests were harvested to grow midwestern cities, the plow was put to native soils. Erosion, municipal sewage, and industrial waste loads were sent downstream. Those changed many rivers, streams, and nearshore habitats of lakes into inhospitable places for a diversity of native aquatic species. Eventually, these provoked institutional responses aimed at preventing and reversing both cultural eutrophication and the effects of toxic compounds.

The hook and the net also played important roles. Although Native Americans fished these waters for millennia (Bogue 2000), engine-powered boats, metal hooks, and nets made of synthetic fiber spread across the region during the early 20th century, providing much more efficient ways to fish. Native fish populations soon felt the effects of growing commercial fisheries that fueled the local economies for hundreds of coastal towns.

The primary target of commercial fisheries was the lake trout. In a food web context, it was the apex predator. Its major prey included several species of sculpins (*Cottidae* spp.) and a diverse assemblage of cisco species (*Coregonus* spp.). Many of the cisco species were endemic, *i.e.*, found only in the Great Lakes. This assemblage of species included fishes that occupied habitats ranging from shallow nearshore waters (*e.g.*, lake whitefish), surface waters offshore (*e.g.*, lake herring), to the deepest waters (*e.g.*, deepwater cisco). The food web was dominated by an assemblage of fishes and invertebrates known as a glacial relict fauna (*e.g.*, deepwater sculpin (*Myoxocephalus thompsonii*) and freshwater or opossum shrimp (*Mysis relicta*), that resembled those present today in parts of Canada, northern Europe, and western Asia (Scott and Crossman 1973).

A growing parade of invasive species followed the technology that enhanced commerce. During the 19th century, completion of the Erie Canal allowed shipping to bypass Niagara Falls via a direct connection between the Hudson River and eastern Lake Erie. Canada's Welland canal provided access through the St. Lawrence River to Lake Ontario and directly to Lake Erie. Both of these natural barriers—the physical barrier of Niagara Falls and the ecological barrier of northerly access to the St. Lawrence—had previously separated the Great Lakes from the Atlantic Ocean. Construction of the canals allowed invaders to bypass that barrier.

As human populations grew and shipping developed through a series of lock and dam systems on the St. Lawrence River, both the path and the vectors (*i.e.*, ballast water) brought a continuing series of new exotics to the Great Lakes (Mills *et al.* 1993, Smith 1995). As a net result, the Great Lakes have been successfully invaded by scores of exotics (Ricciardi 2001), including those purposely introduced (Emery 1985). These species represented every trophic level. Not all exotics had ecological impacts, but the abundance of many native species changed in response to the ecological effects of some particularly important species (Wells and McLain 1973, Madenjian *et al.* 2002, Bunnell *et al.* 2006).

As suggested above, ecosystem changes began well before scientists were able to catalog an undisturbed state for the Great Lakes. Hubbs and Lagler (1949) estimated that 173 fish species were known from the Great Lakes and its tributaries as of 1947. Since then, the relative abundance of many native fishes has changed, including a number of formerly-abundant species (*e.g.*, many of the native cisco species) that are now extirpated (locally extinct) from these ecosystems (Scott and Crossman 1973). Total fish biomass now includes a very large fraction of non-natives in Lake Michigan, Lake Huron, and Lake Ontario. Analogous changes are developing for invertebrate taxa that occupy both pelagic and benthic habitats (Wells and McLain 1973, Mills *et al.* 1993). The parade of invasions continues, as evidenced by the collection of news releases listed by the Great Lakes Directory (http://www.greatlakesdirectory.org/). For purposes of this document, I consider introduced, exotic, non-native, non-indigenous, and invasive as synonyms. By definition, those terms include species that have post-glaciation, ancestral distributions within temperate-zone habitats outside the Great Lakes region and have now established self-sustaining or human-sustained populations in Great Lakes ecosystems.

As the Great Lake ecosystems changed, two important agencies led efforts to restore previous ecological conditions. The International Joint Commission is primarily focused on water quality issues, while the Great Lakes Fishery Commission (GLFC) focuses on fishery resources and their ecological bases. Both were formed by international agreements; both share continuing interests in the restoration of Lake Michigan and the issues surrounding exotic species. Their shared interests promoted an ecosystem approach to research and management (Edwards and Regier 1990). The GLFC also produces a growing body of publications of general and specific relevance to this review. Those include regular updates on the status of fish populations and biological communities in each lake (*e.g.*, Holey and Trudeau 2005). Dozens of reports are available at the GLFC website (http://www.glfc.org/pubs/pub.htm#tech_reports).

This review focuses on major changes in the food web dynamics of Lake Michigan that arose due to fisheries management programs and non-native species invasions (Christie 1974, Eshenroder *et al.* 1995, Kitchell and Sass 2008). There is a continuing discussion about distinguishing between restoration goals (*i.e.*, increasing abundance of native species) and rehabilitation goals (*i.e.*, establishing desirable ecosystem goods and services) (GLFC 1997). In addressing those goals, emphasis is on both native and non-native species representing three levels in a food web:

1. Top predators in the food web (*e.g.*, sea lamprey, stocked Pacific salmon, the native lake trout);
2. Expansion of invading alewife and rainbow smelt at the middle of the food web during the periods that followed invasion and the consequent effects on both pelagic and invertebrate prey; and
3. Invasion by zebra and quagga mussels, their effects on a diversity of invertebrates that consume primary productivity, their role in changing the physical structure of benthic habitats (Higgins *et al.* 2008) and, most recently, evidence of their indirect effects on higher trophic levels (Pothoven and Madenjian 2008).

In the context of a long and complex history, this report is a general, short summary. A sentence or two herein can represent decades of hard-won data, complex trophic interactions in diverse, dynamic biological communities, and unresolved controversies (Holey and Trudeau 2005). This report reflects my overall perspective on the key components that have set the stage for an ecological future.

B. Indigenous Populations

In this section, I provide a brief overview of major events that led to the current state of Lake Michigan. Trophic interactions and management actions were and continue to be very important. More detailed species-specific information, including life history information is provided in Exhibit B-1.

For native fishes, a combination of two new mortality agents arose through both development of commercial fisheries and invasion by the sea lamprey. Local extirpations followed in all Great Lakes except Lake Superior. Rapid decline of fish populations caused management agencies to close fisheries and seek methods to control the sea lamprey. By 1958, sea lamprey control programs were initiated and succeeded in preventing extirpation of lake trout in Lake Superior, then gradually spread to the eastern Great Lakes over the next two decades. The native lake trout disappeared from Lake Michigan before sea lamprey could be effectively controlled. The loss of this apex predator triggered a number of changes in the food web. Prior to extirpation, individuals from some lake trout stocks were preserved in hatcheries (Page *et al.* 2004). Starting in the 1960s, these hatchery fish provided the source for stocking programs intended to restore natural populations. Despite these efforts, little natural reproduction of lake trout has redeveloped in Lake Michigan (Clapp and Horns 2008). Fisheries scientists disagree on what causes are responsible for the lack of success in this restoration effort (Madenjian *et al.* 2002).

In the absence of apex predators, Lake Michigan was invaded by fishes from the Atlantic—rainbow smelt and alewife. Both flourished and had profoundly negative effects on native fishes and invertebrates.

Lake trout in Lake Michigan have not re-established self-sustaining populations but are largely maintained through continued stocking efforts, and they exist in a food web now dominated by exotics. The alewife is now a dominant prey species for lake trout in Lake Michigan, and introduced Pacific salmon now compete with lake trout for prey (Madenjian *et al.* 2002).

C. Effects of Invasives and Introduced Species

Much has changed as the non-native species have become dominant members of the top and middle trophic levels of the Lake Michigan food web. A group of invaders from eastern Europe now dominate the lower levels of the food web. Among those are the zebra and quagga mussels that now function as major consumers of phytoplankton algae. Predaceous invasive zooplankton, such as the spiny water fleas *(e.g., Bythotrephes* and *Cercopagis* from the Caspian Sea), prey on native zooplankton and, therefore, may compete with juvenile fishes (dnr.wi.gov/invasives/fact/spiny.htm). Although these invaders were viewed with concern, there is little direct evidence of strong negative effects on fishes for two reasons. First, competition effects are difficult to demonstrate and, in the case of Lake Michigan, monitoring programs focused on zooplankton are modest. Changes in abundance of juvenile fishes, especially alewife, have more parsimonious evidence in the direct effect of predation by salmonids (Madenjian *et al.* 2002) and the effects of invasive mussels (Pothoven and Madenjian 2008) discussed below. The next level of the food web is now dominated by alewife. They serve as major prey for the Pacific salmon (chinook (*Oncorhynchus tshawytscha*), coho (*Oncorhynchus kisutch*), and steelhead (*Oncorhynchus mykiss*)), the introduced brown trout, and the native piscivores such as lake trout and burbot.

Extensive development of mussel beds, which now extend from shore to shore in the lake, reduces phytoplankton densities, increases water clarity, and promotes growth of attached filamentous algae such as *Cladophora* (Higgins *et al.* 2008). Zebra mussel beds also provide desirable habitat for other non-natives such as the round goby, which competes with native fishes and preys upon their eggs and larvae. At greater depths, increases in the quagga mussel appear to have decreased food supply to the native *Diporeia;* abundances have declined in many areas of Lake Michigan (Nalepa *et al.* 2008).

Changes in *Diporeia* abundance appear to be a major component of subsequent changes in fish abundance, growth rates, and condition factor (weight: length ratios) (Pothoven and Madenjian 2008). There is complexity in the ecosystem scales of specific mussel effects, but there is little doubt that the patterns of habitat-based productivity are changing and will likely continue to do so. Simply stated, the lake is undergoing a "benthification" process caused by mussels (Hecky *et al.* 2004, Higgins *et al.* 2008). This process removes phytoplankton and moves pelagic productivity into littoral and benthic habitats in ways not presently known from the history of ecological changes for this lake. Much the same is occurring in Lake Huron (Riley *et al.* 2008). At this writing, mussel populations continue to expand (Riley *et al.* 2008, Pothoven and Madenjian 2008). We can expect the consequent ecological changes to continue.

Other, recent reports also offer warnings about the future (Riley *et al.* 2008, Pothoven and Madenjian 2008). Stocked salmon have naturalized and now reproduce in local streams. This has boosted the recruitment of new piscivores, especially chinook salmon, even though salmon stocking rates remain steady or decline. This unexpected and poorly documented increase in salmon abundance contributes to an unknown future for Lake Michigan. At the same time, increasing populations of zebra and quagga mussels are radically changing benthic environments and eliminating important food sources (*e.g.*, *Diporeia)* for some native fishes, including alewife (Pothoven and Madenjian 2008). However, native yellow perch, walleye, and smallmouth bass populations are exhibiting recent increases, reflecting an assumed effect of reduced interactions with alewife (Hansson *et al.* 1997) and the addition of round goby as a near shore prey.

The alewife population had seen excesses and rapid declines during the 1960s. Since 1973, the United States Geological Survey's Fishery Science Center has maintained a standardized method for abundance assessments in Lake Michigan. Over the period since 1973, alewife abundance has gradually declined by about half (Bunnell *et al.* 2006), yet continued to show evidence of strong year classes recruiting to the adult stock despite increased predation by salmon (Madenjian *et al.* 2002, Clapp and Horns 2008). This capacity for strong compensation in juvenile survival at low adult densities is similar to the stock-recruitment relationship known for other members of the herring family (*Clupeidae*) (Madenjian *et al.* 2005).

Other efforts at restoration may further confound the ability to manage Lake Michigan food webs. Dam removals on tributary streams are increasing rapidly (Stanley *et al.* 2002), allowing sea lamprey and spawning salmon to colonize new river habitats. Removing dams also removes barriers to the dispersal of other exotics. Those presently constrained by barriers include the "Asian carps" (bighead carp, grass carp, and silver carp), now among the dominant fishes in the Illinois River and amassed below an electrical barrier in Chicago. A power failure there may open the gate to more invasions of the Great Lakes.

With history as a teacher and the Great Lakes as a lesson, we should expect more surprises as new invaders appear and succeed. At last count, more than 180 exotic species have invaded and developed self-sustaining populations (EPA 2008). This review highlights those of greatest ecological significance—sea lamprey, alewife, rainbow smelt, round goby, and zebra and quagga mussels.

There is another very new and ominous development. A virus that causes viral hemorrhagic septicemia (VHS) has appeared in the Great Lakes and is causing an increasing series of fish kills (Environment Canada and EPA 2007). It is presumed to have arrived in ballast water. The virus can affect many species of fish and is water borne. There is no treatment other than attempts to slow its spread into inland lakes. Prospects for effects on Lake Michigan fishes cannot be predicted except to note that large-scale fish die-offs have been reported from the St. Lawrence River, the eastern Great Lakes, and a mortality event reported from Lake Winnebago in Wisconsin, and the most recent reports include VHS symptoms evidenced by a few dead salmon from the Lake Michigan shores (dnr.wi.gov/fish/vhs/).

III. IMPACTS TO ALEWIFE

The following section describes the many pressures that are exerted on the alewife stock in Lake Michigan. Some of the pressures are related to power plants, including PBNP, and some of these pressures derive from the management of other natural resources. The relative magnitudes of those pressures is also evaluated.

A. PBNP Impingement

Impingement of alewife at PBNP does not impact the overall population of Lake Michigan alewife. The section below describes impingement studies conducted at PBNP, as well as an assessment of the impact of alewife impingement on commercial and recreational fisheries. It also considers whether PBNP's thermal discharge exacerbates the impingement effects.

1. 1975-1976 Study Summary

Studies were conducted from March 1975 through February 1976 to evaluate the impacts of the CWIS (WEPCO 1976). In 1975-1976, during 88 impingement sampling events, 265,644 alewife were collected, which represented 84.8% of the total number of fish collected. The biomass of the alewife collected was 17,892 pounds, which represented 94.1% of the total biomass of the fish collected. After reviewing the report, DNR concluded that the location and operation of the intake structure had minimal environmental impact and no modifications to the intake structure were required (Attachment B to EA 2008).

2. 2005-2006 Study Summary

Studies were conducted from December 7, 2005 through November 30, 2006 to estimate impingement (EA 2007). In 2005-2006, during 80 impingement sampling events, 1,595,015 alewife were collected, which represented 99.1% of the total number of fish collected. The biomass of the alewife collected was 12,572 pounds, which represented 93% of the total biomass of the fish collected. Ninety-one percent of the alewife collected were 60-109 mm in length. When scaled to actual plant flows during the study period, an estimated 8,624,000 alewife with a total biomass of 66,687 pounds, were impinged.

The alewife collected in the impingement samples in 2005-2006 have a lower biomass compared to those collected in 1975-1976, which appears consistent with the lake-wide USGS trawl data (Bunnell *et al.* 2007) and data from other sources (Lyons *et al.* 2000) which shows alewife biomass in Lake Michigan has decreased roughly three-fold compared to the early 1970s (EA 2008).

3. Effects of Alewife Impingement on Commercial and Recreational Fisheries

A document associated with this filing (Appendix A to AKRF (2009) provides an evaluation of the effects of impingement at the PBNP on other key species in Lake Michigan. AKRF uses analytical approaches that are commonly employed in fisheries stock assessments. This method calculates annual production by alewife and, based on impingement monitoring at Point Beach, estimates total alewife biomass lost in the sense that it would not be available as a prey resource to support the nine species of fishes targeted by anglers and the fisheries economy that derives from such predators.

Approximately 98% of fishery harvest from Lake Michigan in 2006 was conducted by sport fisheries, while about 2% was commercial fishing. Total fish harvest was estimated as 10,262,513 pounds. Accounting for alewife biomass lost to impingement as the sole prey of this predator assemblage and estimating potential fishery losses relating to that loss produced an estimate of 10,625 pounds of potential lost yield to the combination of commercial and recreational fisheries. In other words, fishery harvest in Lake Michigan would have declined by about 0.1% as a result of PBNP's operations during 2006.

The majority of alewife losses due to impingement derive from huge numbers of larval and juvenile fishes. Using those numbers, distributed across sizes and ages derived from PBNP monitoring programs, is the basis for estimating the lifetime production lost from the potential prey resources for sport and commercial fishes. This approach accounts for life history and production dynamics. It is an "industry standard" in making such estimates and produces a very different number than assuming each alewife lost at PBNP is the equivalent of an adult.

4. Thermal Plume Effects on Alewife Impingement

In October 1975, the "Point Beach Nuclear Plant Demonstration for Thermal Standard Variance" (Demonstration) was submitted to DNR (Limnetics, Inc. 1974). DNR reviewed the Demonstration and, on September 6, 1976, issued a finding that PBNP discharge had no significant detrimental impact on indigenous populations and communities of Lake Michigan. The Demonstration relied on studies of fish populations in the vicinity of PBNP, which were initiated in November 1972 and continued for approximately five years. The conclusion was that the operation of PBNP had very little effect on the fish populations in the vicinity of PBNP (EA 2008).

However, the Demonstration indicated that some representative important species, such as alewife, brown trout, and rainbow trout, exhibited a tendency to be collected more frequently in the thermal plume than in the reference areas during certain seasons (EA 2008). Alewife appeared in late spring in the vicinity of PBNP during spawning runs. Alewife were less numerous from mid-summer through fall and were nearly absent from the area in the winter.

Recently, FPL assessed thermal discharge effects in connection with its plans for an EPU. This report on the planned EPU (EA 2008) indicates that the addition of an increased heat load to the discharge will not endanger the protection of a balanced indigenous community of fish, shellfish, and wildlife in and on Lake Michigan. The EA (2008) report provides several lines of evidence that demonstrate that the thermal plume resulting from the planned EPU will not have any significant adverse environmental impacts. Thermal effects, if any, are predicted to be minor and transitory (*e.g.*, short-term avoidance). The bases for these conclusions include:

- the original plume did not cause "prior appreciable harm," as established in the results of the 1975 Demonstration;

- PBNP's thermal plume, resulting from the planned EPU, will not be substantially larger than the existing/original plume;

- there have been no changes in the aquatic community attributable to the operation of PBNP that would preclude reliance on results of the original Demonstration;

- changes in the Lake Michigan fish community over the past 50 years have occurred on a lake-wide basis; and

- conclusions with respect to the effect of the planned EPU are consistent with assessments undertaken for other power plants on Lake Michigan.

In 2005-2006, approximately 95% of the total impingement occurred from April 23 through August 5, 2006, which mirrored the seasonal impingement of alewife (EA 2008). Peak alewife impingement occurred in early June 2006. Alewife occurred on the screens after the intake temperatures reached 45°F and impingement rates remained high through early June when the intake temperatures averaged 48 - 52°F. During this same time period, the average daily discharge temperatures ranged from 61.2 - 66.5°F. Impingement of alewife declined precipitously when intake water temperatures increased above 55°F from August through early September. Alewife impingement rates only increased slightly through the remainder of the study when intake temperatures declined below 50°F. The lower impingement rates in the fall and early winter were presumably related to the offshore movement of alewife to deeper water for the winter (EA 2008). The mean daily discharge temperatures do not exceed the upper incipient lethal temperatures (UILTs) for young of year alewife, which range from about 72.7°F at an acclimation (ambient) temperature of 48°F to 89.8°F at an acclimation temperature of 77°F (Wismer and Christie 1987). Similarly, the mean daily discharge temperatures do not exceed the UILTs for adult alewife, which is about 74°F at an acclimation (ambient) temperature of 50°F.

There are several, rarely considered mechanisms that may play a role in alewife population dynamics and relate directly to effects of power plants. There is no doubt that power plant effluent plumes produce local aggregations of alewife. The Point Beach plant was one of the sites of early research on Lake Michigan. Stuntz (1973) used acoustic and midwater trawl sampling to evaluate diel (night-day) abundance of fishes in the outfall area as compared to that in a nearshore reference area of comparable depths and several kilometers located north of the outfall area. As expected, fish were more abundant in the thermal plume than in the reference areas.

In a more general result, fish abundance was higher during the daylight period in shallow water regions (~4m) of both the outfall area and reference area, but declined at night due to migrations to greater depth (>4-8m) in the offshore environment. In an independent study at this site, work by Spigarelli *et al.* (1973) produced a similar result.

The results above are contrary to the general expectation that diel migration brings fish up in the water column at night when following the analogous diel migration of their zooplankton prey. That leads to the prospect that fish aggregations in plume areas at PBNP may actually enhance the local availability of potential prey. During the daylight hours, entrained zooplankton and ichthyoplankton may be made more vulnerable to predators aggregated in the plume.

The frequent observation of greater piscivore abundance (especially brown trout) beneath thermal plumes offers an analogous interpretation—power plant plumes create a set of aggregative mechanisms that intensify food web interactions. While the aggregation of fishes—both predator and prey—is well documented, the proximate explanation for the aggregation of prey fishes is typically explained as solely due to temperature preference effects (Otto *et al.* 1976). That may not be independent of the additional effects of increased zooplankton as a potential food resource for the prey fishes. In fact, a first-order and untested assertion would have it that fishes should minimize aggregation in thermal plumes because of the increased vulnerability to their predators in that habitat. Reality may derive from the trade-offs of interactions in a set of three-tiered trophic interactions involving plankton, planktivores and piscivores. A second, potentially positive effect of the thermal plume derives from the recent work reported by Hook *et al.* (2008). Alewives spawn over a protracted period—late May to early August—in the nearshore regions. In general, alewife year class strength in Lake Michigan is positively correlated to summer temperatures. Based on that generality and known thermal heterogeneity of surface waters, a modeling analysis of recruitment success in larval alewives was conducted by simulating growth and survival in alternative habitats. The main result was that individuals from "warm" environments were about twice as likely to grow more rapidly and, therefore, be less vulnerable to predation, have greater energy reserves at the end of the growing season and, therefore, more likely to survive the first winter which appears to be the critical period that precedes establishment of year class strength.

River mouths offer "warmer" environments within the nearshore habitats. Power plant plumes offer warmer environments relative to other nearshore habitats. Warm years provide the strongest year classes and, even during cold years, "warm" habitats such as those in river mouths and power plant plumes may offer thermal refuges that provide for higher growth and survival rates. The unknown, essential corollary of this assertion revolves around food availability in the power plant plumes. As described above, there are logical reasons to view the combination of higher temperatures and greater prey resources as attributes that can be attributed to such plumes.

Evidence and arguments presented above portray a positive and alternative interpretation of the ecological effects of power plant plumes. Those remain untested. Regardless of the outcome, the plume habitat and its analog (river mouth habitats) represent a very small fraction (<1%) of total nearshore habitat area (Hook *et al.* 2008).

B. Cormorant Predation on Alewife

Colonial waterbirds, like the double-crested cormorant (*Phalacrocorax auritus*), are an important part of the Great Lakes ecosystem. A comprehensive study of the cormorant diet in the Beaver Archipelago, Northern Lake Michigan, estimated that cormorants consumed 2.4 and 3.4 million pounds of forage fish in 2000 and 2001, respectively (Seefelt and Gillingham 2008). In comparison, lakewide alewife abundance was estimated at 25.7 million pounds in 2007 by USGS.

Based on a lakewide survey (Cuthbert 2008), cormorants increased from 28,158 nesting pairs in 1997 to 38,446 in 2007. If we assume that the annual lakewide alewife consumption by cormorants fell within the range reported in 2000-2001, this produces an annual estimate of 4.5-7.7 million pounds of alewife consumed in Lake Michigan by breeding cormorants and their offspring in 2007. These data suggest that the percentage of alewife consumed by cormorants in Lake Michigan has risen substantially in recent years. Furthermore, the estimated annual alewife loss via cormorant consumption (4.5 to 7.7 million pounds) would appear to have a much greater impact on the lakewide alewife population than the annual losses currently estimated to occur as result of operating the PBNP CWIS (~ 67,000 pounds).

C. Salmonid Predation on Alewife

Currently, all of the salmonid species in Lake Michigan have alewife as their primary prey. Chinook salmon is the most important component of sport fishery harvest and, as documented in Stewart and Ibarra (1991) and Madenjian *et al.* (2005), is the major predator of alewife in Lake Michigan. Chinook salmon is also the major concern for managers, because this species has been most successful in establishing recruitment from natural reproduction.

A recent study (Warner *et al.* 2008) analyzed an 8-year time series of abundance and diets to evaluate the relationship between the abundance of young chinook (Age 1) and young alewife (ages 0-3). The purpose of the study was to test for selectivity by the predator. Two results are meaningful in the context of this document. First, the alewife is the dominant prey, ranging across years from ~62 to 99% of prey in age-1 chinook diets. Second, diet variability corresponds with variability in alewife abundance. When alewife are less available, alternative prey are primarily smelt and/or juvenile bloaters.

This result confirms the initial intent of choosing salmon as a biological control of excess alewife abundance (Tanner and Tody 2002) and the accumulation of evidence over time that alewife remain the dominant prey of salmon since the original studies (Stewart *et al.* 1981, Stewart and Ibarra 1991, Madenjian *et al.* 2005). Based on the most recent work of Warner *et al.* (2008), it appears that chinook salmon continue to target their predation on alewife, especially those in the size range of age 1 and age 2 fish. That result may help explain how salmon persist even though adult alewife abundance has decreased by about 90%, owing to predation effects on adult alewife abundance, *i.e.* those of age 3 or greater (Madenjian *et al.* 2005). That explanation corresponds with reports of decreased size at age and condition factor for adult salmon that may now prey on smaller alewife.

In addition, recruitment of naturalized salmon has been dominated by chinook and, thereby, increased the intraspecific competition for alewife prey. As referenced in the preceding paragraphs, these outcomes have antecedents in the current state of Lake Huron's food web, where 80% or more of chinook salmon in Georgian Bay derive from natural reproduction. In Lake Michigan, natural reproduction account for about 50% increases in abundance of chinook salmon (Clapp and Horns 2008). Thus, the most potent predator has escaped the controls of management through hatchery stocking policy.

D. Mussel Effects on Alewife

The invasion of dreissenid mussels has created a new and complex challenge for Great Lakes managers. Hecky *et al.* (2004) and Higgins *et al.* (2008) present evidence that these mussels are "ecosystem engineers, *i.e.*, that their ecological effects are making major changes in both the structure and function of the Great Lakes ecosystems. Results apparent in Lake Michigan include increased water clarity owing to the filtering effect of mussels and development of a new nearshore habitat in the form of extensive mussel beds that fosters the success of other invasives (*e.g.*, round goby) and encourages the growth of noxious filamentous algae (*e.g.*, *Cladophora*). In mid-summer, beaches can be littered with extensive deposits of decomposing *Cladophora*, and municipal or industrial water intakes can be clogged. The net effect of these changes on recreational activities is clearly negative and research on ecological effects continues.

A recent analysis by Pothoven and Madenjian (2008) addressed the question of mussel effects on fishes in both Lake Michigan and Lake Huron. Comparison of feeding and growth rates before (1983-1994) and after mussel invasion (1995-2005) provided the basis for evaluation. Based on bioenergetics modeling at the annual scale, alewife consumption of zooplankton in Lake Michigan was 37% lower after mussel invasion and predation on macroinvertebrates such as *Mysis* and *Diporeia* was reduced by 19%. Alewife growth rates declined as a result.

In contrast to the results for alewife, prey consumption rates for lake whitefish (*Coregonus clupeiformis)*, an important commercial fish, evidenced little change as mussels replaced native prey and became a major element of whitefish diets (Pothoven and Madenjian 2008). Whitefish growth rates declined by 38% because the nutritional value of mussels is much less than that of native prey species.

These changing ecological effects are expressed in growth but have unknown effects on alewife population dynamics. In general, reductions in growth rate would correspond with increased susceptibility to two major sources of mortality—size-selective predation (Warner *et al.* 2008) and over-winter survival (Madenjian *et al.* 2005). Again, the evidence of a precipitous decline of alewife in Lake Huron should serve as a warning of continuing effects on alewife in Lake Michigan.

The main lesson in these new results is that the current fish population declines, especially alewife declines, owe to two primary causes;

1. predation by a large and growing population of salmonids, with increased natural recruitment an unknown component of the latter; and
2. reduced food resources owing to the ecological effects of the mussel invasion.

Acting in concert, those are the parsimonious explanations of current vectors for alewife and populations of many fish species. Management actions can alter the abundance of salmonid predators, but control of mussel populations is currently beyond the bounds of reality. As made evident in this document and in previous studies (Spigarelli *et al.* 1981), the role of power plant impingement and entrainment is a very minor component of alewife population dynamics.

IV. ALEWIFE POPULATION DYNAMICS

The major regulators of fish population dynamics in Lake Michigan are:

- direct ecological interactions effected by fishery management practices that control predator populations, and
- indirect ecological changes owing to recent invasions of exotics.

Alewife is at the cornerstone of all this, both in the recent history and the likely future for Lake Michigan. In addition, alewife life history is similar to that of other fish species of concern (*e.g.*, smelt, yellow perch, and several species of the minnow family, Cyprinidae). The views that follow focus on alewife, the focus of DNR's 2008 comments. More importantly, alewife is the nexus of the food web (*i.e.*, prey) that supports recreational fisheries for salmon. It is a dominant competitor and a potent predator. In combination, these have powerful effects on survival of juvenile fishes, both native and exotic

A second, strong message is that the evaluation of alewife dynamics must focus on the lake-wide scale. Their migrations and advection effects on their distribution combine to cause rapid mixing and an overall averaging of local effects on fish populations. As a result, those must be viewed at the largest of scales—that of the whole lake. Hence, local mortality owing to one or more power plants quickly melds into the overall dynamics of the whole population. Previous reviews *(e.g.*, Spigarelli *et al.* 1981) have calculated total losses of alewife, rainbow smelt, and yellow perch as a consequence of estimated power plant effects for the entirety of Lake Michigan. Those are very modest losses relative to total fish production and show little or no correlation with power plant operations.

A. Dominant Controls of Alewife Abundance:

1. Predation by Salmon

Alewife mortality rates caused by salmon are well known and offer reasonably good predictions of predation as a major control of population dynamics for alewife. That is evident in the fact that an index of predation by Lake Michigan salmon is highly correlated with changes in abundance of age-3 alewife (Madenjian *et al.* 2005). This index derives from calculations based on bioenergetics models used to estimate the effect of a predator on its prey (Hanson *et al.* 1997). Alewife remain at the lowest abundance since lake wide estimates were initiated in 1973. The general pattern of decline owes to continuing high predation rates by salmon populations comprised of both hatchery stocks and those deriving from natural recruitment. As stated above, the current challenge to management revolves around the magnitude of salmon recruitment owing to natural reproduction (Madenjian *et al.* 2008).

AKRF estimated the annual lost production by alewife due to impingement at PBNP, estimated the corresponding yield to Lake Michigan fisheries, and then allocated that lost yield to commercial and sport fisheries (see Appendix A). They found that annual impingement at PBNP has the potential to reduce the annual sport fishery harvest by 1,159 salmonids, and the commercial fishery harvest by 241 lbs.

2. Stochastic Effects

The second control, that of stochastic effects, is more problematic. Broadly defined, stochastic means highly variable. The root of the word "stochastic" comes from Greek mythology. Stochastos was an exceptionally powerful archer, but he was blind. Statisticians thought that "stochastic" would be an appropriate descriptor for important, random effects and it remains a central element in the terminology used to describe ecological variability.

Stochasticity in recruitment success is a major feature in population dynamics of many fish species (Winemiller and Rose 1992). Causes of stochastic effects are made evident in the fact that the number of eggs produced by spawning adults offers little or no accurate prediction of the number of juveniles that will become adults. In simple terms, the number of reproductive adults in the current population is a relatively poor predictor of how many adults will appear in the next generation. There is a large body of literature in support of that perception by fisheries scientists and a continuing series of research efforts attempting to resolve its attendant insufficiencies (Walters and Martell 2004). For example, in the extensive review of lake-wide power plant impacts on Lake Michigan fishes, Spigarelli *et al.* (1981) estimated that the maximum effects for all power plants were reductions of biomass amounting to 2.9% for alewife, 0.8% for smelt and 0.3% for yellow perch. Yet, the observed changes in population biomass for these species are often in the order of 5-10X (Madenjian *et al.* 2002).

3. Fish Stock Assessments: The Caveats and Reality

Population dynamics discussed in the preceding sections emphasize relative changes in abundance rather that absolute or precise measures. That is both the reality and the constraint of fish stock assessment (*i.e.*, calculations of abundance and/or biomass). Two elements of the process compromise precision—measurement error and process error (Walters and Martell 2004). In this case, measurement error is used in the statistical context of unexplained variability caused by the differences among samples. Process errors can derive from the important assumption that a sampling program is collecting data from a population in proportion to its distribution and relative abundance across the range of occupied habitats. It can also derive from assumptions that relate to equivalent vulnerability to capture for a range of size and age classes of fish.

Both classes of potential error are involved and estimated in the complex mathematics that produce estimates of fish abundance. These considerations are widely acknowledged and quantitatively evaluated in virtually every fish stock assessment process (Walters and Martell 2004). For example, the USGS Great Lakes Fisheries Science Center is the source of stock assessment evidence for Lake Michigan fishes. Their sampling protocol is based on a depth-stratified (9 to 110 meters of water depth at 9-meter increments) series of daytime bottom trawl samples at selected monitoring sites around the perimeter of the lake (Bunnell *et al.* 2006). This sampling includes neither the shallow, nearshore waters nor the deepest of waters. Analyses are based on catch rates of alewives of age 3 and above. Small, younger fish are not formally included in the stock-recruit estimates because they are less vulnerable to the gear and catch rates are highly variable (Madenjian *et al.* 2005).

This sampling practice produces catches of many other species) that are included in the analyses (Madenjian *et al.* 2002). Some of those species have depth and spatial distributions different from that of alewife. Regardless, the process provides a basis for comparisons of relative changes in abundance over time and across sampling sites. A single, lake-wide average abundance is calculated. That generality reduces the effects of small sample size (measurement error) and process error. It serves as the strongest source of insight in relating cause and effect inferences about ecological change.

Monitoring of entrainment and impingement at power plant intakes offers a very different kind of data, but is subject to both measurement and process errors as well. With emphasis on early life stages, those data represent a huge gulf in space and time calculations required to estimate mortality effects ultimately apparent in the adult fish populations. Estimates of reductions in age-1 abundance due to entrainment and impingement provide an indication of those effects if focused in the intake sites and, as in this case, in comparative, site-specific data collection, but it must be acknowledged that there are orders of magnitude change in abundance as survivors proceed from larval to adult populations.

In general terms, most fishes have evolved a reproductive strategy rather like betting on a lottery (Winemiller 2005). Tens of thousands of eggs are produced per mature adult with each spawning event. Only a very few of those will survive to become adults. Predicting the outcome of a select few has a very low probability of success. Reproductive strategies of these fishes evolved by selection for high fecundity as the offset to highly unpredictable survival potential. As argued in the preceding, ecological interactions dominate population dynamics of most fishes and, as evidenced in the analyses of Spigarelli *et al.* (1981), losses to power plants are collectively very small relative to the long-term, total production and population dynamics of Lake Michigan's dominant fish species.

4. Compensatory Mechanisms

The reason for complexity in predicting future population densities of fishes owes to a set of interactions aggregated as compensatory mechanisms (Rose *et al.* 2001, Jones *et al.* 2003). These are common among fishes; they can be generally defined as demographic processes that tend to increase population growth rates at lower population densities. The mechanistic explanation of compensation commonly owes to density-dependent ecological effects operating through a combination of competition and predation interactions both within the species and with other species.

The alewife exhibits highly variable and strongly compensatory recruitment. That is to say, it produces highly variable and sometimes exceptionally large year classes of offspring at relatively low adult densities. In this case, recruitment is defined as the numbers that survive to age 3 when they "recruit" to the adult population as sexually mature adults. In fact, alewives have produced some of the strongest year classes as the population has been generally declining since 1973. There have also been some weak year classes during that period (Madenjian *et al.* 2005).

The regulatory mechanisms are simply not directly apparent, but the characteristics of population dynamics for this type of fish (a "herring-like" life history) are common in the form of high fecundity, dramatic inter-annual variability in year classes, and strong compensatory potential, *i.e.*, alewife density plays a major role in regulating its own population dynamics (Winemiller 2005). In short, high densities of adults can produce poor year classes, low density of adults can produce some of the strongest year classes; and intermediate densities of adults can produce some of the strongest or weakest year classes. The generalizations above about alewife are appropriate for many other fish species including some of those of specific concern in Lake Michigan, *e.g.*, yellow perch and rainbow smelt.

B. Alewife Effects on Other Fish Species

Alewife effects on other fish species are strong, complex and variable (Kitchell and Crowder 1986). Thus, as salmon predation has reduced overall abundance of alewives over the past three decades, recoveries of many (but not all) native fish species have been observed. Mechanistic explanations for the relative importance of competition and/or predation are poorly known in this case, but the correlations are obvious for changes in many fish species. As alewife increased, many native species declined. More recently, as alewife decreased, many native species increased (Madenjian *et al.* 2002, Schaeffer *et al.* 2008). Those correlations are becoming less apparent in recent years as the "ecosystem engineering" effects of zebra and quagga mussels challenge food web dynamics at the most basic levels. Outcomes remain to be seen. One probable result of the mussel invasion will be an increase in the role of nearshore benthic habitats for many kinds of ecological interactions. Other invaders such as the round goby and/or the "bloody red shrimp" that recently appeared in Lake Michigan (www.seagrant.wisc.edu/AIS/LinkClick.aspx?link=1609&mid=923) may become the foci of food web interactions in nearshore habitats dominated by dreissenid mussels. A second may involve an ecological equivalent in the deepwater areas where quagga mussels dominate. A third and largely unknown prospect will be a general reduction in pelagic productivity owing to mussel effects on primary production by phytoplankton and its consequent effect on fishes. In other words, this ecosystem and its habitats are again challenged by the increasing ecological effects of invasive species.

In a general sense, events owing to invasive species have developed first in the eastern regions of the Great Lakes, then spread to the west. Thus, Lake Huron's history has often served as a bell-weather for invasions that subsequently transpired in Lake Michigan. That has been the case for sea lamprey, alewife, spiny water fleas, and dreissenid mussels. As stated in the preceding, the rapid ecological changes owing to invasive mussels in Lake Huron have preceded and been more extreme than those in Lake Michigan.

Historically, the emerald shiner (*Notropis atherinoides*) was very abundant in Lake Michigan and Lake Huron. Prior to alewife invasion, it was among the most abundant zooplanktivorous fish species in Lake Michigan, but few data are available from those periods and accounts of abundance are largely anecdotal (L. "Tex" Wells, pers. comm.). A very recent report of resurgence by the emerald shiner population in Lake Huron corresponds with continuing and substantial reduction of alewives there (Schaeffer *et al.* 2008). In fact, emerald shiner was not detected in 2004, but their abundance exceeded that of alewife and smelt by 2006. The cause-effect relationship owes to interactions of dreissenid mussel effects on planktonic food resources and increased predation by salmon on alewife, especially chinook salmon, deriving from natural reproduction in tributary streams as well as continued salmon stocking practices. If, and as, the Lake Michigan alewife population feels the combined negative effects of decreased plankton production due to effects of mussels and increased salmon predation, I should not be surprised to see evidence that one of the formerly most abundant native fish—emerald shiner—makes an equivalent recovery in Lake Michigan.

V. CONCLUSIONS

Restating the main message of this assessment, ecological interactions and their outcomes must be viewed as the dominant control of fish population dynamics in the lake. That is especially true for alewife. Both salmon and alewife are broadly distributed and highly migratory. Thus, their interactions and ecological effects demand assessment at the ecosystem scale. Local mortality effects, such as those ascribed to a power plant, are very small parts of a much bigger picture. They are quickly diminished in the lake-wide expressions of fishery management policies, compensatory responses by fishes, and the continuing ecological changes wrought by invasive species. Even at the lake-wide scale, the cumulative effects of all Lake Michigan power plants are a very small part of the bigger picture (Spigarelli *et al.* 1981)

Does power plant impingement account for a significant role in alewife population dynamics? There is no apparent direct relationship between alewife abundance and impingement rates. That is because impingement of juveniles and adults account for a very small proportion of the amount of total annual alewife production (*i.e.*, development of new alewife biomass). As noted above, Spigarelli *et al.* (1981) concluded that power plant effects on alewife biomass are, at the maximum, accounting for biomass losses of only 2.9% per year.

What appears to be the dominant regulator of alewife abundance? The dominant regulator of alewife abundance is predation by salmonid species, especially chinook salmon. The relationship between alewife abundance at age 3 and a calculated index of predation by salmon is strongly inverse (Madenjian *et al.* 2005). Predation by salmon has the strongest known role in regulating adult alewife abundance.

As summarized above, salmon abundance is regulated by a combination of stocking policy, an increasing natural recruitment, and sea lamprey control policies. Thus, the dominant agents of alewife population control are a mix of fishery management practices, effects of predators such as cormorants and native fishes, plus the vagaries of recruitment owing to natural variability. Power plant impingements play a minor role in the regulation of alewife population dynamics.

The GLFC's Lake Michigan Committee offers a recent summary of evidence of changes in alewife biomass and salmon abundance (Clapp and Horns 2008). Results demonstrate interactions between reduced basic productivity evoked from mussel effects and increased predation rates by salmon; both have negative effects on alewife. Reductions in productivity of lower trophic levels and, therefore, of alewife prey, are evident in declining growth and condition factor. Weight of a 175 mm alewife has declined 15-20% over the period of 1994-2004. This is the opposite of effects expected from density-dependent compensatory growth and lends independent support to the argument about lake-wide ecological changes owing to mussels.

Recent analyses of chinook salmon reveal that 50% of the current adult populations derive from natural recruitment (Claramunt *et al.* 2008). In other words, there are twice as many Chinook salmon in the lake as would be estimated from known current stocking policies. Chinook salmon is the most important predator among the salmonids. Ecologically, this means that predation by Chinook on alewife, their primary prey, is approximately doubled. Stocking policies can be changed to accommodate for natural recruits (Clapp and Horns 2008), but recruit abundance is ill-documented and there are lags in the ecological outcome. Chinook have their greatest effect as predators a full three years after entering the lake (Stewart *et al.* 1981). Predation on juvenile alewife is relatively high and effects on total alewife biomass would not be assessed until alewife are age 3 or older (Madenjian *et al.* 2002). Thus, assessment of predation effects owing to salmon has an ecological lag of at least 5-6 years.

In terms of management challenges, this means that using abundance of adult alewife as an indicator of ecological changes will be based on evidence of effects of alewife recruitment and stocking policy that began 5-6 years before the causes of change can be perceived. This problem, termed "predation momentum" (Stewart *et al.* 1981, Stewart and Ibarra 1991) is a major challenge for current and future salmon stocking policies.

In summary, the current low alewife abundance in Lake Michigan owes to ecological interactions that reduced pelagic productivity (mussel effects), increased predation by salmon, and variable recruitment effects. Recent trends in abundance of other species (bloater, smelt, deepwater sculpin and slimy sculpin) parallel those of alewife. Meanwhile, angler catch rates and total harvest of chinook in 2004 are among the highest reported during the past two decades (1985-2004, Claramunt *et al.* 2008). I conclude that parsimonious explanations for the observed changes in Lake Michigan fishes primarily owe to ecological interactions and stocking policies. Power plant effects are minor, at most.

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EXHIBIT B-1

INFORMATION ON KEY/RELEVANT SPECIES IN LAKE MICHIGAN

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POINT BEACH NUCLEAR PLANT
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This exhibit presents information on key/relevant species in regard to an assessment of impacts to alewife related to operation of the offshore cooling water intake structure at Point Beach Nuclear Plant. Both native and exotic or invasive species are discussed.

I. BENTHIC SPECIES

A. Zebra and Quagga Mussels

The changes discussed above reflect "top-down" ecological effects – how apex predators influence other species as their effects cascade down through food webs. At the same time, however, other invasions are shifting trophic interactions from below. Zebra (*Dreissena polymorpha*) and quagga (*D. bugensis*) mussels are commonly and collectively referred to as dreissinids. They are filter-feeders that, when very abundant, affect food webs from the "bottom-up" and create changes in Great Lakes ecosystems as ecologically profound as those owing to introduced fishes.

Zebra mussels were first discovered in Lake St. Clair during 1988 but spread quickly to shallow, warm, and productive habitats near shorelines throughout the Great Lakes (Mills *et al.* 1993). Soon thereafter, the quagga mussel invaded deeper, colder offshore waters and is now spreading into the shallow, warmer habitats (Nalepa *et al.* 2008, Mitchell *et al.* 1996, Diggins 2001). Both of these mussel species were transported here in ship ballast water from their native habitat in the Caspian Sea region and in Eastern Europe. Both have a life cycle that differs from that of native mussels in that they have an immature pelagic (veliger) stage that enables them to disperse widely and rapidly. Juvenile mussels settle and attach to solid substrates then consume large amounts of phytoplankton and small zooplankton by efficiently filtering the water. The extent of their colonization is limited by a combination of factors, including habitat productivity, temperature, and the presence of enough dissolved calcium to build shells.

In the lower Great Lakes, dreissenid mussel numbers can exceed thousands per square meter. They are extremely dense in productive, warm areas such as western Lake Erie, Lake Huron's Saginaw Bay, and Lake Michigan's Green Bay and most nearshore areas (SeaGrant 2001). Their extent continues to increase in Lake Michigan with the deep reef and mid-lake habitats now fully colonized by quagga mussels (Nalepa *et al.* 2008). The lack of calcium limits their extent in Lake Superior. Dreissenids encrust any solid substrate. Barnacles and their equivalents create a similar fouling problem in marine environments, but this has been a wholly new problem in the Great Lakes. These mussels foul municipal or industrial water intakes, docks, piers, buoys, and the bottoms of boats. This has inflated annual removal and maintenance costs to millions of dollars.

Dreissenid mussels are having immense ecological impacts. They encrust and smother native mussel species. Their filtering activity removes phytoplankton and deposits both feces and pseudofeces (undigested organic matter) on the substrate, creating an enriched benthic boundary layer and a water column depleted of planktonic algae (Higgins *et al.* 2008). Understanding their bottom-up impacts on food webs continues to be a major challenge (Strayer *et al.* 2004). By consuming large quantities of phytoplankton, dreissenid mussels often improve water clarity. In western Lake Erie, the water has become twice as clear as that observed before invasion. This effect surpasses the gains wrought by the Clean Water Act. Because increased clarity favors the growth of submerged plants (macrophytes and filamentous algae), these mussels have greatly altered the shallow-water habitat structure and, based on recent observations, are increasing the average water clarity in the offshore regions (Hecky *et al.* 2004, Higgins *et al.* 2008).

Described as ecosystem engineers, the intense filtration by mussels creates what scientists term a "near shore shunt" that captures nutrients in the littoral habitat occupied by mussel beds (Hecky *et al.* 2004). It is a focus of increasing research effort made apparent by a recent, full two-day symposium as part of the annual meeting of the International Association for Great Lakes Research (*e.g.*, Bootsma *et al.* 2007).

Another ecological effect also has become apparent on public beaches. Attached, filamentous algae, *Cladophora*, once limited by light penetration and nutrients, flourishes as dreissenid mussels filter, then digest planktonic algae and recycle essential nutrients which are utilized by the inedible filamentous algae (Higgins *et al.* 2008). Strong wave action detaches large amounts of the filaments and beaches are left littered with mounds of decomposing algae (Higgins *et al.* 2008).

B. Diporeia

In deeper water habitats where quagga mussels have become very abundant, large declines are reported in a deep-water native benthic amphipod, *Diporeia hoyi,* which fed on lake bottom sediments. *Diporeia,* a shrimp-like crustacean, previously occurred at densities of thousands per square meter. It was an important prey resource for many fishes. In some areas of Lake Michigan, especially the deeper waters of the eastern regions, *Diporeia* has now virtually disappeared (Nalepa *et al.* 2006) with similar declines reported in other Great Lakes, with the exception of Lake Superior, where quagga mussels are rare. Because the quagga mussel is a recent invader, the long-term ecological impacts on the Diporeia population in Lake Michigan are not known; therefore, there is no estimate of the possible maximum extent or effects on this species.

II. FORAGE SPECIES

A. Alewife

Alewife is native to the Atlantic Ocean and normally has an anadromous life history, *i.e.*, adults migrate from the sea into freshwater for spawning. During the late 1800s, the alewife is also thought to have invaded from the Hudson River (where they spawn traditionally) through direct access to Lake Erie as provided by the Erie Canal. Alewife successfully colonized each of the four lower lakes, appearing in Lake Michigan in 1949 (Madenjian *et al.* 2008a), but never became established in the cold, ultra-oligotrophic Lake Superior. Alewife entered ecosystems where predators like the lake trout were already severely depleted by sea lamprey and fishery exploitation effects. It flourished and became very abundant. Alewife had strongly negative ecological effects as it competed with native forage fishes and preyed on their larval stages (Kitchell and Crowder 1986, Hansson *et al.* 1997).

Alewife abundance in Lake Michigan reached exceptional levels. At its peak in the 1960s, predation by alewife changed the zooplankton community completely by eliminating the larger species (Kitchell and Carpenter 1987). Stressed by a depleted prey resource, alewife populations soon crashed, with extensive die-offs clogging power plant and municipal water intakes. Beaches were littered with dead adults and the odor of decomposing fish wafted miles inland. These conditions are estimated to have cost hundreds of millions of dollars in tourist revenues and required expensive engineering additions designed to protect water intake structures.

The introduction of alewife in the 1940s to Lake Michigan substantially altered the fish community (Bunnell *et al.* 2006). In 1960, alewife comprised about 8% of the fish biomass in Lake Michigan. By 1967, alewife biomass in the lake had increased to around 80% of total fish biomass. Predation by the introduced sea lamprey on native predators, such as lake trout and burbot, was the major reason for the rapid growth in the alewife population (Sommers *et al.* 1981). Increasing abundance of alewife in Lake Michigan contributed to significant declines in abundance of emerald shiner (*Notropis atherinoides*), deepwater sculpin (*Myoxocephalus thompsoni*), yellow perch, bloater (deepwater cisco (*Coregonus johannae*)), and other native forage species. Alewife predation on lake trout fry may also have contributed to the reduction in lake trout abundance.

The increase in alewife abundance also affected recreational and commercial fisheries. Although a recreational fishery for rainbow smelt flourished for a time in Lake Michigan, the burgeoning success of alewife, a superior competitor, soon diminished rainbow smelt abundance. In addition, complex interactions with alewife and increased fishery exploitation caused a decline in yellow perch populations (Hansson *et al.* 1997). Following the mid-60s rise and fall in population, alewife recovered by the mid-1970s to about one-third of former maximum abundance through successful but variable recruitment (Madenjian *et al.* 2005). Frequent but less intense die-off events continued. Causes of the fluctuations are unknown and cannot be anticipated (Becker 1983). A number of plausible causes for the die-offs include, but are not limited to, the physiological stress of spawning, sharp changes in temperature between the deep, cold waters of the lakes and the shallow, warmer waters inshore, the loss of osmotic control in warmer water because of an exhausted thyroid mechanism. Fishery managers then faced a weighty problem: the loss of lake trout and other native fishes enabled exotics to become abundant, creating profound ecological consequences. To control this nuisance species, they looked to a biological control agent—Pacific salmon.

1. Life History

In the Great Lakes, the alewife is found primarily in open water habitat in 130 to 300 ft of water for most of the year (O'Gorman *et al.* 2000, Wells 1968). Adult alewife move from overwintering areas in deep water to spawning grounds in littoral waters and tributaries during the period between March and July (Goodyear *et al.* 1982). Spawning takes place in small groups and each spawning female can produce between 10,000 to 12,000 eggs per spawn (Wisconsin DNR Publication 223). Alewife spawn in shallow open water or onto a sand and gravel substrate (Wisconsin DNR Publication 223).

Spawning can occur from March-September at 44-72°F, but usually May-August at 55-70°F and peak spawning typically occurs in June and July (Goodyear *et al.* 1982). Eggs hatch in 3-6 days at 60-72°F (Scott and Crossman 1973). Spawning and hatch usually occur at water depths less than 30 ft.

Alewife larvae develop near the spawning grounds (51-75mm) (Scott and Crossman 1973). In September and October, young-of-year (juvenile) alewife have attained a size of about 2 to 3 in. and begin to migrate from shallow water nursery grounds into deeper water to overwinter. The young are most abundant in water less than 30 ft deep. Like adults, juveniles age-1 and older exhibit diel migration patterns during spring and summer. During this period, juveniles are found in shallow water at night and move to a depth of 6 to 10 ft where they stay near the bottom during daylight. Juveniles probably migrate to deeper waters in August together with the adults (O'Gorman *et al.* 2000). In Lake Michigan, alewife generally reach sexual maturity at age 2 to 3 years (Froese and Pauly 2007).

Adult alewife then typically return to their deeper water habitats by August (Froese and Pauly 2007) (Scott and Crossman 1973). The young alewife remain in tributaries and nearshore areas and typically move offshore when nearshore waters cool in September and October. Temperature tolerance and temperature preference of mature and young-of-year (YOY) alewives from Lake Michigan were studied by Otto *et al.* (1976). The preferred temperatures[1] of adult alewives acclimated to ambient inshore Lake Michigan temperatures ranged from approximately 52°F in December to 70°F in May, while the range for YOY was approximately 66°F in December to 77°F in August. The upper incipient lethal temperature (UILT)[2] for YOY alewife ranged from about 59°F at an acclimation temperature[3] of 41°F to 89.8°F at an acclimation temperature of 77°F (Wismer and Christie 1987). The UILTs for adult alewife ranged about 74°F at an acclimation temperature of 50°F to 91.9°F at an acclimation temperature of 83°F.

Alewives are generally classified as pelagic planktivores (Pothoven and Madenjian 2008). They feed on both zooplankton and benthic macroinvertebrates. The taxonomic composition of prey consumed by yearling and adult alewives prior to the dreissenid mussel invasion of Lake Michigan (1983-1994) consisted primarily of cladocerans, copepods, spiny water fleas (*Bythotrephes longimanus*), amphipods (*Diporeia* spp.), opossum shrimp (*Mysis relicta*), and midges (Chironomidae). After the dreissenid mussel invasion (1995-2005), the annual consumption of zooplankton and benthic macroinvertebrates by an average alewife in Lake Michigan was 37 and 19% lower for each trophic category than prior to the mussel invasion (Pothoven and Madenjian 2008). In a detailed study of the food of larval alewives (5.9-6.1 mm total length) in Lake Michigan, Norden (1968) found that cladocerans (mainly *Bosmina*) and copepods (mainly *Cyclops* and *Limnocalanus*) constituted 75% or more of the organisms eaten.

Freshwater populations of alewives are preyed upon by larger piscivorous fishes, such as the native freshwater burbot and lake trout (Scott and Crossman 1973). Pacific salmon were

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[1] The temperatures fish at typically found at and which vary by size, age, season and day and night (Wismer and Christie (1987).

[2] The UILT represents an exposure temperature that 50 percent of the fish can tolerate for 7 days and varies directly with the acclimation temperature.

[3] A constant temperature in the laboratory at which fish have been held for a time sufficiently long to erase the influence of previous thermal exposure (Wismer and Christie 1987).

introduced to Lake Michigan (e.g., chinook (*Oncorhynchus tshawytscha)*, coho (*Oncorhynchus kisutch*), and steelhead (*Oncorhynchus mykiss*)) and are known to eat large quantities of alewives. In other lakes, alewives are reported to be prey for rainbow trout, cisco, northern pike, smallmouth bass, yellow walleye, perch, and lake whitefish (Scott and Crossman 1973).

2. Status

During the 1960s, salmon and trout were stocked in Lake Michigan in order to reduce the impact of alewife on the fish community. The stocking program had the intended effect; in the 1970s and 1980s, the abundance of alewife decreased while the salmonids increased in Lake Michigan (Madenjian *et al.* 2002). Overall, alewife abundance, growth rate, and condition did not exhibit any remarkable trends between 1984 and 1995 (Madenjian *et al.* 2003). However, one recent study compared the energy density (*i.e.*, the amount of energy stored per unit mass) of alewife from 1979 to 1981 and from 2002 to 2004 (Madenjian *et al.* 2006). The authors found that the energy density of alewife had declined by 23% between the two periods. The decline in energy density was attributed to the disappearance of *Diporeia* spp., which occurred after the introduction of zebra and quagga mussels to the lake (Madenjian *et al.* 2002). Alewife biomass, based on bottom trawling, increased from 23 kt (1,000 kt = 1 billion kg) in 2000 to 62 kt in 2002 and then decreased to 14 kt in 2004 (Madenjian *et al.* 2008b). Adult alewife condition (i.e., weight to length relationship) decreased in 1995 and has remained at a low level since then. Specifically, average condition during 1995 - 2004 was about 13% lower than the average condition during 1984 - 1994 (Madenjian *et al.* 2008b). In addition, alewife weight-at-age decreased during the 1990s (Madenjian *et al.* 2003). The decrease in alewife growth and condition during the 1990s has been attributed to a decline in *Diporeia* spp. abundance (Madenjian *et al.* 2003).

B. Round Goby

Zebra mussels create a new type of benthic habitat that actually facilitates the success of other invaders from Eastern Europe. The round goby invaded shortly after zebra mussels, aggressively occupying mussel beds and displacing native near shore fishes. Round goby populations are increasing as the species spreads throughout nearshore habitats in Lake Michigan. This ability of one invader (the zebra mussel) to create favorable ecological conditions for additional invaders like the round goby is sometimes referred to as an "invasional melt-down" (Ricciardi 2001). As with alewife and rainbow smelt, round gobies are becoming important components of local food webs where they displace native sculpin, darter, and minnow species. In many areas, round goby have become a prey resource that fosters increased populations of smallmouth bass and its growing recreational fishery.

III. PREDATOR SPECIES

A. Salmonids

There were attempts to establish Atlantic and Pacific salmon species in the Great Lakes through stocking during the early part of the 20th century. None were successful. In the early 1960s, fishery scientists intensified Pacific salmon stocking in Lake Michigan. They hoped to use salmon as a biological control agent for the alewife problem while establishing a valuable recreational fishery to replace the extirpated lake trout. Coho, chinook, and steelhead salmon were specifically selected because their distribution and behavior offered the greatest potential for predatory impact on alewife.

By the late 1980s, stocking rates approached 15 million juvenile salmon and trout per year with lake trout accounting for about 25% of the total. The results were remarkable. Alewife populations declined to much less than their former abundance, abating the massive die-offs. In response, native fishes including the deepwater cisco (also known as bloater chub) and some sculpin species exhibited strong evidence of recovery (Madenjian *et al.* 2002). Zooplankton community structure returned to dominance by large *Daphnia* and, during the middle 1980s, developed to levels where grazing on phytoplankton by zooplankton promoted a two-fold increase in summer water clarity relative to times when alewife were most abundant (Kitchell and Carpenter 1987, Kitchell *et al.* 1988).

For two decades following the mid-60s, salmon stocking increased in response to public demand and the demonstrated success in Lake Michigan (Kitchell and Sass 2008). Waterfront hotels, restaurants, boutiques, and marina developments prospered as anglers traveled from distant states such as Oregon, Washington, and Iowa. Coastal towns experienced an economic boom based on a new recreational fishing industry estimated at 3-4 billion dollars in annual revenues for the Great Lakes (Talhelm 1988). Although resource economists argue about the dimension and sources of this economic development, nearly all agree that the reversal of a devastated fishery to one with a substantial public value was a miracle of fishery management.

Salmon stocking practices presented two ecological challenges. First, because of strong public encouragement, salmon abundance was not largely determined by the prey resource base, but by the rate at which legislatures and fishery management agencies could allocate funds for hatchery development. This system is uncoupled from natural predator-prey abundance cycles, effectively making prey highly vulnerable to over-exploitation because of artificially high predator abundances. Early cautions about the consequences of over-stocking the system (Stewart *et al.* 1981) were generally disregarded due to the rising wave of public support.

Salmon stocking succeeded in controlling alewife in Lake Michigan. By the 1990s, adult densities were reduced to 10-20% of the peak abundance observed in the 1960s. Based on a mixture of advice and evidence, managers constrained and reduced stocking rates to levels that continue to both support recreational fisheries and reduce the adverse ecological effects of alewife. Along the way, a profound event confirmed this wisdom. In the 1980s, large numbers of dead or dying adult salmon appeared on local beaches shortly after the highest stocking rates on record (Kitchell and Sass 2008, ILDNR 2005). Two interactive components were deduced as cause and effect. Intensive salmon culture practices promoted the development and spread of bacterial kidney disease (NOAA 2005). This disease killed many fish already stressed by an insufficient supply of alewife prey. In the public eye, dead alewives were replaced by dead salmon. That was not a desirable outcome. Managers recognized the consequences of density-dependent constraints and the disease outbreak that followed, and reduced stocking levels accordingly. Lake Michigan now sustains the highest salmon catch rates on record (Clapp and Horns 2008, WDNR 2008). Reduced salmon stocking rates actually produced better fishing.

During the most recent decade, researchers documented a substantial recruitment of juvenile salmon from streams and rivers where salmon had naturalized and developed self-sustaining reproduction. Currently, naturally produced salmon recruits (especially chinook) may be 30% or more of the predator population and that proportion is increasing (Bunnell *et al.* 2006). In response to this, fishery managers have reduced stocking by about 25% and will continue to evaluate that practice as new information comes from studies of natural recruitment. Recent reports of a "collapse" of alewife populations in Lake Huron are associated with a marked increase in recruitment of salmon from naturalized populations (Riley *et al.* 2008, U.S. EPA 2008). In addition, the effects of zebra and quagga mussels have reduced pelagic productivity and benthic invertebrate abundance. There is growing concern about similar developments for Lake Michigan (Bunnell *et al.* 2006).

The second ecological challenge presented by salmon stocking practices of the mid-60s through the mid-80s revolved around the conflict created by the general goal of restoring native fish communities. Like any ecosystem, the ecological productivity of these lakes is limited. Eventually, heavier stocking of hatchery-reared fish can exceed the ability of existing food webs to support these top predators. Although additional salmon initially filled an ecological vacuum, they soon began to encounter ecological constraints. Too many salmon and trout can yield too few alewife, creating intensified competition among the stocked predators.

Lake trout stocking continues in Lake Michigan where fisheries biologists hope to restore a naturally reproducing population. However, public enthusiasm for the salmon fishery constrains this restoration effort, reflecting the finite productivity of the food web and trade-offs among management efforts. The same dilemma persists in Lakes Huron, Erie, and Ontario.

Unlike Lake Michigan, the residual populations of lake trout (*Salvelinus namaycush*) in Lake Superior are established and sustain a full recovery of native stocks (Kitchell *et al.* 2000). Like Lake Michigan, salmon stocking in the other lakes created an expectant public whose angling preferences continue to favor salmon. The most recent analysis of predator-prey interactions in Lake Superior concludes that the top of the food web is at or near carrying capacity owing to the recovery of native lake trout populations and natural recruitment of other salmonids from stream systems. In a general sense, Lake Superior now stands as a victory in the long-term efforts to restore native fish populations (Negus *et al.* 2008)

Five species of salmonids (the family Salmonidae includes trout and salmon) are currently stocked in Lake Michigan. Lake trout is a native species; however, the native population has been severely diminished (Sommers *et al.* 1981). Three non-native species are stocked: chinook salmon, coho salmon, and rainbow trout. In addition, brown trout (*Salmo trutta*), a stream trout introduced from Europe, is now naturalized; it is therefore deemed native to the lake and is also stocked (Bunnell *et al.* 2006). Most of the introduced salmonids have now established some degree of self-sustaining population in the Great Lakes. In terms of biomass, salmonids increased from 1965 to 1986 and declined in the late 80s. The decline was attributed to a reduction in the number of chinook salmon due to the outbreak of BKD. Biomass of chinook salmon increased again from 1994 to 1998 due to reduction in mortality rates caused by the BKD (Madenjian *et al.* 2002). All salmonids predominantly prey on alewife, rainbow smelt, and, to some extent, bloater (Madenjian *et al.* 2002). As the relative abundance and condition of prey species change through time, salmonids can be affected. For example, the decline in energy density of alewife due the recent declines of *Diporeia* spp. requires chinook salmon to consume 21% more alewife to reach 8 kilograms by age-4 (Madenjian *et al.* 2005).

The following section elaborates the life history attributes of these salmonine fishes. Primary sources for this review include Hubbs and Lagler (1949), Scott and Crossman (1973) and Becker (1983).

1. Lake Trout

a. Life History

The lake trout is the largest trout native to the Great Lakes. Lake trout maximum lifespan has been estimated at about 20 years.

Lake trout are iterparous, that is they can spawn many times in a lifetime (Becker 1983). Spawning takes place from mid-October to mid-November on rocky bars in waters from a few inches to around 100 ft deep. After spawning, lake trout disperse at various depths and may, over the course of an annual period, move as much as 100 miles (Becker 1983). Young lake trout become sexually mature at 6 or 7 years of age.

Lake trout prefer cold water. As the ambient lake water warms and thermal stratification develops, the fish seek colder temperatures available at the thermocline or in the hypolimnion. Lake trout are most active at temperatures between 44°F and 53°F and prefer water temperatures between 45°F and 55°F. Peak activity occurs at 51°F. Spawning has been reported between 48°F and 57°F. In general, they prefer temperatures around 50°F, but can alter their habitat preferences to account for changing abundances of prey (Hrabik *et al.* 2006, Jensen *et al.* 2006).

During the winter, the highest densities of lake trout are found in water from 100 to 240 ft deep. Lower numbers are found in shallower water from 75 to 100 ft deep. In spring and early summer, lake trout are predominantly found in waters between 30 and 150 ft deep. In the Great Lakes, they are usually most abundant in depths between 100 and 300 ft (Becker 1983).

Lake trout are predaceous and feed upon a broad range of organisms including freshwater sponges, crustaceans, aquatic and terrestrial insects, and many species of fish, including alewife (Scott and Crossman 1973). Invertebrates, like *M. relicta* and *Diporeia*, are especially important in the diet of young lake trout (Becker 1983).

b. Status

The lake trout population native to Lake Michigan was extirpated in 1950. Although successful lake trout reproduction has been documented since the re-stocking program began, there is no evidence that this reproduction is contributing to the adult population. Stocking of lake trout fingerlings in Lake Michigan predominantly occurs on offshore reefs, although some stocking also takes place in selected harbors (Burzynski 2005). Lake trout are avidly sought by both commercial and sport anglers. Harvests of lake trout continue to be at issue owing to Treaty Rights deliberations with Native American tribes.

2. Coho and Chinook Salmon

Coho and chinook salmon are not native to the Great Lakes, but both now exhibit natural reproduction and are considered naturalized members of the fish community. Both have a semelparous life history; that is to say they spawn only once in a lifetime.

a. Life History

Coho salmon become sexually mature after approximately three years, and die after spawning. The annual spawning migration begins in late October and spawning generally takes place in late November. The average number of eggs spawned per adult is around 3,800. The eggs hatch the spring after spawning and the young remain in the gravel for 2-3 weeks. After spending approximately one year in their natal streams, fry migrate out into the lake in May. Natural reproduction is successful but may not be sufficient to support populations at levels desired by the angling public. In general, the current population depends on restocking.

Adult coho and chinook salmon generally concentrate at stream mouths in late summer and early fall before entering streams to spawn (Goodyear *et al.* 1982). Generally, spawning runs peak in September and October. Chinook salmon spawn in streams over beds of large gravel, near riffles. Generally, within two weeks after spawning, adult Chinook salmon die. The following spring the eggs hatch and the young generally remain in the streams for one year before they migrate to the lake.

As sexual maturation develops, coho and chinook salmon become active after the ice melts in the spring and forage very intensively throughout the summer. Like lake trout, they respond to thermal stratification by seeking cooler temperatures during the summer period. Coho salmon's preferred optimum temperature is around 54°F. Chinook salmon prefer slightly lower temperatures around 52°F.

Local upwelling events may affect the temperature distribution and, in turn, the vertical distribution of coho and chinook salmon in the lake's water column. During the winter and early spring, most salmon are found in the southern portion of the lake in coastal areas to depths up to 140 ft. In other seasons, salmon are mainly found in waters up to about 60 ft deep (Sommers *et al.* 1981).

Young chinook and coho salmon in freshwater feed on terrestrial insects, crustaceans, chironomid larvae, pupae and adults, corixids, caddisflies, stoneflies, beetles, mites, spiders, aphids, and ants. Fishes make up the bulk of the food of salmon older than age 1. Alewives and rainbow smelt are the main diet components for adult coho and chinook salmon.

b. Status

Chinook salmon was first stocked in Lake Michigan in 1967. Hatchery-reared fingerlings (age 6 months) are commonly stocked in harbors and rivers. Chinook salmon is naturally an oceanic anadromous species, but has established a substantial and growing self-sustaining population in Lake Michigan (Burzynski 2005). Growth rate of chinook salmon during the early years of stocking was remarkable, but declined during the early 1980s, but then increased during the late 1980s and early 1990s (Madenjian *et al.* 2002). Natural recruitment of chinook salmon increased from 1970 to present and in 2004 natural recruits were estimated to account for 50% of the lake population (Claramunt *et al.* 2008).

Stocking of coho salmon into Lake Michigan has been a management practice since 1966 (Becker 1983, Sommers *et al.* 1981). Yearling and fingerling coho are stocked in a combination of harbors and rivers (Burzynski 2005). Three key factors prevent coho salmon from fully establishing in Lake Michigan tributaries; these are cold winter temperatures, lack of suitable gravel habitats, and varying water levels. Although some fraction of the population appears to be self-sustaining, an attendant problem with this species is the "over-spawning" behavior when rainbow trout excavate coho salmon nests to lay their own eggs.

3. Brown and Rainbow Trout

The brown trout is not native to the Great Lakes region. They were brought from their native Europe to the Great Lakes region more than a century ago and have successfully naturalized in stream, river, and lake habitats. They generally replaced the native brook trout in many areas because brown trout are more tolerant of and competitive in marginal habitat conditions (high suspended sediments and high temperatures) than brook trout, and because they grow to be important predators on brook trout and other native fish species (Becker 1983, Scott and Crossman 1973).

Rainbow trout were also not native to the Great Lakes region and were introduced more than a century ago from stream and river populations in the Rocky Mountain regions of the western United States. Like brown trout, they naturalized, but have habitat preferences that generally include clearer water and colder temperatures than brown trout (Becker 1983).

a. Life History

Brown trout spawn in late autumn to early winter. Temperatures during spawning are reported to range from 44 - 48°F. Spawning generally takes place in gravelly headwaters. The number of eggs deposited in redds depends upon the size of the female. The optimum temperature range for brown trout is said to be 65 - 75°F. In other words, they are among the most high-temperature tolerant of the salmonids (Becker 1983, Wismer and Christie 1987)

Brown trout spawn in streams in the fall. Many complete their life history in that habitat, but some are found near the stream outlets in spring and early summer and can migrate into Great Lakes habitats. Brown trout are carnivorous and eat a wide variety of organisms, particularly aquatic and terrestrial insects, crustaceans, salamanders, frogs, rodents and a variety of fishes (Becker 1983, Scott and Crossman 1973).

Brown trout have thrived and are firmly established in all of the upper Great Lakes. They are particularly unique in their tendency to aggregate near power plant plumes where they feed on prey fishes (especially alewife) and grow to remarkably large sizes relative to those that remain in streams (Becker 1983). Accomplishing such large sizes makes them attractive to anglers both in the nearshore areas proximate to power plants and in the rivers or streams when anadromous adults migrate to spawn.

Some populations of rainbow trout spend the entirety of their life history in streams and rivers or in lakes. Most of those taken by anglers derive from hatchery origins as there are relatively few populations capable of self-sustaining reproduction. These strains in Lake Michigan have a very different life history than those strains found in the Pacific coastal region of the United States.

The "steelhead" trout is an anadromous strain of rainbow trout first introduced to the Great Lakes several decades ago. In fact, the scientific name of rainbow and steelhead trout has recently been changed from *Salmo gairdnerii* to *Oncorhynchus mykiss,* reflecting the view of fish systematists and taxonomists that this fish is more closely related to the salmon species (genus *Oncohrynchus*) than to trout species. Although rainbow and steelhead share the same scientific name, the distinction between them is based on common names. The trout that are caught in lakes are referred to as Rainbow; those anadromous strains that spend most of their life history in ocean or the Great Lakes, but migrate into streams or rivers to spawn are referred to as Steelheads.

There are many life history strategies expressed by different strains of steelhead. Stocking different strains native to the Pacific coastal area became part of the management practice intended to control alewife because, like salmon, they all feed and grow in the Lake Michigan habitat, are effective predators of alewife, and have strong appeal to the angling public. The harvest of steelhead increased during the late 1980s and remained relatively high during the 1990s (Madenjian *et al.* 2002).

In general, most strains spawn primarily in tributary streams in the spring, although the spawning migrations may begin in spring, summer, or fall and some strains are reported to be spawning in the fall. Managers have supported the practice of stocking several strains because the different spawning migration behaviors and timing makes fish available to nearshore anglers for extended periods of time. As might be expected, the early life history characteristics of stream residence and out-migration to the lake are also strain-dependent. The young trout may migrate to the lake in the first summer after hatching or remain one to three years in the home stream before migrating. Unlike coho and chinook, not all steelhead die after spawning and some may live to reproduce for up to five successive years. As might be expected from the differences in strains, temperature tolerances and preferences cover a wide range. In general, however, brown trout tolerate and prefer warmer temperatures than rainbow or steelhead strains.

b. Status

Both brown trout and rainbow or steelhead are firmly established in each of the Great Lakes. Current populations of trout adults in Lake Michigan are heavily subsidized by stocking policies intended to both control alewife populations and provide support to angler interests. Suitable spawning habitat is probably insufficient to allow self-sustaining populations comparable to the current levels in Lake Michigan.

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APPENDIX C

ECONOMIC ASSESSMENT OF INSTALLING WEDGEWIRE SCREENS AT POINT BEACH NUCLEAR POWER STATION

Prepared by

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Economic Assessment of Installing Wedgewire Screens at Point Beach Nuclear Power Station

Prepared for Florida Power & Light
Point Beach Nuclear Plant, Wisconsin
Under Subcontract to AKRF, Inc.

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I. Introduction and Overview

This report analyzes the costs and benefits of installing 1.75 mm wedgewire screens to reduce impingement of alewife fish at the Point Beach Nuclear Plant ("PBNP") in Wisconsin. Our analysis builds on engineering estimates developed by Alden Research Laboratories (Alden 2007) and biological estimates developed by AKRF, Inc. (Heimbuch 2009). We use standard economic methods, drawing on guidance from the U.S. Environmental Protection Agency ("EPA") and the Office of Management and Budget ("OMB"), to convert the engineering and biological estimates into monetized social costs and benefits.

A. Background on PBNP

PBNP is located near Two Rivers, Wisconsin on Lake Michigan, roughly 100 miles north of Milwaukee. The plant is owned by FPL Energy, LLC ("FPL"). The generating plant consists of two pressurized water reactors, each with net capacity of approximately 500 megawatts. As a nuclear generating station, PBNP has low marginal costs relative to fossil-fired generating units. As a result, it provides base-load generation service, generally operating at full capacity other than during scheduled outages for refueling and routine maintenance and during unplanned outages. The plant began commercial operation in 1970; Units 1 and 2 are currently licensed by the Nuclear Regulatory Commission ("NRC") to operate through 2030 and 2033, respectively.

B. Overview of Report

The remainder of this report is divided into four chapters.

1. *Chapter II* analyzes the costs of the wedgewire screens, including capital costs, operating and maintenance costs, and costs associated with replacement of electricity that would be lost at PBNP due to downtime during construction.

2. *Chapter III* summarizes our estimates of the social benefits of the wedgewire screens. We review the various types of benefits that EPA has identified as potentially applicable to evaluations of cooling water intake structures and conclude that the primary potential

benefits are associated with increased catch of various species. Using economically sound methods, we value this increased catch and compute the overall benefits of wedgewire screens.

3. *Chapter IV* uses the results from the previous two chapters to compute the net costs (costs minus benefits) of the wedgewire screens. We also consider the potential impacts of non-quantified benefits and costs.

4. *Chapter V* analyzes uncertainties in the estimates of costs and benefits. We perform various sensitivity analyses designed to determine how robust our conclusions are regarding the net costs (costs minus benefits) of wedgewire screens.

II. Costs of Wedgewire Screens

In this chapter we summarize cost estimates from two sources: EPA's 2004 estimate made in conjunction with the Section 316(b) final Phase II rule (USEPA 2004a) and an analysis by Alden Laboratories (Alden 2007) for Wisconsin Electric Power Company. Based on those two sources and updated information on the cost of replacement power during the construction outage period, we develop "base-case" estimates.

Section A provides a brief review of basic economic principles for measuring costs. Section B compares the EPA and Alden estimates. Section C summarizes the estimates we have adopted for our "base case." Section D addresses the appropriate time horizon for the analysis and summarizes our cost estimates in terms of present values and annualized costs.

A. Overview of Relevant Costs of Technology

In estimating costs, we take the standard economic approach of measuring costs to society as a whole ("social costs"). This approach is consistent with sound benefit-cost methodology and the approach set forth in the EPA *Guidelines* (EPA 2000).

A complete assessment of the total social cost of an action (e.g., a regulation or a set of permit requirements) would encompass all social opportunity costs, as noted in the EPA *Guidelines*:

> The total social cost is the *sum* of the opportunity costs incurred by society because of a new regulatory policy; the opportunity costs are the value of the goods and services lost by society resulting from the use of resources to comply with and implement the regulation, and from reductions in output (EPA 2000, p. 113, emphasis in original).

The EPA *Guidelines* describe five basic components of total social costs (EPA 2000, pp. 113-114):

1. *Real-resource compliance costs* consist of the actual costs of the additional social resources (e.g., materials for control equipment, labor for the operation of control equipment, and resources related to changes in production processes and product markets), including unpriced social resources, that affected entities would use as a result of the proposed action.

2. *Government regulatory costs* are the costs to the government of monitoring, administering, and enforcing compliance with the proposed policy.

3. *Social welfare losses* are losses in producer and consumer surplus attributable to the proposed policy's effects on prices and the production of goods and services.

4. *Transitional costs* include the value of any displaced resources and the costs of reallocating these resources (e.g., the cost to society of the dislocation caused by unemployment).

5. *Indirect costs* include any adverse effects on product quality, productivity, innovation, and indirect market effects that would result from the policy in question.

The first component—the real-resource costs of compliance—typically is the most significant component of total social costs, as EPA *Guidelines* note:

> The largest fraction of direct social costs arises from the real-resource costs due to the new regulation. These new compliance costs arise from the installation, operation, and maintenance of new capital equipment, or are a result of changes in the production process that raise the price of producing the good (EPA 2000, p. 119).

B. Comparison of EPA and Alden Estimates of Costs

We consider costs associated with installing and maintaining wedgewire screens. These costs include the costs of any studies required prior to construction, up-front capital costs to design and build the screens and supporting structures, the cost of providing replacement power if PBNP must be shutdown for some period during construction/installation, and ongoing operating and maintenance (O&M) costs for the new equipment.

Columns (1) and (2) of Table 1 summarize EPA's and Alden's cost estimates. (We discuss column (3), NERA's base-case estimate, in the next section.) Both include estimates for the capital costs of constructing the necessary structures and purchasing and installing the relevant equipment. However, EPA's estimate is almost triple Alden's, $21.7 million vs. $7.6 million.[1] Our understanding is that this difference reflects in significant part the fact that Alden assumed that a simpler offshore structure than EPA assumed could be used to house and clean the screens.

Table 1. Alternative Estimates of Capital and Net Operating Costs of Wedgewire Screens at PBNP

Item	EPA	Alden	NERA Base Case
	(1)	(2)	(3)
One-time costs			
Capital costs	$21,577,012	$7,577,625	$7,577,625
Pilot study	$2,624,858	NE	$2,624,858
Revenue loss/replacement power	$58,976,199	$32,850,000	$29,456,229
Total one-time costs	$83,178,069	$40,427,625	$39,658,712
O&M costs (annual)	$103,689	$311,000	$311,000

Note: All entries are in 2006 dollars.
"NE" = "not estimated"

Source: "EPA" based on U.S. EPA (2004a), as adjusted in Attachment A.
"Alden" from Alden (2007).
"NERA base case"—see text.

Moving to the second line of the table, EPA estimates that a pilot study prior to construction would cost $2.6 million. Alden did not include costs for such a study.

The third line—the cost of replacement power—is by far the largest in both estimates. It reflects the fact that during part of the construction, it would be necessary to shut down the plant. Some of the shutdown period could be scheduled to coincide with scheduled refueling periods, and hence would not represent a net loss in output. EPA assumes that the net remaining outage period would be 11 weeks, while Alden assumes a 2 month outage would suffice. The appropriate way to value the lost output is to estimate the cost of replacing it with additional generation at other plants. EPA estimated replacement costs using a model of electricity

[1] Using EPA's recommended procedure, we adjusted EPA's estimates of capital and O&M costs based on differences between the flow used in EPA's calculations and the actual flow for the plant. We also updated EPA's estimates to 2006 dollars to be comparable to Alden's estimates. See Attachment A for the details of these adjustments.

dispatch, averaging costs over a year and subtracting operating costs that might be avoided at PBNP during the shutdown period (USEPA 2004a). Alden used a value of $50/MWh based on historical pricing information for the Midwest Cinergy hub (Alden 2007, 42). In total, EPA's estimate of outage costs is 80 percent higher than Alden's, of which about 26 percent results from the longer outage period.[2] The remainder presumably reflects some combination of greater lost output and the use of higher electricity prices; the publicly available materials do not provide the details needed to apportion the remaining difference between those two sources.

EPA's estimate of total one-time costs is more than double Alden's, $83.2 million vs. $40.4 million. As shown in the last line, EPA's estimated annual operating costs are about one-third Alden's, $104,000 vs. $311,000.

C. NERA "Base-Case" Costs

In developing our estimates for our "base-case," we chose among the available alternatives based on several factors, including how site-specific the estimates are, how recently they were made, and the availability of updated information from reliable sources. Our estimates are based on the following:

1. *Capital.* We use Alden's estimates rather than EPA's, because they reflect more recent information and a more site-specific (though still "preliminary" and "conceptual") analysis of what is required.

2. *O&M costs.* For the same reasons, we use Alden's estimate.

3. *Pilot study* prior to construction. We use EPA's estimate because FPL has advised it would conduct such a study and only EPA estimated its cost.

4. *Replacement power costs.* We derive our estimate from two sources. For the length of the outage period and the average power lost per day of outage, we rely on Alden's estimates, which are more site-specific. Alden estimated the unit cost of replacement power based on historical wholesale generation prices. To update the unit value, we rely

[2] EPA assumes a net of 11 weeks = 77 days. Alden assumes a net of two months = 61 days. The ratio is: 77/61 = 1.262.

on forecasts from the Energy Information Administration's Annual Energy Outlook 2009 for the Mid-America Interconnected Network region, which includes PBNP. (See Attachment B for more details.) Based on those forecasts, we use a value of $45/MWh (in 2006 dollars), 10 percent less than Alden's estimate based on historical data.[3]

The last column of Table 1 shows the base-case estimates. Compared to Alden, we use a slightly lower unit cost for replacement power but include the cost of the pilot study. The net effect is that our estimate of one-time costs is slightly lower than Alden's and substantially lower than EPA's.

D. Discounting and Annualization

Some of the costs are incurred only once, during the construction period, while others recur over time. As shown in the next chapter, the benefits of the technology also recur over time and are estimated in annual terms.

There are two equally valid ways to combine one-time and annual costs:

1. *Present value*. Project all costs over the economic life of the project. Using an appropriate discount rate, compute the present value of all costs as of a common starting point, often the last year prior to the start of operation ("Year 0").[4]

2. *Annualization*. Using the same appropriate discount rate, amortize the capital and power-replacement costs over the economic life of the project, thus converting them to annual costs that can be combined with the annual operating costs to get total annualized costs.[5]

These two approaches yield equivalent results. The present-value results for each component of costs or benefits are simply a multiple of the annualized values, where the multiple reflects the

[3] The AEO historical data are consistent with the $50 per MWh estimate used by Alden (2007), but EIA projects slightly lower costs in the 2010-15 period.

[4] The present value of operating costs is simply $PV = \sum_{t=1}^{n} C_t /(1+r)^t$, where n is the number of years, C_t is the operating costs in year t, and r is the discount rate.

[5] The amortized value of the one-time costs is simply the annual amount such that its present value over the life of the installation is equal to the one-time capital and power replacement costs. screens are in operation. The annualized value is like an annual mortgage payment that is uniform over the life of the mortgage.

discount rate (the higher the rate, the lower the multiple) and the time horizon (the longer the horizon, the larger the multiplier).

For the discount rate, we follow OMB's *Guidance*, which recommends a default rate of 7 percent ("real," net of inflation) (OMB 1992). EPA used that value in its analysis, as did Alden. The appropriate time horizon is less clear. For reasons that we have not been able to identify, EPA chose to amortize capital costs over 10 years, but amortized the study costs and power replacement costs over 30 years. This approach is internally inconsistent and does not appear to have any basis in the economic lifetimes of the equipment. It assumes implicitly that all of the capital must be recreated (including construction of various permanent structures) every 10 years, but by using a 30-year period for power replacement costs it implicitly assumes that no outages would be required for complete reconstruction after 10 and 20 years. The 30-year amortization period for the costs of power replacement and the initial study also assumes that the plant would continue to operate for 30 years after installation of the new technology, which may not occur in light of licensing requirements and the age of the plant.[6]

We assume that the relevant ending date is when the recently renewed NRC operating licenses expire, which is October 2030 for Unit 1 and March 2033 for Unit 2 (USNRC 2005). The midpoint of those two expiration dates is the end of 2031, which for simplicity we assume applies to the plant as a whole. With respect to a starting date for operation of the screens, we note that if a decision were made to proceed, it probably would take three or more years from the time of the final decision to bring the wedgewire screens into operation, following the initial study (1 year) and the construction period (2 years). Thus, even if the process were to start in

[6] Alden (2006) uses a ten-year horizon for annualizing all one-time costs, including replacement power costs. Although this approach has the virtue of consistency, Alden provides no justification for assuming 10 years, other than the implicit one that EPA used 10 years to amortize capital costs (but not other one-time costs).

2009, the screens would not be in operation before 2012, leaving about 19 years until the NRC operating licenses expire and along with them the useful life of the screens.[7] Assuming, more realistically, that a final decision is still several years away, the effective lifetime would be further shortened, and might well be closer to 15 years. For simplicity, we assume a project lifetime of 20 years; compared to a shorter horizon that reflects likely delays beyond 2009 in reaching a final decision, this assumption reduces the annualized costs of the project because the one-time costs are spread over a longer period of time.[8]

Table 2 presents our base-case cost estimates and then shows their present and annualized values, both computed using a 7 percent discount rate and assuming a 20-year project lifetime. The present value of costs is about $43 million and the equivalent annualized value is about $4.1 million.

Table 2. Present and Annualized Values of Base-Case Costs

	Raw costs	Present value	Annualized
One-time costs	$39,658,712	$39,658,712	$3,743,502
O&M costs (annual)	$311,000	$3,294,738	$311,000
Total		$42,953,450	$4,054,502

Notes: All entries are in 2006 dollars.
Present values and annualized values computed using a discount rate (real) of 7 percent and a 20-year time horizon

Source: NERA calculations as explained in text.

Table 3 compares the NERA base-case estimates to equivalent estimates based on EPA's and Alden's estimates of one-time and annual costs, where the EPA and Alden estimates are converted to present and annualized values using a 7 percent discount rate and a 20-year horizon.

[7] Our estimates slightly understate costs because they assume implicitly that all of the up-front costs are incurred in "Year 0." However, the costs of the pilot study and many of the construction costs would be incurred earlier. Reflecting that fact in the present and amortized values would increase the effected cost to reflect the time value of money.

[8] In terms of present value, it increases costs and benefits, but increases the latter by a larger proportion because all benefits are annual, not one-time.

Table 3. Comparison of Base-Case Estimates to Alden and EPA Estimates Computed in Equivalent Manner

Source	Present value	Annualized
NERA Base case	$42,953,450	$4,054,502
EPA (adjusted)	$84,276,551	$7,955,110
Alden	$43,722,363	$4,127,082

Note: All entries are in 2006 dollars.
Present values and annualized values computed using a discount rate (real) of 7 percent and a 20-year time horizon

Source: NERA calculations based on values in Table 1.

III. Benefits of Reduced Impingement

The relevant social benefits are the values that individuals in society place on changes in fish populations that could result from the introduction of retrofitting various additional fish-protection technologies at PBNP. The EPA *Guidelines* provide a framework for assessing these benefits. The *Guidelines* emphasize an "effect-by-effect" approach (EPA 2000, pp. 62-66).

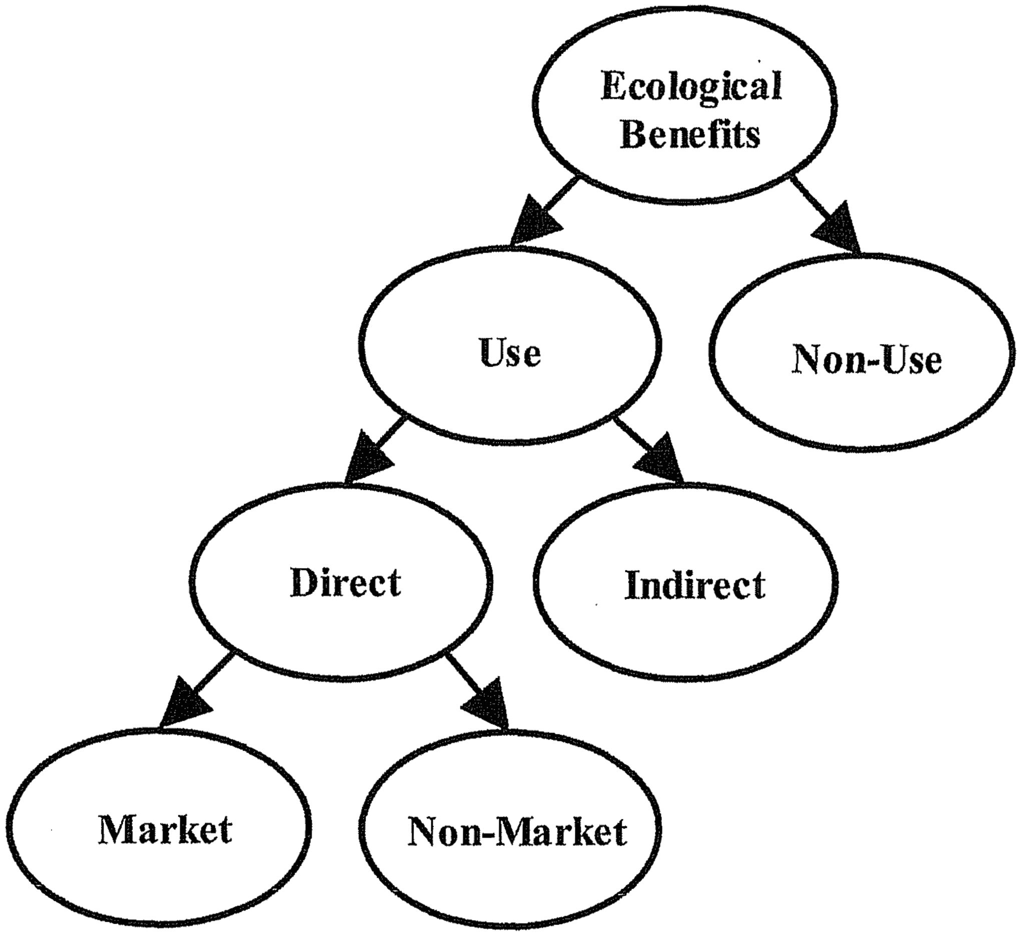
A. Potentially Relevant Benefit Categories

The EPA *Guidelines* provide a summary of the benefit categories relevant to an assessment of ecological benefits, which is the general category of benefits relevant to this assessment. We use the EPA *Guidelines* framework and the related framework in the EPA regional benefits analyses conducted as part of the §316(b) Phase II rulemaking (USEPA 2004b). These frameworks provide a systematic way to identify the potential types of benefits that may be generated.

Figure 1, reproduced from the *Guidelines*, provides a way of organizing the relevant categories based on how they are experienced. The figure divides the ecological benefits into two major categories: "use" benefits and "non-use" benefits.

1. Use benefits

Use benefits can be further subdivided into three subcategories—market benefits, non-market benefits, and indirect benefits. Of these categories, market benefits and non-market benefits are considered direct benefits because they involve direct benefits to users. The other category of use benefits, indirect benefits, relates to ecosystem benefits that accrue to users through indirect paths.



Source: EPA 2000.

Figure 1. Summary of Benefit Classification Scheme from EPA *Guidelines*

These three use-benefit categories cover the gains that individuals may obtain from use of the ecological resource, in this case the additional fish populations in Lake Michigan. The use benefits associated with the installation of the proposed technology would consist primarily of increased catches of fish. These effects may be direct—reduced impingement mortality among species valued by commercial or recreational fishermen). They also may be indirect—reduced mortality among forage species that are not valued directly by people, but which contribute indirectly through trophic transfer to the production of fish that are valued directly. Increased catch may have a market value if it is caught by commercial fisherman or a non-market value if it is caught by recreational fisherman.

2. Non-use benefits

The other first-level category—non-use benefits—consists of potential benefits that are not associated with any direct use by people. The classic example is Grand Canyon; some people may value the fact that Grand Canyon exists even if they will never visit the Canyon or make use of its resources in any other manner. Conceptually, their willingness-to-pay to preserve the Canyon would be a benefit of preserving the Canyon.

Unfortunately, non-use value is extremely difficult—many economists would say impossible—to measure, requiring the use of surveys that ask respondents directly about their willingness to pay[9] Such surveys are expensive to do well, and many economists are skeptical that even the best ones provide reliable information. (see, e.g., the papers collected in Hausman 1993). In its final Phase II rule making for Section 316(b), EPA did not estimate non-use benefits in any of its regional benefit-cost case studies.[10]

In this case, there is little reason to think that non-use values would be significant. As reported below, the potential changes in population are very small—and the fish primarily affected (both directly and indirectly) are not endangered or even native to Lake Michigan.[11] As a result, we see no reason to believe that non-use values would make a material difference, let alone justify the high costs of attempting to measure them.

[9] Specifically, EPA (USEPA 2000, p.84) notes that "contingent valuation is the only established method capable of estimating non-use values." Contingent valuation is a research method in which survey respondents are asked about their willingness to pay for a commodity.

[10] EPA notes that it did not perform a quantitative analysis "because of limitations and uncertainties associated with estimation of non-use benefits on a regional scale" (EPA 2004b, p. G5-1).

[11] Alewives are not native to Lake Michigan. Of the salmonids, only lake trout are native to the Great Lakes (Sea Grant Michigan 2008). Lake trout accounted for only 2 percent of the total recreational catch of salmonids in 2006.

B. Methods for Assessing Use Benefits

The primary benefits of reduced impingement mortality associated with PBNP are the direct and indirect increases in catch valued commercially or recreationally.

1. Valuation of changes in commercial catches

The marginal social benefit of an extra pound of fish caught commercially is the market price of that species minus the incremental costs of catching it.[12] The relevant price is the price at the dock. As the fish moves along the distribution change to ultimate consumers, its value rises, but that rise in value reflects value added at those other stages, not the value of increasing the catch, and is offset by costs incurred at those stages (e.g., fuel and labor to transport the fish from dock to distributor to retail outlet). For fish caught commercially and recreationally, the unit value for fish caught recreationally generally is significantly higher than the value if caught commercially.

To simplify the analysis, we make the conservative assumption that all of the increase in catch is recreational. This assumption biases the benefit estimate upwards, though not by a large amount in this case because commercial catches are a small fraction of the relevant totals.[13]

2. Valuation of changes in recreational catch

Fish caught recreationally do not have a market price. However, economists have developed techniques for estimating the value recreational anglers place on their catch based on "hedonic" methods that look at the tradeoffs that anglers make between going to sites with higher catches and the costs of getting to those sites (primarily travel costs, including the value

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[12] If the potential increase in catch were sufficiently large that it would change (reduce) the market price, we would have to consider changes in consumers' surplus. However, the potential changes in catch, as discussed below, are a small fraction of the total and thus are unlikely to have a material impact on price. To the extent that prices would be driven down by increased supply, out estimates of the benefits are too *high*.

[13] In 2006, approximately 98 percent of catch by weight was recreational in 2006 among the predator species relevant to this assessment.

people place on time lost to travel). The travel costs themselves are not counted as benefits, as the value they represent to anglers is offset by the cost to the angler of the travel. However, using statistical techniques economists can estimate how much surplus anglers receive. There are two basic variants of inferring demand for increased catch (or changes in other characteristics of sites) from data on observed travel behavior. One is called the "Travel Cost Method" (TCM) and the other is the "Random Utility Model" (RUM) (Freeman 2003).

Rather than conduct original TCM or RUM studies, policy analyses usually use existing studies to estimate values. This approach, called "benefits transfer," may employ one of several different methods, depending on the data and resources available. According to EPA's *Guidelines*:

> [A]nalysts will [often] need to look for estimates available from existing sources, and apply these values to the policy case using benefit transfer techniques . (EPA 2000, p.95)

Although EPA endorses meta analysis as the most desirable method of combining results from multiple studies (via a formal statistical analysis) for purposes of benefit transfer, such analyses can be difficult and time-consuming to conduct, in part because published studies often do not include some key information needed to conduct a meta-analysis. In such cases, the study either must be dropped or the additional information must be obtained from the study's author(s). Here we adopt a simpler strategy that estimates benefits using results from each of several studies that have generated estimates for the relevant species (including salmonids) and water bodies (the Great Lakes) and then uses the average for the base case. To the extent that the various studies all point to the same conclusion, there is little to gain from performing a full-fledged meta-analysis that would enable narrowing the range of estimates.

3. Replacement Costs Are Not a Valid Measure of Benefits

Before turning to specific empirical estimates, we note that the use of "replacement-costs" (e.g., the cost of replacing impingement losses with the equivalent number of hatchery fish), although used sometimes to estimate benefits, is *not* among the methods recommended in EPA's *Guidelines* (USEPA 2000) for estimating benefits and has not economic foundation. When applied to hatchery fish costs, this method assumes that if the technology under consideration is less costly than the cost of replacing the lost fish, then the technology provides positive net benefits. However, this approach confuses costs with benefits and often leads to mistaken conclusions. Economists are in agreement that replacement costs are not a valid measure of benefits except in very narrow circumstances that do not apply here.[14] We provide a more complete discussion of these issues in Attachment C.

C. Estimated Increases in Catch from Use of Wedge-Wire Screens

The 1.75 mm wedgewire screens primarily would affect impingement losses at PBNP, and DNR's comments focus on impingement losses (Heimbuch 2009). The vast majority of the fish currently impinged at PBNP are alewives or alewife-type fish (which for convenience we refer to collectively as "Alewives"), which accounted for over 99 percent of the number of fish impinged in 2006 (Heimbuch 2009).

1. Current Potential Losses to Impingement

Alewives in Lake Michigan are not pursued by commercial or recreational fisherman. However, they are forage fish for various predator species, including various types of salmon and

[14] As discussed further in Attachment C, some of the case studies accompanying EPA's 2002 proposed Phase II rules under 316(b) used replacement-cost measures—hatchery costs or habitat replacement costs (HRC), However, it received large numbers of negative comments from economists. When the final rule was issued in 2004, EPA dropped the use of those methods. In responding to comments, EPA acknowledged multiple times that "the HRC and hatchery costs are costs of replacement and not benefits" (USEPA 2004c, e.g., p. 105)

trout. Experts in fishery biology at AKRF, Inc., estimate that the impact of Alewife impingement on predator species is about 18,640 lbs/year (Heimbuch 2009). Not all of the fish comprising this weight would have been caught. To be conservative, however, in valuing the fishing gains we assume that all of them would have been caught (with some caught and then released by sport fishermen).

This total represents only about 0.2 percent of the reported annual harvest of large predators (i.e., Chinook salmon, Coho salmon, lake trout, brown trout, brook trout, rainbow trout, walleye, burbot, and pike) of 10.0 million lbs per year in Lake Michigan[15] (GLFC 2007). Of the total, about 98 percent is salmonids (salmon or trout). For simplicity, we assume that all of the predators affected are salmonids. AKRF estimates that about 98 percent of the lost catch is recreational; for convenience, we assume all of the gains are recreational, which results in a slight overstatement of the monetary gains because fish caught recreationally are valued considerably more than fish caught commercially.

2. Effectiveness of Wedgewire Screens

For purposes of this analysis, we assume that the screens would eliminate *all* losses of alewives due to impingement.

3. Lag in Receipt of Benefits

We also have been conservative in assuming that the impact of the screens on losses of sport fish would be instantaneous, when in fact the effects would be spread over multiple years because there are lags between reductions in the loss of alewives to impingement, the time before the alewives would have been consumed by salmonids, and the time before the salmonids would

[15]Note that in calculating this percentage, we are dividing the loss in total catch (including catch-and-release) by the total harvest of such fish (which does not include catch-and-release fish). As a result, this percentage overstates the actual percentage; impingement in fact causes an even smaller proportional reduction in catch.

have been caught by recreational anglers. When EPA accounted for such delays in its regional case study of the Great Lakes using a discount rate of 7 percent, it reduced benefits by 21 percent (USEPA 2004b); i.e., on average there was a lag of about 3.5 years.[16] For simplicity, however, we do not adjust for such delays, which results in higher estimated benefits.

D. Estimates from the Literature of the Marginal Value of Fish Caught Recreationally

As noted earlier, numerous studies have estimated the marginal value of increased recreational catches. In reviewing estimates from the literature, we have restricted attention to salmonids caught recreationally in the Great Lakes area.

Johnston et al. (2006) provide a useful summary of estimates of the marginal value of catching an additional fish from 48 different studies based on travel cost models (including RUMs). Many of these studies developed separate estimates for different species or groupings of species, yielding a total of more than 120 study-species pairs. Using information from the studies, supplemented with information obtained directly from the studies' authors where necessary, Johnston et al. converted all of the estimates to constant 2003 dollars per fish caught at the margin. These values represent the average willingness to pay of fishermen in the study to catch another fish, averaged across sites.

Some study-species pairs were estimated using more than one model or set of assumptions, in which case Johnston et al. report minimum and maximum values. Six of the studies summarized by Johnston et al. included estimates for salmonids among fisherman in states surrounding Lake Michigan. One of the studies (Lupi et al., 1997) reported estimates for two different species of salmon (Coho and Chinook) and two species of trout (Lake and

[16] $(1/1.07)^{3.5} = 0.79$.

Rainbow), and another reported separate estimates for salmon and trout separately; in both cases, we computed a weighted average for "Salmon/Trout." (See Attachment D for more details on the calculations.)

In addition to the Johnston et al. review of the literature, we also include estimates from two EPA studies. The first of these is an EPA regional case study of the Great Lakes conducted for the 316(b) final phase II rule issued in 2004 (USEPA 2004b). EPA used a random utility model, which it estimated using data from Michigan. The second EPA study (USEPA 2006) is a Great Lakes benefits assessment developed using a meta-analysis of the relevant literature; it was performed in support of the final phase III rule under 316(b).

Table 4. Summary of Estimated Values per Pound of Incremental Catches of Salmonids in Michigan and Wisconsin

	Value per pound (2006$)		
Study	**Minimum**	**Maximum**	**Point/Mid**
Breffle et al	$2.60	$5.21	$3.91
Lupi Hoehn Christie	$2.07	$2.84	$2.45
Murdock	$6.02	$6.02	$6.02
Samples and Bishop	$2.35	$2.35	$2.35
Besedin et al	$2.55	$2.89	$2.72
Lupi et al	$0.78	$1.67	$1.23
US EPA (2004)	$7.21	$7.21	$7.21
US EPA (2006)	$0.97	$1.71	$1.29
Average	$3.07	$3.74	$3.40
Minimum	$0.78	N/A	$1.23
Maximum	N/A	$7.21	$7.21

Note: All dollar values expressed in 2006 dollars.
All entries refer to salmonids (salmon/trout) overall, except Lupi Hoehn Christie (2003), which provides an estimate for lake trout only.
"N/A" indicates that value was not computed because it is not applicable to deriving the range of values.
Source: See Attachment D.

For each estimate, we converted the value per fish to a value per pound, based on a weighted average of weight per fish caught in Lake Michigan. We also updated the estimates to 2006 dollars using the GDP deflator. Attachment D presents the steps followed in detail. The results are shown in Table 4. The point estimates range from $1.23/lb (Lupi et al. 1997) to

$7.21/lb (USEPA 2004b), with a mean of $3.40/lb. If we look at the full ranges (the minimum of the studies' individual minimums and the maximum of the maximums), the same two studies yield the lowest and highest values—$0.78/lb and $7.21/lb, respectively. Note that these estimates are in terms of dollars per pound caught, and thus included catch-and-release as well as harvested fish.[17]

Arguably the 2006 EPA study, which is a meta analysis of multiple studies, should receive equal or greater weight than the Johnston et al. combined estimates (including the EPA 2004 estimate, which was not a meta analysis), rather than be treated as just another study. Doing so would sharply lower the values, because the 2006 EPA estimate is relatively low. In particular, if we averaged the 2006 EPA meta-analysis with the average of the other studies in Table 4, the result would be a mean of $2.49/lb., or 27 percent lower than the estimate of $3.40 shown in Table 4. Thus, our treatment of the EPA 2006 study is conservative and is likely to overstate the benefits.

E. Summary of Benefit Estimates

To calculate estimated annual benefits, we multiply the estimated number of additional pounds of catch by the value per pound. In the base case, the estimated gain in catch due to the screens is 18,640 pounds and the average value per pound is $3.40, for annualized benefits of about $63,000. Converted to present value over 20 years at 7 percent, the value is about $671,000. Even if we use the highest estimate, EPA's value of $7.21 per pound, annual benefits are less than $135,000, with a present value of just over $1,400,000. At the low end, using $0.78

[17] Based on an email exchange with Johnston on January 8, 2009, we understand that the catch rates used in the Johnston et al. meta analysis include catch-and-release as well as fish caught and kept. Similarly, the EPA study used figures on total catch, including catch and release.

per pound from the low end of the Lupi et al. 1997 study, annual benefits are about $14,600, with a present value of about $155,000. Table 5 summarizes the results.

Table 5. Summary of Estimates of Benefits: Base Case, High, and Low

Case	Value per Pound	Annual	Present Value
Base Case	$3.40	$63,328	$670,895
High	$7.21	$134,460	$1,424,468
Low	$0.78	$14,589	$154,551

Note: All values in 2006 dollars.
Present values computed using a discount rate (real) of 7 percent and a 20-year time horizon
Source: NERA calculation as explained in text.

IV. Benefit-Cost Comparison and Qualitative Assessment

In this chapter, we first compare the quantified costs and benefits under our base-case assumptions. As shown in Section A, the costs are many times greater than the benefits. Section B provides a qualitative assessment of potential benefit categories that were not quantified; we find that such benefits, if quantified, likely would not have a material effect on the conclusions, either because the benefit category is not applicable to this case or because any benefits in the category are likely to be insignificant.

A. Net Benefits (Costs) of Wedgewire Screens

It is well accepted among economists and policy analysts that net benefits—benefits minus costs—is the appropriate measure for decision making by government agencies. In general, a project should not be selected unless it is expected to yield positive net benefits. That is because the alternative of doing nothing additional has, by definition, zero benefits and costs and hence zero net benefits.

Table 6 compares estimated costs and benefits on both a present-value and an annualized-value basis. Costs are roughly 60 times as great as benefits, resulting in large positive net costs on both present-value and amortized value bases. For ease of exposition, because our analysis yields negative net benefits, we report net costs (costs minus benefits) rather than net benefits. Net costs are the same as net benefits in terms of magnitude, but the sign is reversed.

Table 6. Comparison of Costs and Benefits of Wedgewire Screens

Item	Annualized	Present Value
Costs	$4.05	$42.95
Benefits	$0.06	$0.67
Net Costs	$3.99	$42.28

Note: Values in millions of 2006 dollars.
Source: NERA calculations.

B. Non-quantified Costs and Benefits

The basic steps in the benefit-cost analysis presented above include identifying the proposed project, determining the effects of the project, valuing the positive effects (benefits) and negative effects (costs) to the extent feasible in dollar terms, and calculating the net costs or net benefits. It is also important to consider the potential effects that are not estimates in monetary terms. Both EPA and OMB recommend describing omitted effects qualitatively and evaluating the implications of omitting these factors when presenting the overall results. EPA notes:

> ... following a net benefit calculation, there should be a presentation and evaluation of all benefits and costs that can only be quantified but not valued, as well as all benefits and costs that can be only qualitatively described (USEPA 2000, p. 177).

Similarly, OMB states:

> A complete regulatory analysis includes a discussion of non-quantified as well as quantified benefits and costs. A non-quantified outcome is a benefit or cost that has not been quantified or monetized in the analysis. When there are important non-monetary values at stake, you should also identify them in your analysis so policymakers can compare them with the monetary benefits and costs. When your analysis is complete, you should present a summary of the benefit and cost estimates for each alternative, including the qualitative and non-monetized factors affected by the rule, so that readers can evaluate them (OMB 2003, p. 3).

In this section we briefly discuss the omitted costs and benefits qualitatively and consider their effects on the overall results. In addition, as discussed in the next section, we also make several conservative assumptions regarding the benefits calculation that have implications for the overall results.

1. Qualitative Assessments of Non-Quantified Costs

Our analysis excludes several costs likely to be associated with installing wedgewire screens:

1. Our estimates of the costs of replacement generation (which is likely to be predominantly fossil-fired) include the costs of air pollutants covered by current cap-and-trade programs, but not the social costs of emissions of other "conventional" pollutants (such as fine particles).

2. Our estimates of the costs of replacement power do not include any accounting of CO_2 emissions, which contribute to global climate change. These could be valued using projected allowance prices under either a regional program (e.g., the proposed Midwest Greenhouse Gas Reduction Accord, of which Wisconsin is a member) or a possible future national cap-and-trade program.

3. Those estimates also do not include any potential losses of fish at plants providing replacement power.

4. There may be some adverse impacts on local areas from construction of the structures for the screens.

2. Qualitative Assessments of Non-Quantified Benefits

As noted in Chapter 3, our benefits assessment considers the relevant benefit categories described both in the EPA *Guidelines* (USEPA 2000) and in the §316(b) regional benefits analyses for Phase II and Phase III facilities (USEPA 2004b, USEPA 2006). It quantifies the relevant and significant benefits categories. Several other benefit components included in these two sets of documents are not included in the quantified benefits because, as discussed below, we judged them either to be irrelevant or unlikely to be significant relative to the benefits that are quantified.

a. Market Benefits

Market benefits in this case relate to commercial fishing. As discussed earlier, commercial fishing is of little importance in this case and we have assigned all catch to recreational fishing, which provides higher unit values. For example, we used a value of $3.40

per pound of fish, but boat-side market prices for salmon and trout caught commercially in Lake Michigan average less than $0.50 per pound.[18]

b. Non-market Direct Use Benefits

Our estimates cover all non-market direct-use benefits identified by EPA in its 316(b) Phase II case studies with the exception of "near-water recreation direct viewing." Such benefits are likely to be zero or near–zero because there is no reason to expect that marginal changes in fish abundance would affect the viewing experience on Lake Michigan.

c. Non-market Indirect Use Benefits

EPA's category of non-market indirect use benefits includes a large number of subcategories. Most of these subcategories are covered implicitly by our inclusion of indirect benefits associate with trophic transfer from alewives to salmonids. The other subcategories appear to be irrelevant in this case. The species involved are not endangered (Alewives are in fact an invasive species in Lake Michigan) and there is no reason to believe that a marginal (0.2 percent) change in the salmonid population would have any material impact on such categories of potential indirect use benefits as scientific research, TV shows or books on nature, or birdwatching.[19]

d. Non-use benefits

For the reasons discussed in Chapter II, there is no reason to expect the very small changes in fish populations to be associated with any material non-use values. In this case we

[18] The Great Lakes Science Center (GLSC 2008), a division of the U.S. Geological Survey, publishes total weights and values of commercial catch by species, lake, state, and year. GLSC reports that, in 2006, 242,283 pounds of salmon and trout were caught commercially on Lake Michigan (the vast majority of which was lake trout), with a total value of $85,689. The average commercial value was thus about $0.35 per pound.

[19] Notably, EPA's review of relevant studies did not find evidence of a connection between impingement and entrainment changes and bird populations: "...EPA's review of these studies did not reveal any documented linkages between I&E and effects on bird populations..." (EPA 2004b, p. A4-8).

have small direct changes in the numbers of a non-native species (Alewife) leading to very small indirect changes in the population of predator fish, amounting to about 0.2 percent of the total catch of salmonids in Lake Michigan.

e. Summary and Implications of Non-quantified Costs and Benefits

We conclude that the benefits we have quantified include the major benefits categories relevant to evaluation of the fish protection alternatives for PBNP. The other benefits components discussed above that are not quantified are not likely to be significant. None of these non-quantified benefit categories, individually or collectively, would be large enough to reverse the basic conclusion above—the costs of installing wedgewire screens would impose costs far in excess of the benefits.

C. Conservative Assumptions

Our base-case analysis incorporates various "conservative" assumptions that are likely to increase the estimated benefits and/or reduce the estimated costs:

1. We have assumed that all of trophic transfer would be to relatively highly valued species (salmonids).
2. We have assumed that all of the additional salmonids would be caught, when in fact many would not be caught.
3. We have assumed that all of the increased catch would be by recreational fishermen, who place a far higher value on fish caught than do commercial fishermen.
4. We treated EPA's 2006 meta analysis as simply another study, rather than giving it greater weight. In light of its relatively low estimates, giving it more weight would have lowered the point estimate of the value per pound.
5. We have assumed a 20-year time horizon, which is likely to exceed the actual economic life of the equipment. The longer the horizon, the more years over which capital and other one-time costs are amortized.

D. Conclusions Regarding Base-Case Results

Our base-case results suggest that the costs of requiring wedgewire screens at PBNP would exceed the quantified benefits by roughly a factor of 60. Although the quantified benefits do not cover all possible benefits, the omitted categories are unlikely to be significant relative to the large gap between quantified costs and benefits. Moreover, in several cases we have made "conservative" assumptions that are likely to overstate the actual benefits quantified.

V. Sensitivity Analyses

Our base-case estimates are based on the best available information or, in some cases, reflect "conservative" assumptions that are likely to overstate benefits or understate costs. As a result, we believe that our base-case estimate of net costs is more likely to be too low than too high. However, there is considerable uncertainty in the estimates of many of the components. In this chapter we test the sensitivity of the results to alternative assumptions, to see if there are any situations in which our basic conclusion would change.

A. The Importance of Evaluating Uncertainties

Economists and policy analysts have long recognized that benefit-cost analyses, no matter how careful and thorough, inevitably are subject to uncertainty because such analyses comprise multiple components, many of which cannot be estimated with certainty. Guidelines on benefit-cost analysis from both EPA and OMB address the importance of uncertainty analysis and ways in which uncertainty can be addressed.

1. EPA Guidelines

EPA's *Guidelines for Preparing Economic Analysis* states that "[t]he issue for the analyst is not how to avoid uncertainty, but how to account for it and present useful conclusions to those making policy decisions" (USEPA 2000, p. 27). EPA stresses the importance of assessing and describing uncertainty in economic analyses and recommends using sensitivity analyses and Monte Carlo analyses where possible. EPA's *Guidelines* stress the importance of accounting for uncertainty, but also recognize that consideration of all possible uncertainties is not possible. As a result, uncertainty analyses should focus on the most critical uncertainties, those most likely to make a material difference to decision makers:

> For most applied economic analyses, a full sensitivity analysis that includes every variable is not feasible. Instead the analyst must limit the sensitivity analysis to those input parameters that are considered to be critical or particularly important. (USEPA 2000, p. 28)

2. OMB Guidelines

In its most recent guidance for benefit-cost analyses conducted by federal regulatory agencies, OMB (2003) stresses the need to identify key elements underlying the costs and benefits estimates and present them as part of the analysis. OMB's guidelines also emphasize the need to characterize the sources and nature of uncertainty. The guidelines suggest reporting the expected value estimates of outcomes, key sources of uncertainty, and the sensitivity of results to important sources of uncertainty.

3. Sensitivity Analysis

Sensitivity analysis provides a means to determine the effects of uncertainties in different input parameters on the overall results—in this case, the net costs of the wedgewire screens. The purpose of a sensitivity analysis is to acknowledge underlying uncertainties. In particular, it should convey how sensitive predicted net costs are to changes in assumptions. If the sign of net costs does not change when we consider the range of reasonable assumptions, then our qualitative conclusion is robust and we can have greater confidence in it (Boardman et al. 2001, p. 166).

Sensitivity analysis involves varying key input parameters, one at a time and in combination, over appropriate ranges to determine their effects on net costs (Boardman et al. 2001). If the basic conclusions of the analysis are robust over a wide range of sensitivity cases, decision makers can have greater confidence in those conclusions, especially if the sensitivity analysis includes cases in which multiple assumptions are varied simultaneously in directions unfavorable to the conclusions. If these more extreme tests yield a different conclusion, then decision makers face a more difficult problem and more sophisticated methods that assess the likelihood of alternative values for key components, in particular Monte Carlo analysis, may be warranted. As we show below, however the basic conclusion from the base case is in fact robust to significant changes in the underlying assumptions.

B. Parameters Varied

Table 7 summarizes the input values used in the sensitivity analyses and compares them to the base-case assumptions. Here is a brief qualitative discussion of how we chose the "high" and "low" values:

Table 7. Summary of Parameters Varied in Sensitivity Analyses

Assumption	Base Case	"High"	"Low"
Basic economic parameters			
Discount rate	7%	10%	3%
Time horizon	20 years	25 years	15 years
Benefits			
Value per pound	$3.40	$7.21	$0.78
Trophic conversion rate	10%	20%	5%
Catch rate	100%	100%	50%
Costs			
Capital	$7.6 million	$21.6 million	$5.7 million
Power replacement	$29.5 million	$44.2 million	$14.7 million

1. *Discount rate*. OMB (1992) *Guidelines* recommend testing the effects of discount rates of 3 percent and 10 percent, in addition to the default value of 7 percent.

2. *Time Horizon*. We test a shorter horizon (15 years), which could reflect a prolonged regulatory and appeals process before planning and construction could begin. The longer time horizon (25 years) is less likely as it requires assuming that the plant would continue to operate into the mid 2030s, which would require, among other things, renewal of the NRC operating licenses in the early 2030s.

3. *Value per pound of fish* caught recreationally: for the high value we use the estimate from EPA's 2004 regional analysis, which was the greatest among the relevant studies. Correspondingly, for the low value we use the value from the study (Lupi et al. 1997) with the lowest value.

4. *Catch rate*. Our base case assumes that all of the increased production would translate into increased recreational yield. As a sensitivity case, we test the assumption that only

50 percent of the increased production is caught. Note that varying the catch rate has the same impact on estimated benefits as equivalent variations in the mortality rate for impingement (absent screens) or the effectiveness of the screens in reducing mortality.

5. *Trophic conversion rate.* Our base case reflects the estimate from AKRF (2009) of 10 percent. As suggested by AKRF, Inc., we also test 20 percent and 5 percent levels.

6. *Capital costs.* For the high value, we use EPA's estimate of $21.6 million. For the low value, we somewhat arbitrarily reduce Alden's estimate by 25 percent.

7. *Replacement power/ outage.* For the high estimate, we assume that the outage would last 50 percent longer (3 months) than estimated by Alden. This would be only about 19 percent longer than EPA's estimate. For the low estimate, we assume that the outage could be cut in half (1 month). Note that power replacement costs are proportional to outage length.

8. *Multiple changes.* We consider two extremes, one in which all of the assumptions tested individually are assume to take on the values most favorable to the project and the second with the opposite set of assumptions. These cases are particularly unlikely because they require that all of the uncertainties go one way, when in fact the outcomes are likely to be mixed, with some favorable to the project and some unfavorable.

C. Results

Table 8 shows the results of the sensitivity analyses and compares them to the base case. To make it easier to compare results with different time horizons and discount rates, we show annualized values rather than present values. As always, however, switching to present values would simply scale up costs and benefits proportionally (although the proportion applied in a particular case would depend on the time horizon and the discount rate). The top row shows the base-case results. For each component tested, we then show the results in the "high" and "low" cases and show the differences in net costs between those cases and the base case.

Table 8. Sensitivity Analysis of Costs and Benefits in Annualized Terms

Parameter Varied	Value	Costs	Benefits	Net Costs	Change
Base Case		$4.05	$0.06	$3.99	$0.00
Basic economic parameters					
Discount rate	10%	$4.97	$0.06	$4.91	$0.91
	3%	$2.98	$0.06	$2.91	($1.08)
Time horizon	25 years	$3.71	$0.06	$3.65	($0.34)
	15 years	$4.67	$0.06	$4.60	$0.61
Costs (millions)					
Capital	$21.58	$5.38	$0.06	$5.31	$1.32
	$5.68	$3.88	$0.06	$3.81	($0.18)
Power replacement	$44.18	$5.44	$0.06	$5.38	$1.39
	$14.73	$2.66	$0.06	$2.60	($1.39)
Benefits					
Value per pound	$7.21	$4.05	$0.13	$3.92	($0.07)
	$0.78	$4.05	$0.01	$4.04	$0.05
Trophic conversion rate	20%	$4.05	$0.13	$3.93	($0.06)
	5%	$4.05	$0.03	$4.02	$0.03
Catch rate	50%	$4.05	$0.03	$4.02	$0.03
Multiple parameters					
All favorable to screens		$1.63	$0.27	$1.36	($2.63)
All unfavorable to screens		$9.30	$0.00	$9.30	$5.31

Note: All entries are annualized values in millions of 2006 dollars.
Source: NERA calculations.

1. Basic Economic Parameters

Varying the discount rate from 7 percent to 10 percent or 3 percent has a significant impact on net costs, but even at 3 percent costs are about 47 times larger than the benefits of increased catch. Varying the time horizon from 20 years to 25 or 15 years has smaller effects.

2. Costs

Using EPA's estimated capital costs increases costs and net costs by $1.3 million per year. Reducing capital costs 25 percent reduces costs and net costs by $0.18 million per year. Varying the outage period plus or minus 50 percent increases or decreases costs, respectively, by about $1.4 million per year.

3. Benefits

The sensitivity analyses of parameters affecting benefits have much smaller impacts on net costs because base-case benefits are so much smaller than costs (less than 2 percent). Using the high estimate of value per pound of recreational fish caught increases benefits by $0.07 million per year and thus reduces net costs by that amount. Using the low estimate increases net costs by $0.05 million per year. Similarly, the higher and lower trophic transfer rates respectively increase benefits by $0.06 million and decrease them by $0.03 million. The alternative catch rate decreases benefits by about $0.03 million.

4. Sensitivity Analyses Varying Multiple Parameter Values

The two runs in the last section show the results of combining all of the sensitivity cases favorable or unfavorable, respectively, to the wedgewire screens These two runs represent extreme cases because they assume that all of the uncertainties are resolved in the same positive or negative direction. Even when all of the positive cases are combined, however, although net costs fall substantially, costs are still more than six times as great as benefits. As a result, our earlier conclusion that net costs are positive is not sensitive to the uncertainties evaluated.

D. Conclusions

The results of the sensitivity analyses reinforce our basic conclusion that the cost of requiring wedgewire screens would far exceed the benefits. As a result, society would incur large net costs if the screens were installed, and net costs would be smaller (zero) with the status quo (i.e., without the screens).

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Attachment A. Adjustments Made to EPA Cost Estimates

This attachment describes the adjustments made to EPA's estimates to account for differences in estimated and actual flows and in the vintages of the dollars in which costs are reported by EPA and by Alden.

As part of its Final Phase II rule under Section 316 (b), in 2004 EPA published estimated costs of implementing the technology identified by EPA as BTA at individual plants, including PBNP (USEPA 2004a).

EPA reported costs in several categories:

1. capital costs,
2. annual net operating costs,
3. the cost of an initial study, and
4. lost revenues as a result of plant shutdown during certain parts of construction.

Row (1) of Table A-1 presents EPA's original estimates in each category.

Table A-1. Summary of EPA Estimates and Adjustments

Item	Adjustments	Capital	Net O&M	Pilot study	Lost revenues
(1) Original EPA Estimates ($2002)		$23,279,870	$111,481	$2,351,844	$52,842,026
(2) Type of cost		One time	Annual	One time	One time
(3) Annualized value (r=7%, n=10)		$3,314,530	$111,481		
Adjust for flow					
(4) Combined Cap. + O&M	$3,426,011				
(5) Difference in flow (GPM)	-225,261				
(6) Adjustment factor ($/GPM)	2.5787				
(7) Adjustment	($580,881)				
(8) Adjusted annualized	$2,845,130				
(9) Reallocated annualized		$2,752,551	$92,579		
(10) Capital costs recapitalized		$19,332,765			
Inflation Adjustment					
(11) Factor	1.116				
(12) Final adjusted estimates ($2006)		$21,577,012	$103,326	$2,624,858	$58,976,199

Source: USEPA (2004a); Alden (2007) for corrected flow; Executive Office of the President (2008) for GDP deflator.

Row (2) of the table shows what types of costs (one-time or annual) are in each category. Row 3 shows annualized values for the first two components, which are required to implement EPA's adjustment procedure. Following EPA, The capital costs are amortized over 10 years at 7 percent, with the results shown in line (3). The O&M costs are already in annual terms

The next section shows the adjustment for the difference in flows. Under EPA's procedure, the adjustment applies to combined annualized capital and O&M costs, shown in row (4). Row (5) shows the difference in flow (measured in gallons per minute, or GPM) that is relevant for EPA's adjustment procedure. Row (6) shows EPA's adjustment factor for PBNP. Row (7) shows the resulting adjustment (the product of rows 5 and 6), and row (8) shows the final adjusted annualized value of $2.8 million. Row (9) then reallocates that total back to the two annualized components, capital costs and O&M costs. Row (10) recapitalizes the annualized amount for capital costs.

Row (11) shows the inflation-adjustment factor used, which is the ratio of the Gross Domestic Product (GDP) deflator in 2006 to its value in 2002, showing an increase of 11.6 percent over those four years. Row (12) is that factor multiplied by the appropriate cost estimates; these are the values reported in the body of the report.

Attachment B. Estimated Costs of Replacement Power During Outage

This attachment describes how we estimate the social costs of lost power resulting from the outage expected to be required for construction of the wedgewire screens.

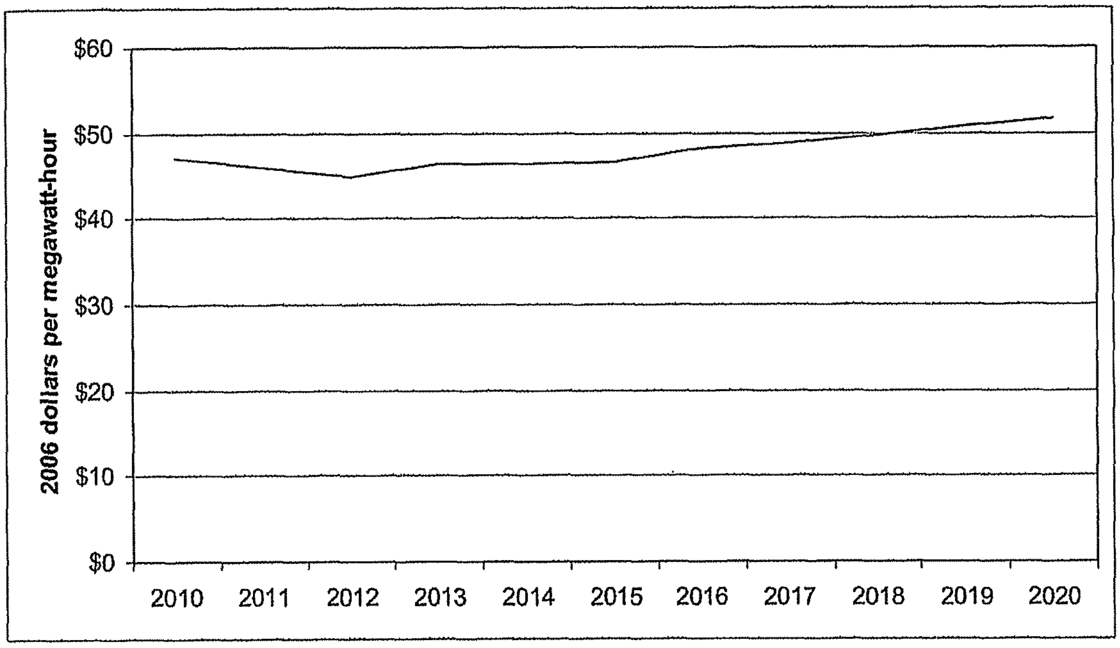
These costs are computed as the product of the regional wholesale electricity price[1] and the quantity (in megawatt-hours) of PNBP output that is expected to be lost. The following sections explain our estimates of both quantities.

A. Cost of Replacement Electricity

We use an estimate of the cost of electricity obtained from the Energy Information Administration (EIA) Annual Energy Outlook 2009. EIA performs detailed modeling of U.S. energy markets using the National Energy Modeling System (NEMS), an integrated model that projects the production, imports, conversion, consumption, and prices of energy using assumptions about supply, demand, financial, technological, and other factors.

The NEMS electricity market module (EMM) produces supply, consumption, trade, and pricing information results for thirteen distinct regions of the U.S. Each region's price forecast is further broken down into service categories: generation, transmission, and distribution. For our purposes, the relevant EMM region is the Mid-America Interconnected Network region, which includes the eastern portion of Wisconsin. Further, since the PNBP outage would involve reductions in generation, its costs only involve the wholesale (generation) portion of the price. Figure B-1 displays a forecast of this price for the years between 2010 and 2020.

[1] This approach ignores some complications that arise in real-world electricity market functionality. For example, in jurisdictions like Wisconsin that have not undergone electricity market restructuring, electricity rates and unit dispatch are typically set by regulators. Despite these complications, the *price* of electricity, as estimated by an appropriately-configured energy market model, is a reasonable proxy for the social *cost* of replacing lost output in a given time period.



Note: Values converted to 2006 dollars using the GDP deflator price index.
Source: EIA (2008)

Figure B-1. Mid-America Interconnected Network Wholesale Electricity Price, 2010-2020

Figure B-1 demonstrates that EIA expects stability in electricity prices in the region of interest over the next decade. Though there is uncertainty regarding when the construction outage for wedgewire screen construction at PNBP would occur, we illustratively select the price forecast for the year 2012, given Alden's estimated construction time of 1.5 to 2 years. Since 2012 is expected by EIA to be the lowest-priced year over the next decade, choosing another year's price would increase our overall cost estimates. However, given the overall stability in prices, the change would be minimal. The 2012 price is 4.60 cents per kilowatt-hour (2007 dollars, as reported by EIA), which, when adjusted for inflation using the GDP deflator price index, is equal to about $45 per megawatt-hour.

The EIA forecast is consistent with current prices at electricity market hubs in Illinois, not far from PNBP (MISO 2008).

B. Quantity of PNBP Output Lost

The Alden (2007) report estimates that 657,000 megawatt-hours of output from PNBP would be lost due to the wedgewire screen construction outage, reflecting a two-month downtime.

Our final base case power cost estimate is about $29.5 million, the product of 657,000 MWh and $44.83 per MWh.

Attachment C. Evaluation of Replacement Costs as a Measure of Benefits

This attachment evaluates the use of replacement costs as a measure of the benefits of technologies used to reduce fish losses, or as a measure of the economic cost of fish losses. In the context of policies involving changes in fish mortality, hatchery costs are the most common type of replacement cost used. Under that approach, fish losses are valued by the cost of replacing those losses with equivalent numbers of hatchery-raised fish. A WDNR official used this method in an email (Gerdman 2008) to estimate that the "value of the major fish species impinged and entrained" at PBNP is about $2.8 million per year.

As we discuss below, replacement cost is *not* a valid measure of economic value except under very limited circumstances that do not apply in this case. Economists are virtually unanimous in reaching this conclusion, which is reflected in EPA's Guidelines for Preparing Economic Analyses (USEPA 2000) and in standard text books on benefit-cost analysis. As we discuss below, although some of the draft case studies in EPA's Section 316(b) Phase II rulemaking used variants of the replacement cost approach for some benefit categories, in response to strongly negative comments from economists and other observers, the Agency acknowledged that replacement costs were not a valid measure of benefits and did not use them in the final regional case studies (USEPA 2004c).

The remainder of this attachment is divided into four sections. Section A summarizes some basic economic principles for valuing benefits. Section B explains what replacement costs measure and why they are not a valid measure of benefits except in very limited circumstances. Section C examines how replacement costs have been treated in EPA's guidelines and 316(b) rulemaking. Finally, Section D shows that *if*, contrary to fact, valid methods were not available in this instance, the use of replacement costs as an upper bound on possible benefits would still lead to rejecting the installation of wedgewire screens at PBNP.

C. Basic Principles for Valuing Benefits

In benefit-cost analysis, the monetized value of the benefits of a project to an individual is how much he would be willing to pay (or accept) in dollars for the contemplated change. Typically the question is phrased in terms of willingness to pay (WTP): what is the maximum the individual would be willing to pay to receive the benefits in question?[2] We then sum these amounts across individuals to get total benefits.

There are various ways to estimate WTP, including inferring values from actual behavior ("revealed preference"). As discussed in the body of the report, for example, recreational fishing values are often estimated using travel-cost methods. Values also may be estimated by asking individuals directly about WTP, but there is very broad agreement that such methods should be used only when revealed preference methods are not available.

The basic purpose of valuing benefits is to be able to compare them to costs to determine whether the proposed action is an improvement over the status quo and to allow comparisons across alternative actions. If the benefits of the proposed action exceed the costs, so there are positive net benefits, then at least in concept, those who receive the benefits could compensate those who bear the costs, while still retaining some surplus benefit. If there is more than one alternative action with positive net benefits, the decision rule is to choose the one that yields the

[2] Alternatively, the question may be phrased in terms of willingness to accept (WTA): what is the minimum that the individual would be willing to accept not to receive the benefit? In theory, WTP and WTA can differ somewhat as a result of what economists call income effects. (In essence the individual has more implicit income in the WTA version.) However, for changes that involve relatively small amounts, the two approaches should give essentially the same results, and any differences between the two are swamped by uncertainties in measurement. The types of changes at issue in this case for any individual are small by any reasonable criterion, so we use "WTP," recognizing that "WTA" also could be appropriate, but with inconsequential differences.

highest net benefits. On the other hand, if none of the alternatives under consideration yields positive net benefits, then the best action is no action—to stay with the status quo.

D. EPA Does Not Endorse the Use of Replacement Costs to Value Reductions in Fish Losses

1. EPA's Guidelines

EPA's *Guidelines for Preparing Economic Analyses* (USEPA 2000) lists six potential methods for valuing benefits that take the form of increased ecosystem services. One of these, "averting behaviors" appears similar to the replacement cost method. This approach,

> ...uses purchases of market goods to infer the value of indirect, non-market services. Willingness to pay is revealed by efforts to substitute for services provided by ecosystems. (USEPA 2000, p. 99)

The *Guidelines* caution, however, that "[t]hat this method is justified only when individuals are proven willing to incur such replacement costs" or when the action contemplated will actually reduce the cost of averting behaviors undertaken currently. We are not aware of any evidence that the affected states have in fact stocked alewives to address current impingement losses.

2. EPA's Phase II Rulemaking

EPA's rejection of replacement costs as a general measure of benefits was reconfirmed in the Agency's Phase II rulemaking under Section 316(b). In support of the proposed rules in 2002, EPA released several benefit-cost case studies, some of which employed some form of the replacement-cost approach despite the conditions specified in the Guidelines. For example, several of the case studies, including those for the Brayton Point facility in Massachusetts and the Whiting facility in Michigan, used what the proposal called the "habitat replacement cost" (HRC) approach (USEPA 2002). The HRC approach estimated ecosystem benefits using the estimated cost of creating additional habitat to support additional fish that would make up for possible losses from impingement and entrainment.

In comments on the proposed rule, numerous economists almost universally condemned the use of either variant of replacement costs. For example, Professor Robert Stavins of Harvard University—former chairman of the Environmental Economics Advisory Committee of EPA's Science Advisory Board—stated that "...inference from hatchery costs...is *not* a valuation method at all and should be deleted from the analysis" (Stavins 2002). He characterized the HRC method as a "completely illegitimate method of analysis." Other economists commenting on the proposed rule raised similar issues. Harrison et al. (2002) of NERA Economic Consulting, for example, called the HRC method "completely unsupported in EPA guidelines and the Economics Literature." EPA's regional benefit-cost analysis of the final Phase II rule did not use replacement costs to estimate benefits in any of the regional benefit-cost studies or in the national analysis. In responding to the numerous negative comments on the use of replacement costs to measure benefits, the Agency repeatedly stated that EPA does not use the HRC approach as part of its benefit cost analysis of the final rule" (e.g., USEPA 2004c, p. 105). The Agency acknowledged that "the HRC and hatchery costs are costs of replacement and not benefits."

Attachment D. Estimates from the Literature of Values per Pound of Recreationally Caught Fish

This attachment describes how we develop estimated values per additional pound of recreational fish catch relevant to PNBP. The attachment begins by explaining how we apply the results of three existing studies: a 2006 published review of past recreational fishing assessments, and two EPA regional case studies for the Great Lakes. It then explains how we combine the results of these three studies to develop our overall estimates.

A. Johnston et al. Literature Review

Our first valuation source is Johnston et al (2006), which provides a useful and detailed summary of existing studies of the marginal value of catching an additional fish recreationally. Table 1 of the paper lists 48 studies and more than 120 study-species pairs (many studies provide estimates for several species or groups of species).

To develop values relevant to PNBP, we select studies from the Johnston et al list that (1) estimate values for salmon, trout, or an aggregation thereof and (2) apply to Lake Michigan or a closely related water body. Table D-1 lists the specific observations that emerge from this screening, including the source studies, the specific species or groups of species, and the minimum and maximum per-pound valuations. (The minimum and maximum are equal for studies for which only a point estimate is available.) The table lists the observations as they appear in Johnston et al, except that we have added more detailed characterizations of the source papers' geographic areas.

Table D-1. Raw Valuation Estimates from Johnston et al (2006)

Study	Species	Region/Body of Water	Minimum Value	Maximum Value
Breffle et al (1999)	Salmon/trout	Green Bay	$20.99	$42.10
Lupi Hoehn Christie (2003)	Lake trout	St. Marys River	$10.12	$13.90
Murdock (2001)	Trout	Wisconsin (statewide)	$32.68	$32.68
Murdock (2001)	Salmon	Wisconsin (statewide)	$51.61	$51.61
Samples and Bishop (1985)	Salmon/trout	Michigan	$19.01	$19.01
Besedin et al (2004)	Salmon/trout	Michigan (Great Lakes)	$20.56	$23.36
Lupi et al (1997)	coho salmon	Michigan (statewide)	$18.33	$18.33
Lupi et al (1997)	rainbow trout	Michigan (statewide)	$10.12	$15.77
Lupi et al (1997)	chinook salmon	Michigan (statewide)	$4.04	$13.25
Lupi et al (1997)	lake trout	Michigan (statewide)	$6.61	$6.61

Note: Values are in June 2003 dollars per fish.
Source: Johnston et al (2006). The "Region/Body of Water" column reflects additional detail obtained through a review of the papers themselves. We were unable to locate Samples and Bishop (1985); Johnston et al (2006) report that it applies to Michigan.

We next modify the Johnston et al values in two ways. First, to ensure consistency with the cost estimates used elsewhere in our study, we convert the values from June 2003 dollars to 2006 dollars using the GDP deflator (the broadest standard price index). Concretely, this step involves multiplying each value by a factor of about 1.094, the ratio of the GDP deflator in 2006 to its value in 2003. Second, to facilitate subsequent calculations, we convert the per-fish values into per-pound values by dividing them by an estimated weight per fish. Table D-2 lists the specific weights per fish we use for this conversion. Weights for specific species are obtained from AKRF (2009), who in turn obtained them from the biological literature. The table also lists weighted-average weights for salmon, trout, and salmonids (salmon+trout) based on the distributions of the respective individual species among total Lake Michigan harvest in 2006 (GLFC 2007).

Table D-2. Average Weights per Fish Used in Conversion

Species	Harvest (lbs)	Avg. weight (lbs)	Implied no. of fish
Chinook salmon	8,446,974	10.25	824,095
Coho salmon	502,077	3.76	133,531
Subtotal, salmon	8,949,051		957,626
Average salmon		9.35	
Lake trout	403,680	5.36	75,313
Brown trout	170,320	6.31	26,992
Rainbow trout	537,120	6.79	79,105
Subtotal, trout	1,111,120		181,410
Average trout		6.12	
Salmon+Trout	10,060,171		1,139,036
Average S+T		8.83	

Source: Harvest from GLFC (2007). Average weight from AKRF (2009). Number of fish and average weights for salmon, trout, and salmonids (salmon + trout) calculated by NERA.

Table D-3 displays the per-pound values resulting from the inflation adjustment and the conversion to per-pound values from per-fish values.

Table D-3. Values per Pound Calculated from Johnston et al (2006$)

		2006 $/fish		Weight	2006$/lb	
Study	Species	Min	Max	(lb/fish)	Min	Max
Breffle et al (1999)	Salmon/trout	$22.96	$46.06	8.83	$2.60	$5.21
Lupi Hoehn Christie (2003)	Lake trout	$11.07	$15.21	5.36	$2.07	$2.84
Murdock (2001)	Trout	$35.75	$35.75	6.12	$5.84	$5.84
Murdock (2001)	Salmon	$56.46	$56.46	9.35	$6.04	$6.04
Samples and Bishop (1985)	Salmon/trout	$20.80	$20.80	8.83	$2.35	$2.35
Besedin et al (2004)	Salmon/trout	$22.49	$25.55	8.83	$2.55	$2.89
Lupi et al (1997)	coho salmon	$20.05	$20.05	3.76	$5.33	$5.33
Lupi et al (1997)	rainbow trout	$11.07	$17.25	6.79	$1.63	$2.54
Lupi et al (1997)	chinook salmon	$4.42	$14.49	10.25	$0.43	$1.41
Lupi et al (1997)	Lake trout	$7.23	$7.23	5.36	$1.35	$1.35

Source: 2006 $/fish are 2003-2006 change in GDP deflator (1.094) times values in Table D-1. Weights from Table D-2.

Next, we express each study as a single pair of estimates (minimum and maximum) to avoid giving disproportionate weight to studies that reported separate estimates for multiple species. To do so, we combine both of the studies that have distinct values for several relevant species (Lupi et al 1997and Murdock 2001) into individual pairs (minimum and maximum) of overall "salmon/trout" estimates. Specifically, in each case, we calculate the average among the species considered in the study, weighted by each species' 2006 Lake Michigan harvest (Table D-2). Table D-5 below provides the final values resulting from our analysis of Johnston et al, reflecting this adjustment of the Lupi et al and Murdock papers.

B. EPA 2004 Great Lakes study

Our second source of value estimates is a Great Lakes recreational fishing valuation study performed by EPA (USEPA 2004) as part of a regional analysis in support of the promulgation of the Phase II rule affecting large existing electric generating plants under Section 316(b) of the Clean Water Act.

To estimate the nationwide social benefits of implementing the rule, EPA performed benefits analyses for seven distinct regions of the U.S. The analysis for the Great Lakes region was based on a random utility model using data on catch rates and other site characteristics from the Michigan Department of Natural Resources and data on travel costs, time costs, and other angler characteristics from the literature. The study estimates Great Lakes salmon/trout losses of 1,666,453 fish, with a total value of $19,053,075 (2002 dollars), implying a value of $57.08 per fish. As we did for the Johnston studies, we convert this value to 2006 dollars using the GDP deflator and convert it to a per-pound value using the average weight of a salmon or trout (8.83 pounds, as indicated in Table D-2). The resulting recreational value is $7.21 (2006 dollars) per pound.

C. EPA 2006 Great Lakes study

The third valuation source we use is an EPA Great Lakes valuation study performed in support of the Phase III rule affecting new offshore oil and gas facilities (and certain other facilities) under Section 316(b) (USEPA 2006). For this study, EPA performed a statistical meta-analysis to estimate the marginal recreational value of fish caught by anglers.

The study presents low, mean, and high valuation estimates for both salmon and trout on a per-fish basis. As shown in Table D-4, we adjust these values for use in our study by a process similar to that outlined above. First, we first convert the salmon and trout per-fish values into per-pound values using the average weights shown in Table D-2. We next combine the salmon and trout estimates into overall salmonid weighted averages, using 2006 harvests of salmon and trout from Lake Michigan as the weights. The result of this step is a set of estimates—low, mean, and high—for salmonids expressed in 2004 dollars per pound. The final step is to convert the values from 2004 dollars per pound to 2006 dollars per pound using the GDP deflator price index.

Table D-4. Values per Pound Calculated from EPA (2006)

	Value per Fish ($)			Weight	Value per Pound ($)			Harvest
Species	Low	Mean	High	(lbs/fish)	Low	Mean	High	(pounds)
Salmon	$8.42	$11.17	$14.83	9.35	$0.90	$1.20	$1.59	8,949,051
Trout	$5.87	$7.94	$10.79	6.12	$0.96	$1.30	$1.76	1,111,120
Weighted Avg. (2004$)	-	-	-	-	$0.91	$1.21	$1.61	-
Weighted Avg. (2006$)	-	-	-	-	$0.97	$1.29	$1.71	-

Note: All dollar values are expressed in 2004 dollars, except the last row, which is expressed in 2006 dollars.
Source: For per-fish values, USEPA 2006. For weights per fish and total harvest, Table D-2.

D. Final Valuation

To develop our overall per-pound recreational value calculations, we combine the six studies arising from our review of Johnston et al (2006) with the values from EPA (USEPA 2004) and EPA (USEPA 2006). Table D-5 displays the results. Note that with the exception of Lupi, Hoehn, and Christie (2003), which is for lake trout, all of the estimates are weighted averages for salmon and trout.

Table D-5. Final Recreational Valuation Calculation

	Value per pound (2006$)		
Study	**Minimum**	**Maximum**	**Point/Mid**
Breffle et al	$2.60	$5.21	$3.91
Lupi Hoehn Christie	$2.07	$2.84	$2.45
Murdock	$6.02	$6.02	$6.02
Samples and Bishop	$2.35	$2.35	$2.35
Besedin et al	$2.55	$2.89	$2.72
Lupi et al	$0.78	$1.67	$1.23
US EPA (2004)	$7.21	$7.21	$7.21
US EPA (2006)	$0.97	$1.71	$1.29
Average	$3.07	$3.74	$3.40
Minimum	$0.78	N/A	$1.23
Maximum	N/A	$7.21	$7.21

Note: Values are expressed in 2006 dollars per pound.
Source: NERA calculations based on Johnston et al (2006), USEPA (2004b), and USEPA (2006). See Table D-3 and text.

Our base case recreational value ($3.40) is a simple average of the average values from each of the eight studies. For the sensitivity analyses performed in Chapter V, the "high" ($7.21) and "low" ($0.78) estimates we use are, respectively, the maximum of the maximums for the individual studies and the minimum of the studies' minimums.

Point Beach Nuclear Plant
Evaluation of the Thermal Effects Due to a Planned Extended Power Uprate

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1. INTRODUCTION

1.1 PROJECT BACKGROUND

Point Beach Nuclear Plant (PBNP) is comprised of two pressurized water reactors with a net capacity of 1,504 megawatts thermal (MWt). Unit 1 began commercial operation in December 1970; Unit 2 in October 1972. In December 2005, the U.S. Nuclear Regulatory Commission renewed the operating licenses for Units 1 and 2 through 2030 and 2033, respectively (20-year extensions). FPL Energy plans to implement an extended power uprate (EPU) at both units in the 2010/2011 time frame that is expected to increase the existing plant output by approximately 17 percent.

The PBNP has two on-shore discharge structures that currently release a combined maximum of 680,000 gallons per minute (gpm) at a mean temperature increase of 11.5°C (20.7°F) above the intake water temperature at the maximum flow rate.

This report provides background information on the project (Section 1), prior studies (Section 2), and the aquatic community (Section 3). Section 4 addresses how the thermal discharges from PBNP will change as a result of the EPU. Section 5 addresses the thermal impacts on Representative Important Species (RIS) expected as a result of the planned EPU. A summary of our conclusions is provided in Section 1.3.

1.2 REGULATORY BACKGROUND

Section 283.31 Wis. Stats. requires a Wisconsin Discharge Elimination System (WPDES) permit for the discharge of a pollutant from a point source into waters of the state. The term "pollutant" includes the addition of ***heat*** from a point source. Because of the planned EPU, the heat load of the point source discharge to Lake Michigan will increase. The current WPDES permit expires on 30 June 2009 and a permit renewal application must be submitted by 1 January 2009. Specific Condition 5.2.6 of that permit requires that:

> "... the permittee shall report to the Department any facility expansion, production increase or process modifications which will result in a new, different or increased discharges of pollutants. The report shall either be by a new permit application, or if the new discharge will not violate the effluent limitations of the permit, a written notice of the new, different or increased discharge of pollutants and a description of the effect of the new or increased discharge on existing waste treatment facilities. Following receipt of this report, the Department may modify this permit to specify and limit any pollutants not previously regulated in the permit."

A "Planned Change Notification" was submitted to the WDNR on 1 August 2008. This report has been prepared to assess potential impacts of the thermal discharge from the planned EPU (i.e., the "Planned Change") and may be included as part of the upcoming permit renewal application. In the interim, since there currently are no temperature limits in the PBNP WPDES permit or thermal water quality standards for Lake Michigan, this report represents a "good faith effort" by PBNP to demonstrate that the impacts of the EPU will not have a significant effect on the fish or shellfish communities in Lake Michigan.

Although not necessarily applicable here, it is useful to look to the process and procedures that have been utilized in assessing thermal impacts under §316(a) of the Clean Water Act (CWA) in evaluating the impacts of the PBNP thermal discharge. Under the CWA, as described below, any source of thermal discharge, existing or new, may seek a §316(a) variance from any limitation on heat that can be shown to be more stringent than necessary to assure the protection and propagation of a balanced, indigenous community (BIC) of aquatic life:

> "*With respect to any point source otherwise subject to the provisions of Section 301 of this title or Section 306 of this title, whenever the owner or operator of any such source, after opportunity for public hearing, can demonstrate to the satisfaction of the Administrator (or, if appropriate, the State) that any effluent limitation proposed for the control of the thermal component of any discharge from such source will require effluent limitations more stringent than necessary to assure the protection and propagation of a balanced, indigenous population of shellfish, fish, and wildlife in and on the body of water into which the discharge is to be made, the Administrator (or, if appropriate, the State) may impose an effluent limitation under such sections for such plant, with respect to the thermal component of such discharge (taking into account the interaction of such thermal component with other pollutants), that will assure the protection and propagation of a balanced, indigenous population of shellfish, fish, and wildlife in and on that body of water.*"

Starting in the early 1970s, utilities nationwide began the process of conducting extensive environmental studies to attain §316(a) variances as allowed under the CWA. In general, these studies demonstrated that the limits based on state water quality standards were more stringent than necessary for the protection and propagation of a BIC of aquatic life. Studies conducted throughout the Great Lakes, and in particular, those for power plants on Lake Michigan, were no exception to that trend.

Guidance on how to conduct such "demonstrations" was prepared by the U.S. Environmental Protection Agency (EPA) in a document entitled "Interagency 316(a) Technical Guidance Manual and Guide for Thermal Effects Sections of Nuclear Facilities Environmental Impact Statements" (the 316(a) Guidance Manual, U.S. EPA 1977). The 316(a) Guidance Manual indicates that applicants may choose one of the following approaches for their Demonstration:

1) **Type I, Absence of Prior Appreciable Harm** is applicable for facilities that have already commenced discharge.

2) **Type II, Predictive Studies** focuses on Representative Important Species (RIS). This type may be done whether or not the discharge has commenced.

3) **Type III studies are** often a hybrid approach in which a study plan is specifically developed for the facility being considered. It is typically used when older studies need to be updated or an existing facility is expanded (EA 1991a and EA 1991b).

3a) **Low Potential Impact Type III Predictive Studies** is appropriate for facilities located on receiving waters for which available data indicate low potential for adverse impacts of cooling water discharges. The Type III Demonstration is appropriate for a site that can be shown to have low potential for significant impacts to aquatic biota, based on available literature, site characterization studies performed for other purposes, or previous thermal discharge studies on similar sites. This study design is flexible and determined by the applicant and the permitting authority, with consideration given to each biotic category, while avoiding collection of unneeded data.

In Wisconsin, the §316(a) process is currently implemented through §283.17 Wis. Stats. and NR 209 Wis. Adm. Code. The PBNP is operated pursuant to WPDES Permit No. WI-0000957 issued by the WDNR in 2004.

1.3 SUMMARY OF CONCLUSIONS

Evaluation of the potential effects the planned EPU may have on the Lake Michigan aquatic community in the vicinity of the PBNP discharge was based on a review of historical and current monitoring data collected in the vicinity of the facility and other power plants that utilize Lake Michigan water for once-through cooling. Those study results were compared to expected responses of 16 WDNR-selected Representative Important Species (RIS) to the projected higher discharge temperatures and larger thermal plume that will result from the planned EPU. The evaluation placed emphasis on the RIS and whether or not a BIC in the vicinity of the PBNP will continue to be protected.

It was determined by the WDNR in 1976 that that a BIC was present in the vicinity of the PBNP discharge and that no appreciable harm had occurred as a result of plant operations (Attachment A). The WDNR finding was based on a Type I 316(a) Demonstration prepared by Wisconsin Electric Power Company (WEPCO 1975) that was based on a study conducted in 1972-73 (see Section 3). Those studies involved investigations of primary and secondary trophic levels from phytoplankton through fish in both reference and thermally-affected areas (Limnetics 1974). The 1972-73 study was conducted at a maximum heat discharge rate of 7,094 million British Thermal Units per hour (MBTU/hr) and the thermal plumes at the plant were within an extreme envelope that covered an area of 1.29 square miles (826 acres) and represented a plume temperature of 1 - 2°C (1.8 -3.6°F) above the receiving water temperature (Limnetics 1974).

The results and conclusions of the 1975 Type I Demonstration for PBNP are still applicable to the existing operating conditions, which are similar to those during the 1972-73 studies. For example, the current maximum head load (7,048 MBTU) is slightly lower than the maximum heat load (7,094 MBTU/hr) during the Type I Demonstration study period. In addition, recent entrainment and impingement monitoring studies at PBNP (EA 2007a) have demonstrated that the same species that were common in the vicinity of the facility remain common near the plant despite lake-wide changes in the Lake Michigan fish community (Kitchell 2007). Recent fisheries data collected from both PBNP and the Kewaunee Nuclear Power Plant (KNPP), which is located only five miles north of PBNP, show that the same species seasonally occur in nearshore areas in the vicinity of the shoreline discharge structures. Changes in the aquatic community in the vicinity of both PBNP and KNPP reflect lake-wide changes summarized by Kitchell (2007) and are not related to power plant operations and therefore do not preclude reliance on the 1975 Type I Demonstration (i.e., the aquatic community was and continues to be "balanced"). That conclusion is consistent with assessments undertaken at other power plants on Lake Michigan that have all demonstrated that a BIC is protected under similar operating conditions as has occurred historically at PBNP.

Evaluation of the modeled discharge temperatures and plume configurations under the planned EPU indicates that the results and conclusions of the 1975 Type I Demonstration for PBNP will remain applicable under the planned EPU for the following reasons: although the EPU maximum heat load (8,273 MBTU/hr) will be about 17 percent higher than the maximum PNBP heat load (7,094 MBTU/hr) studied during the Type I Demonstration, the predicted area, volume, and behavior of the plume will not be substantially different than under current PBNP operating conditions (Section 4). The PBNP model was executed for the 2.0°C (3.6°F) delta discharge temperature for the planned EPU, which was added to the existing 11.5°C (20.7°F) full load delta temperature. Based on the model results using a 0.2 ft/sec along-shore current, the planned EPU would increase the surface area of the 6.0°C contour from 27 to 39 acres; the 4.0°C contour would increase from 79 to 105 acres; and the 2.0°C contour would increase from 315 to 390 acres. These projected increases in surface areas of the three plume contours are relatively small compared to the surface area available for mixing. The model results also showed that except for a nearshore cell close to the discharge, the 1.0°C delta temperatures were never present at or below a depth of 6 ft and that maximum delta temperatures at a 4 ft depth decreased from 2.37°C at 500 ft to 1.65°C at a 4,500 ft down-lake distance from the discharge. These results show that under critical summer conditions the buoyant plume provides an area of safety as well as a zone of passage when discharge temperatures approach or exceed upper avoidance temperatures of the RIS fish.

The RIS evaluation showed that the predicted impact of the warmer and larger thermal plume as a result of the EPU at PBNP will be negligible. Thermal criteria for some of the 12 RIS fish species would be exceeded in the plume, but mainly at the point of discharge or in small areas for relatively brief periods of time. Cool and coldwater fish species would be somewhat restricted with regard to use of the plume area, especially during summer. However, the coldwater species generally spend the summer well offshore where contact with the plume would be very limited. At other times, when plume temperatures are below their documented avoidance temperatures, these coldwater species would have access to the plume area. The warmwater RIS will, if anything, benefit from the warmer temperatures.

The response of RIS to the PBNP discharge under the planned uprate would be expected to be the same as was documented in the 1970s when the plant began operation and as described in this report for other Lake Michigan power plants (Section 3.3). Fish readily move into and out of thermal discharge plumes, depending on their thermal requirements and the thermal regime of the plume at any given time. Research has shown no deleterious effects of these movements on growth or condition of fish, nor does interaction with thermal plumes appear to affect seasonal on- and off-shore movements of RIS such as alewife, rainbow smelt, and lake trout. Also, it should be noted that except in the winter, the plume is primarily a surface phenomenon so that fish can readily move under as well as laterally away from the plume. Lastly, because the plume shifts with wind direction, any particular fish would need to avoid the plume only for brief periods. Thus, avoidance would be short- rather than long-term. When these observations are considered in light of the size of the PBNP plume relative to available lake habitat, it was concluded that the larger and warmer thermal plume resulting from the planned EPU will have a minimal and insignificant impact on the fish community in Lake Michigan.

The warmwater RIS will be at no risk as a result of the planned EPU. Cool and coldwater fishes would have their upper lethal temperatures and avoidance temperatures exceeded in a portion of the plume during the warmest months, particularly in August. Although potentially lethal temperatures will exist in a portion of the plume during the summer, no mortality is expected because each species will use well documented avoidance responses to avoid such temperatures, either by staying outside of that portion of the plume that reaches its avoidance temperature or by swimming underneath the buoyant plume. Also, coldwater species, which is the most thermally sensitive group, naturally avoids the relatively warm (to them) nearshore water of the lake during the summer and therefore are highly unlikely to even encounter the plume during the summer.

Although behavioral responses of the four RIS shellfish are not well known, it is not unreasonable to expect them to respond in a similar manner as the RIS fish. Also, all of the RIS shellfish except for *Mysis relicta* are strongly bottom oriented. Thus, being bottom dwellers, they typically would not encounter the plume when condition would be most limiting (i.e., during the summer) because at this time the plume would be buoyant. It should also be noted that *Mysis relicta* was rare during recent studies near PBNP and *Diporeia* was not collected.

The above conclusions with respect to PBNP are consistent with assessments undertaken at other power plants on Lake Michigan that have offshore intakes and nearshore discharges for withdrawing and discharging heated cooling water. Intensive monitoring studies at power plants with similar pumping capacities and heat loads have consistently shown that the BIC in the vicinity of their discharges have been protected.

The addition of an increased heat load to the discharge as a result of the planned EPU will not endanger the protection and propagation of a BIC of shellfish, fish, and wildlife in and on Lake Michigan. This report provides several lines of evidence that demonstrate that the thermal plume resulting from the planned EPU at PBNP will not have any significant adverse environmental impacts. Thermal effects, if any, are likely to be minor and transitory (e.g., short-term avoidance). Given the short-term duration and small magnitude of any such impacts, we conclude that the thermal impacts of the planned EPU at PBNP will be biologically inconsequential and will not interfere with protection of the BIC.

The bases for this conclusion include:

- The PBNP Type I Demonstration established that the original thermal plume did not cause "prior appreciable harm."
- The PBNP thermal plumes resulting from the planned EPU will not be substantially larger than the original/existing plumes.
- There have been no changes in the aquatic community attributable to operation of the facility that would preclude reliance on the results of the Type I Demonstration for PBNP.
- The changes to the Lake Michigan fish community that have occurred during the past 50 years have occurred on a lake-wide basis.
- The impacts on RIS will be negligible.
- The conclusion with respect to the effect of the planned EPU is consistent with assessments undertaken at other power plants on Lake Michigan.

The bases for these conclusions are addressed in detail in subsequent sections of the report.

2. FACILITY DESCRIPTION AND PERMITTING HISTORY

2.1 FACILITY DESCRIPTION

PBNP is located on the western shore of Lake Michigan in Two Rivers, Manitowoc County, Wisconsin (Figure 1-1). The facility consists of two nuclear powered steam electric generating units with a total net capacity of 1,504 MWt. The units operate with a once-through cooling water system. The cooling water is withdrawn by the intake that is located approximately 1,750 feet (533 m) from the shoreline at the approximate 22-ft (6.7-m) depth contour. Current pumping capacity is estimated to be 680,000 gpm. Each unit discharges the non-contact cooling water to Lake Michigan via its own outfall located approximately 200 ft from the shoreline. During the winter, the cooling water from one of the units can be discharged via a deicing line to the Intake Crib to prevent the formation of frazil ice.

FPL Energy is planning an approximate 17 percent EPU of both units. The total gross generation would increase from approximately 540 to 630 MWe for each unit, thereby increasing the heat load in the discharges to Lake Michigan. Up to a 2.0°C (3.6°F) increase in discharge temperature is expected. Neither the location of the two discharges for PBNP nor the amount of cooling water used by the facility will change as a result of the planned EPU.

2.2 SUMMARY OF WPDES PERMITTING HISTORY

In 1975, the State of Wisconsin implemented thermal standards with the intention that the State would be in compliance with PL 92-500 ("the Federal Clean Water Act"). This law required states to adopt acceptable effluent limitations as part of their pollution control efforts. The standards were challenged on the grounds that the Wisconsin thermal provisions exceeded the stringency of the Federal effluent limit regulations. In 1979, the Wisconsin Supreme Court agreed with the arguments presented by the challengers with the result that the thermal provisions were struck down. WDNR began in the mid-90s to develop revisions to the thermal standards that would be environmentally protective, scientifically and legally defensible, and reasonably implementable (Wenholz 2007). The revised standards are expected to be finalized in the near future.

During the fall of 1972, WEPCO began a five-year study to assess possible thermal impacts to aquatic organisms (Limnetics 1974). In October 1975, the "Point Beach Nuclear Plant Demonstration for Thermal Standard Variance" was submitted to the WDNR (WEPCO 1975). The demonstration utilized the Limnetics data collected in 1972-73. WDNR reviewed the demonstration and on 7 September 1976 issued a finding that the PBNP discharge had no significant detrimental impact on indigenous aquatic organism populations and communities of Lake Michigan (Attachment A). Departmental findings indicated that the study and the 316(a) demonstration followed the appropriate analysis of power plant impacts according to applicable departmental guidelines, and that the studies showed that no appreciable adverse impacts on the physical, chemical, or biological features of the site resulting from operation of the PBNP. Impacts of the thermal plume were judged by WDNR to be minor, and natural features such as the character of the physical habitat, climatic conditions, and behavior of aquatic fauna (e.g., seasonal on-shore and off-shore migratory movements) were judged to exert greater influence on the biotic community of the site than did the plume. Therefore, the PBNP discharge was exempted from thermal discharge requirements.

From March 1975 through February 1976, studies were conducted at PBNP to evaluate the impacts of its cooling water intake structure (WEPCO 1976). Again, WDNR approved the impingement and entrainment study plans and provided guidelines for evaluating these impacts (WDNR 1975). The WDNR concluded that the location and operation of the intake structure had minimal environmental impact and no modifications of the intake structure were required (Attachment B).

3. THE AQUATIC COMMUNITY

The aquatic community near the PBNP (Section 3.1) and elsewhere in Lake Michigan (Section 3.2) is described in this section, along with a discussion on how aquatic organisms react when exposed to thermal discharges. Although much of the available thermal data were collected in the 1970s – early 1980s, it is still relevant because thermal loadings to Lake Michigan at existing generating facilities have not increased substantially during the past 20 years and a number of units that were operational during the early studies (e.g., Zion Nuclear Station) have been retired. Furthermore, the Lake Michigan aquatic community potentially affected by thermal discharges is still dominated by the same organisms. For example, alewife, a RIS[1] for this thermal evaluation, was and continues to be the dominant forage fish in Lake Michigan (Bunnell et al. 2007).

Fish are emphasized in this review for several reasons. First, they are the only component of the aquatic community that is commercially and recreationally important in Lake Michigan. Second, fish occupy the top of the trophic pyramid, and therefore good fish populations can only be maintained if the underlying food sources (e.g., zooplankton and macroinvertebrates) are stable. Thus, the presence of healthy fish populations is an indication that lower trophic organisms are also healthy. Lastly, these lower trophic organisms were studied extensively during the 1970s when many comprehensive 316(a) demonstrations were conducted. As documented later in this section, detrimental impacts to lower trophic level organisms attributable to power plant utilizing once-through cooling have not been documented for Lake Michigan power plants.

3.1 AQUATIC STUDIES NEAR PBNP

Results of environmental surveillance and thermal effects studies conducting in the 1970s for the PBNP were documented in annual reports and summarized in a five-year summary report (WEPCO 1978). The studies documented the physical, chemical, and biological characteristics of Lake Michigan nearshore waters in the vicinity of the plant, including the thermal plume and both north and south reference areas. Water chemistry, bacteria, phytoplankton, zooplankton, periphyton, benthic macroinvertebrate, and fisheries data were collected.

The PBNP 316(a) demonstration followed the draft U.S. EPA "Proposed Guidelines for Administration of the 316(a) Regulations" (U.S. EPA 1974). The WDNR guidance documents "Proposed Guidelines for Demonstration under Section 316 of Public Law 92-500" (WDNR 1975), and "Proposed Outline for 316(a) Demonstration Document" (WDNR 1974), were also consulted.

WEPCO (1978) reported that five years of study of the PBNP discharge and nearby receiving waters had revealed no significant ecological changes in the vicinity of the discharge that were related to power plant operations. No effects from thermal discharges were detected on bacteriological populations or benthic macroinvertebrates. It was concluded that benthic macroinvertebrate populations in the near-plant and reference

[1] RIS designates Representative Important Species selected by the WDNR (see Section 5.5 of this report).

areas were primarily the result of substrate characteristics, as reported in numerous other studies.

The PBNP studies revealed certain responses of phytoplankton, blue-green algae/periphyton, zooplankton, and fishes to the thermal plume. The nature of these responses was consistent with those noted at other power plants on Lake Michigan with once-through cooling systems. Those responses are described below and are discussed with respect to conclusions regarding impacts of thermal discharges from the PBNP.

Thermal Plume

Thermal plumes mapped at PBNP were typically observed to be either shoreline oriented or projected in a northeast direction from the outfalls. In December 1972, the plume was closely attached to the lakeshore, extending approximately 2,000 ft south to the limit of the 1°C isotherm (the receiving water temperature was 0°C (Limnetics 1974). In November 1972, an offshore plume extending to the northeast was measured reaching approximately 2,000 ft offshore at the 5°C degree isotherm (the receiving water temperature was 4.5°C) (Limnetics 1974). A shoreline plume is expected during the influence of onshore winds, a lake current flowing southward along the shore, and/or influence of both along-shore current and the thermal bar during spring that prevents spreading of the plume outward from the littoral, nearshore waters. The northeast oriented plume configuration is expected to result from influence of reduced along-shore current, offshore winds, and stable stratification or mixed lake conditions of summer or fall. These cases serve to define the area over which influence of the PBNP discharge on biota could be expected to be detected, and encompass the sampling locations used in the 1972-73 studies.

Thermal plumes at the plant were within an extreme envelope that covered an area of 1.29 square miles (826 acres) that represented a plume temperature of 1°C - 2°C (1.8°F – 3.6°F) above the receiving water temperature (Limnetics 1974). Despite the extreme envelope, 90 percent of all plumes were <0.43 square miles (275 acres). Thermal plumes were generally larger during the spring and autumn than in the winter or summer. Sinking plumes developed during the winter and floating plumes generally developed in the spring and summer.

Small surface plumes during the summer developed during peak summer stratification when the intake temperatures from the bottom of the lake were considerably cooler than the surface waters where the heated discharge is released.

Phytoplankton

No consistent pattern of differences in total phytoplankton, green algae, diatoms, or blue-green algae was detected between the PBNP thermal plume and the reference areas. Phytoplankton diversity and diatom densities were similar in plume and reference areas. Diatoms were the dominant phytoplankton taxa as has been reported for other Lake Michigan sites (Limnetics 1974). Total phytoplankton exhibited a bimodal density pattern with peaks in spring and fall, similar to that seen at other sites on Lake Michigan (Industrial Biotest 1974, WPSC 1976), and total densities in reference areas were not consistently higher or lower than those in the thermal plume. Densities of green algae were highest in the summer months (June through August) but constituted only a small proportion of the total algae, as found in other studies of Lake Michigan (WPSC 1976). Over the five-year study period, density of green algae in the thermal plume was found to be higher than that in the north reference areas, but did not differ from the densities seen in the south reference area. These differences in green algal density were not considered ecologically significant when compared among the PBNP plume and reference areas and in comparison to reported densities of green algae at other sites. Blue-green algae densities were highest in the fall (September and October), and densities of blue-greens did not differ consistently among the plume and reference areas. No trends of blue-green algal density data were noted over the five-year study.

Phytoplankton productivity was higher in the PBNP thermal plume compared to the intake or reference areas. Productivity was approximately doubled within the plume; the five-year average productivity rate in the plume was 2.60 $mgC/m^3/hr$ versus 1.26 $mgC/m^3/hr$ in the intake water, and the measured differences were generally both consistent and statistically significant. This effect was limited to the thermal plume itself and disappeared within two hours as the discharge cooled to lake temperatures outside the limits of the thermal plume. Other biological groups studied at PBNP revealed that this stimulated phytoplankton productivity had no influence on other biota within the nearby receiving waters of Lake Michigan. A review of effects of power plant condenser passage on phytoplankton productivity (Consumers Power Company 1974) found that an increase in productivity was found only at PBNP among five Lake Michigan power plants that were studied.

Blue-green Algae/Periphyton

Total periphyton growth did not exhibit significant differences among plume and reference locations at PBNP, but the dominance of various algal groups differed somewhat from that seen at other sites studied on Lake Michigan. Some of the differences were apparently related to the use of artificial styrofoam substrates, which were considered to support a periphyton assemblage more similar to that found on natural substrates. Blue-green algae often dominated periphyton growth at PBNP, whereas green algae were of lesser importance and diatoms exhibited variable importance depending on the area. Total periphyton and blue-green algal densities were highest during the warmer summer months. Blue-green algae were more numerous and developed earlier in the season on artificial substrates in the thermal plume than in the reference areas. The reference areas did not differ from each other in terms of blue-green algal growth in periphyton. Diatoms were significantly less dense in periphyton of the thermal plume than in the reference areas, but the north reference area supported lower diatom densities than the south reference area over the five-year study period. Diversity was generally lower on substrates in the thermal plume than on those in the reference areas, but the lower diversity in the plume was statistically significant only when compared to the north lower diversity in the plume was statistically significant only when compared to the north reference area. Periphyton productivity was often higher in the thermal plume than in the reference areas at PBNP.

It was concluded that the PBNP thermal plume produces somewhat higher densities of blue-green algae and greater periphyton productivity than in the reference areas and the discharge may suppress growth of periphytic diatoms. These effects may be related to both currents and temperature in the discharge area. However, due to the lack of suitable substrates and the relatively strong wave action in the nearshore areas in the vicinity of PBNP, little natural substrate suitable for periphyton growth is present. Therefore, the tendency for enhanced blue-green algal periphyton growth and productivity in the thermal plume is not ecologically significant to the nearshore Lake Michigan environment.

Zooplankton

Zooplankton collections were made monthly in the vicinity of the PBNP from 1972 through 1976, and quarterly in 1976-1977. The zooplankton community was dominated by three major groups, rotifers, copepods, and cladocerans, as has generally been reported by other studies in Lake Michigan (WPSC 1976). Total zooplankton, as well as populations of total rotifers, copepods, and cladocerans exhibited population maxima during the summer to early fall months and minima during the winter from December through February. Rotifers were the most abundant zooplankton as reported elsewhere on Lake Michigan. Over the five-year study, no consistent or statistically significant differences existed between the PBNP thermal plume and the reference areas in terms of total zooplankton, total rotifers, or cladocerans. Total copepods were more numerous in the south reference area than in either the thermal plume or the north reference area.

Zooplankton diversity was highest in late fall and winter, and lowest in the warmer summer months. Diversity was greater in the thermal plume than in the reference areas. Reduced diversity in all areas during summer was caused by expanding populations of certain dominant forms, particularly rotifers.

Entrainment mortality of zooplankton at PBNP averaged 10.8 percent and ranged from non-detectable to a maximum of 43.8 percent. Entrainment mortality appeared to peak in the winter (February-March) when populations were generally at annual low densities, and again in summer, when populations generally were at annual high densities. The highest mortality seemed to occur in the winter. Mortality of zooplankton at levels of 10 to 20 percent during condenser passage is ecologically insignificant because zooplankton reproduce rapidly, and the effects of condenser mortality could not be discerned when zooplankton populations in the reference areas and those in the thermal plume were compared.

It was concluded that the PBNP thermal discharge had no significant effect on zooplankton populations of nearby Lake Michigan waters. Differences among the

Benthic Macroinvertebrates

Macroinvertebrates were collected with Ponar grab samplers every other month from November 1972 through November 1976, then quarterly for the fifth year of the program (ending October 1977). Sample locations were in the north and south plume areas, and the north and south reference areas.

The majority of the benthic organisms collected during the five year study were from one of following taxonomic groups: midges (Chironomidea), worms (Oligochaeta), and Amphipods (Amphipoda) dominated the benthic fauna, whereas fingernail clams (Sphaeriidae) were occasionally collected. The south reference area and the north plume area provided the best benthic habitat where the substrates had a higher sand content than at the other sampling locations. During all five years, the maximum densities occurred during the summer months and the minimum densities always occurred during the fall or late winter.

Midges comprised 13.5 percent of the total benthic community. At least 23 different species of chironomids were present, many of which occurred infrequently. The south reference and north plume areas exhibited higher densities that were likely reflect substrate types. Aquatic worms comprised 42.5 percent of the total benthos collected from all locations and were represented by 15 taxa from four families. The south reference area had significantly higher densities than the other areas over the five years of study due to the sandy substrates at that location. Over 99 percent of the amphipod community was comprised of *Pontoporeia (*now classified as *Diporeia)* and less than one percent by *Gammarus.* Both *Diporeia* and *Gammarus* are RIS for this evaluation (see Section 5.5). The south reference area showed significantly higher densities of amphipods due to the sandy substrate, which *Diporeia* prefers. Few fingernail clams were collected in the PBNP study area. Only a single species (*Sphaerium*) was collected and its occurrence was erratic. *Mysis*, the opossum shrimp, is another benthic RIS of interest. Only two individuals were collected and both were collected during the winter.

The five year data set did not show any trends that indicated the operation of PBNP affected the benthic community.

Fishes

Fish populations in the vicinity of PBNP were studied from November 1972 through October 1977. Seines, trawls, and gill nets were used to collect data to characterize species composition, population densities, spatial distributions, and seasonal occurrences. Fish eggs and larvae were sampled with pumps and net tows.

Operation of the plant had very little effect on fish populations in the vicinity of the plant site based on results of the five-year study. Differences in occurrence of species, densities, size and condition factor, and evidence of spawning occurred among the thermal plume and the two reference areas, but the differences were not consistent in relation to the presence or absence of the heated discharge. Densities of fish in the vicinity of PBNP were generally lower than those reported from other areas of Lake Michigan, and the area around the site did not appear to be an important spawning habitat for the species present. Fish responses that appeared to be related to the thermal plume are summarized below.

Some species exhibited a tendency to be collected more frequently in the thermal plume than in one or both of the reference areas during certain seasons. Alewife, a RIS, appeared in late spring in the vicinity of PBNP during spawning runs, and more alewife were collected in the thermal plume area than in either reference area at that time of year. Alewife were less numerous from mid-summer through the fall, and were nearly absent from the area in the winter. The pattern of appearance and numbers of alewife did not exhibit any trend over the five-year study that could be related to the thermal discharge. The data suggested that the twice-monthly sampling may have missed the peak abundance periods for alewife during the spring spawning season in certain years. There was no evidence that the PBNP thermal plume caused alewife to modify their local seasonal migration patterns in the area.

Rainbow smelt, also a RIS, was present in the vicinity of PBNP year-round, but in low numbers from November through February. Rainbow smelt were more numerous when they moved inshore to shallow waters for spawning in March and April and their numbers tended to decline following the spawning season, but increased in early fall as YOY fish appeared in the collections. As was the case for alewife, the twice-monthly collections sometimes missed the rainbow smelt abundance peak associated with spring spawning runs. No trends in abundance in plume or reference areas were apparent during the five-year study, but overall catch rates for rainbow smelt declined from the beginning of the study in 1972 to its completion in 1977. That decline coincided with the lake-wide decline documented for Lake Michigan (Bunnell et al. 2007).

White sucker were present in the vicinity of PBNP year-round in relatively consistent numbers over the five-year study, and exhibited peak abundance each year in late summer. White sucker were generally more abundant in the south reference area than in either the thermal plume or north reference areas, perhaps due to differences in the substrate and benthic communities among these locations. The thermal plume did not appear to significantly influence distribution of white sucker in the area, and no trends in white sucker abundance or condition were noted over the five-year period.

Catches of yellow perch, another RIS, declined in the vicinity of PBNP during the 1972-1977 study, apparently reflecting generally low recruitment throughout western Lake Michigan during that time period (Bunnell et al. 2007). The north reference area had more yellow perch than the thermal plume area or the south reference area. Growth and condition factors for yellow perch exhibited little variation among the thermal plume and reference areas.

Brown trout and rainbow trout were often caught in the thermal plume at higher numbers than in the reference areas. This association with the thermal plume occurred in all seasons, apparently whenever temperatures in the plume tended to approach the preferred range for the species. Attraction of trout to power plant thermal plumes has been reported at other sites on Lake Michigan. Association with the thermal plume had no discernable effect on condition factors or growth of trout at PBNP. These results illustrate a common avoidance/attraction response among Lake Michigan salmonids, especially rainbow trout and brown trout, to thermal plumes. Because of this well-demonstrated response, salmonids are not at risk even though their preferred water temperatures or their thermal tolerance limits may occasionally be exceeded.

In contrast to the association of brown trout and rainbow trout with the thermal plume, the RIS lake trout exhibited no particular tendency to either seek or avoid the PBNP thermal plume. Lake trout were generally absent from the PBNP area during the winter months, when they tend to disperse throughout the lake, and during the warm summer months when they move offshore. Condition factors of lake trout in the thermal plume were higher than in the reference areas, but other age and growth statistics showed little variation among plume and reference areas.

Spigarelli et al. (1974) studied the relationships among body temperature, water temperatures, and fish distribution in the PBNP thermal plume. They found that while body temperatures of fish from the nearshore warmer areas generally approximated the temperature from which they were collected, body temperatures of trout caught from the immediate discharge area were generally lower than the discharge temperatures. They concluded that fish in the vicinity of PBNP thermo-regulated their body temperatures by seeking areas that approximated their preferred temperature range. Trout appeared to move between warmer and cooler areas on a frequent basis to both achieve thermoregulation and to forage in areas warmer than their preferred temperature. Coutant (1975) observed a similar pattern in largemouth bass and smallmouth bass.

Romberg et al. (1974) reported results of mark and recapture studies of fish at PBNP. Fish were tagged and released in the thermal plume, and returns were studied to assess the association of the marked fish with the thermal plume. Of the fish that were recaptured, 84 percent were captured outside the thermal plume. Attraction to the thermal plume as measured by the frequency of recapture varied among species and among individuals. The results suggested that attraction and residency within the thermal plume was not consistent among species or individuals.

In conclusion, the historical fisheries studies at PBNP demonstrated no apparent significant impacts on fishes in the vicinity of the thermal discharge. Brown trout and rainbow trout tended to be associated with the thermal plume, and alewife were collected in greater numbers in the thermal plume than in the reference areas outside the plume. Variations in condition and growth lacked any consistent relationship to occurrence of the fish in the thermal plume or in the reference areas. It is notable that the presence of the thermal plume did not appear to modify the seasonal on-and off-shore movements of such species as alewife, lake trout, rainbow smelt, or white sucker during the five-year study. Movements and activities of these species are apparently controlled any other environmental factors, including seasonal temperature changes in Lake Michigan waters and intermittent upwelling of colder water from greater depths in the lake. Thus, the presence of the PBNP thermal plume did not constitute an ecologically significant influence on their behavior, even within the immediate PBNP area.

Recent Larval Studies near PBNP

From April through September 2006 (EA 2007a), entrainment samples were collected weekly from the PBNP intake forebay with a pump system and offshore ambient samples were collected with paired 335-micron mesh plankton nets deployed along three depth contours. Samples were collected during night and day periods.

"Shellfish" in the entrainment samples included the amphipods *Gammarus* and *Hyalella azteca*. No *Diporeia* and only four *Mysis* were collected during this study. The high occurrence of the RIS *Gammarus* (88 percent of the shellfish collected) in the entrainment samples may represent colonization on the offshore intake crib and/or the intake forebay because of the availability of rocky substrates at those locations.

The most abundant ichthyoplankton taxa in the entrainment samples were rainbow smelt (62 percent of total), followed by alewife type eggs (18.1 percent), unidentified eggs (4.7 percent), juvenile alewife (3.2 percent), unidentified stickleback (2.4 percent), and unidentified Coregoninae (1.6 percent). All other taxa/life stage groups accounted for <1.0 percent of the ichthyoplankton occurring in the entrainment samples

The relative abundance of ichthyoplankton in samples from the three ambient locations varied widely among each other and with the entrainment samples:

		Relative Abundance (percent)			
			Ambient Contour Locations		
Taxa	Life Stage	Entrainment	6 to 8-ft	18 ft	30 ft
Clupeidae	Yolk-sac	--	6.7	11.6	4.9
Alosa	Yolk-sac	--	4.2	16.5	5.6
Yellow perch*	Yolk-sac	--	1.0	11.0	16.9
Stickleback	Post Yolk-sac	--	0.2	2.8	5.0
Rainbow smelt*	Mixed ages	62.2	2.2	21.0	45.7
Alewife type*	Egg	18.1	73.7	3.7	--
Unidentified	Egg	4.7	0.8	0.1	0.6
Alewife*	Juvenile	3.1	0.1	--	--
Coregoninae	Yolk	1.6	3.9	13.5	0.8
Stickleback	Mixed ages	2.4	--	3.6	2.4
Common carp*	Yolk-sac	0.8	4.6	1.0	0.6
Burbot*	Yolk-sac	0.8	0.1	4.7	9.3
Other Taxa	Mixed	6.3	2.7	10.5	8.3
Totals		100.0	100.0	100.0	100.0

*designates RIS.

Rainbow smelt (all life stages) accounted for 62.2 percent of the total entrainment sample compared to only 2.2 percent in the 6 to 8-ft contour samples. The relative abundance of rainbow smelt increased at the 18-ft and 30-ft contours to 21.0 and 45.7 percent, respectively. The 6 to 8-ft contour samples were dominated (73.7 percent) by alewife type eggs; no other taxa accounted for more than seven percent of the total number of ichthyoplankton collected at that location. Relative abundance of taxa in the 18-ft contour samples was more evenly distributed as six taxa/life stage groups accounted for more than 10 percent of the total including rainbow smelt (21.0 percent), yolk-sac larvae of unidentified *Alosa* (16.5 percent) and yolk-sac yellow perch (11.0 percent). Early life stages of yellow perch did not occur in the entrainment samples. In the ambient samples, the highest yellow perch densities occurred in the 30-ft contour samples where they accounted for 16.9 percent of the total sample. Rainbow smelt (all life stages combined) accounted for 45.7 percent of the ichthyoplankton in the 30-ft contour samples. The majority of rainbow smelt collected from the 30-ft contour were post yolk-sac larvae, whereas in the entrainment samples juvenile rainbow smelt were more abundant.

The entrained taxa represented fishes common in Lake Michigan based on historical data collected at PBNP from April through October 1975 (WEPCO 1976). In 1975, a total of 91 fish larvae occurred in the entrainment samples compared to 97 larvae in 2006 using the same fundamental collection system. The 1975 entrainment samples contained rainbow smelt (62.6 percent of the larvae), alewife larvae (18.7 percent), sculpin (16.5 percent), and longnose sucker (2.2 percent). Alewife eggs were the only fish eggs collected during the 1975 study. The relative abundance of early life stages of rainbow smelt and alewife were similar between studies, although alewife eggs were more abundant in the current study than were larval alewife. Samples from the current study contained more taxa than were reported during the 1975 study, including common carp, burbot, unidentified stickleback, *Lepomis*, and several broad taxonomic groups such as Coregoninae, cyprinids, and catostomids.

Recent Impingement Study at PBNP

Impingement sampling was recently conducted at the PBNP on a weekly schedule from December 2005 through early May 2006 and twice weekly from mid-May through November (EA 2007a). The sampling program yielded a total of 80 sampling events that averaged 22.2 hours during the 12-month study.

Species composition during the 2005-06 study was generally similar to that encountered during the 1975-76 study (WEPCO 1976). Thirty-two species were collected in the earlier study compared to 40 species in the 2005-06 study. Twenty-seven of the 46 combined species were common to both studies, including four species (alewife, rainbow smelt, spottail shiner, and yellow perch) selected as RIS by the WDNR for this evaluation (see Section 5.5). Species only encountered in the current study included three exotic species (white perch, threespine stickleback, and round goby) that were either not known to occur in Lake Michigan in the 1970s or occurred in low numbers (Lyons et al. 2000). Slightly fewer salmonid species were collected in the current study (7) than in the 1975-76 study (8). In contrast, more sunfish species were collected during the 2005-06 study (6) than in the 1975-76 study (2). Despite similar species compositions, there were differences between the studies in relative abundance in terms of numbers and biomass primarily because of higher numbers of alewife and fewer rainbow smelt impinged during the 2005-06 study.

During 2005-06 study, alewife accounted for over 99 percent of the total impingement and almost 93 percent of the total biomass. Three other RIS (rainbow smelt, spottail shiner, and gizzard shad) ranked second through fourth numerically, accounting for 0.6, 0.1, and <0.1 percent of the individuals collected, respectively. Three other RIS were represented by more than 100 individuals in the impingement samples: mottled sculpin (627), yellow perch (579), and bloater (105). The relative abundance of the 10 most common species impinged during the 2006-06 study was somewhat different than encountered during the 1975-76 study; primarily reflecting more alewife and spottail shiner, but fewer rainbow smelt and slimy sculpin in 2005-06:

	2005-06 Study		1975-76 Study	
Species	Number	Percent	Number	Percent
Alewife *	1,595,015	99.1	265,644	84.8
Rainbow smelt*	9,144	0.6	43,416	13.8
Spottail shiner*	1,276	0.1	19	<0.1
Gizzard shad*	738	<0.1	577	0.2
Mottled sculpin*	627	<0.1	0	0.0
Yellow perch*	579	<0.1	66	<0.1
Ninespine stickleback	556	<0.1	212	<0.1
Threespine stickleback	517	<0.1	0	0.0
White sucker	198	<0.1	26	<0.1
Slimy sculpin	135	<0.1	2,927	0.9

* designates RIS.

Note: Both studies were conducted over a 12-month period using 24 hr. sampling events. A total of 88 collecting events were conducted in 1975-76 and 80 in 2005-06.

The two most abundant species (alewife and rainbow smelt) collectively accounted for 98.6 to 99.7 percent of the total number collected in each study. Notable differences between studies included both substantial increases and decreases in impingement of several RIS: the number of alewife, spottail shiner, and yellow perch collected during the 2005-06 study was several fold greater compared to the 1975-76 study, whereas the number of rainbow smelt was several fold lower in 2005-06. Mottled sculpin was fairly common in 2005-2006, but was absent in 1975-76.

The majority of species impinged at PBNP during the 2005-06 study were infrequently collected as only eight species occurred in more than 50 percent of the sampling events and none of the species were sampled during all 80 sampling events. The two most abundant species were collected during 62 (alewife) and 67 (rainbow smelt) of the 80 sampling events. Other commonly impinged species that occurred in at least 50 percent of the events included two RIS: mottled sculpin (71events) and spottail shiner (45 events). Most of the impinged taxa occurred in less than a third of the sampling events.

High occurrence of just a few species on the traveling screens was also documented during the 1975-76 study when rainbow smelt, slimy sculpin, alewife, and ninespine stickleback were the only species that occurred in more than 50 percent of the 88 sampling events. Several differences were apparent for common species that were collected during both studies:

Species	2005-06 Study Occurrence (No. Events)	2005-06 Study Percent	1975-76 Study Occurrence (No. Events)	1975-76 Study Percent
Alewife	62	78	59	67
Rainbow smelt	67	84	81	92
Spottail shiner	45	56	13	15
Gizzard shad	31	39	29	33
Mottled sculpin	71	89	0	0
Yellow perch	52	65	28	32
Ninespine stickleback	43	54	58	66
White sucker	46	58	15	17
Slimy sculpin	34	43	79	90

Note: Both studies were conducted over a 12-month period using 24 hr. sampling events. A total of 88 studies were conducted in 1975-76 and 80 in 2005-06.

Species that occurred more frequently during the current study were spottail shiner, mottled sculpin, yellow perch, and white sucker; whereas rainbow smelt and slimy sculpin occurred more frequently during the 1975-76 study. The frequency of occurrence of alewife and gizzard shad was similar during both studies.

Seasonally, approximately 95 percent of the total estimated impingement occurred from 23 April through 5 August 2006, which mirrored the seasonal impingement of alewife. Alewife were impinged from December 2005 through early April 2006 and peaked in early June 2006. The absence of alewife during the winter and early spring is consistent with their offshore/onshore movements in Lake Michigan (Becker 1983). Alewife occurred on the screens after intake temperatures reached 7.2°C (45°F) and rates remained high through early June when water temperatures averaged approximately 8.9 – 11.1°C (48°F - 52°F). Impingement of alewife declined precipitously when water temperatures increased above 12.8°C (55°F) from August through early September, impingement rates then increased only slightly through the remainder of the study when intake temperatures declined below 10°C (50°F). Lower rates in the fall and early winter were presumably related to offshore movements of alewife to deeper water for the winter.

Rainbow smelt was the second most abundant species impinged at PBNP in the 2005-06 study. It occurred in 67 of the 80 samples but accounted for only 0.4 percent of the total estimated impingement. Impingement rates were highest in October 2006 when 48 percent of the rainbow smelt total was impinged. Impingement of rainbow smelt was generally lowest when intake temperatures were highest, from mid-June through September 2006.

Although yellow perch occurred in 52 of the 80 samples, they accounted for <0.1 percent of the total estimated impingement. Impingement rates were highest in the winter (December 2005 through early March 2006) when 56 percent of the yellow perch were impinged. Rates were consistently low when intake temperatures increased above 4.4°C (40°F) and remained low into the summer when intake temperatures were 10 – 12.8°C

(50 - 55°F). Impingement was somewhat higher as intake temperatures declined through the fall.

Seasonal impingement estimates of three other RIS were variable. Gizzard shad were impinged primarily in the winter (December – February) and from the late summer through November. Nearly 50 percent of the total gizzard shad impingement estimate occurred in February, October, and November as a result of three sampling events. Gizzard shad were not impinged from late March through late August, whereas 69 percent were impinged from October through November. Spottail shiner exhibited similar seasonal trends with 68 percent of the estimated impingement occurring from mid-September through mid-October. Mottled sculpin, which was the most frequently encountered RIS, exhibited variable rates from December through late August and increased through early October when 45 percent of the estimated impingement occurred.

3.2 LAKE MICHIGAN FISH COMMUNITY

Even though actual population data are not available for many species, it is clear that the Lake Michigan fish community has changed substantially over the past 50 years (Wells and McLain 1973, Sommers et al. 1981, Jude and Tesar 1985, Mills et al. 1993, Bunnell et al. 2007). The purpose of this section is not to describe those changes in detail, but rather to document the dynamic nature of the fish community as well as to demonstrate that the fishery is highly managed, mainly as a result of salmonid stocking, but also via recreational or commercial harvest limits (e.g., recent changes in yellow perch limits and commercial fishing quotas). Some of the most dramatic changes are attributable to non-native species; some purposely introduced, most not. Although some of the changes in the fish community occurred over 100 years ago (e.g., the near elimination of lake sturgeon before 1900), the majority of the changes have occurred during the 20th century.

Some of the non-native fish species currently found in Lake Michigan includes:

Common carp	Sea lamprey
Alewife	Rainbow smelt
White perch	Ruffe
Round goby	Three-spine stickleback

Some of the non-native macroinvertebrate species currently abundant in Lake Michigan include:

Zebra mussels	Spring water flea
Quagga mussels	Fishhook water flea

Species purposely introduced for exotic fish species management or for recreational benefits include the Pacific salmon (e.g., Chinook and Coho salmon) and many strains of steelhead, brown trout, and brook trout. The introduction of these non-native species has drastically altered the ecology of Lake Michigan. Major changes to the fish community documented by Wells and McLain (1973) and others are:

- Rainbow smelt; studies have documented this species' impact on lake herring and walleye populations in Green Bay; it subsequently was harvested by both commercial and recreational fishermen;

- Sea lamprey, which Smith (1968) estimated were destroying five million pounds of fish (mainly coregonids) per year in the mid-1950s;

- Lake trout essentially being eliminated by the sea lamprey by ~1960;

- Alewife, which in the mid- to late 1960s accounted for more than 80 percent of the lake's biomass; studies have documented its impacts on the emerald shiner, lake trout, Atlantic salmon, burbot, deepwater sculpin, and yellow perch populations (Madenjian et al 2008);

- Salmonid introductions.

One of the greatest success stories in the history of fisheries management is the stocking of salmonids in Lake Michigan, starting in the 1960s. These stockings were initiated to both reestablish lake trout and to control the huge alewife population. Although lake trout are native to Lake Michigan, the stocked salmonids (Chinook salmon, Coho salmon, rainbow trout, and brown trout) are not native. There are several important facts to consider regarding Lake Michigan salmonids. First, this large predator biomass, though very popular, requires a huge forage base to support it. Second, there has been no meaningful reproduction observed for either the introduced salmonids (until recently) or native lake trout. Thus, for salmonids, Lake Michigan is managed primarily as a put-and-take fishery. In the case of lake trout, stocking and harvest limits continue to be manipulated in attempts to establish a sustainable lake trout population. Stockings of the other salmonids are adjusted annually to account for changes in the forage base, mainly alewife.

Based on annual USGS trawl data (Bunnell et al. 2007) and data from other sources (Lyons et al. 2000), major changes in Lake Michigan during the past 30 years are:

- Alewife biomass has decreased roughly three-fold compared to the early 1970s.
- Rainbow smelt, emerald shiner, and yellow perch numbers are currently very low.
- Bloater (an important commercial species) biomass has changed considerably; first a large increase in the 1980s, followed recently by a substantial decrease in the 1990s.
- Several large coregonids (chubs) have been either greatly reduced in Lake Michigan (e.g., lake herring) or become extinct (e.g., deepwater cisco [*Coregonus johannae*] and shortnose cisco [*Coregonus reighardi*])

In this report, we attempt to address the impact of thermal discharges from a variety of perspectives but want to point out the difficulties of applying a "balanced indigenous community" approach to such a dynamic and manipulated system.

3.3 THERMAL EFFECTS STUDIES AT OTHER LAKE MICHIGAN POWER PLANTS

Major thermal effect studies have been performed at a number of large, steam electric power plants located along Lake Michigan that use lake water for once-through cooling operations. Findings from these plants were summarized by Duke/Fluor Daniel (1992) and are reproduced here with only minor modifications. These studies are applicable because they actually represent worse case conditions during a period of higher heat loading to Lake Michigan than exists today, due to power plant unit retirements over the past 20 years. Several units that were operational in the 1970s are now retired, including Zion Nuclear Units 1and 2, Oak Creek Power Plant Units 1-4, Edgewater Units 1 and 2, and Port Washington Units 4 and 5.

3.3.1 Oak Creek Power Plant

The waters of Lake Michigan near the Oak Creek Power Plant (OCPP) were studied from November 1972 through October 1973 (Limnetics 1974) when all eight units were operating. During this one-year period, most trophic levels were sampled twice a month in the spring, summer, and fall and monthly during the winter. The trophic levels studied were phytoplankton, periphyton, zooplankton, macroinvertebrates, and fishes. Sampling was conducted along transects at the 12-, 18-, and 24- ft depth contours within the thermal plume area and at a reference area situated approximately one mile north of the OCPP.

Phytoplankton – Overall, phytoplankton communities in the reference and plume areas were similar in terms of density, evenness, species dominance, and composition (Limnetics 1974). In addition, these measures followed similar patterns in both the plume and reference areas indicating that the plant's thermal discharge did not affect normal seasonal patterns of abundance, composition, or diversity of the phytoplankton community.

Periphyton – There were no significant annual or monthly differences in periphyton abundance between the reference and plume areas except in August when blue-green algae were more abundant in the plume (WEPCO 1975). There were no differences in periphyton biomass between the two areas and composition, though seasonally variable, was generally similar between the two areas.

Macrophytes – None were found in either the plume or reference areas due to unsuitable physical conditions (e.g., high wave energy impacting shallow shoreline areas.

Zooplankton – There were no consistent differences between the two areas in terms of zooplankton distribution or abundance (Limnetics 1974). Overall, abundance and composition were similar and seasonal patterns were nearly identical.

Macroinvertebrates – Macroinvertebrates were sampled both within the plume and reference areas at the 12-, 18-, and 24-ft depth contours. Within both areas, the benthic community was dominated by worms, midges, and snails. Artificial substrates deployed at the 12-ft contour within the plume were colonized by macroinvertebrate communities that were **more** abundant and **more** diverse than those deployed in the reference area. In particular, the artificial substrates within the plume area contained many more caddisflies, a group that is relatively sensitive and provides a valuable food source. Thus, the net effect of the plume on the macroinvertebrate community was found to be positive.

Diporeia was uncommon in all the benthic collections near the plant and no *Mysis* were found indicating that the plume poses minimal risk to these organisms. However, during the 1975-76 intake monitoring study conducted by WEPCO, both of these macroinvertebrates were entrained through OCPP.

Thus, overall no significant impacts from the eight-unit operation of OCPP were found at any of the lower trophic levels. In fact, if anything, the net effect was probably beneficial due to the warmer temperatures and nearshore riverine-like conditions provided by the discharge. The discharge created a microhabitat suitable for various beneficial benthic organisms, especially caddisflies.

Studies conducted at other Lake Michigan power plant discharges have reached the same conclusion, i.e., that lower trophic level organisms are not impacted by once-through cooling.

Fish

Fish in the vicinity of the OCPP were sampled at the 12-, 18-, 24- ft depth contours twice a month (except during the winter) using gill nets and trawls. The fish communities in both plume and reference areas were typical of those expected for the nearshore waters of Lake Michigan indicating that the thermal discharge did not prevent the establishment of a BIC.

The gill net collections yielded 9,318 fish representing 26 species, with rainbow smelt and alewife accounting for about two-thirds of the total. Trawling yielded 5,192 fish representing only four species. The trawl catch was overwhelmingly dominated by alewife (77 percent) and rainbow smelt (23 percent).

On an annual basis, lake trout, trout-perch, lake chub, brown trout, spottail shiner, carp, rainbow trout, longnose sucker, white sucker, yellow perch, and rainbow smelt were found more frequently in the plume than at the reference areas, whereas alewife, Coho salmon, and longnose dace were found more frequently at the reference areas than in the plume: (Limnetics 1974). However, these differences were not necessarily significant. Those showing significant differences between the plume and reference areas over the course of the study were:

Plume	Reference
Brown trout	Alewife
Spottail shiner	Longnose dace
Common carp	
Longnose sucker	
White sucker	
Rainbow smelt	

Thus, of the 26 species collected gill netting, most (69 percent) exhibited no preference for the plume or the reference area. Of those exhibiting a preference, six species preferred the plume and only two species preferred the reference area. Because of the lack of preference for one area or the other, there was not a correlation between water temperature and abundance for most species (Limnetics 1974).

Sufficient data were available to compare body condition for 14 species between the discharge and reference areas. Eleven of those 14 species exhibited no significant difference in body condition between the two areas (Limnetics 1974). Alewife and lake chub, on average, had significantly higher condition factors within the reference area, whereas the reverse was true for rainbow smelt which had significantly higher condition factors in the plume.

In summary, the 1972-73 thermal study at OCPP (Limnetics 1974) revealed the following important findings concerning the fish community.

- The fish community near the OCPP was similar to that expected for the southwest shore of Lake Michigan.
- Community composition was similar in both the plume and reference area.
- Most fishes neither preferred nor avoided the discharge plume.
- Of those exhibiting a preference for one area or the other, most (six of eight species) preferred the plume.
- As judged by condition factors, no evidence of adverse effects on growth was detected. Most species showed no significant difference in condition factors between the two areas. Alewives and lake chubs had higher condition factors in the reference area, whereas rainbow smelt had significantly higher condition values within the plume.
- Fish moved freely about the area; there was no evidence that the thermal plume blocked or disrupted migratory movements.
- In fact, it was these migratory or seasonal movements that controlled the distribution of fish within the study area, not the presence or position of the OCPP thermal plume. For example, the three dominant fishes exhibited expected seasonal patterns. Alewife and rainbow smelt overwintered in offshore, deepwater areas, moved nearshore in the spring to spawn, spawned, and then largely vacated the nearshore area during the summer as they moved to deeper waters prior to overwintering. Yellow perch also overwintered in offshore waters and then were relatively abundant near shore from June through the end of the study in October.

- The thermal plume was relatively small, the 2°C ΔT isopleths, even under worst case conditions, never covered more than about one square mile. Lake Michigan covers about 22,300 square miles.

The larval fish study documented successful reproduction by alewife and rainbow smelt, the two dominant species near the OCPP. On the other hand, no yellow perch larvae were found despite the fact that it was the third most common species in the gill net collections. The apparent absence of yellow perch larvae, and the near absence of larvae of most species, suggested that the OCPP area was not a significant or unique spawning area for most Lake Michigan species.

Recent Larval Studies near OCPP

Beginning in 2002, ichthyoplankton studies were conducted in the intake canal for OCPP as well as in offshore Lake Michigan waters (EA 2003 and EA 2004). Information was collected to enable We Energies to make decisions regarding offshore intake placement and design strategies to minimize impingement and entrainment. The program was designed to allow comparison with historical studies and to provide information concerning nearshore and offshore ichthyoplankton populations, including spatial and seasonal differences in composition and abundance.

The first year of ichthyoplankton collections began in June 2002 and continued through September 2002, whereas in 2003, the collection period was from May through September. During each collection period, samples were collected every two weeks during nighttime hours (to reduce net avoidance). The sampling program consisted of two components (nets and pumps). To collect eggs and larvae, paired one-meter 335 micron mesh ichthyoplankton nets were towed along five transects: in the intake canal, near the mouth of the intake canal along the 18-ft contour in both years, and along the 30-, 35- and 40-ft contours in 2002, and along the 40-, 43- and 46-ft contours in 2003. Except in the shallower intake canal, where two depths were sampled, samples along each contour from 18- to 43-ft were collected at three depths; surface, mid-depth, and near bottom. In addition to the tows, a diaphragm trash pump was utilized to collect duplicate samples from two locations on the bottom along each of the five transects. Larvae and eggs were identified to the lowest practical taxon and counted (EA 2003 and 2004).

In both years, the ichthyoplankton collections using plankton nets were dominated by forage taxa, predominately alewife larvae. Alewife/spottail shiner eggs dominated the pump samples along with other forage taxa such as *Pimephales* type, spottail shiner, and sculpins. Although no yellow perch eggs were collected in 2003, nearly 30 percent of the larvae collected with tow nets in the 2003 were yellow perch. No other sport or gamefish were collected.

In the earlier 1975 lake survey (WEPCO 1976), alewife larvae were also dominant (80 percent), but the second most abundant larvae collected was rainbow smelt (13.5 percent). In 2003, only one percent of the larvae were rainbow smelt; the reduced number of larvae is likely the result of a lake-wide decline in rainbow smelt (Bunnell et al. 2007). Only one yellow perch larvae was collected in the 1975 study, whereas 4.5 percent of the larvae collected in the 2002 net program were yellow perch.

The 2003 netting effort resulted in the collection of 28 taxa of which at least 18 were different species. Eggs comprised 11.5 percent of the specimens, whereas larvae comprised 88.5 percent. The eggs consisted almost entirely of alewife/spottail shiner type (99.5 percent) with the remaining 0.5 percent being unidentified Cyprinidae. The net samples were dominated by alewife larvae (50.2 percent), followed by yellow perch larvae (28.9 percent), alewife/spottail shiner type eggs (11.4 percent) and mottled/slimy sculpin (2.2 percent). All remaining taxa, which included gizzard shad, rainbow smelt, lake chub type, common carp, spottail shiner type, *Pimephales* type, cyprind spp, longnose sucker type, burbot, ninespine stickleback, Johnny darter type, round goby, mottled sculpin, slimy sculpin, and deepwater sculpin, comprised 7.3 percent of the collection.

Fish eggs dominated the 2003 pump samples, which included alewife/spottail shiner (96.0 percent) and unidentified Cyprinidae (2.6 percent). The remaining 1.4 percent of the eggs included rainbow smelt, stickleback type, sculpin type, and trout-perch/sculpin type. Larval specimens in the pump samples included alewife, ninespine stickleback, unidentified stickleback, round goby, mottled sculpin, and mottled/slimy sculpin. The 2002 pump samples yielded similar results.

Given that 29 taxa representing at least 19 species were collected during the two years combined, these data show that a naturally reproducing, diverse fish assemblage continues to be seasonally present near OCPP despite approximately 50 years of operation. These data showed that the larval fish community, as expected, was dominated by alewife, the dominant forage fish in the lake. These data also showed that deepwater species (e.g. burbot, bloater, deepwater sculpin.) were rarely collected, even at the 46-ft contour. They also show that larval fish relative abundance in 2002-2003 was similar to that seen 30 years earlier, except that yellow perch numbers appeared to be are higher today while rainbow smelt numbers were lower.

3.3.2 Zion Nuclear Station

The Zion Nuclear Station (now retired) is located on the southwestern shore of Lake Michigan in northern Illinois, approximately 3.5 miles south of the Wisconsin-Illinois state line and ~135 mi south of the PBNP. The Zion Station was comprised of two 1,085 MW nuclear-fueled, steam electric generating units that withdrew once-through cooling water from Lake Michigan. The maximum design temperature increase (ΔT) was approximately 11.1°C (20°F). The plant operated at 85 percent of design thermal capacity from July 1973 to June 1976 and was authorized to operate at 100 percent of thermal output after 25 June 1976.

The Zion Station cooling water intake and discharge are both located offshore. The intake structure is located 2,600 feet offshore at a water depth of 22 feet. Twin discharge structures extend 760 feet into the lake from locations 154 feet either side of the intake, and deflect the cooling water discharge away from the shoreline and intake structure at 45-degree angles. Maximum cooling water flow rate was 1.68 million gpm (2,419 MGD). During the period from 1973 through 1978, Zion Units 1 and 2 typically operated at capacity factors of 20 to 90 percent.

Environmental monitoring to document pre-operational and operational environmental conditions in Lake Michigan in the vicinity of the Zion Station and to identify possible impacts of plant operations, including thermal impacts, was conducted from January 1970 through September 1978. Results of these studies were summarized in Hazleton Environmental Sciences (1979). Studies at the Zion Station included current and thermal plume measurements, and studies of water quality, phytoplankton, zooplankton, periphyton, benthos, fish eggs and larvae, and adult fishes.

Thermal Plume

The Zion Station thermal plumes (2°F isotherm) were generally shore-associated plumes extending approximately 3 to 6 km (1.9 to 3.7 miles) north or south of the station, and approximately 2 to 3 km (1.2 to 1.9 miles) south from the shore throughout the year (Hazelton Environmental Services 1979).

Water Quality

Water quality studies did not detect impacts attributable to operation of the Zion Station. Nearshore turbulence that increased suspended sediments and associated nutrients, the seasonal effects of increased or decreased biological activity, and circulation patterns of Lake Michigan waters were the controlling influences on water quality in the vicinity of the Zion Station.

Phytoplankton

Composition of the phytoplankton community and seasonal trends of abundance and associated productivity rates were similar during pre-operational and post-operational periods and among thermally affected and control areas. Control and plume locations exhibited typical bimodal seasonal patterns with spring and fall maxima.

Zooplankton

Zooplankton populations did not differ between the thermally-affected and control areas near the Zion Station. Variations in zooplankton densities and taxonomic distributions at the Zion Station were similar to those expected due to natural variation in the nearshore Lake Michigan waters.

Periphyton

Periphyton growth was made up of species typical of the shoreline communities of Lake Michigan, and fluctuations in periphyton growth could not be attributed to operation of the Zion Station. No trends or evidence of growth stimulation or inhibition in periphyton could be detected.

Macroinvertebrates

Benthic macroinvertebrates generally increased in density and exhibited a shift toward more eutrophic forms throughout the study area from 1970 through 1978. Similar trends were apparent at corresponding depths at both plume and reference stations, so the changes observed appeared to reflect regional phenomena, rather than a response to the Zion Station thermal discharge.

Fish

Seasonal abundance and distribution of fish eggs and larvae were studied in the Zion cooling water plume and adjacent receiving waters. Although egg and larval abundance of some species exhibited large year-to-year fluctuations, no trends were found during the study. Rainbow smelt and alewife eggs and larvae, two RIS for this evaluation, were the most abundant ichthyoplankton, and these were the only species for which spatial distribution differences could be demonstrated. Eggs, larvae, and YOY were most numerous in the nearshore zone from the 10- to 30-ft depth contours. No differences in distribution of rainbow smelt or alewife larvae or YOY were found among transects arrayed perpendicular to the shoreline.

Adult fish were collected with gill nets, trawls, and minnow nets. A total of 37 species were collected from 1971 through 1978 with rainbow smelt and alewife the most numerous species collected. The collections did not demonstrate any consistent changes in seasonal movements or fish distribution within the areas surrounding Zion Station. Statistically significant differences among locations based on trawl catches sometimes occurred, but no patterns or trends were evident. Studies indicated no adverse effects on the local fisheries due to temperature changes, or due to temperature preference and avoidance. Major changes in abundance of three RIS (alewife, rainbow smelt, and bloater) occurred during the study, but these changes were consistent with lake-wide fluctuations (Bunnell et al. 2007) and could not be related to operation of the Zion Station.

Age and growth studies of lake trout and yellow perch showed that the population structure of these species did not change appreciably during the study period. Growth of alewife showed no variation among sampling zones. No changes in food habits of lake trout, yellow perch, or slimy sculpin occurred during the study, and no biologically significant changes in condition factors of fish in the vicinity of the Zion Station occurred. Fecundity of alewife and rainbow smelt during the study varied in a manner suggestive of compensatory responses to year-to-year changes in population levels, but these responses could not be related to operation of the Zion Station.

Alewives, rainbow smelt, and salmon showed some tendency to be attracted to the thermal plume early in their spawning migrations. Rainbow smelt and alewife eggs were sometimes found on transects influenced by the Zion thermal plume. This may have resulted from attraction of spawning fish to the plume during the spawning season, concentration of eggs due to current patterns, or purging of eggs by impinged females at the cooling water intake.

3.3.3 Kewaunee Nuclear Power Plant

The Kewaunee Nuclear Power Plant (KNPP) is located on the western shore of Lake Michigan, approximately eight miles south of the city of Kewaunee, and 90 miles north of Milwaukee, Wisconsin (WPSC 1976). It is located approximately five miles north of PBNP. KNPP became operational in 1974 and consists of a pressurized water reactor with a turbine generator capable of producing 540 MW of electrical power. The plant uses Lake Michigan water for its once-through condenser cooling system and employs a shoreline discharge. The cooling water intake structure is located approximately 1,600 ft offshore at a depth of 16 feet. Condenser cooling water is drawn from Lake Michigan at a rate of 287,000 gpm (413 MGD) during the winter and 413,000 gpm (595 MGD) during the summer. The design maximum temperature rises corresponding to these flow rates are 8.7°C (15.6°F) and 6.2°C (11.1°F), respectively. Cooling water is discharged into an outlet basin at the shoreline through a pipe located just below the lake surface.

In May 1976, Wisconsin Public Service Corporation submitted a 316(a) demonstration (WPSC 1976) to WDNR to apply for a variance from the limitations imposed by the then-effective Lake Michigan thermal standards for surface waters (WDNR 1975). The demonstration followed the draft U.S. EPA "Proposed Guidelines for Administration of the 316(a) Regulations" (U.S. EPA 1974). Wisconsin Department of Natural Resources (WDNR) guidance documents "Proposed Guidelines for Demonstration under Section 316 of Public Law 92-500" (Wisconsin DNR 1974), and "Proposed Outline for 316(a) Demonstration Document" (WDNR 1974) were also consulted in preparation of the KNPP 316(a) demonstration.

The KNPP 316(a) demonstration concluded that no appreciable harm to Lake Michigan shellfish, fish, or wildlife had resulted from the thermal component of the KNPP cooling water discharge and therefore, that the thermal discharge had not disturbed the BIC in the vicinity of the KNPP. The limitations imposed by the Lake Michigan thermal standards were judged to be more stringent than necessary to protect aquatic communities near the KNPP discharge, and a modification of the discharge limitations for the continuation of the thermal discharge was granted by the WDNR.

The KNPP 316(a) demonstration contains an evaluation of Lake Michigan data collected in the zone of influence of the KNPP thermal discharge as well as areas outside the discharge zone. The evaluation included information on the physical, chemical, and biological character of the lake in the vicinity of the KNPP. The data collected characterized the effects of plant operation and thermal discharge on water quality, fisheries, benthic macroinvertebrates, phytoplankton, zooplankton, periphyton, and aquatic macrophytes.

Data collected in Lake Michigan near KNPP indicated that water quality in the vicinity of the plant was representative of general Lake Michigan conditions. Comparison of water quality within and immediately outside the KNPP thermal plume demonstrated that the plant had no adverse impact on Lake Michigan water quality.

Comparisons of pre-operational and operational data showed no appreciable influence of the thermal discharge on the local fishery. There were no major changes in the species composition, nor were there any changes in the seasonal abundance and spatial distribution of important species that could be attributed to the thermal discharge. No noticeable increase or decrease in the use of the affected area for spawning was detected, and there were no remarkable increases or decreases in the numbers of individuals for species frequenting the area. The demonstration concluded that the KNPP thermal discharge caused no appreciable harm to the fishery in the discharge zone and had no demonstrated effect on the fishery in the area of Lake Michigan immediately outside the discharge zone.

At certain times of the year, many species of fish appeared to be attracted to the thermal discharge to some extent, which appeared to be associated with times of peak abundance in the area and with spawning seasons. Attraction to the thermal discharge was believed to be a response to preferred temperatures, but fish also avoided the discharge when discharge temperatures were too high.

Biological monitoring revealed certain responses to the operation of the condenser cooling water system at KNPP. Zooplankton, phytoplankton, and periphyton exhibited significant differences from conditions existing either outside the zone of influence of the thermal discharge or prior to operation of the KNPP. However, it was concluded that these differences did not constitute deleterious effects on the health and maintenance of the balanced aquatic community.

Thermal Plume

Typical thermal plume configurations at the KNPP extend both north and south of the plant and eastward into the open waters of Lake Michigan (WPSC 1976). In general, the area influenced by the thermal plumes (to the limit of the 1°C (1.8°F) excess temperature isotherm) extended approximately 2 km (1.2 miles) north and south, and 2 km (1.2 miles) eastward from the discharge point. The position of the Kewaunee Plant on a point extending into the lake appears to cause the thermal plume to be less likely attached to the shoreline in response to along-shore currents or onshore winds than would occur on a more linear, north-south oriented shoreline area such as exists at PBNP. The area influenced by the thermal plumes was sampled to determine impacts of the thermal discharge on Lake Michigan biota as described below.

Zooplankton

Studies of the effects of condenser passage and increased temperatures on the zooplankton population in the vicinity of KNPP found that mechanical damage was the primary factor causing immotility of entrained zooplankton. Plume immotilities were highest nearest the discharge and decreased as the discharge mixed with the receiving water. Plume entrainment (as distinguished from intake entrainment) appeared to have no effect on zooplankton viability and plume temperatures did not reach critical thermal tolerance levels for zooplankton. No substantial alterations in community structure were found in the vicinity of the plume, and it was concluded that operation of KNPP did not cause appreciable harm to the zooplankton community inside or outside of the discharge zone.

Phytoplankton

The effects of condenser passage and increased temperatures were measured on the phytoplankton population in the vicinity of KNPP. A slight overall stimulation of productivity, measured as carbon fixation, was observed immediately following condenser passage. The overall productivity increase due to temperature was approximately 16 percent. Thus, passage through the plant actually resulted in increased productivity. Likewise, phytoplankton entrained in the KNPP thermal plume exhibited elevated abundance, carbon fixation rate, and chlorophyll *a* concentration relative to phytoplankton from a control location. Recovery to near ambient levels of abundance, carbon fixation rates, and chlorophyll *a* concentrations was demonstrated by the time the organisms had reached the outer edge of the thermal plume.

Total phytoplankton abundance increased from the pre-operational to the operational period due primarily to the occurrence of large numbers of epilithic diatoms. Detection of a similar increase in the control area in 1974 suggests that this trend may have been due to natural variations in regional populations.

A measurable increase in epilithic diatoms occurred in the discharge area between the pre-operational and operational periods. The occurrence of these species in the plume appeared to be influenced by season, and was also related to the scouring in the discharge canal. Abundant growths of periphytic diatoms were recorded in samples from the discharge canal wall that may have been the source of the high diatom concentrations observed.

Results of phytoplankton studies at control locations indicated that the phytoplankton community structure in the nearshore area of western Lake Michigan in the vicinity of the KNPP remained essentially unchanged between the preoperational and the operational periods. It was concluded that there had been no appreciable harm to the phytoplankton community in either the discharge zone or the receiving water body.

Periphyton

Larger standing crops of periphyton on either side of the discharge canal during November 1973-74 were a result of a larger number of substrates available for algal colonization than were present at either of the two control locations. These substrates consisted of riprap placed around the discharge canal during construction of the plant to prevent shoreline erosion. In addition, the substrates at the discharge canal were usually protected from harsh lake conditions by variations in shoreline and bottom topography. The most abundant algae encountered were green algae, followed by diatoms. Blue-green algae were usually minor constituents of the periphyton community.

The seasonal variations of species of green algae, occurrence of dominant diatoms, and algal standing crops within the discharge canal were similar to those found in the shoreline periphyton community. The occasional occurrence of higher numbers of diatoms and blue-green algae, and dominance of some species in the discharge canal were localized effects associated with the operation of KNPP.

Differences in the periphyton assemblages among locations outside the discharge zone were comparable between pre-operational and operational periods at the KNPP and could not be related to any effect of plant operation. This conclusion was supported by the absence at the north and south control locations of high numbers of some of the species typical of the discharge canal periphyton assemblage.

Macroinvertebrates

Effects of the KNPP discharge on the macroinvertebrate community were not detected based on pre-operational and operational monitoring studies conducted during the 1970s. Densities of major taxa were similar between discharge and reference sites and the community outside the immediate discharge area had not changed.

Fish

Comparisons of pre-operational and operational monitoring showed no appreciable influence of the thermal discharge on the fishery in the vicinity of KNPP based on species composition, seasonal abundance, and spatial distribution patterns of the common fish species. A shift in the use of the affected area for spawning was not detected and there were no remarkable increase or decreases in the number of fish in the vicinity of the discharge. Some species were seasonally attracted to the thermal discharge that was associated with normal inshore seasonal movements when preferred temperatures occurred, whereas avoidance was evident when discharge temperatures were highest. The 316(a) demonstration for KNPP concluded that the discharge of heat had not caused appreciable harm to the fishery in the vicinity of the plant

Recent Studies in the Vicinity of KNPP

A recent Impingement Mortality and Entrainment Characterization Study for KNPP, which was conducted between February 2006 and February 2007 (EA 2007b), provided results that suggest the fish community in the vicinity of the plant is similar to that documented by the 1970s studies. The recent study showed that species that were common near KNPP in the 1970s remain the most common in 2006. KNPP is only five miles north of PBNP, and although it is located on a point (rather than along a straight shoreline as at PBNP) and the inshore habitats differ between plants, the recent data at

KNPP are consistent with recent entrainment and impingement data collected at PNBP (EA 2007a).

Juvenile and adult fish in the vicinity of KNPP were sampled from April through October 2006 at three locations using seines and experimental gill nets. The northern most locations represented a reference site and two locations bracketed the KNPP site. Nearshore and offshore locations were established at the 6 to 8-ft and 15-ft depth contours, respectively. Peak fish abundance was documented in May, with a smaller peak in October for the inshore location, all driven by alewife catches. Alewife dominated the catch at all locations, and was slightly more abundant inshore, and the two locations nearest KNPP. No consistent pattern was evident that would suggest markedly different communities north or south of the plant, or between the inshore and offshore locations.

Seine catches were higher from May through August at all locations and there were no consistent patterns of greater or lesser abundance at any one sampling location. Comparison of the ambient juvenile/adult data and impingement data collected during the KNPP entrainment and impingement study showed that alewife dominated both collections, but more so in the impingement samples. A number of species were more abundant in the ambient catch relative to the impingement catch, including lake chub, longnose dace, white sucker, longnose sucker, round whitefish, brown trout, and lake trout. Conversely, rainbow smelt, mottled sculpin, and northern clearwater crayfish, three RIS for the PBNP thermal evaluation, were relatively more abundant in the impingement samples. Three other RIS (gizzard shad, spottail shiner, and yellow perch) produced similar percentages in the two KNPP programs. All of the species that were more abundant in the impingement samples than in the ambient collections were smaller species, whereas most of the species that were more abundant in ambient samples were larger species (e.g., lake trout).

Impingement studies conducted from February 2006 through January 2007 at KNPP confirmed the dominance and seasonal occurrence of alewife in the nearshore waters, as was the case at PBNP. The impingement collections were overwhelmingly dominated by alewife, which accounted for 99.7 percent of the catch by number and 94.8 percent by weight. The collection of only five other fish exceeded 100 individuals including four RIS (rainbow smelt, yellow perch, mottled sculpin, and spottail shiner). Although some impinged fish were collected in all sampled months, the catch in June and July accounted for over 90 percent of all impinged fish (primarily alewife) collected during the year. A lesser alewife peak occurred in October and November 2006. Other common species, including three RIS (rainbow smelt, mottled sculpin, and northern clearwater crayfish) were most abundant during late spring and summer. Yellow perch, another RIS, exhibited two peaks in abundance, one in August 2006 and the other in January 2007. These seasonal impingement patterns are consistent with known seasonal movements of these species and were similar to seasonal patterns shown by results from the juvenile and adult surveys conducted from April through October 2006 at KNPP. Furthermore, they are consistent with the seasonal patterns that occurred during the recent impingement studies at the PBNP (EA 2007a).

Annual estimated impingement at KNPP was compared between the 1975-76 study (NALCO undated) and 2006-07 study (EA 2007b). The total estimate for the most recent study was greater than that in 1975-76, due almost entirely to the greater estimated number of alewife impinged in 2006-07. The combined totals of species other than alewife did not differ greatly between study years. However, there were some notable differences between studies for certain species. The estimated number of four RIS (spottail shiner, burbot, mottled sculpin, and yellow perch) impinged were substantially greater in 2006-07 than in 1975-76. Conversely, the estimate for rainbow smelt, another RIS was much higher in 1975-76. Some of the differences between study years may be explained by changes in the fish communities in Lake Michigan. For example, the 12-fold increase of yellow perch in 2006-07 may reflect an increasing lake population in recent years. Bunnell et al. (2007) reported that the 2005 year class of yellow perch was by far the largest in a 33-year record. Greater impingement of burbot in 2006-07 was consistent with the greater density of adult burbot reported by Bunnell et al. (2007) from the mid-1980s to 2006. The greater abundance of alewife in 2006-07 is misleading because the lake-wide population has been declining for several years (Bunnell et al. 2007). Spatial distribution patterns for alewife has been patchy and some areas (e.g., at both KNPP and PBNP) may produce relatively high numbers, but the overall population level is down in the lake. Rainbow smelt impingement was notably lower in 2006-07 and this may be related to their declining numbers since the mid-1990s.

Entrainment sampling carried out at KNPP from March 2006 through February 2007 yielded 15 ichthyoplankton taxa in several developmental stages and three macrozooplankton. The amphipod *Gammarus* accounted for 93 percent of entrained organisms based on annual density, compared to 99.7 percent at PBNP during an entrainment study conducted during the same period (EA 2007a). Unidentified fish eggs were next in abundance, although they represented <3.0 percent of the collection. Larvae of three RIS (burbot, alewife, and common carp) were the most abundant fish larvae collected, but occurred in very low numbers compared to *Gammarus* and unidentified fish eggs. Young life stages of fish were primarily present during spring and summer, although peak densities of four RIS occurred in April (burbot larvae), June (common carp larvae), July (rainbow smelt larvae), and August (alewife larvae). Of the three invertebrate forms entrained, *Gammarus*, a RIS for this thermal evaluation, was present in all months, but occurred in the highest densities from July through November. *Mysis relicta*, another invertebrate RIS, occurred during March and April, and from December through February. The seasonal ambient samples collected from the lake yielded similar results, with young life stages of ichthyoplankton primarily occurring in spring and summer, and invertebrates, chiefly *Gammarus sp.*, present throughout the March – October study period.

A previous entrainment study that was conducted at KNPP from April 1975 to March 1976 by NALCO (undated) yielded an annual entrainment estimate of 66 million organisms of which two-thirds were alewife eggs. Rainbow smelt eggs, larvae, and juveniles accounted for an additional 30 percent of the annual estimate. In terms of the estimated number of ichthyoplankton entrained (55 – 66 million), the two study results were quite similar. However, there were some notable annual differences at the taxa level. Rainbow smelt larvae and juveniles were nearly three times more abundant during the 1975-76 study, and the estimate of fish eggs entrained was twice as high in the earlier study. Conversely, larval abundance of alewife, common carp, burbot, Coregoninae, and Catostomidae was greater in 2006 by factors ranging from seven- to 103-fold.

These differences between studies may in large part reflect changes in species abundances in Lake Michigan in the intervening years between studies. In the earlier discussion of impingement, it was noted that abundance of burbot was higher in 2006-07, which is consistent with the entrainment comparison. Similarly, rainbow smelt and slimy sculpin were markedly lower in impingement abundance, and again this is consistent with the entrainment comparison. Alewife, although reduced in abundance lake-wide (Bunnell et al. 2007), were apparently locally abundant near KNPP during the current study, as was the case at PBNP (EA 2007a). Unlike impingement, where factors other than localized abundance can affect impingement rates, entrainment abundance generally reflects water column abundance in the vicinity of the plant.

The above comparison of historical fishery, entrainment, and impingement data from KNPP with current data collected primarily in 2006 indicate consistent similarities between the data available from studies conducted in the 1970s and importantly with both historical and current data from similar studies conducted at PBNP. Results from recent studies at both plants confirm the 316(a) determinations that the thermal discharges have not caused appreciable harm to aquatic community in the vicinity of both power plants, a universal finding for other Lake Michigan facilities.

3.3.4 Donald C. Cook Nuclear Plant

The Donald C. Cook Nuclear Plant is located on the southeastern shore of Lake Michigan, about 15 miles south of Benton Harbor, Berrien County, Michigan (Sharma and Freeman 1980, White and Winnell 1986). The plant consists of two units with a combined capacity of 2,200 MW. Unit I became operational in 1975, and Unit II began operating in 1978. Once-through condenser cooling water is withdrawn through intakes that extend into the lake to a distance of about 2,200 ft to a depth of 24 ft. These intakes are set into the lake bottom, and are protected by bar racks with 2.63-in spaces between bars, and equipped with a velocity cap to prevent vortices and vertical flows. Combined maximum cooling water flow rate for both units is 1,637,785 gpm (2,358 MGD). The ΔTs for the two units are 12.2°C (22°F) and 9.4°C (17°F). The intake and discharge structures are protected by a covering of riprap consisting of rock up to 1.0 m in size.

<u>**Nearshore Environment**</u>

The lake bottom near the Cook Plant slopes lakeward at a rate of about 3 m per km (~16 ft per mi), and bottom sediments are coarse to fine sand with patches of silt and organic accumulations. Prevailing lake currents flow from south to north at speeds up to about 0.3 m/sec (1 ft/sec). The summer thermocline forms at a depth of about 20 to 30 m (~66 to 98 ft) in the vicinity of the Cook Plant site.

Phytoplankton, Zooplankton, and Benthos

Extensive studies of phytoplankton, zooplankton, and benthos were conducted at the Cook Plant in fulfillment of pre- and post-operational licensing and permitting requirements over the period from 1967 through 1986 (Ayers and Feldt 1983, Evans, et al. 1985, White and Winnell 1986, Zawacki 1985). The pre- and post-operational surveys demonstrated that no notable changes in zooplankton occurred in the waters near the Cook Plant following operations through the early 1980's. Phytoplankton and benthos communities near the Cook Plant were also similar to those found in other nearby areas of Lake Michigan, and did not indicate any adverse impact of Cook Plant operations on Lake Michigan communities, including impacts of entrainment in the condenser cooling water flow.

Fish

Results from studies of fish populations in the area near the Cook Nuclear Plant were reported by Tesar and Jude (1985) and by Tesar et al. (1985). Fish populations were dominated by three RIS for this evaluation: alewife, spottail shiner, and rainbow smelt. Plant operations had no apparent impact on abundance and distribution of alewife in the area. Annual catches of alewife declined over the period of study from 1973 to 1979, reflecting the lake-wide pattern of abundance for this species (Bunnell et al. 2007). No plant impacts on spottail shiner distributions or numbers were detected. Fluctuations of rainbow smelt abundance appeared to reflect influences of natural population fluctuations, spawning runs, upwellings, or apparent preferences for one sampling area over another independent of the effects of the plant's intake or discharge.

Other abundant species near the Cook Plant were bloaters, yellow perch, and trout-perch. Bloaters increased in numbers during the study, but no difference in catches between study and control areas could be attributed to plant effects. The bloater is a cool to coldwater species that was collected over a temperature range of 6 to 19°C (42.8 to 66.2°F), and may have responded to upwelling events that occasionally reduced water temperatures in the nearshore area at certain times. Trout-perch were generally collected from the offshore zone rather than the nearshore beach area. Trout-perch exhibited a diel migration pattern; this species moved inshore during the night, and returned offshore during the day. Trout-perch catches exhibited no relationship to power plant operations. Yellow perch abundance was greater near the plant during both pre- and post-operational years. This may have been caused by attraction to the rocky habitat structure created by riprap areas used near the plant.

Other commonly caught species near the Cook Power Plant included rainbow trout, brown trout, Chinook salmon, Coho salmon, common carp, gizzard shad, lake trout, Johnny darter, longnose dace, longnose sucker, and white sucker.

A total of 33 fish species were categorized as occurring rarely near the Cook Plant, including lake whitefish, burbot, lake herring, three species of redhorse, and a variety of other warmwater species. Although some rare species exhibited differences in distribution and abundance among the study areas, these variations could not be related to power plant effects. Only the redhorse species were collected to a greater extent in post-operational years near the plant discharge area compared to other areas. It was hypothesized that redhorse may have exhibited a tendency to be attracted to the discharge.

Summary

Studies at the Donald C. Cook Nuclear Power Plant did not generally detect any impacts from the plant's discharge on fishes in the vicinity of the plant site. Differences in habitat characteristics between the various study and control areas, together with lake-wide fish population trends, determined fish distribution and abundance, rather than plant operations. Some fish appeared to be attracted to the plant area because of habitat structure and prey presence associated with the riprap used to protect various structures from wave damage. Only redhorse exhibited a possible attraction to the power plant discharge area.

3.3.5 Summary of Results at Other Lake Michigan Power Plants

All the studies described above conducted near Lake Michigan thermal discharges found very limited effects attributable to those discharges. Furthermore, when differences between the thermal plume areas and nearby reference areas have been detected, they are typically minor in scope and magnitude. None of the studies involving these thermal discharges found effects that could be characterized as adversely affecting the maintenance of balanced indigenous communities near the subject plants. This uniform lack of adverse impacts clearly demonstrates that thermal impacts associated with the use of once-through cooling on Lake Michigan's aquatic life are insignificant.

4. EVALUATION OF THE PLANNED EPU

The effect of the planned EPU at PBNP on the Lake Michigan aquatic community in the vicinity of the plant is dependent on the resultant discharge temperatures, elevated plume temperatures, and the size of the plume. To provide an understanding of typical variation of intake and discharge temperatures, several years of historical plant operating data provided by PBNP were examined. The response of the plume to the EPU was based on a three-dimensional hydrodynamic model that was developed to simulate thermal plumes in Lake Michigan in the vicinity of the PBNP discharge. The model was verified using thermal plume mapping data measured during surveys in 1972 and 1973 (WEPCO 1978).

4.1 EXISTING OPERATING CONDITIONS

Daily PBNP data for intake and discharge temperatures and discharge flow were obtained for the November 2004 to May 2008 period. The data set did not include data for April through August, and October 2005. Thus, only two years of data were available for the summer months (June through August), while four years of data were available for the cold weather months (December through March). Frequency distributions of the two-unit operating data by month are provided in Tables 4-1 through 4-3. A discharge delta temperature was calculated from the intake and discharge temperatures and these results are provided in Table 4-4.

Cooling water use from November 2004 through May 2008 ranged from 392,000 gpm in the winter months to 680,000 gpm during the remainder of the year (Table 4-1). Cooling water flows were 680,000 gpm at least five percent of the time in all months except January. During the peak summer months (July and August), cooling water use was always at 680,000 gpm, whereas in January and February water use was 392,000 gpm.

Intake temperatures during the November 2004 through May 2008 period ranged from 0.3°C (32.5°F) in January to 22.4°C (72.3°F) in September (Table 4-2). Intake temperatures were always less than 10°C (50°F) from December through April. Spring, early summer, and fall intake temperatures were less than 20°C (68°F), whereas summer (August and September) intake temperatures occasionally exceeded 22°C (71.6°F). The frequency distributions from the November 2004 through May 2008 period demonstrate variable intake temperatures in the summer months and comparatively stable temperatures in the winter. The variable summer temperatures likely reflect effects of thermal stratification and occasional upwelling effects during the summer. Although winter temperatures exhibited a limited range compared to the summer conditions, the winter intake temperatures likely reflect the effect of recirculation to control icing at the offshore intake crib.

Discharge temperatures from November 2004 through May 2008 ranged from 9.8°C (49.6°F) in November to 33.7°C (92.7°F) in August (Table 4-3). Discharge temperatures were less than 28°C (82.4°F) except in August and September when maximum discharge temperatures approached 34°C (93.2°F). The frequency distributions demonstrate variable discharge temperatures throughout the year that likely reflect effects of intake temperatures and plant loads.

The temperature rise across the PBNP condensers, termed the discharge delta temperature (or ΔT) in this report, from November 2004 through May 2008 varied from 1.4°C (2.5°F) in November to 19.3°C (34.7°F) in January (Table 4-4). The annual mean discharge delta temperature was 13.6°C (24.5°F) and monthly mean ΔT ranged from 9.8°C (17.6°F) in November to 18.0°C (32.4°F) in February.

According to the data provided by PBNP, the full load discharge delta temperature is 11.5°C (20.7°F) when operating at a pumping capacity of 680,000 gpm. During the winter discharge flow is reduced with a corresponding increase in the discharge delta temperatures. The facility operates primarily at a maximum 680,000 gpm discharge flow during the months of June through September; April, May, October, and November are transition months (Table 4-1). During January, February, and March the facility operates primarily at a flow of 392,000 gpm. During July and August, when the pumps were at a uniform 680,000 gpm rate, the reported full load 11.5°C (20.7°F) delta temperature corresponded to an approximate upper 95-percentile temperature (Table 4-4). The slight exceedances of the reported discharge delta temperatures above 11.5°C may result from the accuracy of the recording instrumentation.

The planned EPU would increase the full load discharge delta temperature by 2.0°C (3.6°F). The circulating water flow would remain the same. To provide an indication of expected discharge temperatures with the planned EPU, the frequency distribution of discharge temperatures was adjusted by applying the 2.0°C (3.6°F) EPU ΔT at the maximum 680,000 gpm discharge flow (Table 4-5). During winter months when the plant is operating with one-half the pumps, the discharge temperature at full load with the planned EPU would be approximately 4.0°C (7.2°F). The discharge temperatures in the November 2004 to May 2008 data set were increased by 2.0 to 4.0° C as a function of the reported daily discharge flow. The resulting discharge temperatures with the planned EPU are provided in Table 4-5. The average discharge temperature resulting from the EPU would be 23.7°C (74.7°F) or 2.9°C (5.2°F) higher than under existing conditions. On a monthly basis, winter temperatures under the EPU scenario would be 3.5 to 3.7°C (6.3 to 6.7°F) higher, whereas in the summer (June through September) discharge temperatures would average 2.0 to 2.2°C (3.6 to 4.0°F) higher.

The higher discharge temperatures that would result from the EPU were evaluated relative to the avoidance and upper tolerance limits of the Representative Important Species (RIS) selected by the WDNR for this evaluation (Section 5.5).

4.2 HISTORICAL PLUME SURVEYS

Twenty–two thermal plume mapping surveys were performed during 1972 and 1973 at PBNP (Limnetics 1974). The survey dates and operating conditions during each survey, including intake and discharge temperatures, discharge flow, surface and bottom temperatures at the intake crib, the survey temperature selected as ambient, and the plume area associated with the 1°C (1.8°F) delta temperature contour are provided in Table 4-6.

Discharge flows ranged from 223,000 to 770,000 gpm during these 22 plume surveys (Table 4-6). The delta temperature between the intake and discharge ranged up to 14.1°C (25.4°F). The maximum discharge delta temperature at a 770,000 gpm flow rate was 10.2°C (18.4°F). Although the maximum reported discharge flow in the early 1970s, was higher than the current flow of 680,000 gpm; the heat rejection for a 770,000 gpm discharge flow at 10.2°C (18.4°F) is very similar to the heat rejection rate for the 680,000 gpm flow at 11.5°C (20.7°F).

The plume mapping surveys used for model verification were limited to those that were conducted under the maximum discharge flow of 770,000 gpm. At the maximum flow, discharge delta temperatures ranged from 7.9 to 10.2°C (14.2 to 18.4°F). Measured plume areas associated with the 1°C (1.8°F) delta temperature contour ranged from 2.34 to 45.25×10^6 ft^2 (~54 to 1,039 acres). This wide range of plume sizes under a uniform pumping rate and a moderate variation in delta temperature is unusual. Limnetics (1974) expressed a similar concern and hypothesized the variable plume sizes were related to wind and upwelling events. Accounting for these types of site conditions in a model is beyond the scope of this analysis due to both a lack of detailed wind and current data for the 1972-1973 surveys and limitations in the current model. Plume surveys with 1°C (1.8°F) delta temperature area contours less than 5.0×10^6 ft^2 (~115 acres) were also removed from consideration for model verification. Of the remaining surveys, six had delta discharge temperatures of 7.9 to 8.5°C (14.2 to 15.3°F), one was at 9.8°C (17.6°F), and three surveys were at 10.2°C (18.4°F).

Two discharge delta discharge temperature model scenarios were established for model verification. The six 7.9 to 8.5°C surveys were represented by an 8.3°C (14.9°F) delta temperature scenario and a 10.2°C (18.4°F) scenario was used for the three surveys conducted at that temperature. The nine surveys selected for model verification are indicated in Table 4-6. Measured plume areas for a range of delta temperatures are provided in Table 4-7 for the six 8.3°C (14.9°F) surveys and the three 10.2°C (18.4°F) surveys.

The delta temperature-area relationship for the nine verification surveys is displayed in Figure 4-1. Traditionally delta temperature-area relationships follow the form:

$$\text{Area} = a\, e^{(b\, dT/dT0)}$$

Where a, b = regression coefficients
dT0 = discharge delta temperature
dT = area contour delta temperature

In the above relationship, the discharge temperature is normalized to 1.0. This relationship plots as a straight line when plume area is on a log axis (Figure 4-2).

The resulting regression equation for plume area is:

$$\text{Area}(\text{x}10^6\ \text{ft}^2) = 72.3\ e^{(-9.34\ dT/dT0)}$$

The range of measured plume areas, particularly at the 1°C (1.8°F) delta temperature contour, remains a concern. Data analysis indicated that the plume areas were inversely proportional to the surface/bottom temperature gradient at the intake crib. We concluded that when strong thermal stratification was present, the ambient temperatures selected for the original plume survey data were over estimated. That is, the selected survey temperatures were measured too high in the water column and were not adequately beyond the plume's influence. For model verification, revising the survey ambient temperatures was considered and rejected. For revised temperatures, attention was placed on the intake and mid-depth temperature between the surface and bottom intake crib temperature. These temperatures were commonly 0.5-1.5°C (0.9 to 2.7°F) lower than the ambient selected by Limnetics (1974). Decreasing the ambient temperature by 0.5 to 1.0°C (0.9 to 1.8°F), particularly for surveys with 1°C (1.8°F) delta temperature plume areas less than $20\text{x}10^6$ ft^2 (~459 acres) would noticeably improve (reduce variation) in the delta temperature –area relationship (Figure 4-1) and the normalized delta temperature-area relationship (Figure 4-2). A revision of this size is considered within the accuracy of the survey data.

4.3 MODEL DEVELOPMENT

The Environmental Fluid Dynamics Computer Code (EFDC) model was developed by researchers at the Virginia Institute of Marine Science (Hamrick, 1992, 1996). Further development was provided by the U.S. EPA (Region 4) and Tetra Tech (Tetra Tech, 2002). Recent versions of the model are available through the U.S. EPA Region 4 and Tetra Tech's ftp sites. Dr. Hamrick, the principle developer, has applied the model to the James and York Rivers, and the Chesapeake Bay estuarine system and the model has been used for simulation of power plant cooling water discharges.

An EFDC model grid was constructed to represent Lake Michigan in the vicinity of the PBNP (Figure 4-3). The model extends 15,500 ft (4,724 m) along the shoreline and 7,900 ft (2,408 m) offshore. The active model domain consists of 74 cells along the shoreline and 35 cells in the offshore direction for a total of 2,590 cells. A 65 ft (20 m) cell width was used near shore increasing to 328 ft (100 m) beyond a 2,700 ft (823 m) offshore distance. Along the shoreline, a 49 ft (15 m) cell width was used in the vicinity of the discharge, increasing to 328 ft (100 m) several thousand feet in both north and south of the discharge. The discharge structure was placed approximately 4,500 ft (1,372 m) from the north end of the model and 11,000 ft (3,353 m) from the south end (Figure 4-3).

An engineering drawing provided by PBNP indicates that the discharge consists of two openings, each 33 ft (10.1 m) wide and with a bottom depth 17.4 ft (5.3 m) below the site datum. The distance between the two openings is 171 ft (52 m). The site datum is 580.2 ft relative to the International Great Lakes Datum (IGLD). The normal Lake Michigan water surface level is 578 ft IGLD. Thus the bottom of the discharge structure is 15.2 ft (4.6 m) below normal lake level. Each of the two discharge structures was represented by a single 48 ft (15 m) cell, and separated by three cells. The total width of the two openings and the intervening distance in the model was 246 ft (75 m), only slightly greater than the actual distance of 237 ft. The depth of the discharge cell in the model was set at 13.1 ft (4 m). Personnel at PBNP indicated that moveable bed material is present in the vicinity of the discharge structures. A modeled discharge depth slightly shallower than 15.2 ft (4.6 m) also compensates for the modeled width being slighter greater, thus preserving the cross-sectional area of the discharge opening.

A water surface elevation was applied at the southern boundary and a north to south along-shore current was applied at the northern boundary. The model is considered to be symmetric such that northerly or southerly along-shore currents would be a mirror image of each other. The model was always executed with the current from north to south. Figure 4-3 indicates that the discharge was placed closer to the northern end of the model to provide a greater distance for plume development in the along-shore current direction.

A depth was assigned to each model cell using the bathymetric profile contained in Figure 5.3-0 of the Limnetics (1974) report. Depths were approximately 4-ft (1.2 m) in the first nearshore cell and increased to 20 ft (6.1 m) at a location 1,600 ft (488 m) offshore in the vicinity of the intake crib. The depth was set at 30 ft (9.1 m) beyond 4,700 ft (1,433 m) offshore. A 13 ft (4.0 m) depth was used in the vicinity of the discharge structure as previously described.

Each model cell was divided into six depth layers. The EFDC assigns a fraction of the total water depth to each layer throughout the model domain. The top four layers were assigned depth fractions of 0.15 and the remaining two deeper layers used a depth fraction of 0.20. The actual layer thickness varies throughout the model domain in proportion to the total water depth. At a shallow 4-ft (1.2 m) shoreline cell the surface layer would be 0.6 ft (0.2 m) thick, increasing to 3.0 ft (0.9 m) at an offshore cell in 20 ft (6.1 m) of water.

The PBNP model was developed for the calculation of delta temperatures in Lake Michigan. The discharge delta temperatures were added to a uniform model temperature and applied to the two outfall cells. The model was executed for two days using a six second time step. Two days was considered adequate to allow the discharge plume configuration to reach a steady-state distribution within the model domain. The model-predicted delta temperatures were added to the ambient temperatures to provide absolute temperatures within the discharge plume.

4.4 MODEL VERIFICATION

The PBNP model was verified using thermal plume mapping data collected during surveys in 1973 as presented in Section 4.2. The plume mapping report provided commentary on lake conditions at the time of each survey including along-shore currents. Lake current information was not available for all surveys, and the data provided indicated that currents typically ranged from 0.1 to 0.3 ft/sec (0.03 to 0.09 m/sec). Therefore, for each of the two delta discharge temperature scenarios (8.3 and 10.2°C), three current scenarios (0.1, 0.2, and 0.3 ft/sec) were executed. A comparison to a range of along-shore currents is intended to encompass some of the survey to survey variation evident in the 1973 plume mapping results.

The normal water surface elevation in Lake Michigan is 578 ft IGLD. Lake water levels were obtained from a NOAA web site for 1972-1973 at Sturgeon Bay and Milwaukee. Lake elevation during the nine surveys selected for model verification ranged from 581.0 to 581.6 ft. An average water surface elevation for the nine surveys was applied at the south model boundary for the verification model runs. The normal water surface elevation of 578 ft was used for the planned EPU scenarios.

For model verification, the relationship between predicted plume areas and delta temperature was compared to the measured plume areas (Table 4-7). A range of vertical dispersion rates, which represent the primary model calibration parameter, was examined. A comparison of the six 8.3°C surveys to model predictions is provided for a $5x10^{-5}$ m^2/sec (Figure 4-4) and $1x10^{-4}$ m^2/sec (Figure 4-5) vertical dispersion. Similarly, the three 10.2°C surveys are compared to model predictions in Figures 4-6 and 4-7. Each figure includes results for the 0.1, 0.2, and 0.3 ft/sec along-shore currents included in the model. The predicted plume areas are provided in Table 4-8.

Section 4.2 discussed EA's conclusion that the 1973 ambient survey temperatures were over estimated on several occasions, particularly for 1°C (1.8°F) delta temperature plume contours less than $20x10^6$ ft^2 (~459 acres). An examination of Figures 4-4 to 4-7 indicates that lowering the ambient temperatures, raising the delta temperature-area curves by 0.5°C (0.9°F) for surveys with a 1°C (1.8°F) delta temperature contours less than $20x10^6$ ft^2 (<459 acres) would significantly improve the agreement between observed and model predictions. For example in Figure 4-7, Survey 21 has a 1°C (1.8°F) temperature area of $17.7x10^6 ft^2$ a (~406 acres) and by raising the survey 21 curve by 0.5C (0.9°F) would place the mapped area in the proximity of the model predictions.

The various model scenarios were similar at delta temperatures above 3°C (5.4°F). At a 10.2°C (18.4°F) delta temperature and a 0.2 ft/sec (0.06 m/sec) current, the 1°C (1.8°F) contour decreased 34 percent from 60.4 to $39.9x10^6$ ft^2 (~1,387 to 916 acres) as the vertical dispersion increased from $5x10^{-5}$ to $1x10^{-4}$ m^2/sec (Table 4-8). For the 10.2°C (18.4°F) delta temperature and a $1x10^{-4}$ m^2/sec dispersion, the 1°C (1.8°F) contour decreased 58 percent from 79.0 to $33.5x10^6$ ft^2 (~1,814 to 769 acres) as the along-shore current increased from 0.1 ft/sec to 0.3 ft/sec (Table 4-8). The agreement between the model predictions and the historical scenarios was considered slightly better for the higher $1x10^{-4}$ m^2/sec dispersion value. The higher vertical dispersion value would also result in more heat mixed into the water column and thus represent a biologically more sensitive case relative to zone of passage issues. A $1x10^{-4}$ m^2/sec vertical dispersion was used in the EPU model predictions in the following section.

4.5 MODEL PREDICTIONS FOR PLANNED EPU

The PBNP model was executed for the planned 2.0°C (3.6°F) delta discharge temperature under the EPU. This discharge temperature increase was added to the existing 11.5°C (20.7°F) full load delta temperature. The resulting 13.5°C (24.3°F) delta discharge temperature scenario was executed using a 680,000 gpm discharge flow. A vertical dispersion of $1x10^{-4}$ m^2/sec and a normal 578 ft Lake Michigan water surface level was used. Contoured surface plume temperatures are provided in Figures 4-9 and 4-10 for the 0.2 and 0.3 ft/sec along-shore current scenarios.

A comparison between the existing 11.5°C (20.7°F) and planned 13.5°C (24.3°F) discharge delta temperature scenarios is provided in Table 4-9 for along-shore currents of 0.1, 0.2, and 0.3 ft/sec. At a 0.2 ft/sec (0.06 m/sec) along-shore current, the EPU increased the surface area of the 6.0°C (10.8°F) contour from 1.17 to $1.69x10^6$ ft^2 (27 to 39 acres), the 4.0°C (7.2°F) contour increased from 3.42 to $4.56x10^6$ $ft^{2,}$ (79 to 105 acres), and the 2.0°C (3.6°F) contour increased from 13.98 to $16..98x10^6$ ft^2 (315 to 390 acres). These projected increases in surface areas of the three plume contours represent increases of 44, 34, and 24 percent respectively.

Predicted vertical temperatures are provided in Table 4-10 for increasing distances offshore and in a southerly direction from the discharge. Except for a nearshore cell close to the discharge, 1.0°C (1.8°F) delta temperatures were never present at or below a 6 ft (1.8 m) depth. Maximum delta temperatures at a 4 ft (1.2 m) depth decreased from 2.37°C (4.27°F) at 500 ft (152 m) to 1.65°C (2.97°F) at a 4,500 ft (1,372 m) down-lake distance.

A frequency distribution of anticipated discharge temperatures with the 2.0°C (3.6°F) EPU ΔT was provided in Table 4-5. Based on those results and assuming a full load discharge delta temperature of 13.5°C (24.3°F), modeled temperatures were determined at the edge of the mixing zone for Lake Michigan under the WDNR's proposed thermal ruling making (Wenholz 2007). The proposed rule would allow a $3.125x10^6$ ft^2 (~72 acres) mixing zone in Lake Michigan. The resulting plume temperatures at the edge of proposed mixing zone for a 0.2 ft/sec (0.06 m/sec) along-shore current are provided in Table 4-11. Mean edge of mixing zone temperatures were 14.0°C (57.2°F) in June, 16.9°C (62.4) in July, and 23.5°C (74.3°F) in August. At an upper 95-percentile, edge of mixing zone temperatures ranged from 19.0°C (66.2°F) in June to 26.9°C (80.4°F) in August. These edge of mixing zone temperatures are 8.8°C (15.8°F) less than the projected EPU discharge temperatures provided in Table 4-5.

5. IMPACT ASSESSMENT OF PLANNED EPU

This section of the report addresses the predicted thermal impacts from the planned EPU for the PBNP. Because of the highly managed Lake Michigan fishery, the dynamic nature of that fishery, and the lack of biocriteria or other well-established benchmarks for Lake Michigan, the effects of the EPU on the thermal discharge and plume have been evaluated from the perspectives listed below:

1. The PBNP Type I Demonstration established that the original thermal load did not cause "prior appreciable harm";
2. The thermal plume resulting from the EPU, although somewhat larger than the original plume, is not expected to disrupt the balanced indigenous community (BIC);
3. There have been no changes in the aquatic community that would preclude reliance on the results of the original Type I Demonstration;
4. The changes to the Lake Michigan fish community over the past 50 years have occurred on a lake-wide basis;
5. The impact on Representative Important Species (RIS) will be negligible; and.
6. The conclusion with respect to the increased heat load is consistent with assessments undertaken at other power plants on Lake Michigan.

Each of these is described in greater detail below.

5.1 THERMAL LOAD EFFECTS

During a one-year period from November 1972 through October 1973, Limnetics (1974) conducted a study to determine whether the thermal plume from the PBNP impacted aquatic organisms (see Section 3.1 for a description of those studies). The study included all trophic levels from phytoplankton through fish. They reported that there either were no effects or the effects, though measurable, were minor and transitory (e.g., short term avoidance of the plume).

Based on the data collected by Limnetics (1974), WEPCO prepared a §316(a) demonstration and concluded that a BIC was present and that the plant caused no "prior appreciable harm" as described by U.S. EPA (1974).

The WDNR reviewed the demonstration, concurred with WEPCO that there were no significant impacts and thus granted an alternative thermal limit. This finding was based on PBNP operating as a 1,504 megawatt thermal (MWt) facility. As shown below, the PBNP planned capacity would be increased approximately 17 percent to 1,760 MWt and the resultant heat discharge will increase the discharge temperatures and enlarge the plume compared to the original operating conditions (see Section 4 for comparison of thermal conditions under existing and planned EPU conditions). The results and conclusions reached during the 1970s are transferable to the planned larger capacity at e PBNP for the following reasons:

- The new heat load for (8,273 MBTU/hr) will only be about 14 percent higher than the original (7,094 MBTU/hr) heat load studied during the 1972-73 Type I study.
- The predicted area of the 2°C (3.6°F) contour under the planned EPU will increase by 24 percent compared to the original size of the 2°C contour.

5.2 THERMAL PLUME EFFECTS

Measurements taken by Limnetics (1974) demonstrated that the PBNP thermal plume often becomes trapped along the shoreline. This causes the plume to have limited mixing with the open lake and keeps the plume temperatures along the shoreline elevated above ambient conditions for a greater down-lake distance.

The PBNP discharge under the planned EPU will be 680,000 gpm and the maximum amount of heat discharged will be 8,273 MBTU/hour. The maximum amount of heat discharged during the 1972-73 Type I study period was 7,094 MBTU/hour at a flow rate of 770,000 gpm. Modeling shows that the maximum plume size for PBNP under existing conditions is about 78.68×10^6 ft^2 (~1,807acres) at the 1.0°C (1.8°F) isotherm with an along-shore current of 0.1 ft/sec (Table 4-9). In contrast, the corresponding size for the 1.0°C isotherm under the EPU will be about 94.92×10^6 ft^2 (~2,179 acres). That 21 percent increase would be somewhat higher at along-shore currents of 0.2 and 0.3 ft/sec (o.06 to 0.029 m/sec) when plume size would increase by 28 to 24 percent, respectively (Table 4-9).

Maximum temperatures will occur in August and September (Table 4-5); during this period the plume will exist as a surface plume, and, as such will not contact the bottom except very near the point of discharge. This will allow fish to swim under the plume (see Section 5.6 for a complete discussion on avoidance). It also means that benthic invertebrates (e.g., *Diporeia* and *Mysis*), which are found primarily on or near the bottom, will not likely be exposed to the elevated water temperatures. Fish will use their well-demonstrated avoidance abilities (Brungs and Jones 1977, Talmege and Opresko 1981), and simply vacate areas that are overly warm. Lastly, as with other substances, the potential for either short- or long-term harm is a function of dose and length of exposure. In this case, as will be discussed in Section 5.5, upper lethal temperatures (generally reported as 96 hr LC50s) will be exceeded only for a few, mostly coldwater species and the period of exposure for any given organism will be brief because the plume will shift regularly depending on wind direction.

In summary, the PBNP plume under the planned EPU will not significantly impact the aquatic environment, nor will it preclude the continuation of the BIC.

5.3 PROTECTION OF THE BALANCED INDIGENOUS COMMUNITY

When Limnetics (1974) studied the fish community near the PBNP, they found that a BIC was present. They found that all trophic levels from phytoplankton through fish were well represented and that none of these groups were adversely affected by the thermal discharge. With regard to fish, they found that all expected species and ecological niches were represented. They found large numbers of forage fishes like rainbow smelt, alewife, sculpins, and spottail shiner. Similarly, they also found good numbers of top predators, especially the various salmonids. Cool water species such as yellow perch, suckers, and sculpins were also well represented. Conversely, they found that neither nuisance species (e.g., common carp) nor thermally tolerant warmwater species (e.g., gizzard shad) were more abundant in the plume. The fish community near the PBNP, both within the plume and in the nearby reference areas, was representative of areas along the lakeshore without thermal discharges. In short, they established a basis for concluding that a BIC existed.

After more than 30 years of PBNP operation since the 1972-73 study (Limnetics 1974), the available evidence supports the continued presence of a BIC. Impingement and entrainment studies conducted in 2005-06 indicate that fish community structure is similar to that in the 1970s (EA 2007a). Alewife continues to be the dominant fish species in this area of the lake. Species such as yellow perch and spottail shiner also continue to be well represented in the collections near the plant. There is no evidence that common carp or gizzard shad numbers have increased significantly. Similarly, thermally tolerant species or groups were essentially absent from the recent collections. This suggests that there has not been a shift from a cool/coldwater community to a warmwater community. In other words, the available fisheries data supports the conclusion that a BIC has been maintained.

The main quantitative change that has occurred over the 30+-year period is a decline in both the relative and absolute abundance of rainbow smelt in the area. However, rainbow smelt populations have declined lake-wide, so their local decline clearly cannot be attributable to thermal inputs from PBNP.

5.4 CHANGES IN THE LAKE MICHIGAN FISH COMMUNITY

The absence of site-specific impacts due to thermal discharges is addressed elsewhere in this report. There have been a number of significant changes in the Lake Michigan fishery and the Great Lakes in general that have occurred lake-wide. Therefore, these changes are not the caused by power plant discharges (or withdrawals), but rather, are the result of major changes in the ecology of the lake that affect the entire lake, or even the entire Great Lakes system (Kitchell 2007). Examples of such changes are briefly discussed below.

Rainbow Smelt

Rainbow smelt were first noted in Lake Michigan in 1923 and by 1936, this species occupied the entire lake (Wells and McLain 1973). In 1958, commercial fishermen took 9.1 million pounds of smelt from the lake compared to less than 0.5 million pounds in 2006 (National Ocean Economics Program 2007). Rainbow smelt numbers have recently declined lake-wide and causes for the decline remain unclear (Lyons et al. 2000, Bunnell et al. 2007).

Sea Lamprey

Sea lamprey was first reported from Lake Michigan in 1936 (Wells and McLain 1973). By the early 1950s lake trout were nearly eliminated from the lake and by the mid-1950s, sea lampreys were destroying five million pounds of fish per year (mainly deepwater ciscoes). Sea lamprey control measures now help keep this species somewhat under control, but the damage had already been done. Lake trout were effectively eliminated from the lake and various coregonids were either greatly reduced or even driven to extinction (Lyons et al. 2000).

Alewife

Alewife first appeared in Lake Michigan in 1949 and by 1953 was dispersed nearly lake-wide. By 1957, alewife were abundant in the southern half of the lake and by the mid-1960s, were present in nuisance numbers. Wells and McLain (1973) characterized their increase in the late 1950s and early 1960s as "explosive". Alewife has unquestionably had detrimental effects on native fish stocks, probably mainly through competition with the young of native species for planktonic food or by predation on the same young (Wells and McLain 1973). The importance of this competition was borne out by the fact that after the alewife population was brought under control by introduced Pacific salmon, certain native species, particularly bloater and yellow perch, exhibited major population increases.

Salmonids

Essentially put and take fisheries have been established on Lake Michigan for five salmonids: lake trout, brown trout, rainbow trout, Coho salmon, and Chinook salmon. As noted by Wells and McLain (1973), the success of salmon introductions into the lake has been "spectacular". These salmonids have brought the alewife population under control and have generated a multi-billion dollar sport fishing industry. Except for a few tributaries in Michigan, spawning success for all five species in Lake Michigan is nil. This lack of spawning success (at least on the Wisconsin side of the lake) along with adult avoidance behavior involving higher temperatures in the nearshore areas of the lake means that no thermal protection is necessary for spawning salmonid adults, eggs, or fry.

Other Fishes

Other significant introductions (mostly unintentional) include round goby, white perch, ruffe, and common carp.

Zebra and Quagga Mussels

Changes to the aquatic community of Lake Michigan have not been confined to fish. Exotic zebra and quagga mussels are now abundant in Lake Michigan and have altered the lake's ecology both directly and indirectly. Direct effects include reductions in phytoplankton numbers, whereas indirect effects include reduction in the organisms that use this trophic resource (e.g., various invertebrates, native unionid mussels) and enhanced water clarity, which in turn affects attached algae growth and a variety of other aquatic organisms.

Although these organisms gained entrance to the Great Lakes through a variety of sources, each has had profound impacts on the ecology of the lake. In addition, each of the above-listed organisms is now distributed lake-wide and most are common or even abundant. The changes wrought by organisms dwarf any measured or proposed thermal impacts.

5.5 REPRESENTATIVE IMPORTANT SPECIES

The WDNR provided a list of Representative Important Species (RIS) during a 13 May 2008 meeting held at the WDNR office in Mishicot to discuss the planned EPU for PBNP. Based on §316(a) guidelines (EPA 1977), RIS "are those species that are representative, in terms of their biological requirements, of a balanced indigenous community of shellfish, fish and wildlife in the body of water into which the discharge is made". RIS may include species that are:

1. Commercially or recreationally important;
2. Threatened or endangered;
3. Critical to the structure and function of the receiving water body;
4. Potentially capable of becoming a localized nuisance;
5. Necessary in the food chain; and
6. Representative of thermal requirements of important species, but which themselves may not be important.

The RIS selected by the WDNR (Table 5-1) represent five of the six RIS categories; the list does not include threatened or endangered species. Federally listed shellfish and fish species (USFWS 2007) are not known to occur in Lake Michigan in the vicinity of PBNP and only a single lake sturgeon, which is listed by the State of Wisconsin as a species of special concern (WDNR 2007), was collected during recent impingement studies at PBNP (EA 2007a). Protection for lake sturgeon is regulated through open/closed fishing seasons.

The selected RIS include commercially and recreationally important species (e.g., bloater, lake whitefish, lake trout, and yellow perch), forage species that are or were historically critical to the structure and function of the Lake Michigan aquatic community (e.g., amphipods, crayfish, and alewife); species that could potentially become a nuisance (gizzard shad and common carp); and other species representative of thermal requirements of important species (e.g., burbot and mottled sculpin). Shellfish are an important part of the food chain. Some of the species represent more than one RIS category; for example, bloater is a commercially important species and juvenile bloater provides forage for the lake's large, predatory species.

As part of this assessment, possible impacts to each RIS were evaluated based on known temperature requirements for each RIS (Table 5-2). Emphasis was placed on upper thermal limits when available, primarily upper incipient lethal temperature (UILT) and occasionally ultimate upper incipient lethal temperature (UUILT) when available[2]. In cases where UILT or UUILT data were not available, critical thermal maxima (CTM) were used (i.e., for rainbow smelt and burbot). CTM differs from the UILT/UUILT criteria in that fish are subjected to a constant linear increase in temperature until a near lethal endpoint (usually loss of equilibrium) is reached (Beittinger et al. 2000). Thermal criteria for the RIS fishes were generally obtained from the "Acute Temperature Information" report compiled by the WDNR for developing proposed thermal criteria for Wisconsin waters (Wenholz 2007). Thermal criteria in the form of UILT, UUILT or CTM were generally not available for the invertebrate RIS, so preferred and optimum temperatures for those RIS were used to assess potential thermal impacts resulting from the planned EPU.

Diporeia

The burrowing amphipod *Diporeia*, commonly known as the deep-water sideswimmer, was the most abundant invertebrate entrained at PBNP in 1975 but was absent in entrainment and ambient net samples collected in 2006 (EA 2007a). It comprised over 99 percent of the amphipods occurring in the bottom substrate samples collected in 1972-73 at both reference and plume areas (Limnetics 1974). The absence of *Diporeia* in the 2006 samples is consistent with its lake-wide decline in Lake Michigan where it was once the dominant benthic taxa in offshore waters (>30 m). Broad scale population declines were first noted in the early 1990s and were coincident with the invasion of zebra and quagga mussels (dreissenids). A common hypothesis for the decline of *Diporeia* is that dreissenids out compete them for food; however, the mechanism for that decline has not been determined because declines have occurred in areas of the lake that are far removed from dreissenid colonies (Nalepa et al. 2006).

Diporeia historically was an important forage species in the offshore waters of the Lake Michigan food chain. It is found in the upper sediments and feeds on settled organic matter. Recent changes in the condition, distribution, and abundance of several fish

[2] UILT represents an exposure temperature that 50 percent of the fish can tolerate for 7 days and varies directly with acclimation temperature. UUILT is the point where further increases in acclimation temperature results in no increase in the tolerated temperature.

species have been attributed to the loss of *Diporeia*, including the commercially-important lake whitefish (Mohr and Nalepa 2005). Lake-wide densities of *Diporeia* in 1994/1995 declined by 65 percent in 2000 across depth intervals (Nalepa et al. 2006). Densities at <30 m declined by nearly 80 percent. These declines and their absence from the 2006 PBNP entrainment samples suggest the thermal plume would not impact this historically important amphipod.

A three-year study of the southern two-thirds of Lake Michigan found that *Pontoporeia* (now *Diporeia*) can tolerate bottom temperatures from about 1.5 - 18°C (34.7 - 64.4°F) and even though a positive correlation occurred there was a weak association between mean densities and bottom water temperatures (Alley 1968). Alley (1968) cited optimum water temperatures and upper thermal limits from other researchers. Optimum temperatures of 8.0 – 12.0°C (46.4 – 53.6°F) were developed from laboratory tests and upper thermal tolerance limits of 14.0 – 20°C (57.2 - 68°F) were based on various field studies. These temperatures and historically higher offshore abundance in depths of 10 to 30 m (~33 to 98 ft) suggest that the PBNP plume had limited impact on the *Diporeia* population in the vicinity of the facility. The current status of *Diporeia* suggests that the planned EPU will not impact this once important amphipod because of the apparent nearshore decline that is unrelated to the operation of the PBNP. Also, because of their bottom orientation, Diporeia, even if present, would typically not contact the plume during warmer periods when the plume "behaves" as a surface plume.

Gammarus

Species of the amphipod *Gammarus* are generally scavengers, feeding on plant and animal matter that settles to the lake bottom. They tend to be found among aquatic macrophytes and under rocks or debris when not moving or mating. They occur at most depths between the shore and up to about 11 m (35 ft). *Gammarus* was the most abundant macroinvertebrate in net samples collected at PBNP during 2006; the abundance of *Gammarus* was extremely high yielding an annual entrainment estimate of nearly 4.1 billion whereas none were entrained in 1975 (EA 2007a). Nearly 90 percent of the *Gammarus* collected during the 2006 study were in entrainment samples rather than the ambient samples that were collected at locations outside the influence of the PBNP plume, suggesting that the high occurrence of *Gammarus* in the entrainment samples represents colonization in the offshore intake crib and/or the intake forebay because of the availability of rocky substrates at those locations. However, it could also indicate ongoing changes in the nearshore benthic community as was suggested by high numbers of *Gammarus* in the diets of Age-0 and Age-I yellow perch in southeastern Lake Michigan, rather than more traditional food items such as *Diporeia* and *Mysis* (Pothaven et al. 2000). *Gammarus* accounted for less than one percent of the amphipods in the Ponar samples collected in the vicinity of the PBNP discharge during the early 1970s, whereas *Diporeia* accounted for 99 percent of the amphipods and 42 percent of the benthic macroinvertebrates collected during that study (Limnetics 1974).

The abundance and importance of *Gammarus* as fish food and their entrainment at other power plants led to an early assessment of survival following exposure to elevated temperatures (Ginn et al. 1976). That study reported no increased latent mortality for periods up to 10 days after *Gammarus* were exposed to an 8.3°C (14.9°F) ΔT above an ambient temperature of 25.5°C (77.9°F) for periods up to 60 minutes. Thus, they could survive temperatures of 33.8°C (92.8°F). At lower ambient temperatures of 11.7°C (53.1°F), *Gammarus* survived ΔTs up to 16.7°C (30°F) for up to 180 minutes without any apparent increase in latent mortality.

These high tolerance limits suggests that *Gammarus* exposed to entrainment at the PBNP would not be impacted by the planned EPU because the maximum average discharge temperature following the EPU was estimated to be less then 33.8°C (92.8°F) all months except August and September (Table 4-5). Discharge temperatures would average 32.3°C (90.1°F) in August and would be less than 33.8°C (92.8°F) 70 and 85 percent of the time, respectively in August and September.

Mysis relicta

The opossum shrimp *Mysis relicta* is a large zooplankter historically common in the hypolimnetic waters of Lake Michigan. It played a key role in the food-web and, along with *Diporeia*, has been among the most important food items for forage fish including alewife and rainbow smelt, two RIS species. Following declines in *Diporeia* in Lake Michigan in the late 1990's, the importance of *Mysis* as a food source increased, especially for lake whitefish, another RIS species. Recent studies suggest the abundance of *Mysis* is lower in areas where *Diporeia* are absent relative to areas where declines in *Diporeia* are only beginning (S. Pothaven, unpublished data).

Entrainment data collected at PBNP corroborate the decline of *Diporeia* and *Mysis* (EA 2007a). Entrainment of amphipods varied widely between studies conducted in 1975 and 2006 in terms of species composition and entrainment estimates. *Mysis* was entrained during both studies, but were much more abundant in 1975 than in 2006: the 1975 annual entrainment estimate was 10.2 million compared to the 2006 estimate of 62,838. The 1975 entrainment estimate for *Diporeia* was 13.9 million and they were absent in the 2006 samples.

Mysis relicta is a cold-water species that is adversely affected when water temperatures are above 10°C (50°F); Smith (1970) reported that *M. relicta* acclimated at 7.5°C (45.5°F) had a 96-hr median tolerance limit of 16°C - 16.5°C (60.8 - 61.7°F). However, he cited unpublished data from earlier researchers that suggested the upper thermal limits varied from 18 - 22°C (64.4 - 71.6°F) depending on acclimation temperatures that ranged from 5°C - 14°C (41.0 - 57.2°F). In a recent laboratory study, it was reported that mysids prefer temperatures 6 - 8°C (42.8 - 46.4°F) and exhibited limited movements into waters 14 - 16°C (57.2 - 60.8°F) if prey items were available (Boscarino et al. 2007). Based on these temperature limits and the deep-water habitats used by mysids, they would not be expected in the nearshore areas in the vicinity of PBNP where they may be exposed to the thermal plume; however, they would be exposed to elevated temperatures for short periods in the plume as a result of entrainment. Mysids only occurred in low numbers in net samples in April and May 2006 when water temperatures were less than 10°C (50°F)

(EA 2007a). Based on their temperature preference and occurrence in the nearshore waters during recent entrainment monitoring at PBNP, exposures of mysids will be over a short period during the spring and therefore they would not be exposed to maximum discharges temperatures during the summer. Mean discharge temperatures in April and May (Table 4-5) would approach or slightly exceed the upper thermal limits of 18 - 22°C (64.4 - 71.6°F).

Orconectes propinquus

The Great Lakes crayfish (*Orconectes propinquus*), also known as the Northern clearwater crayfish, is a widely distributed crayfish that is common in the eastern Wisconsin drainages to Lake Michigan. It is an aggressive species that feeds on a variety of food items and is known to occur in a wide range of aquatic habitats (Hobbs and Jass 1988). It serves as a food source for top predators like smallmouth bass and is known to prey on lake trout eggs (Ellrott et al. 2007). In lakes, it is typically associated with gravel and rocky shorelines or reefs.

The occurrence of *O. propinquus* in the vicinity of PBNP was documented during impingement studies conducted from December 2005 through November 2006 (EA 2007a). Their occurrence on the intake screens suggests that crayfish habitat is located offshore in the vicinity of the intake crib and the intake forebay where rocky habitats are available. Crayfish were impinged in low numbers during the each month of the 12-month study, but were most abundant in the summer when nearly 67 percent of the annual estimated impingement occurred:

Date	Monthly Estimate	Percent of Total
Winter	64	9.0
Spring	76	10.8
Summer	472	66.8
Fall	95	13.4
TOTALS	707	100.0

Impingement rates were likely related to activity levels which would be expected to be lower when water temperatures are coolest, especially from the late fall through early spring, a period of seven months when only 17 percent of the crayfish were impinged. Studies have shown that *O. propinquus* borrows in the fall when water temperatures reach 10°C (50°F) and become more active in mid-April when temperatures rise to 12°C (53.6°F). Crayfish have relatively high temperature tolerances as shown by the 12-hr. median tolerance limit of 35°C (95°F) for *O. propinquus* (Hobbs and Jass 1988). Maximum discharge temperatures in August and September with the EPU would reach the median tolerance limit for this RIS, but would be less than that limit 85 (August) to 95 (September) percent of the time (Table 4-5). The high tolerance limit suggests that crayfish exposed to the PBNP plume would not be impacted and the apparent association of crayfish with the offshore intake crib and forebay suggest that that PBNP plume has a low potential to impact *O. propinquus*. Also as a bottom dweller, impacts to *O. propinquus* would not be expected.

Alewife

Alewife (*Alosa pseudoharengus*) has been a key forage species in Lake Michigan since the 1950s and as a larval predator can affect recruitment of native fishes, including other RIS: burbot, lake trout, and yellow perch (Bunnell et al. 2007). Adult alewife abundance has been declining since 2002 in part because of predation by stocked salmon and trout and likely in response to the decreasing abundance of *Diporeia* that has been attributed to the dreissenid mussel invasion of Lake Michigan (Nalepa et al. 2006). Offshore movements of alewife to deeper water in the fall through the early spring limits their exposure to the PBNP plume to the period from about April through September. Alewife move inshore to spawn in the spring and remain nearshore through the summer. The 2005-06 entrainment and impingement study at PBNP documented that early life stages of alewife were entrained from early July through the first week of August (EA 2007a). The impingement study confirmed that adults moved nearshore in late April when they first occurred on the intake screens after water temperatures reached 7.2°C (45°F). Rates remained high through early June when water temperatures were 8.9 - 11.1°C (48 - 52°F). Impingement of alewife declined precipitously from August through early September when water temperatures increased above 12.8°C (55°F). Impingement rates were lower in the fall and early winter when temperatures declined below 10°C (50°F).

Alewife were common in the vicinity of PBNP during studies conducted in the 1970s and in 2005-06. They were collected by trawling, seining, and gill netting operations conducted in the vicinity of PBNP from 1972 through 1977 (WEPCO 1978) and accounted for >97 percent of the fish collected from the intake screens during impingement studies conducted at PBNP from May 1973 – October 1977. Gill netting operations in the vicinity of PBNP indicated alewife were most abundant during the spring/summer and least abundant in the winter. Comparison of mean gill netting catches between those in the plume and two non-thermal reference areas suggested there was little difference among the three sampling zones, especially in the winter and fall when most alewife presumably had moved offshore. In the spring, catch rates were somewhat higher in the north reference area than in the plume or south reference area suggesting possible avoidance of the plume relative to the north reference area. The opposite occurred in the summer when more alewife were caught in the plume than the north reference area, although the plume and south reference areas had similar average catch rates. Those data indicate that although there was some avoidance or attraction of alewife to the discharge area, the seasonal catches rates in the vicinity of PBNP were consistent with their movement patterns elsewhere in Lake Michigan.

Based on the temperature tolerance data compiled in Table 5-2, there will be no threat to survival of either adult or juvenile alewife in the plume. Although the maximum projected discharge temperature of 35.7°C (96.3°F) is above the upper lethal temperatures (32-33 °C) for juveniles and adults, alewife are expected to avoid these critical temperatures (see Section 5.6), which are projected to occur about 40 percent of the time in August and 15 percent of the time in September (Table 4-5). During the warmest summer period, portions of the thermal plume may exceed the 25°C (77°F) preferred temperature of juveniles by a degree or two. Juveniles may avoid areas of the plume at such times. The 16°C (60.8°F) preferred temperature of adults is an August observation correlated, according to Otto et al. (1976), with their natural offshore migration in late summer. These authors demonstrated that, as seasonal ambient temperatures increase, the preferred temperature of adult alewife decreases. The net effect, if any, of summer plume temperatures on adults may be to trigger somewhat earlier offshore movement to areas outside the plume.

Gizzard shad

Gizzard shad (*Dorosoma cepedianum*) is a warmwater species that was introduced to Lake Michigan either through the Chicago River Canal or the Fox-Wisconsin Canal at Portage (Becker 1983). It is a forage species that can become a nuisance in the vicinity of thermal discharges if the warmer water temperatures encourage its survival and recruitment. Although gizzard shad were collected in fisheries surveys in the vicinity of PBNP from 1972 through 1977, it was uncommon, especially compared to the more abundant alewife population (WEPCO 1978). Annual impingement studies from 1972 through 1977 yielded only 820 gizzard shad compared to 1.1 million alewife. In comparison, the 2005-06 impingement study yielded 785 gizzard shad compared to 1.6 million alewife (EA 2007a). Although the 2006 total nearly equaled the five-year total from the 1970s, the ratios between alewife and gizzard shad were similar between studies indicating that the population of gizzard shad in the vicinity of PBNP has not increased substantially over the past 30 years.

As a warmwater species, gizzard shad will not be negatively impacted by the higher discharge temperatures and larger plume size that would result from the planned EPU. Its upper thermal limits (34-36 °C; Table 5-2) would only be exceeded briefly at the point of discharge in August and September (Table 4-5). The size and behavior of the plume is not expected to provide conditions that would be substantially more beneficial to the success of the gizzard shad population in the vicinity of PBNP than currently exists, so an increase to nuisance levels is not likely. Furthermore, the available data suggests that gizzard shad has been and will continue to be a minor component of the fish assemblage in the vicinity of PBNP.

Common carp

Common carp (*Cyprinus carpio*) is another warmwater species introduced to Lake Michigan that was collected in the vicinity of PBNP during the 1970s (WEPCO 1978) and more recently during the 2005-06 impingement study (EA 2007a). They were collected in low numbers by trawling, seining, and gill netting operations conducted in the vicinity of PBNP from 1972 through 1977 (WEPCO 1978). They were a very minor component of the fishery in the vicinity of PBNP during both study periods as indicated by the impingement studies from 1973-77 when only 47 common carp were collected and during the 2005-06 impingement study when only six were collected.

As a warmwater species, common carp will not be negatively impacted by the higher discharge temperatures and plume size that would result from the planned EPU. Its upper thermal limits (36-38 °C; Table 5-2) would not be exceeded and the size and behavior of the plume is not expected to provide conditions that would be substantially more beneficial to the success of the common carp population in the vicinity of PBNP than currently exists. It would not be expected to increase to nuisance levels. Furthermore, the available data suggests that common carp has been and will continue to be a minor component of the fish assemblage.

Spottail shiner

Spottail shiner (*Notropis hudsonius*) is a native warmwater species that is common in Lake Michigan and was collected in the vicinity of PBNP during the 1970s (WEPCO 1978) and more recently during the 2005-06 impingement study (EA 2007a). They were a very minor component of the fishery in the vicinity of PBNP during the earlier studies as only 19 were collected during impingement studies from 1973 - 1977. In comparison, 1,276 were collected during the 12-month impingement study conducted in 2005-06, when they were the third most abundant species impinged. These data suggest that the spottail shiner abundance has increased in the vicinity of PBNP. As an important forage species, especially because of the decline of emerald shiner in Lake Michigan, it is not likely that spottail shiner would be considered a nuisance species even if the thermal discharge benefited the population.

As a warmwater species, spottail shiner will not be negatively impacted by the higher discharge temperatures and larger plume size that would result from the planned EPU. Its upper thermal limits would not be exceeded (Table 5-2) and the size and behavior of the plume is not expected to provide conditions that would be substantially more beneficial to the success of the spottail population in the vicinity of PBNP than currently exists. Furthermore, the available data suggests that spottail shiner is a relatively minor component of the fish assemblage.

Channel catfish

Channel catfish (*Ictalurus punctatus*), a fourth warmwater RIS, was collected in low numbers during studies at PBNP. It was not collected during trawling, seining, or gill netting operations conducted in the vicinity of PBNP from 1972 through 1977 (WEPCO 1978) and only two were collected from the intake screens during impingement studies conducted from May 1973 - October 1977. Channel catfish occurred more frequently (12 of 80 sampling events) during the 2005-06 impingement study, but in low numbers (29 individuals total), suggesting this warmwater species, as was the case for the previous three warmwater RIS, has not benefited significantly from the PBNP thermal discharge.

As a warmwater species, channel catfish will not be negatively impacted by the higher discharge temperatures and plume size that would result from the planned EPU. Its upper thermal limits (Table 5-2) would not be exceeded and the size and behavior of the plume is not expected to provide conditions that would be substantially more beneficial to the success of the channel catfish population in the vicinity of PBNP than currently exists.

Furthermore, the available data suggests that channel catfish has been and will continue to be a minor component of the fish assemblage.

Rainbow smelt

Rainbow smelt were introduced to Michigan's inland waters as food for stocked salmon in the 1900s and soon escaped to Lake Michigan. It was initially considered a nuisance species, but became an important forage and recreational fish during their spring spawning runs. Although adults are important food for lake trout in the nearshore waters, rainbow smelt are not as utilized as much by other salmon and trout species as are alewife. Based on long-term bottom trawling results, adult rainbow smelt were most abundant in Lake Michigan from 1981 to 1993, but have been at relatively low densities from 1994 to the present (Bunnell et al. 2007). Despite their decline, they support a commercial fishery in Wisconsin and Michigan.

Rainbow smelt were common in the vicinity of PBNP during studies conducted in the 1970s and in 2005-06. They were collected by trawling, seining, and gill netting operations conducted from 1972 through 1977 (WEPCO 1978) and accounted for 2.2 percent of the fish collected from the intake screens during impingement studies conducted from May 1973 – October 1977. Rainbow smelt were also commonly collected during the 2005-06 entrainment and impingement studies (EA 2007a). Gill netting operations in the vicinity of PBNP indicated that rainbow smelt were most abundant during the spring and least abundant in the winter. Comparison of mean gill netting catches between the plume and the two non-thermal reference areas suggested there was little difference between the three sampling zones, especially in the winter and spring. In the summer and fall, catch rates were somewhat higher in the south reference area, but average catch rates from the plume and north reference area were essentially the same. Those data indicate there was no notable avoidance or attraction of rainbow smelt to the discharge area and the seasonal catches rates are consistent with their movement patterns elsewhere in Lake Michigan.

Small rainbow smelt were entrained from early July through late September 2006 when water temperatures ranged from 10.6 - 23.5°C (51.4 - 74.3°F). Juvenile and adult rainbow smelt were commonly impinged during the studies conducted in the 1970s and 2005-06. During the most recent study, impingement was lowest from mid-June through September 2006 when intake temperatures were highest suggesting that rainbow smelt had moved offshore to deeper water where water temperatures were optimum. Maximum impingement occurred in October 2006 when 48 percent of the annual estimate occurred and intake temperatures had declined to <11.7°C (53°F).

Rainbow smelt typically occur in waters 14 - 64 m deep and are most abundant in waters 18 - 26 m (Becker 1983). Adults move inshore in dense schools when water temperatures are 4.4°C (40°F) to spawn in tributaries from late March through early May. Age 0 rainbow smelt move out of tributaries back to the lake where they are pelagic. Adults move to deep water after spawning (Becker 1983), which is consistent with the pattern observed during entrainment and impingement studies at PBNP.

Temperature tolerance data for this species are limited; Becker (1983) reported that optimum temperatures range from 6.1 - 13.3°C (43 -53°F) and Reutter and Herdendorf (1976) reported a CTM of 24.9°C (76.8°F) for rainbow smelt from Lake Erie. Rainbow smelt will not be negatively impacted by the higher discharge temperatures and plume size that would result from the planned EPU. Although its upper thermal limits would be exceeded in the plume during the summer and early fall, the natural offshore migration of this species as described by Becker (1983) would minimize contact between this species and the plume. Similarly, and the size and behavior of the plume is not expected to provide conditions that would be substantially affect the rainbow smelt population in the vicinity of PBNP than currently exists.

Lake whitefish

Lake whitefish (*Coregonus clupeaformis*) is a native cold species that provides an important commercial fishery in Lake Michigan. It was collected in the vicinity of PBNP during the 1970s (WEPCO 1978) and more recently during the 2005-06 impingement study (EA 2007a). They were a minor component of the fishery during the 1970s studies as only 30 were collected during impingement studies from 1973 - 1977 and only four were collected during the 12-month impingement study conducted in 2005-06 (EA 2007a). They occur infrequently in the vicinity of the intake crib as they were found in only three to four percent of the impingement samples collected in 1975-76 and 2005-06 (EA 2007a). The number of lake whitefish collected by trawling, seining, and gill netting operations conducted in the vicinity of PBNP from 1972 through 1977 were also low (WEPCO 1978). These available data sets suggest that lake whitefish are infrequently exposed in low numbers to the thermal plume.

Although they are typically found in waters deeper than the 6.7 m (22 ft) depth where the PBNP intake crib is located, lake whitefish are considered a "shallow" water coregonid that utilizes the Lake Michigan littoral zone. Becker (1983) reports that lake whitefish in Green Bay are found in waters <18 m in May, 18 - 24 m in September, and in waters 37 - 55 m deep after ice-out. During the fall - early winter spawning season, they are found in waters 2 - 18 m deep over gravel or rock substrates. The optimum temperatures for lake whitefish has been reported to be 3.2 - 8.1°C (37.8 - 46.6°F) based on laboratory tests (Becker 1983). Upper thermal limits of YOY whitefish (Table 5-2) has been reported to range from 21.6 - 26.6°C (70.9 - 79.9°F) based on acclimation temperatures ranging from 5.0 - 20.0°C (41- 68°F).

Based on the offshore distribution of lake whitefish during much of the year and onshore movements in the spring and fall when ambient temperatures are low, this coldwater species will not be exposed to maximum plume temperatures during the summer when their upper temperature limits would be exceeded. That seasonal distribution pattern coupled with the low occurrence of lake whitefish documented in the vicinity of PBNP suggests it will not be negatively impacted by the higher discharge temperatures and plume size that would result from the planned EPU.

Bloater

Bloater (*Coregonus hoyi*) is another native coldwater species that occurs infrequently in the vicinity of PBNP. It is an important forage fish, especially as juveniles, which are utilized by salmon and nearshore lake trout (Bunnell et al. 2007). Bloaters also support a commercial fishery in Lake Michigan. Bloater were collected in the vicinity of PBNP during the 1970s (WEPCO 1978) and more recently during the 2005-06 impingement study (EA 2007a). They were a minor component of the fishery during the earlier studies as only a single bloater was collected during impingement studies from 1973 – 1977, although an additional 26 juvenile coregonids were only identified as *Coregonus* during that study. Bloater were collected in higher numbers (105) during the 2005-06 impingement study and occurred more frequently (19 percent of the samples) than in 1975-76 when they were collected during only five of 88 sampling events (WEPCO 1976). The Lake Michigan bloater population was at a very low level during most of the 1972 – 1977 study period, increased through the 1980s and has declined since 1989 (Bunnell et al. 2007). The somewhat higher number of impinged bloater in 2005-06 followed a four-fold increase in the density of Age-0 bloater in 2004 and 2005 (Bunnell et al. 2007). Low numbers were collected by trawling, seining, and gill netting operations conducted near PBNP from 1972 through 1977 (WEPCO 1978). The available data sets suggest that bloater are infrequently exposed in low numbers to the thermal plume.

Bloater are deep-water coregonids that occur at depths typically deeper than the nearshore zone in the vicinity of the PBNP and the 6.7 m (22 ft) depth where the PBNP intake crib is located. Becker (1983) reports they typically occur in water 22 - 178 m deep at water temperatures of 1.5 - 11.4°C (34.7 - 52.5°F) and are typically more abundant at 3.8 - 7.0°C (38.8 - 44.6°F). They are winter (November and December) spawners that move shoreward in May into waters <37 m, but avoid warmer inshore waters except when upwelling cools the inshore waters (Becker 1983). Their preference for low water temperatures at greater depths likely explains their infrequent occurrence in the vicinity of PBNP. Upper thermal limits of Age-I bloater (Table 5-2) has been reported to range from 22.2 – 26.2°C (72.0 – 79.2°F) based on acclimation temperatures ranging from 5.0 - 20.0°C (41 - 68°F).

Based on the offshore distribution of bloater during much of the year, avoidance of warmer inshore waters, and historical low occurrence in the vicinity of PBNP suggest it will not be negatively impacted by the higher discharge temperatures and larger plume size that would result from the planned EPU, because, like lake whitefish, bloaters naturally avoid the nearshore waters of Lake Michigan during the summer.

Lake trout

Lake trout (*Salvelinus namaycush*) is a native coldwater species that provides an important commercial and recreational fishery in Lake Michigan. It was collected in the vicinity of PBNP during the 1970s (WEPCO 1978) and more recently during the 2005-06 impingement study (EA 2007a). They were commonly collected during the 1970s studies, occurring in gill nets set during all seasons and occurring in 43 percent of the impingement samples collected in 1975-76 (WEPCO 1976). Despite that relatively high frequency of occurrence, only 89 lake trout were collected during impingement studies from 1973 – 1977 and only seven were collected during the 12-month impingement study conducted in 2005-06. Low numbers were collected by gill netting operations conducted in the vicinity of PBNP from 1972 through 1977.

These available data sets suggest that lake trout in the vicinity of the PBNP disperse to deep water during the winter, move inshore in the spring and then move offshore to deeper water when the inshore waters warm during the summer. Increased catch rates in the fall coincide with inshore fall spawning movements. Catch rates were generally similar between the plume and reference areas although the spring catch rates suggest some avoidance of the plume compared to the north and south reference areas (WEPCO 1978). More lake trout were collected in the north reference area in the fall than in the plume, where catch rates were higher than in the south reference area. Occasional higher catch rates in the summer in the vicinity of the PBNP have been attributed to upwelling (WEPCO 1978).

Lake trout is a deepwater fish typically found at 30 - 90 m (100 - 300 ft) near the lake bottom (Becker 1983). Optimum fall spawning temperatures are 7.8 - 11.1°C (46 - 52°F) and YOY are found in waters that are 5.6 - 17.2°C (42 - 63°F). Age I and II fish prefer temperatures that range from 3.9 - 11.7°C (39 - 53°F) and seldom remain in water >18.3°C (65°F). Upper thermal limits of year-old lake trout have been reported to range from 22.5 - 23.6°C (72.5 - 74.5°F) based on acclimation temperatures ranging from 8.0 - 20.0°C (46.4 - 68°F) (Table 5-2).

Based on the distribution of lake trout during much of the year and onshore spawning movements in the fall, this coldwater species will not be exposed to maximum plume temperatures during the summer when their upper temperature limits would be exceeded. That seasonal distribution pattern suggests it will not be negatively impacted by the higher discharge temperatures and larger plume size that would result from the planned EPU.

Burbot

Burbot (*Lota lota*) is a native cool/coldwater species that occurs in the vicinity of the PBNP. It was infrequently collected by trawling, seining, and gill netting operations conducted from 1972 through 1977 and only five burbot were collected during annual impingement studies during the same period (WEPCO 1978). A total of 33 burbot were impinged during the 2005-06 impingement study and a single yolk-sac larva occurred in the entrainment samples, compared to over 100 larvae collected in the ambient samples collected at the 30-ft depth contour (EA 2007a).

Life stages of burbot display distinct spatial distribution patterns: larvae are pelagic, juveniles (Age 0 and/or Age I) are typically found in the littoral zone, and adults occur in the deeper profundal zone. The Lake Michigan burbot population collapsed between the

1930s and 1960s because of sea lamprey predation and recovery occurred during the 1980s following lamprey control efforts (Stapanian et al. 2006). Decline in alewife abundance is also considered a factor in the recovery of burbot. Following recovery from the 1980s, through most of the 1990s, the Lake Michigan burbot population has declined since 1997, apparently in response to increased predation by sea lamprey (Bunnell et al. 2007).

Although burbot prefer cold waters and have an optimum temperature range of 14.6 - 18.3°C (60 - 65°F) (Becker 1983), the upper thermal limits of young (10-30 cm) burbot (Table 5-2) has been reported to range from 27.1 - 31.7°C (80.8 - 89.1°F) based on acclimation temperatures ranging from 5.2 - 19.6°C (41.4 - 67.3°F). Based on the distribution of burbot in Lake Michigan, their relatively high thermal limits, and limited occurrence in the vicinity of PBNP, burbot are not likely to be negatively impacted by the higher discharge temperatures and larger plume size that would result from the planned EPU.

Mottled sculpin

Mottled sculpin (*Cottus bairdi*) is a nearshore species associated with shoals along the Lake Michigan shore (Becker 1983). It normally occurs in waters 0.3 - 4.9 ft (0.1 - 1.5 m) deep and requires cover. Although sculpin were collected during studies in the vicinity of PBNP in the 1970s, mottled sculpin were not reported (WEPCO 1978). Slimy sculpin (*Cottus cognatus*) was the third most abundant species impinged at PBNP between May 1973 and October 1977 (WEPCO 1978). In addition to mottled sculpin, both slimy sculpin and deepwater sculpin (*Myoxocephalus thompsoni*) occurred in ichthyoplankton samples collected during the 2006 entrainment study and all three species were impinged (EA 2007a). Mottled sculpin accounted for 82 percent of the sculpins impinged during the current study.

Limited temperature data were identified for mottled sculpin; Becker (1983) reported that they spawn at 8.9 - 13.9°C (48 - 57°F) and rarely are found when water temperatures are >29°C (84°F). Becker (1983) also reported that they tended to avoid a thermal plume in Lake Monona, Wisconsin. A CTM of 30.9°C (87.6°F) has been reported for mottled sculpin (Table 5-2). The dominance of mottled sculpin on the PBNP intake screens relative to other sculpin species suggest that mottled sculpin are using habitat provided by the offshore intake crib and/or the intake forebay.

The bottom orientation of mottled sculpin and the limited available temperature tolerance data suggests they will not be impacted by the higher discharge temperatures and larger plume size that would result from the planned EPU.

Yellow perch

Yellow perch (*Perca flavescens*) is a native cool water species that provides an important commercial and recreational fishery in Lake Michigan. It was collected in the vicinity of PBNP during the 1970s (WEPCO 1978) and more recently during the 2005-06 entrainment and impingement study (EA 2007a). They were commonly collected in the vicinity of PBNP during the 1970s studies, occurring in gill nets set during all seasons and occurring in 32 percent of the impingement samples collected in 1975-76 (WEPCO 1976). Yellow perch was the fifth most abundant species collected during impingement studies from 1973 – 1977 and ranked sixth during the 12-month impingement study conducted in 2005-06.

In the 1970s, seasonal gill net catches were highest in the spring and summer and lowest in the winter. More yellow perch were caught in the north reference area than in the plume or south reference area throughout the four-year study, indicating neither strong avoidance nor attraction to the PBNP discharge.

Yellow perch are found nearshore shortly after ice out (April - early May) when water temperatures are 7.2 - 11.1°C (45 - 52°F) (Becker 1983). Becker (1983) reported that yellow perch avoided the thermal discharge in Lake Monona where they preferred water temperatures of 27.1°C (81°F). Upper thermal limits for adult yellow perch have been reported to range from 21.0. - 32.3°C (69.8 - 90.1°F) based on acclimation temperatures ranging from 5.0 - 25.0°C (41 - 77°F) (Table 5-2).

These available data sets suggest that yellow perch in the vicinity of PBNP are most abundant nearshore during the spring and summer when discharge temperatures are the highest, although comparison of gillnet catches suggests that they are not particularly attracted to the plume. Increased catch rates in the spring coincide with inshore spawning movements.

At its maximum projected discharge temperature under the planned EPU, the PBNP discharge will exceed lethal temperatures for yellow perch (Table 5-2) during August and September (Table 4-5). Discharge temperatures would be less than 32.3°C (90.1°F) 50 percent of the time in August and 80 percent of the time in September. Temperatures for optimum growth of adults (13.0 -20.0°C; Brungs and Jones 1977) would be exceeded in the plume during the warmest part of the summer and some avoidance likely would occur relative to the warmest portions of the plume (see Section 5.6). In contrast, the optimum growth temperature for juveniles (28°C) would typically not be exceeded in the plume. Therefore, any location in the plume could enhance growth of juveniles. The preferred temperature for juveniles is the same as the growth optimum; therefore, juveniles would be expected to utilize the plume during the warmer season, and experience near optimum growth. Adults prefer water a few degrees cooler than juveniles; consequently, there likely would be portions of the plume that adults would avoid during the warmest season.

Significant impacts to spawning caused by the thermal plume are not anticipated. The only potential effect would be earlier spawning in the plume, which would be warmer than nearby ambient areas. This would be a very small area, and would not be expected to have any adverse effect on reproduction of yellow perch.

Summary

Based on this review of the thermal requirements for RIS, the predicted impact of the warmer and larger thermal plume as a result of the EPU at PBNP will be negligible. Thermal criteria for some of the 12 RIS would be exceeded in the plume, but mainly only at the point of discharge or in small areas for relatively brief periods of time. The cool and coldwater fish species would be somewhat restricted with regard to use of the plume area, primarily during summer. However, as pointed out above, the coldwater species generally spend the summer well offshore where contact with the plume would be very limited. At other times, when plume temperatures are below their documented avoidance temperatures, these coldwater species would have access to the plume area. The warmwater species (channel catfish, common carp, gizzard shad, and spottail shiner) will, if anything, benefit from the warmer temperatures.

The response of RIS to the PBNP discharge under the planned EPU would be expected to be the same as has been documented in the 1970s when the plant began operation and as described for other Lake Michigan power plants in Section 3. Fish readily move into and out of thermal discharge plumes, depending on their particular thermal needs and the thermal regime of the plume at any given time. Research has shown no deleterious effects of these movements on growth or condition of fish or other health measures. Nor does interaction with the plumes appear to affect migratory patterns, i.e., the seasonal on and off-shore movements of species such as alewife, rainbow smelt, and lake trout. Also, it should be noted that except in the winter, the plume is primarily a surface phenomenon so that fish could readily move under as well as laterally away from the plume. Lastly, because the plume shifts with wind direction any particular fish would need to avoid the plume only for brief periods. Thus, avoidance would be short- rather than long-term. When these observations are considered in light of the size of the PBNP plume in relation to available lake habitat, we conclude that the larger and warmer thermal plume resulting from the planned EPU will have a minimal and insignificant impact on the fish community in Lake Michigan.

5.6 AVOIDANCE OF THE PLUME BY RIS FISHES

To determine how fish would respond to the higher temperatures that will result from the planned EPU, the 12 RIS fish species were placed into three guilds: warmwater, cool water, and coldwater. Assignment to guilds was based primarily on how these species were classified by the WDNR during their planned thermal rule-making (Wenholz 2007). They classified some fishes as "Great Lakes" species, which appear to be coldwater species so we placed those species in the coldwater guild because it more accurately conveys their thermal tolerances. The RIS were placed into the following guilds:

Warmwater	Cool Water	Coldwater
Gizzard shad	Yellow perch	Lake trout
Channel catfish	Burbot	Lake whitefish
Common carp	Alewife	Bloater
Spottail shiner	Mottled sculpin	Rainbow smelt

For each guild, we determined the upper lethal temperature (usually the UILT) and the upper avoidance temperature (Table 5-2). To determine these endpoints, we used primarily the same data sources utilized by WDNR during the ongoing thermal rule-making (Wismer and Christie 1987). For each category (i.e., upper lethal and avoidance), we determined the range of values for the endpoint of interest, then selected the midpoint of that range to establish frequency distributions (Tables 5-3 to 5-8). The guild approach was used because endpoints are not available or not well established for several species, especially the more sensitive coldwater species. Also, the endpoints used, especially the UILT, vary directly with acclimation temperature. Several species have not been tested at high acclimation temperatures that will result in the endpoint value being lower than had that species been tested at higher acclimation temperatures. We excluded, when values from higher acclimation temperatures were available, UILT values determined on fish acclimated to <20°C (68°F) because ambient temperatures near PBNP during the critical mid-summer period equal or exceed 20°C (Table 4-2). Using UILT values from fish acclimated to lower temperatures (i.e., <20°C) would inaccurately imply that the species (or guild) was more sensitive than it really was. Values used were:

	Upper Lethal (°C)		Avoidance (°C)	
Guild	Range	Midpoint	Range	Midpoint
Warmwater	36-38	37	30-35	32.5
Cool Water	25-32	28.5	20-30	25
Coldwater	22-27	24.5	15-20	17.5

Based on the model described in Section 4, we determined how much of the plume exceeded each endpoint temperature. Because the plume will be a buoyant surface plume during the summer, we also determined the average depth to which the plume extended below the surface. This was done to ensure that there would be a zone of passage not only around the perimeter of the plume but also under it. In making these comparisons, we considered the entire plume for the UILT endpoint because it is necessary to protect organisms against acute toxicity both inside and outside of the mixing zone. This protection would take the form of temperatures always being below the short term lethal endpoint (e.g., the UILT) or by fish avoiding potentially lethal temperatures; with avoidance being the primary mechanism at most power plants. Because avoidance is more of a long-term response, we considered only that portion of the plume outside the mixing zone that exceeded the various avoidance temperatures. Avoidance will certainly also take place within the mixing zone but is not considered in this evaluation.

Upon evaluation of the model output, it is apparent that neither of the two endpoints for members of the warmwater guild would be exceeded under the planned EPU (Tables 5-3 and 5-4). Thus, none of the species in this guild would be expected to avoid the plume nor would any of them be at risk in terms of lethal consequences anywhere within the plume. With regard to the cool water guild, exceedance of the 28.5°C (83.3°F) lethal temperature would occur mainly in August, when five percent of the time the area of the plume in which temperatures exceeded 28.5°C would be $1.33 x 10^6$ ft^2 (~30.5 acres) (Table 5-5). Fifty percent of the time, the size of the plume ≥28.5°C would occupy 0.49 $x 10^6$ ft^2 (~11.3 acres). However, even when the plume exceeded the upper lethal threshold for cool water fishes, those lethal temperatures would occupy only the top 2.0 to 2.5 ft (0.6 to 0.8 m) of the water column leaving a large area under the floating plume where cool water fishes could safely reside or pass through (Table 5-5). Also, as discussed in greater detail later, the floating nature of the plume would allow a broad zone of passage for cool water fishes that might want to move past the plume.

Outside the 3,125,000 ft^2 (~ 71.7 acres) mixing zone proposed by WDNR for Lake Michigan power plants (Wenholz 2007), cool water fishes would need to avoid the area only in August and September and then only occasionally (Table 5-6).

In theory, coldwater fishes should be the guild most affected by the thermal discharge from the planned EPU because they are the most thermally sensitive group. Some exceedances of the upper thermal tolerance of this guild would occur in June and July, but the area where these temperatures occurred would be quite limited (Table 5-7). In August, a larger area would be occupied by these temperatures. Fifty percent of the time in August, the portion of the plume equaling or exceeding 24.5°C (76.1°F) would occupy an area of $2.22 \times 10^6 ft^2$ (~51 acres) and five percent of the time it would occupy an area of $11.82 \times 10^6 ft^2$ (~271 acres) (Table 5-7). Again, even if the portion of the plume ≥24.5°C was relatively large, these warm temperatures would extend down about 3.4 ft (1.0 m) below the surface, thus providing the majority of the water column for coldwater fishes to either reside in or move through. The percentile distribution in September is similar to that in July, but in September a somewhat larger area is occupied at the higher percentiles (Table 5-7).

In late July, there was a fairly large area (~623 acres) outside the mixing zone that coldwater fishes would avoid five percent of the time (Table 5-8). Of note is that in part of September and much of August, the ambient nearshore waters of Lake Michigan would exceed the avoidance temperature of 17.5°C (63.5°F); thus forcing most salmonids well off-shore. In fact, this summer off-shore movement of salmonids is well established throughout Lake Michigan. Thus, when plume temperatures for coldwater species are most limiting either in terms of lethality or avoidance, few, if any, salmonids would encounter the plume.

To ensure that an adequate zone of passage under the plume was available, we used the model to construct a series of transects at varying distances downstream (i.e., along the shoreline) from the point of discharge. At each transect, the discharge delta temperature is shown at various distances offshore and at 2 ft (0.6 m) vertical increments in the water column. At the point of discharge, the temperature rise is small (<1°C) at all points in the water column at and below 6 ft (1.8 m) except at 280 ft (~85 m), the closest offshore point (Table 5-9). At this point, there is a 1.62°C (2.9°F) temperature rise 8 ft (2.4 m) below the surface. At all succeeding transects, the temperature rise 6 ft (1.8 m) below the surface is small (<1°C), and at and below 10 ft (3.0 m) below the surface, the temperature rise is negligible (<0.1°C) (Table 5-9). In summary, at all transects, the bottom three quarters of the water column experiences <1°C temperature rise, and <0.1°C rise in most of this area, so there will always be an area under the plume where cool and coldwater fishes can safely reside. Similarly, any such species wanting to move past the plant will always have zone of passage under the plume during the summer, even when temperatures within the mixing zone would otherwise be limiting.

In summary, warmwater RIS will be at no risk as a result of the planned EPU. Cool and coldwater fishes would have their upper lethal temperatures and avoidance temperatures exceeded in a portion of the plume during the warmest months, particularly in August. Although potentially lethal temperatures will exist in a portion of the plume during the summer, no mortality is expected because each species will use well documented avoidance responses to avoid such temperatures, either by staying outside of that portion of the plume that reaches its avoidance temperature or by swimming underneath the buoyant plume. Also, the coldwater group, which is the most thermally sensitive group naturally avoids the relatively warm (to them) near shore water of the lake during the summer and therefore are highly unlikely to even encounter the plume during the summer.

Although behavioral responses of the four RIS shellfish are not well known, it is not unreasonable to expect in a similar manner as the RIS fish. Also, all of the RIS shellfish except for *Mysis relicta* are strongly bottom oriented. Thus, being bottom dwellers, they typically would not encounter the plume when conditions were most limiting (i.e., during the summer) because at this time the plume would be buoyant. It should also be noted that *Mysis relicta* was rare during recent studies near PBNP and *Diporeia* was not collected (EA 2007a).

5.7 ASSESSMENTS AT OTHER LAKE MICHIGAN POWER PLANTS

One of the best ways to predict what will happen once PBNP ramps up is to consider what has happened at other once-through cooled power plants. After the operation of nearly 30 such plants, not only have there not been lake-wide or cumulative impingement or entrainment impacts attributable to these plants (Spigarelli et al. 1981), there have been no significant thermal impacts documented near any of the large operating or recently retired Lake Michigan plants.

The results of several of these studies were summarized in Section 3.3. In all cases, the studies concluded that there were no adverse thermal impacts. This is not to say that no measurable effects were found. Changes in the abundance or distribution of fish relative to the discharge plume were noted; however, in all cases these changes, though measurable, were considered to be transitory, minor, and insignificant overall. Moreover, none of these changes threatened the establishment or maintenance of the BIC near each facility. These findings are particularly important because most of the plants studied had similar cooling water usage compared to the PBNP as shown below:

Plant	Cooling Water Flow (gpm)	ΔT (°C)
OCPP (8-units)	1,232,000	6.7
DC Cook	1,637,500	12.2
Point Beach	680,000	11.5
Point Beach with EPU	680,000	13.5
Zion	1,680,000	11.1
Kewaunee	413,000	8.9

As shown above, both the DC Cook Plant and the now retired Zion Plant utilize nearly 2.5 times more cooling water as does PBNP and when operating all eight units, the OCPP used nearly twice as much cooling water as does PBNP. The increase in temperatures across the condensers were similar among the DC Cook, PBNP, and Zion plants, although the ΔT under the planned EPU for PBNP is somewhat higher (13.5°C) than at the DC Cook plant (12.2°C).

5.8 IMPACT SUMMARY.

Sections 5.1 through 5.7 describe lines of evidence that demonstrate that the thermal plume resulting from the planned EPU at the PBNP will not have any significant adverse environmental impacts, nor will it prevent the continuation of a BIC near the facility. Impacts, if any, are likely to be minor and transitory (e.g., short-term avoidance). Given the short-term duration and small magnitude of any such impacts, we conclude that the thermal impacts of the PBNP discharge as a result of the planned EPU will be biologically inconsequential and will not interfere with continuation of the BIC.

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ENCLOSURE 2

NEXTERA ENERGY POINT BEACH, LLC
POINT BEACH NUCLEAR PLANT, UNITS 1 AND 2

LICENSE AMENDMENT REQUEST 261
EXTENDED POWER UPRATE
RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

UPDATE TO SITE TERRESTRIAL ACTIVITIES

Subsequent to the submittal of License Amendment Request (LAR) 261, Point Beach Nuclear Plant (PBNP) identified the need for additional Extended Power Uprate (EPU) project and operating plant support facilities to provide office space for personnel (i.e. trailers) and parking facilities on site. For the placement of the trailers and construction of the parking lots, environmental permitting from the state and county has been obtained. The environmental permits for parking address County Soils and Erosion and Wisconsin Pollution Discharge Elimination System (WPDES) construction storm water requirements. Storm water monitoring for the parking facilities will continue after EPU implementation.

EPU plant modifications are scheduled to be completed in the spring 2011 outage for Unit 2 and the fall 2011 outage for Unit 1. Therefore, the trailer facilities should not be needed beyond EPU implementation for Unit 1.

A review of these activities shows no environmental significance. Therefore, NextEra reaffirms the conclusion that EPU operation would not significantly affect human health or the natural environment.