Exelon Generation LLC's Petition to Approve Alternative Thermal Effluent Limitations

Exhibit 1

Dresden Nuclear Station §316(a) Demonstration, May 29, 2015

Dresden Nuclear Station

§316(a) Demonstration

May 29th, 2015

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ACRONYM LIST

ACOE	Army Corps of Engineers
ANS	Aquatic Nuisance Species
ATL	Alternate Thermal Limit
AT&SF	Atchison, Topeka, and Santa Fe Railroad
Battelle	Battelle Northwest
BIC	Balanced Indigenous Community
Bio-Test	Industrial Bio-Test Laboratories, Inc.
cfs	Cubic Feet per Second
ComEd	Commonwealth Edison Company
CSSC	Chicago Sanitary and Ship Canal
CTM	Critical Thermal Maximum
CWA	Clean Water Act
DELT	Deformities, Erosions, Lesions, and Tumors
DHI	Danish Hydraulic Institute
DMR	Discharge Monitoring Report
DNS	Dresden Nuclear Station
DO	Dissolved Oxygen
EA	EA Engineering, Science, and Technology, Inc., PBC
EAV	Emergent Aquatic Vegetation
EJ&E	Elgin, Joliet, and Eastern Railroad
GPS	Global Positioning System
HD	Hester-Dendy artificial substrate sampler
IBI	Index of Biotic Integrity
ICI	Invertebrate Community Index

IDNR	Illinois Department of Natural Resources
IEPA	Illinois Environmental Protection Agency
IESPB	Illinois Endangered Species Protection Board
IFR	Instrument Flight Rules
I&M Canal	Illinois and Michigan Canal
IWBmod	Modified Index of Well-Being
msl	Mean Sea Level
NRC	Nuclear Regulatory Commission
NAWQA	National Water-Quality Assessment
NPDES	National Pollutant Discharge Elimination System
PAH	Polycyclic Aromatic Hydrocarbons
PATCO	Professional Air Traffic Controllers Organization
PCB	Polychlorinated biphenyls
PV	Provisional Variance
RIS	Representative Important Species
RTK	Real Time Kinematic
SAV	Submerged Aquatic Vegetation
SOC	Synthetic Organic Compounds
T&E	Threatened & Endangered
TMDL	Total Maximum Daily Limit
TNT	Trinitroluene
UIW	Upper Illinois Waterway
USEPA	United States Environmental Protection Agency
VFR	Visual Flight Rules
USGS	United States Geological Survey

1.0 INTRODUCTION

1.1 Roadmap to the Demonstration

This Demonstration is in support of Exelon Generation, LLC's ("Exelon") request for alternative thermal limits (ATL) for Dresden Nuclear Station (DNS) under §316(a) of the Clean Water Act. It is based on 46 years of monitoring and analyses of the fauna and ecosystems associated with the Upper Illinois Waterway (UIW) in the vicinity of DNS. This area includes portions of the Kankakee River, Des Plaines River, and Illinois River upstream (Dresden Pool) and downstream of the Dresden Island Lock and Dam. These programs and analyses are discussed in detail in the documents that comprise this Demonstration. The Demonstration presents both prospective (Appendix B) and retrospective (Appendix C) analyses which show that the proposed alternative thermal limits will assure the protection and propagation of a balanced, indigenous community (BIC) of shellfish, fish, and wildlife in and on the Dresden Pool, thereby meeting the §316(a) standard.

While each of the appended documents contains important information supporting Exelon's request, this Summary, along with Appendices B and C, are likely to be of particular interest to most readers. Section 2 of this Summary describes the proposed ATLs and explains the historical and legal context for the request. Section 3 presents the Master Rationale which summarizes the key findings of this Demonstration in support of the conclusion that the BIC of the Upper Illinois Waterway (UIW) in the vicinity of DNS will be protected under the proposed ATL. Section 4 presents the Representative Important Species (RIS) Rationale which summarizes field, laboratory, and literature data used in the development of this Demonstration to explain that RIS will not suffer appreciable harm as a result of the proposed ATL. Section 5 presents the Biotic Category Rationale and summarizes the Demonstration findings that impacts associated with the proposed ATL will be sufficiently inconsequential to assure that each of the biotic categories constituting the BIC will be protected. Section 6 summarizes engineering and hydrothermal information used in the development of this Demonstration and the above rationales.

Appendix A describes in detail the Des Plaines, Kankakee, and Illinois Rivers in the vicinity of DNS while Appendix B and C provide prospective and retrospective assessments described above. Appendix D details the operations at DNS and recent hydrothermal analysis of the DNS discharge while Appendix E reviews the various DNS data collection programs which are referenced throughout this Demonstration. Appendices F through H present annual fish and benthic macroinvertebrate monitoring reports from 2013 and 2014, and results of an October 2014 mussel survey.

1.2 Resource Agency Interaction

A study plan in support of the Demonstration was developed and submitted to the Illinois Environmental Protection Agency (IEPA) and the Illinois Department of Natural Resources (IDNR) on 14 April 2014. During the ensuing agency consultation process, the agencies recommended changes to the study plan. These changes included the following:

1) The addition of white sucker, smallmouth bass, and black crappie to the RIS list, and

2) The addition of four semi-quantitative transects and two qualitative search areas for the freshwater mussel investigation. Two additional transects were suggested for each bank of the Illinois River, upstream of the DNS discharge with qualitative search areas between the added transects.

Exelon accepted each of the recommended changes and incorporated them into the studies and analysis for the Demonstration.

2.0 PROPOSED ALTERNATE THERMAL LIMITS

2.1 Background and Proposed Alternate Thermal Limits

DNS Unit 1 produced power commercially from 1960 until it was shut down on 31 October 1978. Unit 1 currently is in long term safe storage. Units 2 and 3 started producing power in 1969 and 1970, respectively, and continue to operate. Since the National Pollutant Discharge Elimination System (NPDES) program took effect in 1972, DNS has held an NPDES permit.

The DNS cooling water system circulates water used to cool and condense steam from the generating process that is discharged to a hot canal that flows to a Lift Station where the water is pumped to the cooling pond. DNS has two primary modes of operation: Closed Cycle and Indirect Open Cycle. DNS normally operates in a Closed Cycle mode from 1 October through 14 June of each year. In this mode, cooling water is drawn into the DNS intake structure, passes through the DNS heat exchangers, and discharges to a Hot Canal that routes the water approximately two miles to the Lift Station. The Lift Station is used to transfer the cooling water from the Hot Canal up to the cooling pond. The cooling water flows through the cooling pond and over a spillway into the cold canal. The water continues to flow through the cold canal approximately two miles back to DNS where Flow Regulating Gates are used to direct the majority of the cooling water back to the intake structure for reuse. The Cold Canal and Hot Canal cooling system is used to provide supplemental cooling capacity to the cooling pond prior to water being discharged back to the Illinois River. The canal cooling tower systems are once-through systems and are comprised of two sub-systems: the Hot Canal cooling towers and the Cold Canal cooling tower. The Hot Canal cooling towers take suction from the hot canal, cool the water via a counter flow of air, and discharge back into the hot canal downstream of the suction supply. The Cold Canal system takes suction from the cold canal, cools the water via a counter flow of air, and discharges back to the cold canal downstream of the suction supply. DNS also operates in Indirect Open Cycle from 15 June through 30 September of each year. In this mode, cooling water flow mimics the closed cycle process. However, the Flow Regulating Gates divert all the cooling water from the Cold Canal to the Illinois River via the Units 2/3 Discharge Canal. Further details on DNS operations are provided below in Section 6.0 and in Appendix D.

Thermal limits, that are set forth in Special Condition 3 of the plant's NPDES Permit, are based on Illinois environmental regulations and studies and demonstrations performed under §316(a) of the Clean Water Act, that were approved by the Illinois Pollution Control Board (IPCB) Order PBC 79-134 in 1981 (IPCB 1981). In PCB 79-134, the Board approved ATLs for DNS pursuant to §316(a) and IPCB Rule 410(c), since recodified as 35 Ill. Admin. Code 304.141(c). In accordance with the Board's Order in PCB 79-134, the NPDES Permit sets thermal limits for much of the year based on the generally applicable thermal standards of 35 Ill. Admin. Code 302.211(d) and 302.211(e), and sets ATLs for the June 15 through September 30 time period.

The Permit limits, which are based on Section 302.211(d) and (e), restrict the Plant's thermal discharge from causing natural temperatures in the Illinois River to rise above 5ºF, and from causing River temperatures to exceed 60ºF and 90ºF in the winter and summer, respectively, with an allowance of 3ºF above these maximum temperatures for 1% of the hours per calendar year. Compliance with these limits is measured at the edge of a mixing zone. The ATLs in the Permit restrict the temperature of Plant's discharge from June 15 through September to 90ºF, with an allowance to exceed 90ºF up to 3ºF for 10% of the hours available during that time period. Compliance with the ATL is measured end of pipe discharge point from DNS to the River.

This Demonstration was conducted to consider whether thermal limits granted by the IPCB in PCB 79-134 continue to meet the §316(a) criteria for ATL. The Demonstration also addresses whether revised, less stringent ATLs are justified under the 316(a) criteria. As shown in the Demonstration, there is no evidence that operation of DNS in accordance with the ATLs authorized by the plant's NPDES permit has caused appreciable harm to a BIC in the Illinois River. In addition, this Demonstration shows that the BIC will be adequately protected if the 3ºF temperature increase above 90ºF, currently allowed for 10% of the time from June 15 through September, is raised to 5ºF (i.e., to 95ºF), provided that (1) discharges above 93ºF are allowed only when cooling water intake temperatures are above 90ºF, and (2) any single episode of such discharges does not exceed 24 hours in duration.

The plant's existing thermal standards and the proposed alternative thermal standards are summarized in Table 1-1 and detailed in Section 5.0 of Appendix D.

Table 1-1. Existing and Proposed Alternative Thermal Limits for Dresden Nuclear Station

Current Temperature Limits					Proposed Maximum Excursion Temperature (°F)
Month	End of Mixing Zone[1]		End of Pipe		
	Excursion Threshold Temperature (°F)	Current Maximum Excursion Temperature (°F)[2]	Excursion Threshold Temperature (°F)[1]	Current Maximum Excursion Temperature (°F)[2]	
January	60	63	-	-	No Change
February	60	63	-	-	No Change
March	60	63	-	-	No Change
April	90	93	-	-	No Change
May	90	93	-	-	No Change
1-15 June	90	93	-	-	No Change
15-30 June	-	-	90	93	95[3]
July	-	-	90	93	95[3]
August	-	-	90	93	95[3]
September	-	-	90	93	95[3]
October	90	93	-	-	No Change
November	90	93	-	-	No Change
December	60	63	-	-	No Change

[1]No change in these values is proposed.

[2]Closed cycle excursion hours limited to 1% in the 12-month period ending with any month and indirect-open cycle excursion hours limited to 10% for the 15 June through 30 September time period.

[3]Allowed only when intake temperature is 90°F or above; each episode between 93°F and 95°F is limited to a 24 hour period.

3.0 MASTER RATIONALE FOR DEMONSTRATION

This Section summarizes findings of this §316(a) Demonstration in support of Exelon's application for renewal and revision of the alternative thermal effluent limitations previously allowed by the IPCB for the DNS cooling water discharges. The Demonstration has been prepared in accordance with 35 Ill. Admin. Code 106, Subpart K, consistent with 40 CFR 125.70-125.73 (Federal Register 2014) and the Draft *Interagency Technical Guidance Manual* (USEPA and NRC 1977) (Interagency Guidance Manual). Under §316(a), the proposed alternative thermal effluent limitation (ATL) must, *"assure the protection and propagation of a balanced, indigenous community* (BIC) *of shellfish, fish, and wildlife in and on the body of water into which the discharge is made"* (USEPA and NRC 1977). 35 Ill. Admin. Code 106.1110 and 40 CFR Subpart H defines the BIC as the *"biotic community typically characterized by diversity, the capacity to sustain itself through cyclic seasonal changes, presence of necessary food chain species, and by a lack of domination by pollution tolerant species."*

To support the issuance of ATLs the applicant may use predictive methods, or in the case of an existing facility such as DNS, use studies to demonstrate the *absence of prior appreciable harm* (USEPA and NRC 1977). This Demonstration employs both methods. The retrospective evaluation demonstrating that existing operation of the DNS indirect open cycle cooling water system annually between 15 June and 30 September has not caused prior appreciable harm to the BIC is presented in Appendix C of this Demonstration. Hydrothermal surveys and modeling of the DNS thermal discharge in the Illinois River were performed (Appendix D) to support a detailed assessment that predicts negligible potential effects of the thermal discharge on selected RIS (Appendix B). Support for these conclusions is summarized below.

3.1 Supporting Information

3.1.1 Retrospective Demonstration of No Prior Appreciable Harm to the Balanced, Indigenous Community

Monitoring programs conducted under prior and existing NPDES permits for DNS show that the operation of the DNS indirect open cycle cooling mode of operation under the current ATLs has not resulted in *prior appreciable harm* to the BIC occurring in and on the Illinois River downstream of the DNS cooling water discharge. The retrospective assessment of the DNS discharge (Appendix C) discusses the findings of these studies relative to the biotic categories the Interagency Guidance Manual recommends for evaluation in conducting §316(a) Demonstrations: phytoplankton, habitat formers, zooplankton, shellfish and macroinvertebrates (including freshwater mussels), fish, and other vertebrate wildlife. These empirical studies in the Des Plaines, Kankakee, and Illinois Rivers clearly document the normal temporal and spatial variability of the aquatic community characteristic of complex ecosystems. Nearly two decades of studies with the DNS cooling system operating in its current configuration (under the approved alternative effluent limits) indicate that the aquatic community in the vicinity of the DNS discharge is similar to that in adjacent areas of the lower Des Plaines and Kankakee Rivers, and Illinois River upstream of the DNS discharge, which is not influenced by the DNS thermal plume. Findings for each of these biotic categories are summarized in Section 5.0.

3.1.2 Predictive Biothermal Assessment

A predictive biothermal assessment (Appendix B) was undertaken to complement the retrospective analysis and to provide additional information for assessing potential effects of the DNS thermal discharge on the BIC of the UIW under both the current and the proposed alternate thermal limits. The predictive assessment uses intensive thermal surveys and a hydrodynamic model of the DNS thermal plume to describe the distribution and dynamics of the thermal plume in the Illinois River under the following typical, typical high temperature, and unusual extreme high temperature scenarios:

- The **typical condition** assessment scenario used median monthly flows in the upper Illinois River (combined flows from the Des Plaines and Kankakee Rivers). The ambient Illinois River temperatures were estimated at the 60 percentile based on flow-weighted mixing of ambient temperatures in the Des Plaines and Kankakee Rivers. The median DNS discharge temperatures were used for this scenario.

- The **typical high temperature** condition assessment scenario used 5 percentile monthly flows in the upper Illinois River. These flows are half of those used for the typical condition scenario. The ambient Illinois River temperatures were estimated at the 95 percentile based on flow-weighted mixing of ambient temperatures in the Des Plaines and Kankakee Rivers. The 95 percentile DNS discharge temperatures were used for this scenario.

- To evaluate thermal plume characteristics under infrequent, more extreme meteorological conditions (**extreme high temperature scenario**) approximately equivalent to the proposed ATLs, the hydrothermal model was used to assess the unusual conditions of high air temperatures and low flow such as those that occurred during July 2012. Maximum daily ambient water temperatures during 6-8 July 2012 were in the upper 3 percent of the period of record (2003-2014); the maximum recorded ambient water during this 3-day period was 34.4°C (93.9°F). DNS cooling water intake temperatures were above 33.9°C (93°F). The DNS discharge temperature exceeded 34.4°C (94°F) for about 3 hours and exceeded 33.9°C (93°F) for about 11 hours.

Given the diversity of the fish communities in the vicinity of DNS, it is not feasible to evaluate every species that could be affected; therefore, consistent with Interagency Guidance Manual, selected Representative Important Species (RIS) were used to characterize and assess the potential effects of the thermal discharge on important life history functions (e.g., migration, reproduction, growth, performance, and survival). The RIS were selected as representative of the BIC that exists in the vicinity of DNS currently, or could exist with other improvements in water quality and aquatic habitat that might result from the ongoing TMDL process upstream in the Des Plaines River.

The hydrothermal model developed for the Dresden Pool in the vicinity of the DNS discharge is an effective tool for assessing the spatial distribution and range of temperatures within the DNS thermal plume relative to temperature effects on aquatic organisms predicted by laboratory studies. Consequently, the model is used in conjunction with laboratory-based thermal effects data to predict the potential effects of operation of DNS in accordance with currently authorized

ATLs as well as under the proposed ATLs on survival, growth, and reproduction of RIS. This biothermal analysis supports a determination that the requested ATLs are not expected to cause appreciable harm to the BIC in the Illinois River upstream of Dresden Island Lock and Dam.

Under the typical and typical high temperature scenarios modeled for this Demonstration, discharge temperatures do not exceed the chronic or acute thermal mortality threshold or avoidance temperatures for the RIS. These two scenarios are typical of existing indirect open cycle operations at DNS. Thus, no appreciable harm is predicted under the existing ATLs, which is consistent with the demonstration of no prior appreciable harm (Section 5—Biotic Category Rationale).

Consistent with the Interagency Guidance Manual, these predictive analyses demonstrate that the current ATLs at DNS assure the propagation and protection of the BIC represented by the RIS that could reside in the Illinois, Des Plaines, and Kankakee Rivers. The modeled extreme high temperature scenario further indicates that the proposed ATLs would result in temperature conditions adequate to support and protect the BIC in the vicinity of the DNS thermal discharge. Survival, reproduction, development, and growth are not appreciably reduced in the vicinity of DNS due to operation of DNS under the proposed ATLs. The potential for mortality associated with high discharge temperatures is negligible under typical, typical high, and extreme high temperature conditions at DNS under the proposed ATLs. Similarly, the DNS thermal plume is not expected to block or inhibit access to spawning habitat, spawning activities, or the development and growth of eggs, larvae, and early juveniles of RIS and the BIC. Consequently, the DNS thermal discharge is not expected to reduce normal annual growth and performance of RIS and the BIC in the UIW.

3.1.3 Potential for Increase in Abundance or Distribution of Nuisance or Pollution-Tolerant Organisms

Aquatic nuisance species (ANS) are organisms introduced into new habitat that have the ability under certain conditions to alter ecosystems and lead to degradation of biological communities and habitats by reducing biodiversity through competition with native species, alteration and degradation of habitat, and declines in populations of important indigenous species. The impacts from certain species of ANS may cause not only environmental degradation, but can also have economic impacts associated with lost commercial and/or recreational opportunities and increased cost for prevention, eradication, and control. Of 16 ANS fauna and flora found in the various Illinois waterways (Aquatic Nuisance Task Force 1999), 5 fish (grass carp, silver carp, round goby, striped bass, and white perch) and two invertebrates (zebra mussel and rusty crayfish) have been collected near DNS.

The ANS occur incidentally and in low abundance in the vicinity of DNS; at the observed abundance these ANS are not expected to have an adverse impact on the ecosystem of this reach of the UIW. The DNS thermal plume has not caused a significant increase in abundance. Striped bass, silver carp, and grass carp have been collected only during 1 or2 years since 1991. White perch have been collected sporadically since 1991, but generally only 1-2 individuals were collected per annual survey. Round goby is a relatively recent introduction to the Great Lakes basin and has been collected each year since 2003; greatest abundance (25 individuals) occurred in 2008.

Consistent with the Interagency Guidance Manual, the currently authorized and proposed ATLs for the DNS thermal discharge have not and are not expected to cause a shift in composition and abundance toward nuisance or pollution-tolerant species. Ongoing monitoring programs demonstrate no shift in community composition towards nuisance concentrations/abundance of these species in the vicinity of DNS.

3.1.4 A Safe Zone of Passage Is Available

Given that this assessment indicates that the RIS and aquatic community that they represent are not likely to avoid significant areas of habitat in the vicinity of the DNS thermal plume under typical and typical high temperature conditions, it is unlikely that the thermal plume would interfere with the migration and localized movement patterns (e.g., diel and seasonal onshore/offshore, upstream/downstream, or spawning) of the fish community in the upper Illinois River. Even under extreme high temperature conditions such as those observed during July 2012, avoidance of primarily channel habitat downstream of the DNS discharge would be of very short duration and, therefore, would not be expected to affect overall access and utilization of habitat in the area.

Reported thermal mortality metrics indicate that white sucker would be the most sensitive RIS to elevated plume temperatures, particularly under rare, extremely warm conditions such as those that occurred during July 2012. Although it is expected that white sucker might avoid significant areas of the DNS thermal plume during such extreme conditions by moving to more moderate upstream habitat, the duration that avoided temperatures persist will be limited, less than 24 hours. Such limited durations when white sucker would avoid portions of the DNS thermal plume are unlikely to have extended effects on habitat utilization by this species, which, in any event, has been only an incidental component of the aquatic community over the historical operation of DNS (Appendixes A, C, F, and G).

Both retrospective and predictive assessments demonstrate that an adequate zone of passage for seasonal migrants and resident fish species is available during their respective periods of occurrence in the vicinity of the DNS cooling water discharge.

3.1.5 No Adverse Impact on Threatened or Endangered Species

Federally threatened and endangered (T&E) fish species have not been collected in Dresden Pool or adjacent study areas in the upstream Des Plaines and Kankakee Rivers, or downstream of Dresden Island Lock and Dam. Pallid sturgeon (*Scaphirhynchus albus*) is the only federally listed fish species known to occur in Illinois; it is listed in seven southwestern Illinois counties that border the Mississippi River (USFWS 2014), but not in the vicinity of DNS.

The stated-listed threatened river redhorse (*Moxostoma carinatum*) and endangered greater redhorse (*M. valenciennesi*) were collected infrequently and in low numbers upstream and downstream of the Dresden Island Lock and Dam. The pallid shiner (*Hybopsis amnis*), also state- endangered in Illinois, was first collected from the DNS study area in 2001 and has been collected each year since. It was also collected upstream and downstream of Dresden Island Lock and Dam but primarily upstream in the Kankakee River. The state-endangered Western sand darter (*Ammocrypta clara*) was collected infrequently in low numbers and downstream of Dresden Island Lock and Dam. The state-threatened banded killifish (*Fundulus diaphanus*) was first collected as part of the DNS monitoring program in 2013 and were collected again in 2014. Operation of DNS has a low potential impact on these species because their preferred riverine habitats are upstream in the Kankakee River and downstream of Dresden Island Lock and Dam outside the thermal influence of the DNS discharge.

Two state threatened mussel species were encountered during the 2014 survey (see Appendix H), purple wartyback (*Cyclonaias tuberculata*) and black sandshell (*Ligumia recta*). Both species were present upstream and downstream of Dresden Island Lock and Dam. Five adult *C. tuberculata* were collected, including four downstream and one upstream. Four adult *L. recta* were collected, including three downstream and one upstream. Nearly 80 percent of the listed species were collected downstream of Dresden Island Lock and Dam.

It is therefore unlikely that the DNS cooling water discharge has or would be expected to have adverse effects on any state or federally listed species.

3.1.6 No Impact to Unique or Rare Habitat

Aquatic habitat in Dresden Pool and upstream Des Plaines and Kankakee Rivers in the vicinity of DNS is dominated by open, relatively deep channel with fine sediment substrate. Extensive shallow vegetated and un-vegetated habitat is found in greatest abundance and diversity upstream of the Dresden cooling water discharge. No unique or rare aquatic habitat has been identified in the portion of the Dresden Pool that could have been affected by operation of the DNS cooling water system during its operating history. Flow modification of the UIW for navigation has permanently altered flow conditions and aquatic habitat. Riffle and run habitat preferred by taxa such as redhorse, suckers, and darters occur sporadically below dams and control structures and do not exist in Dresden Pool in the vicinity of DNS.

Long-term, irreversible modification of aquatic habitat in the UIW is not the result of historical operation of the DNS cooling water system and would continue to exist in the absence of the discharge. Therefore, these influences have been suitably taken into account in analyzing the BIC that would occur in the vicinity of DNS in the absence of the thermal discharge and other pollutant-related impairments.

3.1.7 No Appreciable Harm to the Balanced, Indigenous Population by the Use of Biocides

Historically, DNS treated its cooling water system with sodium hypochlorite (chlorine). Sodium hypochlorite is normally used as the sole biocide for treatment of the circulating water system (*See Section 4.2 in Appendix D of this Demonstration for additional details about biocide application at DNS.*). Sodium bisulfite is used as a neutralizing agent prior to discharge to the river to ensure compliance with the TRC/TRO limit of 0.05 ppm. The detection limit is 0.05 ppm, an order of magnitude lower than the levels that cause fish mortality. Therefore, the DNS discharge of chlorine is well below levels that would cause harm to fish and DNS's use of biocides cannot reasonably be expected to alter or cause harm to fish communities in the Des Plaines, Kankakee, and Illinois River, nor does it pose risk of harm to the BIC. Potential interaction of the thermal discharge with the biocides is similarly harmless.

The periodic treatment with chlorine to control biofouling in the condenser cooling system

at DNS is regulated under its NPDES permit. The concentration, duration, and frequency of biocide application results in exposure conditions for aquatic organisms that have not, and are not likely to cause, appreciable harm to the balanced, indigenous community. The addition of biocides allowed by DNS's NPDES permit does not influence the potential impacts of the DNS thermal discharge on the BIC of the UIW.

3.2 Final Assessment Determination

3.2.1 Standard for Determination of Successful §316(a) Demonstration

In a 316(a) Demonstration, the standard used in the assessment of the thermal component of power plant discharges is whether a BIC of shellfish, fish, and wildlife has been and will be maintained in or on the receiving water body despite the thermal discharge. Consistent with the Interagency Guidance Manual (1977), the standard -- protection of the BIC-- is satisfied if the following are met:

- No substantial increase in abundance or distribution of any nuisance species or heat tolerant community;
- No substantial decreases of formerly abundant indigenous species or community structure to resemble a simpler successional stage than is natural for the locality and season, other than nuisance species;
- No unaesthetic appearance, odor, or taste of the water;
- No elimination of an established or potential economic or recreational use of the waters;
- No reduction in the successful completion of life cycles of indigenous species;
- No substantial reduction of community heterogeneity or trophic structure;
- No adverse impact on threatened or endangered species;
- No destruction of unique or rare habitat;
- No detrimental interaction with other pollutants, discharges, or water-use activities.

Because this demonstration includes a request for a change in the currently-authorized thermal limits, the demonstration addresses how these criteria will continue to be satisfied in the future if the proposed limits are adopted. For the reasons summarized below, the retrospective and prospective evaluations of the DNS thermal discharge demonstrate that the above criteria will be satisfied if the proposed ATLs are adopted.

3.2.2 No substantial increases in abundance or distribution of any nuisance species or heat tolerant community

To date, no substantial changes in abundance of nuisance species have been observed. The relatively small amount of additional heat that will be discharged under the proposed ATLs is not expected to cause changes in abundance or distribution of nuisance species**.**

3.2.3 No substantial decreases of formerly abundant indigenous species other than nuisance species

Based on results reported by the monitoring programs described in Appendix A, abundance of most indigenous species in the vicinity of DNS either has been unchanged or has increased since the plant began using indirect open cycle cooling, authorized by the current §316(a) ATLs. Overall, the retrospective analysis shows similar trends in abundance at locations both upstream and downstream of the DNS discharge, suggesting that the thermal discharge does not significantly influence species abundance. In addition, the prospective analysis shows that the proposed ATLs will not interfere with maintaining the indigenous fish species populations in the waters that receive the Plant's thermal discharge.

A special mussel study conducted in 2014 shows that, in beds that have similar habitat, unionid mussels are similar in species composition and abundance upstream and downstream of the DNS discharge. This indicates that the thermal discharge has not caused appreciable harm to the unionid mussel community in the Illinois River upstream of the Dresden Island Lock and Dam. The proposed ATLs will adequately protect the balanced, indigenous unionid community in the DNS receiving waters.

The demonstration of no prior appreciable harm on benthic macroinvertebrate, shellfish, and fish communities presented by the retrospective assessment supports the conclusion that the lower trophic levels on which they are dependent for food have been similarly unaffected and that no appreciable harm will result from the small increment of added heat that may be discharged if the proposed ATLs are authorized.

3.2.4 No unaesthetic appearance, odor, or taste of the water

There is no evidence of an unnatural odor or an unaesthetic appearance in the DNS receiving waters and implementation of the proposed ATLs is not expected to cause such impacts. The reach of the Illinois River influenced by the DNS discharge is not currently listed as an impaired waterbody for use potentially affected by such conditions. The small increment in additional heat and the brief time over which such an increment would occur if the proposed ATLs were authorized are not expected to cause a change in odor or aesthetic appearance in the vicinity of the DNS discharge.

3.2.5 No elimination of an established or potential economic or recreational use of the waters

No economic or recreational uses of the upper Illinois River have been eliminated or minimized as a result of the DNS thermal discharge. Recreational fisheries are depressed because of the fish consumption advisories for the UIW issued due to PCB contamination that is unrelated to operation of DNS. The prospective demonstration for the RIS indicates the small increment in additional heat that would be allowed under the proposed ATLs will not affect these conditions.

3.2.6 No reductions in the successful completion of life cycles of indigenous species, including those of migratory species

Retrospective analyses of the long-term monitoring program and historical biological analyses indicate that thermal effects have not compromised the overall success of indigenous species in completing their life cycles. These observations combined with the prospective demonstration for RIS indicate that the small increment in added heat that could be released if the proposed ATLs are authorized will not cause change in these conditions.

3.2.7 No substantial reductions of community heterogeneity or trophic structure

Data collected during the long-term monitoring program conducted at DNS since the 1970s indicate that the number of species collected has remained reasonably constant across years. Long-term changes in the fish community can be attributed to changes in the UIW unrelated to the operation of DNS. These changes are seen system wide in the UIW and there is no evidence that the DNS thermal discharge has contributed to these changes. Similarly, the proposed, relatively small, change in the ATLs is not expected to contribute to such changes.

3.2.8 No adverse impacts on threatened or endangered species

The retrospective analysis identified five state-listed fish species and two state-list mussel species, but no federally listed threatened or endangered species. Our analysis indicates that these state-listed species have not been impacted by the DNS thermal discharge and are not expected to be impacted if the proposed ATLs are authorized.

3.2.9 No destruction of unique or rare habitat, without a detailed and convincing justification of why the destruction should not constitute a basis of denial

There are no unique habitats downstream of the DNS discharge that could potentially be affected by the thermal discharge. The Dresden Island Lock and Dam permanently altered the habitat of Dresden Pool into which DNS cooling water discharges. The habitat downstream of the DNS discharge is dominated by relatively deep open channel with substrates that are common throughout the UIW. Shallow water vegetated and non-vegetated habitat is generally limited to a narrow band immediately adjacent to the shoreline downstream of the DNS discharge, but is considerably more diverse and expansive upstream as a result of river morphometry, particularly at the confluence of the Des Plaines and Kankakee Rivers.

3.2.10 No detrimental interactions with other pollutants, discharges, or water-use activities

Operation of DNS has not had a detrimental effect on recreational (e.g. boating and fishing) or commercial (e.g. shipping and fishing) water-use activities in the upper Illinois, Des Plaines, or Kankakee River. Cumulative effects of thermal additions discharged by industries upstream have not occurred. No harmful interactions with other pollutants such as organic carbon, phosphorus, and nitrogen are expected if the proposed ATLs are adopted.

3.2.11 Findings of Demonstration for Alternative Thermal Limits under §316(a)

Consistent with the Interagency Guidance Manual, the prospective analysis uses physiological and behavioral responses of RIS to temperature to predict that the temperatures, dimensions, and configuration of the DNS thermal plume operating with currently-authorized alternative effluent limits do not have the potential to adversely affect the reproduction, growth, and survival of these key species. Although temperature tolerance data are not available for *all* life history functions for every RIS, the predictive analysis using available data in conjunction with the retrospective analysis, supports a finding that the operation of the DNS under the proposed ATLs would continue to maintain the BIC.

Consistent with the Interagency Guidance Manual, the prospective assessment demonstrates that the operations under the proposed ATLs does not cause appreciable harm to, or interfere with the successful completion of, key life history functions of the RIS. Adequate area is available for migratory and resident species to move upstream and downstream. Under the proposed ATLs, temperatures in the thermal plume are such that RIS might exhibit avoidance behavior. However, avoidance of these limited areas will not preclude RIS access to rare, unique, or critical habitat. Temperatures that could adversely affect development and maturation of eggs, larvae, and early juvenile life stages of RIS are limited to a very small portion of the thermal plume; due to their planktonic nature or limited swimming ability, these life stages are not expected to remain within these small high temperature areas long enough to exhibit permanent adverse effect.

Aquatic organisms experience considerable spatial variation in water temperature and a wide range of seasonal temperatures in the absence of a thermal plume; cumulative growth of aquatic organisms is the culmination of their overall thermal experience throughout the year. At any time the temperature experienced by an organism may be below, above, or at optimum conditions. Under the proposed ATLs, the DNS thermal plume will not significantly alter this overall experience; at any given time, portions of the plume can also be below, above, or at optimum for growth. During some periods, temperatures within the plume can be closer to optimum than ambient temperatures. Temperatures in the DNS thermal plume that could be above optimum for the most thermally sensitive RIS (white sucker) are limited to the area between the DNS discharge and the Dresden Island Lock and Dam and only for brief periods during unusual extremely warm meteorological conditions. Elevated temperatures within the thermal plume are not likely to result in an increase in mortality to RIS above background natural mortality. Potentially lethal temperatures are limited to a small portion of the plume during extremely warm meteorological conditions, and juvenile and adult fish are generally able to detect and avoid potentially lethal temperatures.

The retrospective (Appendix C) and prospective (Appendix B) analyses presented in this Demonstration support findings relative to the Interagency Guidance Manual that:

1. *There has been no prior appreciable harm to the BIC associated with the long history of DNS operation, and specifically operation under the alternative thermal effluent limits of the existing NPDES Permit;*

2. *The existing aquatic community in the vicinity of the DNS thermal discharge is similar to that observed in other parts of the UIW outside of the influence of the DNS thermal plume;*

3. *The BIC is characterized by typical diversity, a capacity to sustain itself through seasonal cycles, and a dynamic food chain including an appropriate mix of key trophic level species; and*

4. *The proposed ATLs will not preclude overall improvements to the composition of the BIC in response to future improvements in water quality and habitat conditions.*

Consistent with the Interagency Guidance Manual, these findings support a determination in favor of authorization of the proposed ATLs.

4.0 REPRESENTATIVE IMPORTANT SPECIES RATIONALE

A discharger applying for an ATL pursuant to §316(a) must demonstrate that the alternative limits will assure the protection and propagation of a BIC of shellfish, fish, and wildlife in and on the body of water receiving the discharge. The BIC should typically be characterized by diversity, the ability to sustain itself through cyclic seasonal changes, and include a balance of species among trophic levels to sustain the food chain. Where impaired water quality has affected the aquatic community, the desired BIC should not be dominated by species whose presence is the result of a water quality impairment that will be eliminated by compliance with §301(b)(2).

The following five decision criteria outlined in the Interagency Guidance Manual have been evaluated as part of the predictive assessment of potential effects on RIS of proposed ATLs. The RIS were selected as representative of the community of fish and shellfish that could be present in the Illinois River upstream of Dresden Island Lock and Dam (i.e., Dresden Pool) in the vicinity of DNS. Appendix C determined that no prior appreciable harm to the BIC has resulted from the long-term operation of the DNS thermal discharge under the currently-authorized §316(a) ATLs. Historical and site-specific surveys of selected biotic categories representing appropriate food chain trophic levels demonstrated that the aquatic community in the immediate vicinity of the DNS discharge is not consistently or significantly different from that found upstream in the Des Plaines and Kankakee Rivers or downstream of Dresden Island Lock and Dam outside of the influence of the DNS thermal plume.

Given ongoing regulatory efforts to reduce nutrient and pollutant sources and loadings to the UIW, this Demonstration evaluates whether continued operation of DNS with proposed ATLs might prevent or reduce the effectiveness of other actions to improve water quality conditions in the UIW to support designated uses and aquatic biota more indicative of an unimpaired waterbody. That is, can a shift in the composition of the BIC occur in the presence of alternative thermal effluent limitations at DNS when other water quality improvements occur in the UIW as a result of compliance with §301(b)(2) of the Clean Water Act. The goal of the predictive assessment (Appendix B) was to demonstrate that species representative of the potential BIC (the selected RIS) would not be adversely affected by the proposed ATLs. The decision criteria set forth in the Interagency Guidance Manual are necessary to demonstrate completion of critical life cycle functions in order to sustain the populations of these species in the UIW and maintain a BIC of fish and shellfish to meet the designated uses of the segments of the UIW in proximity to DNS. Each decision criterion is discussed below.

4.1 Potential for Blockage of Migration

As part of this application for ATLs for the DNS indirect open cycle cooling water discharge, Exelon is required to demonstrate that an adequate zone of passage for resident and seasonal migrant species is assured. For the purposes of this assessment, a 75 percent of the cross-section of the water body benchmark has been used for determining whether adequate area is available to support migration.

Migration of RIS to preferred habitat for spawning typically occurs when DNS operates in closed cycle mode, prior to 15 June. Although across their geographic range channel catfish and bluegill can continue spawning into August, median ambient water temperatures typically exceed the upper temperature range for spawning by early July. During the seasonal periods when adults or juveniles of these RIS may migrate through the UIW in the vicinity of DNS, the proposed ATLs will provide area for adequate passage by the RIS. Therefore, the thermal plume associated with typical and typical high temperature conditions during DNS indirect open cycle operation is not predicted to interfere with migratory functions (Appendix B) associated with spawning of resident RIS. Under unusual extreme high temperature conditions, water temperatures that could be high enough to cause avoidance by the most thermally sensitive RIS, white sucker, thus, providing little or no ZOP for that species during brief periods of up to 24 hours. However, white sucker are an uncommon and infrequent component of the aquatic community in this reach of the UIW because preferred habitat and substrate are not available for the species. Such relatively minor effects will not preclude maintaining the BIC in the vicinity of DNS.

4.2 Potential for Exclusion from Unacceptably Large Areas of Habitat

Areas of the thermal plume with water temperatures in excess of avoidance temperatures or the tolerance limits of fish and aquatic invertebrates would be unavailable to the affected species. Mobile aquatic organisms generally avoid water temperatures that are potentially lethal; consequently, extensive mortality from exposure to elevated temperatures is rare, but exclusion from the warmest areas of the DNS thermal plume could be a concern during infrequent extreme ambient temperature conditions. Thermal tolerance data reviewed for this demonstration support the finding that greater than 75 percent of the cross-section at the DNS thermal discharge can be inhabited for extended periods of time with little likelihood of thermal-related mortality under both the typical and typical high temperature scenarios (Appendix B). There is no rare, unique, or critical habitat in Dresden Pool downstream of the DNS discharge from which the RIS might be excluded.

Although thermally sensitive species such as white sucker may avoid much of the segment of Dresden Pool downstream of the DNS discharge during extreme high ambient temperature conditions, such high temperatures are not predicted to persist more than a few days. In addition, the dominant aquatic habitat available between the DNS discharge and Dresden Island Lock and Dam, is not preferred habitat for white sucker.

4.3 Potential Effects on Spawning and Early Development

Reproductive success is integral to sustaining populations and the BIC through their typical seasonal cycles. Maturation of gonads and the timing and progression of spawning are closely tied to water temperature (among other factors) for many aquatic species. In addition, the survival, development, and hatching of fertilized eggs and maturation of larvae can be strongly influenced by water temperature among many other factors. The timing, frequency, duration, and intensity of spawning events and development of early life stages for many species in the UIW near DNS are strongly influenced by storms and associated runoff that can affect freshwater flow, air temperature trends, and water physicochemistry.

As discussed in Section 4.1, most spawning by RIS occurs prior to 15 June when DNS operates in closed cycle cooling mode and would, consequently, not be affected by the proposed ATLs. Results from ichthyoplankton surveys in the vicinity of DNS support this finding.

Approximately 85 percent of ichthyoplankton drift in the vicinity of the DNS cooling water intake occurs prior to 15 June and over 95 percent occurs prior to the beginning of July. Thus, indirect open cycle cooling mode has a negligible effect on survival, development, and growth of ichthyoplankton and therefore on the reproductive success of fish in the UIW near DNS.

The data reviewed in the predictive assessment indicate that the DNS thermal discharge would not have an adverse effect on spawning and early development of resident and seasonal RIS that could potentially utilize habitat in Dresden Pool; water temperatures acceptable for these activities would be available in at least 75 percent of the DNS thermal plume cross-section under typical and typical high temperature scenarios (Appendix B) throughout most of the spawning period of these species. In addition, no unique or critical habitat for spawning and early development of RIS or threatened/endangered species exists in the Dresden Pool.

4.4 Potential Effects on Performance and Growth

Although theoretical "optimum" conditions for physiological performance, feeding, and growth of aquatic organisms may occupy a narrow temperature range, these functions and activities are ongoing and vary over the wide range of seasonal temperatures experienced by these organisms. Many temperate species typically exhibit negligible growth during winter with peak growth during the warmer seasons. Thus, aquatic organisms in their natural environment rarely experience temperatures at optimum conditions reflected by controlled laboratory studies for a significant length of time. Most species experience optimum temperature conditions during a relatively short period of the annual seasonal cycle and those conditions are likely to vary from year to year. Even on a daily basis, natural ambient water temperatures can fluctuate in and out of the optimum range. As long as the cumulative conditions that promote growth occur over an annual period adequate to sustain normal growth increments the BIC will be sustained.

Many mobile aquatic species have demonstrated in laboratory "preference-avoidance" studies the ability to detect and select a preferred range of temperatures within a temperature gradient. The range of temperatures preferred by a species generally coincides with temperatures associated with optimum growth and physiological performance under the specified acclimation conditions. In their natural environment mobile aquatic organisms are able to select areas within appropriate habitat where water temperatures are most amenable to physiologic performance and optimum growth. Other factors, including the availability of preferred food items, also have a strong influence on growth.

Data for thermal preference and growth generally indicate that predicted temperatures within most of the DNS thermal plume under typical and typical high temperature conditions are within the maximum range for optimum growth and well below the upper zero growth temperature of the RIS, with the exception of white sucker and black crappie. Under the extreme high temperature condition during July 2012, ambient temperatures were generally near the upper zero growth temperature and exceed the upper optimum temperature for growth for all of the RIS for a few days, except for the more thermally tolerant channel catfish, common carp, and largemouth bass. Similarly, much of the area downstream of the DNS discharge would have been relatively unfavorable for growth during several days over which this heat event occurred.

Although temperatures in the DNS thermal plume during the summer are not particularly favorable to the growth of white sucker and black crappie, except in the Kankakee River, ambient temperatures upstream of the DNS discharge are also generally not favorable to the optimum growth of these two species. Although both species were selected as RIS because of their thermal sensitivity, they have been collected only incidentally during field surveys since 1994. The predicted relatively poor ambient thermal conditions for growth of these two species indicates that even in the absence of the DNS discharge, neither species would constitute a more significant component of the BIC.

For all of the RIS that are typical components of the BIC in the UIW (i.e., excluding white sucker and black crappie) ambient temperatures upstream of the DNS discharge and in the thermal plume downstream of the DNS discharge are adequate to support normal growth patterns under typical and typical high temperature conditions in the waterway. This is consistent with data collected during field surveys between 1994 and 2014 that show relatively good growth for the more common species including RIS. The only RIS (white sucker and black crappie) for which thermal conditions are predicted to be less than optimal under some conditions in the vicinity of the DNS discharge are not common in the study area, including upstream of the DNS discharge and downstream of Dresden Island Lock and Dam.

4.5 Potential for Reduced Survival from Thermal Shock

Thermal shock can result from a sudden increase (plume entrainment) or decrease (cold shock) in the temperature to which aquatic organisms are acclimated.

4.5.1 Cold Shock

The proposed ATLs do not affect the period during cooler ambient temperatures between October and 15 June, when DNS operates in closed cycle cooling mode.

4.5.2 Thermal Plume Entrainment

Early life stages of fish and invertebrates whose distribution and transport are dominated by water currents would be at greater risk of plume entrainment and exposure to rapid temperature increases. The majority of the early life stages of species that comprise this drift move through the area of the DNS thermal plume prior to 15 June (EA 2007) and would therefore not be affected by the proposed ATLs. For ichthyoplankton that do occur into July mortality is not predicted based on available thermal tolerance data. Early life stages frequently have higher thermal tolerance than adults. Eggs and larvae of several RIS (common carp, channel catfish, and bluegill; Appendix B) acclimated to temperatures of 10-33°C (50-91.4°F) tolerate acute exposure to temperatures of 31-41°C (87.8-105.8°F) and chronic exposure up to 38.8°C (101.8°F).

5.0 BIOTIC CATEGORY RATIONALE

This section presents the Biotic Category Rationale and summarizes the Demonstration findings that any impacts associated with the proposed ATL will be sufficiently inconsequential to assure that the biotic categories constituting the BIC will be protected. Supporting detailed information is provided primarily in Appendix C and additional supporting detail is provided in Appendices A, E, F, G, and H.

5.1 Phytoplankton

5.1.1 Phytoplankton Decision Criteria

In accordance with the Interagency Guidance Manual, the phytoplankton section of the §316(a) Demonstration will be judged successful if the applicant can demonstrate that:

1. *A shift towards nuisance species of phytoplankton is not likely to occur;*
2. *There is little likelihood that the discharge will alter the indigenous community from a detrital to a phytoplankton based system; and*
3. *Appreciable harm to the balanced indigenous population is not likely to occur as a result of phytoplankton community changes caused by the heated discharge.*

5.1.2 Phytoplankton Rationale

Phytoplankton studies conducted during the 1970s showed there was no adverse influence on phytoplankton populations in the Illinois River from indirect open-cycle operation of DNS. While there were minor annual shifts in species composition and abundance, there were no substantial changes in the community structure and no unusually large shifts in abundance among the algal divisions during the years studied. Data collected during indirect open-cycle operation indicated that the composition of the phytoplankton community at the cooling water intake was similar to the discharge during the months studied (ComEd 1996).

Phytoplankton surveys conducted in the UIW and its tributaries in 1991 and 1993 evaluated chlorophyll and phytoplankton abundance along the waterway from the Chicago Locks downstream to below Dresden Island Lock and Dam. Results from that study indicated that total phytoplankton density increased with distance downstream in the UIW. Since nearly all of the phytoplankton community originated as components of the periphyton, improved and expanded periphyton habitat in the Brandon and Dresden Pools resulted in Dresden Pool having the highest total density of phytoplankton (ComEd 1996). These studies also showed that phytoplankton populations in the UIW are in a state of flux associated with changes and gradients in physical and chemical factors moving downstream; species in the UIW and its tributaries are those adapted to eutrophic (nutrient rich, warmwater) systems.

Observations made by EA field staff during fish and benthic monitoring efforts (1994 to present) indicate that phytoplankton blooms typically begin in the backwater areas of the UIW during late June and are often seen throughout the main channel areas by mid to late July. These blooms, which typically continue into late September, do not appear to be dominated by “nuisance” species of algae.

Based on the studies conducted at other facilities and data collected as part of the operational studies at DNS, the DNS thermal discharge has not caused appreciable harm to the phytoplankton community. Hence, the proposed, relatively small, incremental changes in the DNS's thermal limits are not expected to have detectable effect on the phytoplankton community in the Dresden Pool and, thus, will not cause appreciable harm to the BIC.

Although evidence of degradation from a long history of agriculture, urbanization, commercial, and industrial uses has been documented in the UIW and its tributaries, the aquatic community in the vicinity of the DNS discharge is not significantly different than areas outside of the influence of the thermal plume. Operation of the DNS thermal discharge in indirect open cycle mode does not release other pollutants or adversely affect other water quality parameters (e.g., nutrients) that have been implicated in impairment of the aquatic community, specifically in the Des Plaines River. Further, recent improvements associated with reduced nutrient loadings as a result of enhanced treatment of wastewater and stormwater runoff to the UIW watershed have not been impeded by the continued operation of the DNS indirect open cycle cooling water system.

Consistent and the Interagency Guidance Manual, these historical data demonstrate that the current ATLs for the DNS cooling water system have *not caused appreciable harm* to the phytoplankton and periphyton communities of the UIW. Operation of the DNS indirect open cycle cooling water system under the present effluent limitations has *not caused a shift in the phytoplankton community towards nuisance species* and blooms. Operation of the DNS indirect open cycle cooling water system has not caused a change in the sources of primary production that support the UIW ecosystem. The seasonal *cycles in diversity, species composition, and abundance of the primary producer community have been sustained* from year to year over the more than 40-year operational history of DNS. The diversity of phytoplankton and periphyton primary producers *supports a diverse food chain* in the UIW, unaffected by thermal discharges from DNS. The incremental increase in temperatures under the proposed ATLs would not be predicted to have adverse effects on phytoplankton communities in the vicinity of DNS.

5.2 Habitat Formers

5.2.1 Habitat Former Decision Criteria

In accordance with the Interagency Guidance Manual (USEPA and NRC 1977), the habitat former section of the §316(a) Demonstration will be judged successful if the applicant can show that:

1. *The heated discharge will not result in any deterioration of the habitat formers community or that no appreciable harm to the balanced indigenous population will result from such deteriorations;*

2. *The heated discharge will not have an adverse impact on threatened or endangered species as a result of impact upon habitat formers.*

5.2.2 Habitat Former Rationale

Dresden Pool downstream of the DNS discharge is dominated by relatively deep open channel with limited habitat diversity; shallow habitat (less than 2.5 meters) accounts for only about 15 percent of available habitat in this area and is confined to a narrow band along both banks. Upstream of the DNS discharge a diversity of shallow habitat accounts for about 50 percent of available habitat. Shallow habitat includes areas of submerged aquatic vegetation, American lotus beds, and non-vegetated flats. Substrate in the shallow areas is variably silt, mud, and sand with patches of gravel and cobble. The Kankakee River channel is dominated by sand while the channel of the Illinois and Des Plaines Rivers is a mix of silt, sand, gravel, and debris with some scoured hardpan.

Most of the shallow habitat and associated vegetation is upstream beyond the influence of the DNS thermal plume. Downstream-vegetated habitat is similar to that observed upstream, but is limited to the narrow available shallow shore zone and not by the DNS thermal plume.

Beds of freshwater mussels can provide habitat and forage for some fish species including several of the selected RIS. Mussel distribution appears largely affected by substrate composition with the highest densities of mussels occurring in areas with substrates composed primarily of gravel mixed with sand and/or silt. Downstream of the DNS discharge to the Dresden Island Lock and Dam, the largest areas and highest densities of mussels encountered during the survey occurred along the right descending bank within the flow path of the thermal plume.

Qualitative Habitat Evaluation Index scores (QHEI) varied depending on mesohabitat type. Mean QHEI scores based on sampling during the 1990s were lowest in main channel habitats, the dominant mesohabitat in the UIW. Conversely, mean QHEI scores were best in tailwaters, which is not represented in the area affected by the DNS thermal plume and one of the least available mesohabitats in the UIW. Habitat in the area influenced by the DNS thermal plume generally scored poor to fair. The low QHEI scores were the result of a lack of riffle/run habitat, lack of clean, hard substrates (i.e., gravel/cobble), excessive siltation, channelization, poor quality riparian and floodplain areas, and lack of cover.

In order to evaluate aquatic habitat changes that may have occurred in the Des Plaines, Kankakee, and Illinois Rivers since the mid-1990s, a habitat assessment was performed at electrofishing locations in the vicinity of DNS during 2014. QHEIs were completed before and after aquatic macrophytes had matured and were supplemented with substrate characterization data. Habitat ranged from poor to fair and mean QHEI scores were again less than 60 at all sampling locations.

Similar to the results of the 1990s sampling, the low 2014 QHEI scores are the result of many factors, including a lack of riffle/run habitat, lack of clean, hard substrates, excessive siltation, channelization, poor quality riparian and floodplain areas, and lack of cover. Most notably, the mesohabitat least desirable to riverine fishes, main channel, dominates the surface area of the Dresden Pool, as well as the majority of the entire UIW. Conversely, the habitat favored by most riverine species (i.e., dam tail waters) constitutes a very small amount of the surface area (ComEd 1996). While aquatic macrophyte growth in the Dresden Pool may offer some habitat to fish and benthic macroinvertebrates, the dominance of a single habitat type, particularly downstream of the DNS discharge, low habitat quality, and the lack of habitat complexity are limiting factors for the biota in Dresden Pool near DNS. None of these factors is affected by operation of the DNS indirect open cycle cooling system.

In summary, the DNS thermal discharge does not affect the quality of aquatic habitat and has not caused appreciable harm to the habitat former community. The distribution and abundance of habitat formers and habitat quality are affected primarily by dominance of relatively poor channel habitat and relatively fine substrate characteristic of deep channel and pool areas upstream of lock and dam facilities. The habitat former community would be essentially the same regardless of continued operation of the DNS cooling water discharge with the proposed ATLs.

5.3 Zooplankton

5.3.1 Zooplankton Decision Criteria

In accordance with the Interagency Guidance Manual, the zooplankton section of the §316(a) Demonstration will be judged successful if the applicant can show that:

1. *Changes in the zooplankton community in the primary study area that may be caused by the heated discharge will not result in appreciable harm to the balanced indigenous population;*

2. *The heated discharge is not likely to alter the standing crop, relative abundance, with respect to natural population fluctuations in the far field study area from those values typical of the receiving water body segment prior to plant operation;*

3. *The thermal plume does not constitute a lethal barrier to the free movement (drift) of zooplankton.*

5.3.2 Zooplankton Rationale

The zooplankton community is not expected to be adversely impacted by thermal discharges. First, because they spend their entire life in a variable environment, they have evolved broad physiological tolerances and behavioral patterns that allow them to survive changing conditions. Second, zooplankton are rapidly transported and dispersed by currents, such that no organism would spend significant amount of time (conservatively less than 10 minutes) in the immediate discharge zone. Third, they have short generation times and high reproductive capacities, allowing populations to readily offset the loss of individuals and to recover rapidly from local and short-term perturbations. With optimum temperature and food supply, zooplankton such as rotifers and cladocerans can double their numbers up to five times per day (Edmondson et al., 1962; Hall 1964). Accordingly, the probability is low that there could be meaningful change (positive or negative) in growth or reproduction of zooplankters transported through the DNS thermal plume.

Zooplankton studies at DNS were conducted during indirect open-cycle operation from 1971 to 1974. The zooplankton communities observed in samples consisted mostly of copepods, cladocerans, and rotifers (ComEd 1980). These studies indicated a difference in the zooplankton assemblage between the Kankakee and Des Plaines Rivers. Total zooplankton abundance was much higher while diversity was lower in the Des Plaines River than in the Kankakee River, which probably reflects differences in hydrology, physicochemistry, and morphology of the two rivers. The Des Plaines River study area and downstream Illinois River resemble lake habitat with increased residence time and higher fertility, compared to the Kankakee River that promotes reproduction and dramatically increase zooplankton abundance in the Des Plaines River.

Typically, the zooplankton assemblage downstream of the discharge on the north shore of Dresden Pool was very similar to that upstream of the DNS discharge along the north shore of the Des Plaines River. Zooplankton densities and species composition downstream of the discharge on the south side of the Dresden Pool exhibited characteristics of both the Kankakee and Des Plaines Rivers, which reflects mixing of the two rivers downstream of their confluence. Species composition and abundance downstream of the discharge in Dresden Pool was very similar to that upstream of the discharge on the south shore of the Illinois River (ComEd 1980).

The zooplankton studies in in the vicinity of DNS generally reflect the community differences between the Des Plaines and Kankakee Rivers. Because of the difference between communities in two rivers and mixing of these communities immediately upstream of the DNS discharge, differences in zooplankton abundance and species composition in the DNS discharge from the cooling pond during indirect open cycle cooling was masked when the discharge mixes in Dresden Pool with zooplankton communities transported and dispersed downstream from the Des Plaines and Kankakee Rivers. Therefore, it was concluded that the DNS discharge had no measurable effect on the downstream zooplankton assemblage.

Sampling during indirect open cycle cooling operations indicates that the thermal discharge has not caused *appreciable harm* to the zooplankton community in the near field of the DNS cooling water discharge or in the UIW. Studies conducted during the 1970s indicate that the composition of zooplankton community in portions of Dresden Pool influenced by the DNS thermal plume is similar to the mixed communities of the Des Plaines and Kankakee Rivers well upstream of the influence of the DNS thermal discharge. The *seasonal cycles of zooplankton composition and abundance have been sustained* in the UIW subsequent to operation of DNS. The incremental increase in temperatures under the proposed ATLs would not be predicted to have adverse effects on zooplankton communities in the vicinity of DNS.

5.4 Shellfish and Macroinvertebrates

5.4.1 Shellfish and Macroinvertebrate Decision Criteria

In accordance with the Interagency Guidance Manual, the shellfish and macroinvertebrate section of the §316(a) Demonstration will be judged successful if the applicant can show that no appreciable harm to the balanced indigenous population will occur as a result of macroinvertebrate community changes caused by the heated discharge including the following criteria:

1. *Standing crop – Reductions in the standing crop of shellfish and macroinvertebrates may cause no appreciable harm to the balanced indigenous population within the water body segment;*

2. *Community Structure – Critical functions of the macroinvertebrate fauna are being maintained in the water body segment;*

3. *Drift – Invertebrates do not serve as a major forage for the fisheries, food is not a factor limiting fish production in the water body segment, and/or drifting invertebrate fauna are not harmed by passage through the thermal plume.*

5.4.2 Shellfish and Macroinvertebrate Rationale

5.4.2.1 Benthic Macroinvertebrate Community

The aquatic macroinvertebrate community in the vicinity of DNS was sampled from both natural and artificial substrates intermittently from 1972 through 2014. Data from the benthic macroinvertebrate monitoring program conducted from 1972 through 1977 (Hazelton 1979), as summarized in the 1980 Demonstration (ComEd 1980), formed the basis for previous thermal evaluation of the potential effects of indirect open cycle operation of DNS. Monitoring of the benthic macroinvertebrate community was subsequently conducted in 1993 in association with a study of the UIW (ESE 1994) and 12 years between 1999 and 2014 using Ponar grab samples and Hester-Dendy (HD) samplers. Use of the artificial substrate samplers (Hester-Dendy plates) removes the sources of variability among stations associated with sediment type, grain size, and organic and carbon content of sediment.

Benthic macroinvertebrate data for the period 1972 through October 1974, when DNS was operating indirect open-cycle cooling mode indicated collection primarily of Tubificidae (worms) and Chironomidae (midges) in the natural substrates of Dresden Pool with Tubificidae dominating the assemblage. The tubificid *Limnodrilus hoffmeisteri*, which is tolerant of organic enrichment, was the most common identifiable tubificid species. Upstream of the DNS discharge, the composition of the benthic community during the 1974 through 1976 studies consisted primarily of Tubificidae (worms) and Chironomidae (midges) taxa with Ephemeroptera (mayflies) of secondary abundance. However, artificial substrate samples indicate that availability of good quality natural substrates rather than temperature limits the benthic macroinvertebrate diversity downstream of DNS. Artificial substrate samples, even in the discharge canal, indicated high densities and a diversity of insects not observed in natural substrate samples from Dresden Pool.

The 1993 UIW macroinvertebrate samples were collected from natural substrates and artificial substrate samplers. Results of this study suggested some level of environmental stress in the vicinity of DNS based on lower taxa richness, lower diversity, and higher densities among Ponar samples downstream of the DNS discharge. However, greater densities, high biotic index (BI) scores, and lower diversity was evident downstream of the DNS discharge from artificial substrate samples. It was reported that HD densities in the DNS discharge had the highest invertebrate community index (ICI) score of any location sampled, indicating a good community condition in the DNS discharge canal. It was concluded that spatial differences observed in the macroinvertebrate community in Dresden Pool was influenced by several factors including flow, flow-induced sampling variation, and differences in water quality other than temperature (ESE 1994).

Macroinvertebrate data collected by Ponar grab and HD artificial substrate samplers from 1999 through 2014 in the vicinity of DNS were consistent with the results of the earlier studies. The most recent data indicate that a poor benthic community exists in Dresden Pool and in the Illinois River downstream of the Dresden Island Lock and Dam. The fauna at all locations in the DNS study area included primarily tolerant or facultative taxa. The Ponar samples indicated that the highly tolerant Oligochaeta dominated at most locations. With a few exceptions, intolerant groups such as EPT taxa (Ephemeroptera, Plecoptera, and Trichoptera) generally were not well represented and when present were collected in relatively low numbers. The number of EPT taxa in natural substrates was lower than might be expected for a waterway of this size. However, the artificial substrates samples typically had higher total taxa richness, higher EPT taxa richness, and a more even distribution of abundance among the taxa than did Ponar samples in natural substrate from the same locations.

No significant upstream/downstream differences were observed in total density (all taxa), densities of Oligochaeta, Chironomidae, and Pelecypoda, and taxa richness in the most recent Ponar samples. Comparisons among the Ponar data collected from Dresden Pool since 1999 showed there were no significant differences in the mean densities of Ephemeroptera for areas combined or the two areas individually. In addition, no significant annual differences were observed among the upstream densities of Chironomidae and taxa richness. Total density (all taxa) and Oligochaeta densities upstream of DNS were statistically similar among all years except 2008 when the lowest density was recorded. Downstream of DNS, total density, Oligochaeta density, Chironomidae density, and taxa richness were statistically similar except the comparison between the years with the lowest and highest densities.

Artificial substrate results generally showed that the relative abundance of Chironomidae and Oligochaeta was higher upstream of DNS, whereas Trichoptera relative abundance was higher downstream of DNS. Ephemeroptera was a minor component upstream and downstream of DNS. Chironomidae densities were higher upstream of DNS than downstream of DNS; however, the opposite was the case for Oligochaeta. The total number of taxa was higher upstream of DNS while the number of EPT taxa was similar between areas. Mean Ephemeroptera densities among years were not significantly different. In addition, results were statistically similar among the majority of study years for all parameters. However, there were some inter-year significant differences in mean densities for all taxa, Oligochaeta, Chironomidae, and Trichoptera. These annual differences could be the result of a number of factors including natural annual variation, stream flow conditions, food availability, predator abundance, and legacy pollutants.

Consistent with Interagency Guidance Manual, these empirical data demonstrate that the indigenous macroinvertebrate community in the natural substrates of the UIW is dominated by pollution tolerant taxa adapted to organically enriched fine sediments. However, pollutant sensitive EPT taxa are more evenly represented throughout the area in the vicinity of DNS including the DNS discharge canal, on artificial substrate samplers. This indicates that spatial differences in the benthic macroinvertebrate community in the

natural sediments in the vicinity of DNS are influenced by substrate conditions rather than the DNS thermal plume. The empirical data indicate that the current DNS ATLs have *not caused appreciable harm* to the benthic community in the vicinity of the DNS discharge. Operation of the DNS indirect open cycle cooling water system under the present alternative effluent limitations has not and is not expected to result in reductions in standing crop of the benthic macroinvertebrate community. Operation of the DNS indirect open cycle cooling water system has not and is not expected to result in a reduction in the diversity of the benthic macroinvertebrate community. Operation of the DNS under the proposed ATLs is *not expected to interfere with maintenance or critical, seasonal, life history cycles* (e.g., spawning and recruitment) of the benthic macroinvertebrate community in the vicinity of DNS.

5.4.2.2 Freshwater Mussels

A mussel survey conducted in 2014 (Appendix H) showed the presence of a diverse mussel assemblage upstream and downstream of the Dresden Island Lock and Dam. Recruitment was evident throughout the study area, although the downstream assemblage had a greater proportion of adult mussels than upstream. Substrate and depth varied upstream and downstream of Dresden Island Lock and Dam but also varied within the upstream study reach. The study reach downstream of Dresden Island Lock and Dam was generally shallower (mean depth of approximately five feet) and substrates were coarser (i.e., gravel, sand and cobble). The study reach upstream of Dresden Island Lock and Dam was typical of an impounded river channel with a mean depth of approximately 13 feet and substrates with a generally larger proportion of finer sediments such as silt, sand, and clay in addition to gravel.

The mussel survey showed the presence of a diverse mussel assemblage upstream and downstream of the Dresden Island Lock and Dam. Recruitment was evident throughout the study area although the upstream assemblage had a more even mix of immature and adult mussels than downstream. A total of 3,349 individuals representing 25 species were collected within the survey area from semi-quantitative and qualitative sampling efforts; 928 individuals representing 20 species were collected downstream of the Dresden Island Lock and Dam and 2,421 individuals representing 24 species were collected upstream of Dresden Island Lock and Dam. The same three species were most abundant both upstream and downstream of Dresden Island Lock and Dam. Mussel distribution appears largely influenced by substrate composition with the highest densities of mussels occurring in areas with substrates composed primarily of gravel mixed with sand and/or silt.

Downstream of the DNS discharge to the Dresden Island Lock and Dam, mussel densities were high along the right descending bank and low along the left descending bank. The largest areas and highest densities of mussels encountered during the survey occurred along the right descending bank within the flow path of the elevated temperatures in the thermal plume, but where preferred substrate occurred. Of the transects located immediately downstream of the discharge along the left descending bank, the transect located within the warmest portion of the plume contained the greatest number of mussels. Mussel densities upstream of the DNS discharge were variable with the lowest average densities encountered during the survey occurring along the right descending bank and the third highest average densities along the left descending bank.

Consistent with Interagency Guidance Manual, these empirical data demonstrate that a balanced, indigenous mussel community is supported in the vicinity of DNS and has not been adversely affected by operation of the DNS indirect open cycle cooling system annually. Operation of the DNS indirect open cycle cooling water system has not and is not expected to result in a reduction in the diversity of the freshwater mussel community. Operation of the DNS under the proposed ATLs is *not expected to interfere with maintenance or critical, seasonal, life history cycles* (e.g., spawning and recruitment) of the freshwater mussel community in the vicinity of DNS.

5.5 Fish

5.5.1 Fish Decision Criteria

In accordance with the Interagency Guidance Manual, the finfish section of the §316(a) Demonstration will be judged successful if the applicant can prove that the fish community will not suffer appreciable harm from:

1. *Direct or indirect mortality from cold shock;*
2. *Direct or indirect mortality from excess heat;*
3. *Reduced reproductive success or growth as a result of plant discharge;*
4. *Exclusion from unacceptable large areas; or*
5. *Blockage of migration.*

5.5.2 Fish Rationale

5.5.2.1 Reproductive Success

Monitoring studies conducted to evaluate possible impacts of operating under the currently-authorized §316(a) ATLS for DNS provide empirical data to support a determination that the DNS indirect open cycle cooling water discharge has not adversely affected spawning and reproductive success of the diverse fish community inhabiting the UIW. EA (2007) conducted ichthyoplankton sampling in Dresden Pool and the Kankakee River in the vicinity of DNS. Sampling for juvenile and adult finfish during 1991-2014 provides information about seasonal abundance and diversity, inter-annual variability, and long term trends of these life stages in the Illinois, Des Plaines, and Kankakee Rivers, and whether the current ATLs have caused appreciable harm to the fish community and its ability to sustain typical seasonal cycles of reproduction and recruitment.

The distribution and dispersal of ichthyoplankton (early life stages of fish, i.e., eggs, larvae, and early juveniles) are strongly affected by ambient currents in riverine habitat. Based on data collected during ichthyoplankton monitoring of the UIW and entrainment studies at DNS (EA 1995 and EA 2007), icthyoplankton occurred in the drift in 2005 and 2006 when ambient river temperatures ranged from 10.5 to 31.4°C (51 to 88.5°F), which suggests that ichthyoplankton were not exposed to temperatures high enough or for sufficient duration to cause thermally-induced mortality during the 2005 and 2006 study. Of the fish eggs, larvae, and juveniles estimated to be in the Kankakee River drift in 2005, 82.5 percent passed the DNS intake by 15 June, during closed cycle cooling operations. Most of remaining drift during 2005 occurred during indirect open cycle cooling operations from mid-June through late August. In 2006, 86.5 percent of the drift passed the DNS intake by mid-June (closed-cycle operations) and 13.5 percent occurred in the river during indirect open cycle operations after 15 June.

The majority (90 percent) of the eggs and larvae in the Kankakee River upstream of DNS were freshwater drum, gizzard shad, Cyprinidae, sunfish (*Lepomis* spp.), and carpsucker (*Carpiodes* spp.) in 2005 and 2006. Freshwater drum eggs accounted for 72 to 76 percent of the drift; of the other taxa collected, only gizzard shad accounted for more than three percent of the annual total, except in 2006 when *Carpiodes* yolk-sac larvae accounted for 17 percent of the ichthyoplankton compared to less than one percent in 2005. The abundance of both freshwater drum and gizzard shad in the drift is indicative of their open water spawning habits; the high relative abundance of freshwater drum eggs in the drift is because their eggs are semi-buoyant. These same taxa dominated entrainment collections in similar relative abundance at the DNS intake. Taxa with more specialized spawning behavior such as nest builders that provide parental care (e.g., channel catfish and sunfish) and species with adhesive eggs were collected infrequently and in low numbers.

5.5.2.2 Juvenile and Adult Distribution

Studies conducted in Dresden Pool (including upstream of DNS in the lower Des Plaines and Kankakee Rivers) and downstream of Dresden Island Lock and Dam between 1991 and 2014, documented the occurrence of 96 fish species including 90 native species and six introduced/exotic species. Monitoring of the fish community in Dresden Pool from 1991 through 2014 yielded annual counts of 36 to 70 species with an average of 54 species. Native species have dominated the catch since 1991. Twenty-one native species were collected each of the 20 years monitored from 1991 through 2014. Common carp was the only non-native species collected each year. The common native species represented several trophic levels including forage species (gizzard shad, emerald shiner, bluntnose minnow, and bullhead minnow), omnivores (e.g., channel catfish, rock bass, green sunfish, and bluegill), and top predators (e.g., smallmouth bass and largemouth bass). Other native species collected each year included two cyprinids (spotfin shiner and spottail shiner), five suckers (river carpsucker, quillback, shorthead redhorse, smallmouth buffalo, and golden redhorse), orangespotted sunfish, logperch, and freshwater drum. Except for a declining trend between 1993 and 2000, species counts generally increased with the highest count (70) in 2014. However, statistical analyses indicate that these differences are not significant. Surveys downstream of the Dresden Island Lock and Dam from 1991 through 2014 yielded 86 species, 78 that were also collected upstream of Dresden Island Lock and Dam. As for the Dresden Pool, native species and common carp dominated the annual catches downstream of Dresden Island Lock and Dam. Thirty species were collected during five or fewer of the survey years.

Comparison of native species richness metrics among sampling years indicates that a diverse fish community has been maintained in the vicinity of DNS since it began operations. As discussed in Appendix A, the species not collected during most years have been incidental, occasional, or exotic species. The RIS selected for the predictive assessment (Appendix B) were collected during most years that monitoring was conducted. Exceptions were white sucker and black crappie that were always minor components of the fish community, but were selected as RIS because of their perceived thermal sensitivity. Differences in native species richness between areas upstream and downstream of DNS primarily reflect the presence or absence of uncommon species and differences in availability and diversity of habitat types. Better habitat quality in the Kankakee River compared to the other sampling locations in the study area contributes to the higher native species richness values upstream of DNS.

Total summer (15 June through August) electrofishing catch rates of native species ranged from 47.8 to 299.0 fish per km. The 2014 total CPE was exceeded only by the record rate reported in 2003. Total catch-per-effort (CPE) of native species in 1994 was significantly ($P<0.05$) lower compared to all years except 1995 but CPEs were statistically similar among 15 of the 17 years compared. Catch rates for the RIS followed the same trend as the total CPE, accounting about three-quarters of the total native species CPE. Gizzard shad, emerald shiner, bluegill, and largemouth bass CPEs were the most variable of the RIS, whereas CPEs of common carp, golden redhorse, channel catfish, smallmouth bass, logperch, and freshwater drum were stable in comparison. White sucker and black crappie were rarely collected in Dresden Pool and always at low rates. Catch rates of gizzard shad, emerald shiner, and golden redhorse exhibited cyclical trends, whereas catch rates of bluegill and largemouth bass generally increased over the 1991-2014 monitoring period. Catch rates of channel catfish were stable except in 1998 and 1999 when rates were lowest but rates reached their highest levels in 2000 and 2003 and remained well above the lowest rates through 2014. Smallmouth bass catch rates were stable except for higher CPEs in 2003 and 2008. Logperch catch rates average less than 2 per km except in 2014 when record catches were recorded. Except for high catch rates in 1994 and 2003, freshwater drum were caught in low numbers, less than 2 fish per km since 2004.

Several metrics have been calculated to characterize the overall condition of the fish community in the vicinity of DNS, including modified Index of Well Being (IWBmod), relative weight (*Wr*), and DELT incidence. Ohio EPA (1987, 1989, and 2006) uses IWBmod scores to assign streams or stream segments to the following classifications: Exceptional = ≥9.6; Very Good = 9.1-9.5; Good = 8.5-9.0; Marginally Good = 8.0-8.4; Fair = 6.4-7.9; Poor = 5.0-6.3; and Very Poor = <5.0. Mean IWBmod scores for the 15 June through August monitoring period ranged from 5.3 to 7.4. Those scores were statistically similar for 13 of the 17 years compared and the highest score in 2003 was statistically higher than only four of the 17 years monitored. According to the Ohio EPA classification, the fish community in the lower Dresden Pool segment during the mid-June through August time period would be considered poor in 1994, 1995, and 1999 and fair in all other years. Mean IWBmod scores upstream of DNS averaged 0.3 higher than downstream; however, the upstream/downstream differences were not statistically ($P>0.05$) different for 15 of the 17 years monitored indicating that operation of DNS had little effect on the wellbeing of the fish community in Dresden Pool. Environmental conditions in the UIW resulting from impoundment of the Illinois River, operation of the navigation system, and significant discharges from wastewater treatment facilities has a greater effect on the fish community and prevents it from meeting higher IWBmod scores that would be indicative of a healthy natural river system. Habitat, channel morphology, and flow conditions downstream of the Dresden Island Lock and Dam are considerably different from conditions in the Dresden Pool. IWBmod scores ranged from 6.7 to 7.9 and were not statistically different among the 15 years sampled. Based on the Ohio EPA classification outlined above, the fish community downstream of the Dresden Island Lock and Dam during the mid-June through August time period would be considered fair for each of the 15 years monitored.

Relative weight (*Wr*) is a measure of fish condition used to assess fish growth. A *Wr* range of 90-100 is considered optimal for most fish species. When mean *Wr* values are well below 100, problems may exist in food availability and feeding relationships. Based on *Wr* data, fishes collected from Dresden Pool and downstream of Dresden Island Lock and Dam since 1994 were consistently in good condition, especially the six RIS for which adequate data were available to calculate *Wr*. Although most summer *Wr* means approached 90 bottom feeding species occasionally had marginal *Wr* values less than 90 that suggest health, food availability, and/or feeding relationship problems.

A high incidence of DELT anomalies is an indicator of stress or contamination, which may be caused by a variety of environmental factors, including chemically contaminated substrates (Ohio EPA 1989). Inter-year comparisons of the incidence of DELT anomalies during the summer (15 June through August) show that summer affliction rates in Dresden Pool decreased steadily from 13.6 percent in 1995 to 1.6 percent in 1999 and, with few exceptions, have been consistently near two percent during the last 14 study years. For large river sites like the UIW, the Ohio IBI scoring criteria is as follows: percent DELT anomalies <0.5 = 5 (good), 0.5-3.0 = 3 (fair), and >3.0 = 1 (poor). Based on the overall (all species combined) incidence rates observed for the 15 June through August period, fish in Dresden Pool were in the fair category with few exceptions. Bottom feeders such as common carp, golden redhorse, shorthead redhorse, smallmouth buffalo, and channel catfish have typically exhibited the highest DELT anomaly affliction rates in Dresden Pool and downstream of Dresden Island Lock and Dam. Overall, 3.0 percent of the RIS examined from Dresden Pool had DELT anomalies compared to 5.3 percent downstream of the Dresden Island Lock and Dam. Differences between the two areas largely reflect higher incident rate of channel catfish downstream of Dresden Island Lock and Dam. Disproportionately higher affliction rates among bottom feeders suggest that substrates within the DNS study area may contain contaminants that are responsible for many of the DELT anomalies observed on these species (Bertrand and Sallee 1992; Burton 1995; ComEd 1996).

Water temperatures with the potential to exclude key members of the fish community are limited to a relatively small area and for brief periods of time downstream of the DNS cooling water discharge compared to the available surface area and volume of the UIW. Beach seine and electrofishing samples indicate that the most abundant species are widely distributed in the vicinity of DNS with no evidence of avoidance of areas influenced by the DNS thermal plume. If, in fact there is an area of the DNS thermal plume from which the majority of fish are excluded, that area is relatively small and short-lived and has not been detected by the extensive and long-term sampling efforts.

Consistent with the Interagency Guidance Manual, these empirical data demonstrate that the current and proposed ATLs are *supportive of seasonal cycles* of spawning and reproduction of the fish community in Dresden Pool; these *important life history functions are sustained* and do not appear to be reduced in the vicinity of the DNS thermal plume compared to upstream areas of the Dresden Pool including the Des Plaines and Kankakee Rivers. A typical, *diverse, fish community is supported* in the UIW and does not appear to be excluded from a significant portion of the Dresden Pool unique or critical habitats. An *adequate zone of passage exists* in the vicinity of the DNS thermal plume with the current

and proposed ATLs.

5.6 Other Vertebrate Wildlife

The DNS thermal discharge plume does not disrupt normal migratory patterns by attracting large numbers of birds during spring and fall migration periods or by causing conditions that attract large overwintering populations of otherwise migratory species. In addition, as discussed in this Demonstration, there is no unique or critical nesting, rearing, or feeding habitat for waterfowl in the immediate vicinity of DNS.

The waters and shoreline of the UIW and Dresden Pool is used by various resident mammals (e.g., muskrat, white-tailed deer, and wild turkey), song birds (e.g., black-capped chickadee and tufted titmice), reptiles (e.g., northern water snake and red-eared slider), and amphibians (e.g., northern leopard frog and American bullfrog). Wildlife use the DNS study area for nesting, nursery, and foraging grounds, and by migratory birds (e.g., waterfowl and American white pelicans) for resting areas. Water birds commonly seen in the area include local and migratory waterfowl and wading birds (e.g. Canada geese and great-blue heron). Bald eagles have been observed along the UIW and in the vicinity of Dresden Pool during monitoring studies at DNS. They overwinter along the Illinois River and have recently nested in northeast Illinois in Cook, Kane, and Will counties. Nesting sites are not known to exist along the Dresden Pool shoreline.

The Dresden Pool does not provide unique or critical habitat for the survival and growth of these wildlife species. Activity of other vertebrate wildlife has not been limited by the thermal limits that DNS has operated under since 1981 and are not expected to be affected by the proposed limits. The thermally-influenced area is relatively small and higher water temperatures occur in the summer when migratory waterfowl use is at its lowest.

Consistent with Draft Interagency Guidance (1977), other vertebrate wildlife can be considered as a *low potential impact biotic category* relative to the DNS thermal discharge.

6.0 ENGINEERING AND HYDROLOGICAL SUMMARY

This section summarizes engineering and hydrothermal information used in the development of the Demonstration and the above rationales. Supporting detailed information is provided in Appendix D.

6.1 Dresden Nuclear Station Operations

DNS is a nuclear-fueled steam electric generating facility located at the confluence of the Des Plaines and Kankakee Rivers near Morris, Illinois, at River Mile 272.3. Unit 1 started commercial service on August 1, 1960. Unit 2 started commercial service on April 13, 1970 and Unit 3 started commercial service on July 22, 1971. Dresden Unit 1 was permanently shut down in 1978 and is in long term safe storage with the reactor fuel stored in dry casks at the plant site. In 2004, the Nuclear Regulatory Commission granted Dresden Units 2 and 3 a 20-year extension of their operating licenses until 2029 and 2031, respectively. The two boiling water reactors have a combined maximum generating capacity of 1,824 megawatts electric.

The Station discharges wastewater in accordance with a National Pollutant Discharge Elimination System (NPDES) Permit No. IL0002224, which was issued by Illinois EPA on December 1, 2011.

DNS normally operates in a Closed Cycle mode from October 1st through June 14th of each year. In this mode, cooling water is drawn into the Station's intake structure, passes through the Station's heat exchangers, and discharges to a Hot Canal that routes the water to the Lift Station. The Lift Station is used to transfer the cooling water from the Hot Canal up to the cooling pond. The cooling water flows through the cooling pond into the cold canal. The water flows through the cold canal back to the Station. Flow Regulating Gates direct the majority of the cooling water back to the intake structure for reuse. A small portion of the water is diverted as blowdown flow to the Illinois River via the Units 2/3 discharge canal (Outfall 002). Makeup water is obtained through the Station's Kankakee River intake.

Dresden's current NPDES permit authorizes the Station to operate in an Indirect Open Cycle mode from June 15th to September 30th of each year. In the Indirect Open Cycle mode, cooling water flow mimics the closed cycle process. However, the Flow Regulating Gates divert all the cooling water from the Cold Canal to the Illinois River via the Units 2/3 Discharge Canal (Outfall 002). This cooling water flow is withdrawn through the Kankakee River intake. The Illinois Pollution Control Board ("IPCB") approved this operational arrangement and the related alternate thermal standards on July 9, 1981, (IPCB #79-134).

6.1.1 Time-Temperature Relationship

Time of passage from the intake structure to Outfall 002 during indirect open cycle operation (June 15 through September 30) is approximately 2.5 days with both units at full power and all six circulating water pumps operating. During closed cycle operation (October 1 through June 14), under cold weather conditions, the travel time through the cooling pond is approximately 3.5 days. During cold weather periods the number of circulating water pumps may be reduced from three (3) pumps to two (2) pumps per unit. This results in a reduced cooling water flow and an associated increase in travel time through the system. During closed cycle operation period, the majority of cooling water is routed back into the plant intake.

6.1.2 Thermal Interaction

The Des Plaines River is listed as an impaired water body by the USEPA. This information is maintained and routinely updated in the USEPA's Watershed Assessment, Tracking, and Environmental Report. The various causes of impairment are as follows:

Cause of Impairment	Cause of Impairment Group
Dissolved Oxygen	Organic Enrichment/Oxygen Depletion
Fecal Coliform	Pathogens
Mercury	Mercury
Nitrogen, Total	Nutrients
Phosphorus, Total	Nutrients
Polychlorinated Biphenyls (PCBs)	Polychlorinated Biphenyls (PCBs)
Silver	Metals (other than Mercury)
pH	pH/Acidity/Caustic Concerns

As detailed in Appendix A, there is no evidence to suggest DNS operations impacts levels of these parameters found in the upper Illinois River Basin.

6.2 Hydrology

DNS is located just downstream of the confluence of the Des Plaines and Kankakee Rivers that merge to form the Illinois River. As such, DNS is located in an area of fairly complex hydrology.

The Kankakee River Basin drains the largest part (27.6 percent or approximately 1,934,031 acres) of the Upper Illinois River Basin. The Kankakee River flows from its headwaters in northeast Indiana toward Illinois in a general northeast to southwest direction and turns northwest at its confluence with the Iroquois River, about 4.8 miles upstream of Kankakee, Illinois (USGS 1999). The mean annual flow of the Kankakee River near Wilmington, Illinois from 1934 to 1999 was 4,739 cfs (ranging from 1,965 to 8,153 cfs); seasonal flows parallel those of the Illinois River (USGS 2000). The Kankakee River flows 57 miles before joining the Des Plaines River to form the Illinois River near the Grundy and Will County line in Illinois.

The Des Plaines River originates just south of Union Grove, Wisconsin, and enters Illinois near Russell, Illinois. The river flows 157 miles and drains approximately 13.3 percent (931,978 acres) of the Upper Illinois River Basin. It flows north to south from Wisconsin into Lake and Cook Counties, Illinois, turns southwest at Lyons, Illinois, follows the CSSC, and joins the Kankakee River (USGS 1999). The mean annual flow of the Des Plaines River just above its confluence with the Kankakee River is approximately 6,080 cfs; seasonal flows parallel those of the Illinois River (USGS 1999, 2000). The Des Plaines River drainage area includes 430,720 acres that originally drained to Lake Michigan through the Chicago and Calumet Rivers. The Des Plaines River is the primary drainage system for the greater Chicago/Cook County area (USGS 1999).

Mean annual flow of the Illinois River at Marseilles, Illinois, approximately 26.5 miles downstream of DNS was 10,820 cfs (ranging from 7,568 to 16,380 cfs) over the 1920 to 1999 time period. Flows tend to be highest in spring (March - May), when the Upper Illinois River Basin receives snowmelt and runoff from spring rains, and lowest during late summer and early fall (August - October) when precipitation in the region is lowest (USGS 2000).

6.3 Intake and Outfall Configuration and Operation

6.3.1 Intake

The Kankakee River is the only surface water intake source for cooling water. When both units are at power, cooling water flows through the Unit 2 and 3 condensers and service water systems at a rate that varies from 688,000 gallons per minute (gpm) (1,533 cfs) in the winter to 1,017,000 gpm (2,266 cfs) during the summer. Under low river flow conditions, a high percentage of the condenser cooling water is pulled into the Intake Canal from the Des Plaines River. This percentage increases as flow in the Kankakee River decreases.

For 8½ months of the year (October 1st to June 14th), the cooling water system is configured in a mode referred to as “closed-cycle with blowdown flow”. In this mode, the majority of the cooling water flow is routed back to the intake canal.

For 3½ months of the year (June 15th to September 30th), all the cooling water flows required for Units 2 and 3 are taken directly from the Kankakee River, routed once through the cooling pond, and then, discharged to the Illinois River. This “once-through” cooling mode is called “indirect open-cycle”.

6.3.2 Discharge

DNS has two separate discharge canals. One discharged cooling water from Unit 1 condenser, which is shutdown, and the other discharges water from the return canal of the cooling pond. To completely understand the discharge from the Units 2 and 3 canal, a brief explanation of the cooling pond and discharge flume is follows:

Cooling water, once passed through the cooling condensers, exits the plant through the Units 2 and 3 discharge flume where it becomes the Hot Canal. A lift station is located at the end of the Hot Canal adjacent to the cooling pond. The lift station raises of this hot water into the cooling pond. The water then circulates through the pond where it meets the Discharge spillway gates (adjacent to the lift station). Discharge is controlled by a adjusting the spillway gates. The pond discharge water then flows through the Cold Canal which runs parallel to the Hot Canal and is returned to a point near the Units 2 and 3 crib house intake. Gate structures in the return canal, intake canal, and river discharge canal are used to regulate the division of flow for recirculation and discharge to the Illinois River.

The Cold Canal and Hot Canal cooling system is used to provide supplemental cooling capacity to the cooling pond prior to water being discharged back to the Illinois River. The canal cooling tower systems are once-through systems and are comprised of two sub-systems: the Hot Canal cooling towers and the Cold Canal cooling tower.

During most periods the Units 2 and 3 cooling system operates closed cycle. Discharge to the Illinois River consists essentially of cooling pond blowdown that averages approximately 50,000 gpm. Blowdown is discharged for control of dissolved solids in the cooling pond. When DNS operates in a completely open-cycle mode, discharge from the Units 2 and 3 averages about 1,000,000 gpm.

6.4 Hydrothermal Analysis

From 2013 to 2014, a three-dimensional hydrothermal model was developed for the discharge from the DNS to the Illinois River (Appendix D). The model was executed for 32.2°C, 33.3°C, and 34.4°C (90°F, 92°F and 94°F, respectively) DNS discharge temperatures for two river flow scenarios. The modeling results indicate that a major portion of the Illinois River cross-section between the DNS discharge and the Dresden Island Lock and Dam maintains temperatures adequate to support biological communities under both typical summer and adverse river conditions (See Section 3.1.2 and Appendix B). In addition, these conditions are maintained at discharge temperatures above DNS's current 32.2°C (90°F) discharge permit condition. Additional details of the hydrothermal modeling and analyses are provided in Appendix D.

7.0 REFERENCES

Aquatic Nuisance Task Force. 1999. Illinois State Comprehensive Management Plan for Aquatic Nuisance Species. http://www.anstaskforce.gov/illinois_state_plan.htm. October.

Bertrand and Sallee. 1992. Results and analysis of fish monitoring by the Department of Conservation at seven locations on the Upper Illinois Waterway.

Burton, G.A. 1995. Upper Illinois Waterway Study Interim Report: 1994-1995 Sediment Contamination Assessment. Prepared for Commonwealth Edison Company. Prepared by The Institute for Environmental Quality, Wright State University, Dayton, OH.

Commonwealth Edison Company (ComEd). 1980. §316(a)-410(c) Demonstration for The Dresden Nuclear Generating Station. December.

Commonwealth Edison Company and the Upper Illinois Waterway Ecological Study Task Force (ComEd). 1996. Final Report. Aquatic Ecological Study of the Upper Illinois Waterway Volumes 1 and 2. Commonwealth Edison Company, Chicago, Illinois.

EA Engineering, Science, and Technology, Inc. (EA). 1995. The Upper Illinois Waterway Study. 1994 Ichthyoplankton Investigation, RM 276.2-321.7. Prepared for Commonwealth Edison Company, Chicago.

_____________. 2007. Entrainment Characterization Study, 2005 – 2007, Dresden Station. Prepared for Exelon Nuclear, Warrenville, IL.

Edmondson, U.T., G.W. Comita, and G.C. Anderson. 1962. Reproductive rates of copepods in nature and its relation to phytoplankton population. Ecology 43(4):625-634

Environmental Science & Technology, Inc. (ESE). 1994. The Upper Illinois Waterway Study. Interim Report. 1993 Benthic Macroinvertebrate Investigation and Habitat Assessment RM 272.0-323.0. Prepared for Commonwealth Edison Company, Chicago, IL.

Federal Register. 2014. Criteria for Determining Alternative Effluent Limitations Under Section 316(a) of the Act. Subpart H of 40 CFR 125.70-125.73. Docket No. EPA-HQ-OW-2008-0667-3164; 2040-AE95. August.

Hall, D.J. 1964. An experimental approach to the dynamics of a natural population of Daphnia *galeata mendotae*. Ecology 45(1): 94-112.

Illinois Pollution Control Board (IPCB). 1981. PCB Order 79-134 dated 9 July 1981.

Ohio Environmental Protection Agency (OEPA). 1987. Biological criteria for the protection of aquatic life: Vol. II. User's manual for biological field assessment of Ohio surface waters. Div. Water Quality Monitoring and Assess., Surface Water Sect. Columbus, OH.

______________. 1989. Biological criteria for the protection of aquatic life: Vol. III. Standardized field and laboratory methods for assessing fish and macroinvertebrate communities. Div. Water Quality Planning and Assess., Ecological Assess. Sect., Columbus, OH.

______________. 2006. Methods for Assessing Habitat in Flowing Waters: Using the Qualitative Habitat Evaluation Index (QHEI). Div. of Surface Water, Groveport, OH.

U.S. Environmental Protection Agency (USEPA) and Nuclear Regulatory Commission (NRC). 1977. *Interagency 316(a) Technical Guidance Manual and Guide for Thermal Effects Sections of Nuclear Facilities Environmental Impact Statements, Draft*. Office of Water Enforcement, U.S. Environmental Protection Agency, Washington, D.C. 1 May 1977.

U.S. Fish and Wildlife Service (USFWS). 2014. Illinois County Distribution: Federally Endangered, Threatened, and Candidate Species. http://www.fws.gov/midwest/endangered/lists/illinois-cty.html. December.

U.S. Geological Survey (USGS). 2000. Water Year 1999 Annual Report.

______________. 1999. Ecological Status and Trends of the Upper Mississippi River System 1998: A Report of the Long Term Resource Monitoring Program; USGS Survey, Upper Midwest Environmental Sciences Center, LTRMP 99-T001. La Crosse, Wisconsin. April

Wismer, D.A. and A.E. Christie. 1987. Temperature Relationships of Great Lakes Fishes: A data Compilation. Great Lakes Fish, Comm., Spec. Pub. 87-3. 165 pp. Great Lakes Fishery Commission, Ann Arbor, MI.

APPENDIX A

Description of the Des Plaines, Kankakee, and Illinois Rivers

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1.0 HYDRODYNAMICS AND HYDROLOGY

1.1 Hydrology

The Dresden Nuclear Station (DNS) is located just downstream of the confluence of the Des Plaines and Kankakee Rivers, where they merge to form the Illinois River (Figure A-1). The Illinois River Basin has a drainage area of 28,906 square miles and contains the following major sub-basins: Kankakee, Iroquois, Fox, Des Plaines, Chicago, Vermilion, Mackinaw, Spoon, Sangamon, and La Moine Rivers. The watershed drains portions of Illinois (24,778 sq. miles), Indiana (3,058 sq. miles), and Wisconsin (1,070 sq. miles) (Illinois State Water Survey 2003). From the headwaters to the confluence with the Mississippi River in Grafton, Illinois, the Illinois River drains 43 percent of the state of Illinois. Flows in the Des Plaines River are derived principally from three sources: discharge from Chicago area storm drains and wastewater treatment plants, flow diversion from Lake Michigan, and runoff from its 1,500 square mile drainage area. The Des Plaines and the Kankakee Rivers drain 2,111 and 5,165 square miles, respectively (Illinois State Water Survey 2003). The navigational river system from Chicago to the Mississippi River is collectively known as the Illinois Waterway.

The Illinois Waterway provides transportation for barge traffic from Lake Michigan in Chicago, Illinois to the Mississippi River at Grafton, Illinois. The Illinois Waterway flows 327 miles through eight navigational pools from Lake Michigan to the Mississippi River. Locks and dams are located at Lockport (mile 291.1), Brandon Road (mile 286.0), Dresden Island (mile 271.5), Marseilles (247.0), Starved Rock (mile 231.0), Peoria (mile 157.7), and LaGrange (mile 80.2) (ACOE 2012). The locks and dams, including the Dresden Island Lock and Dam, are operated by the U.S. Army Corps of Engineers (ACOE).

1.1.1 Riverine Flow

Since the late 1800s, the Illinois River has undergone extensive changes. In 1871, the flow of the Chicago River was reversed in order to divert sanitary wastes from the City of Chicago away from Lake Michigan to protect the drinking water source for the City. The polluted water of the Chicago River was directed through the Illinois and Michigan (I&M) Canal into the Des Plaines River and subsequently into the Illinois River. The Chicago Sanitary & Ship Canal (CSSC) was opened in 1900, adding several thousand cubic feet per second (cfs) of diverted Lake Michigan water. The new canal was cut into the channels of the South Branch of the Chicago River and I&M Canal through the Chicago Portage area. At that point, it becomes a separate third channel parallel to the Des Plaines River and the old I&M Canal. About 40 miles downstream, it enters the Des Plaines River between Lockport and Joliet (ComEd 1996).

In 1919, the State began constructing the Illinois Waterway, which created a new, larger channel through the Chicago River, CSSC, Des Plaines River, and Illinois River, shaping them into a continuous navigation route at least 9 feet deep and at least 300 feet wide from Lake Michigan to the Mississippi River. The waterway project required construction of seven major locks and a new set of higher dams. Three of these locks and dams were constructed in the vicinity of or upstream of DNS. There is a 22-foot-high dam at Dresden Island (Dresden Island Lock and Dam), approximately two miles downstream from the confluence of the Kankakee and Des Plaines Rivers, a 34-foot-high dam just south of Joliet at Brandon Road, and a 40-foot-high dam on the Des Plaines River just south of Lockport (ComEd 1996). Construction of these dams has resulted in a series of reservoirs, called “Pools”, that are maintained principally to facilitate barge traffic. Pool elevations are controlled, eliminating natural seasonal flushing events, and are manipulated frequently (ComEd 1996).

Mean annual flow of the Illinois River at Marseilles, Illinois, approximately 26.5 miles downstream of DNS was 10,820 cfs (ranging from 7,568 to 16,380 cfs) over the 1920 to 1999 time period. Flows tend to be highest in spring (March - May), when the Upper Illinois River Basin receives snowmelt and runoff from spring rains, and lowest during late summer and early fall (August - October) when precipitation in the region is lowest (USGS 2000).

The Dresden Island Lock and Dam forms Dresden Pool, which has a normal pool elevation of 505 feet above mean sea level (msl) that can vary from 503.0 to 506.5 feet above msl. The pool level below the Dresden Island Lock and Dam is 483.4 feet above msl (ComEd 1995a). Dresden Pool has natural, as opposed to armored, shoreline areas and a number of tributaries. The two upper pools at Lockport and Brandon have altered the Des Plaines River significantly over time and are mostly artificial, straight-dredged channels with nearly vertical sides, augmented by flow diverted from Lake Michigan. There are a wide variety of historical and present-day sources of pollutants to these pools. As a result, the water column and sediments have been contaminated by these sources along the river and its tributaries (ComEd 1996).

Extensive shallow areas with patches of rubble and aquatic vegetation characterize habitat of the Dresden Pool in the vicinity of DNS; fallen trees also provide cover in some areas. Silt substrates characterize the majority of the area; however, there are some areas with sand substrates. Much of the area is classified as lentic (i.e., standing water, such as a reservoir) due to the influence of Dresden Island Lock and Dam. The exception is the discharge canal from DNS, which is more lotic (i.e., flowing water, such as a stream) in nature and consists of a dredged canal with a swift current and riprapped substrates colonized with periphytic algae (ComEd 1993).

The Kankakee River Basin drains the largest part (27.6 percent or approximately 1,934,031 acres) of the Upper Illinois River Basin. The Kankakee River flows from its headwaters in northeast Indiana toward Illinois in a general northeast to southwest direction and turns northwest at its confluence with the Iroquois River, about 4.8 miles upstream of Kankakee, Illinois (USGS 1999). The mean annual flow of the Kankakee River near Wilmington, Illinois from 1934 to 1999 was 4,739 cfs (ranging from 1,965 to 8,153 cfs); seasonal flows parallel those of the Illinois River (USGS 2000). The Kankakee River flows 57 miles before joining the Des Plaines River to form the Illinois River near the Grundy and Will County line in Illinois.

The Des Plaines River originates just south of Union Grove, Wisconsin, and enters Illinois near Russell, Illinois. The river flows 157 miles and drains approximately 13.3 percent (931,978 acres) of the Upper Illinois River Basin. It flows north to south from Wisconsin into Lake and Cook Counties, Illinois, turns southwest at Lyons, Illinois, follows the CSSC, and joins the Kankakee River (USGS 1999). The mean annual flow of the Des Plaines River just above its confluence with the Kankakee River is approximately 6,080 cfs; seasonal flows parallel those of the Illinois River (USGS 1999, 2000). The Des Plaines River drainage area includes 430,720 acres that originally drained to Lake Michigan through the Chicago and Calumet Rivers. The

Des Plaines River is the primary drainage system for the greater Chicago/Cook County area (USGS 1999).

1.1.2 Groundwater

DNS is located within the Central Lowland Province that consists of glaciated lowland stretching from the Appalachian Plateau on the east to the Great Plains on the west. DNS is situated in a subdivision of this province called the Kankakee Plain, a level to gently undulating plain that occupies the position of a basin between areas of higher moraine to the east and west (AEC 1973). The site lies on the plain near the intersection of the Kankakee and Des Plaines Rivers. The geology in the vicinity of the site consists of topsoil comprised of black silt and some sand and clay (Battelle 1972). Below the topsoil are dense, cohesive glacial till soils consisting of sandy silts with clay and clay silts with sand. This glacial till extends to the top of bedrock at depths of 12 to 31 feet below ground surface. Underlying this glacial till are rocks known as Coal Measures that consist of interbeds of sandstone, clay, shale, and one or more seams of coal that are Pennsylvanian in age (AEC 1973).

Groundwater resources in the region are developed from four aquifer systems. These consist of the glacial drift aquifer (i.e., the alluvial aquifer), shallow dolomite aquifer located mainly in Silurian rock, Cambrian-Ordovician aquifer, and the Mt. Simon aquifer (AEC 1973). The alluvial aquifer is hydraulically connected to the DNS cooling pond, but is isolated from the Cambrian-Ordovician aquifer from which the plant withdraws water (AEC 1973). DNS has three groundwater wells. Two are installed to depths of approximately 1,500 feet below ground surface within the Cambrian-Ordovician aquifer (AEC 1973). The third well is installed to a depth of approximately 160 feet in the shallow dolomite aquifer. The Cambrian-Ordovician aquifer is used almost exclusively as the groundwater supply for municipal and industrial use in the area (Battelle 1972).

1.1.3 Direct Precipitation

The frequency and duration of air masses originating over Canada and the Arctic, the Pacific Ocean, and the Gulf of Mexico generally influence the regional climate. Lake Michigan also affects the climate of northeastern Illinois, producing cooler summers and warmer winters. The large thermal mass of Lake Michigan tends to create summer cloudiness and precipitation (Illinois State Water Survey 2003). Winter precipitation is enhanced by lake-effect snow. The region receives an average of 36.69 inches total precipitation annually, including about 30 inches of annual snowfall (USDA 1998).

1.2 Anthropogenic Freshwater Sources

The Illinois Department of Natural Resources (IDNR) notes that the State of Illinois owns the land and water rights at the Dresden Island Lock and Dam, that the IDNR administers the use of those lands and waters, and that it requires leases for occupancy of the land and use of the water for generation. Agreements between the State of Illinois and the United States recognize the ACOE as having sole jurisdiction and control of the waterway, structures, and waterpower rights (Chief of Engineers, United States Army, 1930).

The primary roles of the dam and lock system and the reservoir are to maintain water at an elevation acceptable for commercial navigation. The ACOE operates the lock and dam system in a run-of-river mode and the navigational pools provides no storage.

1.2.1 Wastewater Treatment Plant Discharges

DNS has an operable sewage treatment plant that provides primary and secondary treatment before it is discharged into the Kankakee River[1]. Sanitary wastewater treatment is provided by an activated sludge facility operating in the extended aeration mode. The system is composed of two independent treatment trains that receive raw sanitary waste from one of two available surge tanks. Each train consists of an extended aeration system, solids clarification tanks, gravity sand filter. Filtered effluent flows from the clear wells through a v-notch weir in the flow metering chamber, then through the UV disinfection unit after which the effluent is discharged to the Kankakee River. Flows are continuously monitored and recorded on a flow-totalizer. A portion of the solids digestion system has been taken out of service and the solids generated are currently being transported to an off-site, municipal sewage treatment facility permitted with the state. The sewage treatment system has a design to process an average flow of 50,000 gallons per day. During normal work periods, approximately 700 to 1,000 people are at the DNS on a daily basis. This normal operation period produces an average flow rate of 15,000 gallons per day. During the one month period when DNS performs its re-fueling outage, (typically in November) the number of people on site increases and the average flow rate approaches 50,000 gallons per day. The sewage treatment plant is licensed by the State of Illinois and is under the process oversight of two K-licensed sewage-treatment operator.

DNS also operates an industrial wastewater treatment system in addition to the sewage treatment system. This wastewater system is designed to remove solids and hydrocarbons from various inputs at the station including: Crib-house sump pits, transformer drainage areas, floor drains from some of the stations out-buildings and some building roof-drains. Some of the areas where hydrocarbons inputs are possible first pass through an oil/water separator system before entering the wastewater treatment system. The water inputs to the wastewater treatment system are first captured in a large equalization tank (surge tank) where a belt skimmer unit removes any additional floating hydrocarbons. This water is them pumped to a splitter box system where the chemical flocculent, alum (aluminum sulfate), is injected. At this point the water is processed through two independent treatment trains. Each train consists of a flocculation/clarifier tank where solids are separated from the waste stream. The effluent then passes through a gravity sand filters that discharges the filtered water to a clear well tank. This clear well tank then discharges the treated water to the stations Hot Canal where it then passes through the Cooling Pond and out to the Illinois River via the 2/3 Discharge Canal. The wastewater treatment plant is licensed by the State of Illinois and is under the process oversight of two K-licensed sewage-treatment operator.

1.2.2 Combined Sewer Overflows

There are no combined sewer overflows from DNS.

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[1] Dresden Station NPDES Permit no. IL0002224 with an effective date of 1 December 2011 and an expiration date of 30 November 2016.

2.0 GEOLOGY

DNS is located on rolling prairie along the south shore of the Illinois River, downstream of the confluence of the Des Plaines and Kankakee Rivers. The 953-acre site is situated near the intersection of Sections 25, 26, 35 and 36, Goose Lake Township (Section 34) North, Range 8 East, approximately 14 miles southwest of Joliet, Illinois. DNS is situated in a physiographic subdivision called the Kankakee Plain, which is a level to gently undulating plain that occupies the position of a basin between higher moraines to the east and west. Low ridges, terraces, bars, and dunes locally rise above the general level. Elevations in the immediate vicinity of DNS varies from 509 to 526 feet above sea level. The only significant topographic deviation in the area around DNS is a feature known as the Kankakee Bluffs, at 591 feet to 624 feet, located just northeast of DNS on the opposite shore of the Illinois River.

2.1 Bedrock Geology of Northeastern Illinois

The following description of bedrock geology was taken from the following environmental reports prepared in the licensing of DNS:

- Dresden Station Supplemental Environmental Report, Dresden Unit 3, USAEC License DPR-25, January, 1972.

- Final Environmental Statement related to operation of Dresden Nuclear Power Station Units 2 and 3, Commonwealth Edison Company, Docket Nos. 5-237 and 5-249, November, 1973.

The geologic column of the dry prairie vegetated site where DNS is situated is blanketed by a layer of topsoil (about 1 foot deep) composed of black silt and some sand and clay. The topsoil is generally underlain by an upper layer of Pennsylvanian Pottsville sandstone of variable thickness (40 to 50 feet), followed by a 15- to 35-foot layer of Ordovician Maquoketa Divine limestone based on a 65-foot layer of Maquoketa dolomite shale. The Ordovician system has a total thickness approaching 1,000 feet with the Cambrian system directly below.

The upper layer of bedrock varies across the region, being primarily Silurian or Ordovician age. The upper layer of the smaller portion, which includes the DNS site, is of Pennsylvanian age. The rocks of the Pennsylvania system belong to the “Coal Measures” or strata associated with beds of coal. They consist mainly of fine grained sandstone, clay, shale, and one or two seams of coal. The DNS cooling pond is situated on top of an old abandoned coal mine which was discovered during construction of the lake. These conditions were evaluated with respect to the safety aspects of plant operations.

The topsoil in the area of the site is typically one to two and one half feet thick, composed of black silt with some sand, clay, and organic material. Beneath the topsoil are dense, cohesive glacial till soils consisting of sandy silts with clay and clayey silts with sand. This glacial till extends to the top of bedrock, which ranges from 12 to 31 feet below the surface (Com Ed 1973).

Gray sandstone is exposed in the intake channel extending from the Kankakee River to Unit 1 and in the discharge channel extending to the Illinois River. The exposed sandstone in the intake channel displays prominent cross-bedding, in both large and small scale. The uppermost layers are nearly horizontal, while the underlying layers severely dip to the west, forming angles from approximately 5 to 20 degrees with the horizontal. Because of the varying degrees of cementation exhibited by the sandstone, some layers are more resistant to weathering than others. Weathered sections are discernible by a bluff or light brownish-gray color.

2.2 Pre-Glacial History

The landscape in the surrounding area of the DNS is largely the result of deposition and erosion during the Woodfordian Substage of the Wisconsinan Glacial Stage. The Woodfordian surface and deposits have been modified somewhat by further erosion and deposition during the Holocene Stage, after the last glaciers melted away. The Woodfordian glacier reached its maximum westward extent about 21,000 years B.P., when it reached beyond Hennepin in Putnam County to block the ancient Mississippi River from its ancestral course south of the "great bend" of the present-day Illinois River. After establishing the Mississippi in its modern course, the ice front melted back.

Water from rapid melting of the ice front eastward from near Lockport about 15,500 years B.P., combined with huge volumes of meltwater from several hundred miles of ice front in Michigan, Indiana, and Illinois, accumulated in the Kankakee Valley, creating what is referred to as the Kankakee Flood.

When the glacier that had deposited the Tinley Moraine began to melt back from that moraine about 14,500 years B.P., the proglacial Lake Chicago was formed between the melting ice front and the back slope of the moraine. As the ice margin continued to melt, the lake expanded northward. Lake Chicago drained by way of an outlet through the Valparaiso and Tinley Moraines southwest of the present site of Chicago. This outlet, the "Chicago Outlet," consisted of two channels (the Des Plaines and Sag Channels) that crossed the Tinley and Valparaiso moraines and converged near Sag Bridge to form a single channel, the Des Plaines Valley.

The Des Plaines River probably originated as a subglacial channel while the Lemont Drift was being deposited in the Chicago area, and it persisted as an outlet for meltwater while the Valparaiso and younger moraines formed. About 13,500 years B.P., the Woodfordian ice front melted back from Illinois into the Lake Michigan Basin, but the Chicago Outlet continued to drain basin meltwater.

2.3 Glacial History

Glacial scour during the Ice Age and filling by glacial melt water formed the Great Lakes Basin. During the Pleistocene, at least four great ice sheets are thought to have influenced the Great Lakes region. These glaciers occurred during the Nebraskan, Kansan, Illinoian, and Wisconsinan glacial ages. The slightly rolling topography in the Des Plaines River Valley is the result of advance and retreat of the Wisconsin Glacier some 10,000 to 14,000 years ago. The Des Plaines River bluffs typically rise 30 to 40 feet above the valley floor and consist of gravelly till deposited by glacial moraines (MWRD 1999).

The upper layer of bedrock varies across the area, being primarily of Silurian or Ordovician age, with a smaller portion being of Pennsylvanian age. Precambrian granitic rocks underlie the area at depths ranging from about 1,000 ft below land surface in the northern part of the basin to about 7,000 ft in the southeastern part. Ordovician-aged rocks (Maquoketa Shale) overlie the Cambrian rocks and are composed predominately of limestone and dolomite, but also include some sandstone and shale (MWRD 1999). The Dresden Island Lock and Dam lies on Ordovician-aged bedrock (Maquoketa shale) (ISGS 1996).

2.4 Erosion and Sedimentation

Erosion rates are measured by estimating soil loss in upland areas and measuring stream bank and stream bed erosion along drainages. In an investigation of the causes of bank erosion of the Illinois River, normal fluctuations of river stages proved to have a dominant impact on bank erosion, followed by seepage, waves, disturbances created by river traffic, local surface drainage, and the weathering of banks caused by freezing and thawing (Bhowmik 2014).

Sedimentation is the process by which eroded soil is deposited in stream channels, lakes, wetlands and floodplains. Erosion rate measurements can be estimated indirectly using evaluation of sediment transport rates based on in-stream sediment measurements and empirical equations. In natural systems that have achieved dynamic equilibrium, the rates of erosion and sedimentation are in balance over a long period of time. This results in a stable system, at least until disrupted by extreme events. However, in ecosystems where there are significant human activities such as farming, construction, and hydraulic modifications, the dynamic equilibrium is disturbed, resulting in increased rates of erosion in some areas and a corresponding increased rate of sedimentation in other areas (Leopold et al. 1992).

In 1980, the Illinois State Water Survey established the Illinois Benchmark Sediment Monitoring Network (BSMN) consisting of 50 monitoring stations throughout Illinois. Over a 25-year period, two stations located on the Kankakee River (one located at Momence and the other located near Wilmington, just upstream of where the Kankakee and Des Plaines Rivers form the Illinois River) showed statistically significant decreasing trends in both annual mean load and annual mean suspended sediment concentration (Demissie et al. 2004).

3.0 METEOROLOGY

This section provides a meteorological description of the site and its surrounding areas. DNS is located in rolling prairie terrain typical of much of Illinois. Lake Michigan is the only topographical feature which could have some effect on the local meteorology.

3.1 Air Temperature

The frequency and duration of air masses originating over Canada and the Arctic, the Pacific Ocean, and the Gulf of Mexico generally influence the regional climate. Lake Michigan also affects the climate of northeastern Illinois, producing cooler summers and warmer winters. Temperatures in the region range from 4.0°C (39.2°F) for the average daily minimum temperature, to 15.3°C (59.6°F) for the average daily maximum temperature (Illinois State Water Survey 2003).

3.2 Precipitation

The region receives an average of 36.69 inches total precipitation annually, including about 30 inches of annual snowfall (USDA 1998). During the summer the large thermal mass of Lake Michigan tends to create cloudiness and precipitation (Illinois State Water Survey 2003). A 24-hour maximum rainfall of 6.24 inches has been recorded. Thunderstorms occur an average of 49 days per year in the site region. On the average, hail storms occur about 2 days per year, and freezing rain occurs approximately 12 days per year.

Winter precipitation is enhanced by lake-effect snow (USDA 1998). The average annual snowfall since 1929 was 37.1 inches. The maximum snowfall from 1929 through mid-1967 was 66.4 inches, recorded in the winter of 1951-1952. The maximum radial thickness of ice expected in the site region is about 1 inch.

3.3 Relative Humidity

Average relative humidity observed in summer 2012 and 2013 at the Aurora Airport and Lewis University ranged from 64.3% in June to 71.1% in September (NOAA 2014). From the same sources and same periods, relative humidity measured at 0600-1200 hours averaged 62.6%, while at 1200-1800 hours relative humidity averaged 52.0% (NOAA 2014).

4.0 WATER QUALITY

The lower Des Plains River, Kankakee River, and Dresden Pool are on the State of Illinois list of impaired waters due to priority organics, metals, nutrients, and siltation. The lower Des Plaines River has been heavily impacted for nearly a century by channelization of the Des Plaines River, construction of the Dresden Island Lock and Dam in 1933, periodic dredging, stormwater runoff from expansion of upstream urban areas, and its use as a conduit for sanitary and industrial discharges from the greater Chicago metropolitan area within the Upper Illinois River Basin. Although water quality has improved in the Basin over the last 50 years because of advances in municipal and industrial waste treatment, segments of the lower Des Plaines River and Dresden Pool remain impaired (IEPA 2014). Research and management programs such as Total Maximum Daily Limits (TMDLs), Best Management Practices, Wetland Restoration, and Pesticide Management and Monitoring have been initiated to address point and nonpoint source pollution in the basin through the Upper Illinois River Basin National Water-Quality Assessment (NAWQA) (USGS 1998).

DNS Unit 1 produced power commercially from 1960 until it was shut down on 31 October 1978. Unit 1 currently is in long term safe storage. Units 2 and 3 started producing power in 1969 and 1970, respectively, and continue to operate. Since the National Pollutant Discharge Elimination System (NPDES) program took effect in 1972, DNS has held an NPDES permit.

The water quality of the DNS effluents is regulated through the National Pollutant Discharge Elimination System (NPDES). The Illinois Environmental Protection Agency (IEPA) is authorized to issue NPDES permits. The current permit (IL0002224) was issued 3 November 2011; in accordance with the 5-year renewal cycle is due to expire 30 November 2016. This permit specifies effluent limits for pH, total residual chlorine, oil, grease, biological oxygen demand, fecal coliform, total suspended solids, boron, temperature, and flow. DNS operates with cooling water flows through the Unit 2 and Unit 3 condensers and service water systems at a rate that varies from 688,000 gpm in the winter to 1,017,000 gpm during the summer. A silt dispersant and scale inhibitor are injected at the river intake. Additionally, biocide, silt dispersant, and a corrosion inhibitor are injected into the service water system. Sanitary waste from DNS is sent to the wastewater treatment system and the treated effluent is then discharged to the Illinois River. Water quality (water temperatures, dissolved oxygen, specific conductivity, and water transparency) data are recorded during the DNS aquatic monitoring program (May through September) at locations both above and below the DNS discharge in the Lower Des Plaines River, Kankakee River, Dresden Pool, and downstream of Dresden Island Lock and Dam (Appendix F; Appendix G).

4.1 Water Temperature

Thermal limits for DNS are based on Illinois environmental regulations and studies and demonstrations performed under §316(a) of the Clean Water Act, that were approved by the Illinois Pollution Control Board in 1981. (Cite PCB 79-134) In PCB 79-134, the Board approved alternative thermal limits (ATLs) for DNS pursuant to §316(a) and IPCB Rule 410(c), since recodified as 35 Ill. Admin. Code 304.141(c). In accordance with the Board's Order in PCB 79-134, the NPDES Permit sets thermal limits for much of the year based on the generally applicable thermal standards of 35 Ill. Admin. Code 302.211(d) and 302.211(e), and sets alternative thermal limits for the 15 June through 30 September time period, when the plant is allowed to operate in an indirect open cycle mode.

The Permit limits, which are based on generally applicable thermal standards restrict the Plant's thermal discharge from causing natural temperatures in the river to rise above 5° F, and from causing river temperatures to exceed 60° F and 90° F in the winter and summer, respectively, with an excursion allowance of 3° F above these maximum temperatures for 1% of the hours per calendar year. Compliance with these limits is measured at the edge of a mixing zone. The ATLs established under Section 316(a) restrict the temperature of Plant's discharge from 15 June through 30 September to 90° F, with an excursion allowance to exceed 90° F of up to 3° F for 10% of the hours available during that time period. Compliance with the ATL is measured at the end of pipe discharge point from DNS to the River.

During the DNS long-term aquatic monitoring program (1991-2014), June through September water temperatures ranged from 15.8° to 35.0°C (60.4 to 95.0°F) with the warmest temperatures in the DNS discharge canal and the coolest temperatures at locations either in the lower Des Plaines or Kankakee River upstream of the discharge. Warmer water temperatures generally occurred in July or August and the coolest in late September. Mean temperatures have been less than 30.6°C (87.1°F) with all locations outside the discharge canal being 0.3° to 7.5°C (0.5 to 13.5°F) cooler.

4.2 Dissolved Oxygen

Dissolved oxygen (DO) is a critical water quality parameter; its concentration and presence or absence has a dramatic impact on the distribution and abundance of fish and aquatic life in both the Kankakee River and Des Plaines River. DO in the water is essential for healthy waterways. Aquatic plants consume oxygen at night even in healthy waters, so oxygen levels in the water can change naturally. Severe depletion of oxygen, however, is usually due to human activities that increase the amount of plant parts, chemicals or animal and human waste in the water. Prolonged periods of low DO are harmful to most aquatic life and can cause fish kills and large dead zones (areas that can't support aquatic life). Low DO and decay can cause foul smells and make waterfront properties and recreation unattractive. When excess organic matter enters the water and decays, it depletes the oxygen below levels that fish and other aquatic life forms need to survive. Some types of chemical pollutants also decrease oxygen in water and have similar effects. Runoff of chemical and manure-based fertilizer applied to lawns and croplands, septic or untreated sewage overflow, animal wastes from livestock farming and pets, and industrial waste such as discharges from pulp and paper mills can cause low oxygen. Reservoirs and activities that involve straightening streams can also cause oxygen-poor waters because they mix the air and water less than normal stream flow and decrease aeration. Prolonged high temperatures can also decrease oxygen since warm water cannot hold as much oxygen as cold water. Data describing the presence, spatial distribution, and temporal variability of dissolved oxygen were collected from streams in the upper Illinois River Basin from 1987-90 as part of the USGS's NAWQA program. Median DO concentrations ranged from 3.4 to 12.2 milligrams per liter at eight long-term monitoring stations in the basin. During low-flow conditions, DO concentrations at 59 percent of the sites in the agricultural Kankakee River Basin and 49 percent of the sites in the urban Des Plaines River Basin were less than the Illinois water-quality standard of 5.0 milligrams per liter. Upward trends in dissolved oxygen concentrations were indicated at the two most downstream stations in the upper Illinois River Basin (USGS 1995).

Based on data from IEPA's ambient monitoring station on the Des Plaines River at Joliet, Illinois, upstream of DNS, March 2006 through December 2011 DO concentrations ranged from 0.45 mg/L to 11.66 mg/L (IEPA 2015). DO concentrations averaged 7.46 mg/L over the available data record.

DO concentrations from June through September during the DNS long-term monitoring program ranged from 2.8 to 17.5 parts per million (ppm) and averaged 7.5 to 10.6 ppm, depending on location. Mean DO was generally higher in the Kankakee River with similar values at all other locations within the Dresden Pool (means = 7.5 to 8.8 ppm). DO concentrations in the discharge canal and thermally-influenced locations in Dresden Pool averaged 0.5 to 1.4 ppm lower than outside that influence of the discharge. However, DO concentrations were consistently above the General Use minimum standards for the Upper Illinois Waterway (UIW) of 5.0 ppm, at all times from March through July, and 3.5 ppm from August through February.. Concentrations below 5.0 ppm have occurred in the Des Plaines and Kankakee Rivers upstream of the DNS discharge.

DNS operations have not been shown to impact dissolved oxygen levels in the upper Illinois River Basin.

4.3 **Fecal Coliform**

Disease-causing bacteria and other microbes (viruses and protozoa) are called pathogens, and they usually come from human or animal waste. They are the most commonly reported cause of water pollution nationwide, with over 10,300 waters identified. These microbes enter US waterways from both man-made and natural sources, and can affect human and animal health as well as several beneficial uses. They reach the water directly in urban and suburban areas from wastewater treatment plants, sewer overflows, and failing sewer lines; slaughterhouses and meat processing facilities; tanning, textile, and pulp and paper factories; fish and shellfish processing facilities; sewage dumped overboard from recreational boats; and pet waste, litter and garbage. Rural sources include livestock manure from barnyards, pastures, rangelands, feedlots, unfenced farm animals in streams, improper manure or sewage land application, poorly maintained manure storage, and wildlife sources such as geese, beaver and deer. The amount of bacteria and other microbes present, and thus the health risks they represent, can change rapidly due to factors such as rainfall and runoff from the sources mentioned above. Serious but rarely life-threatening illnesses are caused mainly by swallowing pathogen-contaminated water during swimming or other recreation, but can also come from skin contact with the water or eating contaminated fish or shellfish. Livestock, pet, and wildlife illnesses can also occur. Besides causing illnesses, pathogens in waterways can cause significant economic losses due to beach closures, swimming and boating bans, and closures of shellfish harvest beds. When present in raw drinking water sources, they can be treated but require advanced and expensive methods to disinfect and filter the water supply.

DNS operations have not been shown to impact the levels of fecal coliform found in the upper Illinois River Basin.

4.4 **Mercury**

Mercury is found in many minerals, including coal. Released into the air by coal-fired power plants, it settles on land and is washed into waterways. Spills and improper treatment and disposal of mercury-containing products or wastes are among other top sources of mercury in water. Mercury can build up in fish, which then poses health risks to people and animals that eat fish. Mercury, a metal that is found in air, water and soil, is known to most people for its use in products like thermometers, switches, and some light bulbs. Mercury ranks among the top ten national causes of water pollution, with over 4,300 waters reported. Many of these reported waters are in northern states where special studies have detected large numbers of mercury-polluted lakes, including many in remote areas. As a water pollutant, mercury can build up in fish tissue, be dissolved in the water, or be deposited in bottom sediments. Mercury is found in many rocks, including coal. When coal is burned, mercury is released into the environment. Coal-burning power plants account for over half of all US man-made mercury emissions, but mercury in the air also involves worldwide sources. Burning hazardous wastes, producing chlorine, breaking mercury products, and spilling mercury, as well as improper treatment and disposal, can also release it into the environment. Mercury in the air eventually settles into water or onto land where it can be washed into water. Once deposited, certain microbes can change it into a highly toxic form that builds up in fish, shellfish and animals that eat fish. The most common way people can be exposed to mercury is by eating fish or shellfish that are contaminated with mercury. Eating fish from mercury-polluted waters should be avoided, especially by children and nursing or pregnant women. Eating mercury-contaminated fish or shellfish can affect the human nervous system and harm the brain, heart, kidneys, lungs, and immune system.

DNS operations have not been shown to impact the levels of mercury found in the upper Illinois River Basin.

4.5 Nutrients

Descriptions of nutrients, including total nitrogen, total phosphorus and ammonia loads in the Illinois River Basin were described by Sullivan (2000). Below is an excerpt from his study:

"The probable sources of nutrients to streams in upper Illinois River Basin were described by Terrio (1995). Data compiled from the early 1980's indicated that about 54 percent of the total nutrient load in upper Illinois River Basin streams was attributed to nonpoint sources and about 46 percent from point sources (Gianessi 1986). Most domestic and industrial wastewaters have much higher concentrations of ammonia, nitrate, and phosphorus than stream water does; thus, the approximately 196 wastewater-treatment plants in the study area (USEPA 1997) are a major influence on study-area streams. Zogorski and others (1990) estimated that about 2,810 cfs of effluent is discharged into streams in the upper Illinois River Basin by these facilities. Of this amount, about 75 percent (2,100 cfs) comes from the three largest treatment plants—Northside, Stickney, and Calumet—which discharge to the North Shore Channel, the CSSC, and the Little Calumet River, respectively. Urban nonpoint sources can cause elevated nutrient concentrations in urban-area streams. About 17 percent of the Illinois River Basin was urbanized as of 1990 (Arnold et al. 1999). According to estimates by Terrio (1995), total urban runoff contributes about 17 percent as much phosphorus to streams in the study area as agriculture, and only about 1.5 percent as much total nitrogen."

4.5.1 Total Nitrogen

Nitrogen in surface water may be present in various organic and inorganic forms. As a result, the estimation of total nitrogen content may be based on direct analytical determination, or the combined sum of individual forms such as organic nitrogen, ammonia, nitrite, and nitrate. Nitrogen is an important plant nutrient and has been used in agricultural fertilizers to stimulate the production of agricultural crops, especially corn. Runoff from areas with intensive cultivation or large livestock densities is an important source of nitrogen. In addition, certain industrial discharges and municipal wastewater effluents may contain high concentrations of inorganic nitrogen, especially ammonia or nitrate nitrogen. In oxygenated surface waters, including the Kankakee and Des Plaines Rivers, the dominant form of nitrogen is normally nitrate. As a result, total nitrogen concentrations closely follow the patterns and trends exhibited by nitrate nitrogen.

Based on data from IEPA's ambient monitoring station on the Des Plaines River at Joliet, Illinois, upstream of DNS, May 2006 through December 2010 total Kjeldahl nitrogen (TKN) concentrations ranged from 0.53 mg/L to 1.61 mg/L (IEPA 2015). TKN concentrations averaged 1.01 mg/L over the available data record.

DNS operations have not been shown to impact the levels of total nitrogen found in the upper

Illinois River Basin.

4.5.2 Total Phosphorus

Phosphorus is an essential plant nutrient and is normally the major element affecting eutrophication in freshwater systems. Like nitrogen, phosphorus can be measured in several forms, but total phosphorus, representing the sum of all those forms, is most commonly measured and reported in water quality surveys. The USEPA has previously suggested a total phosphorus concentration of 0.1 mg/L as a general guidance for protection of flowing waters from eutrophication (Mackenthun 1973). Total phosphorus concentrations were high throughout the entire UIW (USGS 2004), with values greater than the USEPA goal of 0.1 mg/L that was established to prevent excessive growth of algae. In general, wastewater treatment plant discharges and urban and agricultural nonpoint source inputs are major sources of phosphorus. In particular, agricultural watersheds contributing high concentrations of sediment are especially important because phosphorus is commonly bound to sediment particles.

Nitrogen and phosphorus (also called nutrients) are natural elements in the environment that are essential for plant and animal growth in normal amounts but are harmful in excess. Most nutrient pollution comes from runoff or discharges from fertilizing lawns and croplands, municipal waste treatment systems, and animal wastes from livestock farming. Excess nitrogen or phosphorus can cause too much aquatic plant growth and algae blooms, sometimes choking off waterways and causing toxic or oxygen-poor conditions that can kill fish and other aquatic life. Nitrogen and phosphorus pollution can be harmful to human health if the affected waterway is used for swimming or drinking water. These pollutants can also harm local economies through increased drinking water treatment costs, poor fish and shellfish harvests, less income from reduced recreational tourism, and potentially reduced property values on polluted waterways.

Based on data from IEPA’s ambient monitoring station on the Des Plaines River at Joliet, Illinois, upstream of DNS, March 2006 through December 2011 total phosphorus concentrations ranged from 0.26 mg/L to 2.13 mg/L (IEPA 2015). Total phosphorus concentrations averaged 0.81 mg/L over the available data record.

Recently, the USEPA has been requiring the States to establish TMDL’s for its surface waters. Illinois is beginning to look at this issue and has recently suggested that DNS has a significant loading to the Illinois River. If TMDL’s for nutrients are established for the Illinois River (whole or in part) and phosphorus is determined to be in excess, then all contributors will be required to reduce their individual loading by a specific amount.

DNS operations have not been shown to impact the levels of phosphorus in the upper Illinois River Basin.

4.5.3 Ammonia

Ammonia occurs naturally and is used in small amounts by plants for growth, but too much of it becomes poisonous to aquatic life especially in higher water temperatures and pH. Ammonia is a common cause of fish kills and can harm people’s health after it is converted to nitrate by bacteria in the water. Also, excess ammonia can cause heavy growth of harmful algae, which can cause illness in humans if swallowed during recreational activities such as swimming. Too much ammonia can also cause oxygen-poor waters, since DO in water is used up by bacteria and other microbes in converting ammonia into their food. Common man-made sources of ammonia pollution include fertilizer production and use, manure application to farmland, septic seepage, concentrated animal feeding operations, untreated sewage overflow, and animal and industrial waste. Around 400 waters have been reported as polluted by ammonia. However, ammonia pollution also plays a big role in nitrogen and phosphorus pollution, which is currently the third highest reported cause of water pollution in the US affecting over 6,000 waterways.

Based on data from IEPA's ambient monitoring station on the Des Plaines River at Joliet, Illinois, Upstream of DNS, Ammonia-nitrogen concentrations ranged from 0.15 mg/L in April 2011 to 0.61 mg/L in May 2011 (IEPA 2015). Ammonia-nitrogen concentrations averaged 0.38 mg/L over the available data record.

DNS operations have not been shown to impact the levels of ammonia found in the upper Illinois River Basin.

4.6 Polychlorinated Biphenyls (PCBs)

PCBs are a toxic mixture of chlorinated chemicals that were banned in the late 1970s but are still a common pollutant because they build up in fish flesh and are long-lasting in the bottom sediments of rivers and lakes. PCBs have reached waterways worldwide by direct dumping, leakage from landfills not designed to handle hazardous waste, and through the air after burning PCB-containing waste. PCBs have been shown to cause cancer in animals. Studies have also provided evidence of potential cancer-causing effects in humans. Non-cancer health effects on the immune system, reproductive system, and nervous system in animals have been documented. PCBs are also related to deformities in birds and heart effects in young fish. PCB risks to human health occur when PCBs build up through eating PCB-contaminated fish and other sources. Other negative effects on people include recreational and commercial fishing bans at numerous PCB-contaminated lakes and rivers and the related economic impacts over the past 30 years.

DNS operations have not been shown to impact the levels of PCBs found in the upper Illinois River Basin.

4.7 Silver

Metals such as silver occur in nature, although the amount occurring naturally varies according to local geology. The common metals occurring in water are arsenic, cadmium, chromium, copper, lead, nickel, selenium, zinc, and mercury, but EPA tracks mercury separately. Metals in waterways can come from human activities (industrial processes, mining, and rainwater runoff from urban areas) and natural processes (mainly erosion of soil and rocks) resulting in the release of metals into air, water, and soil. Disturbed soils in metals-enriched areas can wash into streams during storms. Metals in the air from industrial emissions can be deposited onto waters or land surfaces. All metals can be toxic to aquatic animals and humans at sufficiently high exposure levels. Human health problems from high exposure, such as drinking contaminated water over a prolonged period, can include damage to organs. Excess metals at toxic concentrations can affect the survival, reproduction, and behavior of aquatic animals and can result in fish kills. Additionally, toxic levels of metals can decrease a waterway's suitability for industrial and household water uses. Metals can be removed from water destined for human use, but treatment can be expensive.

Based on data from IEPA's ambient monitoring station on the Des Plaines River at Joliet, Illinois, upstream of DNS, total silver concentrations from March 2006 through December 2011 ranged from 0.43 ug/L to 7.87 ug/L record (IEPA 2015). Total silver concentrations averaged 2.1 ug/L over the available data record. Dissolved silver concentrations from March 2006 through December 2011 ranged from 0.4 ug/L to 7.41 ug/L and averaged 1.7 ug/L over the available data record (IEPA 2015).

DNS operations have not been shown to impact the levels of silver found in the upper Illinois River Basin.

4.8 **pH**

The health and survival of aquatic plants and animals depends heavily on pH, which is a measurement of how acidic or basic the water is. Most aquatic plants and animals under extreme pH conditions have reduced ability to grow, reproduce, and survive. Low pH can cause toxic metals such as aluminum and copper to dissolve into the water from bottom sediments. High pH can increase the toxic form of ammonia, which can further harm fish and other aquatic life. Natural sources that influence acidity in waterways are the surrounding rock and soils, and processes such as decay of plants. Human activities that can result in acidity include agriculture (animal feedlots), urbanization and industry (emissions from vehicles and coal-fired power plants leading to acid rain and ocean acidification), and mining (acid mine drainage). Although human activities commonly result in more acidic conditions, high alkaline conditions can occur by means of stormwater runoff from sources associated with agriculture (lime-rich fertilizers) and urbanization (asphalt roads), wastewater discharges and leakage from sources associated with industry (e.g., soap manufacturing plants), and mining (oil and gas brine mining wastes). Around 4,000 waters have been reported as polluted by pH problems, making this the 8^{th} most common reporting category.

Based on data from IEPA's ambient monitoring station on the Des Plaines River at Joliet, Illinois, upstream of DNS, pH concentrations from March 2006 through December 2011 ranged from 6.98 to 7.74 and averaged 7.41 over the available data record (IEPA 2015).

DNS operations have not been shown to impact pH levels found in the upper Illinois River Basin.

4.9 **Organic Carbon**

Organic carbon is not a cause of impairment for the Des Plaines River. Based on data from IEPA's ambient monitoring station on the Des Plaines River at Joliet, Illinois, upstream of DNS, total organic carbon (TOC) concentrations from March 2006 through December 2010 ranged from 4.1 mg/L to 8.32 mg/L (IEPA 2015). Total organic carbon concentrations averaged 5.43 mg/L over the available data record (IEPA 2015).

DNS operations have not been shown to impact organic carbon levels found in the upper Illinois River Basin.

4.10 Specific Conductance

Specific conductance from June through September during this long-term monitoring program ranged from 400 to 1,665 µS/cm with mean readings of 603 to 998 µS/cm, depending on location, season, and/or river flow conditions. For sampling periods combined, mean conductivity readings were consistently greater than 700 µS/cm in all study areas including the mouth of the lower Des Plaines River and at the mouth of the Kankakee River upstream of DNS as well as downstream of the discharge canal in Dresden Pool and downstream of Dresden Island Lock and Dam.

DNS operations have not been shown to impact specific conductance levels found in the upper Illinois River Basin.

4.11 Water Transparency

Based on data from IEPA's ambient monitoring station on the Des Plaines River at Joliet, Illinois, Upstream of DNS, turbidity concentrations from March 2006 through December 2011 ranged from 7 NTU to 80 NTU and averaged 22.77 NTU over the available data record (IEPA 2015). Total Suspended Solids (TSS) concentrations from February 2009 through December 2010 ranged from 4 mg/L to 101 mg/L and averaged 24.57 mg/L over nearly 2 years in the available data record (IEPA 2015).

Water transparency based on Secchi disk readings from June through September during the DNS long-term monitoring program (Appendix E) ranged from 3 to 151 cm with mean readings of 40 to 110 cm. Operation of DNS had little effect on transparency as mean readings at the thermally-influenced locations (65 cm, range = 41-89 cm) were similar to those at the other locations (62 cm, range = 40 to 110).

DNS operations have not been shown to impact water transparency or TSS levels found in the upper Illinois River Basin.

5.0 HUMAN USE

DNS is located in Goose Lake Township, Grundy County, Illinois, on the south shoreline of the Illinois River at the confluence of the Des Plaines and Kankakee Rivers (immediately below the junction of the Kankakee and Des Plaines Rivers at river mile 272.4). The DNS site consists of approximately 2,500 acres owned by Exelon with an additional 17 acres of river frontage leased from the State of Illinois. In addition to the two nuclear reactors and their turbine building, intake and discharge canals, cooling pond and canals, and auxiliary buildings, the site includes switchyards and DNS Unit 1 (retired 31 August 1984) (ComEd 1995a).

Approximately one-half of the cooling pond is in Wilmington Township, Will County, and the other half is in Goose Lake Township, Grundy County, Illinois.

No major metropolitan areas occur within six miles of DNS. The nearest town is Channahon, approximately three miles northeast of DNS. The site is approximately eight miles east of Morris, Illinois, 15 miles southwest of Joliet, Illinois, and 50 miles southwest of downtown Chicago. The area within six miles of the site includes parts of both Grundy and Will Counties.

The setting around DNS is largely rural, characterized by farm land, woods, and small residential communities. The Goose Lake Prairie State Natural Area is located approximately one-mile southwest of the DNS turbine building. This 2,537-acre preserve contains the largest remnant of prairie left in Illinois and includes open grasslands and prairie marshes (IDNR 2002). Directly across the Kankakee River from DNS is the Des Plaines Fish and Wildlife Area. This 500-acre park offers a variety of recreational facilities, including the largest pheasant hunting facility in the state (IDNR undated). To the east of the Des Plaines Fish and Wildlife Area is the Midewin National Tallgrass Prairie, a 16,000-acre site, formerly the Joliet Army Ammunition Plant. This area was transferred to the U.S. Forest Service in 1997 and will be managed to restore, maintain, and enhance the prairie ecosystem (USDA 2001).

Industrial sites located near DNS include the General Electric Morris Operation and Midwest Generation's closed Collins Station (GE Nuclear Energy 2000). Approximately five miles southwest of DNS is Heidecke Lake that served as the cooling pond for the Collins Station, and the Goose Lake Prairie Natural Area which provides fishing and hunting opportunities (ComEd 1995b).

5.1 Surrounding Land Use

DNS surrounding land usage categories and rates are agricultural (57.8 percent), forest and grassland (7.8 percent), undeveloped (2.1 percent), urban/built-up (19.7 percent), conservation open space (5.4 percent), mineral extraction (0.4 percent), water (2.3 percent), wetlands (2.6 percent), and parks (1.9 percent) (Shay 2001).

5.2 Recreational Uses

Recreational use of the Des Plaines and Illinois Rivers near DNS is primarily confined to pleasure boating, much of this by boats in transit along the waterway. Several marinas are located just upstream of the Des Plaines River and also in a channelized residential area upstream and across the Kankakee River from DNS which have mooring provisions for approximately 150 and 100 boats, respectively.

There are private recreational facilities such as gun clubs and picnic grounds scattered throughout the strip-mined areas south of DNS. A small unnamed public park is located 1.5 miles east of DNS on the Des Plaines River. Public access is available to the Dresden Island Lock and Dam, and a public path parallels the I&M Canal which is 0.7 miles north of DNS at its closest point.

In the immediate area swimming is permitted in the Kankakee River along the Kankakee State Park campgrounds and at a few sites upstream of the city of Wilmington, where there is also a Community Swimming Club. This club has provisions for docking small pleasure boats and a river shore picnic area.

Some of the pothole ponds and lakes located to the south of DNS are used for boating, water skiing, and some skin diving. Most of the lakes are owned by private clubs that require an annual membership fee. One of these, the Braidwood Recreation Club, located approximately 10 miles south of DNS has a modern bathhouse and large beach (Exelon 2002).

The Des Plaines and Illinois Rivers in the vicinity of DNS do not support sport fishing. However, the non-navigable Kankakee River, located adjacent to the plant, is used for recreational fishing. The sport fish in this river system include redear sunfish, warmouth, smallmouth bass, White bass, Channel catfish, bullheads, Freshwater drum, crappies, Bluegills, and common carp which are taken by hook-and-line anglers in the upper reaches of the Kankakee River system (Exelon 2002).

5.3 Shipping

Major rivers within 5 miles of DNS are the Illinois, Des Plaines, and Kankakee Rivers. The Kankakee River joins the Des Plaines River east of the plant to form the Illinois River, which extends along the north boundary of the site. The closest navigational channel is on the Illinois River, located approximately 0.5 miles north of the plant.

The closest river lock is the Dresden Island Lock and Dam, approximately one mile northwest of the plant. Construction was completed in 1932. The river traffic passing by the site consists mainly of cargo barges. The commodities that passed through the Dresden Island Lock over a period of 6 years consisted mainly of coal, petroleum, steel, sludge, and agricultural products (ACOE 2012).

5.4 Commercial and Industrial Use

In addition to commercial use of the Dresden Island Lock and Dam other commercial industrial users within five miles of DNS include Reichhold Chemical Company, Van Den Bergh Foods, Enron Liquids Pipeline, Inc., and Exxon-Mobil Oil Company.

The nearest boundary of the former Joliet Ammunition Plant is approximately two miles east of DNS. The area has been redeveloped including two industrial parks, the Will County Landfill, the Abraham Lincoln National Cemetery and the Midewin National Tallgrass Prairie. The government retained a portion as the Joliet Army Training Area.

Major highways within 5 miles of the plant are Interstate 55, 4 miles east of the plant, and U.S. Route 6, 1.9 miles north of the plant. The nearest secondary road is Collins (or Goose Lake) Road, approximately 0.5 miles south of the plant. The heaviest traffic is on Interstate 55. Collins Road has only light traffic.

There are four railroads within 5 miles of DNS. The Elgin, Joliet, and Eastern (EJ&E) Railroad is approximately 1.5 miles west of DNS and provides spur access to the plant. The AT&SF and the Chicago, Missouri, and Western (Amtrak) Railroads are approximately 3.9 miles southeast of the plant. The track used by the Iowa and Chessie Railroads is 3.7 miles northwest of the plant. A short EJ&E track approximately 2.5 miles northwest of the plant connects this track to the main EJ&E track.

5.5 Contaminants

Land use practices, floods, other natural events, spills, and other human caused incidents within the watershed affect contaminant levels in river water and sediments. These, in turn, affect quality and quantity of fish and wildlife habitat. Water quality of the UIW has improved in recent decades in terms of wastewater pollution, but the river still receives a wide array of agricultural, industrial, and urban contaminants.

As part the Dresden Island Hydroelectric Project (FERC No. 12626) license application process, Northern Illinois Hydropower, LLC conducted sediment analysis in 2008 in four locations within Dresden Pool and in two locations downstream of Dresden Island Lock and Dam. The survey detected several metals in concentrations exceeding IEPA's Tiered Approach to Corrective Action Objectives Tier 1 Soil Remediation Objectives standards in the impoundment during the survey. Sediment analysis detected arsenic at 26.2 mg/kg, chromium at 478 mg/kg, lead at 482 mg/kg, and mercury at 0.83 mg/kg. Downstream of the dam, mercury was detected at 0.15 mg/kg. PCBs and pesticides were not detected either upstream or downstream of the Dam (Patrick Engineering 2008).

5.5.1 Organic Contaminants—Types, Sources, and Risks

The Illinois River receives a variety of organic wastes, some of which are detrimental to human health and aquatic organisms. Urban areas, farms, factories, and individual households all contribute to contamination of the UIW by organic compounds.

The most significant factors controlling the concentrations of organic contaminants in rivers are the physical processes of dispersion and dilution. Within this physical framework, the most significant chemical and biological processes controlling the fate of organic contaminants in the Des Plaines, Kankakee, and Illinois Rivers are (1) sorption to the sediment and removal by deposition, (2) desorption and diffusion of contaminants from bed sediments back into the water, (3) biological transformation to intermediate compounds, or biodegradation for complete removal, (4) volatilization to the atmosphere, (5) bioconcentration and magnification in the food chain, (6) photolysis, or the breakdown of contaminants under the influence of sunlight, and (7) hydrolysis, or the decomposition of contaminants by taking up the elements of water.

Hydrophobic organic compounds are adsorbed onto sediments in concentrations that are a thousand to a million times greater than are dissolved in water. Once they are adsorbed, the contaminants can be deposited in the bottom sediments. Accumulated contaminants can be remobilized by re-suspension of sediments. Likewise, sedimentary organic matter may decompose, reintroducing its adsorbed contaminants to the water column by desorption and diffusion of organic colloids. If the contaminants are adsorbed onto the sediments in high concentrations, they can adversely affect bottom-dwelling organisms. The tendency of a contaminant to adsorb onto the sediment is frequently indicative of its capacity to bioaccumulate and become magnified in the food chain.

Historical water quality data from the Des Plaines River show a trend of improving water quality for several constituents that can be related to changes made by the chemical manufacturing industry to address the environmental fate of problematic chemicals and improved wastewater treatment by municipal and industrial dischargers. Converting primary treatment facilities to secondary treatment has resulted in improved water quality, although chemicals that are not completely removed present a challenge for treatment technology (Meade et al. 1995).

5.5.2 Heavy Metals Contaminants

As discussed in Section 4.7, concentrations of metals that occur naturally vary according to local geology. The common metals occurring in water are arsenic, cadmium, chromium, copper, lead, nickel, selenium, zinc, and mercury. Nationally, metals are the fifth most reported cause of waterbody pollution. Typical sources of heavy metals released to the Des Plaines River over time include municipal wastewater-treatment plants, manufacturing industries, mining, and agricultural activities. Heavy metals are transported as either dissolved species in water or as an integral part of suspended sediments, and may be volatilized to the atmosphere or stored in riverbed sediments. Toxic heavy metals are taken up by organisms with the metals dissolved in water having the greatest potential of causing the most deleterious effects.

The Des Plaines River is listed as an impaired water body by the USEPA. This information is maintained and routinely updated in the USEPA's Watershed Assessment, Tracking and Environmental Report. Two causes of impairment for the Des Plaines River are mercury (see Section 4.2.3) and silver (see Section 4.2.6).

5.6 Other Stressors

During 1999-2001, water quality in upper Illinois River Basin streams and rivers largely reflected the amount of agricultural or urban land in their basins (USGS 2004). Since the mid-1850s, channel and drainage modifications, urban development in the Chicago area, agricultural runoff, and other activities have altered water quality, biological communities, and habitat for aquatic organisms. Concentrations of chemicals in basin surface waters occasionally exceeded guidelines for the protection of aquatic life and drinking water, such as for nitrate, phosphorus, diazinon, and organic wastewater compounds. Concentrations in the Des Plaines and Kankakee Rivers were least likely to exceed standards and guidelines. Although area streams and rivers generally are not used as drinking water sources, elevated concentrations can affect aquatic wildlife and the quality of water for downstream Illinois River water users (USGS 2004).

5.6.1 Contaminant Concentrations in Surface Waters

Land use practices, floods, other natural events, spills, and other human caused incidents within the watershed affect contaminant levels in river water and sediments. Agricultural fields, animal feedlots, and urban areas are principle sources for plant nutrients that enter the river (Soballe and Wiener 1999). Excessive inputs of nitrogen and phosphorus can cause algal blooms, contribute to excessive plant growth and subsequent decomposition that depletes DO (limiting fish and other aquatic life distribution and survival), and cause public health concerns. Plant decomposition in the sediment can also be a source of ammonia that adversely affects burrowing organisms such as fingernail clams and mayflies (Groschen et al. 2004).

Water quality conditions summarized for the upper Illinois River basin show that major influences on streams and aquatic biology include (1) application of pesticides and fertilizers in urban and agricultural areas, (2) discharges from wastewater treatment facilities, (3) runoff from urban and agricultural areas, (4) stream modifications and artificial drainage, and (5) destruction of riparian cover along stream banks (USGS 2004). The USGS report describes how ammonia concentrations at the CSSC at Romeoville were the highest measured in the upper Illinois River Basin and the fourth highest of 109 streams and rivers measured nationwide. In every stream water sample collected from urban or mixed land use watersheds, phosphorus concentrations exceeded the USEPA desired goal to prevent excessive growth of algae and other nuisance plants (0.10 mg/l). Nitrate concentrations of 12.3 mg/l in the agricultural stream sites near Sugar Creek at Milford and the Iroquois River near Chebanse were the highest among 109 streams during the 1999-2001 sampling period. Natural features (including glacial geology, soils, and hydrology) and land management practices (including artificial drainage) affect nutrients in streams, as indicated by nitrogen in runoff at the Iroquois River near Chebanse and the Kankakee River near Momence, Illinois. The insecticide diazinon was detected frequently in streams and rivers in urban and mixed land use areas. Eighteen percent of the samples collected exceeded the guideline for the protection of aquatic life. Benthic invertebrates that are sensitive to pollution and habitat disturbance such as mayflies, stoneflies and caddisflies, were most common in streams whose watersheds are less than 4% urban land. Aquatic communities were found degraded where urban areas cover as little as 25% of the watershed. Herbicides were detected frequently in streams and rivers, particularly those draining agricultural land.

5.6.2 Contaminant Concentrations in Sediments

The Des Plaines River transports moderate to high quantities of sediments that enter the river from row crop farming, mining, and urban development that reflects a substantial increase in inputs from erodible agricultural lands. Sediments fill backwaters and reduce the diversity of water depths. Sediments also absorb and transport containments.

Nationwide, some of the highest levels of polycyclic aromatic hydrocarbons were detected in sediment near Chicago. Polycyclic aromatic hydrocarbons (PAHs) are formed by the incomplete combustion of hydrocarbons, namely coal, oil, gasoline and wood and can result from many urban sources including fires, industrial and power plant emissions, home heating, and automobile and other vehicle emissions. PAHs are toxic to aquatic life, and several are suspected carcinogens, causing tumors in fish and other animals (USGS 2004). Concentration of total PAHs in sediment at sites in the upper Illinois River Basin were among the highest 25% of all sites sampled nationwide by the NAWQA Program (USGS 2004). Ten of twelve PAH guidelines were exceeded at Des Plaines River at Riverside (mixed urban and agricultural land use).

5.6.3 Contaminant Concentrations in Animal Tissue

Many pesticides and other synthetic organic compounds (SOC), particularly those with low solubility, show a tendency to bioaccumulate in organisms (USGS 2004) and, thus, can be harmful and/or toxic to aquatic organisms when present in water or sediment even at very low concentrations. Organisms may bioaccumulate pesticides and other SOCs from water, food, or sediments, and their tissue may accumulate, in time, concentrations several orders of magnitude higher than concentrations in the source water. Many of the effects of bioaccumulation are complex and unknown (USGS 2004). Pesticides and other SOCs have been shown to be potentially toxic, carcinogenic, and mutagenic (USGS 2004). However, less information is available on sources, fates, and effects of pesticides and other SOCs in aquatic environments than for many other water-quality constituents. Much of the difficulty in understanding the behavior and effects of organic compounds is the result of the large number of SOCs potentially available to the environment and the relatively short period of time these compounds have been used and were available for study. Pesticides and other SOC's also may have negative effects on aquatic ecosystems, which may not directly affect human health. For example, high concentrations of herbicides flushed to surface water during spring runoff may adversely affect the growth and survival of aquatic plants, which are essential food sources and breeding grounds for aquatic organisms (USGS 1998).

As described in Section 4.6, PCBs are a toxic mixture of chlorinated chemicals that were banned in the late 1970s but are still a common pollutant because they build up in fish flesh and are long-lasting in the bottom sediments of rivers and lakes. PCBs in fish that are eaten by humans and wildlife can build up and may have cancer-causing and other health effects. PCBs are a listed cause of impairment of the Des Plaines River watershed (IEPA 2014) and fish consumption advisories are listed for the Des Plaines, Kankakee, and Illinois Rivers because of PCB concentrations in fish tissue (IPHD 2014).

As described in Section 4.7 and 5.5.2, mercury is found in air, water, soil and is known to most people for its use in products like thermometers, switches, and some light bulbs. Mercury ranks among the top ten national causes of water pollution, with over 4,300 waters reported. Many of these reported waters are in northern states where special studies have detected large numbers of mercury-polluted lakes, including many in remote areas. As a water pollutant, mercury can build up in fish tissue, be dissolved in the water, or be deposited in bottom sediments. The most common way people can be exposed to mercury is by eating fish or shellfish that are contaminated with mercury. Eating fish from mercury-polluted waters should be avoided, especially by children and nursing or pregnant women. Eating mercury-contaminated fish or shellfish can affect the human nervous system and harm the brain, heart, kidneys, lungs, and immune system. Mercury is a listed cause of impairment of the Des Plaines River watershed (IEPA 2014).

6.0 AQUATIC HABITATS

The kinds and numbers of riverine or stream fishes and aquatic macroinvertebrates are strongly related to the physical and chemical characteristics of a stream or river (Rankin 1989). Similarly, resource agencies recognize that the physical habitat (i.e., the place where aquatic organisms live) directly affects the abundance and diversity of the aquatic biota. For example, Ohio EPA (1989) found that rivers and streams with good habitat support more diverse fish and macroinvertebrate communities than waterways in which the habitat has been degraded. Because it is clear that habitat quality, diversity, and quantity affect the aquatic biota, it is appropriate to assess habitat quality in the UIW. Such an assessment is particularly appropriate given the morphology, history, and evolution of the UIW.

From 1992 to 1994, aquatic habitat surveys were conducted to categorize UIW segments into the available mesohabitats and to determine the extent that habitat was limiting the aquatic biota of the UIW. A similar survey was conducted in 2014 during the fish and mussel assessments to evaluate aquatic habitat and changes that may have occurred in the Des Plaines, Kankakee, and Illinois Rivers since the mid-1990s (Appendix G).

6.1 Habitat Types

The 1992 to 1994 studies illustrated that any riverine habitat near DNS that existed prior to hydrologic regulation of the waterway for navigation has largely been diminished and replaced by lentic-like pools (ComEd 1996). Of the mesohabitats observed, main channel was clearly the dominant type near DNS, and main channel habitat quality, as measured by the Qualitative Habitat Evaluation Index (QHEI) was lowest among all habitat types, consistently in the poor to fair range.

Despite the observed increase of macrophytes near DNS since the mid-2000s, the 2014 aquatic habitat survey results confirmed that habitat complexity and quality have changed only minimally over the past 20+ years. QHEI scores remained in the poor to fair categories among all locations evaluated. Likewise, main channel habitat is the dominant habitat type throughout and particularly between the DNS discharge and Dresden Island Lock and Dam. Out of the 11 primary aquatic habitat types identified near DNS, three are present downstream of DNS while all 11 are observed in areas upstream of the DNS discharge (Figure A-2). The lack of complexity in the most downstream portion of lower Dresden Pool is a function of the proximity to Dresden Island Lock and Dam while the confluence of two large rivers upstream of DNS provides for greater habitat complexity.

6.2 Substrates

As with the aquatic habitat near DNS, substrate complexity in the vicinity is generally low (Figure A-2; Appendix H). Gravel is the predominant substrate type throughout the area followed by silt, sand, and clay. Areas with significant coarse substrate, such as boulder and cobble, are generally absent upstream of Dresden Island Lock and Dam. Substrate composition differed noticeably between upstream of the Dresden Island Lock and Dam and the downstream tailwater. The predominant substrate downstream of Dresden Island Lock and Dam was gravel followed by sand and cobble.

7.0 AQUATIC LIFE

7.1 Producers

7.1.1 Aquatic Macrophytes

Aquatic macrophytes have long been recognized as a key component in the functioning of aquatic ecosystems. They modify and diversify habitats, fuel secondary production by producing oxygen, cycling nutrients, stabilizing sediments, and by providing cover for fishes and substrate for fish food organisms (Raschke 1978, Wright *et al.* 1981, Wiley and Gorden 1984, Barko *et al.* 1982, Engel 1990). Macrophytes modify sediment and water chemistry (Sculthorpe 1967, Westlake 1973, Hutchinson 1975, Dawson *et al.* 1978, Chen and Barko 1988), often by substance uptake and release (Hill 1979, Jaynes and Carpenter 1986, Smith and Adams 1986).

Submerged and emergent aquatic plants historically flourished in the Illinois Waterway, but in the early 1960s much of the vegetation disappeared from the Illinois River and its bottomland lakes. Sedimentation and turbidity associated with navigation coupled with fluctuating water levels had a significant effect on the aquatic vegetation by reducing light penetration and creating unstable substrates (Bellrose *et al.* 1977). In the late 1970s, limited growth of more tolerant submerged aquatic plants including pondweeds (*Potamogeton* spp.), eelgrass or water celery (*Vallisneria americana*), and coontail (*Ceratophyllum demersum*) was reported (Havera *et al.* 1980). In the early 1980s, a resurgence in the aquatic vegetation was observed at certain locations in the Dresden Pool that prompted aquatic vegetation and general habitat quality studies (Appendix E).

An aquatic macrophyte study in the UIW was conducted from 1992 through 1995 as part of an UIW Ecological Study (ComEd 1996). The investigations resulted in the identification of 34 distinct aquatic macrophyte taxa, most of which are common and relatively pollution tolerant. While no aquatic vegetation was found immediately above or below the Dresden Island Lock and Dam (presumably due to highly erosive habitats in that area caused by river traffic), other areas upstream of the Dam in Dresden Pool contain several habitats conducive to macrophyte growth. In fact, over 85 percent of the vegetation observed in the 53-mile study reach was located in Dresden Pool, including such habitats as tailwaters, side channels, tributary deltas, and slough areas, which are removed or protected from the impacts of barge/boat traffic on the UIW. Vegetation coverage in these habitats varied annually, but generally ranged from 10 to 30 percent. Results from this study and previous studies indicated that the resident aquatic macrophyte community in Dresden Pool remained relatively stable over a ten year period (ComEd 1996).

Since the mid-2000s, EA field crews have observed increasing macrophyte production throughout Dresden Pool. Given the change in habitat, additional observations were made during the 2013 and 2014 thermal plume, fish, and mussel surveys. This information combined with recent aerial photography and substrate data were used to generally describe the current aquatic habitat types in the vicinity of DNS (Figure A-2; Appendix G; Appendix H). Qualitative survey results illustrate an increase in both submerged and emergent aquatic vegetation compared to the 1992-1995 results. Areas that exhibited the greatest increase in production were along the southeast bank of the Des Plaines River and adjacent north bank of the Kankakee

River, at and upstream of the confluence as well as along the north bank of the Illinois River immediately upstream of Dresden Island Lock and Dam (Figure A-2). Despite the observed increase of macrophytes near DNS in recent years, the 2014 aquatic habitat survey results confirmed that because the area near DNS is dominated by main channel habitat, where macrophytes do not grow, habitat complexity and quality have changed only minimally over the past 20+ years.

7.1.1.1 Submerged Aquatic Vegetation (SAV)

Submerged aquatic vegetation (SAV) includes plants that grow below the surface of the water and are usually anchored to the bottom by t roots. SAV generates dissolved oxygen, filters suspended material, stabilizes bottom sediments, and cycles nutrients (Rogers and Theiling 1999). This group of plants provide crucial fish habitat, substrate for invertebrate growth, and are important foods for mammals and migratory birds. SAV are most often found in backwater areas of low water velocity, adequate light penetration, and relatively stable water levels.

During the aquatic macrophyte study conducted from 1992-1995, SAV accounted for about 75 percent of the total areal coverage. Over the four year period, the Dresden Pool had an average areal coverage of 26.61 hectares of SAV, with the greatest coverage in the DuPage Delta (RM 277) (EA 1996). SAV identified in the study included American elodea (*Elodea Canadensis*), water star grass (*Heteranthera dubia*), water milfoil (*Myriophyllum* sp.), curlyleaf pondweed (*Potamogeton crispus*), sago pondweed (*Potamogeton pectinatus*), flatstem pondweed (*Potamogeton foliosus*), common arrowhead (*Sagittaria latifolia*), and water celery (*Vallisneria americana*) (Appendix E).

Compared to 1992-1995, submerged macrophytes have increased noticeably along both the northeast and southeast banks of the Des Plaines River upstream of the Kankakee River confluence (Figure A-2).

7.1.1.2 Emergent Aquatic Vegetation (EAV)

Emergent aquatic vegetation (EAV) are plants whose roots are anchored under water with much of the plant extending above the water surface. They are backwater plants adapted to low water velocities and shallow- to deep-water marsh conditions (USFWS, 2006).

During the aquatic macrophyte study conducted from 1992-1995, EAV accounted for about 25 percent of the total coverage. Over the four year period, Dresden Pool had an average areal coverage of 8.92 hectares of EAV, with the greatest coverage located in the side channel at Treats Island (RM 279.5). EAV identified in the study included water willow (*Justicia americana*), needle rush (*Eleocharis acicularis*), purple loosestrife (*Lythrum slicaria*), reed grass (*Pharagmites communis*), common arrowhead (*Sagittaria latifolia*), river bulrush (*Scirpus fluviatilis*), softstem bulrush (*Scirpus validus*), and narrowleaf cattail (*Typha angustifolia*) (EA 1996).

The observations performed in 2014 show a significant increase in American lotus (*Nelumbo lutea*) near DNS compared to the 1992-1994 surveys. The most dramatic changes occurred along the southeast bank of the Des Plaines River and adjacent north bank of the Kankakee

River, at and upstream of the confluence as well as along the north bank of the Illinois River immediately upstream of Dresden Island Lock and Dam (Figure A-2). The greatest increases have occurred upstream of the DNS discharge and are not related to DNS operations.

7.1.2 Phytoplankton and Periphyton

Monitoring of both periphyton and phytoplankton in the vicinity of the DNS has been conducted periodically since 1968. Early studies evaluated a variety of algal community parameters such as community composition, density, and chlorophyll production. Phytoplankton surveys conducted in the UIW and its tributaries in 1991 and 1993 evaluated the algal community and chlorophyll concentrations along the waterway from the Chicago Locks to below the Dresden Island Lock and Dam (ComEd 1996). Results indicated that total phytoplankton density increased with distance downstream in the UIW. Since all but two of the members of the phytoplankton community originated as components of the periphyton, improved and expanded habitats in Dresden Pool provided more extensive periphyton development resulted in Dresden Pool having the highest total density of phytoplankton (ComEd 1996).

The 1991 and 1993 studies showed that phytoplankton populations in the UIW were in a state of flux associated with changes in physical and chemical factors. Species in the UIW and its tributaries are those adapted to eutrophic (nutrient rich, warmwater) systems. Warmwater effluents stimulated production of the most abundant species and inhibited a few minor contributors to the total phytoplankton population. A majority of those individuals that appeared to be inhibited were not eliminated from the waterway, but appeared at other sites within the system.

The community below Dresden Island Lock and Dam (i.e., Illinois River) was similar to that in the upper Des Plaines River and the Kankakee River. These results indicate that members of the phytoplankton communities in the system receiving warmwater effluents were similar to those removed from this influence and that they were not impacted on a long term basis by power generation (ComEd 1996).

During the period of indirect open-cycle operation at DNS, no effects on the algal community outside the immediate discharge area were detected that could be attributed to DNS operation. Differences that were identified upstream and downstream of the DNS discharge were attributed to spatial and temporal variations, differences in river hydrology and morphology, and differences in ambient water temperatures. These various parameters could result in seasonal shifts in numbers and taxa within the algal community structure at various sampling locations (ComEd 1980).

7.2 Consumers

7.2.1 Zooplankton

Limited zooplankton sampling was conducted near DNS during indirect open-cycle operation from 1972 to 1975 (Appendix E). Samples were collected at several locations upstream and downstream of the DNS discharge to the Dresden Pool, in the area of the DNS discharge, the DNS intake on the Kankakee River, and in the Des Plaines River. The zooplankton community in general reflected the different community structures found in the Des Plaines and Kankakee Rivers. Total zooplankton abundance was much higher while diversity was lower in the Des

Plaines River than in the Kankakee River, which is a reflection of differences in hydrology and morphology of the two rivers. The Des Plaines River is very similar to lake habitat with increased residence time and differences in fertility as compared to the Kankakee River that allows for increases zooplankton production. The zooplankton communities observed in samples consisted mostly of taxa belonging to Copepoda, Cladocera, and Rotifera (ComEd 1980).

Typically, the zooplankton assemblage downstream of the discharge on the north shore of Dresden Pool was very similar to the north shore of the Des Plaines River. Downstream of the discharge on the south side of the Dresden Pool zooplankton densities and species composition were intermediate between the Kankakee and Des Plaines Rivers. This reflects mixing of the two rivers. Downstream of the discharge, species composition and abundance was very similar to that upstream of the discharge on the south shore of Dresden Pool. This information suggests that the difference in zooplankton abundance and species composition of the cooling pond discharge is attenuated once dilution occurs, and that the discharge has no measurable effect on the downstream zooplankton assemblage (ComEd 1980).

7.2.2 Benthic Invertebrates

Benthic macroinvertebrate surveys in the vicinity of DNS have been conducted periodically between 1968 and 2014 (Appendix E; Appendix F; Appendix G). The studies have been conducted primarily to characterize the benthic community composition, statistically analyze temporal and/or spatial differences, and examine these results in respect to potential effects related to the DNS discharge.

Although study objectives may have been similar, the scope and methods used to assess the benthic community in the vicinity of DNS have varied. In 1968 to 1971, benthic collections were made using a Ponar dredge during a single sampling event at 10 to 49 locations in the lower Des Plaines and Kankakee Rivers to the confluence of the Vermillion River with the Illinois River near LaSalle, Illinois. The study approach changed during the 1972 to 1977 period when sampling was conducted quarterly, the number of locations was reduced to between three and five, and the primary sampling device was a multi-barrel core sampler. Hester-Dendy (HD) artificial substrate samplers were added to the study from 1974 to 1977 (Appendix E).

In 1993, benthic macroinvertebrate sampling was completed at 30 locations in the UIW, including six stations near DNS. Sampling was conducted in a variety of different habitat types using HD artificial substrate samplers and Ponar dredge.

Benthic macroinvertebrate surveys completed in 1999 were conducted in support of a provisional variance granted by IEPA. Sampling was conducted biweekly in August, once in mid-September and biweekly in October. Replicate Ponar samples were collected at six locations in the Des Plaines, Kankakee, and Illinois Rivers, upstream and downstream of Dresden Island Lock and Dam.

Between 2001 and 2014, benthic community surveys have been conducted during 11 of 14 years with few changes to the study scope. In each of these study years, the benthic community in the vicinity of DNS was evaluated at six locations in the Des Plaines, Kankakee, and Illinois Rivers, upstream and downstream of Dresden Island Lock and Dam. Sampling has been conducted using a combination of Ponar dredge and HD artificial substrate samplers.

Early study results (1968 to 1977) reported that the benthic community in the Des Plaines, Kankakee, and Illinois Rivers was composed primarily of taxa that are considered tolerant of organic pollution and can flourish in habitats with soft sediment. The benthic community was dominated by highly tolerant aquatic worms while pollution intolerant mayflies, stoneflies, and caddisflies (collectively referred to as EPT taxa) were absent or found in low abundance among the locations upstream and downstream of DNS.

The 1993 study concluded that, although there had been obvious water quality improvements and increased numbers of more pollution intolerant EPT taxa, pollution and/or poor habitat tolerant taxa continued to dominate the assemblage. The results of the 1993 surveys suggest that habitat, sediment, and water quality were the primary factors regulating the benthic community and that temperature was not a contributing factor.

Subsequent benthic macroinvertebrate studies conducted between 2001 and 2014 have corroborated these earlier studies. The benthic community throughout the DNS study area is dominated by pollution tolerant taxa that are capable of achieving high densities in habitats that consist of low current velocity, unconsolidated sediment, and frequent disturbance associated with barge traffic.. Statistical analysis of these data exhibit no consistent trends associated with spatial or thermal differences. These collective results, show that the DNS discharge has had no measurable effect on the downstream benthic macroinvertebrate assemblage.

7.2.3 Mussels

Freshwater mussels were occasionally taken with the Ponar dredges used for the benthic macroinvertebrate surveys conducted in the vicinity of DNS (Section 7.2.2). Nine mussel species were collected upstream and downstream of the DNS discharge and downstream of Dresden Island Lock and Dam between 2001 and 2014 (Appendix E; Appendix F; Appendix G):

Species	Upstream DNS	Downstream DNS	Downstream Dresden Island L&D
Amblema plicata	X	X	X
Quadrula pustulosa	--	X	--
Quadrula quadrula	X	X	X
Utterbackia imbecillis	--	X	X
Leptodea fragilis	X	X	--
Potamilus alatus	--	--	X
Toxolasma parvus	--	X	X
Truncilla donaciformis	--	--	X

A survey was subsequently conducted during October 2014 (see Appendix H) to characterize the mussel community in the DNS study area because the Ponar grabs indicated a mussel community existed in the DNS study area. The objectives of the survey were to characterize the freshwater mussel community and evaluate the community relative to DNS operations (Appendix H). The survey area included approximately 2,300 meters of the Illinois River including approximately 400 meters upstream of the DNS discharge to the Dresden Island Lock and Dam and from below the lock and dam to Little Dresden Island. Semi-quantitative sampling was conducted along 30 transects with qualitative sampling between transects.

The 2014 mussel survey documented the presence of a diverse mussel assemblage upstream and downstream of the Dresden Island Lock and Dam. Recruitment was evident throughout the study area although the downstream assemblage had a greater proportion of adult mussels than upstream. Two state threatened species, *Cyclonaias tuberculata* and *Ligumia recta* were encountered within the study area and were slightly more abundant downstream of the Dam. The highest mussel densities within the study area were found in both shallow and deep water habitats with substrates of gravel mixed with sand and/or silt. Given the distribution of mussels within the study area versus typical dispersion of the DNS thermal plume, it is apparent that DNS operations are not affecting the freshwater mussel assemblage within the vicinity (Figure A-3).

7.2.4 Fish

7.2.4.1 Long-term monitoring studies

Modifications to and multiple competing uses of the UIW influences the overall diversity of the fish community in the vicinity of the DNS. The fish community has been monitored with a variable scope of study since 1971 with the approach becoming more standardized in 1991 (Appendix E). Studies conducted downstream of the Dresden Island Lock and Dam, in Dresden Pool, and upstream of DNS in the lower Des Plaines River and Kankakee River have documented the occurrence of 105 species including 80 native species and 25 introduced/exotic species (Table A-1). Native species have dominated the catch over the 43-year monitoring period from 1971 through 2014 following start-up of DNS. Eleven species that were collected during at least 14 of the 15 years monitored between 1971 and 1989 were collected each of the 20 years monitored from 1991 through 2014. All were native species except common carp; the common native species included forage species (gizzard shad, emerald shiner, bluntnose minnow, and bullhead minnow), channel catfish, and five sunfish species (rock bass, green sunfish, bluegill, smallmouth bass, and largemouth bass). During the 1991-2014 monitoring period, 11 other native species were collected each year: two cyprinids (spotfin shiner and spottail shiner), five suckers (river carpsucker, quillback, shorthead redhorse, smallmouth buffalo, and golden redhorse), two sunfish species (orangespotted sunfish and black crappie), logperch, and freshwater drum. In total, 25 species were collected all or nearly all the years that the fish community in the vicinity of DNS was monitored.

In contrast to the commonly occurring species, 22 species were collected after 1989 and of those, 16 occurred in only one to four of the annual catches including grass carp, silver carp, greater redhorse, four minnow species, and three darter species (Table A-1). Silver carp were collected in 2005 and 2014 and are apparently increasing in Dresden Pool based on monitoring efforts of the Asian carp Regional Coordinating Committee (ACRCC 2014). Infrequently collected species include exotic species to the UIW: alewife, threadfin shad, salmonid species, common carp x goldfish hybrid, western mosquitofish, white perch, and round goby. The occurrence of white perch and round goby in the DNS study area coincided with their introduction to Lake Michigan. Both species have been consistently collected since 2003.

Nine native species that were collected from the DNS study area prior to 1989 have not been collected since. Eight of those species occurred infrequently (1-4 years) and in low numbers. Common shiner was collected in low numbers but was encountered in nine of the 15 annual surveys conducted prior to 1991. Striped shiner, which is closely related to common shiner, was also collected nine of the 15 years prior to 1991, but not always the same year as common shiner. Striped shiner has been reported all 20 years that were monitored between 1991 and 2014, whereas common shiner was not reported during that same period.

Pallid shiner, listed as endangered in Illinois, was first collected from the DNS study area in 2001 and has been collected each year since. Although occasionally caught throughout the DNS study area, most pallid shiner were collected upstream of DNS in the Kankakee River (Appendix G). Once thought to have been extirpated from Illinois, it was discovered in the Kankakee River in 1983 (Kasprowicz et al. 1985). Four other state-listed species have been infrequently collected in low numbers from the DNS study area: the state-threatened river redhorse and state-endangered greater redhorse, western sand darter, and banded killifish.

7.2.4.2 Impingement Studies

A two-year impingement study conducted at DNS from April 2005 through March 2007 reported 37 native fish species and four introduced/invasive species that were impinged at the DNS intake (Appendix E). All impinged fish species had previously been reported during the long-term monitoring program for DNS, represented the most common species observed during the long-term studies, and included the 10 Representative Important Species (RIS) addressed by the prospective biothermal assessment (Appendix B). The majority of impinged fish were small fish representing juveniles of larger species (e.g., gizzard shad, channel catfish, and freshwater drum) or juveniles and adults of smaller species (e.g., minnows and trout-perch).

Sportfish (including channel catfish, flathead catfish, rock bass, bluegill, largemouth bass, smallmouth bass, white crappie, black crappie, sauger, and walleye) were not commonly impinged. Impinged introduced/invasive fish species included threadfin shad, common carp, white perch, and round goby. Impingement samples from the two-year study also included three "shellfish" species: rusty crayfish (*Orconectes rusticus*), northern crayfish (*O. virilis*), and giant floater (*Pyganodon grandis*), a freshwater mussel. No shellfish or fish species listed as endangered or threatened by the U.S. Fish and Wildlife Service were collected during the two-year study. One pallid shiner, listed as endangered in Illinois, was impinged during the first year of study but none were collected during the second year.

7.2.4.3 Ichthyoplankton

An ichthyoplankton study of the UIW was conducted in spring and summer 1994 to determine what portion of the fish community in the Illinois River drainage is currently using the UIW as a spawning or nursery area as well as when and where use occur (Appendix E). Approximately half of the identified fish eggs collected during the study were common carp; smaller numbers of carp/goldfish and freshwater drum eggs were also collected. Larval and young-of-the-year (YOY) fish representing at least 48 species and 14 reproductive guilds were collected. Because some larvae could be identified only to the genus or family level, it is possible that as many as 62 species were collected. Most of the ichthyoplankton taxa likely represented the common species collected during the long-term monitoring program for DNS but in many cases egg and larval stages are not adequately described to identify them to species. The six most commonly collected taxa (*Lepomis* spp., gizzard shad, common carp, bluntnose minnow, unidentified *Pimephales* spp., and emerald shiner) share early life history characteristics that appear to be most successful in the UIW. Collectively, these species or taxa accounted for more than 86 percent of all larvae/juveniles collected during the study.

A two-year entrainment (intake canal) and ichthyoplankton (river)study conducted at DNS from April through August 2005 and 2006 assessed the ichthyoplankton community in the Kankakee River in front of the intake canal; and in the DNS intake and discharge canals (EA 2007b). Species composition in the intake canal was similar to that in the Kankakee River. Overall, freshwater drum dominated the samples accounting for 58 percent of the total number collected in the intake canal in 2005 and 73 percent in 2006. Forage fish taxa contributed approximately 16 to 20 percent of the ichthyoplankton collected in the intake canal both years. Excluding

Freshwater drum, early life stages of sportfish (primarily yellow bass, channel catfish, *Lepomis* spp., and unidentified *Pomoxis* spp.) accounted for 21 percent of the total intake canal collections in 2005 and 3.2 percent in 2006. Forage fish taxa contributed nearly 20 percent of the ichthyoplankton in the intake canal in 2006 versus 5.8 percent in the river and sucker larvae accounted for less than one percent in the intake canal compared to 18 percent in the river.

7.2.5 Birds

Illinois possesses a moderately diverse bird population with 403 species reported from the state, which consists of 204 breeding species and 199 migrant/vagrant species (INHS 2014). With the changes in land use practices and population density/urbanization, the composition and distribution of bird species in Illinois has continued to shift throughout the past 100 years (Walk et al. 2010). Migratory and resident waterfowl and songbirds are commonly found in the surrounding area of DNS. Such species include blackcapped chickadee (*Poecile atricapilla*). Migratory waterfowl such as mallard (*Anas platyrhynchos*), black duck (*Anas rubripes*), and Canada goose (*Branta canadensis*) nest near the lock and dam because the area provides productive foraging habitat. Bald eagle (*Haliaeetus leucocephalus*) also use the UIW in the winter and fall (Village of Channahon 1983 and 1990).

7.3 Threatened and Endangered Species

This section addresses Federal and State of Illinois species with threatened or endangered (T&E) status that are known to or potentially occur near DNS.

7.3.1 Federally Listed Species

Twenty-nine species are listed in Illinois by the USFWS as T&E, two species are candidates for listing, and one species is proposed for listing as endangered (USWFS 2014). Most of the federally-listed species in Illinois are not known to occur in Grundy or Will counties or would not be affected by the operation of DNS because they are terrestrial.

Federally-protected freshwater mussels are not known to currently exist within the vicinity of the DNS. The federally endangered sheepnose (*Plethobasus cyphyus*) once existed in the Illinois and Des Plaines Rivers but was last observed in 1940 in the Illinois River and 1970 in the Des Plaines River. The sheepnose is now believed extirpated from both the Illinois and Des Plaines Rivers (Federal Register 2012). Current observation records suggest the sheepnose maintains a stable population within the Kankakee River from its confluence with the Iroquois River to 27 river miles downstream, terminating 10 miles upstream of the DNS discharge (Federal Register 2012). In addition, the snuffbox (*Epioblasma triquetra*) is federally listed for Will County (Federal Register 2012). Neither species was collected in an October 2014 mussel survey conducted in the vicinity of DNS (Appendix H).

The only federally-listed fish species occurring in the vicinity of DNS, pallid sturgeon (*Scaphirhynchus albus*) is listed in seven southwestern Illinois counties that border the Mississippi River and is not known to occur near DNS.

Federally-listed terrestrial species would not be affected by the operation of DNS. In Grundy County, these species include the Indiana bat (*Myotis sodalis*) and eastern prairie fringed orchid (*Platanthera leucophaea*). One candidate insect species, rattlesnake-master borer (*Papaipema* *eryngil*) is listed in both Grundy and Will counties. The remaining terrestrial species listed in Will County include the Hine's emerald dragonfly (*Somatochlora hineana*), eastern prairie fringed orchid (*Platanthera leucophaea*), lakeside daisy (*Hymenopsis herbacea*), leafy-prairie clover (*Dalea foliosa*), Mead's milkweed (*Asclepias meadii*), and the eastern massasauga (*Sistrurus catenatus*), a candidate for listing (Federal Register 2012).

7.3.2 State Listed Species

The Illinois Endangered Species Protection Board (IESPB) lists 28 state-listed T&E species in Grundy County and 76 in Will County (IDNR 2014). Of these species, the six mussel and twelve fish species listed in the below table are potentially affected by operation of DNS if they occur in the vicinity of DNS.

Mussel and Fish Species Listed as Threatened (ST) or Endangered (SE) by the IESPB.

Scientific Name	Common Name	State Status
MUSSELS		
Alasmidonta viridis	slippershell	ST
Cyclonaias turberculata	purple wartytback	ST
Elliptio dilata	spike	SE
Ligumia recta	black sandshell	SE
Plethobasus cyphyus	sheepnose	SE
Simpsonaias ambigua	salamander mussel	SE
FISH		
Erimystax x-punctatus	gravel chub	ST
Hybopsis amnis	pallid shiner	SE
Notropis boops	bigeye shiner	SE
Notropis chalybaeus	ironcolor shiner	ST
Notropis heterolepis	blacknose shiner	SE
Notropis texanus	weed shiner	SE
Moxostoma carinatum	river redhorse	ST
Moxostoma valenciennesi	greater redhorse	SE
Fundulus diaphanus	banded killifish	ST
Fundulus dispar	starhead topminnow	ST
Ammocrypta clarum	western sand darter	SE
Etheostoma exile	Iowa darter	ST

Two state–listed species mussel species were encountered during an October 2014 survey conducted near DNS (Appendix H): purple wartyback (*Cyclonaias tuberculata*) and black sandshell (*Ligumia recta*). Both species were present upstream and downstream of the Dresden

Island Lock and Dam. Five adult *C. tuberculata* (mean age = 9.6 years) were collected, including four downstream and one upstream. Four adult *L. recta* (mean age = 9.3 years) were collected, including three downstream and one upstream (Appendix H).

Of the state-listed fish species noted above, long-term monitoring in the river system near DNS has collected pallid shiner, banded killfish, western sand darter, river redhorse, and greater redhorse. The threatened river redhorse (*Moxostoma carinatum*) and endangered greater redhorse (*M. valenciennesi*) were collected infrequently and in low numbers. Twenty-two river redhorse were collected throughout the study area during about a third of the 35 annual surveys conducted from 1971 through 2014. Slightly more than a third were collected downstream of the Dresden Island Lock and Dam where the riverine habitat is more suitable for redhorse. Only five greater redhorse were collected, one each from 1991-1993 and in 2000; three were collected downstream of the Dresden Island Lock and Dam and one upstream of DNS in the upper Des Plaines River. Modification of the Illinois River has eliminated much of historical redhorse habitat. Golden redhorse (*Moxostoma erythrurum*) was selected as a surrogate RIS because the incidental occurrence of both the state-listed redhorse species precluded evaluation of thermal effects on these species.

Four of the state-endangered western sand darter (*Ammocrypta clara*) were collected downstream of the Dresden Island Lock and Dam, one each in 2003 and 2006 and two in 2014. Habitat downstream of the Dresden Island Lock and Dam is more suitable for darters than in Dresden Pool where the river channel is flooded by the impounded UIW.

Pallid shiner (*Hybopsis amnis*), listed as endangered in Illinois, was first collected from the DNS study area in 2001 and has been collected each year since. Once thought to have been extirpated from Illinois, it was discovered in the Kankakee River in 1983 (Kasprowicz et al. 1985). Although occasionally caught throughout the DNS study area, most pallid shiner were collected primarily upstream of DNS in the Kankakee River (Appendix F; Appendix G). Of the 905 pallid shiner collected to date, nearly 90 percent were taken from either the Kankakee River (86 percent) upstream of DNS or the Illinois River downstream of the Dresden Island Lock and Dam (3 percent), where suitable riverine habitat occurs. The occurrence of pallid shiner 30 some years following the start-up and operation of DNS indicates the plant operations had not impacted that population.

Banded killifish (*Fundulus diaphanus menona*), listed as threatened in Illinois, was first observed in the DNS study area during 2013 when two specimens were collected in Dresden Pool. The 2014 sampling effort collected 10 total specimens, eight from Dresden Pool and two from downstream of Dresden Island Lock and Dam. EA field crews have observed increasing numbers of this state threatened species throughout the lower Des Plaines River (Appendices F and G). Although the reasons for this trend are unclear, given their habitat requirements, the increased macrophyte production in the lower Des Plaines River since the mid-2000s may be a factor.

In addition to fish and mussels, several state-listed T&E species of migratory and resident waterfowl and songbirds are commonly found in the surrounding area of DNS (Table below).

State Listed Bird Species in Will and Grundy Counties

Scientific Name	Common Name	State Protection	County	# of Occurrences	Last Observed
Bartramia longicauda	upland sandpiper	LE	Grundy	1	May 1980
			Will	4	May 2013
Botaurus lentiginosus	American bittern	LE	Grundy	1	1991
Circus cyaneus	northern harrier	LE	Grundy	1	Summer 2002
			Will	1	2000
Gallinula chloropus	common moorhen	LE	Grundy	1	July 1991
			Will	3	June 1999
Ixobrychus exilis	least bittern	LT	Grundy	1	June 1982
			Will	2	June 1999
Lanius ludovicianus	loggerhead shrike	LE	Grundy	2	1988
			Will	2	2013
Rallus elegans	king rail	LE	Grundy	1	July 1994
			Will	2	June 1993
Nycticorax nycticorax	black-crowned night heron	LE	Will	1	2012
Tyto alba	barn owl	LE	Will	1	September 2006
Xanthocephalus xanthocephalus	yellow-headed blackbird	LE	Will	1	May 1991

Before the industrialization of the UIW, the Illinois River Valley was one of the most important fall waterfowl migratory staging areas in the country. Prior to the 1950s, diving ducks and other birds were abundant and their numbers increased substantially between 1946 and 1950. After some population fluctuations during the early 1950s, the Illinois River population was near eliminated and have not recovered. Loss of primary diving duck food sources such as fingernail clams and wild celery reduced diving duck habitat value in the Illinois River to the point that diving ducks shifted their migratory patterns to the Mississippi River Valley. Dabbling ducks also were affected by habitat loss. Between 1946 and 1982, dabbling duck use of the Illinois River declined by about 20 million use-days. To date, diver populations have not returned and dabbling duck populations have stabilized at about 500,000 birds (USGS 1999).

7.4 Other Species

Mammal species commonly found in the forest habitat in the vicinity of DNS include white-tailed deer (*Odocoileus virginianus*), opossum (*Didelphis virginiana*), gray squirrel (*Sciurus carolinensis*), and raccoon (*Procyon lotor*) (Village of Channahon 1983 and 1990).

Additionally, a number of reptile and amphibian species occur in Grundy and Will County. Some of the more common species may also use waters and lands adjacent to DNS lands. The below table lists species that may occur within the surrounding area of DNS.

Reptiles and Amphibian Species of Grundy County (INHS 2003)

Scientific Name	**Common Name**
Ambystoma tigrinum	tiger salamander
Bufo americanus	American toad
Bufo fowleri	Fowler's toad
Acris crepitans	cricket frog
Rana blairi	plains leopard frog
Rana clamitans	green frog
Rana pipiens	northern leopard frog
Chelydra serpentine	snapping turtle
Chrysemys picta	painted turtle
Graptemys geographica	map turtle
Apalone spinifera	spiny shoftshell
Ophisaurus attenuates	slender glass lizard
Cnemidophorus sexlineatus	six-lined racerunner
Coluber constrictor	racer
Elaphe vulpine	fox snake
Heterodon platirhinos	eastern hognose snake
Nerodia sipedon	northern water snake
Pituophis melanoleucus	bull snake
Regina septemvittata	queen snake
Thamnophis radix	plains garter snake
Thamnophis sirtalis	common garter snake

8.0 COMMUNITY ECOLOGY

8.1 Vegetation Communities

The original vegetation near the DNS was a mosaic of upland forests, dolomite prairies, and wetlands. Much of this natural diversity was lost with industrial development of the area. Three dominant vegetation types – dry prairie/old field/shrub, bottomland forest, and wetland – now occur near the area of DNS. These vegetative types are a result of past disturbance, but are now in a stable, somewhat natural state (MWRD 1999). Bottomland forests border the UIW in many areas. These forests contain deciduous tree species typical of this forest type, and various undergrowth. The wetland systems of the area are primarily associated with river hydrology (forested floodplains) or isolated depressions. Disturbance activities such as industrial or commercial excavation, dikes, and impoundments created many of the isolated wetlands (MWRD 1999).

The aquatic community within the DNS study area reflects the historical modification of the Illinois River that dates to 1871 when the Chicago River flow was reversed to divert sanitary wastes from the City of Chicago away from Lake Michigan to protect the City's drinking water. These modifications resulted in changes to the flora as well as the fauna in the Illinois River near DNS. As water quality has improved, the aquatic community has generally improved. However, introductions and expansions of invasive species within the Illinois River Basin have continued to alter the flora and fauna of the river.

8.2 Lower Dresden Pool Fish Communities

The aquatic community within the DNS study area reflects the historical modification of the UIW, described in Section 1.1.1 above. The Lower Des Plaines River watershed was surveyed in 2008 by the IDNR and the IEPA as part of a statewide monitoring program to measure the health of Illinois streams. Results of that survey included species composition, species distribution, and determination of stream quality based on the Index of Biotic Integrity (IBI), as well as information on the sport fishery that was documented and compared to previous surveys in the basin (IEPA/IDNR 2010).

The IDNR and IEPA showed that the Lower Des Plaines River watershed is urbanized throughout much of basin, and as reported in previous surveys, streams within the basin reflect impacts from intensive development within the basin. Most of the areas that were sampled had low to moderate stream quality with fish communities composed primarily of tolerant species. Primary factors affecting the Lower Des Plaines River fish communities, as observed in 2008 and as previously reported (Pescitelli and Rung 2005) include current and past water quality problems, habitat limitations, and fragmentation due to dams. That assessment is consistent with the IEPA evaluation that lists most locations within the watershed as impaired for aquatic life uses (IEPA 2010).

Despite widespread impairments in the Lower Des Plaines River watershed, some selected areas had relatively high species richness and support abundant sportfish populations. These areas include the Lower Des Plaines River, which offer opportunities for urban anglers, as well as potential sources of species recruitment for other, upstream areas now fragmented by dams. The

IDNR/IEPA report suggests that fairly stable conditions for fish communities and stream quality throughout much of the watershed. However, overall only 3 stations out of 32 sampled in 2008 exceeded an IBI score of 41, one of the criteria to meet the full aquatic life use designation (IEPA/INDR 2010).

In comparison to results of a 1983 survey of the Lower Des Plaines River Basin (Bertrand 1984, IEPA 1988), conditions from 1997-2008 improved in many areas of the watershed. Mean species richness and IBI for stations on the mainstem of the Des Plaines River were 11 and 17, respectively. In 2008, at the same stations sampled in 1983, mean species richness of 23 and a mean IBI of 29 was reported. Considering that conditions have been stable from the period 1997 to 2008, it is likely that most of the benefits have been realized resulting from water quality improvements.

Fragmentation due to dams was shown to be one of the most significant factors affecting fish assemblages on the upper Des Plaines River, even when compared to land use and water quality effects (Slawski et al. 2008).

Bluegill, channel catfish and largemouth bass were the three most abundant sport species at the mainstem stations (IDNR/IEPA 2010). Other moderately abundant species collected in the mainstem were black crappie, rock bass, and smallmouth bass. Catch rates were variable for most species. Channel catfish and black crappie catch rates have increased over the sampling period; northern pike numbers were much higher in 2008. Catch rates were variable for most other species, indicating no definitive trends.

Fish collections within the lower Des Plaines River mainstem were largely dominated by tolerant species, with few sensitive species present, or present only in low abundance. For example, of the ten most numerous species collected, five are considered tolerant (Smogor 2004), and none were in the intolerant category. Tolerant species such as bluntnose minnow, gizzard shad, carp, green sunfish, and white sucker, are generalist, omnivorous fishes, tolerant of a wide range of conditions. These five species together accounted for over 50% of the total abundance on the mainstem (IEPA/IDNR 2010). Collections from the less urbanized rivers in Northeastern Illinois such the Kankakee River typically contain fewer tolerant species (Pescitelli and Rung 2009). The absence and low abundance of more specialized, sensitive species is reflected in the low to moderate IBI scores observed throughout the Lower Des Plaines River mainstem locations. Native sucker and invertivorous species were also particularly low compared to other northeastern Illinois rivers.

The recent EA Surveys that were conducted in 2013 and 2014 also assessed fish community at 10 locations in the Kankakee, Des Plaines, and Illinois Rivers adjacent to DNS. 2013 fish sampling (electrofishing and seining) was conducted three times: once in July, August, and September to emphasize fish distribution and abundance (Appendix F, Figures F-1; Appendix G, Figure G-1). 2014 fish sampling was conducted eight times: once in mid-May, once before 15 June, and twice monthly in July, August, and September with two additional stations downstream of Dresden Island Lock and Dam (Appendix F, Figures F-1; Appendix G, Figure G-1). Fish were also examined to assess fish condition and the incidence of disease and anomalies.

In 2013, 3,708 fish were collected by EA representing 50 species and one hybrid. Numerically, the combined catch was dominated by spotfin shiner (24.8 percent), bluegill (14.0 percent), gizzard shad (11.5 percent), and bluntnose minnow (8.7 percent). Thirty-four specimens of the state-endangered pallid shiner were collected (all from Dresden Pool), compared to three to 152 pallid shiner collected since 2007. In most recent years, pallid shiner numbers have increased. Two specimens of the state-threatened banded killifish were also collected in Dresden Pool. 2013 marked the first time banded killifish was collected as part of DNS fish monitoring program. No other state or federal listed fish species were collected during the June through September 2013 program.

In 2014, 12,986 fish were collected by EA representing 50 species and one hybrid. Numerically, the combined catch was dominated by spotfin shiner (17.5 percent), gizzard shad (15.4 percent), bluntnose minnow (7.3 percent), and emerald shiner (7.1 percent). One hundred and twenty-eight specimens of the state-endangered pallid shiner were collected (114 in Dresden Pool and 14 downstream of Dresden Island Lock and Dam), compared to three to 152 pallid shiner collected since 2007. In most recent years, pallid shiner numbers have increased. Two specimens of state-endangered western sand darter were collected downstream of Dresden Island Lock and Dam. This marks the third occurrence in the study area (all downstream of Dresden Island Lock and Dam) and the first since 2006. 10 specimens of the state-threatened banded killifish were also collected (eight in Dresden Pool and two downstream of the Dresden Island Lock and Dam) compared to two in Dresden Pool during 2013. Banded killifish numbers have increased from upstream to downstream in the lower Des Plaines River in recent years. One specimen of the state-threatened river redhorse was collected downstream of the Dresden Island Lock and Dam. River redhorse has been collected sporadically over the years (10 discreet collections) both upstream and downstream of Dresden Island Lock and Dam. The most recent collection prior to 2014 was in 2002 downstream of the dam. Two silver carp were collected in 2014. One specimen was observed in the DNS discharge canal and one was collected downstream of the Dresden Island Lock and Dam. This is the first collection of silver carp in Dresden Pool as part of the DNS monitoring effort and the first collection in the study area since 2008.

9.0 ENERGY FLOW AND TROPHODYNAMICS

9.1 Energy Flow and the Riverine Food Web

The transfer of food energy from the source in plants through a series of organisms with repeated eating and being eaten is referred to as the food chain (Odum 1971). At each transfer, 80 to 90 percent of the potential energy is lost as heat. Therefore, the number of steps or “links” is usually limited to four or five. The shorter the food chain (i.e., the closer the organism is to the beginning of the food chain), the greater the available energy.

Food chains are of two basic types: the grazing food chain, which, starting from a green plant base, goes to grazing herbivores (i.e., organisms eating living plants) on to carnivores (i.e., animal eaters); and the detritus food chain, which goes from dead organic matter into microorganisms and then to detritus-feeding organisms (detritivores) and their predators. Food chains are not isolated sequences but are interconnected with one another. The interlocking pattern is often called the food web. In complex natural communities, organisms whose food is obtained from plants by the same number of steps are said to belong to the same trophic level. Thus, green plants (i.e., producers) occupy the first trophic level, plant-eaters the second level (i.e., primary consumers), carnivores, which eat the herbivores, are the third level (i.e., secondary consumers), and the secondary carnivores the fourth level (i.e., tertiary consumers).

Figure A-4 is a diagram of a simplified river system food web (Odum 1971). With the exception of certain species, this food web is characteristic of the food web in the Kankakee, Des Plaines and Illinois Rivers.

10.0 REFERENCES

Asian Carp Regional Coordinating Committee (ACRCC) Monitoring and Response Workgroup. 2014. 2013 Asian Carp Monitoring and Response Plan Interim Summary Reports. April.

Arnold, T.A., Sullivan, D.J., Harris, M.A., Fitzpatrick, F.A., Scudder, B.C., Ruhl, P.M., Hanchar, D.B., and Stewart, J.S. 1999. Environmental setting of the upper Illinois River Basin and implications for water quality: U.S. Geological Survey Water-Resources Investigations Report 98–4268, 67 p.

Bankson, A. 2001. Illinois Department of Transportation, Annual Average Daily Traffic Volumes, personal communication with E. N. Hill, TtNUS, 7 February.

Barko, J.W., D.G. Hardin, and M.S. Matthews. 1982. Growth and morphology of submersed freshwater macrophytes in relation to light and temperature. Canad. J. Bot. 60:877-887.

Battelle. 1972. Supplement II, The Dresden Site Station Environment, Regional Impact of Dresden 3, Environmental Impact of Alternatives, Balancing of Alternatives, Considerations in regard to the National Environmental Policy Act. January.

Bellrose, F.C., R.E. Sparks, F.L. Paveglio, Jr., D.W. Steffeck, R.C. Thomas, and R.A. Weaver. 1977. Fish and Wildlife Habitat Changes Resulting from the Construction of a Nine-foot Navigation Channel in the Illinois Waterway from LaGrange Lock and Dam Upstream to Lockport Lock and Dam. Prepared by the Illinois Natural History Survey Havana Research Laboratory for the Department of the Army, Chicago District, Corps of Engineers.

Bhowmik, N. 2014. Bank Erosion of the Illinois River. World Environmental and Water Resources Congress 2014; pp. 1112-1119.

Chen, R.L., and J.W. Barko. 1988. Effects of freshwater macrophytes on sediment chemistry. J. Freshw. Ecology 4(3):279-289.

Commonwealth Edison Company and the Upper Illinois Waterway Ecological Study Task Force (ComEd). 1996. Final Report. Aquatic Ecological Study of the Upper Illinois Waterway Volumes 1 and 2. Commonwealth Edison Company, Chicago, Illinois.

Commonwealth Edison Company (ComEd). 1980. §316(a)-410(c) Demonstration for The Dresden Nuclear Generating Station. December.

_____________. 1993. Final Report Dresden Station Aquatic Monitoring 1992. Prepared by EA Engineering, Science, and Technology. Chicago, IL. March.

_____________. 1995a. Updated Final Safety Analysis Report for Dresden Station, Rev.01A, December.

_____________. 1995b. Upper Illinois Waterway Study Summary Report. Physical - Chemical

Study of the Upper Illinois Waterway Summer 1993 – Spring 1994, Document Number 95-03-B198, Project No. 1801 003, Chicago, IL. August.

Dawson, F.H., E. Castellano, and M. Ladle. 1978. Concept of species succession in relation to river vegetation and management. Verh. Internat. Verin. Limnol. 20:1429-1434.

Demissie, M., R. Xia, L. Keefer, and N. Bhowmik. 2004. The Sediment Budget of the Illinois River. Illinois State Water Survey. Contract Report 2004-13. December.

EA Engineering, Science, and Technology, Inc. (EA). 2007b. Entrainment Characterization Study, 2005 – 2007, Dresden Station. Prepared for Exelon Nuclear, Warrenville, IL.

Engel, S. 1990. Ecosystem responses to growth and control of submersed macrophytes: a literature review. Wisc. Dept. Nat. Resources Tech. Bul. No. 170.

Exelon. 1972. Dresden Station Supplemental Environmental Report, Dresden Unit 3, USAEC License DPR-25. January.

______________. 1973. Final Environmental Statement related to operation of Dresden Nuclear Power Station Units 2 and 3, Commonwealth Edison Company, Docket Nos. 5-237 and 5-249. November.

______________. 2002. Applicant's Environmental Report Operating License Renewal Stage: Dresden Nuclear Power Station Units 2 and 3.

______________. 2004. Exelon Station Updated Final Safety Analysis Report (UFSAR). Braidwood Station, Units 1 and 2. Facility Operating License Nos. NPF-72 and NPF-77. NRC Docket Nos. STN 50-456 and STN 50-457. December.

Federal Register. 2012. Endangered and Threatened Wildlife and Plants; Determination of Endangered Status for the Rayed Bean and Snuffbox Mussels Throughout Their Ranges. Department of the Interior, Fish and Wildlife Service. 50 CFR Part 17. Docket No. FWS–R3–ES–2010–0019; 4500030113. February.

GE Nuclear Energy. 2000. Applicant's Environmental Report for Morris Operation, NEDE-32966. May.

Gianessi, L.P. 1986. Water pollutant discharge and pesticide usage estimates for NAWQA surface water study regions: Report to U.S. Geological Survey, 19 p

Grundy County. 1996. Grundy County Land Use Plan – Year 2010 Update, Grundy County, Illinois, adopted July, 1996.

Havera, S.P., F.C. Bellrose, H.K. Archer, F.L. Paveglio, Jr., D.W. Steffeck, K.S. Lubinski, R.E. Sparks, W.U. Brigham, L. Coutant, S. Waite, and D. McCormick. 1980. Projected effects of increased diversion of Lake Michigan water on the environment of the Illinois River valley. Repport to the Chicago District, U.S. Army Corps of Engineers. Ill. Nat. Hist. Surv., Champaign, IL.

Hill, B.H. 1979. Uptake and release of nutrients by aquatic macrophytes. Aquat. Bot. 7:87-93.

Hutchinson, G.E. 1975. A Treatise on Limnology. Vol. III Limnological Botany. John Wiley & Sons, New York, NY.

Illinois Department of Natural Resources (IDNR). 2002a. Goose Lake Prairie State Natural Area, available at http://dnr.state.il.us//lands/landmgt/parks/i&m/east/goose/home.htm.

______________. 2014. Illinois Endangered Species Protection Board: Illinois Threatened and Endangered Species by County. http://www.dnr.illinois.gov/ESPB/Documents/ET_by_County.pdf. October.

______________. Undated. "Des Plaines Fish and Wildlife Area", brochure.

Illinois Environmental Protection Agency (IEPA) and Illinois Department of Natural Resources (IDNR). 2010. Status of Fish Communities and Stream Quality in the Des Plaines and Du Page Rivers: 1997-2008. September.

______________. 2014. Illinois Integrated Water Quality Report and Section 303(d) List, 2014 Clean Water Act Sections 303(d), 305(b) and 314, Water Resource Assessment Information and List of Impaired Waters, Volume I: Surface Water. Illinois Environmental Protection Agency, Bureau of Water, Springfield, IL.

Illinois Natural History Survey (INHS). 2003. Reptiles and Amphibians of Will County. http://www.inhs.uiuc.edu/cbd/collections/amprep/counties/will.hmtl. Last updated 2/10/2003.

______________. 2014. http://wwx.inhs.illinois.edu/collections/ilspeclist/.

Illinois Public Health Department (IPHD). 2014. Illinois Fish Advisories. Accessed January 2015. http://www.idph.state.il.us/envhealth/fishadvisory/index.htm.

Illinois State Geological Survey (ISGS). 1996. Quaternary Deposits of Illinois, 1996. http://www.isgs.uiuc.edu/nsdihome/.

Illinois State Water Survey. 2003. Illinois State Climatologist Office, Illinois State Water Survey. http://www.sws.uiuc.edu/atmos/statecli/General/Illinois-climate-narrative.pdf.

Jaynes, M.L., and S.R. Carpenter. 1986. Effects of vascular and nonvascular macrophytes on sediment redox and solute dynamics. Ecology 67:875-882.

Kasprowicz, J.M., M.J. Wetzel, K.S. Cummings, and W.U. Brigham. 1985. Survey of Kankakee River Fishes and Mussels at Illinois Route 53 Bridge in Wilmington, Will County, Illinois. IDOT Job Number P-91-051-79. Illinois Natural History Survey, Section of Faunistic Surveys and Insect Identification Technical Report 1985(4).

Leopold, L.B., M.G. Wolman, and J.P. Miller. 1992. Fluvial Processes in Geomorphology. Dover Publications, Inc., New York, NY.

Mackenthun, K.M. 1973. Toward a Cleaner Aquatic Environment. U.S. Environmental Protection Agency, Washington, D.C., 273 p.

Meade, R.H., J.R. Garbarino, H.C. Hayes, D.A. Roth, R.C. Antweiler, T.I. Brinton, and H.E.Taylor. 1995. 22 Contaminants in the Mississippi River, U.S. Geological Survey Circular 1133. Reston, VA.

Metropolitan Water Reclamation District of Greater Chicago (MWRD). 1999. Lockport License Application (FERC No. 2866).

National Oceanic and Atmospheric Administration (NOAA). 2014. http://cdo.ncdc.noaa.gov/qclcd/QCLCD

Odum, E. 1971. Fundamentals of Ecology: Eugene Odum.

Ohio Environmental Protection Agency (OEPA). 1989. Biological criteria for the protection of aquatic life: Vol. III. Standardized field and laboratory methods for assessing fish and macroinvertebrate communities. Div. Water Quality Planning and Assess., Ecological Assess. Sect., Columbus, OH.

Patrick Engineering. 2008. Report of Investigation - Sediment Sampling. Lisle, IL.

Rankin, E.T. 1989. The qualitative habitat evaluation index (QHEI). Rationale, methods, and applications. Ohio EPA, Div. Water Quality Planning and Assess., Ecological Analysis Sect., Columbus, OH.

Raschke, R.L. 1978. Macrophyton. Pages 39-50 in W.T. Mason, ed. Methods for the assessment and prediction of mineral mining impacts on aquatic communities: a review and analysis. Workshop Proc. U.S. Fish Wildl. Serv. Biol. Serv. Prog. FWS/OBS-78/30.

Rogers, S. and C. Theiling. 1999. Submersed aquatic vegetation. In. Ecological status and trends of the Upper Mississippi River System 1998: A report of the Long Term Resource Monitoring Program. U.S. Geological Survey, Upper Midwest Environmental Sciences Center, La Crosse, WI. April 1999. LTRMP 99-T001. 236 pp.

Sculthorpe, C.C. 1967. The biology of aquatic vascular plants. Edward Arnold Publishers Ltd. London.

Shay, M. 2001. Current Land Usage Rates for Will County, personal communication with E. N. Hill, TtNUS, 2 February.

Smith, C.S., and M.S. Adams. 1986. Phosphorus transfer from sediments by Myriophyllum spicatum. Limnol. Oceanogr. 31: 1312-1321.

Soballe, D. and J. Weiner. 1999. Water and Sediment Quality. In. Ecological status and trends of the Upper Mississippi River System 1998: A report of the Long Term Resource Monitoring Program. U.S. Geological Survey, Upper Midwest Environmental Sciences Center, La Crosse, WI. LTRMP 99-T001.236 pp. April.

Sparks, R.E., P.P. Tazik, K.D. Blodgett, G.L. Warren, and M.J. Wetzel. 1986. Des Plaines River Long-Term Monitoring Program. Phase I. Aq. Biol. Tech. Rep. 1986(6). Ill. Nat. Hist. Surv., Champaign, IL.

Sullivan, D. J., 2000. Nutrients and Suspended Solids in Surface Waters of the Upper Illinois River Basin in Illinois, Indiana, and Wisconsin, 1978–97: U.S. Geological Survey Water-Resources Investigations Report 99–4275, 57 p.

Talkington, L. 1991. Illinois River working for our state. Misc. Publication 128. Illinois State Water Survey, Champaign, IL.

Tazik, P.P. 1988. Des Plaines River Long-Term Monitoring Program. Phase III. Aq. Biol. Tech. Rep. 1988(5). Ill. Nat. Hist. Surv., Champaign, IL.

Tazik, P.P. and R.E. Sparks. 1987. Des Plaines River Long-Term Monitoring Program. Phase II. Aq. Biol. Tech. Rep. 1987(4). Ill. Nat. Hist. Surv., Champaign, IL.

Tazik, P.P., and S.T. Sobaski. 1992. Des Plaines River Long-Term Monitoring Program: Vegetation Analysis and Habitat Characterization. Aq. Ecol. Tech. Rep. 92/1. Ill. Nat. Hist. Surv., Champaign, IL.

Terrio, P.J. 1995. Water-quality assessment of the upper Illinois River Basin in Illinois, Indiana, and Wisconsin—Nutrients, dissolved oxygen, and fecal-indicator bacteria in surface water, April 1987 through August 1990: U.S. Geological Survey Water-Resources Investigations Report 95–4005, 79 p.

U.S. Army Corps of Engineers (ACOE). 2012. Illinois Waterway Locks & Dams. ACOE, Rock Island Dsitrict.

U.S. Atomic Energy Commission (AEC). 1973. Final Environmental Statement Related to the Operation of Dresden Nuclear Station, Units 2 and 3, Commonwealth Edison Company, Docket Nos. 50-237 and 50-249, November.

U.S. Department of Agriculture (USDA). 1998. Illinois Climate. http://www.nass.usda.gov/il/1998/9816.htm. Accessed 20 October 2008.

______________. 2001. Midewin National Tallgrass Prairie Proposed Land and Resource Management Plan. May.

U.S. Environmental Protection Agency (USEPA) Office of Information Resources Management. 1997. USEPA regulated facilities, point locations from Envirofacts for conterminous U.S. Digital Data Accessed.

U.S. Fish and Wildlife Service (USFWS). 2014. Illinois County Distribution: Federally Endangered, Threatened, and Candidate Species. http://www.fws.gov/midwest/endangered/lists/illinois-cty.html. December.

U.S. Geological Survey (USGS). 1995. Report 95-4005: Water-quality assessment of the upper

Illinois River Basin in Illinois, Indiana, and Wisconsin; nutrients, dissolved oxygen, and fecal-indicator bacteria in surface water, April 1987 through August 1990.

______________. 1998. Water-Resources Investigations Report 96-4135: Surface-Water-Quality Assessement of the Upper Illinois River Basin in Illinois, Indiana, and Wisconsin—Pesticides and Other Synthetic Organic Compounds in Water, Sediment, and Biota, 1975-1990. Urbana, Illinois.

______________. 1999. Ecological Status and Trends of the Upper Mississippi River System 1998: A Report of the Long Term Resource Monitoring Program; USGS Survey, Upper Midwest Environmental Sciences Center, LTRMP 99-T001. La Crosse, Wisconsin. April

______________. 2000. Water Year 1999 Annual Report.

______________. 2004. Circular 1230, Water Quality in the Upper Illinois River Basin, Illinois, Indiana and Wisconsin, 1999-2001.

Village of Channahon. 1983. License application.

Village of Channahon. 1990. License application.

Walk, J.W., M.P. Ward, T.J. Benson, J.L. Deppe, S.A. Lischka, S.D. Bailey, and J.D. Brawn. 2010. Illinois Birds, a Century of Change. Illinois Natural History Survey Special Publication 31, Champaign, IL.

Westlake, D.F. 1973. Aquatic macrophytes in rivers. A review. Pol. Arch. Hydrobiol. 20:31-40.

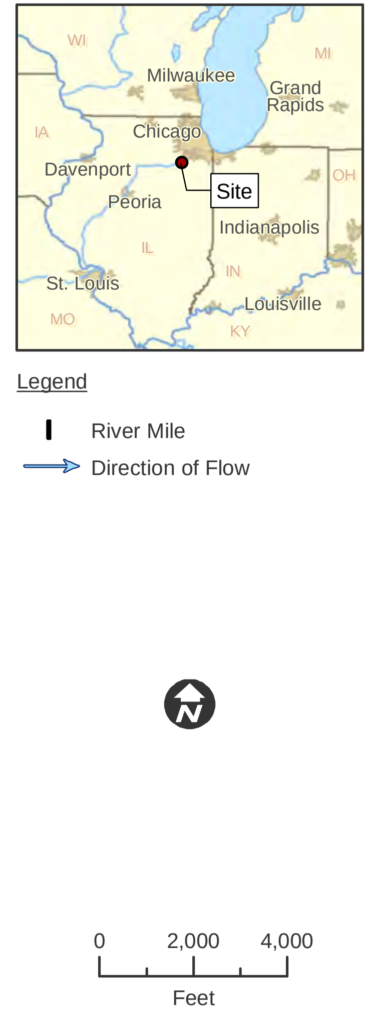
Wiley, M.J., and R.W. Gordon. 1984. Biological control of aquatic macrophytes by herbivorous carp. Part 2. Biology and ecology of herbivorous carp. Aq. Biol. Tech. Rep. (11). Ill. Nat. Hist. Surv., Champagne, IL.

Will County. 1990. Will County Land Resource Management Plan, Will County, Illinois. adopted 18 October 1990.

Wright, J.F., P.D. Hiley, S.F. Ham, and A.D. Berrie. 1981. Comparison of three mapping procedures developed for river macrophytes. Freshw. Biol. 11:369-380.

Zogorski, J.S., Blanchard, S.F., Romack, R.D., and Fitzpatrick, F.A. 1990. Availability and suitability of municipal wastewater information for use in a national water-quality assessment—A case study of the upper Illinois River Basin in Illinois, Indiana, and Wisconsin:U.S. Geological Survey Open-File Report 90–375, 68 p.

FIGURES

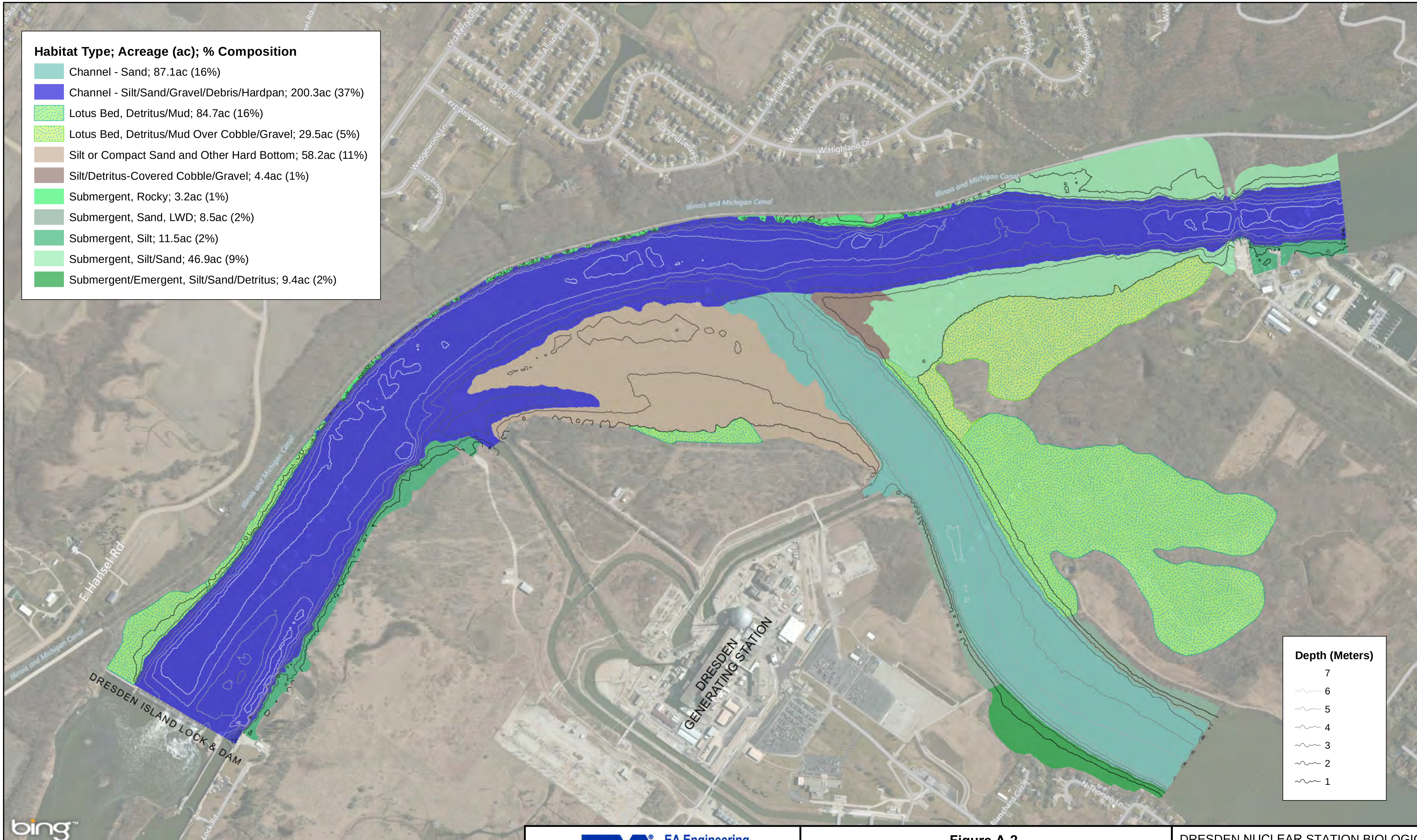


January, 2015

Figure A-1.
Location of the Kankakee,
Des Plaines, and Illinois Rivers
Near Dresden Nuclear Station

Document Path: C:\EA\projects\6157816\MXD\LocationMap.mxd

SOURCE: Bing Maps Hybrid ©2010 Microsoft Corporation and its data suppliers



EA Engineering, Science, and Technology, Inc.

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BJO	1500404	12/5/2014

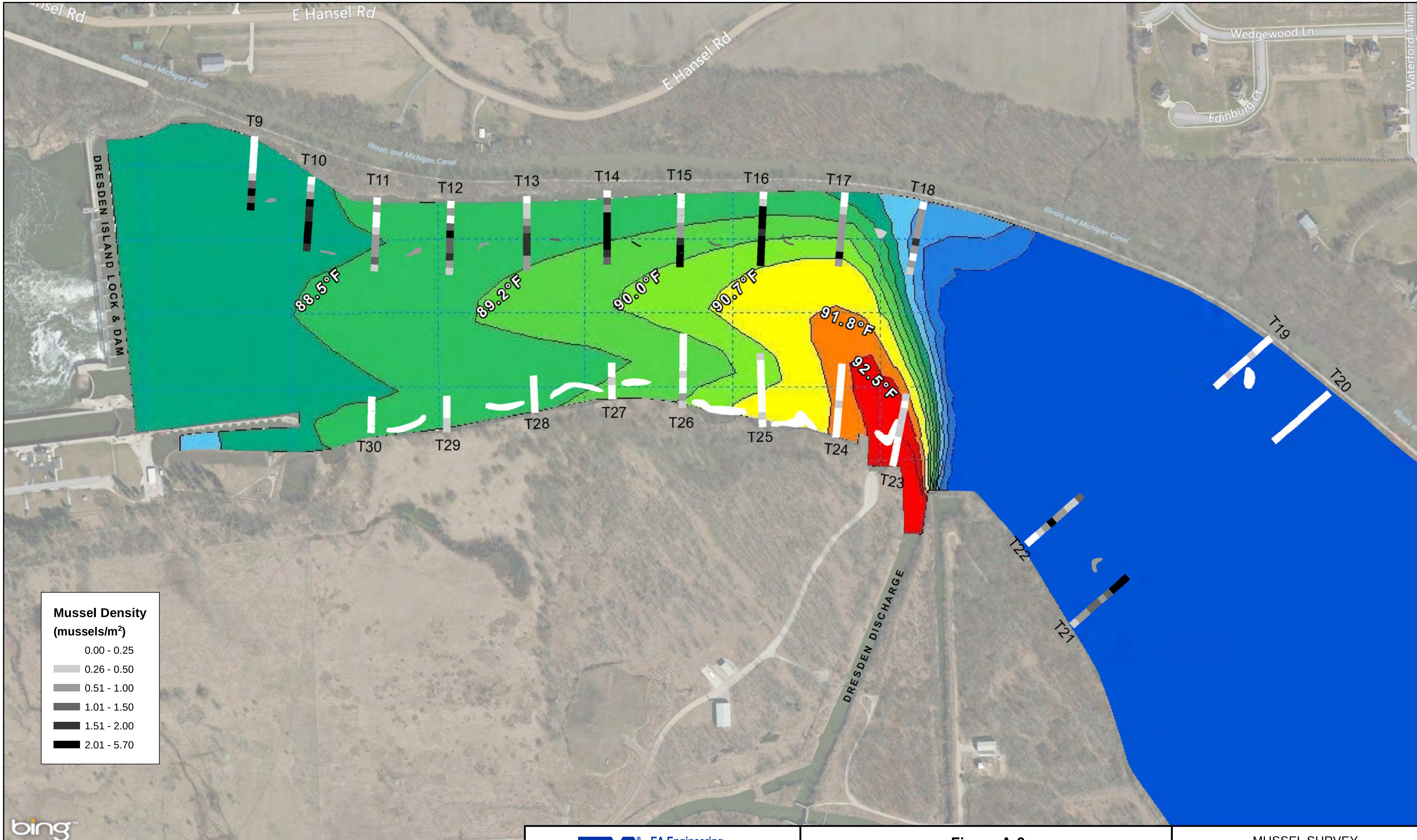
Figure A-2
Distribution of habitat in the Illinois, Des Plaines, and Kankakee Rivers within the area bounded by the hydrothermal model for the DNS cooling water discharge.

DRESDEN NUCLEAR STATION BIOLOGICAL MONITORING: MUSSEL SURVEY GRUNDY COUNTY, ILLINOIS

SCALE	FIGURE
1 inch = 800 feet	1

2014.12.05 C:\Users\bonelli\Desktop\Exelon\Dresden_Biological.mxd EA-Deerfield bonelli

SOURCE: Bing Maps Hybrid ©2010 Microsoft Corporation and its data suppliers



0 400 800 1,200 1,600 Feet

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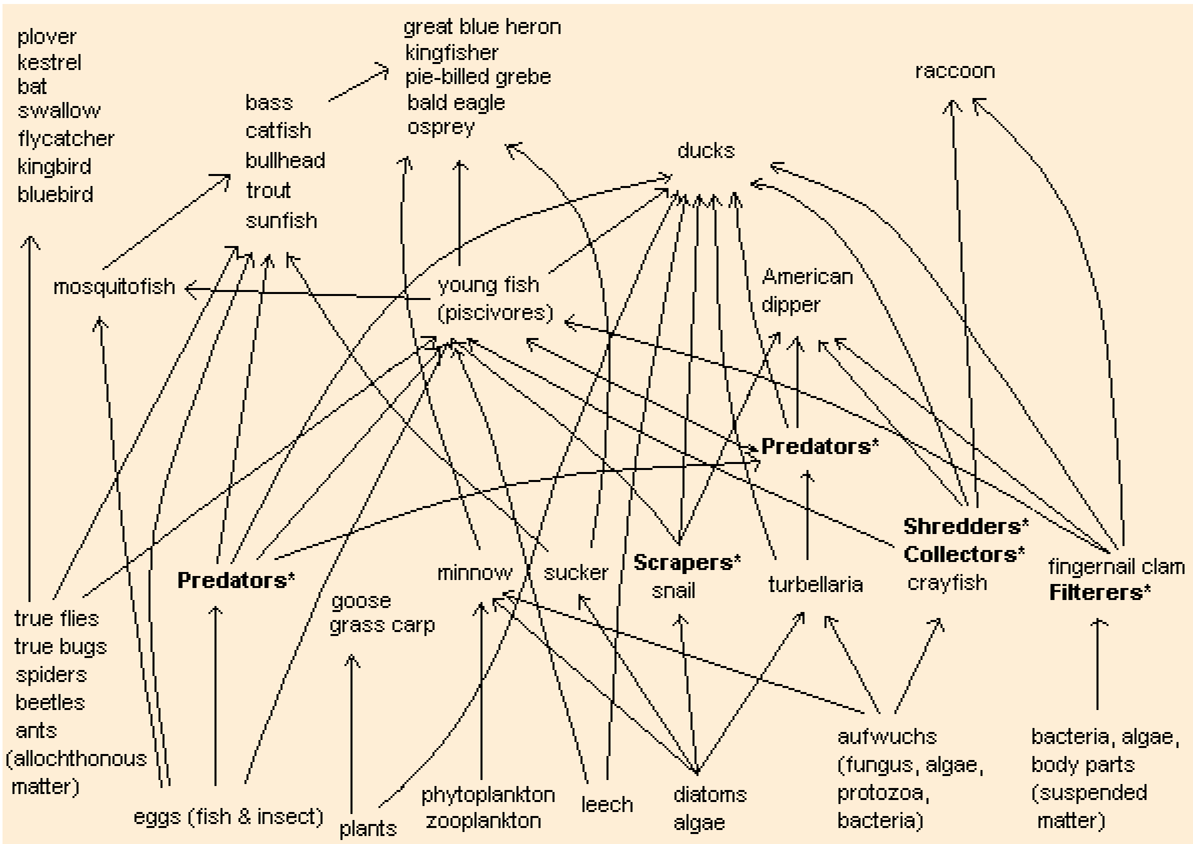
EA Engineering, Science, and Technology, Inc., PBC			**Figure A-3** MUSSEL SURVEY RESULTS AND THERMAL PLUME UNDER MEDIAN JULY RIVER CONDITIONS	MUSSEL SURVEY DRESDEN GENERATING STATION GRUNDY COUNTY, ILLINOIS	
DRAWN BY BJO	PROJECT NO 15004.04	DATE 1/28/2015		SCALE 1 inch = 400 feet	FIGURE

Figure A-4. Simplified food web for a typical river system



TABLES

Table A-1. Checklist of Fish Species Collected near Dresden Nuclear Station Upstream and Downstream of Dresden Island Lock and Dam, 1971-1989 and 1991-2014.

Common Name	Scientific Name	1971-1989	1991-2014
SPOTTED GAR	*Lepisosteus oculatus*	--	1
LONGNOSE GAR	*Lepisosteus osseus*	12	19
SHORTNOSE GAR	*Lepisosteus platostomus*	2	6
BOWFIN	*Amia calva*	1	--
SKIPJACK HERRING	*Alosa chrysochloris*	12	18
ALEWIFE	*Alosa sapidissima*	3	--
GIZZARD SHAD	*Dorosoma cepedianum*	15	20
THREADFIN SHAD	*Dorosoma petenense*	3	14
GOLDEYE	*Hiodon alosoides*	7	7
MOONEYE	*Hiodon tergisus*	4	1
RAINBOW SMELT	*Osmerus mordax*	--	1
CHINOOK SALMON	*Oncorhynchus tshawytscha*	--	1
NORTHERN PIKE	*Esox lucius*	4	6
MUSKELUNGE	*Esox masquinongy*	1	--
GRASS PICKEREL	*Esox niger*	5	7
CENTRAL STONEROLLER	*Campostoma anomalum*	6	14
GOLDFISH	*Carassius auratus*	14	6
GRASS CARP	*Ctenopharyngodon idella*	--	3
RED SHINER	*Cyprinella lutrensis*	10	11
SPOTFIN SHINER	*Cyprinella spiloptera*	13	20
STEELCOLOR SHINER	*Cyprinella whipplei*	2	--
COMMON CARP	*Cyprinus carpio*	15	20
SHOAL CHUB	*Macrhybopsis hyostoma*	--	2
SILVER CHUB	*Macrhybopsis storeriana*	1	2
SILVERJAW MINNOW	*Notropis buccatus*	--	1
HORNYHEAD CHUB	*Nocomis biguttatus*	3	11
RIVER CHUB	*Nocomis micropogon*	1	--
GOLDEN SHINER	*Notemigonus crysoleucas*	8	16
PALLID SHINER	*Hybopsis amnis*	--	11
SILVER CARP	*Hypophthalmichthys molitrix*	--	2
EMERALD SHINER	*Notropis atherinoides*	15	20
GHOST SHINER	*Notropis buchanani*	6	16
STRIPED SHINER	*Luxilus chrysocephalus*	9	20
COMMON SHINER	*Luxilus cornutus*	9	--
REDFIN SHINER	*Lythrurus umbratilis*	3	13
RIVER SHINER	*Notropis blennius*	4	--
BIGMOUTH SHINER	*Notropis dorsalis*	3	--
SPOTTAIL SHINER	*Notropis hudsonius*	12	20
ROSYFACE SHINER	*Notropis rubellus*	3	6
SAND SHINER	*Notropis stramineus*	9	20
MIMIC SHINER	*Notropis volucellus*	1	18
PUGNOSE MINNOW	*Opsopoeodus emiliae*	--	1

Table A-1 (Continued)

Common Name	Scientific Name	1971-1989	1991-2014
CHANNEL SHINER	*Notropis wickliffi*	--	1
SUCKERMOUTH MINNOW	*Phenacobius mirabilis*	2	7
BLUNTNOSE MINNOW	*Pimephales notatus*	15	20
FATHEAD MINNOW	*Pimephales promelas*	6	7
BULLHEAD MINNOW	*Pimephales vigilax*	15	20
CREEK CHUB	*Semotilus atromaculatus*	1	2
RIVER CARPSUCKER	*Carpiodes carpio*	14	20
QUILLBACK	*Carpiodes cyprinus*	12	20
HIGHFIN CARPSUCKER	*Carpiodes velifer*	3	6
WHITE SUCKER	*Catostomus commersonii*	13	10
NORTHERN HOG SUCKER	*Hypentelium nigricans*	1	8
SMALLMOUTH BUFFALO	*Ictiobus bubalus*	12	20
BIGMOUTH BUFFALO	*Ictiobus cyprinellus*	7	8
BLACK BUFFALO	*Ictiobus niger*	--	11
SPOTTED SUCKER	*Minytrema melanops*	4	8
SILVER REDHORSE	*Moxostoma anisurum*	10	19
RIVER REDHORSE	*Moxostoma carinatum*	3	8
BLACK REDHORSE	*Moxostoma duquesnei*	2	3
GOLDEN REDHORSE	*Moxostoma erythrurum*	11	20
SHORTHEAD REDHORSE	*Moxostoma macrolepidotum*	13	20
GREATER REDHORSE	*Moxostoma valenciennesi*	--	4
BLACK BULLHEAD	*Ameiurus melas*	10	2
YELLOW BULLHEAD	*Ameiurus natalis*	7	10
CHANNEL CATFISH	*Ictalurus punctatus*	15	20
STONECAT	*Noturus flavus*	2	1
TADPOLE MADTOM	*Noturus gyrinus*	2	5
FLATHEAD CATFISH	*Pylodictis olivaris*	6	18
TROUT-PERCH	*Percopsis omiscomaycus*	6	15
BANDED KILLIFISH	*Fundulus diaphanus*	--	2
BLACKSTRIPE TOPMINNOW	*Fundulus notatus*	1	13
WESTERN MOSQUITOFISH	*Gambusia affinis*	--	11
BROOK SILVERSIDE	*Labidesthes sicculus*	9	20
WHITE PERCH	*Morone americana*	--	11
WHITE BASS	*Morone chrysops*	13	16
YELLOW BASS	*Morone mississippiensis*	8	11
STRIPED BASS	*Morone saxatilis*	3	2
ROCK BASS	*Ambloplites rupestris*	15	20
GREEN SUNFISH	*Lepomis cyanellus*	15	20
PUMPKINSEED	*Lepomis gibbosus*	9	9
WARMOUTH	*Lepomis gulosus*	--	7
ORANGESPOTTED SUNFISH	*Lepomis humilis*	13	20
BLUEGILL	*Lepomis macrochirus*	14	20
REDEAR SUNFISH	*Lepomis microlophus*	2	5
NORTHERN SUNFISH	*Lepomis peltastes*	6	19
SMALLMOUTH BASS	*Micropterus dolomieu*	15	20
LARGEMOUTH BASS	*Micropterus salmoides*	14	20

Table A-1 (Continued)

Common Name	Scientific Name	1971-1989	1991-2014
WHITE CRAPPIE	*Pomoxis annularis*	13	13
BLACK CRAPPIE	*Pomoxis nigromaculatus*	12	20
WESTERN SAND DARTER	*Ammocrypta clara*	--	3
RAINBOW DARTER	*Etheostoma caeruleum*	--	2
BLUNTNOSE DARTER	*Etheostoma chlorosoma*	--	1
JOHNNY DARTER	*Etheostoma nigrum*	2	17
ORANGETHROAT DARTER	*Etheostoma spectabile*	1	--
BANDED DARTER	*Etheostoma zonale*	1	7
YELLOW PERCH	*Perca flavescens*	4	4
LOGPERCH	*Percina caprodes*	13	20
BLACKSIDE DARTER	*Percina maculata*	1	10
SLENDERHEAD DARTER	*Percina phoxocephala*	3	17
RIVER DARTER	*Percina shumardi*	--	1
SAUGER	*Sander canadensis*	--	4
WALLEYE	*Sander vitreus*	6	14
FRESHWATER DRUM	*Aplodinotus grunniens*	12	20
ROUND GOBY	*Neogobius melanostomus*	--	9
TOTAL SPECIES		**83**	**95**

APPENDIX B

Information Supporting Representative Important Species Rationale: Biothermal Assessment – Predictive Demonstration

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1.0 ANALYTICAL METHODOLOGY – COMPARISON WITH PRIOR 316(A) ASSESSMENT

Commonwealth Edison (Edison) filed a §316(a) Demonstration (Edison 1980) with the Illinois Pollution Control Board to support its request for alternative thermal limits (ATLs) for the DNS. That Demonstration used a retrospective analysis of aquatic community monitoring data collected during DNS operations in indirect open-cycle mode, between 15 June and 30 September. These biological data were used to demonstrate that the existing thermal limitation requiring closed cycle cooling year-round was “more stringent than necessary to assure the protection and propagation of a balanced, indigenous population of shellfish, fish, and wildlife.” The Demonstration showed no prior appreciable harm to the aquatic community resulted from indirect open cycle operations (between 15 June and 30 September) that took place between September 1971 and October 1974. The DNS Simulation Model provided a qualitative analysis of thermal conditions in the Dresden Pool under two operating scenarios (closed cycle year round and indirect open cycle 15 June through 30 September).

The present Demonstration, conducted to consider whether the existing ATLs continue to satisfy the §316(a) criteria, utilizes two technical approaches to evaluate the effects of Station operations on water temperature, aquatic habitat utilization, and the condition of the aquatic community. The first approach (Appendix C), similar to the 1980 Demonstration, presents a retrospective analysis of the balanced indigenous community (BIC) to demonstrate the absence of prior appreciable harm to this community, relying on an expanded database of nearly 20 years of additional monitoring of the aquatic community collected subsequent to the 1980 Demonstration. This extensive database, collected under operating conditions similar to the proposed ATLs, provides a rigorous test for demonstrating the absence of prior appreciable harm. The second approach, not included in the 1980 Demonstration, uses quantitative hydrothermal modeling to predict thermal conditions under various operating and ambient flow conditions, integrated with metrics of thermal requirements and tolerance limits identified in scientific literature for selected aquatic species representative of the BIC. This prospective analysis is used to predict the response of the aquatic community to the effects of the DNS thermal discharge plume on the biological community and receiving water body. For this Demonstration, a three-dimensional mathematical model (MIKE 3) that was used to estimate ambient temperatures under various river flow conditions and DNS thermal plume conditions under 3 representative flow and temperature scenarios (Appendix D), including conditions representative of the proposed ATLs. The model was calibrated and validated using a recent bathymetric survey and three field surveys of water temperature and velocity conducted under various river flow and weather conditions during 2013-2014. The calibrated model was used to estimate water temperature within each model cell under various ambient flow and station operating scenarios to estimate dilution and dispersion of elevated thermal plume temperatures. Model estimated cross section and bottom water temperatures are compared to biothermal metrics to estimate the extent of otherwise available aquatic habitat that would be excluded or would be at less than optimum conditions for selected life history functions (e.g., spawning, growth, survival) of representative important species (RIS) due to water temperature.

2.0 ENVIRONMENTAL CONDITIONS STUDIED AND HYDRODYNAMIC MODEL INPUTS

2.1 Hydrodynamic Model

Thermal modeling utilized DHI's MIKE3 model (DHI, 2012), which provides a state-of-art, three-dimensional modeling framework. The model domain included portions of both the Des Plaines and Kankakee Rivers upstream of their confluence and extended downstream to the Dresden Island Lock and Dam. Bathymetric mapping, three-dimensional field surveys of water temperature and flow, and meteorological conditions were used as inputs to calibrate and validate the MIKE3 model used to predict the configuration and temperature distribution of the DNS thermal plume under selected operating, river flow, and weather conditions. The model grid (Appendix D, Figure D-12) is composed of 1,530 rectangular or triangular cells divided into 12 vertical layers. The upper three layers were confined to a maximum 1.0 m depth. Below 1.0 m, layer thickness increased from 0.5 m to 1.0 m in the deepest layer. These additional layers were adjusted as necessary to extend to the river bottom. The shape and horizontal dimensions of the cells vary depending on complexity of mixing conditions in that portion of the model grid; the finest model grid was constructed in the vicinity of the thermal plume to increase the model resolution in the primary area of interest for the biothermal analysis.

2.2 Station Operating and Environmental Conditions Evaluated

This analysis examines three scenarios of flow and water temperature in conjunction with operation of DNS at full load using indirect open cycle cooling between 15 June and 30 September. These scenarios include:

1. Typical flow (50^{th} percentile) and water temperature (60^{th} percentile);
2. Typical high temperature conditions (5^{th} percentile flow and 95^{th} percentile water temperature); and
3. Extreme meteorologic/high temperature conditions similar to those that occurred during the exceptional heat wave in early July 2012.

More detailed discussion of flow and ambient river temperature conditions for these scenarios is presented in Section 2.5.1.

2.3 Biothermal Metrics Evaluated

The prospective analysis of potential thermal effects on aquatic biota integrates sophisticated hydrothermal modeling (Appendix D) of the dynamics of the thermal plume under selected DNS operations and river flow conditions with critical thermal response metrics for the selected RIS (Appendix B, Section 3). Data from scientific literature are used to characterize the thermal sensitivity of each of the RIS and critical life stages that could potentially utilize the area influenced by the DNS thermal discharge plume. The potential effects of the DNS thermal discharge on RIS were evaluated for five categories of thermal effects as recommended in the Draft *Interagency Technical Guidance Manual* (USEPA and NRC 1977) (Interagency Guidance Manual):

1. Temperature requirements for survival of juveniles and adults.

2. Avoidance temperature.

3. Temperature requirements for early development.

4. Optimum temperature for performance and growth.

5. Thermal shock tolerance.

This information was then compared to the spatial and temporal characteristics of, and thermal gradients in the thermal plume to predict the potential effects of the plume on the RIS under each assessment scenario. The primary biothermal metrics used in this analysis were:

- Spawning temperature range
- Optimum temperature for growth
- Temperature avoidance
- Chronic thermal mortality (prolonged exposure).

2.3.1 Spawning

For many aquatic species the maturation of gonadal tissue, the onset of spawning migration and spawning, and completion of spawning are closely tied to water temperature (among other environmental and physiological triggers). Most records of spawning temperatures are based on field observation of spawning runs and physiological condition of gonads at various locations within the geographic range of the species. When adequate thermal range data have been documented, a polygon was plotted on the thermal effects figure that indicates the reported temperature range for spawning based on the seasonal period during which spawning typically occurs in the vicinity of DNS.

2.3.2 Growth

Water temperature plays a significant role in the growth of aquatic species, affecting metabolic rates and the energy expended seeking and capturing food material. The optimum temperature range for growth occurs when there is a balance between the energy expended capturing food, energy for maintenance, and for growth. Most freshwater fish species exhibit seasonal patterns in growth; for most temperate species growth is minimal during the winter and peaks between spring and fall, while boreal species often exhibit minimal growth during peak summer temperatures or move to deeper, cooler waters. Much available data for temperature and growth is for smaller species or early life stages that are more readily reared under laboratory or hatchery conditions. The relationship between temperature and growth varies. During some periods of the year, portions of the thermal plume may provide optimal temperatures for growth that are not present with available ambient temperatures (e.g., spring and fall for many species). Outside of the optimum temperature range, growth can continue to occur at a lower rate. Aquatic organisms typically prefer water temperatures that are within the optimum range for growth; preferred temperatures can be used as a surrogate for the optimum range of growth and performance.

2.3.3 Temperature Avoidance

Many species of fish and invertebrates actively avoid potentially stressful temperatures, both high and low, depending on their acclimation conditions. Although this ability minimizes the potential exposure of organisms to temperatures that could result in mortality, avoidance of elevated temperatures may preclude access to critical habitat located within a thermal discharge plume. When avoided temperatures exist over a large enough cross-section of the receiving water body, passage of organisms upstream or downstream of the discharge location may be inhibited. As with many other thermal effects parameters, the water temperatures avoided by an organism are typically dependent on an organism’s acclimation history.

2.3.4 Thermal Mortality

Mortality associated with temperature has been measured using several metrics (e.g., Upper Incipient Lethal temperature [UILT], Critical Thermal Maximum [CTM], TL50, TL95, LD 50, and LD100). These data can also be qualified by rate of temperature increase and by the exposure duration ranging from seconds (thermal shock, typical of rapid entrainment into higher temperature portion of the thermal mixing zone) to days (typical of the experience of organisms exposed to temperatures in the more diluted portion of the plume).

Exposure to rapid short-term changes in water temperature can cause mortality to organisms passing through, or resident within, portions of the thermal discharge plume. Thermal shock can occur in conjunction with a rapid decrease in water temperature, cold shock, or a rapid increase in water temperature associated with plume entrainment. The attraction of some species to thermal discharge plumes during winter and early spring when ambient temperatures are low has been well documented. During a station shutdown when the heat source is suddenly discontinued, organisms acclimated to warm plume temperatures can be stressed to the point of mortality when they are suddenly returned to colder ambient temperatures, depending on the rate and magnitude of the temperature decrease. In contrast, planktonic organisms entrained into the thermal plume near the discharge point with ambient dilution water can experience rapid short-term increases in temperature that may be capable of causing mortality. Similar to general thermal mortality discussed above, thermal shock has been measured using various metrics including the TL95, TL50, and LD50 from high temperature, short exposure tests, and CTM.

CTM is estimated with tests where organisms are subjected to a controlled rate of temperature increase over time (e.g., 0.5 °C/min [0.9°F/min]) until loss of equilibrium; resulting CTM metrics can be difficult to compare to real-world conditions due to the variation in test methods (e.g., temperature step, rate of increase, observed test end point). The tolerance limit for 95 percent of test organisms (TL95) measures the temperature at which 95 percent of the organisms survive for the exposure period; that is, negligible mortality associated with temperature. In contrast, lethal dose to 50 percent of the test organisms (LD50) measures the temperature causing mortality to 50 percent of the test organisms. Thus a TL50 and LD50 would be equivalent and the TL95 would be comparable to an LD5.

Information for metrics in each of these categories was identified through review of scientific literature including peer-reviewed literature, compilation reviews, and utility industry project reports for studies conducted to support various §316(a) Demonstrations. Other measures of organism response to temperature (including preference, thermal shock, cold shock) were also reviewed as the relative relationship of these various metrics provides a level of quality assurance for evaluating the reliability of individual values reported in the scientific literature and project laboratory or field study reports.

As water temperature increases, organisms progressively exhibit a range of integrated physiological and behavioral responses including avoidance, impaired growth and reduced feeding, impaired swimming ability, loss of equilibrium, and finally mortality. Genetics and acclimation history affect the physiological response of species and individual organisms to abiotic factors, such as temperature, in their environment. Laboratory studies are able to control a range of variables that can affect an organism’s physiology in order to isolate and assess the specific influence of temperature under those specific conditions. In contrast, organism in their natural environment rarely experiences constant abiotic conditions, but are adapted to considerable variability. Because most of these physiological and behavioral responses are affected by acclimation temperature, it is important that the results from laboratory studies of thermal effects are evaluated relative to acclimation history. It is also important to understand, that while potentially lethal temperatures may exist in a waterbody or near a thermal discharge, it is unusual to observe mortality related to elevated water temperatures because of the ability of many organisms to avoid potentially lethal temperatures.

2.4 Representative Important Species (RIS) Evaluated

2.4.1 Selection of RIS

Candidate RIS were selected from a checklist of native fish species collected during surveys of Dresden Pool near DNS and downstream of the Dresden Island Lock and Dam. Surveys of the Dresden Pool were conducted during 17 years between 1994 and 2014 and surveys downstream of Dresden Island Lock and Dam were conducted during 15 years between 1994 and 2014

(Appendix G). Electrofishing and seining between 1994 and 2014 documented the presence of 96 fish species in the vicinity of DNS (Table B-1). The catch included 20 species that dominated the abundance or biomass of the fish community over much of this period (Tables B-2 and B-3). These 20 species were collected in all four river survey segments (Des Plaines River, Kankakee River, and Illinois River upstream and downstream of the Dresden Island Lock and Dam) and during 18 of 19 survey years in at least one segment between 1991 and 2013 (Table B-2). Seventy-one species were collected in at least three of the survey river segments while 19 species were collected in only one river survey segment. Twenty-six species were collected during only one or two annual surveys (Table B-2).

To adequately assess the potential effects of DNS's thermal discharge plume and operating conditions on all of these species would be extremely difficult and, in the case of many species with minimal available data on their thermal requirements, nearly impossible. Recognizing this, the Interagency Guidance Manual proposes an approach for predictive demonstrations (Type II[1]) that relies on selection and assessment of effects on a subset of RIS. The rationale for this approach is that the species selected for detailed analysis of potential thermal effects are representative of key species or groups of species that comprise the dynamic, complex aquatic community affected by the thermal discharge, that is, a BIC. Some species are selected because they fill critical roles seasonally or during occasional years. Interagency Guidance Manual list six categories of fish that may be considered RIS:

1. Commercially or recreationally important species;

2. Threatened or endangered species;

3. Species critical to ecosystem structure and function of the receiving water body;

4. Species potentially capable of becoming a localized nuisance;

5. Species necessary in the food chain; and

6. Species representative of critical thermal requirements, but which themselves may not be important.

Factors considered in the selection of RIS for the DNS prospective biothermal analysis include:

- Numerical dominance or prominence in the BIC (see Appendix C);

- Their role in energy transfer through the aquatic food chain as important forage or predator species;

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[1] The Interagency Guidance Manual also discusses two other predictive demonstrations Type 111 Low Potential Impact and Type 111 Regular (Biological, Engineering, and Other Data) and a Non-Predictive Demonstrations - Type I (Absence of Prior Appreciable Harm). RIS discussions are not required in the Type 1 or in the Regular Type 111 and TYPE 111 Low Potential Impact unless a particular biotic category has a high potential impact

- Important links between primary producers, primary consumers, and secondary consumers;
- Similarity of their food, habitat, and life history requirements to groups of other species utilizing aquatic habitat in the vicinity of the DNS thermal plume;
- Support of important commercial or recreational fisheries;
- Thermally sensitive species;
- Species of special interest or concern (e.g., rare, threatened, or endangered species);
- Non-native and potential nuisance species; and
- Species with unique or critical habitat or life history stages in the vicinity of the thermal discharge.

Only fish species were selected as RIS for the DNS thermal evaluation because fish represent the top of the food chain, are important to the public because of their recreational and/or commercial value, and because their overall wellbeing shows that the lower trophic levels are supporting the trophic levels occupied by the RIS. Lower trophic levels (e.g., phytoplankton, zooplankton, periphyton, and benthic macroinvertebrates) were not selected as RIS because of a general lack of thermal endpoint data and historical §316(a) studies have shown only localized thermal effects on lower trophic levels that have not resulted in adverse harm (Duke/Fluor Daniel 1992). The potential effects of thermal discharges from DNS on these lower trophic levels are addressed as part of the retrospective assessment (Appendix C of this Demonstration) demonstrating no prior appreciable harm to the BIC.

Twelve fish species were selected as RIS (Table B-4) for the DNS thermal evaluation. Each of these species represents one or more of the categories listed above from the Interagency Guidance Manual. In order to be a candidate, species had to have published thermal tolerance endpoints in order to conduct the required thermal evaluation. Based on these criteria, the following 12 species were selected as RIS:

- Gizzard shad
- Common carp
- Golden redhorse
- White sucker
- Channel catfish
- Emerald shiner
- Largemouth bass
- Smallmouth bass
- Bluegill
- Black crappie
- Logperch
- Freshwater drum

Except for common carp, hybrids and exotic species were excluded. Forty-two species considered incidental (I) and occasional (O) constituents of the community were excluded from the RIS list; these species were collected in only 1 study reach and/or during less than 5 sampling years (shaded in Table B-4). When several congeneric species were common in the vicinity of DNS, generally only one was selected as an RIS. For example, of the abundant minnows collected near DNS (emerald shiner, spotfin shiner, bluntnose minnow, and bullhead minnow), only emerald shiner was chosen as it has slightly lower thermal endpoints than the other three species. One exception, both congeneric smallmouth bass and largemouth bass were selected because both are the target in recreational fisheries.

Federally threatened and endangered (T&E) fish species have not been collected in Dresden Pool or adjacent study areas in the upstream Des Plaines and Kankakee Rivers, or downstream of Dresden Island Lock and Dam. Five state-listed fish species were collected. The state-listed threatened river redhorse (*Moxostoma carinatum*) and endangered greater redhorse (*M. valenciennesi*) were collected infrequently and in low numbers upstream and downstream of the Dresden Island Lock and Dam. The pallid shiner (*Hybopsis amnis*), also state-endangered in Illinois, was first collected from the DNS study area in 2001 and has been collected each year since. It was also collected upstream and downstream of the Dam but primarily upstream in the Kankakee River. The state-endangered western sand darter (*Ammocrypta clara*) was collected infrequently in low numbers and downstream of the Dresden Island Lock and Dam. The state-threatened banded killifish (*Fundulus diaphanus*) was first collected as part of the DNS monitoring program in 2013 and were collected again in 2014.

The selected RIS include species that feed primarily on one or several of the following: detritus, phytoplankton, zooplankton, crustaceans, mollusks, insect larvae, other invertebrates and benthos, and fish. They include pelagic and demersal species that utilize habitats in channel, pool, run, riffle, or backwater areas. Individual RIS have preferences for a variety of substrate, including hard or soft bottom with mud, muck, and silt, sand, gravel, cobble, and rock; some RIS prefer dense vegetation or structure (e.g., roots, woody debris, and boulders). The selected RIS include species representative of various levels of the food chain including primary consumers, omnivores, forage species, and top predators, and species that are common targets for recreational or commercial fisheries.

In general, species that occur infrequently or in low abundance (I or O in Table B-4) in the vicinity of DNS were excluded from consideration as RIS, except for state or federally listed sensitive species (e.g., pallid shiner, river redhorse, greater redhorse) where thermal data are available or species considered to be thermally sensitive (e.g., white sucker, black crappie). The area in the vicinity of DNS does not provide unusual, unique, or critical habitat that would be necessary to complete important life history functions (Table B-4) for any of the incidental or occasional species that were excluded (Table B-4, shading).

Other dominant and common species not selected as RIS have habitat, feeding, and life history requirements very similar to the selected RIS, which is the rationale for use of RIS to evaluate the effects of the discharge on aquatic biota. The trophic relationships within the aquatic community in the vicinity of DNS for which each of the selected RIS are representative are summarized below and in Table B-4:

- Gizzard shad – the most common and abundant pelagic species in the vicinity of DNS feeding primarily on invertebrates in mud substrate as well as zooplankton and phytoplankton. Juvenile gizzard shad are an important component of the forage base.
- Common carp – omnivore and scavenger; non-native species that is considered a nuisance species where it occurs in high abundance.
- Golden redhorse – representative of a diversity of 15 species in the sucker family (Catostomidae) collected in the area of DNS including other redhorse species, buffalo, sucker, and carpsucker. Golden redhorse is a surrogate for the state-listed river redhorse and greater redhorse.
- White sucker – considered a thermally sensitive member of the sucker family, although rarely collected in the study area.
- Channel catfish – representative of a variety of catfish species collected in the vicinity of DNS and can be an important recreational target species.
- Emerald shiner – one of the most abundant forage species in the area and is representative of the diversity of shiners and minnows in the aquatic community. Emerald shiner is a surrogate for the state-listed pallid shiner.
- Largemouth bass and smallmouth bass – representative of an array of piscivorous top predators in the vicinity of DNS and important targets of recreational anglers.
- Bluegill – representative of a variety of sunfish species (Centrarchidae) collected near DNS and is an important target for recreational anglers.
- Black crappie – considered a thermally sensitive recreational species also in the Centrarchid family, but relatively uncommon in the vicinity of DNS.
- Logperch – representative of a variety of darter species collected occasionally in the vicinity of DNS.
- Freshwater drum – an important demersal species feeding extensively on mollusks and crawfish that support commercial and recreational fisheries. The species is also an important host species for glochidia, the larval life stage of several freshwater mussel species.

More detailed life history information and thermal requirements relevant to their interaction with the DNS thermal discharge are summarized for each RIS in the following subsections. Sources of the life history information summarized below include Scot and Crossman (1973), Smith (1979), Trautman (1981), Etnier and Starnes (1993), Pflieger (1997), and Page and Burr (2011).

2.4.2 Gizzard shad (*Dorosoma cepedianum*)

Gizzard shad is an important forage species in the aquatic ecosystem near DNS. It is a prolific warmwater species that produces abundant juvenile year classes used as forage by top predators such as largemouth bass. Gizzard shad is typically one of the most abundant species captured during electrofishing and seining surveys of the Des Plaines, Kankakee, and Illinois Rivers. It occurs throughout the state and the Illinois River drainage. This schooling species is most common in large rivers and reservoirs and is often seen in large schools in the upper water column. Gizzard shad is in the simple breeding guild (i.e., broadcast spawning without parental care) producing adhesive eggs that adhere to vegetation and substrate. In the Illinois River and its tributaries, spawning occurs in open water from about late April through June. No gizzard shad eggs were collected during the 2005-2006 ichthyoplankton surveys at DNS.

Ambient water temperatures when the first yolk-sac larvae were observed in the vicinity of DNS during 2005-2006 were between 10°C (50°F) and 15°C (59°F) (EA 2007). Peak densities of yolk-sac larvae occurred from mid-May to mid-June in 2005 and late-May to early July in 2006; water temperatures during these periods were 14°C (57.2°) to 27°C (80.6°F). Post yolk-sac larvae were most abundant during June in 2005 and mid-June to mid-July 2006 at a temperature range of 18°C (64.4°F) to 28°C (82.4°F).

Annual electrofishing catches from 1991 through 2014 near DNS averaged 1,075 gizzard shad (range = 422 to 2,019). It was the most or second most abundant species collected during 19 of the 20 years surveyed (Table B-3). Gizzard shad were among the 10 most abundant species in beach seine sampling during the same period. Annual mean electrofishing catch rates were generally higher in the Kankakee and Illinois Rivers upstream of the Dresden Island Lock and Dam than in the Des Plaines River or downstream of the Dresden Island Lock and Dam. Its average biomass since 2000 has ranked second highest accounting for 15 percent of the mean biomass. Abundance of gizzard shad increased from a seasonal low in spring (prior to 15 June), through summer, and into fall (after 30 September).

2.4.3 Common carp (*Cyprinus carpio*)

Common carp, a non-native, warmwater species introduced to Lake Michigan in the 1800s (Fuller et. al 1999), was collected during all fish survey years in the vicinity of DNS. When abundant, common carp are considered a nuisance species; particularly during spawning season common carp can be responsible for high turbidity levels as they thrash about in shallow weed beds and over silty substrates. Since 2000 common carp has not ranked higher than 12th (average rank, 15) in abundance and except in 2001, fewer than 100 common carp have been collected in all gear annually since 1994 (Table B-3). They are in the Illinois River up and downstream of Dresden Island Lock and Dam and in the Kankakee River carp have generally declined in abundance over the last decade compared to the early 1990s. Although they were not numerically abundant (Table B-3), common carp comprised at least 16 percent of the annual biomass (Appendix C). The disparity between the numerical rank and biomass rank reflects the large average size of common carp routinely collected.

Common carp spawn in shallow weedy areas during spring and early summer; eggs are broadcast over debris and vegetation. Eggs were collected on one sampling date in mid-May 2006 during ichthyoplankton sampling in the vicinity of DNS; no eggs were collected in 2005 (EA 2007). Yolk-sac and post yolk-sac larvae were collected in the Kankakee River and at the DNS cooling water intake and discharge between mid-May and the first week of July during 2005. During 2006 larvae were collected intermittently between early May and late August. During the week prior to collection of the first carp yolk-sac larvae, water temperatures in the Kankakee River upstream of DNS were between 10°C (50°F) and 15°C (59°F). Common carp eggs and larvae accounted for less than one percent of the ichthyoplankton collected in the vicinity of DNS during 2005 and 2006.

2.4.4 Emerald shiner (*Notropis atherinoides*)

Emerald shiner is a native forage species that utilizes nearshore habitats in shallow water. It is most common in open water near the surface and avoids dense vegetation (Trautman1981). Emerald shiner is in the simple breeding guild (i.e., broadcast spawning without parental care). Spawning occurs in open water from about May through June when water temperatures are 22°C (71.6°F) to 24°C (75.2°F) (ESE 1992). Few emerald shiner larvae and early juveniles were identified in samples collected during the 2005-2006 ichthyoplankton survey in the vicinity of DNS (EA 2007). Yolk-sac larvae, post yolk-sac larvae, and early juveniles of the Cyprinid family were collected between mid-May and late August. Water temperatures during the week prior to the first observation of cyprinid yolk-sac larvae were between 15°C (59°F) and 20°C (68°F). Peak larval abundance occurred between early June and early July in both years (EA 2007). Early juveniles were most abundant in early August during 2005 and from early July through mid-August during 2006 (EA 2007).

Mature and immature shiner were collected during all except one year and was the most abundant minnow species collected near DNS (Table B-3). It was generally the first or second most common species collected by beach seine and electrofishing between 1991 and 2014.

2.4.5 Golden redhorse (*Moxostoma erythrurum*)

Golden redhorse is a native riverine species in the sucker family, widely distributed in Illinois that prefers clear rivers and medium-sized streams with gravelly riffles, permanent pools, and moderate currents. Habitat preference, spawning habits, and food preference is similar to many other redhorse sucker species including the state-listed river redhorse. Adults grub in the bottom substrate in riffles and adjacent pools, selectively feeding on insect larvae and other benthic invertebrates. Juveniles feed in backwater areas on algae and micro-crustaceans. Redhorse are a popular sport fish for hook and line anglers.

Golden redhorse typically spawn in riffle habitat during April and May; eggs are dispersed over sand and gravel substrate with no parental care. In larger rivers, adults move into tributaries to spawn as water temperatures increase in the spring. During the 2005-2006 ichthyoplankton survey at DNS, early life stages of golden redhorse were not specifically identified in collections taken in the vicinity of DNS (EA 2007). *Moxostoma* spp. yolk-sac larvae and post yolk-sac larvae were collected in the Kankakee River between mid-May and late June with peak densities

(120-140 organisms per million gallons) in early June. Water temperatures during the week prior to the first observation of *Moxostoma* yolk-sac larvae were between 15°C (59°F) and 20°C (68°F). Early juveniles were collected in June during the 2006 survey. *Moxostoma* spp. was not collected in the vicinity of the Dresden cooling water intake or discharge (EA 2007).

Mature and immature golden redhorse were collected each sampling year from 1991-2014; it was the ninth most abundant species collect by electrofishing and fifteenth collected by beach seine over this period (Table B-3). It is the most abundant of five redhorse species collected near DNS. Its average biomass ranked seventh highest since 2000 accounting for 4 percent of the ten-year mean biomass. Golden redhorse accounted for two to four percent of the annual numerical electrofishing catch between 1991 and 2014 (Table B-3). The beach seine catch per haul for golden redhorse increased steadily between 2000 and 2007 in the Kankakee and Des Plaines Rivers, followed by a sharp decline between 2008 and 2014. Abundance in the Illinois River upstream and downstream of the Dresden Island Lock and Dam remained low in beach seines and demonstrated no trend over this period. The catch per hour for electrofishing was also relatively high, particularly in the Kankakee and Des Plaines Rivers from 2002 to 2008 and declined after 2008.

2.4.6 White sucker (*Catostomus commersonii*)

White sucker is a native, demersal warmwater species, widely distributed in Lake Michigan and throughout Illinois. It prefers sand and coarse substrates in clear creeks and small rivers (Smith 1979), but can be found in habitat with silt and fine sediment. White sucker is not common in the vicinity of DNS, but is included in this thermal assessment because it is considered to be relatively sensitive to increases in summer water temperatures above ambient. Spawning occurs during April and May over gravel substrate in riffles and pools; eggs are broadcast with no parental care and typically hatch in approximately three weeks depending on water temperature. During 2005 ichthyoplankton surveys (EA 2007), white sucker post yolk-sac larvae were collected in the Kankakee River during the second week of June. Yolk-sac and post yolk-sac larvae were collected in the Kankakee River during 2006 between the last week of May and late June. Water temperatures during the week prior to the first observation of white sucker yolk-sac larvae were between 17°C (62.6°F) and 23°C (73.4°F). Post yolk-sac larvae were collected near the DNS cooling water intake once in mid-July 2006; no early life stages of white sucker were collected in the vicinity of the DNS cooling water discharge in either year.

White sucker comprise less than one percent of the overall catch in surveys between 1994 and 2014 and have been collected in four or fewer years over that period in the study reaches of the Illinois, Des Plaines, and Kankakee Rivers (Table B-3). They were only collected in the Kankakee River upstream of DNS in one annual survey. White sucker was not collected between 1993 and 2004 by electrofishing or between 1993 and 2006 by beach seine.

2.4.7 Channel catfish (*Ictalurus punctatus*)

Channel catfish is a common native sport and food fish widely distributed in Illinois. It is usually found in greatest abundance in fast-flowing, medium to large rivers with sand and gravel-substrates, but can tolerate a wide range of habitats that exist near DNS. Adults typically inhabit deep water in large pools near submerged logs, debris, and other cover. Juvenile catfish feed primarily on small insects; adults are omnivores and scavengers, feeding on fish, crayfish, mollusks, insects, plant material, and other organic material. Channel catfish is in the complex breeding guild. They use natural cavities and undercut banks to lay their eggs. The male builds the nest and remains over the nests to fan the fertilized eggs and guard hatched larvae. As a result of this behavior, eggs and larvae are uncommon in ichthyoplankton surveys. Spawning typically occurs in June and July. A few yolk-sac larvae were collected in the Kankakee River and at DNS cooling water intake and discharge during July in 2005; no post yolk-sac larvae were collected (EA 2007). Water temperatures during the week prior to the first observation of channel catfish ichthyoplankton were between 21°C (69.8°) and 24°C (75.2°F) during 2005. No channel catfish larvae were collected during the 2006 surveys. Early juveniles leave the nest and become more vulnerable to the sampling gear. Juveniles were collected in the Kankakee River and in the vicinity of the DNS cooling water intake and discharge from late June through mid-August during the 2005 and 2006 surveys (EA 2007).

Channel catfish have been collected each year upstream and downstream of Dresden Island Lock and Dam and was the most abundant of six catfish species collected near DNS accounting for 88 percent of the catfish in the Dresden Pool electrofishing catch since 2000 (Table B-3). Its average biomass ranked third highest since 2000 accounting for 12 percent of the 10-year mean biomass. Since 2000, channel catfish have generally been more abundant in the Illinois River downstream of Dresden Island Lock and Dam than upstream or in the Des Plaines or Kankakee Rivers.

2.4.8 Smallmouth bass (*Micropterus dolomieu*)

Smallmouth bass is a popular recreational species widely distributed in much of northern Illinois. It prefers clear streams and rivers with gravel and rocky substrate, moderate to fast currents, and relatively cooler summer conditions than do largemouth bass. They utilize cover and structure in large pools, but will forage for minnows and other fish in shallow water near the shoreline. They are relatively intolerant of turbidity and siltation. Insect larvae and micro-crustaceans are the primary food for young bass; adults feed primarily on crayfish and fish, but also opportunistically consume insects. Spawning occurs in May and June. Males excavate nests in gravel and guard the developing eggs, larvae, and young fry. Nests are typically constructed in sheltered areas near shore with negligible flow. No larvae or early fry were collected in the 2005-2006 ichthyoplankton surveys, a reflection of nesting habitat, nest building and parental protection that minimizes their vulnerability to ichthyoplankton sampling gear.

Numerically smallmouth bass ranged from 3rd to 13th in annual electrofishing surveys between 1994 and 2014, averaging 7th overall. Annual abundance was variable among the study reaches, but was considerably higher in the Des Plaines River between 2003 and 2008 than the other study reaches. Abundance of smallmouth bass was highest in the spring/early summer sampling periods and generally declined through the summer and fall sampling periods. This may reflect the use of deeper, cooler areas as seasonal water temperatures increase through the summer that are deeper than the effective depth of the electroshocking equipment.

2.4.9 Largemouth bass (*Micropterus salmoides*)

Largemouth bass is closely related to smallmouth bass and are also a popular recreational species. It is widely stocked in ponds and lakes to support recreational fishing. It utilizes a wide range of habitat from small streams to large rivers and lakes and is common throughout Illinois. It prefers shallow weedy lakes and river backwaters, the type of habitat preferred by bluegill. Adults feed predominantly on crustaceans and fish and may feed more actively in shallow areas in the evening. Adults prefer deeper habitat with structure such as boulders snags and root wads during daylight hours. They are relatively intolerant of turbidity and siltation. Spawning typically occurs in May and June with nest construction in sand gravel and around vegetation with the male guarding the nest and early life stages similar to smallmouth bass. Largemouth bass larvae or early fry were not collected in the 2005-2006 ichthyoplankton surveys (EA 2007), a reflection of spawning habitat, nest building, and parental protection by this species which minimizes their vulnerability to ichthyoplankton sampling gear.

Largemouth bass were more abundant than smallmouth bass in the DNS study reaches (Table B-3). Between 1994 and 2014 largemouth bass numerically ranked from 2nd to 8th annually and averaged 6th over this period in electrofishing surveys. Abundance in beach seines was relatively low as beach seines are relatively ineffective in habitat frequented by largemouth bass except during spawning. The species exhibited a general trend of increasing abundance in the vicinity of DNS since 2000, particularly in the Des Plaines River and Illinois River upstream of Dresden Island Lock and Dam (Table B-3).

2.4.10 Bluegill (*Lepomis macrochirus*)

Bluegill is a widely distributed native species that is usually most abundant in clear lakes with aquatic vegetation, but can tolerate a wide range of habitats as exists near DNS. Bluegill is widely distributed target for recreational fishing. They are gregarious and occur in small schools. Bluegill feed primarily on aquatic insects, small crustaceans, and small fish; peak feeding activity typically occurs around dawn and dusk. They prefer gravel substrates to build nests, but will utilize most substrates. Nests are constructed in relatively high density in shallow water. Spawning begins in late May and often continues into August. Male bluegill guards eggs and larvae on the nest, but do not guard the young fry as do smallmouth and largemouth bass. Bluegill were not specifically identified in the 2005-2006 ichthyoplankton samples; however, *Lepomis* spp. yolk-sac and post yolk-sac larvae were collected from early June through late August both years (EA 2007). Water temperatures during the week prior to the first observation of *Lepomis* yolk-sac larvae were between 23°C (73.4°F) and 27°C (80.6°F). Early juveniles were also collected from early July through the end of sampling in August (EA 2007).

Bluegill was the most abundant of six sunfish species collected by electrofishing near DNS, accounting for over 50 percent of the sunfish collected between 2000 and 2014 (Table B-3). It ranked 1st to 7th annually in abundance in electrofishing surveys from 1994 -2014 and averaged 2nd overall. It was the 4th in abundance in beach seine collections between 2000 and 2014. Bluegill abundance has generally trended higher since 2000 (Table B-3). Its average biomass ranked ninth since 2000 accounting for 3 percent of the mean biomass over that period.

2.4.11 Black crappie (*Pomoxis nigromaculatus*)

Black crappie is a popular sportfish widely distributed in Illinois. It is relatively intolerant of turbidity and silt, avoids areas with strong currents, and is common in well-vegetated habitat. Black crappie do not school, but can be found in loose aggregations around cover, such as root wads, woody debris, boulders and aquatic vegetation. Aquatic insects, crustaceans, and small fish are primary food for crappie. Spawning begins when water temperatures rise above 13°C (55.4°F); males fan fine sediment and debris from a nest, but nest building is minimal compared to the activities of bluegill and bass. Nests are often created in close proximity to each other and near underwater structure and cover. Males guard the nest until fry leave the nest. Black crappie was not identified to species during the 2005-2006 ichthyoplankton surveys; however, *Pomoxis* spp. was collected in relatively low abundance in the Kankakee River. Yolk-sac larvae were collected between late April and late June in 2005 and between mid-May and early June in 2006 (EA 2007). Water temperatures during the week prior to the first observation of *Pomoxis* yolk-sac larvae were between 15°C (59°) and 20°C (68°F) during both years. Post yolk-sac larvae occurred from early May through mid-June in 2005 and late May to late June in 2006. *Pomoxis* larvae were not collected at the DNS cooling water intake or discharge during 2006 (EA 2007). A few larvae were collected at the intake on one sampling date in 2005.

Black crappie was never abundant in the DNS study area, but was collected in low numbers during electrofishing surveys during most years in all four study reaches (Tables B-2 and B-3). It ranked 51st in relative abundance in all sampling gear between 1991 and 2014 and 45th in electrofishing collections.

2.4.12 Logperch (*Percina caprodes*)

Logperch is a widely distributed darter species that occurs throughout Illinois where streams are large and stable enough to provide habitat. It is particularly common in the sluggishly flowing and sand-bottomed Illinois River and associated pools. It is a demersal species that prefers mixed sand and gravel substrates. In riffle habitat, it often takes cover in brush and woody debris and commonly buries itself in sandy substrates. Its primary food consists of immature stages of aquatic insects. Logperch spawn over gravel in strong riffles during April. Logperch early life stages were not identified to the species level during the 2005-2006 ichthyoplankton surveys. Nine species of darter have been identified during fish surveys in the vicinity of DNS between 1991 and 2014 (Table B-3); most have been occasional or incidental occurrences. Logperch was the only darter among the common dominant taxa collected; most of the darter early life stages collected during the 2005-2006 ichthyoplankton surveys are likely to have been logperch. Darter yolk-sac larvae were collected between the beginning of sampling in early April through late June in 2005-2006; during the 2006 ichthyoplankton survey a few yolk-sac larvae were collected again on one date in mid-July and again in late August (EA 2007). Water temperatures at the time of the first observation of darter yolk-sac larvae were between 10° (50°) and 15°C (59°F). Post yolk-sac darter larvae were collected from mid-April to mid-July in 2005 and early May to mid- August in 2006. Early juveniles were only collected during 2005, between mid-June and mid-July.

Logperch was collected every sampling year between 1991 and 2014 in at least one sampling gear; it was collected in every year in the Kankakee River and all but one year in the Illinois

River upstream and downstream of the Dresden Island Lock and Dam (Table B-3). Their presence in the Des Plaines River was more sporadic; logperch was not collected in 6 of 19 sampling years. It was the most abundant of nine darter species collected near DNS accounting for 77 percent of the darters collected in the four study reaches since 1991 (Tables B-2 and B-3). The catch of the other eight darter species totaled 237 individuals compared to 795 logperch (Table B-3). Logperch catches were low relative to the other RIS as they contributed less than one percent of the total numerical catch since 2000 and ranked 17th in the electrofishing catch from 1994 through 2014.

2.4.13 Freshwater drum (*Aplodinotus grunniens*)

Freshwater drum is a native species in Illinois that prefers large rivers, but also occurs in large lakes and may ascend smaller rivers. It is the target of both sport and commercial fisheries. In rivers, it is most common in large pools and avoids strong currents. It is a bottom-dwelling species most abundant in turbid water over a bottom of mixed sand and silt. It feeds on mollusks, crayfish, and fish, and generally forages for food organisms in bottom substrates. Information on spawning habits of drum is limited, but it appears that spawning occurs during May and June and may be preceded by migration from lakes and large rivers into smaller tributaries. Eggs are released and float to the surface and hatch quickly. During the 2005-2006 ichthyoplankton surveys, freshwater drum eggs were the most abundant taxa/lifestage by an order of magnitude and were common from mid-May to late June; during 2006 eggs continued to be abundant into early July (EA 2007). When eggs first appeared in ichthyoplankton surveys water temperatures were 18-20°C (64.4-68°F) in the Kankakee River. Yolk-sac larvae occurred in much lower numbers than eggs from early June into early July (EA 2007). A few post yolk-sac larvae were observed in late June and early July.

Freshwater drum was collected in all four study reaches during almost every survey year since 1991 (Table B-2) and probably continuously since the early 1970s. Beach seines were ineffective sampling drum, but it was common in electrofishing samples. Numerically it ranked 13th in abundance in the electrofishing catch between 1994 and 2014 (Table B-3). Abundance is variable from year to year, but freshwater drum has generally been most abundant in the study reach of the Illinois River downstream of Dresden Island Lock and Dam since 2000. Since 2000 average biomass of freshwater drum ranked 4th highest, accounting for 11 percent of the mean biomass of all species collected over this period. It was most abundant in the spring (prior to 15 June); abundance declined slightly through the summer and into the fall (after 15 September).

2.5 Methods Employed and Species-Specific Information Used

The prospective analysis developed for evaluation of the DNS thermal discharge plume combines information on the response (behavioral and physiological) of aquatic organisms to temperatures associated with the predicted hydrodynamic characteristics of the thermal plume under selected ambient flow and station operating conditions. The primary steps in this analysis include:

- Prediction of the spatial and temporal configuration and characteristics of the DNS thermal plume using output of the three-dimensional MIKE 3 model (Appendix D).

Selection of operating and environmental scenarios for model simulation.

- Determination of ambient/acclimation temperature for the MIKE3 model grid using ambient temperatures recorded upstream in the Kankakee and Des Plaines Rivers and at the DNS cooling water intake (Appendix D).
- Identification of thermal endpoints related to growth, avoidance, chronic mortality, and temperature shock for each of the 12 RIS, as available (Appendix D).
- Identification of the period of occurrence of key life stages of the RIS in the vicinity of DNS (Section 2.5.3).
- Comparison of identified thermal endpoints for RIS with the predicted thermal plume temperatures (Section 3).
- Tabulation of cumulative cross section and bottom area affected by water temperatures in excess of selected temperature endpoints (Section 3).

2.5.1 Acclimation-Ambient Temperature Thermal Assessment Scenarios

Acclimation temperature is an important factor in evaluating most of the biothermal metrics selected in order to relate them to the effects of temperature exposure in a thermal plume. Fish are cold blooded organisms, that is, they are unable to control their body temperature, which is consequently determined by the temperature of the surrounding water. The rates of various physiologic and metabolic processes are therefore affected by the water temperature to which the organism is acclimated. Acclimation temperature is the temperature to which an organism has been exposed for a period adequate to achieve physiological equilibrium; it can take a few days to more than a week for an organism to fully acclimate to a new temperature regime. The acclimation condition can affect the response of an organism to a water temperature gradient. As an example, a group of organisms acclimated to winter or early spring water temperatures typically exhibit avoidance or preference for temperatures significantly lower than the same organisms acclimated to warmer summer ambient water temperatures.

The behavioral or physiological response of many aquatic organisms to changes or gradients of water temperature is affected by the temperature and other physical and chemical conditions to which the organism has acclimated over a period of time. Under laboratory test conditions these conditions can be fixed and controlled; under natural conditions in a waterbody, natural ambient water temperature and other factors can vary spatially over short distances (e.g., shallow shore zone versus open water, or surface versus bottom in thermally stratified areas) and on the scale of hours (diel), days, weeks, and seasons. Thus, in the natural environment acclimation temperature represents an integration of an array of conditions to which the organism has been exposed over space and time. Consequently, in the assessment of potential thermal effects from exposure to the DNS thermal plume, laboratory thermal effects data that are tied to a controlled laboratory acclimation temperature need to be considered in the context of the acclimation history of organisms that might be exposed to the DNS thermal plume and conditions in available proximal habitat (i.e., immediately upstream of the DNS thermal plume).

To predict potential thermal effects of the DNS thermal discharge plume based on results from laboratory studies, seasonal natural ambient temperature of the Illinois River predicted from upstream Des Plaines and Kankakee River temperatures and flows can be used to represent acclimation temperature. The assumption the ambient temperature represents the acclimation condition of the community is conservative because a portion of the community can be acclimated to higher temperatures in the DNS plume which could result in higher thermal tolerance and avoidance temperatures for some organisms. Several sources of water temperature data are available for the vicinity of DNS. Water temperature is continuously monitored at the DNS cooling water intake on the Kankakee River (0.4 miles upstream of the DNS discharge) in compliance with the DNS NPDES permit. As part of the §316(a) Demonstration studies, water temperature was monitored at the following three additional USGS monitoring sites, since September 2012:

- Des Plaines River at Channahon, 4.1 miles upstream of the DNS discharge;
- Kankakee River at Wilmington, 6 miles upstream of the DNS discharge;
- Illinois River at Seneca, 19 miles downstream of the DNS discharge.

Acclimation temperature curves were estimated (Figure B-1) using the 7-day running average ambient temperature for each of these monitoring stations and the cooling water intake; the 7-day average was selected as representative of an organism's acclimation state under variable natural water temperatures. Water temperatures in the Kankakee River are consistently cooler than those in the Des Plaines River; by as much as 8°C (14.4°F) during fall and winter and approximately 2-4°C (3.6-7.2°F) during spring and summer (Figure B-1). Water temperature at the Dresden cooling water intake typically falls between temperatures in the Des Plaines and Kankakee rivers; more similar to the Kankakee River during fall, winter, and spring and closer to the Des Plaines River during summer (Figure B-1). Water temperatures at Seneca also typically fall between those recorded in the Des Plaines and Kankakee rivers. During seasonal low-flow periods (summer-fall), flows in the Des Plaines River are generally higher than in the Kankakee River (Figure B-2); however, during high flow events Kankakee River flows are typically higher than flows in the Des Plaines River. Ambient temperature in the Illinois River downstream of the confluence of the Des Planes and Kankakee Rivers near the DNS discharge was estimated based on flow-weighted mixing of the respective upstream temperatures from the Des Plaines and Kankakee Rivers (Figure B-3). The flow-weighted temperatures in the upper Illinois River and measured temperatures downstream at Seneca are typically warmer than at the DNS cooling water intake which entrains primarily water from the Kankakee River.

For this analysis the following three scenarios of flow and water temperature (Tables B-5 and B-6, Figure B-4) were examined:

1. Typical flow (median, 50^{th} percentile) and water temperature (60^{th} percentile);

2. Typical high temperature conditions (5th percentile flow and 95th percentile water temperature); and

3. Extreme high temperature conditions reflected flow (<5 percentile in the Des Plaines and 15-20 percentile in the Kankakee River) and air and water temperatures (maximum water temperatures in the range of 97-99 percentile) that occurred during an exceptional heat wave in early July 2012 (Table B-6 and Figure B-4).

July flows under the typical high temperature scenario were about 60 percent of flows for the typical scenario and flows during the extreme event of July 2012 were 38-52 percent of flows under the typical conditions scenario. Under the typical high temperature scenario ambient July water temperature did not exceed 31.7°C (89°F) and DNS discharge temperatures did not exceed 33.3°C (92°F).

In order to more adequately evaluate the potential effects of the DNS discharge under the ATLs, the model was used to estimate thermal plume conditions during extremely warm meteorologic conditions that occurred during early July 2012. During July 2012, DNS operated under a provisional variance with significantly higher DNS intake and discharge temperatures than represented by the typical high temperature scenario. During the extremely warm event of July 2012, daily maximum air temperatures increased steadily from 30.0°C (86°F) on 1 July to 37.8°C (100°F) on 7 July, while maximum daily intake water temperatures increased from about 29.4°C to 34.4°C (85°F to 94°F) over the same period (Figure B-4). DNS discharge temperatures increased from about 31.1°C (88°F) to slightly more than 34.4°C (94°F) (Figure B-4). The heat wave broke during the 8-9 July overnight period with night-time low air temperature dropping to 16.7°C (62°F); during this 36-hr period intake and DNS discharge water temperatures decreased from about 34.4°C to 31.1°C (94°F to 88°F) (Figure B-4).

2.5.2 Thermal Assessment Diagrams for RIS

Thermal diagrams (Figures B-5 to B-16) were constructed for each RIS to graphically present the relationship of acclimation temperature and the selected biothermal response metrics (as discussed in Section 2.3) to help interpret the potential effects of thermal loading from the Dresden cooling water discharge on the RIS and the aquatic community that they represent. The diagrams illustrate the relative relationship and progression of the selected biothermal response metrics and the inherent variability among individual responses for each species. Figures B-5 to B-16 are used in Section 3 (Results of Biothermal Assessment), in conjunction with thermal plume modeling and habitat mapping (Section 2.5.4), to predict potential effects of the DNS thermal plume on the aquatic community represented by the RIS.

With regard to the data presented in Figures B-5 to B-16, for each metric, the individual test results reported in the scientific literature are graphed along with the associated linear regression line for these data when appropriate. For clarity in reading the diagrams, the markers and trend lines for each specific metric are plotted in the same color with different data sources represented by distinct marker styles, as listed in the legend. Acclimation temperature (X axis) and response temperature (Y axis) are plotted at the same scale on the diagrams for all 12 RIS to facilitate comparison of relative thermal sensitivity among species. Although thermal water quality criteria are written in terms of °F, the majority of thermal data are reported in °C. To facilitate analysis of the thermal data and development of the Master Rationale (Section 3, Dresden 316(b) Demonstration Summary), thermal endpoints are plotted in °C against the left-hand vertical axis; for reference the equivalent °F scale is presented on the right-hand vertical axis. Also for reference and to facilitate interpretation, horizontal lines are plotted on each figure at key regulatory temperatures, 32.2°C, 33.9°C, and 35°C (90°F, 93°F, and 95°F, respectively).

2.5.2.1 Acute thermal mortality under short exposure duration (dark red line and markers)

This metric depicts the lethal response of organisms to dynamic temperature increases over a relatively short period. This response is measured by the CTM which is not necessarily an indication of final mortality, but frequently uses the loss of equilibrium as the test endpoint.

2.5.2.2 Chronic thermal mortality under prolonged exposure (light green line and markers)

This line depicts the species' mean tolerance limit; that is, the acclimation/exposure-temperature combinations at which 50 percent mortality would occur due to elevated temperatures for a prolonged exposure of more than 24 hours (typically 24 to 96 hours). Based on Coutant (1972), the temperature at which the species' chronic thermal mortality approaches zero is about 2°C (3.6°F) lower than the mean tolerance line (TL5024 to 96 hrs) shown in the thermal diagram. By extension, assuming a normal distribution, chronic thermal mortality would effectively be 100 percent at 2°C (3.6°F) higher than the TL50. This 2°C (3.6°F) range around the mean is an expression of the variable response of individuals within a population to a prolonged exposure to elevated temperatures. Chronic mortality is very conservative measure of potential thermal effects because it assumes that fish are unable to avoid potentially lethal elevated temperatures by moving to cooler temperatures along a temperature gradient, and thus could potentially succumb to elevated temperatures during a prolonged exposure.

2.5.2.3 Avoidance (dark blue line and markers)

A thermal avoidance response occurs when mobile species evade stressful high temperatures by moving to water with lower, more acceptable temperatures (Meldrim et al. 1974, Mathur et al. 1983). While the avoidance response can minimize the potential for thermal mortality associated with elevated water temperatures in portions of a thermal plume, it can also deter organisms from occupying otherwise useful or critical habitat that may occur in the vicinity of a thermal plume. The plotted avoidance data (acclimation/response temperature) and line represent the expected mean avoidance response of a population.

2.5.2.4 Thermal preference zone (orange line and markers)

The zone of thermal preference is defined by a range of laboratory acclimation/preferred temperature response data reported for some RIS. The ideal temperature range for growth cannot be accurately characterized under controlled laboratory conditions for those species for which captive rearing methods have not been developed. The thermal preference polygon provides a surrogate to delineate the acclimation and exposure temperature combinations for which optimal growth (i.e., preferred temperatures) would be predicted (McCullough 1999). Optimal temperatures for growth are defined as the preferred temperature of fish in a thermal gradient; for "cold-blooded" organisms (ectotherms), such as fish, this is an adaptive mechanism that allows organisms to selectively utilize habitat within a waterbody where temperatures are such that they can maintain optimal physiological performance (Coutant 1977; Hutchison and Maness 1979).

The occurrence and distribution of both optimal and non-optimal water temperatures will naturally vary on a spatial, diel, and seasonal basis; the presence and configuration of the thermal plume overlays this natural variability. Maximum weekly average temperature for growth (MWAT) is a metric that attempts to account for this variability, using a 7-day running average of ambient water temperature to capture this variability and characterize the acclimation conditions of the organisms that affect growth. The RIS selected for DNS exhibit a period of zero growth between late fall and early spring when water temperatures are less than their threshold for growth. Peak summer ambient water temperatures in portions of the ecosystem and portions of the thermal plume can exceed the upper zero growth (bright red line on thermal diagram) temperature for some species. Thus, growth occurs to a greater or lesser extent over a range of temperatures and a thriving population can be maintained even when temperatures non-optimal during certain periods or in a segment of a waterbody. In the presence of a thermal plume, growth can begin earlier in the spring or continue later in the fall in some segments of the waterbody and fish have the ability to move from areas with non-optimal temperatures to areas with more optimal water temperatures. For this reason it is difficult to quantify the effect of the thermal plume on growth of individuals within a population utilizing habitat in the vicinity of the DNS thermal plume. Instead, this analysis looks at the relative amount and frequency of habitat affected by the thermal plume where water temperatures are outside of the optimum range for growth.

2.5.2.5 Thermal tolerance zone (purple line)

The thermal tolerance zone extends beyond the preference zone. It delineates the temperature regime over which each species can survive and continue to grow, but at less than optimum rates. Optimum temperatures for maximum growth do not consistently occur spatially or temporally in nature and delineation of a tolerance "zone" makes clear the fact that non-optimal temperatures are not necessarily adverse. Areas outside the polygon of the tolerance zone and below the onset of predicted chronic mortality (within the 2°C [3.6°F] range of variability below the chronic thermal mortality line discussed above), delineate the temperature regime over which a species can survive, but in which they may be stressed and experience near-zero or negative growth, that is, weight loss (Bevelhimer and Bennett 2000; Beitinger and Bennett 2000).

2.5.2.6 Thermal range for spawning (bright green line)

When adequate thermal range data have been documented, a polygon on the thermal effects figure indicates the reported temperature range for spawning based on the seasonal period during which spawning typically occurs in the vicinity of DNS. This range is typically based on field observations of natural spawning activity.

2.5.2.7 Lower lethal temperatures (teal line and markers)

Lower incipient lethal temperatures (chronic exposure) and cold shock (acute rapid exposure) measure mortality caused when organisms acclimated to warm temperatures in the thermal plume are exposed to significantly colder ambient water temperatures. This typically occurs when fish attracted to plume during the winter are exposed to cold ambient water temperatures in conjunction with a station outage. Similar to the upper chronic thermal mortality graphic the lower thermal threshold has a range of variation of ±2°C (3.6°F) and falls about 2°C (3.6°F) below the lower boundary of the tolerance zone polygon. When a station has multiple operating units, the potential for this source of mortality is mitigated in that all units are typically not taken offline and therefore organisms acclimated to the thermal plume do not experience a full decrease to ambient temperatures. Given that the focus of this Demonstration is the period of indirect once-through cooling (15 June through 30 September) lower incipient lethal temperatures and cold shock are presented for completeness but are not a significant issue for this analysis.

2.5.3 Periods of Occurrence

The temporal focus of this biothermal assessment is the period 15 June through 30 September when DNS operates in indirect once-through cooling mode. With the exception of cyprinids (e.g., emerald shiner) and freshwater drum, most of the RIS spawn prior to 15 June. Ichthyoplankton sampling during 2005-2006 collected few or no eggs of most of the RIS; most of the RIS have eggs that are demersal, adhesive, or deposited in nests in shallow areas protected by the adults and thus have limited vulnerability to the sampling gear, but also have minimal exposure to the DNS thermal plume. Freshwater drum was the only species for which eggs were collected in abundance during the 2005-2006 surveys. Their eggs are buoyant and pelagic and were collected between early May and mid-July with peak abundance between early June and early July.

During the 2005-2006 sampling program in the Kankakee River in the vicinity of the DNS cooling water intake, 85-88 percent of the ichthyoplankton drift occurred prior to 15 June, before DNS switches from closed cycle to indirect open cycle cooling (EA 2007, Figures 3-13 and 3-14). With the exception of emerald shiner and freshwater drum, peak abundance for yolk-sac larvae of most of the RIS also occurs before mid-June. Abundance of post yolk-sac larvae and early juvenile life stages of all RIS typically peaks during the period when DNS operates in indirect once-through cooling mode.

Young of the year and adults of the RIS occur throughout the summer when DNS operates in indirect open cycle cooling mode and at which time the proposed ATLs would apply. The abundance of young of the year through adult life stages of the most common RIS (gizzard shad, emerald shiner, and bluegill) during the 2005-2006 surveys increased gradually from spring (before 15 June), through summer into fall (after 30 September). Smallmouth bass and channel catfish, in much lower abundance, exhibited the reverse trend, decreasing in numbers from spring through fall. All other RIS occurred in relatively low and variable abundance with no apparent seasonal trend. Thus, during the summer period of interest, when ambient temperatures are at maximum and river flows are typically at annual lows, the abundance of RIS fish in the vicinity of DNS is generally at an intermediate level, compared to spring and fall.

2.5.4 Species Habitats

Habitat in the area encompassed by the thermal model (approximately 544 acres), from Dresden Island Lock and Dam upstream to the lower reaches of the Des Plaines and Kankakee Rivers above their confluence, is dominated by relatively deep channel (greater than 2.5 meters) accounting for approximately 53 percent of the study area (Figure B-17). The channel area in the modeled reach of the Kankakee River is dominated by sand substrates, whereas substrates in the channels of the Des Plaines River and Illinois River is a variable mix of silt, sand, gravel, hardpan, and debris.

Between the DNS discharge and Dresden Island Lock and Dam, habitat less than 2.5 m accounts for about 15 percent of available aquatic habitat. Within the larger boundaries of the hydrothermal model and bathymetric survey, depths less than 2.5 meters account for about 47 percent of the area. Several large depositional areas, primarily located upstream of the DNS discharge, significantly increase the diversity and available shallow habitat of the reach including: upstream of the discharge along the left bank at the inside bend of the Illinois River between the DNS intake and discharge (hard bottom compact sand and silt with limited lotus beds close to shore); and the point and backwater areas between the channels of the Des Plaines and Kankakee Rivers at their confluence (submerged macrophytes and lotus beds with sand or detritus/mud over gravel and cobble). A small area along the right bank immediately upstream from Dresden Island Lock and Dam (lotus beds with detritus/mud substrate) provides limited shallow water habitat downstream of the DNS discharge. The shallow shore zone habitat throughout much of the rest of the study reach extends only a short distance from the shoreline with submerged and limited emergent vegetation generally over rocky, sand, or silt substrate. These habitat types are delineated on Figure B-17 including a summary of the areas encompassed by each habitat type.

These shallows typically have substrates comprised of silt and detritus overlaying sand, gravel, or cobble. These areas could provide spawning habitat for the four centrarchid RIS (largemouth and smallmouth bass, bluegill, and black crappie). Large woody debris provides cover in the shallow right bank embayment immediately upstream of the dam and is typical of channel catfish spawning habitat. Scattered submerged aquatic vegetation (SAV) occurs along the inside bend of the Illinois River upstream of the Dresden discharge. Lotus beds are common in the shallow and backwater habitat between the Des Plaines and Kankakee Rivers. Habitat with SAV and other floating vegetation beds (approximately 153 acres or 23 percent of the area within the reach) could provide spawning habitat for common carp and other cyprinids (e.g., emerald shiner). Aquatic vegetation in these shallow areas can also provide cover and foraging habitat for top predator species such as smallmouth and largemouth bass.

Riffles, typically used by logperch, golden redhorse, and to some extent by white sucker as spawning habitat, do not occur within the geographic boundaries of the hydrothermal model. The closest riffle/run habitat occurs downstream below the Dresden Island Lock and Dam and in tributary habitat in Aux Sable Creek about 3 miles below the dam. Upstream of the DNS discharge, the closest riffle habitat is about 5 miles in the Kankakee River, near the I-55 bridge. Additional riffle habitat is also found in Grant Creek, a tributary to the Des Plaines River about 3 miles upstream of the DNS discharge.

3.0 RESULTS OF THE BIOTHERMAL ASSESSMENT

3.1 Thermal Plume Assessment Scenarios

3.1.1 Typical river conditions

The typical condition assessment scenario used median monthly flows in the upper Illinois River (combined flows from the Des Plaines and Kankakee Rivers) that ranged from 9,720 cfs in June to 5,366 cfs in September (Table B-5). The associated typical ambient Illinois River temperatures (60 percentile flow-weighted for the Des Plaines and Kankakee Rivers) ranged from about 25°C (77°F) in June and September to 27.6°C (81.7°F) in August. The median DNS discharge temperatures ranged from 29.8°C (85.7°F) in June to 30.8°C (87.4°F) in July, and 28.6°C (83.5°F) in September (Table B-5).

The cross-sectional and bottom areas affected by the DNS thermal plume are used to assess the potential effects of the plume on aquatic habitat and RIS populations in the vicinity of the DNS discharge. The hydrothermal model was used to estimate the percent of the cross-sectional area at fixed transects below specified water temperatures for each of the four months evaluated (Table B-7 to B-10) and percent of the bottom area upstream and downstream of the DNS discharge below specified water temperatures (Table B-11). The area encompassed by selected temperatures was compared to the biothermal metrics for each of the RIS, and presented in Sections 3.2 to 3.7, below. Zone of passage (ZOP) was evaluated against a 75% benchmark to determine if temperatures in at least 75 percent of the plume cross section are less than the avoidance temperature for an RIS.

Under the typical condition scenario, river flows and temperatures and DNS discharge temperatures are most constraining during July and August. At the upstream transect, in July the Kankakee River (KP-1800) ranged from 24.1°C to 24.5°C (75.4°F to 76.1°F), while water temperatures in the Des Plaines ((DP-1700) were 6-7°F higher (Table B-8). At a median DNS discharge temperature of 30.8°C (87.4°F) in July (Table B-5), temperatures immediately downstream of the discharge (IL125) ranged from 27.6°C to 30.3°C (81.7°F to 86.6°F); temperatures in 75 percent of the cross-section were less than 29.0°C (84.2°F) (Table B-8). Moving downstream to the Dresden Island Lock and Dam, in July the range of cross-section

(IL1000) temperatures narrowed (28.5°C to 28.9°C [83.3°F to 84°F]) with mixing and dilution. Predicted water temperatures near the bottom upstream of the DNS discharge are 24.1-28.2°C (75.4-82.8°F) and 27.1-30.8°C (80.8-87.4°F) downstream of the discharge in July (Table B-11). Water temperatures in 75 percent of bottom habitat upstream of the DNS discharge are less than 27.9°C (82.3°F), and downstream of the discharge are less than 28.7°C (83.7°F) (Table B-11). Water temperatures in bottom habitat upstream of the DNS discharge are about 2.2-2.8°C (4-5°F) lower than downstream.

During August, the median DNS discharge temperature is about 0.3°C (0.5°F) lower than July, but temperatures at the upstream Des Plaines and Kankakee Rivers transects are about 1.7°C (3°F) higher than in July (Table B-9); combined flow from the Des Plaines and Kankakee Rivers is about 900 cfs lower (15 percent) than in July. During typical August conditions, the highest temperature immediately downstream of the DNS discharge (transect IL125) is predicted to be 0.1°C (0.2°F) lower than in July, but the coolest temperatures in the transect are 0.4°C (0.8°F) higher than in July. Water temperatures at transect IL125 are less than 29.2°C (84.5°F) in 75 percent of the cross-section. Downstream near Dresden Island Lock and Dam (IL1000), water temperatures are about 0.3-0.4°F higher than in July, and 75 percent of the cross-section is predicted to be below 29.0°C (84.2°F) (Table B-9), with a maximum temperature of 29.1°C (84.3°F). Predicted water temperatures near the bottom upstream of the DNS discharge are 24.8-28.3°C (76.7-83.0°F) and 28.0-30.6°C (82.4-87.0°F) downstream of the discharge in August (Table B-11). Water temperatures in 75 percent of bottom habitat upstream of the DNS discharge are less than 28.1°C (82.5°F) and downstream of the discharge are less than 28.9°C (84.1°F) (Table B-11). Water temperatures in bottom habitat upstream of the DNS discharge are about 2.2-2.8°C (4-5.5°F) lower than downstream.

3.1.2 Typical high temperature conditions

The typical high temperature condition assessment scenario used 5 percentile monthly flows in the upper Illinois River (combined flows from the Des Plaines and Kankakee Rivers) that ranged from 4,134 cfs in June to 3,032 cfs in September (Table B-5). These flows are 42-56 percent of those used for the typical condition scenario (Section 2.3.1.1). The associated typical ambient Illinois River temperatures (95 percentile flow-weighted for the Des Plaines and Kankakee Rivers) ranged from about 27.2°C (81°F) in June to 31.1°C (88°F) in July and 28.3°C (83°F) in September. The 95 percentile DNS discharge temperatures ranged from 31.8°C (89.2°F) in June to 33.2°C (91.8°F) in July and 31.6°C (88.8°F) in September (Table B-5).

Under the typical high temperature scenario, river flows and temperatures and DNS discharge temperatures are most constraining during July and August. At the upstream transect, in July the Kankakee River (KP-1800) ranged from 29.4°C to 30.9°C (84.9°F to 87.6°F), while water temperatures in the Des Plaines ((DP-1700) were 31.3-31.4°C (88.3-88.5°F) (Table B-8). At a 95 percentile, DNS discharge temperature of 33.2°C (91.8°F) in July (Table B-5), the temperatures immediately downstream of the discharge (IL125) ranged from 31.9 to 32.9°C (89.5°F to 91.3°F); temperatures in 75 percent of the cross-section were less than 32.7°C (90.9°F) (Table B-8). Moving downstream to the Dresden Island Lock and Dam, in July the range of cross-section (IL1000) temperatures narrowed (32.5°C to 32.6°C [90.5°F to 90.6°F]) with mixing and dilution. Predicted typical high temperature condition water temperatures near the bottom upstream of the DNS discharge are 29.4-32.0°C (84.9-89.6°F) and 31.0-33.2°C (87.8-91.8°F) downstream of the discharge in July (Table B-11). Water temperatures in 75 percent of bottom habitat upstream of the DNS discharge are less than 31.4°C (88.5°F) and downstream of the discharge are less than 32.6°C (90.6°F) (Table B-11). Water temperatures in bottom habitat upstream of the DNS discharge are about 1.1-1.7°C (2-3°F) lower than downstream.

During August, the 95 percentile DNS discharge temperature is about 0.6°C (1°F) lower than July, but temperatures at the upstream Des Plaines and Kankakee river transects are about 1.1°C (2°F) and 2.5°C (4.5°F) lower, respectively, than in July (Table B-9); combined flow from the Des Plaines and Kankakee rivers in August are about the same as in July. During typical high temperature conditions in August, the highest temperature immediately downstream of the DNS discharge (IL125) is predicted to be 0.7°C (1.3°F) lower than in July, and the coolest temperatures in the transect are 0.6°C (1°F) lower than in July. Water temperatures at transect IL125 are less than 31.9°C (89.5°F in 75 percent of the cross-section, about 0.8°C (1.5°F) less than July. Downstream, near Dresden Island Lock and Dam (IL1000), water temperatures are about 0.8°C (1.5°F) lower than in July and 75 percent of the cross-section is predicted to be below 31.7°C (89°F), with a maximum temperature of 31.7°C (89.1°F) (Table B-9). Predicted high temperature scenario water temperatures near the bottom upstream of the DNS discharge are 26.8-31.0°C (80.3-87.8°F) and 29.1-32.6°C (84.3-90.7°F) downstream of the discharge in August (Table B-11). Water temperatures in 75 percent of bottom habitat upstream of the DNS discharge are less than 30.2°C (86.4°F) and downstream of the discharge are less than 31.7°C (89.0°F) (Table B-11). Water temperatures in bottom habitat upstream of the DNS discharge are about 1.7-2.2°C (3-4°F) lower than downstream.

3.1.3 Extreme high temperature conditions

Typical high temperature scenario conditions can occur about 5 percent of the time; under these conditions DNS discharge temperature approaches 33.3°C (92°F) only during July and does not exceed 32.8°C (91°F) in August or 32.2°C (90°F) in June. Consequently, to evaluate the potential effects of the proposed ATLs on the RIS, the extreme high temperature conditions that occurred during July 2012, that were similar to the temperatures that could be experienced under the proposed ATLs, were evaluated.

During these extreme temperature and river flow events, intake temperatures increase rapidly, due to upstream intrusion of more buoyant (i.e., warmer) water from the Des Plaines River over the less buoyant (i.e., cooler) water from the Kankakee. Temperatures typically moderate downstream of the confluence, upstream of the DNS discharge where the Des Plaines and Kankakee Rivers mix. To evaluate thermal plume characteristics under infrequent, more extreme meteorological conditions, the hydrothermal model was used to assess unusual conditions of high air temperatures and low flow that occurred during July 2012.

During early July 2012, maximum daily air temperatures steadily increased from about 30°C (86°F) on 1 July to 37.8°C (100°F) on 7 July (Figure B-4); overnight temperatures were in the low to high 70s°F and also increased during this period. The heat wave broke the evening of 7-8

July and DNS intake and discharge temperatures responded relatively quickly, decreasing by about 3.1°C (5.5°F) over the next 36 hours. Maximum daily intake temperatures during 6-8 July 2012 were in the upper 3 percent of the period of record (2003-2014) (Table B-6); the maximum recorded intake water during this 3-day period was 34.4°C (93.9°F) which occurred at about 1500 hours, the afternoon of 7 July 2012. DNS cooling water intake temperatures were above 33.9°C (93°F) for about 9 hours between 1100 and 2000 hours on 7 July (Figure B-18). The DNS discharge temperature peaked a few hours later at about 34.9°C (94.9°F); the discharge temperature exceeded 34.4°C (94°F) for about 3 hours and exceeded 33.9°C (93°F) for about 11 hours. Night-time low water temperatures were in the upper 4-5 percent of the record. The diurnal cycle of air temperature and its effect on intake temperature and DNS discharge temperature is apparent in Figure B-4. The combined flow from the Des Plaines and Kankakee Rivers during this period ranged from slightly below to slightly above the 7Q10 (2456 cfs) calculated from the upstream USGS gages (Appendix D) scaled to the confluence of the two rivers.

Under the proposed ATLs, the plant's discharge could exceed 93°F (up to 95°F) for up to 24 hours when intake temperatures exceed 90°F (32.2°C). Using the July 2012 extreme heat event, modeled mixed ambient water temperatures at surface, middle, and bottom depths upstream of the DNS discharge (transect IL-200) peaked above the 90°F (32.2°C) threshold at 33.3°C (92°F) for 1-4 hours on 7 July (Figure B-18). The duration that ambient water temperatures were above 32.8°C (91°F) increased with depth (Figure B-18) as cooling of surface waters was enhanced by overnight cooling of water over the large shallow habitat (Figure B-17) in the immediate vicinity of transect IL-200 upstream of the DNS discharge. Downstream of the DNS discharge (transect IL475), modeled water temperatures at surface, middle and bottom depths exceeded 33.3°C (92°F) on 6 July for about 15 hours, declining below 33.3°C (92°F) for about three hours near dawn on 7 July, then increasing again to the peak for the 3-day period on the afternoon of 7 July. Temperatures at this transect exceeded 33.9°C (93°F) for approximately 6 hours on 7 July (Figure B-19). Temperatures at all depths were below 32.8°C (91°F) by 0300 on 8 July. Temperatures at this transect again exceeded 32.8°C (91°F) briefly on the afternoons of 17, 18, and 19 July (Figure B-20); temperatures upstream of DNS discharge did not exceed 32.5°C (90.5°F) on these three dates and bottom temperatures remained below 90°F (Figure B-21). Temperatures for the remainder of July and August were typically below 31.1°C (88°F) upstream at transect IL-200 and below 31.7°C (89°F) downstream at transect IL475.

3.2 Potential for Thermal Mortality at Elevated Temperatures

Acute and chronic thermal mortality data are known for the following RIS:

Species	Acute	Chronic
Gizzard shad		x
Emerald shiner	x	x
Common carp	x	x
Golden redhorse	x	
White sucker	x	x
Channel catfish	x	x
Largemouth bass	x	x
Smallmouth bass	x	
Bluegill	x	x
Black crappie	x	x
Logperch	x	
Freshwater drum	x	

Acute mortality data represent effects of short term (minutes to hours) exposure to high temperatures, while chronic mortality data are the result of longer exposures (48-96 hours) to elevated temperatures. Acute data are shown as dark red lines and markers at top of Figures B-5 to B-16 and chronic data are shown as light green lines and markers several °F below the acute data on Figures B-5 to B-16. At ambient/acclimation temperatures above 29.4°C (85°F), acute mortality is not predicted for the RIS until temperatures in the thermal plume exceed 35-37.2°C (95-99°F), which is well above temperatures predicted under the three scenarios evaluated in this assessment.

Based on these data (Figures B-5 to B-16), no acute or chronic mortality is predicted for any of the RIS under the typical conditions scenario. For this scenario, upstream ambient temperatures are below 28.3°C (83°F) and DNS discharge temperatures are below 31.1°C (88°F) (Tables B-7 to B-9) during July and throughout the indirect open cycle period from June through September. At this acclimation temperature, chronic mortality is typically not observed for most of the RIS until exposure temperatures exceed 32.2°C (90°F (Figures B-5 to B-16), 1.7°C (3°F) higher than the highest discharge temperatures under this scenario.

Under the typical high temperature scenario, upstream ambient temperature (95 percentile) near the DNS discharge is 31.1°C (88°F) in July and less than 30°C (86°F) the remainder of the indirect open cycle period. Discharge temperatures (95 percentile) are 32.6°C (90.7°F) in June and 33.2°C (91.8°F) in July. Chronic mortality data indicate that white sucker is the most thermally sensitive of the RIS selected for this analysis; at an acclimation temperature of 31.1°C (88°F) the predicted threshold for chronic thermal mortality is about 32.2°C (90°F). Because fish may be acclimated to temperatures higher than the upstream ambient, if they reside in portions of the plume, the assumption that ambient is representative of acclimation temperatures is conservative and could predict higher potential for thermal mortality than would actually be observed in the DNS thermal plume. It should also be noted, that although white sucker have been included as an RIS due to their thermal sensitivity, it occurs incidentally in the vicinity of DNS and has only been collected during three of the past 20 sampling years.

During July, the typical high temperature scenario with a DNS discharge temperature of 33.2°C (91.8°F), the Illinois River between the DNS discharge and Dresden Island Lock and Dam becomes relatively well mixed with temperatures at each of the modeled transects generally between 32.2°C (90°F) and 32.8°C (91°F) (Tables B-8 and B-11). Although temperatures in this range could create stressful conditions for white sucker under an extended period of exposure (e.g., 48-96 hour typical thermal mortality test durations), the exposure conditions in the DNS thermal plume are unlikely to result in any thermal mortality due to several mitigating factors. As discussed previously, DNS intake and discharge temperatures vary diurnally in response to daily cycles in air temperature (Figure B-4). Consequently, aquatic organisms are not exposed to constant elevated temperatures, but experience thermal reductions each evening as air temperatures decline. In addition, under various thermal mortality test protocols, the test organisms are exposed in a test chamber with well mixed and constant temperature, whereas, in natural riverine habitat, a range of temperatures are often available and organisms are capable of avoiding stressful temperatures (Section 3.3). Although the thermal model predicts that much of the area between the DNS discharge and the Dresden Island Lock and Dam is well mixed at 32.2-32.7°C (90-91°F), the majority of aquatic habitat immediately upstream of the DNS discharge is predicted to be less than 31.7°C (89°F) during July under the typical high temperature scenario (Tables B-8 and B-11). The majority of aquatic habitat downstream of the DNS discharge consists of deeper channel which is also abundant upstream (Figure B-17); other shallow water habitat found downstream is significantly more abundant upstream of the DNS discharge for temporary utilization by organisms potentially displaced for brief periods by elevated thermal plume temperatures.

The heat wave that occurred July 2012 provides extremely unusual natural thermal conditions to evaluate potential effects of the DNS thermal plume on aquatic resources in the area of the upper Illinois River. During these extreme temperature conditions, intake temperatures exceeded 32.2°C (90°F) for 3 days from the afternoon of 5 July to the evening of 8 July with a peak of 34.4°C (93.9°F). DNS discharge temperatures exceeded 32.2°C (90°F) intermittently from 2 July to 8 July. Discharge temperatures were above 33.9°C (93°F) for about 6 hours on the evening of 5 July and about 11 hours during the day on 7 July with a maximum of 34.6°C (94.3°F) (Table B-6; Figures B-4 and B-19). Between 1200 and 1600 on 7 July the percent of the cross-sectional area downstream of the DNS discharge in excess of 33.9°C (93°F) (yellow shaded cells in Table B-12) increased from less than 5 percent at the transect 125 m (IL125) downstream to greater than 95 percent 475 m downstream. During this same period upstream transects in the Des Plaines and Kankakee Rivers had ambient temperatures above 33.9°C (93°F) in 75 percent of the cross-sectional area. Between 1800 and 2000 on 7 July discharge temperatures began to decrease and the area with temperatures above 93°F began to contract, cool immediately downstream of the DNS discharge, and shift farther downstream toward Dresden Island Lock and Dam (Table B-12). Although the area influenced by 33.9°C (93°F) temperatures began to decrease downstream of DNS during this period, the area with ambient temperatures above 33.9°C (93°F) increased upstream in the Des Plaines and Kankakee Rivers as a result of atmospheric conditions. By 2200, 7 July, water temperatures throughout the reach were below 33.9°C (93°F).

Most RIS for which chronic temperature tolerance data are available are able to tolerate water temperatures above 35°C (95°F) for extended periods of time (48-96 hours) at acclimation temperatures above 29.4°C (85°F), with the exception of white sucker. For white sucker, the upper thermal tolerance limit for chronic exposure for juveniles appears to be about 35°C (93°F) at an acclimation of 32.2°C (90°F); the highest thermal tolerance chronic exposure for adults is 32.5°C (90.5°F) at an acclimation temperature of 26°C (78.8°F). However, under the extreme conditions observed during early July 2012, the maximum exposure duration was approximately 11 hours, considerably less than the exposure durations for the test data. During this period, ambient water temperatures beyond the influence of the DNS thermal plume that are predicted to have been less than 32.5°C (90.5°F) were available in 10-25 percent of the habitat upstream of the DNS discharge to allow white sucker the opportunity to avoid habitat with warmer temperatures downstream.

Although under extreme conditions, temperatures exist within the DNS thermal plume with the potential to cause mortality under extended chronic exposure, these conditions are rare and of relatively short duration. Refuge for fish avoiding these high water temperatures is available in extensive habitat upstream of the DNS discharge. Consequently, temperatures in the plume, even under extreme meteorological condition, are unlikely to result in any significant mortality. In fact, during the 2012 July heat event no fish kills were observed in the vicinity of the DNS and the Dresden Island Lock and Dam. While white sucker may be relatively more sensitive than the other RIS to elevated water temperatures in the DNS thermal plume during extreme conditions, the species occurs only incidentally in the Des Plaines, Kankakee, and upper Illinois Rivers in the vicinity of DNS.

3.3 Thermal Avoidance and Habitat Loss

As discussed in the previous section, except in unusual circumstances, mortality of fish as a result of exposure to high water temperatures is rare because many species have demonstrated the ability to sense and avoid stressful elevated temperatures when areas with cooler temperatures are available. Even in the event of the extreme heat event of July 2012, substantial channel and shallow water habitat is available upstream of the DNS discharge with cooler water temperatures for fish that may avoid portions of the thermal plume. While the ability to avoid stressful water temperatures minimizes the potential for fish mortality, it could result in avoidance of important habitat areas that may be affected by portions of the thermal plume.

Avoidance data were identified and reviewed for gizzard shad, channel catfish, largemouth bass, smallmouth bass, and bluegill; these data are plotted in dark blue in Figures B-6 and B-10 to B-13. As would be expected these avoidance data plot a few degrees below the chronic mortality data on these figures.

Avoidance temperature test data (Table B-13; Figures B-6, B-10, B-11, and B-13) indicate that at ambient/acclimation temperatures (30.6-33.3°C [87-92°F]) representative of the three assessment scenarios (Table B-5 and B-6), gizzard shad, channel catfish, largemouth bass, smallmouth bass, and bluegill would not avoid any portions of the plume under typical, typical warm, and extreme warm conditions. For each of these RIS the temperatures avoided are typically several degrees higher than the highest plume cross-section (Tables B-8 and B-12) and bottom (Table B-11) temperature estimated for each assessment scenarios. These avoidance temperatures are also typically several degrees below the chronic mortality temperatures.

RIS for which avoidance data were not available generally exhibited acute and/or chronic mortality metrics within a similar range to the five RIS with avoidance information discussed above. For species where avoidance has been documented, fish typically avoid temperatures slightly below the threshold of chronic mortality. Thus, it is likely that the RIS for which avoidance data are not available exhibit a similar pattern of avoidance and would not be expected to avoid significant areas of habitat in the vicinity of the DNS thermal plume. This assessment supports the finding that the DNS thermal plume would not be expected to cause avoidance of aquatic habitat for any of these species, even at very low river flow conditions (1-4 percentile), high air temperatures (37.8°C [100°F]), and high DNS discharge temperatures (34.79°C [4.5°F]) (1-3 percentile).

3.4 Potential for Blockage of Migration

Given that this assessment indicates that the RIS and the aquatic community that they represent are not likely to avoid significant areas of habitat in the vicinity of the DNS thermal plume, it is unlikely that the thermal plume would interfere with the migration and localized movement patterns (e.g., diel and seasonal onshore/offshore, upstream/downstream, or spawning) of the fish community in the upper Illinois River. As discussed in Sections 3.2 and 3.3, more than 75 percent of the cross-section at selected transects within the DNS thermal plume and more than 75 percent of the channel bottom habitat is predicted to have water temperatures below the chronic mortality and avoidance temperatures of most of the RIS under a likely range of station operating, hydrologic, and meteorological conditions to be encountered in the upper Illinois River in the vicinity of DNS.

Reported thermal mortality metrics indicate that white sucker would be the most sensitive of the RIS to elevated plume temperatures, particularly under rare, extreme high temperature conditions such as occurred during July 2012. Although it is likely that white sucker might avoid significant areas of the DNS thermal plume during such extreme conditions, moving to more moderate upstream habitat, the duration that avoided temperatures persist is short, less than 24 hours. Such short durations when white sucker might avoid portions of the DNS thermal plume are unlikely to have any extended effect on habitat utilization by this species which, in any event, has been only an incidental component of the aquatic community over the historical operation of DNS (Appendixes A, C, F, and G).

3.5 Temperature during Critical Reproductive Seasons

Most spawning by the RIS in the vicinity of DNS appears to occur prior to 15 June during the period of closed cycle cooling operation and is, therefore, not affected by indirect open cycle cooling operation that is the subject of this assessment. It should be noted that the reported range of spawning temperatures for a given species is typically based on the observation of spawning across the geographic range of the species and may not be indicative of conditions at a given site. Gizzard shad, white sucker, golden redhorse, black crappie, and logperch typically finish spawning prior to mid-June and the start of indirect open cycle cooling operation at DNS and would, therefore, not be affected.

Emerald shiner, common carp, smallmouth bass, largemouth bass, and freshwater drum typically spawn during May and June and could, therefore, be affected by indirect open cycle cooling operation of DNS during the final quarter of the spawning season. The reported (Wisconsin 2007) upper range of spawning temperatures for emerald shiner is about 27.2°C (81°F); water temperature exceeds 27.2°C (81°F) in less than 10 percent of the cross-section of the Illinois River for a distance of about 475 m downstream of the DNS discharge under the typical condition scenario in June. Under the typical high temperature scenario, ambient temperatures are predicted to exceed 27.8°C (82°F) in the Illinois and Des Plaines River upstream of DNS discharge in June. Thus, it is likely that emerald shiner spawning would end as a result of rising ambient temperatures during typical and extremely warm years prior to initiation of indirect open cycle cooling at DNS.

The reported (Wismer and Christie 1987) upper range of spawning temperatures for common carp is about 27.8°C (82°F); water temperature rarely exceeds 82°F in any portion of the cross-section of the Illinois River downstream of the DNS discharge under the typical condition scenario in June. Under the typical high temperature scenario, ambient temperatures are predicted to exceed 27.8°C (82°F) in the Illinois and Des Plaines Rivers upstream of DNS discharge in June as well as most of the Illinois River cross-section downstream of the DNS discharge. Thus, it is likely that common carp spawning would end as a result of rising ambient temperatures during typical and extremely warm years prior to initiation of indirect open cycle cooling at DNS.

The reported (Wisconsin 2007) upper range of spawning temperatures for largemouth bass and smallmouth bass is about 22.8°C (73°F). Under the typical and typical high temperature scenarios ambient temperatures are predicted to exceed 24.4°C (76°F) in the Illinois and Des Plaines River upstream of DNS discharge in June; even in the cooler Kankakee River, ambient temperatures are predicted to exceed 23.3°C (74°F) (Table B-7). Thus, it is likely that largemouth bass and smallmouth bass spawning would end as a result of rising ambient temperatures during typical years, prior to initiation of indirect open cycle cooling at DNS. Since smallmouth bass and largemouth bass spawn in shallow weed free habitat which would tend to warm faster, it is likely that bass spawning ends before June in the Illinois River. In addition preferred spawning habitat is considerably more common upstream of the DNS discharge (Figure B-17).

The reported (Small and Bates 2001) upper range of spawning temperatures for freshwater drum is about 28.9°C (84°F). Under the typical temperature scenario, ambient temperatures are not predicted to exceed 28.9°C (84°F) in the Illinois, Des Plaines, and Kankakee Rivers upstream of DNS discharge or in any portion of the DNS thermal plume in June (Table B-7). Under the typical high temperature scenario, water temperatures above 28.9°C (84°F) occupy more than 90 percent of the cross-section of the Illinois River downstream of the DNS discharge. Thus, it is likely that freshwater drum spawning would not occur downstream of the DNS discharge during the latter half of June under typical high temperature conditions, but would continue to spawn into the end of June upstream of DNS. Open water spawning habitat utilized by freshwater drum is abundant upstream in the Illinois, Des Plaines, and Kankakee Rivers (Figure B-17).

The only RIS likely to spawn after June are channel catfish and bluegill, which may continue to spawn into July or August in some parts of their range. The reported (Wismer and Christie 1987) upper range of spawning temperatures for channel catfish and bluegill is about 28.9-29.4°C (84-85°F). Under the typical temperature scenario, ambient temperatures are not predicted to exceed 28.9-29.4°C (84-85°F) in the Illinois, Des Plaines, and Kankakee Rivers upstream of DNS discharge or in most of the DNS thermal plume in June-August (Tables B-7 through B-9). Under the typical high temperature scenario, water temperatures above 28.9°C (84°F) occupy more than 90 percent of the cross-section of the Illinois River downstream of the DNS discharge during June-August. Thus, it is likely that channel catfish and bluegill spawning would not occur downstream of the DNS discharge later than mid-June under typical or extreme high temperature conditions, but would continue to spawn into the end of June upstream of DNS. Ambient temperatures in the Illinois and Des Plaines Rivers upstream of DNS are generally 86-31.7°C (89°F) during July and August (Tables B-8 and B-9), well above the reported upper spawning temperature. Thus, it is unlikely that channel catfish and bluegill continue to spawn past the end of June in the vicinity of DNS during typical high temperature years.

Ichthyoplankton drift sampling in the Kankakee River in the vicinity of the DNS cooling water intake during 2005-2006 (EA 2007) indicate that 85-88 percent of the annual production of early life stages of fish in the vicinity of DNS occur prior to 15 June. This is consistent with the findings above, that most spawning by RIS and the species they represent occurs prior to initiation of indirect open cycle cooling at DNS on 15 June.

For ichthyoplankton that do occur into late June and July mortality is not predicted based on available thermal tolerance data. Early life stages frequently have higher thermal tolerance than adults. Eggs and larvae of several RIS (common carp, channel catfish, and bluegill) acclimated to temperatures of 10-33°C (50-91.4°F) tolerate acute exposure to temperatures of 31-41°C (87.8-105.8°F) and chronic exposure up to 38.8°C (101.8°F) (Wismer and Christie 1987; Beitenger et al. 2000). These temperatures are considerably higher than those predicted in the vicinity of the DNS thermal plume even under the modeled extreme high temperature scenario.

3.6 Critical Temperatures for Growth

Reported optimum thermal conditions for growth are generally difficult to interpret and are frequently qualitative or anecdotal. The rate of growth is variable and is affected in individuals and populations by a number of factors including water temperature, food availability, habitat availability, physico-chemical conditions, and population density, among others. Because the methods and resources to hold and test adult and larger fish species are limited, quantitative data on growth is frequently limited to early life stages or species that are reared in hatcheries as part of commercial or recreational fisheries management programs. Laboratory results where constant temperatures and food rations can be regulated provide quantifiable results, but are difficult to interpret in the context of variability that occurs in the natural environment and habitat of these species. It is often reported that the range of temperatures preferred by a species is representative of the temperature range promoting optimum growth. As a result the range of optimum growth reported for many of the RIS can appear to be artificially constrained given the seasonal range of temperatures over which growth occurs.

The RIS all exhibit a seasonal growth pattern typical of temperate zone fishes with zero growth over winter beginning when temperatures decline below some critical temperature in the fall. Growth resumes in the spring as temperatures rise above that critical temperature and peak during the summer. If peak temperatures rise above a critical level, growth may decline or cease for a period during the summer. Between reported upper temperature for optimum growth and upper zero growth temperature, growth continues, but at a slower rate. While elevated temperatures in portions of a thermal plume may inhibit growth during peak summer periods, they may also stimulate growth earlier and later in the year than typically observed without the artificial source of heat in the water body.

The reported upper zero growth temperatures for gizzard shad, emerald shiner, common carp, channel catfish, largemouth bass, and smallmouth bass exceed 33.9°C (93°F) (Table B-14). It is unlikely that temperatures in the DNS thermal plume, even under the extreme conditions of July 2012, would adversely affect growth or cause a cessation of growth for these RIS.

The upper zero growth temperature for bluegill and freshwater drum is about 32.8°C (91°F) (Table B-14). During conditions reflected by the typical high temperature scenario, July temperatures in much of the thermal plume between the DNS discharge and the Dresden Island Lock and Dam are in the range of 32.2-32.8°C (90-91°F) (Table B-8), approaching the zero growth temperature. However, temperatures immediately upstream of DNS are within the optimum range for these two species. Under the extreme high temperatures scenario of July 2012, upstream ambient temperatures as well as DNS thermal plume temperatures (Table B-12) are above the zero growth temperatures for these two species. During the period 6-8 July 2012, it is possible that growth of bluegill and freshwater drum diminished to zero, but would have resumed as ambient and DNS discharge and plume temperatures cooled below 32.8°C (91°F) on 8 July (Figures B-20 and B-21).

Black crappie and white sucker have been included as RIS because they are expected to be more sensitive to high temperatures. These two species have the lowest reported zero growth temperatures of the RIS, 30.5°C and 29.6°C (86.9°F and 85.3°F, respectively). Under the typical scenario, ambient and plume temperatures are below the zero growth temperature throughout the summer for both species. For the typical high temperature scenario during June ambient temperatures and at least 90 percent of the DNS plume are below the zero growth temperature for black crappie (30.5°C [86.9°F], Tables B-7 and B-14).

During July, ambient temperatures in the upstream Illinois River, Des Plaines River, and throughout the DNS thermal plume (Table B-8) exceed the zero growth temperature for black crappie. During August, ambient temperatures in the upstream Illinois and Des Plaines Rivers approach or exceed the zero growth temperature for black crappie (Table B-9); temperatures throughout the DNS thermal plume also exceed the zero growth temperature. In September, under the typical high temperature scenario, upstream ambient temperatures are below the black crappie upper zero growth temperature, but higher than the upper temperature range for optimum growth except in a portion of the Kankakee River (Table B-10). At least 90 percent of the DNS thermal plume exceeds the black crappie upper zero growth temperature by 0.1-0.6°C (0.2-1.1°F). During the extreme high temperature scenario of July 2012, the entire modeled reach, including ambient temperatures in upstream areas, exceeded the black crappie zero growth temperature by 2.2-3.3°C (4-6°F) (Table B-12).

White sucker occur incidentally within the Des Plaines, Kankakee, and upper Illinois Rivers. During July and August under the typical conditions scenario, ambient temperatures in the Des Plaines and upper Illinois Rivers exceed the upper range for optimum growth of white sucker. During July-September under the typical high temperature scenario, ambient temperatures in the Des Plaines and upper Illinois Rivers exceed 27°C (80.6°F), the upper range of temperatures for optimum growth of white sucker (Tables B-8, B-9, and B-14). During these periods under both typical and typical high temperature scenarios, ambient temperatures in the Kankakee River remain within the range for optimum growth of white sucker. During July and August under the typical high temperature scenario ambient temperatures in much of the upstream area exceed the white sucker zero growth temperature (29.6°C [85.3°F]; Tables B-8 and B-9). During July-September the entire DNS thermal plume and during June about 50 percent of the plume exceed the white sucker zero growth temperature (Tables B-7 to B-11). During the extreme high temperature scenario of July 2012 the entire modeled reach, including ambient temperatures in upstream areas, exceeded the white sucker zero growth temperature by 3.3-4.4°C (6-8°F) (Table B-12).

This analysis indicates that for most of the RIS and the community they represent, temperatures in the DNS thermal plume are not expected to adversely affect normal patterns of growth. For white sucker (which occurs only incidentally in the upper Illinois, Des Plaines, and Kankakee Rivers) and black crappie under typical high temperature and extreme high temperature conditions, even ambient temperatures during July and August can exceed the upper temperature for optimum growth and the zero growth temperature.

3.7 Potential for Cold Shock Mortality

Cold shock can occur when fish are quickly exposed to much lower temperatures than those to which they are acclimated such as when fish attracted and acclimated to a thermal plume during winter are returned to much colder ambient temperatures in the event of a station shutdown. DNS operates using closed cycle between October and mid-June; the risk of cold shock is minimal because the winter thermal plume is relatively small with less differential over ambient temperatures. Although for completeness, cold chock data are presented when available for each of the RIS (Figures B-5 to B-6), the proposed ATLs do not affect the period during cooler ambient temperatures between 1 October and 14 June, when DNS operates in closed cycle cooling mode.

4.0 CONCLUSIONS OF BIOTHERMAL ASSESSMENT

This biothermal assessment has been prepared to support Exelon's request for renewal and revision of the alternative thermal standards in the DNS NPDES Permit. During the period 15 June-30 September, when water temperatures at the DNS intake exceed 90°F, Exelon has requested that the temperatures at the DNS discharge be allowed to exceed 33.9°C (93°F) up to a maximum excursion of 35°C (95°F), for a duration not to exceed 24 hours per episode and for a total of no more than 10 percent of the hours available during this time period - 259 hours. This predictive assessment used the MIKE3 model to characterize and predict hydrothermal conditions in the lower Des Plaines and Kankakee Rivers and the Illinois River from their confluence downstream to the Dresden Island Lock and Dam located approximately 1,000 meters downstream of the DNS discharge (Sections 1.3 through 1.6). The MIKE 3-predicted thermal plume dimensions and distribution in the Illinois River were compared to available biothermal metric data (Section 2.1.4) related to survival, avoidance, spawning, and growth of fish. This assessment evaluated the predicted effects of DNS thermal plume temperatures (Section 2.3) on the aquatic community represented by 12 selected RIS (Section 2.1.5) under 3 scenarios (Section 2.3.1) of river flow and ambient water temperature conditions (Tables B-5 and B-6):

1. Typical Scenario—50^{th} percentile river flow and 60^{th} percentile ambient river temperature;

2. Typical High Temperature Scenario—5^{th} percentile river flow and 95^{th} percentile ambient river temperature; and

3. Extreme High Temperature Scenario—equivalent to the proposed ATLs. Based on modeled conditions for the unusual heat wave event of July 2012 when intake temperatures exceeded 32.2°C (90°F), the 97^{th} or higher percentile for ambient temperature. Flows were in the lower $1\text{-}4^{th}$ percentile for the Des Plaines River and $15\text{-}20^{th}$ percentile for the Kankakee River.

Ambient temperatures did not exceed 32.2°C (90°F), the proposed ATLs' threshold, under either the Typical or Typical High Temperature scenarios. DNS discharge temperatures did not exceed 88°F under the Typical Scenario or 33.3°C (92°F) under the Typical High Temperature Scenario. Thus, both scenarios did not exceed the 33.9°C (93°F) maximum discharge temperature excursion allowed under the existing permit.

The Extreme High Temperature Scenario, based on the July 2012 event, provides a good match for analysis of the proposed ATLs. Under this assessment scenario, intake temperatures upstream of the DNS cooling water discharge reached 34.4°C (93.9°F) and the maximum discharge temperature reached 34.9°C (94.9°F), the approximate maximum excursion temperature requested by Exelon. Conditions similar to those modeled for the July 2012 Extreme High Temperature Scenario are unusual occurrences; during the July 2012 event modeled for scenario 3, ILEPA issued a provisional variance for continued DNS operations. The worst case conditions during this extreme event extended from 6 to 8 July 2012 with peak temperatures in portions of the DNS thermal plume of 33.9-34.4°C (93-94°F) for a continuous period of about 12 hours on 7 July and in more than 50 percent of the plume for 6-8 hours.

The following findings are drawn from the biothermal assessment developed in Section 3:

1. **Potential for Thermal Mortality—**although under extreme conditions, temperatures exist within the DNS thermal plume that have the potential to cause mortality under extended chronic exposure, these conditions are rare and of relatively short duration. Refuge for Fish have the ability to avoid these high water temperatures and extensive and diverse aquatic habitat is available upstream of the DNS discharge. Most of the aquatic habitat affected by the DNS thermal plume is open deep channel habitat; significant channel habitat is available upstream of the DNS thermal plume. There is little shallow water habitat available downstream of the DNS thermal discharge and is typically limited to a narrow margin near the shoreline; extensive shallow water habitat is available immediately upstream of the DNS discharge. Consequently, temperatures in the plume, even under extreme meteorological conditions, are unlikely to result in any significant mortality. During the 2012 July heat event (the Extreme High Temperature Scenario) no fish kills were observed during monitoring in the vicinity of DNS and the Dresden Island Lock and Dam.

   For white sucker, the upper thermal tolerance limit for chronic exposure for juveniles appears to be about 35°C (93°F) at an acclimation of 32.2°C (90°F); however, the highest thermal tolerance chronic exposure for adults is at an acclimation temperature of 26°C (78.8°F). White sucker is the only RIS for which the potential exists for mortality associated with chronic exposure to temperatures above 32.5°C (90.5°F) in the DNS thermal plume that are predicted to occur during these extreme conditions. These conditions did not persist for more than 24 hours in the thermal plume and throughout this period ambient temperatures in 10-25 percent of the area immediately upstream of the DNS discharge was less than 32.5°C (90.5°F) and would have provided refuge for white sucker avoiding the potentially stressful high thermal plume temperatures. While white sucker may be relatively more sensitive than the other RIS to elevated water temperatures in the DNS thermal plume during extreme conditions, the species occurs only incidentally in the Des Plaines, Kankakee, and Illinois River in the vicinity of DNS.

2. **Temperature Avoidance and Habitat Avoidance—**Except in unusual circumstances, mortality of fish as a result of exposure to high water temperatures in their natural habitat is rare because fishes have a demonstrated ability to sense and avoid stressful elevated temperatures when areas with cooler temperatures are available. While the ability to avoid stressful water temperatures minimizes the potential for fish mortality, it could result in avoidance of important habitat areas that may be affected by portions of the thermal plume. Avoidance data available for gizzard shad, channel catfish, largemouth bass, smallmouth bass, and bluegill indicate that these RIS would not avoid any portions of the plume under extreme ambient and discharge temperature conditions. For each of these RIS, the temperatures avoided are typically several degrees higher than the highest plume cross-section and bottom temperature estimated during extreme conditions. Other

RIS for which avoidance data were not available, generally exhibited acute and/or chronic mortality metrics within a similar range to the five RIS with avoidance information. For species where avoidance has been documented, fish typically avoid temperatures slightly below the threshold of chronic mortality. It is likely that the RIS without upper avoidance temperature data would exhibit a similar pattern of avoidance and would not be expected to avoid significant areas of habitat in the vicinity of the DNS thermal plume. This assessment supports the finding that the DNS thermal plume would not be expected to cause avoidance of aquatic habitat for any of these species, even at very low river flow conditions (1-4 percentile), high air temperatures (37.8°C [100°F]), and high DNS discharge temperatures (34.9°C [94.9°F]) (1-3 percentile). Although it is likely that white sucker might avoid significant areas of the DNS thermal plume during such extreme conditions, moving to more moderate upstream habitat, the duration that avoided temperatures persist is short, less than 12 hours. Such short durations when white sucker would avoid portions of the DNS thermal plume are unlikely to have any extended effect on habitat utilization by this species which has been only an incidental component of the aquatic community. Because avoidance is predicted to be minimal and of short duration the DNS thermal plume is unlikely to inhibit local movement or diel and seasonal migrations of RIS.

3. **Temperatures during Critical Spawning Periods—**Most spawning by the RIS in the vicinity of DNS appears to occur prior to 15 June during the period of closed cycle cooling operation and is, therefore, not affected by indirect open cycle cooling operation that is the subject of this assessment. Gizzard shad, white sucker, golden redhorse, black crappie, and logperch typically finish spawning prior to mid-June and the start of indirect open cycle cooling operation at DNS and would, therefore, not be affected. Over their geographic range emerald shiner, common carp, smallmouth bass, largemouth bass, and freshwater drum typically spawn during May and June; the only RIS reported to spawn after June across their geographic range are channel catfish and bluegill which may continue to spawn into July or August in some regions. However, ambient temperatures in the Des Plaines, Kankakee and Illinois Rivers typically exceed the reported upper temperatures range for spawning by these species before the end of June, particularly during warmer years. Ichthyoplankton drift sampling in the Kankakee River in the vicinity of the DNS cooling water intake indicate that 85-88 percent of the annual production of early life stages of fish in the vicinity of DNS occur prior to 15 June. This is consistent with the findings above, that most spawning by RIS and the species they represent occurs prior to initiation of indirect open cycle cooling at DNS on 15 June and would therefore, not be affected by the proposed ATLs..

4. **Critical Temperatures for Growth—**This analysis indicates that for most of the RIS and the community they represent, temperatures in the DNS thermal plume are not expected to adversely affect normal patterns of growth. The RIS all exhibit a seasonal growth pattern typical of temperate zone fishes with zero growth over winter beginning when temperatures decline below some critical temperature in the fall. Growth resumes in the spring as temperatures rise above that critical temperature and peak during the

summer. If peak temperatures rise above a critical level, growth may decline or cease for a period during the summer. Between the reported upper temperature for optimum growth and the upper zero growth temperature, growth continues, but at a slower rate. While elevated temperatures in portions of a thermal plume may inhibit growth during peak summer periods, they may also stimulate growth earlier and later in the year than typically observed without the artificial source of heat in the water body. The reported upper zero growth temperatures for gizzard shad, emerald shiner, common carp, channel catfish, largemouth bass, and smallmouth bass exceed 33.9°C (93°F). It is unlikely that temperatures in the DNS thermal plume even under the extreme conditions of July 2012 would adversely affect growth or cause a cessation of growth for these RIS. For white sucker (which occurs only incidentally in the upper Illinois, Des Plaines, and Kankakee River) and black crappie under typical high temperature and extreme high temperature conditions, ambient temperatures during July and August can exceed the upper temperature for optimum growth and the zero growth temperature and the DNS Thermal plume would not exacerbate this condition. During rare, but extremely warm years represented by July 2012, the observed high ambient temperatures are predicted to limit growth for a brief period of several days for thermally sensitive species such as white sucker and black crappie. The brief period of extreme ambient temperatures is not predicted to have an extended long-term effect on growth patterns. Both of these species are uncommon in the fish community in the vicinity of DNS.

The findings from this predictive assessment indicate that temperatures in the DNS thermal plume under the proposed ATLs are unlikely to have more than minimal and transitory effects on incidental components of the aquatic community even under rare and extreme meteorological conditions.

5.0 REFERENCES

Baker, S.C. and R.C. Heidinger. 1996. Upper lethal temperature tolerance of fingerling black crappie. *J of Fish Biology, 48: 1123-1129.*

Barans, C.A. and R.A. Tubb. 1973. Temperatures selected seasonally by four fishes from western Lake Erie. *J. Fish. Res. Board Canada, 30: 1697-1703*.

Beitinger, T.L. and W.A. Bennett. 2000. Quantification of the role of acclimation temperature in temperature tolerance of fishes. *Environmental Biology of Fishes, 58: 277-288.*

Beitinger, T.I., W.A. Bennett, and R.W. McCauley. 2000. Temperature tolerance of North American freshwater fishes exposed to dynamic changes in temperature. *Env. Biology of Fishes, 58: 237-275.*

Bevelhimer, M. and W. Bennett. 2000. Assessing cumulative thermal stress in fish during chronic intermittent exposure to high temperatures. *Environ. Sci. & Policy. Vol. 3, Suppl. 1. Pub.* Elsevier Science Ltd.

Cheetham, J. L., C. T. Garten, Jr., C. L. King, and M. H. Smith. 1976. Temperature tolerance and preference of immature channel catfish (*Ictalurus punctatus*). *Copeia:* 1976: 609-612.

Cherry, D.S., K.L. Dickson, and J. Cairns. 1975. Temperatures selected and avoided by fish at various acclimation temperatures. *J. Fish. Res. Board Canada, 32: 485-491*.

Cincotta, D.A., J.R. Stauffer Jr., and C.H. Hocutt. 1982. Fish responses to temperature to assess effects of thermal discharge on biological integrity. *Journal of the American Water Resources Assoc, 18: 437–450*.

Coutant, C.C. 1977. Compilation of temperature preference data. *J. Fish. Res. Board Can, 34: 739-745*.

Coutant, C.C. 1972. Biological aspects of thermal pollution. I: Entrainment and discharge canal effects. *CRC Crit. Rev. in Environ. Cont. 3:341-381*.

Duke/Fluor Daniel. 1992. North Oak Creek Power Plant 316(a) Demonstration, Information Review. Report to Wisconsin Electric Power Company by Duke/Fluor Daniel, Charlotte, North Carolina, April.

EA Engineering, Science, and Technology, Inc., PBC (EA). 2015. Dresden Station Aquatic Monitoring 2014. Upper Illinois Waterway, River Mile 270.5-273.4. Prepared for Exelon Nuclear, Morris, IL.

EA Engineering, Science, and Technology, Inc. (EA). 2007. Entrainment Characterization Study 2005-2006 Dresden Station. Prepared for Exelon Nuclear, Warrenville, IL.

Etnier, D.A. and W.C. Starnes. 1993. *Fishes of Tennessee.* University of Tennessee Press, Knoxville, Tennessee. 689 pp.

Farless, N. and S. Brewer. 2014. Critical Thermal Maximum of Stream Fishes from the Arbuckle Mountains Ecoregion. The Nature Conservancy and Oklahoma State University.

Fuller, P.L., L.G. Nico, and J.D. Williams. 1999. Nonindigenous Fishes Introduced into Inland Waters of the United States. *American Fisheries Society, Special Publication 27*, Bethesda, Maryland.

Hokanson, K.E.F. 1977. Temperature requirements of some percids and adaptations to the seasonal temperature cycle. *J. Fish. Res. Board Can., 34: 1524-1550*.

Hutchison, V.H. and J.D. Maness. 1979. The role of behavior in temperature acclimation and tolerance in ectotherms. *American Zoologist. 19:367-384*.

Illinois Endangered Species Protection Board. 2011. Checklist of Endangered and Threatened Animals and Plants of Illinois. Effective 11 February 2011. Illinois Endangered Species Protection Board, Springfield, IL. http://www.dnr.illinois.gov/ESPB/Documents/ETChecklist2011.pdf

Jobling, M. 1981. Temperature tolerance and the final preferendum—rapid methods for the assessment of optimum growth temperatures. *J. Fish Biology, 19: 439-455*.

Koenst, W.H. and L.L. Smith. 1985. Factors Influencing Growth and Survival of White Sucker, *Catostomus commersoni*. Prepared for U.S. EPA, Monticello Ecological Research Station. University of Minnesota, St. Paul, MN.

Mathur, D., R.M. Schutsky, E.J. Purdy Jr., and C.A. Silver. 1983. Similarities in avoidance temperatures of freshwater fishes. *Canadian. Journal of Fisheries. and Aquatic Sciences, 40:2144–2152*.

McCullough, D.A. 1999. A review and synthesis of effects of alternations to the water temperature regime on freshwater life stages of salmonids, with special reference to Chinook salmon. Columbia River Inter-Tribal Fish Comm., Portland OR.

Meldrim, J.W., J.J. Gift, and B.R. Petrosky. 1974. The Effect of Temperature and Chemical Pollutants on the Behavior of Several Estuarine Organisms. Bull. 11. Ichthyological Associates, Inc.

Matthews, W.J. and J.D. Maness. 1979. Critical thermal maxima, oxygen tolerances and success of cyprinid fishes in a southwestern river. *American Midland Naturalist*, 102: 374-377.

McCormick, J.H. and C.F. Kleiner. Growth and survival of young-of-the-year emerald shiners

(*Notropis atherinoides*) at different temperatures. *J. Fish. Res. Board Canada, 33: 839-842*.

Page, L.M. and B.M. Burr. 2011. Peterson Field Guide to Freshwater Fishes of North America North of Mexico, 2nd Edition. Houghton Mifflin Harcourt Publishing Company, New York, New York, 663 pp.

Pflieger, W.L. 1997. *Fishes of Missouri.* Missouri Department of Conservation, Jefferson City, Missouri, 372 pp.

Reash, R.J., G.L. Seegert, and W.L. Goodfellow. 2000. Experimentally-derived upper thermal tolerance for redhorse suckers: revised 316(a) variance conditions at two generating facilities in Ohio. *Environmental Science and Policy, 3: S191-S196.*

Reutter, J.M. and C.E. Herdendorf. 1974. Environmental Evaluation of a Nuclear Power Plant on Lake Erie. Ohio State University Project F-41-R-5, U.S. Fish and wildlife Service Report (6/1/73-5/31/74. 84 pp.

Reynolds, W.W. and M.E. Casterlin. 1977. Temperature preference of four fish species in an electronic thermoregulatory shuttlebox. *The Progressive Fish-Culturist, 39:123-125*.

Scott W.B. and E.J. Crossman. 1973. *Freshwater Fishes of Canada.* Fisheries Research Board of Canada, Bulletin 184, Ottawa, 966 pp.

Smith, P.W. 1979. *Fishes of Illinois.* University of Illinois Press, Urbana, Illinois, 314 pp.

Trautman, M.B. 1981. *Fishes of Ohio.* Ohio State University Press in Collaboration with the Ohio Sea Grant Program, Columbus, Ohio, 782 pp.

Twomey, K.A., K.A. Williamson, and P.C. Nelson. 1984. Habitat Suitability Index Models and Instream Flow Suitability Curves: White Sucker. FWS/OBS-82/10.64. 56 pp. U.S. Fish and Wildlife Service, Fort Collins, CO.

U.S. Environmental Protection Agency (USEPA) and Nuclear Regulatory Commission (NRC). 1977. *Interagency 316(a) Technical Guidance Manual and Guide for Thermal Effects Sections of Nuclear Facilities Environmental Impact Statements, Draft.* Office of Water Enforcement, U.S. Environmental Protection Agency, Washington, D.C. 1 May 1977.

Walsh S.J., D.C. Haney, C.M. Timmerman, and R.M. Dorazio. 1998. Physiological tolerance of juvenile robust redhorse, Moxostoma robustum: conservation implications for an imperiled species. *Env Biology of Fishes, 51: 429-444*.

Wenholz, M. 2007. Technical Support Document for Wisconsin's Thermal Water Quality Rules, Draft. Wisconsin Department of Natural Resources, Madison, Wisconsin.

Wismer, D.A. and A.E. Christie. 1987. Temperature Relationships of Great Lakes Fishes: A data Compilation. Great Lakes Fish, Comm., Spec. Pub. 87-3. 165 pp. Great Lakes Fishery Commission, Ann Arbor, MI.

Yoder, C.O. 2012. Development of a Database for Upper Thermal Tolerances for New England Freshwater Fish Species. Prepared for Environmental and Natural Resources Law Clinic, Vermont Law School. Midwest Biodiversity Institute, Columbus, OH.

FIGURES

Figure B-1. Seven-day rolling average of water temperatures at four monitoring locations, Sept 2012 - Sept 2014.

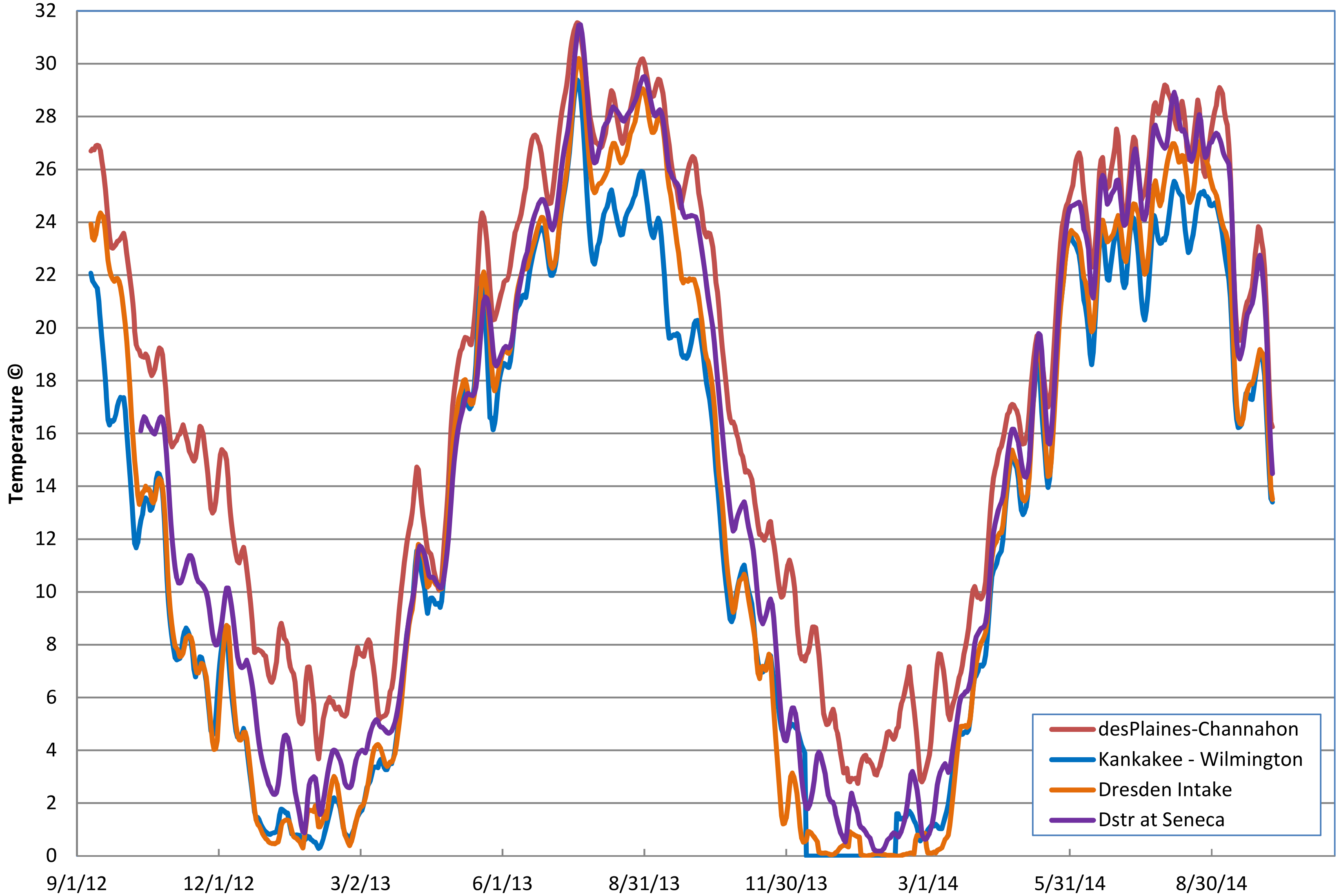


Figure B-2. Measured flows from USGS gages on the Kankakee and Des Plaines rivers, Sept 2012 - Oct 2014.

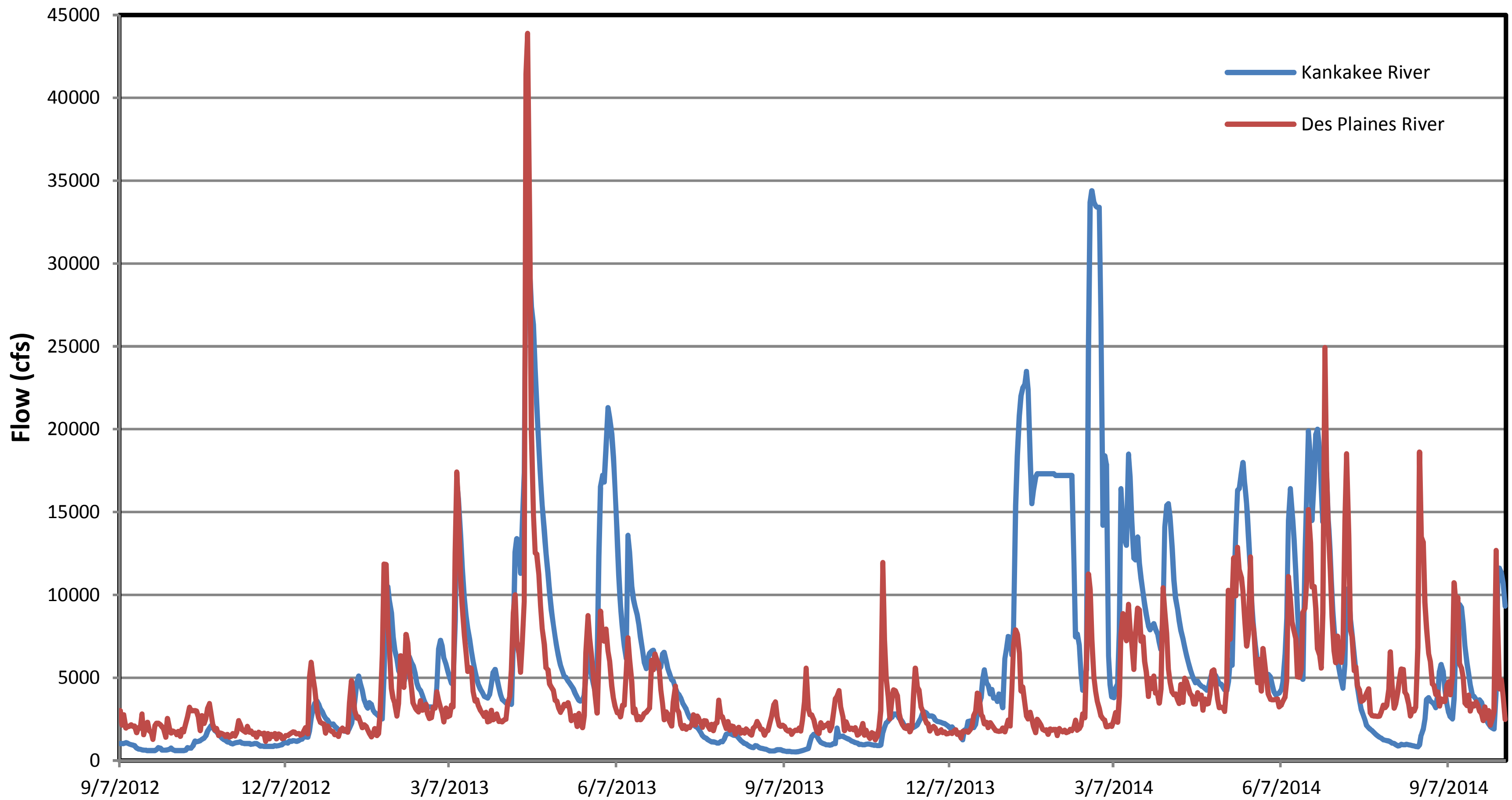


Figure B-3. Seven-day rolling average of estimated flow-weighted ambient water temperatures in the Illinois River downstream of the confluence of the Kankakee and Des Plaines Rivers, Sept 2012 - Sept 2014.

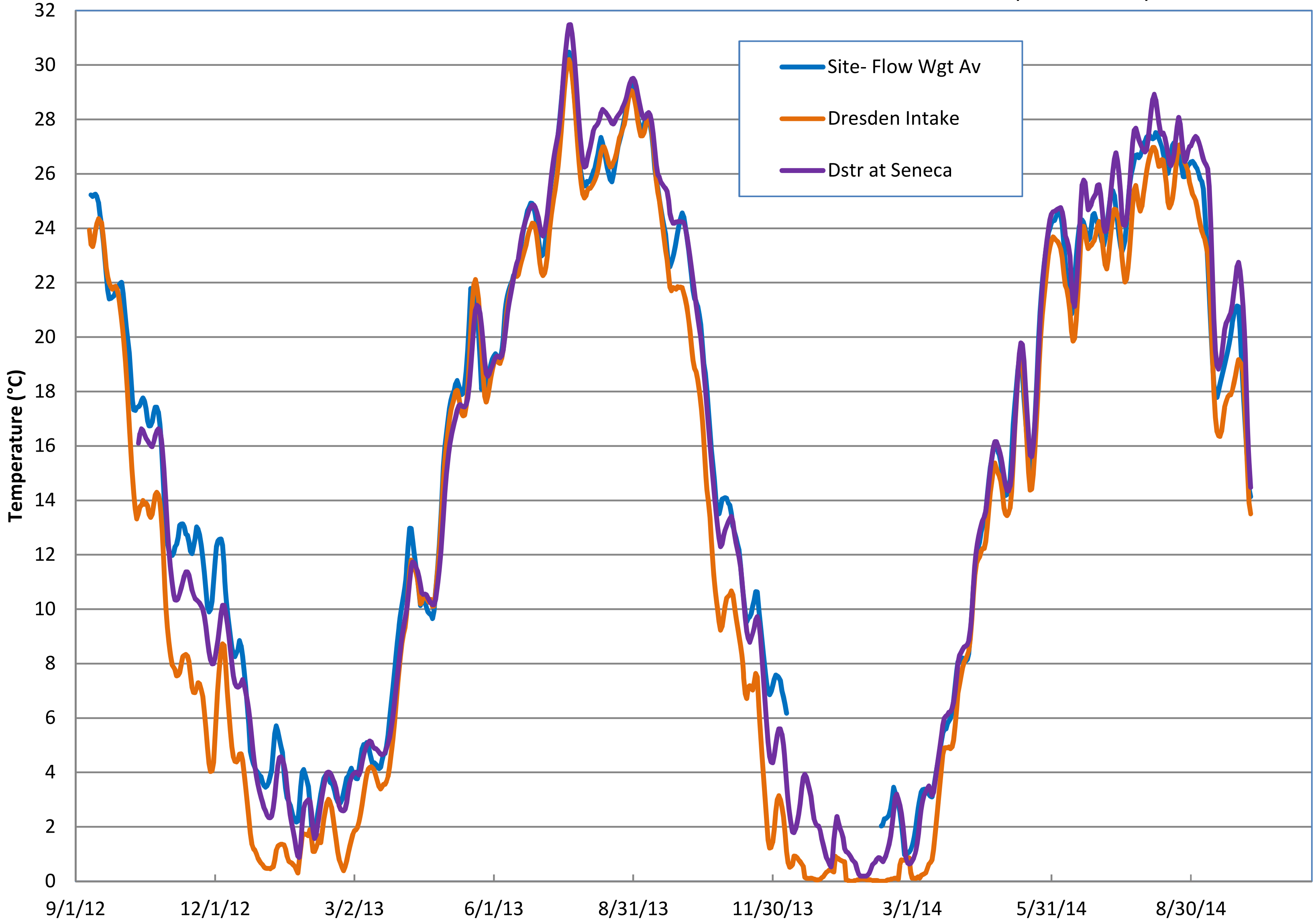
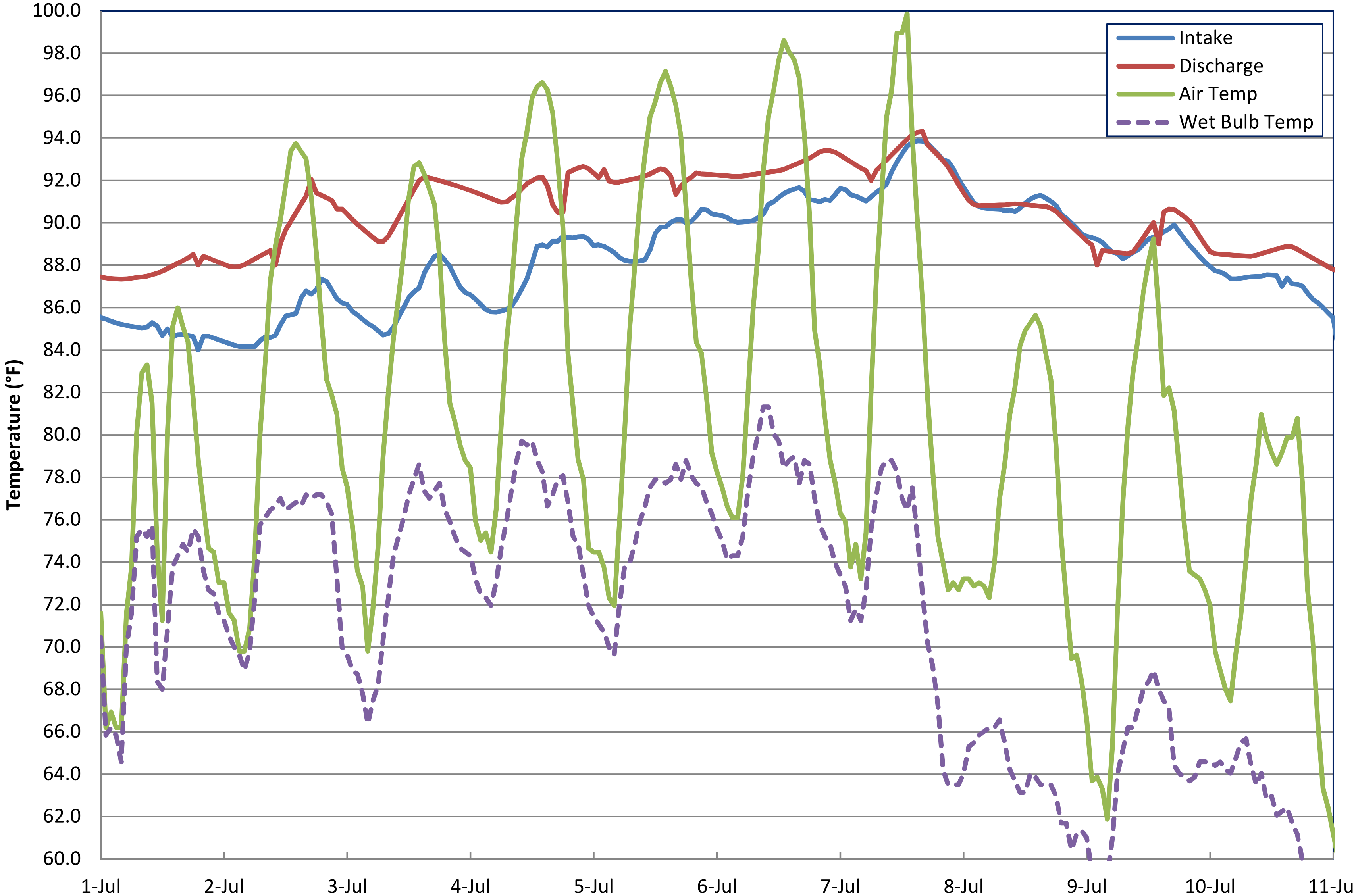


Figure B-4. DNS intake and discharge temperatures and air and wet bulb temperatures, 1-11 July 2012.



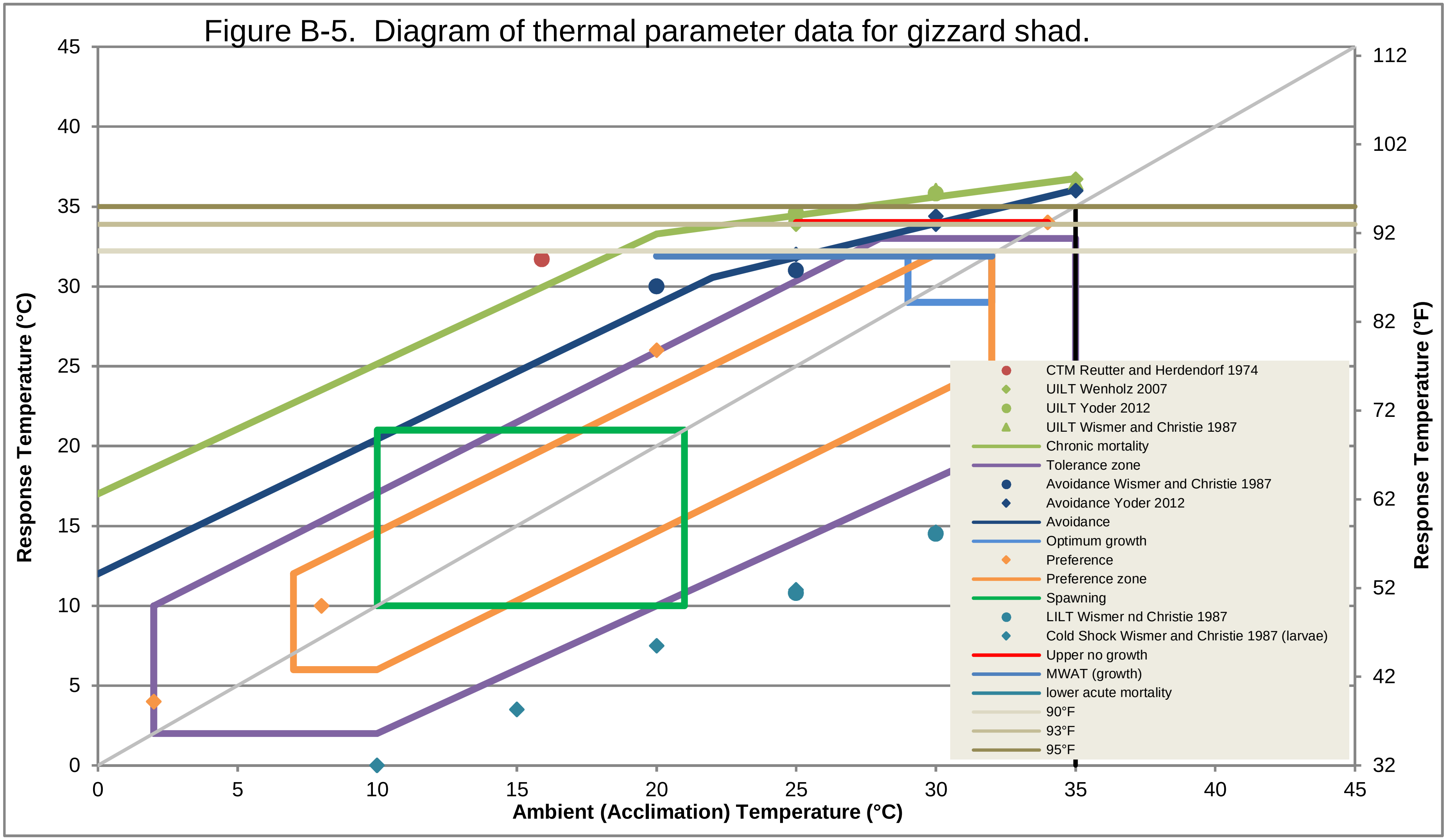


Figure B-5. Diagram of thermal parameter data for gizzard shad.
Response Temperature (°C)
Response Temperature (°F)
Ambient (Acclimation) Temperature (°C)
0
5
10
15
20
25
30
35
40
45
32
42
52
62
72
82
92
102
112
CTM Reutter and Herdendorf 1974
UILT Wenholz 2007
UILT Yoder 2012
UILT Wismer and Christie 1987
Chronic mortality
Tolerance zone
Avoidance Wismer and Christie 1987
Avoidance Yoder 2012
Avoidance
Optimum growth
Preference
Preference zone
Spawning
LILT Wismer nd Christie 1987
Cold Shock Wismer and Christie 1987 (larvae)
Upper no growth
MWAT (growth)
lower acute mortality
90°F
93°F
95°F

Figure B-6. Diagram of thermal parameter data for emerald shiner.

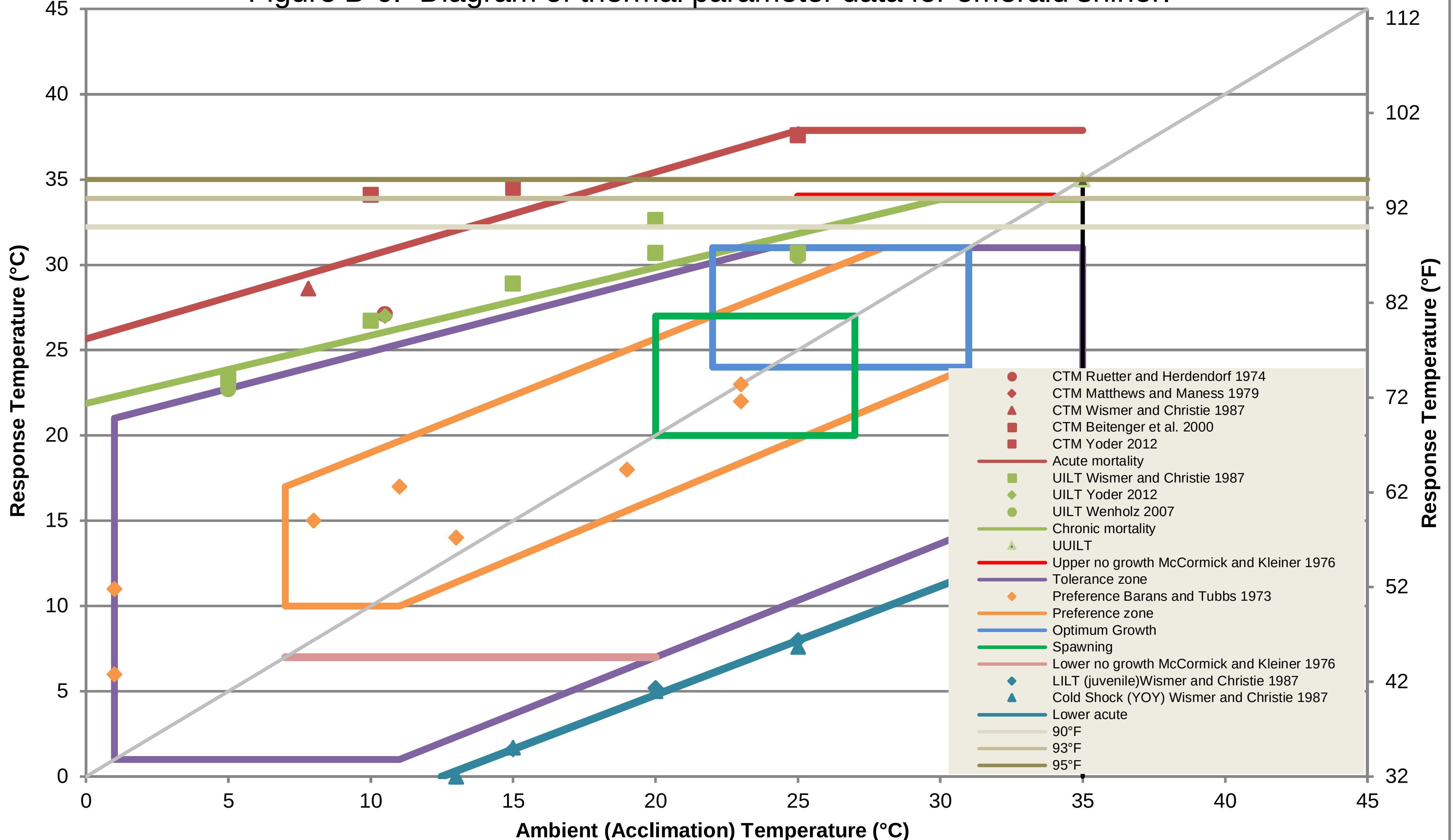


Figure B-7. Diagram of thermal parameter data for common carp.

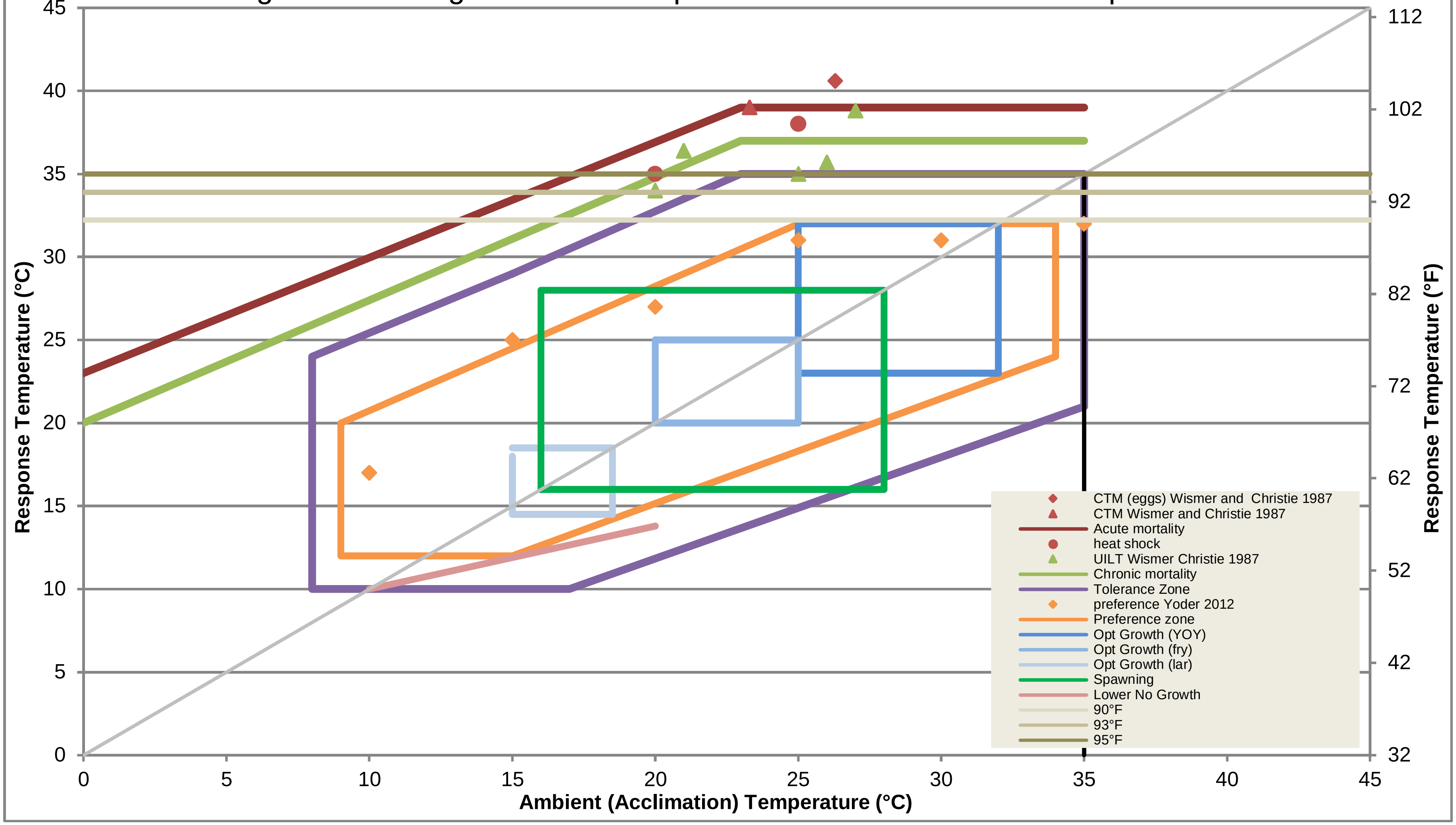
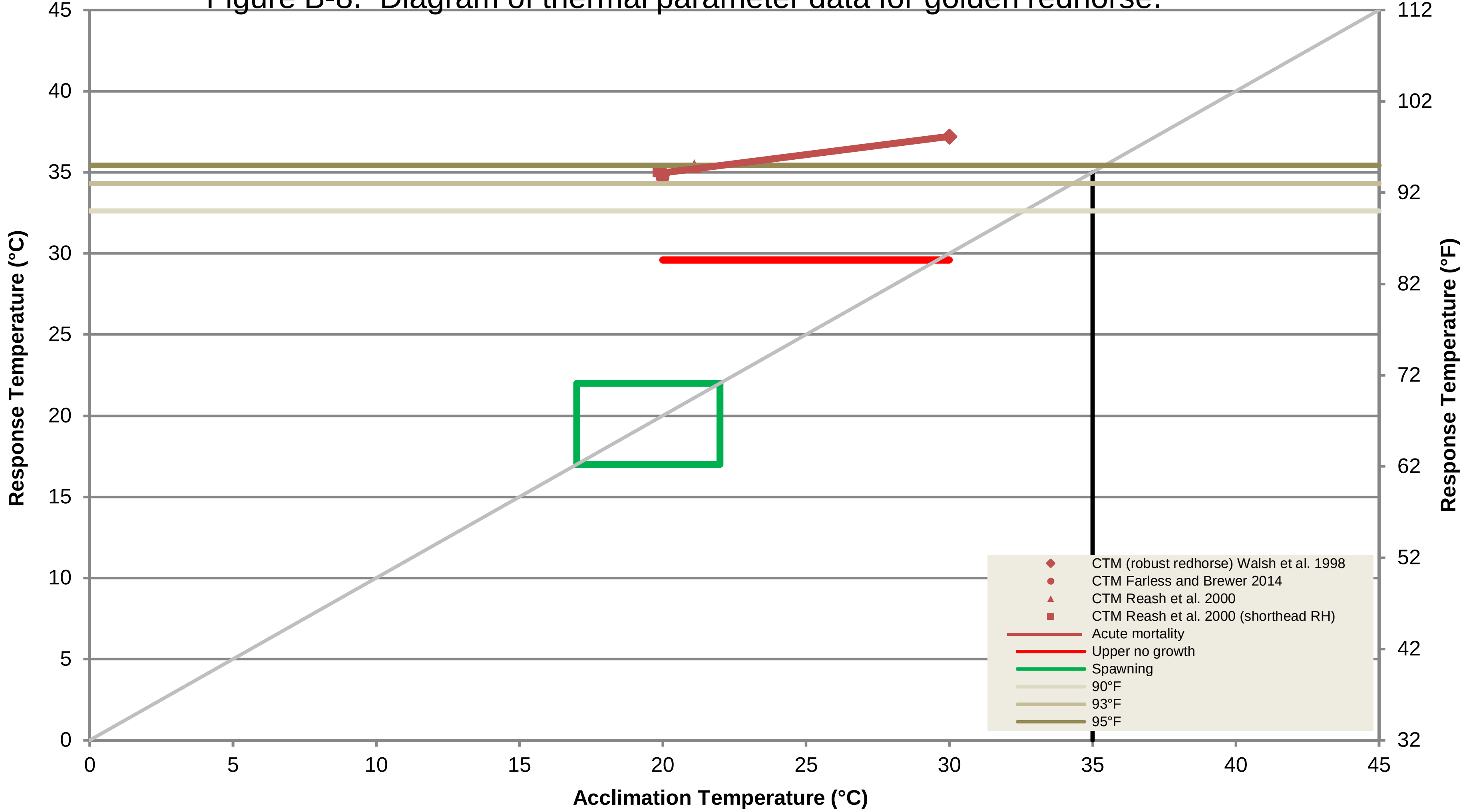


Figure B-8. Diagram of thermal parameter data for golden redhorse.



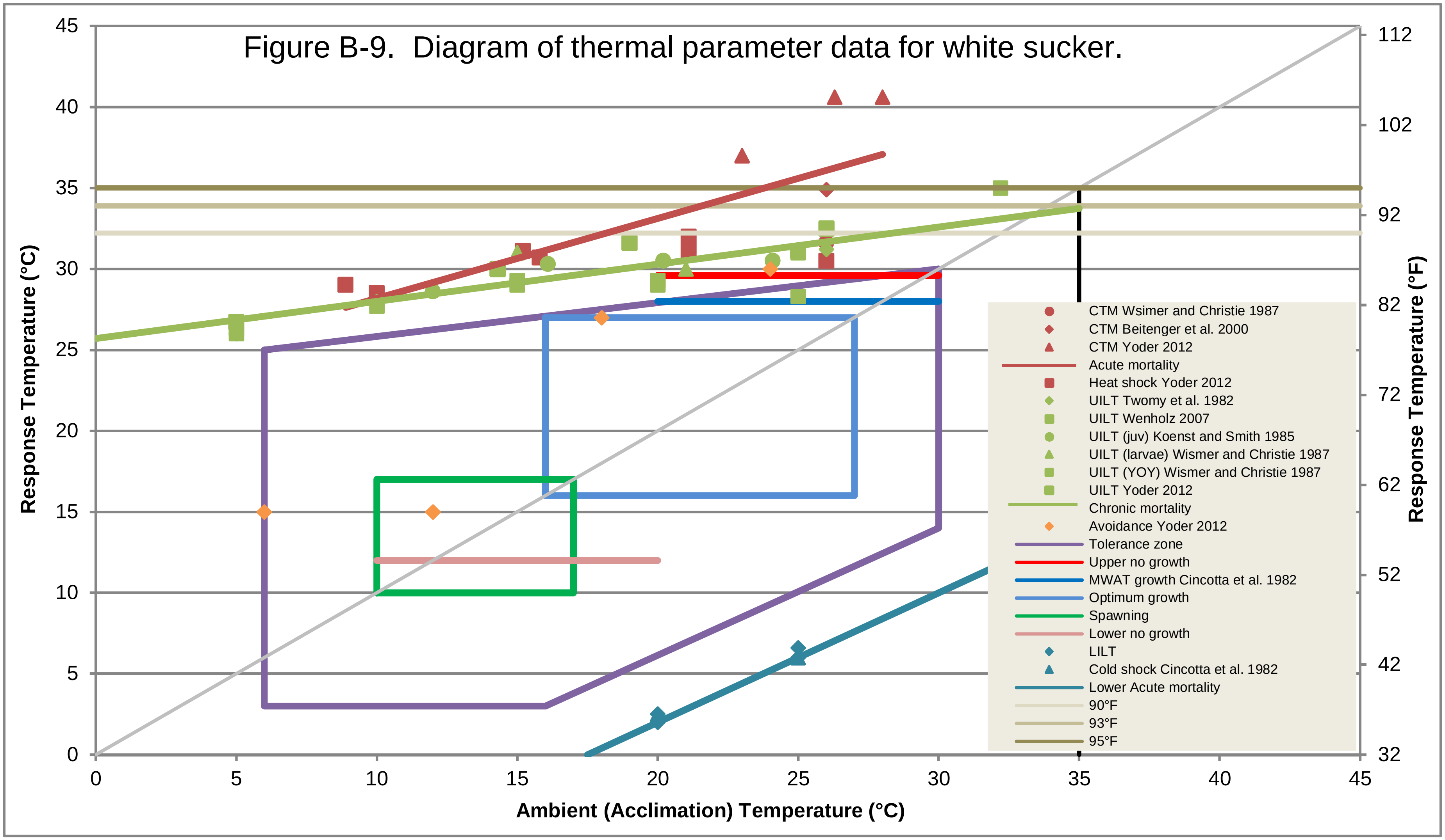


Figure B-9. Diagram of thermal parameter data for white sucker.
Response Temperature (°C)
Response Temperature (°F)
Ambient (Acclimation) Temperature (°C)
0
5
10
15
20
25
30
35
40
45
32
42
52
62
72
82
92
102
112
CTM Wsimer and Christie 1987
CTM Beitenger et al. 2000
CTM Yoder 2012
Acute mortality
Heat shock Yoder 2012
UILT Twomy et al. 1982
UILT Wenholz 2007
UILT (juv) Koenst and Smith 1985
UILT (larvae) Wismer and Christie 1987
UILT (YOY) Wismer and Christie 1987
UILT Yoder 2012
Chronic mortality
Avoidance Yoder 2012
Tolerance zone
Upper no growth
MWAT growth Cincotta et al. 1982
Optimum growth
Spawning
Lower no growth
LILT
Cold shock Cincotta et al. 1982
Lower Acute mortality
90°F
93°F
95°F

Figure B-10. Diagram of thermal parameter data for channel catfish.

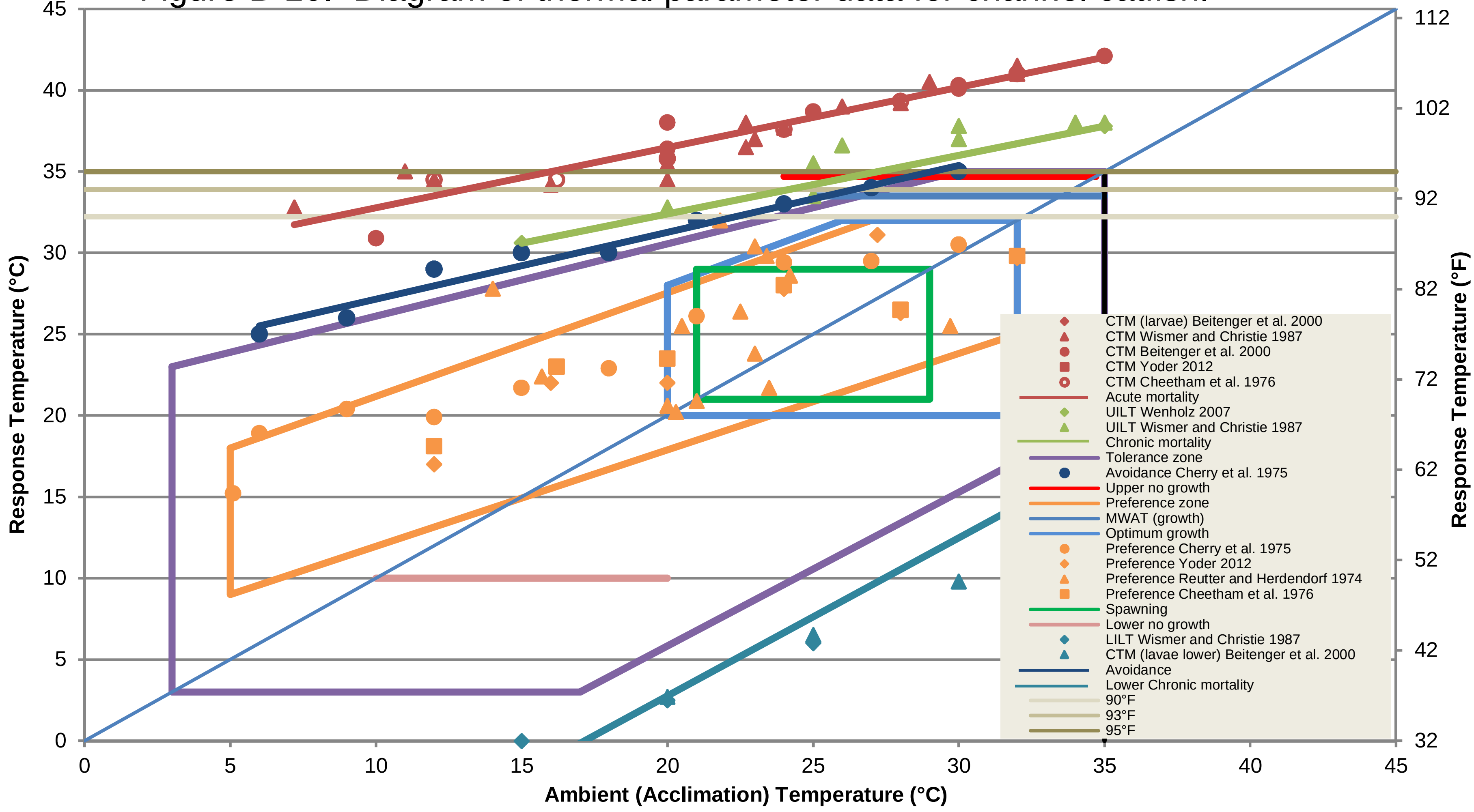


Figure B-11. Diagram of thermal parameter data for largemouth bass.

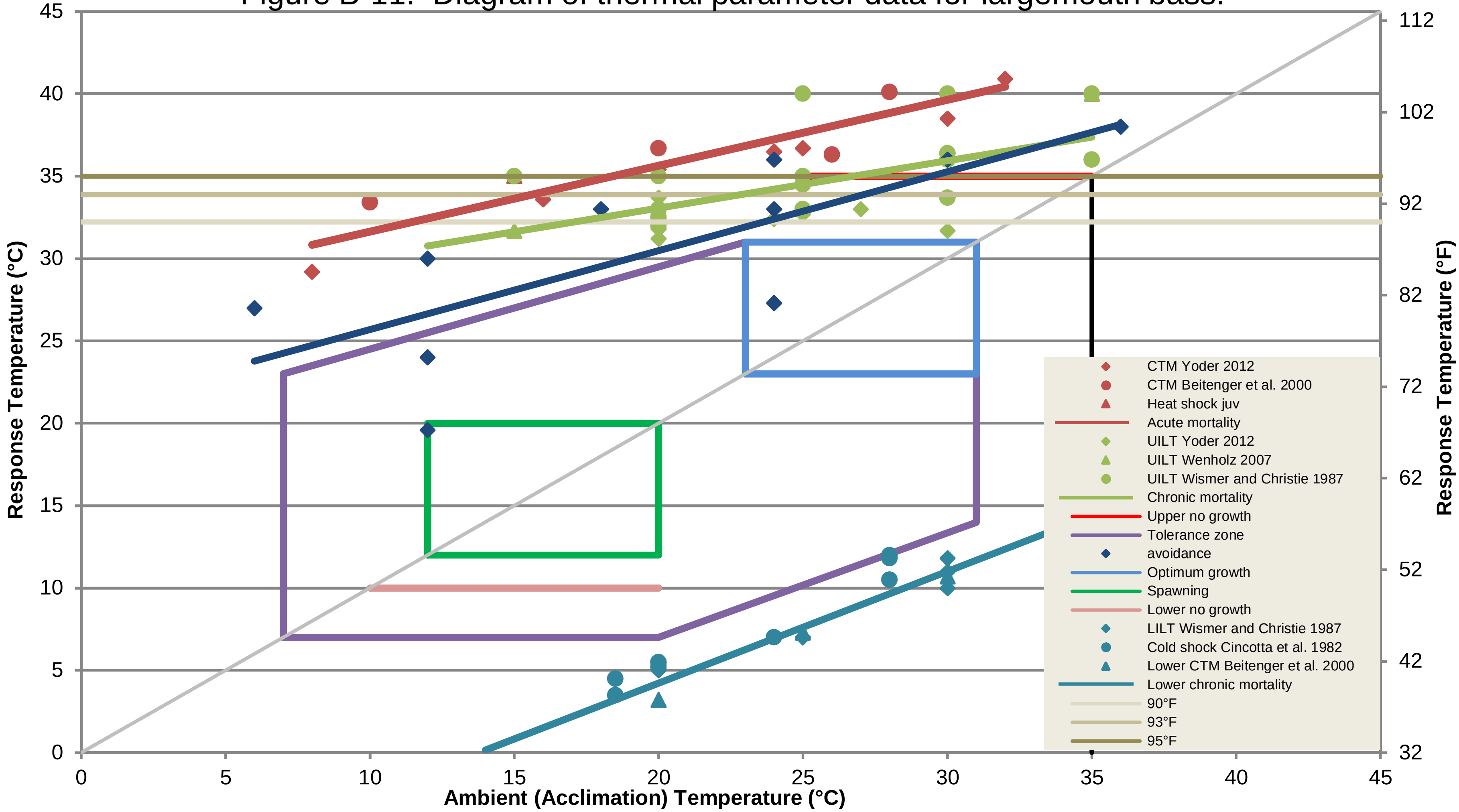
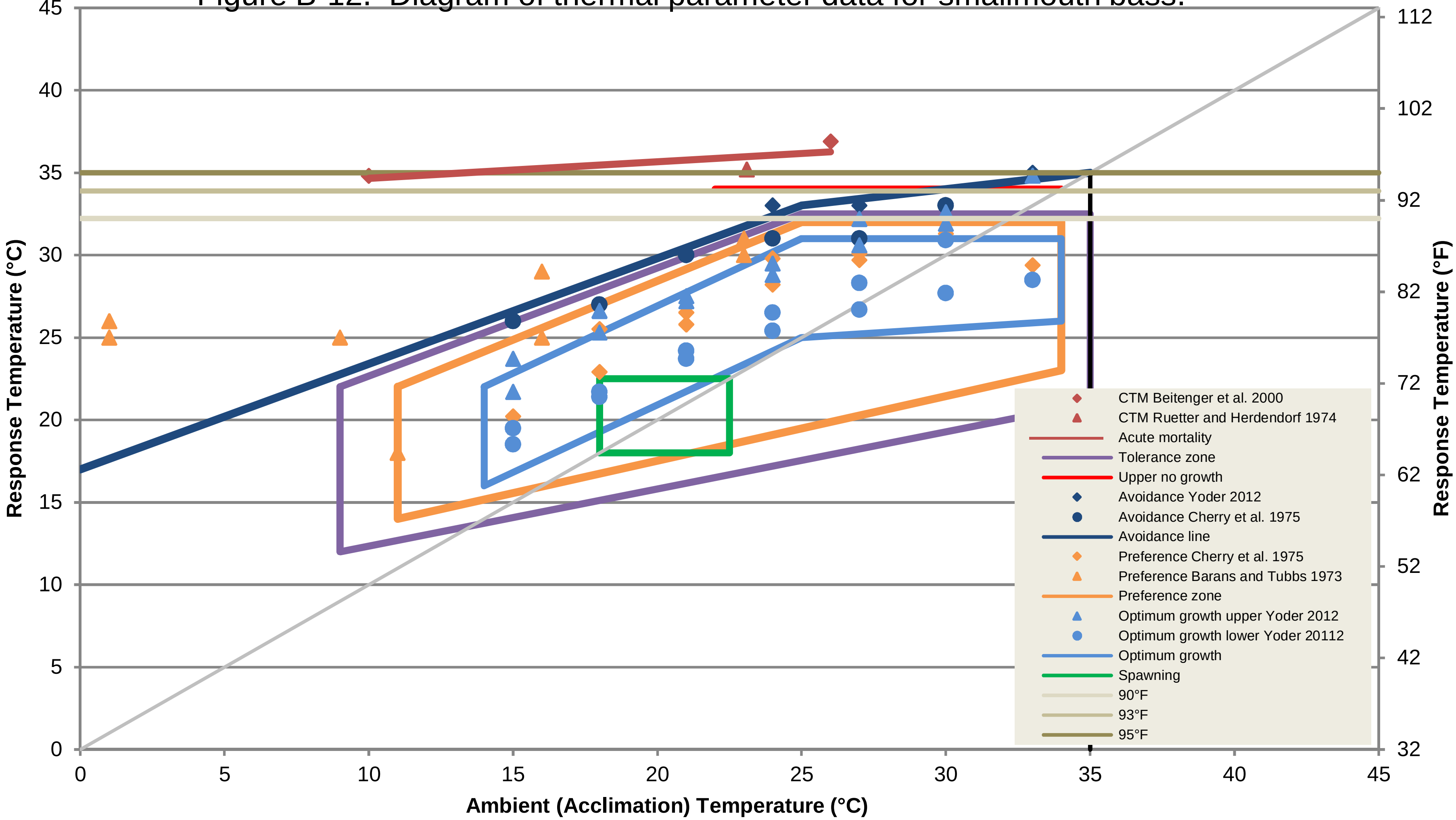


Figure B-12. Diagram of thermal parameter data for smallmouth bass.



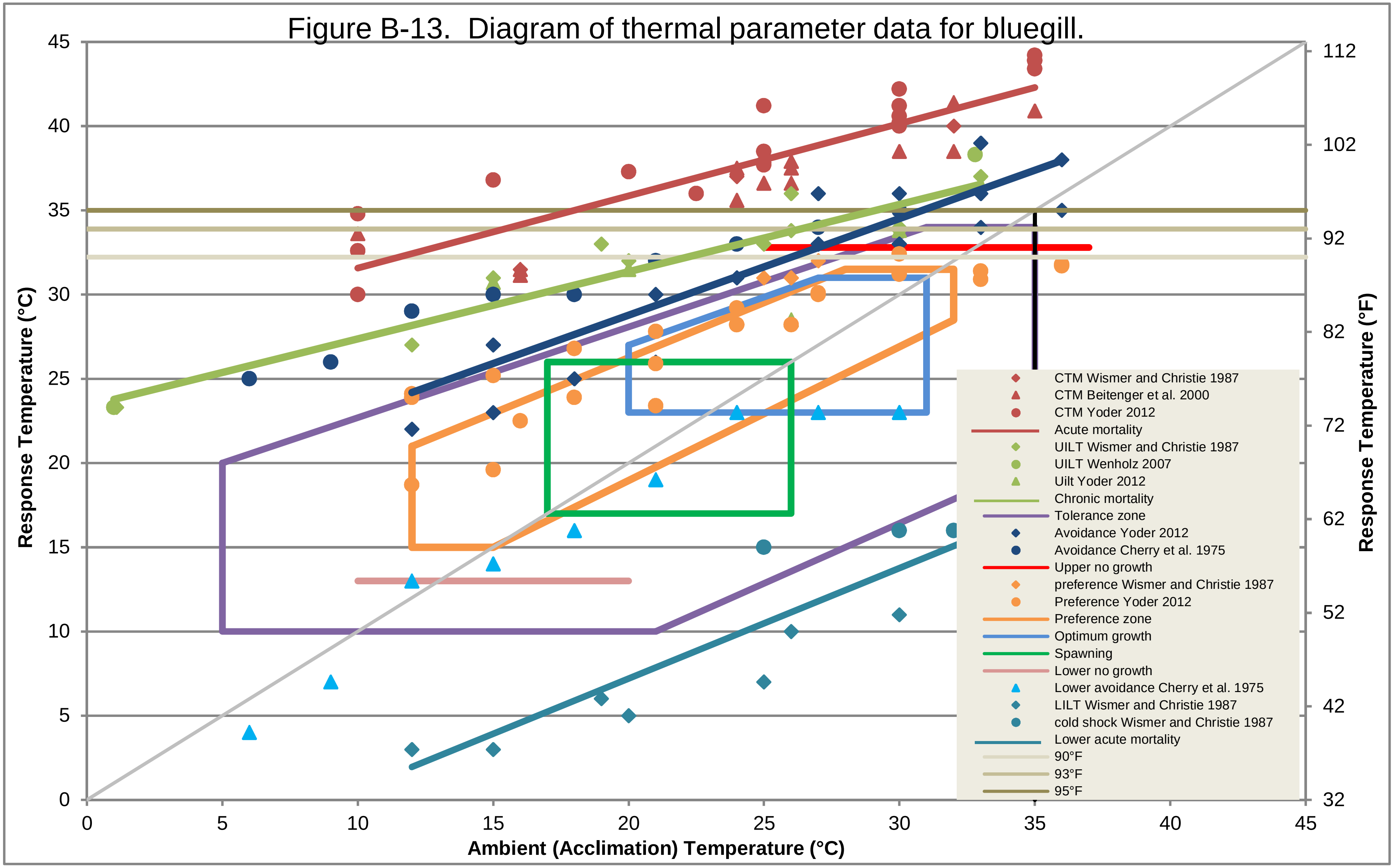
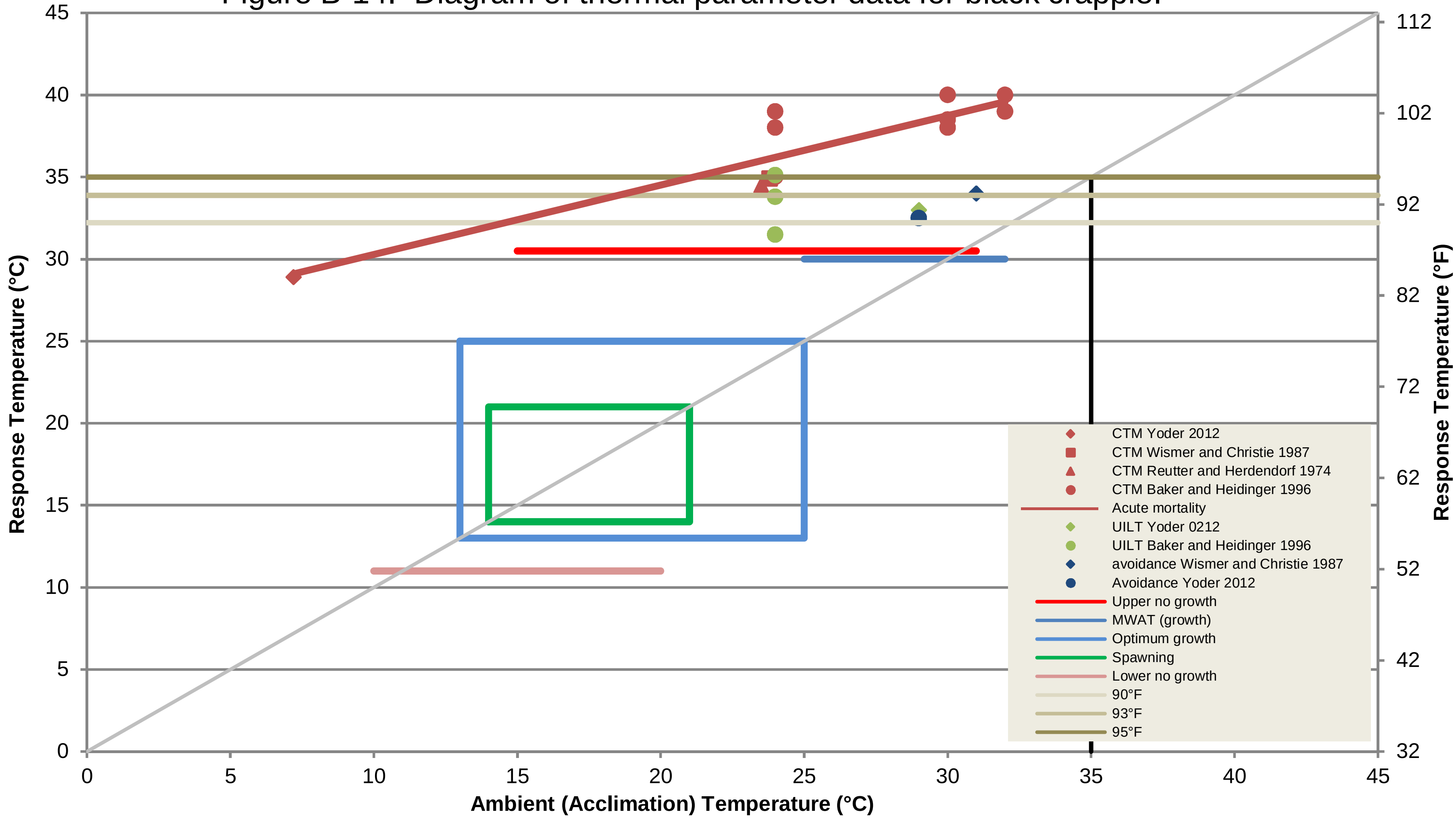


Figure B-13. Diagram of thermal parameter data for bluegill.
Response Temperature (°C)
Response Temperature (°F)
Ambient (Acclimation) Temperature (°C)
0
5
10
15
20
25
30
35
40
45
32
42
52
62
72
82
92
102
112
CTM Wismer and Christie 1987
CTM Beitenger et al. 2000
CTM Yoder 2012
Acute mortality
UILT Wismer and Christie 1987
UILT Wenholz 2007
Uilt Yoder 2012
Chronic mortality
Tolerance zone
Avoidance Yoder 2012
Avoidance Cherry et al. 1975
Upper no growth
preference Wismer and Christie 1987
Preference Yoder 2012
Preference zone
Optimum growth
Spawning
Lower no growth
Lower avoidance Cherry et al. 1975
LILT Wismer and Christie 1987
cold shock Wismer and Christie 1987
Lower acute mortality
90°F
93°F
95°F

Figure B-14. Diagram of thermal parameter data for black crappie.



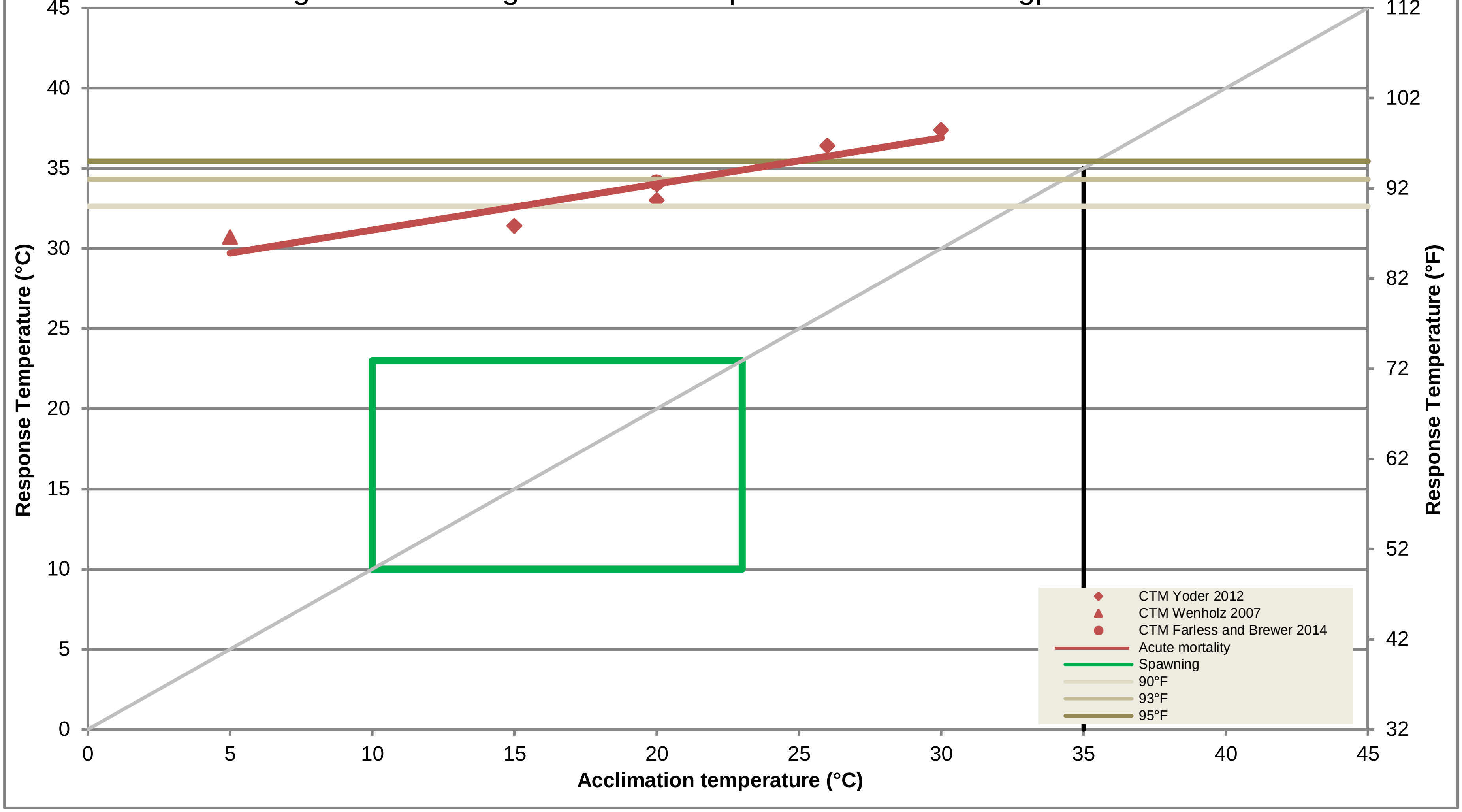


Figure B-15. Diagram of thermal parameter data for logperch.

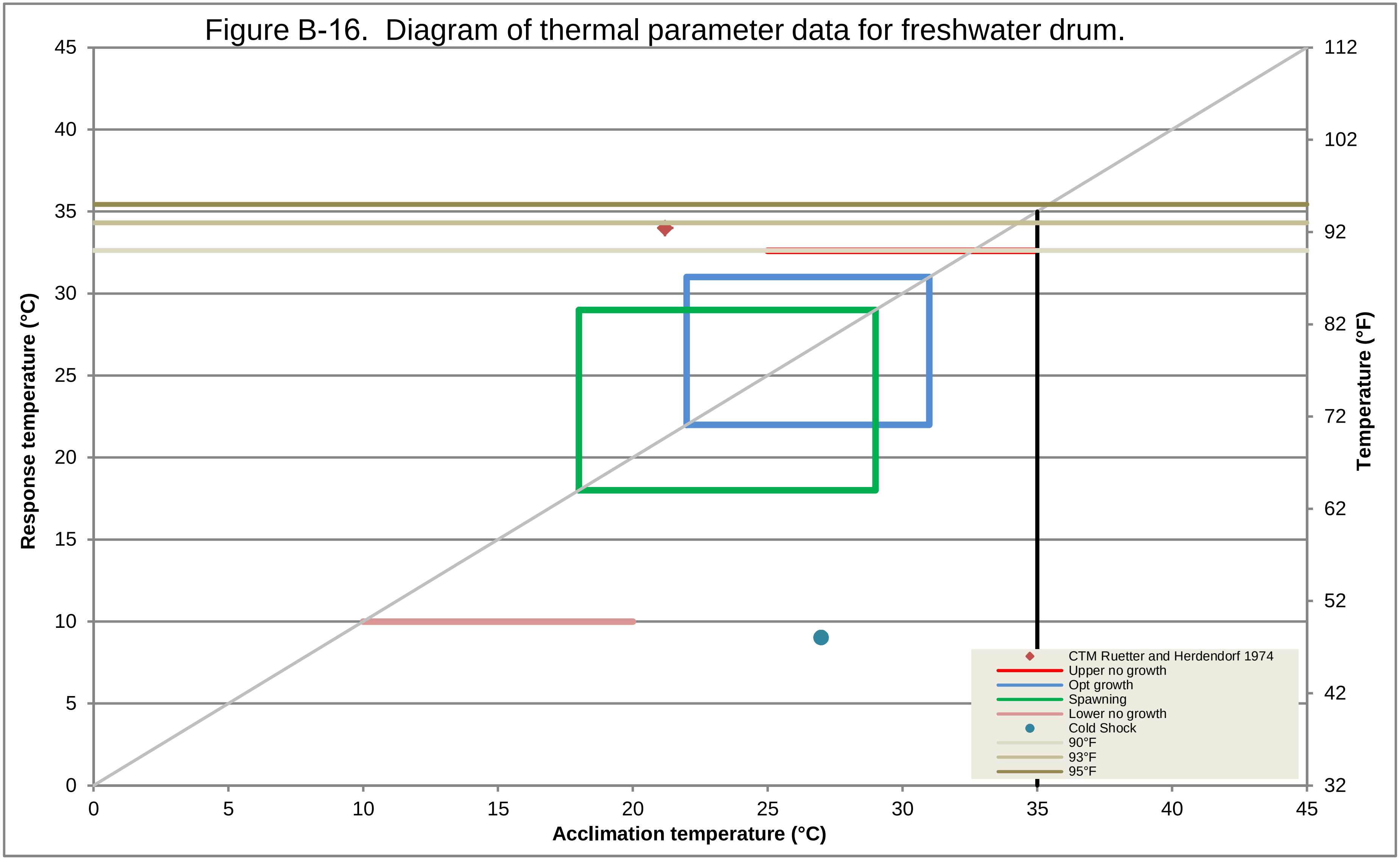
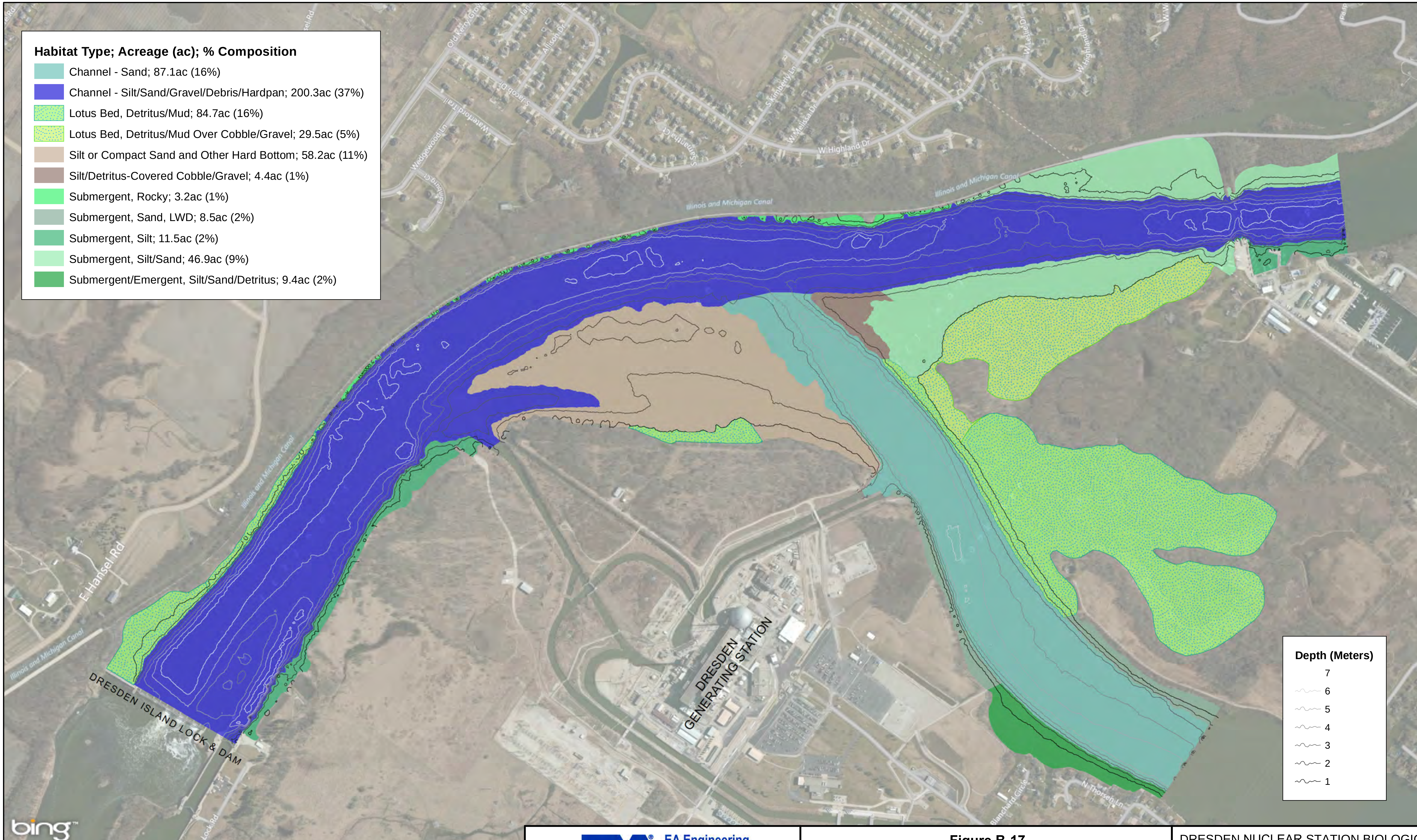


Figure B-16. Diagram of thermal parameter data for freshwater drum.
Response temperature (°C)
45
40
35
30
25
20
15
10
5
0
0
5
10
15
20
25
30
35
40
45
Acclimation temperature (°C)
Temperature (°F)
112
102
92
82
72
62
52
42
32
CTM Ruetter and Herdendorf 1974
Upper no growth
Opt growth
Spawning
Lower no growth
Cold Shock
90°F
93°F
95°F

SOURCE: Bing Maps Hybrid ©2010 Microsoft Corporation and its data suppliers



0 800 1,600 2,400 3,200 Feet

EA Engineering, Science, and Technology, Inc.

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BJO	1500404	12/5/2014

Figure B-17
Distribution of habitat in the Illinois, Des Plaines, and Kankakee Rivers within the area bounded by the hydrothermal model for the DNS cooling water discharge.

DRESDEN NUCLEAR STATION BIOLOGICAL MONITORING: MUSSEL SURVEY GRUNDY COUNTY, ILLINOIS

SCALE	FIGURE
1 inch = 800 feet	1

2014.12.05 C:\Users\bonelli\Desktop\Exelon\Dresden_Biological.mxd EA-Deerfield bonelli

Figure B-18. DNS Intake and Discharge Temperatures and Modeled Surface, Mid, and Bottom Temperatures at IL-200 , 6-8 July 2012

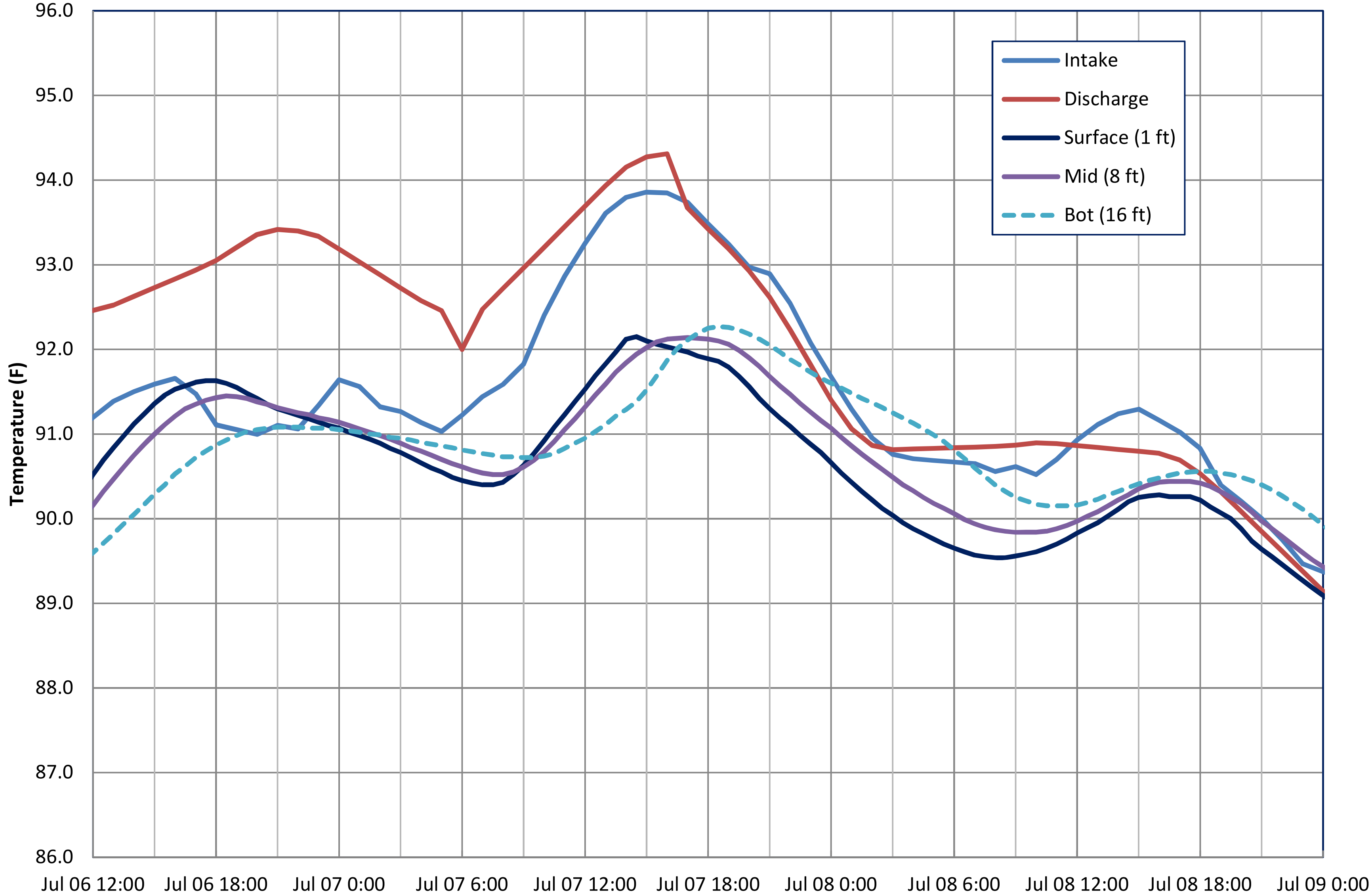


Figure B-19. DNS Intake and Discharge Temperatures and Modeled Surface, Mid, and Bottom Temperatures at IL475 , 6-8 July 2012

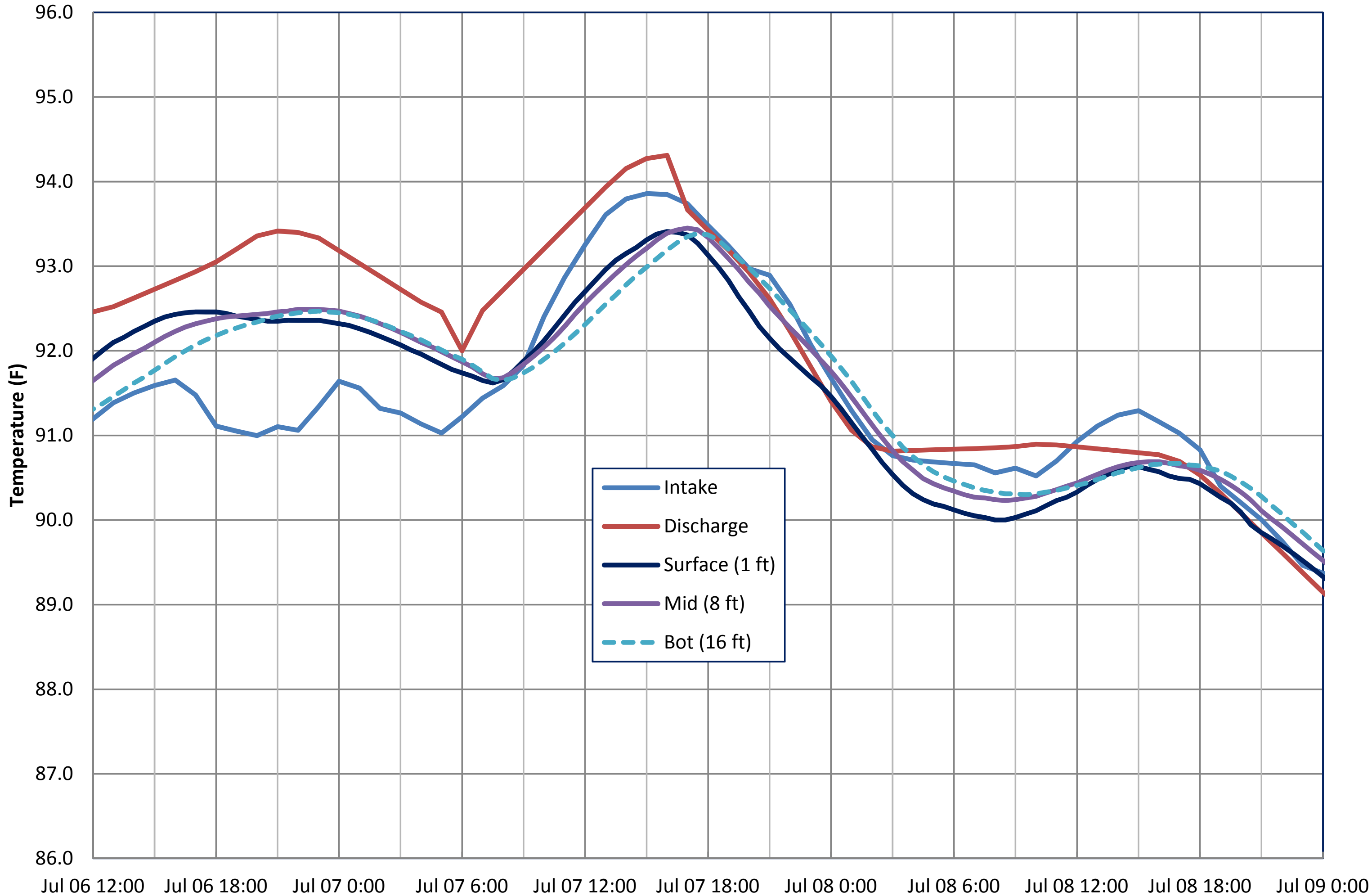
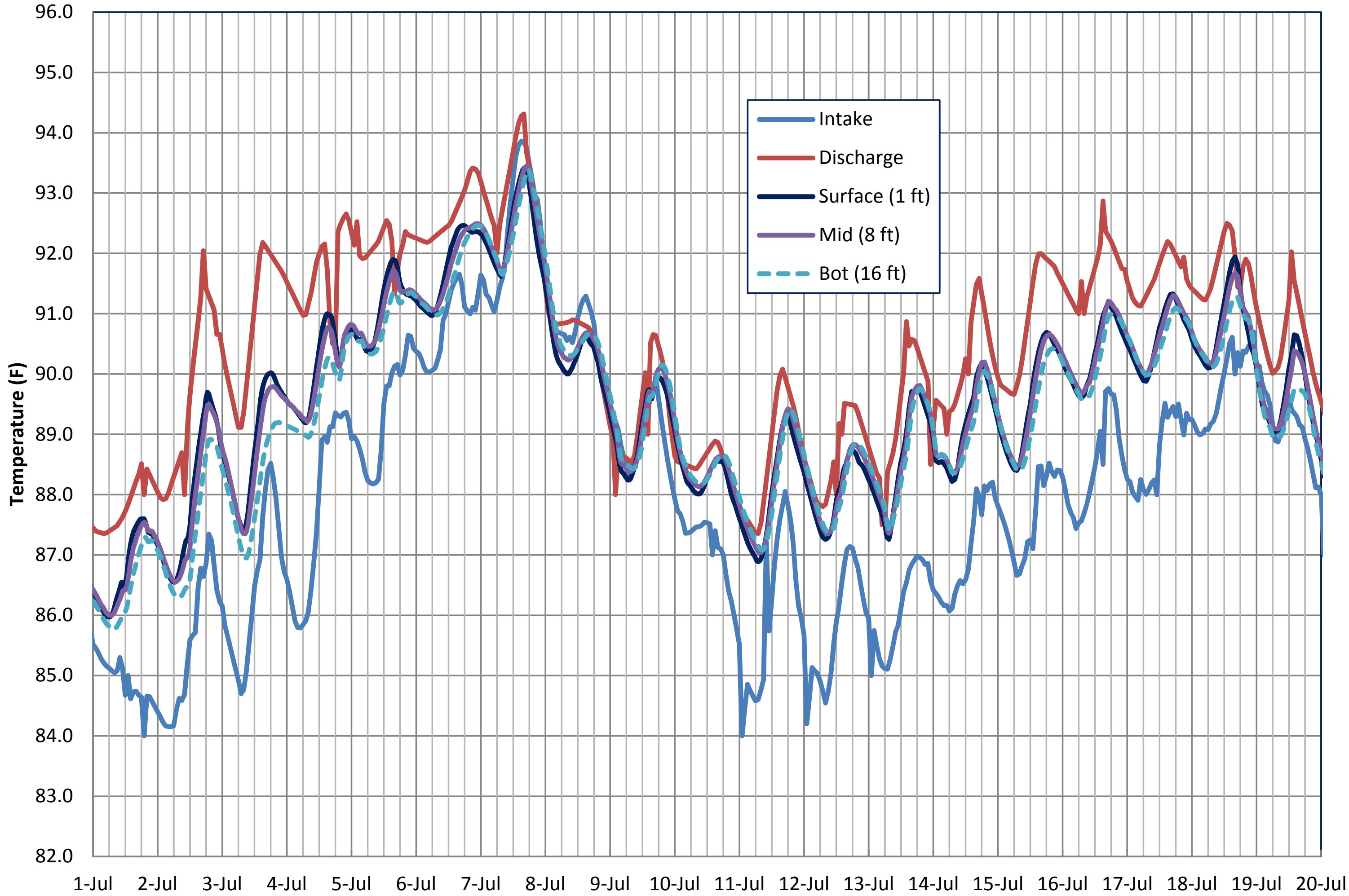


Figure B-20. DNS Intake and Discharge Temperatures and Modeled Surface, Mid, and Bottom Temperatures at IL475 , 1-20 July 2012



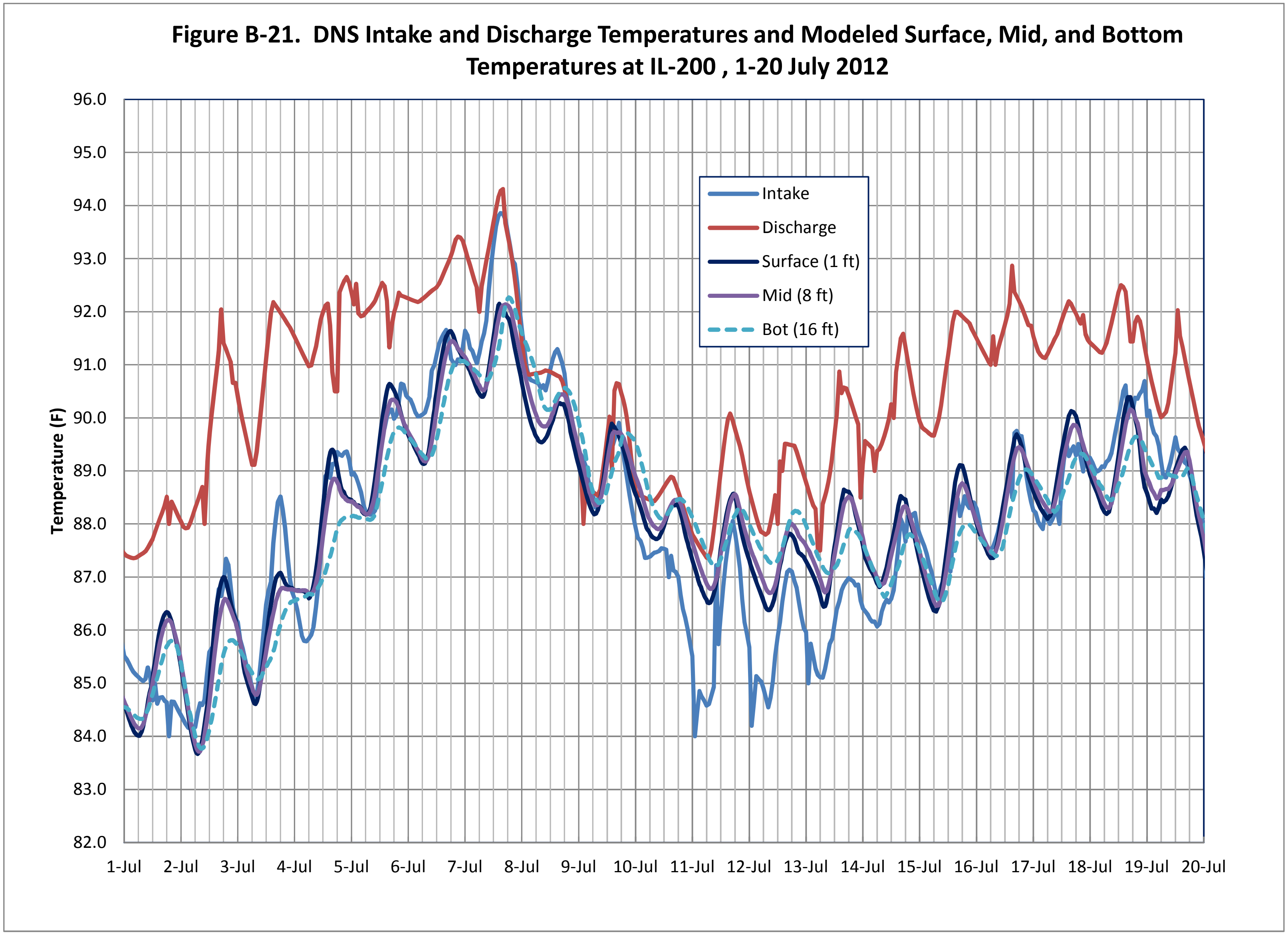


Figure B-21. DNS Intake and Discharge Temperatures and Modeled Surface, Mid, and Bottom Temperatures at IL-200 , 1-20 July 2012
Temperature (F)
96.0
95.0
94.0
93.0
92.0
91.0
90.0
89.0
88.0
87.0
86.0
85.0
84.0
83.0
82.0
1-Jul
2-Jul
3-Jul
4-Jul
5-Jul
6-Jul
7-Jul
8-Jul
9-Jul
10-Jul
11-Jul
12-Jul
13-Jul
14-Jul
15-Jul
16-Jul
17-Jul
18-Jul
19-Jul
20-Jul
Intake
Discharge
Surface (1 ft)
Mid (8 ft)
Bot (16 ft)

TABLES

Table B-1. Taxa Collected by Various Techniques in the Vicinity of Dresden Station, 1991-2014.

Common Name	Scientific Name	Electrofishing	Seine	Gillnet
SPOTTED GAR	*Lepisosteus oculatus*	X	--	--
LONGNOSE GAR	*Lepisosteus osseus*	X	X	X
SHORTNOSE GAR	*Lepisosteus platostomus*	X	--	X
SKIPJACK HERRING	*Alosa chrysochloris*	X	X	X
GIZZARD SHAD	*Dorosoma cepedianum*	X	X	X
THREADFIN SHAD	*Dorosoma petenense*	X	X	X
GOLDEYE	*Hiodon alosoides*	X	--	X
MOONEYE	*Hiodon tergisus*	--	--	X
CHINOOK SALMON	*Oncorhynchus tshawytscha*	--	--	X
RAINBOW SMELT	*Osmerus mordax*	--	X	--
GRASS PICKEREL	*Esox americanus vermiculatus*	X	--	--
NORTHERN PIKE	*Esox lucius*	X	X	X
CENTRAL STONEROLLER	*Campostoma anomalum*	X	X	--
GOLDFISH	*Carassius auratus*	X	X	X
GRASS CARP	*Ctenopharyngodon idella*	X	--	--
COMMON CARP	*Cyprinus carpio*	X	X	X
SILVER CARP	*Hypophthalmichthys molitrix*	X	--	--
SILVERJAW MINNOW	*Notropis buccatus*	X	X	--
SHOAL CHUB	*Macrhybopsis hyostoma*	X	X	--
SILVER CHUB	*Macrhybopsis storeriana*	--	--	X
HORNYHEAD CHUB	*Nocomis biguttatus*	X	X	--
GOLDEN SHINER	*Notemigonus crysoleucas*	X	X	--
PALLID SHINER	*Hybopsis amnis*	X	X	--
EMERALD SHINER	*Notropis atherinoides*	X	X	X
GHOST SHINER	*Notropis buchanani*	X	X	--
STRIPED SHINER	*Luxilus chrysocephalus*	X	X	X
PUGNOSE MINNOW	*Opsopoeodus emiliae*	X	--	--
SPOTTAIL SHINER	*Notropis hudsonius*	X	X	X
RED SHINER	*Cyprinella lutrensis*	X	X	--
ROSYFACE SHINER	*Notropis rubellus*	X	X	--
SPOTFIN SHINER	*Cyprinella spiloptera*	X	X	X
SAND SHINER	*Notropis stramineus*	X	X	--
REDFIN SHINER	*Lythrurus umbratilis*	X	X	--
MIMIC SHINER	*Notropis volucellus*	X	X	--
CHANNEL SHINER	*Notropis wickliffi*	X	--	--
SUCKERMOUTH MINNOW	*Phenacobius mirabilis*	X	X	--
BLUNTNOSE MINNOW	*Pimephales notatus*	X	X	--
FATHEAD MINNOW	*Pimephales promelas*	X	X	--
BULLHEAD MINNOW	*Pimephales vigilax*	X	X	--
CREEK CHUB	*Semotilus atromaculatus*	X	X	--
RIVER CARPSUCKER	*Carpiodes carpio*	X	X	X
QUILLBACK	*Carpiodes cyprinus*	X	X	X
HIGHFIN CARPSUCKER	*Carpiodes velifer*	X	--	--
WHITE SUCKER	*Catostomus commersonii*	X	X	X

Table B-1 (Continued)

Common Name	Scientific Name	Electrofishing	Seine	Gillnet
NORTHERN HOG SUCKER	*Hypentelium nigricans*	X	X	--
SMALLMOUTH BUFFALO	*Ictiobus bubalus*	X	X	X
BIGMOUTH BUFFALO	*Ictiobus cyprinellus*	X	--	X
BLACK BUFFALO	*Ictiobus niger*	X	X	X
SPOTTED SUCKER	*Minytrema melanops*	X	--	X
SILVER REDHORSE	*Moxostoma anisurum*	X	X	X
RIVER REDHORSE	*Moxostoma carinatum*	X	X	X
BLACK REDHORSE	*Moxostoma duquesnei*	X	--	--
GOLDEN REDHORSE	*Moxostoma erythrurum*	X	X	X
SHORTHEAD REDHORSE	*Moxostoma macrolepidotum*	X	X	X
GREATER REDHORSE	*Moxostoma valenciennesi*	X	--	--
BLACK BULLHEAD	*Ameiurus melas*	X	--	X
YELLOW BULLHEAD	*Ameiurus natalis*	X	X	X
CHANNEL CATFISH	*Ictalurus punctatus*	X	X	X
STONECAT	*Noturus flavus*	--	X	--
TADPOLE MADTOM	*Noturus gyrinus*	X	X	--
FLATHEAD CATFISH	*Pylodictis olivaris*	X	--	X
TROUT-PERCH	*Percopsis omiscomaycus*	X	X	X
BANDED KILLIFISH	*Fundulus diaphanus*	--	X	--
BLACKSTRIPE TOPMINNOW	*Fundulus notatus*	X	X	--
WESTERN MOSQUITOFISH	*Gambusia affinis*	X	X	--
BROOK SILVERSIDE	*Labidesthes sicculus*	X	X	--
WHITE PERCH	*Morone americana*	X	X	X
WHITE BASS	*Morone chrysops*	X	X	X
YELLOW BASS	*Morone mississippiensis*	X	X	X
STRIPED BASS	*Morone saxatilis*	X	--	X
ROCK BASS	*Ambloplites rupestris*	X	X	X
GREEN SUNFISH	*Lepomis cyanellus*	X	X	X
PUMPKINSEED	*Lepomis gibbosus*	X	X	--
WARMOUTH	*Lepomis gulosus*	X	--	--
ORANGESPOTTED SUNFISH	*Lepomis humilis*	X	X	X
BLUEGILL	*Lepomis macrochirus*	X	X	X
REDEAR SUNFISH	*Lepomis microlophus*	X	--	--
NORTHERN SUNFISH	*Lepomis peltastes*	X	X	--
SMALLMOUTH BASS	*Micropterus dolomieu*	X	X	X
LARGEMOUTH BASS	*Micropterus salmoides*	X	X	X
WHITE CRAPPIE	*Pomoxis annularis*	X	X	X
BLACK CRAPPIE	*Pomoxis nigromaculatus*	X	X	X
WESTERN SAND DARTER	*Ammocrypta clara*	--	X	--
RAINBOW DARTER	*Etheostoma caeruleum*	--	X	--
BLUNTNOSE DARTER	*Etheostoma chlorosoma*	--	X	--
JOHNNY DARTER	*Etheostoma nigrum*	X	X	--
BANDED DARTER	*Etheostoma zonale*	X	X	--
YELLOW PERCH	*Perca flavescens*	X	X	--
LOGPERCH	*Percina caprodes*	X	X	--
BLACKSIDE DARTER	*Percina maculata*	X	X	--

Table B-1 (Continued)

Common Name	Scientific Name	Electrofishing	Seine	Gillnet
SLENDERHEAD DARTER	*Percina phoxocephala*	X	X	--
RIVER DARTER	*Percina shumardi*	X	--	--
SAUGER	*Sander canadensis*	X	--	--
WALLEYE	*Sander vitreus*	X	X	X
FRESHWATER DRUM	*Aplodinotus grunniens*	X	X	X
ROUND GOBY	*Neogobius melanostomus*	X	X	--
	Total Number of Species	87	73	46

Table B-2. Number of Years Collected for All Taxa in All Gear During the 19 Survey Years: 1991-1995, 1997-2008, 2011, and 2013

Species	Des Plaines River	Kankakee River	Illinois River Upstream L&D	Illinois River Downstream L&D
GIZZARD SHAD	19	19	19	17
COMMON CARP	19	19	19	17
BLUNTNOSE MINNOW	19	19	19	17
GOLDEN REDHORSE	19	19	19	17
CHANNEL CATFISH	19	19	19	17
GREEN SUNFISH	19	19	19	17
BLUEGILL	19	19	19	17
SMALLMOUTH BASS	19	19	19	17
EMERALD SHINER	18	19	19	17
SPOTFIN SHINER	18	19	19	17
LARGEMOUTH BASS	19	18	19	17
FRESHWATER DRUM	18	19	18	17
BULLHEAD MINNOW	16	19	19	17
SPOTTAIL SHINER	17	18	19	16
SMALLMOUTH BUFFALO	19	14	19	17
SHORTHEAD REDHORSE	13	19	18	17
LOGPERCH	13	19	18	17
ORANGESPOTTED SUNFISH	12	19	17	15
BROOK SILVERSIDE	10	18	18	16
NORTHERN SUNFISH	12	18	17	14
STRIPED SHINER	12	15	19	11
QUILLBACK	8	16	17	16
RIVER CARPSUCKER	17	7	15	16
SILVER REDHORSE	7	16	16	16
FLATHEAD CATFISH	8	17	16	9
SAND SHINER	5	13	14	17
LONGNOSE GAR	5	12	13	16
ROCK BASS	9	16	13	6
BLACK CRAPPIE	10	8	12	14
SKIPJACK HERRING	11	7	12	13
THREADFIN SHAD	6	11	12	12
BLACKSTRIPE TOPMINNOW	12	9	10	10
MIMIC SHINER	--	9	7	14
SLENDERHEAD DARTER	--	13	5	10
GHOST SHINER	5	10	9	13
WHITE BASS	2	11	8	14
GOLDEN SHINER	7	10	10	5
JOHNNY DARTER	2	15	8	7
WHITE CRAPPIE	--	7	3	10
ROUND GOBY	7	6	8	5
PALLID SHINER	5	10	5	4

Table B-2 (Continued)

Species	Des Plaines River	Kankakee River	Illinois River Upstream L&D	Illinois River Downstream L&D
TROUT-PERCH	2	11	6	5
REDFIN SHINER	8	3	6	6
Moxostoma sp.	3	6	8	5
WALLEYE	3	8	4	6
CENTRAL STONEROLLER	2	4	10	4
BLACK BUFFALO	7	1	7	5
REDEAR SUNFISH	--	5	--	--
RED SHINER	1	5	5	8
WHITE PERCH	--	2	3	9
GOLDEYE	--	3	5	5
YELLOW BASS	--	2	3	8
HORNYHEAD CHUB	3	2	8	3
WESTERN MOSQUITOFISH	4	1	1	10
SAUGER	--	--	--	4
PUMPKINSEED	1	5	6	3
BLACKSIDE DARTER	4	4	4	3
YELLOW BULLHEAD	6	--	4	1
WARMOUTH	--	4	3	--
SUCKERMOUTH MINNOW	--	3	3	4
NORTHERN HOG SUCKER	1	2	3	7
GOLDFISH	2	--	4	3
ROSYFACE SHINER	1	--	3	5
HIGHFIN CARPSUCKER	2	--	--	4
RIVER REDHORSE	1	1	5	5
WHITE SUCKER	3	1	3	4
FATHEAD MINNOW	--	2	2	4
SPOTTED SUCKER	3	4	1	--
BANDED DARTER	--	2	3	2
SHORTNOSE GAR	1	--	1	4
GRASS PICKEREL	1	--	3	2
NORTHERN PIKE	1	2	2	3
GRASS CARP	--	--	--	2
SHOAL CHUB	--	--	--	2
SILVER CHUB	--	--	--	2
GREATER REDHORSE	1	--	--	3
WESTERN SAND DARTER	--	--	--	2
RAINBOW DARTER	--	--	2	--
BIGMOUTH BUFFALO	3	2	1	1
BLACK REDHORSE	--	1	1	3
TADPOLE MADTOM	2	--	2	1
STRIPED BASS	--	1	--	2
YELLOW PERCH	--	--	2	1
SPOTTED GAR	--	--	--	1
MOONEYE	--	--	--	1

Table B-2 (Continued)

Species	Des Plaines River	Kankakee River	Illinois River Upstream L&D	Illinois River Downstream L&D
CHINOOK SALMON	--	--	1	--
RAINBOW SMELT	--	--	--	1
SILVER CARP	--	--	--	1
SILVERJAW MINNOW	--	--	1	--
PUGNOSE MINNOW	--	1	--	--
CHANNEL SHINER	--	--	1	--
CREEK CHUB	--	--	1	1
BLACK BULLHEAD	1	--	--	1
STONECAT	--	1	--	--
BANDED KILLIFISH	1	--	--	--
BLUNTNOSE DARTER	1	--	--	--
RIVER DARTER	--	--	--	1
Number Taxa in Segment	66	70	78	86

Table B-3. Total Abundance of Fish Taxa Collected in all Gear and River Segments, 1991-2014.

Common Name	1991	1992	1993	1994	1995	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2011	2013	2014	AVG
EMERALD SHINER	1503	2430	976	655	2198	604	900	915	402	1262	3382	2376	972	2263	4023	2530	1670	172	73	923	1511
GIZZARD SHAD	2086	1465	809	729	565	441	634	1146	635	1582	1343	1189	636	1937	1561	2141	1918	518	426	2000	1188
BLUEGILL	244	1433	209	33	128	154	237	655	957	893	1829	2261	913	3038	1818	1189	1285	663	520	494	948
BLUNTNOSE MINNOW	236	879	409	163	186	70	183	177	378	543	1105	1846	700	2809	1161	1470	818	274	323	947	734
SPOTFIN SHINER	373	891	435	208	669	53	40	195	266	794	390	849	784	1492	1706	673	721	462	921	2274	710
BULLHEAD MINNOW	785	438	499	142	206	295	153	458	298	475	114	916	967	1049	319	333	305	142	192	887	449
GREEN SUNFISH	266	986	212	64	47	96	184	583	483	328	520	931	458	454	300	348	267	112	92	159	345
THREADFIN SHAD	1942	--	--	--	--	--	--	36	61	129	86	32	17	3	29	1	123	38	9	858	240
LARGEMOUTH BASS	116	166	72	35	55	51	62	138	89	227	305	325	203	441	355	415	259	188	126	596	211
SPOTTAIL SHINER	88	384	89	134	99	44	8	16	33	279	106	78	32	526	72	172	183	16	13	558	147
GOLDEN REDHORSE	160	76	166	41	101	44	53	71	78	76	272	369	138	189	284	321	279	45	26	100	144
SMALLMOUTH BASS	113	305	170	55	55	63	67	73	92	147	191	343	169	122	119	159	202	42	59	303	142
BROOK SILVERSIDE	27	111	17	29	10	1	11	10	46	51	72	380	121	331	321	190	241	128	226	357	134
COMMON CARP	293	254	184	97	84	29	29	82	54	100	71	53	45	94	56	58	67	37	19	88	90
FRESHWATER DRUM	176	264	118	65	34	47	16	11	61	97	142	138	79	90	96	103	100	14	14	99	88
PALLID SHINER	--	--	--	--	--	--	--	--	--	12	15	77	150	126	37	165	151	10	34	128	82
GHOST SHINER	--	15	324	10	193	32	--	--	2	9	4	61	16	83	32	386	123	--	1	12	81
CHANNEL CATFISH	159	118	46	65	42	37	15	23	63	61	126	139	101	100	132	78	98	37	25	129	80
NORTHERN SUNFISH	8	6	16	1	--	18	8	13	4	45	45	111	31	34	75	77	149	72	107	331	61
SAND SHINER	20	30	19	7	40	3	1	2	6	145	90	107	66	156	92	45	62	36	45	201	59
LOGPERCH	36	31	60	8	9	23	34	25	33	37	34	36	22	111	56	144	42	15	39	180	49
STRIPED SHINER	45	35	44	2	4	9	5	1	20	27	101	43	62	103	83	67	187	27	15	7	44
BLACKSTRIPE TOPMINNOW	--	--	--	--	--	--	1	--	4	9	6	35	39	51	63	76	45	54	130	62	44
SHORTHEAD REDHORSE	77	62	74	31	56	6	17	13	7	40	31	38	24	47	28	38	52	20	36	142	42
ORANGESPOTTED SUNFISH	19	72	19	5	11	14	8	2	7	56	56	264	25	41	29	42	56	11	6	59	40
SMALLMOUTH BUFFALO	61	51	42	31	12	9	11	31	50	79	69	42	39	28	40	42	51	12	7	61	38
MIMIC SHINER	3	7	41	4	5	15	--	--	1	1	10	49	1	46	38	23	10	1	16	345	34
QUILLBACK	195	46	36	26	56	3	5	4	5	13	6	5	10	91	16	8	12	1	6	10	28
ROUND GOBY	--	--	--	--	--	--	--	--	--	--	--	5	29	20	11	35	77	11	3	46	26
RIVER CARPSUCKER	78	88	40	56	21	3	6	7	6	15	16	6	16	14	5	11	9	1	3	13	21
SILVER REDHORSE	29	27	22	18	53	7	4	4	3	9	4	1	25	11	12	18	14	--	5	92	19
TROUT-PERCH	1	24	136	--	4	23	3	1	--	32	13	22	8	--	--	2	2	1	--	1	18
SKIPJACK HERRING	151	45	10	8	4	2	5	4	1	17	16	4	1	3	10	--	8	--	2	3	16
WESTERN MOSQUITOFISH	--	--	--	--	--	--	--	--	3	5	--	7	14	12	8	6	4	3	84	1	13
WHITE BASS	17	23	10	13	30	1	--	--	4	9	17	21	15	8	6	3	8	--	--	21	13
GOLDEYE	12	3	8	54	7	--	--	--	1	1	--	--	--	--	--	--	--	--	--	--	12
ROCK BASS	6	2	5	1	1	3	2	3	2	6	15	7	8	13	24	15	54	5	14	33	11
LONGNOSE GAR	28	18	15	12	12	1	--	3	6	11	6	11	3	8	9	6	23	4	1	25	11
REDFIN SHINER	--	1	26	2	8	--	--	--	--	--	--	23	--	16	14	4	6	3	10	9	10

Table B-3 (Continued)

Common Name	1991	1992	1993	1994	1995	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2011	2013	2014	AVG
GOLDEN SHINER	25	8	3	--	3	1	2	--	1	9	--	--	7	60	7	6	9	12	2	5	10
JOHNNY DARTER	1	--	12	4	1	1	--	--	1	3	1	24	16	28	13	12	3	6	4	25	9
GOLDFISH	14	3	--	1	--	--	--	--	--	--	--	--	--	--	--	7	2	--	--	27	9
ROSYFACE SHINER	--	--	--	--	--	--	--	--	--	--	--	4	4	1	--	--	--	3	17	24	9
SUCKERMOUTH MINNOW	9	32	--	--	--	--	--	--	--	7	8	1	--	--	--	--	1	--	--	1	8
FLATHEAD CATFISH	8	3	7	--	--	4	1	3	6	9	16	18	8	7	9	14	7	8	8	12	8
NORTHERN HOG SUCKER	--	10	--	--	5	--	--	--	--	--	2	--	--	18	--	3	3	1	--	19	8
SHOAL CHUB	--	--	--	--	--	--	--	--	--	--	--	--	--	8	4	--	--	--	--	--	6
BANDED KILLIFISH	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2	10	6
CENTRAL STONEROLLER	4	2	1	--	--	--	--	--	3	14	1	3	4	2	1	19	5	--	4	6	5
PUMPKINSEED	3	--	2	--	--	--	--	--	2	--	--	--	--	--	10	1	1	2	9	13	5
BLACK CRAPPIE	9	5	5	1	1	1	1	2	5	2	6	8	6	9	1	4	4	6	1	16	5
WALLEYE	3	3	5	--	2	1	--	--	--	3	5	4	3	--	3	1	3	--	--	23	5
SLENDERHEAD DARTER	2	1	13	3	--	1	4	1	1	1	1	15	3	--	7	5	9	2	1	--	4
FATHEAD MINNOW	2	--	--	--	--	--	--	--	--	--	16	1	3	1	--	--	3	--	--	2	4
RED SHINER	2	12	--	--	6	2	1	3	2	1	4	5	--	--	--	--	--	--	--	4	4
REDEAR SUNFISH	--	--	--	--	--	--	--	--	--	--	--	1	--	1	9	5	1	--	--	--	3
SILVERJAW MINNOW	--	--	3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	3
WHITE PERCH	2	4	1	--	--	--	--	--	--	3	4	3	1	1	--	1	2	--	--	11	3
WHITE CRAPPIE	5	4	5	--	--	--	--	--	1	2	4	1	2	2	--	1	5	2	--	3	3
BLACK BUFFALO	4	5	2	--	1	1	--	--	1	2	1	11	--	--	--	--	--	2	--	1	3
RIVER REDHORSE	8	--	3	1	2	--	3	--	2	--	2	--	--	--	--	--	--	--	--	1	3
YELLOW PERCH	1	2	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	6	3
BLACKSIDE DARTER	--	--	2	--	1	--	--	--	--	--	--	7	--	4	1	4	1	1	1	1	2
YELLOW BASS	5	1	2	1	--	--	--	4	1	--	2	--	--	1	--	1	3	--	--	1	2
MOONEYE	--	--	--	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2
BLACK REDHORSE	--	--	--	--	--	--	--	--	1	--	1	4	--	--	--	--	--	--	--	--	2
STRIPED BASS	1	3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2
YELLOW BULLHEAD	--	1	--	--	--	--	--	--	--	1	2	3	1	--	--	1	--	4	--	3	2
HIGHFIN CARPSUCKER	1	4	1	--	1	--	--	--	--	--	--	1	--	--	--	--	--	--	--	4	2
BANDED DARTER	--	1	--	1	--	--	--	--	1	--	--	--	2	--	1	--	3	--	--	4	2
HORNYHEAD CHUB	1	1	1	--	--	--	--	--	--	--	--	2	1	4	1	1	4	1	2	--	2
NORTHERN PIKE	--	1	--	4	--	--	--	--	--	1	--	--	--	--	--	--	2	1	1	--	2
WHITE SUCKER	2	5	1	1	--	--	--	--	--	--	--	1	--	--	--	1	1	--	--	1	2
TADPOLE MADTOM	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2	--	--	2	1	1	2
SILVER CHUB	--	--	1	--	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2
GRASS PICKEREL	1	--	1	1	--	1	--	--	--	--	--	--	1	--	--	--	--	--	--	4	2
SILVER CARP	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	2	2
BIGMOUTH BUFFALO	1	--	--	1	--	--	--	--	1	2	--	--	--	--	--	--	--	--	--	2	1
GRASS CARP	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	1	--	--	--	2	1

Table B-3 (Continued)

Common Name	1991	1992	1993	1994	1995	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2011	2013	2014	AVG
WESTERN SAND DARTER	--	--	--	--	--	--	--	--	--	--	--	1	--	--	1	--	--	--	--	2	1
WARMOUTH	--	--	1	--	--	--	1	--	--	--	1	1	1	2	2	--	--	--	--	--	1
SHORTNOSE GAR	1	2	--	--	--	--	--	--	--	--	1	1	--	--	--	--	--	--	--	1	1
SPOTTED SUCKER	--	1	1	--	--	--	--	--	1	2	--	1	1	--	--	--	--	--	1	1	1
SPOTTED GAR	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	1
CHINOOK SALMON	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1
RAINBOW SMELT	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1
PUGNOSE MINNOW	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	1
CHANNEL SHINER	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--	1
CREEK CHUB	--	--	1	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	1
GREATER REDHORSE	1	1	1	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--	1
BLACK BULLHEAD	1	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	1
STONECAT	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	1
RAINBOW DARTER	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	1	--	--	--	1
BLUNTNOSE DARTER	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	1
RIVER DARTER	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	1
SAUGER	--	--	--	--	--	--	--	--	--	--	--	--	1	--	1	1	1	--	--	--	1

Table B-4. Summary of Life History and Habitat Information for Species Collected During Monitoring Studies Conducted in the Vicinity of Dresden Nuclear Station, 1979-2014.

Species	Frequency[a]	Non-Native	Feeding Habits[b,c]	Habitat[c,d]	Ecosystem Role[c,e]	State-Listed	RIS
GIZZARD SHAD	D		Z, A, PH,I	P, M	F		X
COMMON CARP	D	X	O, S	P, M, V	F, R,C, N		X
BLUNTNOSE MINNOW	D		D, V, IV	P, H	F		
GOLDEN REDHORSE	D		B, I	Rn, H	--		X
CHANNEL CATFISH	D		O	P, Rn, S, St	R		X
GREEN SUNFISH	D		O	B, M	F		
BLUEGILL	D		O	P, B, V	R		X
SMALLMOUTH BASS	D		P, C, I	P, S, St	TP, R		X
EMERALD SHINER	D		I, C, A	Pg, S	F		X
SPOTFIN SHINER	D		I, V, P	Rn, S	F		
LARGEMOUTH BASS	D		P, C, I	B, P, H, St	TP, R		X
FRESHWATER DRUM	D		M, P, I, C	D, S, M	R, C		X
BULLHEAD MINNOW	D		O	Rn, B, M, S	F		
SPOTTAIL SHINER	D		I, A, V	Pg, H, S	F		
SMALLMOUTH BUFFALO	D		B	C, D, H	C		
SHORTHEAD REDHORSE	D		B, I	R, D, H, S	R, C		
LOGPERCH	D		I, C	R, S, V, St	F		X
ORANGESPOTTED SUNFISH	D		C, I, P	P, M	F		
BROOK SILVERSIDE	D		I, Z	B, P, S	F		
NORTHERN SUNFISH	D		I, IV, P	P, S	R		
STRIPED SHINER	C		O	Rn, H, S	F		
QUILLBACK	C		B, O	P, D, H, S	F, C		
RIVER CARPSUCKER	C		B, O	D, P, M, S	F		
SILVER REDHORSE	C		I	P, D, H, St	R, C		
FLATHEAD CATFISH	C		P, C	P, S, St, R	R		
SAND SHINER	C		O	Rn, S	F		
LONGNOSE GAR	C		P	P, V	TP		
ROCK BASS	C		I, C, P	P, S, V, St	R		
BLACK CRAPPIE	C		P, I, C	B, V	R		X
SKIPJACK HERRING	C		C, P	Pg, S	--		
THREADFIN SHAD	C	X	Z, I	P, M, S	F		
BLACKSTRIPE TOPMINNOW	C		I, C, A	P, V, St	F		
MIMIC SHINER	C		I, IV, C	Pg,	F		
SLENDERHEAD DARTER	O		I, C	R, Rn, S	F		
GHOST SHINER	O		I, C, A	Pg, P, M, S	F		
WHITE BASS	O		P	P, H, Pg	TP, R		
GOLDEN SHINER	O		O	P, V, M	F		
JOHNNY DARTER	O		I, C	P, S	F		
WHITE CRAPPIE	O		P, I, C	P, St	R		
ROUND GOBY	O	X	--	--	N		
PALLID SHINER	O			P, V	F	X	
TROUT-PERCH	O		B, I	P, B, M, S	F		
REDFIN SHINER	O		I	P, M	F		
WALLEYE	O		P, Z	V, St	TP, R		

Table B-4 (Continued)

Species	Frequency[a]	Non-Native	Feeding Habits[b,c]	Habitat[c,d]	Ecosystem Role[c,e]	State-Listed	RIS
CENTRAL STONEROLLER	O		A, D	R, S	F		
BLACK BUFFALO	O		B	C, D, H	--		
RED SHINER	O		I, IV	S	F		
WHITE PERCH	O		O	C, B, P,Pg	R		
GOLDEYE	O		I, P	Rn, S	--		
YELLOW BASS	O		P, I	P, H, Pg	TP, R		
HORNYHEAD CHUB	O		O	R, S	F		
WESTERN MOSQUITOFISH	O		I	B, P, V	F		
REDEAR SUNFISH	I		M, C, I, P	P, V	R		
SAUGER	I		P, C, I	B, V, St	TP, R		
PUMPKINSEED	I		I, M	P, V	R		
BLACKSIDE DARTER	I		I, C	P, H, R	F		
YELLOW BULLHEAD	I		B, O	D, B, P, V	R		
WARMOUTH	I		P,O	P, M, V, St	R		
SUCKERMOUTH MINNOW	I		B, I	R, S	F		
NORTHERN HOG SUCKER	I		B, I	D, R, P, S	--		
GOLDFISH	I	X	O, S	P, V	N		
ROSYFACE SHINER	I		IV, D, V	Pg, Rn, S	F		
HIGHFIN CARPSUCKER	I		B, O	R, P, H, S	--		
RIVER REDHORSE	I		M, I, B	D, R, H, S	--	X	
WHITE SUCKER	I		B, I, O	D, S, H	R, C		X
FATHEAD MINNOW	I		D, A, V	B, M	F		
SPOTTED SUCKER	I		M, I	D, H	--		
BANDED DARTER	I		I	R, S	F		
SHORTNOSE GAR	I		P, I, C	S, M	TP		
GRASS PICKEREL	I		P, I, C	P, V	TP, R		
NORTHERN PIKE	I		P, C, T	P, V	TP, R		
GRASS CARP	I	X	H, S	V	N		
SHOAL CHUB	I		B, I	S, Rn	F		
SILVER CHUB	I		B	P, S	F		
GREATER REDHORSE	I		B	D, Rn, H, St	--	X	
WESTERN SAND DARTER	I		I	C, S	F	X	
RAINBOW DARTER	I		I	R, Rn, S	F		
BIGMOUTH BUFFALO	I		I, Z	B, P, M	R, C		
BLACK REDHORSE	I		B, I, C	P, St	R		
TADPOLE MADTOM	I		C, I	B, M, V	F		
STRIPED BASS	I	X	P, C	C, P, Pg	TP, R		
YELLOW PERCH	I		O	P, B, V, St	R		
SPOTTED GAR	I		P	P, V	TP		
MOONEYE	I		O	Rn, H	--		
CHINOOK SALMON	I	X	P	GL	TP, R		
RAINBOW SMELT	I	X	I, C, Z	Pg	R		
SILVER CARP	I	X	--	--	N		
SILVERJAW MINNOW	I		I	R, S	F		
PUGNOSE MINNOW	I		I, C	P, M, V	F		
CHANNEL SHINER	I		I, IV, C	Pg,	F		

Table B-4 (Continued)

Species	Frequency[a]	Non-Native	Feeding Habits[b,c]	Habitat[c,d]	Ecosystem Role[c,e]	State-Listed	RIS
CREEK CHUB	I		O	M, St	F		
BLACK BULLHEAD	I		B, O	D, P, B, M	R		
STONECAT	I		I, C, P	R, H, S	F		
BANDED KILLIFISH	I		I, Z	Pg, P, B, V	F	X	
BLUNTNOSE DARTER	I		I, C	B, M	F		
RIVER DARTER	I		I, C	C, Rn, S	F		
RIVER SHINER	I		I, C, A	Rn, S	F		
BIGMOUTH SHINER	I		I, A, D	Rn, S	F		
ALEWIFE	I	X	P, PH, Z	Pg, S	F		
STEELCOLOR SHINER	I		I, IV, V	Rn, r, S	F		
ORANGETHROAT DARTER	I		I	R, P, S	F		

a. D=dominant (all segments and average more than 15 years); C=common (4 segments and average 10-15 years); O=occasional (3-4 segments and average 4-10 years); I=incidental (1-4 segments and average fewer than 4 years)

b. A=algae; B=bottom feeder; C= crustaceans; D=detritivore; H=herbivore I=insectivore; IV=invertebrates; M=mollusks ; O=omnivore; P=piscivore; PH=phytoplankton; S=scavenger; T=terrestrial; V=vegetation; Z=zooplankton

c. From Smith (1979), *Fishes of Illinois* ; PflIeger (1997), *Fishes of Missouri* ; and Scott and Crossman (1973) *Freshwater Fishes of Canada;* Etnier and Starnes (1993) *The Fishes of Tennessee* ; Becker (1983) *Fishes of Wisconsin* ; Page and Burr (2011).

d. B=backwater, sloughs; C=channel; D=demersal; H=hard bottom; M=mud, muck; Pg=pelagic; P=pools; R=riffles; Rn=run, fast current; S=sand/gravel; St=structure; V=vegetation/detritus; GL=Great Lakes

e. F=forage; TP=top predator; R=recreational; C=commercial; N=Invasive/Nuisance

Table B-5. River Flow and Temperature and DNS Discharge Temperature for Typical and Typical High Temperature Conditions.

Parameter	June	July	August	Sept
Typical Conditions				
Flow (cfs) (50%)				
Des Plaines	4,350	3,870	4,801	4,026
Kankakee	5,370	2,370	1,549	1,340
Total	9,720	6,240	6,350	5,366
Temperature (F) (60%)				
Des Plaines	79.9	82.9	83.1	80.1
Kankakee	74.5	76.1	77.4	68.9
Flow Wgt Av	76.9	80.3	81.7	77.3
Discharge Temp (F)				
50%	85.7	87.4	87.0	83.5
Delta	8.8	7.1	5.3	6.2
Unusually Warm Conditions				
Flow (cfs) (5%)				
Des Plaines	2,794	2,214	2,243	2,119
Kankakee	1,340	849	808	913
Total	4,134	3,063	3,051	3,032
Temperature (F) (95%)				
Des Plaines	82.8	88.9	86.9	85.5
Kankakee	76.8	85.6	81.0	77.0
Flow Wgt Av	80.9	88.0	85.3	82.9
Discharge Temp (F)				
95%	89.2	91.8	90.7	88.8
Delta	8.3	3.8	5.4	5.9

Table B-6. River Flow and Water Temperature Conditions During Extremely Warm Event, 6-8 July 2012.

River Flow

Date	Flow (cfs)[1]			Percentiles[2]	
	DesPlains	Kankakee	Total	DesPlains	Kankakee
6-Jul	2,170	1,000	3,270	4.6	19.8
7-Jul	1,910	910	2,820	2.0	18.5
8-Jul	1,610	770	2,380	1.0	15.3

Water Temperature[3]

Date	Temperature (F)		Percentiles[4]	
	Min	Max	Min	Max
6-Jul	90.0	91.7	96	97
7-Jul	91.0	93.9	96.5	99
8-Jul	89.5	91.7	95	97

1. Flow percentiles relative to 2005-2013 historical data
2. DNS design flow = 2,265 cfs
3. Intake temperatures used as proxy for upstream historical ambient water temperature.
4. Temperature percentiles relative to 2003-2014 DNS intake temperatures.

Table B-7. Cross-Sectional Temperature Distribution at Nine Transects in the Illinois River for Typical and Typical High Temperature (95 percentile) River Conditions during June.

Typical Temperature Conditions

Percentile (%)	Temperature (F) in Cross-Section at Transect								
	DP-1700	KP-1800	IL-1000	IL-200	IL125	IL275	IL475	IL720	IL1000
Max	79.6	74.5	79.6	79.0	84.3	82.8	81.6	80.6	79.7
Min	79.3	73.8	73.8	74.4	76.6	77.4	77.9	78.3	78.6
90	79.6	74.4	79.4	78.9	81.8	81.6	80.7	80.3	79.5
75	79.6	74.3	79.3	78.6	78.8	79.4	79.6	79.8	79.4
50	79.4	74.0	78.6	78.4	78.5	78.6	78.7	79.0	79.2
25	79.3	73.9	74.2	76.7	77.8	78.2	78.4	78.7	79.1
10	79.3	73.8	73.9	74.5	77.5	77.7	78.1	78.5	78.9

High (95%) Temperature Conditions

Percentile (%)	Temperature (F) in Cross-Section at Transect								
	DP-1700	KP-1800	IL-1000	IL-200	IL125	IL275	IL475	IL720	IL1000
Max	82.5	77.7	82.4	82.6	88.1	87.2	86.7	86.5	86.0
Min	82.2	76.1	76.8	82.1	82.9	83.8	84.4	85.0	85.5
90	82.5	76.8	82.4	82.3	87.5	86.8	86.5	86.2	85.9
75	82.4	76.7	82.3	82.2	86.8	86.5	86.2	86.0	85.8
50	82.3	76.4	82.2	82.1	85.7	85.8	85.8	85.7	85.7
25	82.2	76.2	81.5	82.1	84.1	85.0	85.2	85.6	85.6
10	82.2	76.1	78.7	82.1	83.5	84.5	84.9	85.3	85.6

Note: Temperature at cross-sectional area percentile

June River Conditions

Source	Average		Hign (95%)	
	Temp (F)	Flow (cfs)	Temp (F)	Flow (cfs)
Des Plaines River	79.9	4,350	82.8	2,794
Kankakee River	74.5	5,370	76.8	1,340
Dresden Discharge	85.7	2,265	89.2	2,265

Table B-8. Cross-Sectional Temperature Distribution at Nine Transects in the Illinois River for Typical and Typical High Temperature (95 percentile) River Conditions during July.

Typical Temperature Conditions

Percentile (%)	Temperature (F) in Cross-Section at Transect								
	DP-1700	KP-1800	IL-1000	IL-200	IL125	IL275	IL475	IL720	IL1000
Max	82.6	76.1	82.6	81.9	86.6	85.7	85.2	84.6	84.0
Min	82.3	75.4	75.6	81.5	81.7	81.9	82.2	82.7	83.3
90	82.6	76.0	82.5	81.8	85.9	85.1	84.7	84.3	84.0
75	82.5	75.9	82.3	81.7	84.2	84.4	84.3	84.1	83.9
50	82.4	75.7	82.0	81.7	82.6	83.6	83.8	83.9	83.8
25	82.3	75.5	79.2	81.6	82.0	82.7	83.1	83.4	83.7
10	82.3	75.4	76.2	81.6	81.8	82.3	82.6	83.1	83.5

High (95%) Temperature Conditions

Percentile (%)	Temperature (F) in Cross-Section at Transect								
	DP-1700	KP-1800	IL-1000	IL-200	IL125	IL275	IL475	IL720	IL1000
Max	88.5	87.6	88.5	90.0	91.3	91.0	90.9	90.8	90.6
Min	88.3	84.9	87.3	88.5	89.5	90.1	90.3	90.5	90.5
90	88.5	86.2	88.5	89.4	91.1	90.9	90.8	90.7	90.6
75	88.5	85.7	88.5	88.9	90.9	90.8	90.7	90.7	90.6
50	88.4	85.3	88.4	88.6	90.6	90.6	90.6	90.6	90.6
25	88.4	85.1	88.4	88.5	90.2	90.5	90.5	90.5	90.5
10	88.3	84.9	88.3	88.5	89.8	90.3	90.4	90.5	90.5

Note: Temperature at cross-sectional area percentile

July River Conditions

Source	Average		Hign (95%)	
	Temp (F)	Flow (cfs)	Temp (F)	Flow (cfs)
Des Plaines River	82.9	3,870	88.9	2,214
Kankakee River	76.1	2,370	85.6	849
Dresden Discharge	87.4	2,265	91.8	2,265

Table B-9. Cross-Sectional Temperature Distribution at Nine Transects in the Illinois River for Typical and Typical High Temperature (95 percentile) River Conditions during August.

Typical Temperature Conditions

Percentile (%)	Temperature (F) in Cross-Section at Transect								
	DP-1700	KP-1800	IL-1000	IL-200	IL125	IL275	IL475	IL720	IL1000
Max	82.8	77.5	82.8	82.7	86.4	85.7	85.3	84.8	84.3
Min	82.5	76.7	77.7	82.4	82.5	82.6	82.9	83.2	83.7
90	82.8	77.3	82.7	82.6	85.8	85.3	84.9	84.5	84.3
75	82.8	77.2	82.6	82.5	84.5	84.7	84.6	84.4	84.2
50	82.6	77.0	82.5	82.5	83.0	83.9	84.1	84.2	84.1
25	82.5	76.8	82.0	82.5	82.6	83.2	83.5	83.8	84.1
10	82.5	76.7	79.5	82.5	82.5	82.9	83.2	83.5	83.9

High (95%) Temperature Conditions

Percentile (%)	Temperature (F) in Cross-Section at Transect								
	DP-1700	KP-1800	IL-1000	IL-200	IL125	IL275	IL475	IL720	IL1000
Max	86.5	86.1	86.5	88.4	90.0	89.6	89.4	89.4	89.1
Min	86.3	80.3	82.0	86.2	87.5	88.3	88.6	88.7	88.7
90	86.5	84.9	86.5	87.6	89.8	89.5	89.4	89.2	89.0
75	86.5	83.1	86.4	86.9	89.5	89.4	89.3	89.1	89.0
50	86.4	80.9	86.4	86.5	89.1	89.1	89.1	89.0	89.0
25	86.4	80.6	86.2	86.4	88.5	88.8	88.9	88.9	88.9
10	86.3	80.4	84.9	86.3	88.0	88.6	88.8	88.9	88.8

Note: Temperature at cross-sectional area percentile

August River Conditions

Source	Average		Hign (95%)	
	Temp (F)	Flow (cfs)	Temp (F)	Flow (cfs)
Des Plaines River	83.1	4,801	86.9	2,243
Kankakee River	77.4	1,549	81.0	808
Dresden Discharge	87.0	2,265	90.7	2,265

Table B-10. Cross-Sectional Temperature Distribution at Nine Transects in the Illinois River for Typical and Typical High Temperature (95 percentile) River Conditions during September.

Typical Temperature Conditions

Percentile (%)	Temperature (F) in Cross-Section at Transect								
	DP-1700	KP-1800	IL-1000	IL-200	IL125	IL275	IL475	IL720	IL1000
Max	79.8	78.0	79.8	79.5	82.9	82.3	81.9	81.5	81.1
Min	79.5	68.2	69.2	78.9	79.0	79.3	79.7	80.2	80.6
90	79.8	73.2	79.7	79.3	82.5	81.9	81.5	81.3	81.0
75	79.7	70.1	79.5	79.1	81.4	81.4	81.3	81.1	81.0
50	79.6	68.6	79.1	79.0	80.2	80.9	80.9	81.0	80.9
25	79.5	68.4	77.8	78.9	79.5	80.1	80.4	80.7	80.9
10	79.5	68.2	72.3	78.9	79.2	79.8	80.1	80.4	80.8

High (95%) Temperature Conditions

Percentile (%)	Temperature (F) in Cross-Section at Transect								
	DP-1700	KP-1800	IL-1000	IL-200	IL125	IL275	IL475	IL720	IL1000
Max	85.1	84.7	85.1	86.6	88.1	87.8	87.6	87.6	87.2
Min	84.9	76.3	77.3	84.4	85.8	86.5	86.8	86.9	86.9
90	85.1	83.4	85.0	85.8	88.0	87.7	87.6	87.4	87.2
75	85.1	80.6	84.9	85.1	87.7	87.6	87.4	87.3	87.2
50	85.0	77.0	84.5	84.8	87.3	87.3	87.2	87.2	87.2
25	85.0	76.6	83.8	84.7	86.8	87.1	87.1	87.1	87.1
10	85.0	76.4	80.8	84.6	86.2	86.8	87.0	87.1	87.0

Note: Temperature at cross-sectional area percentile

September River Conditions

Source	Average		Hign (95%)	
	Temp (F)	Flow (cfs)	Temp (F)	Flow (cfs)
Des Plaines River	80.1	4,026	85.5	2,119
Kankakee River	68.9	1,340	77.0	913
Dresden Discharge	83.5	2,265	88.8	2,265

Table B-11. Bottom Temperature Distribution Upstream and Downstream of the DNS Discharge for Typical and Typical High (95%) River Conditions, June to September

June River Conditions

Percentile (%)	Bottom Temperature (F)			
	Typical		High (95%)	
	Upstr	Dstr	Upstr	Dstr
Max	79.8	85.7	82.7	89.2
Min	73.8	74.4	76.1	80.9
90	79.6	79.4	82.4	86.2
75	79.3	79.1	82.3	85.7
50	76.5	78.6	82.1	85.3
25	74.2	78.2	79.2	84.1
10	73.8	77.4	76.2	82.5

July River Conditions

Percentile (%)	Bottom Temperature (F)			
	Typical		High (95%)	
	Upstr	Dstr	Upstr	Dstr
Max	82.8	87.4	89.6	91.8
Min	75.4	80.8	84.9	87.8
90	82.6	84.1	88.5	90.7
75	82.3	83.7	88.5	90.6
50	81.2	83.1	88.4	90.5
25	76.2	82.1	87.8	90.2
10	75.4	81.7	85.0	89.2

August River Conditions

Percentile (%)	Bottom Temperature (F)			
	Typical		High (95%)	
	Upstr	Dstr	Upstr	Dstr
Max	83.0	87.0	87.8	90.7
Min	76.7	82.4	80.3	84.3
90	82.8	84.3	86.5	89.2
75	82.5	84.1	86.4	89.0
50	82.4	83.6	86.3	88.9
25	78.9	82.7	84.2	88.4
10	76.8	82.5	80.4	87.1

September River Conditions

Percentile (%)	Bottom Temperature (F)			
	Typical		High (95%)	
	Upstr	Dstr	Upstr	Dstr
Max	80.0	83.5	86.0	88.8
Min	68.2	77.2	76.3	82.5
90	79.8	81.2	85.1	87.4
75	79.5	80.9	85.0	87.2
50	78.9	80.5	84.5	87.1
25	75.1	79.5	82.4	86.7
10	68.3	79.0	76.4	85.4

Table B-12. Percent of Cross-section Predicted at Less than Modeled Temperatures at 4 Transects Upstream and 5 Transects Downstream of the DNS Discharge During Peak of Heat Wave on 7-8 July 2012 (Shaded Cells Indicate Portions of Cross-section with Temperatures equal to or above 93.0°F)

Percent of X-Section	Upstream of DNS Discharge				Downstream of DNS Discharge				
	Temperature (°F) at Percent of Cross-Section								
7-7 1200	DP-1700	KP-1800	IL-1000	IL-200	IL125	IL275	IL475	IL720	IL1000
Max	92.07	92.44	91.47	92.48	93.20	93.02	92.91	92.75	92.53
Min	90.50	90.41	90.59	90.36	91.72	92.10	92.16	92.07	91.99
95	91.99	92.25	91.40	92.17	93.15	92.95	92.84	92.57	92.41
90	91.89	92.03	91.35	91.99	93.09	92.91	92.78	92.50	92.34
75	91.71	91.64	91.11	91.58	92.95	92.75	92.61	92.39	92.26
50	91.49	91.02	90.84	91.20	92.73	92.55	92.43	92.28	92.17
25	91.26	90.68	90.68	90.90	92.38	92.39	92.30	92.18	92.12
10	91.10	90.43	90.61	90.68	91.98	92.26	92.24	92.16	92.07
5	91.06	90.41	90.61	90.52	91.86	92.20	92.21	92.12	92.05
7-7 1400	**DP-1700**	**KP-1800**	**IL-1000**	**IL-200**	**IL125**	**IL275**	**IL475**	**IL720**	**IL1000**
Max	93.02	93.54	92.28	92.88	93.67	93.45	93.38	93.33	92.89
Min	91.65	90.43	90.59	91.04	92.10	92.55	92.61	92.50	92.32
95	92.92	93.34	92.17	92.62	93.63	93.42	93.31	93.09	92.77
90	92.85	93.14	92.07	92.40	93.59	93.38	93.24	93.01	92.73
75	92.68	92.44	91.78	92.03	93.45	93.24	93.07	92.86	92.66
50	92.44	91.39	91.31	91.65	93.22	93.00	92.89	92.73	92.59
25	92.10	90.88	90.88	91.36	92.87	92.86	92.77	92.63	92.52
10	91.91	90.53	90.72	91.20	92.41	92.73	92.70	92.58	92.42
5	91.86	90.47	90.64	91.18	92.27	92.64	92.66	92.54	92.37
7-7 1600	**DP-1700**	**KP-1800**	**IL-1000**	**IL-200**	**IL125**	**IL275**	**IL475**	**IL720**	**IL1000**
Max	93.42	93.87	92.73	92.62	93.94	93.69	93.58	93.49	93.07
Min	92.05	90.81	90.72	91.54	92.89	93.13	93.07	92.82	92.55
95	93.36	93.75	92.60	92.52	93.89	93.63	93.54	93.36	93.03
90	93.33	93.65	92.46	92.35	93.85	93.60	93.51	93.33	93.00
75	93.22	93.17	92.14	92.23	93.62	93.51	93.43	93.22	92.97
50	92.93	92.69	91.59	92.05	93.34	93.38	93.30	93.09	92.91
25	92.71	92.13	91.11	91.80	93.24	93.27	93.16	93.02	92.80
10	92.38	91.65	90.88	91.74	93.08	93.20	93.13	92.91	92.62
5	92.23	91.31	90.82	91.69	93.00	93.18	93.11	92.87	92.59

Table B-12 (Continued)

Percent of X-Section	Upstream of DNS Discharge				Downstream of DNS Discharge				
	Temperature (°F) at Percent of Cross-Section								
7-7 1800	**DP-1700**	**KP-1800**	**IL-1000**	**IL-200**	**IL125**	**IL275**	**IL475**	**IL720**	**IL1000**
Max	93.47	93.87	92.89	92.62	93.31	93.36	93.42	93.38	93.25
Min	91.53	90.82	90.95	91.27	92.68	92.77	93.00	92.89	92.34
95	93.43	93.61	92.77	92.56	93.24	93.36	93.40	93.38	93.24
90	93.39	93.52	92.66	92.50	93.16	93.33	93.38	93.36	93.20
75	93.31	93.29	92.38	92.39	93.07	93.29	93.38	93.34	93.15
50	93.14	92.94	91.76	92.23	92.98	93.24	93.36	93.31	93.02
25	92.89	92.51	91.31	91.87	92.91	93.18	93.31	93.22	92.89
10	92.53	92.39	91.11	91.60	92.86	93.06	93.22	93.10	92.69
5	92.35	91.72	91.05	91.53	92.81	92.98	93.16	93.03	92.64
7-7 2000	**DP-1700**	**KP-1800**	**IL-1000**	**IL-200**	**IL125**	**IL275**	**IL475**	**IL720**	**IL1000**
Max	93.22	93.43	92.71	92.44	92.77	92.95	93.13	93.25	93.20
Min	89.65	89.38	89.92	90.57	92.19	91.92	92.25	92.37	91.17
95	93.19	93.32	92.61	92.34	92.73	92.91	93.08	93.20	93.17
90	93.16	93.22	92.53	92.31	92.71	92.89	93.02	93.16	93.13
75	93.11	93.00	92.31	92.26	92.68	92.84	92.98	93.13	93.00
50	93.06	92.76	91.80	92.17	92.61	92.79	92.88	93.04	92.82
25	92.85	91.99	91.40	91.71	92.53	92.68	92.74	92.88	92.64
10	92.38	91.73	91.20	91.18	92.46	92.52	92.57	92.68	92.48
5	91.63	90.77	91.06	91.08	92.37	92.44	92.50	92.59	92.34
7-7 2200	**DP-1700**	**KP-1800**	**IL-1000**	**IL-200**	**IL125**	**IL275**	**IL475**	**IL720**	**IL1000**
Max	92.88	92.82	92.52	92.03	92.37	92.48	92.61	92.79	92.79
Min	86.92	88.36	88.84	89.56	91.53	91.42	91.71	91.62	90.19
95	92.84	92.79	92.44	92.00	92.32	92.43	92.56	92.73	92.71
90	92.78	92.66	92.35	91.96	92.29	92.41	92.53	92.66	92.66
75	92.66	92.43	92.17	91.90	92.14	92.37	92.49	92.61	92.55
50	92.55	91.63	91.74	91.84	92.07	92.29	92.38	92.48	92.43
25	92.16	90.90	91.40	91.49	92.01	92.14	92.18	92.28	92.16
10	91.11	90.74	91.15	90.48	91.92	91.99	92.02	92.07	91.98
5	90.58	89.94	90.77	90.32	91.87	91.92	91.94	91.96	91.79
7-8 0000	**DP-1700**	**KP-1800**	**IL-1000**	**IL-200**	**IL125**	**IL275**	**IL475**	**IL720**	**IL1000**
Max	92.39	92.28	92.61	91.72	91.83	91.90	92.08	92.26	92.26
Min	85.42	87.12	88.65	88.70	91.15	91.18	91.26	91.24	90.09
95	92.31	92.11	92.48	91.69	91.78	91.85	92.05	92.22	92.24
90	92.27	91.99	92.42	91.63	91.72	91.83	92.00	92.17	92.21
75	92.17	91.63	92.17	91.59	91.54	91.78	91.95	92.12	92.14
50	92.04	90.53	91.90	91.53	91.44	91.71	91.83	92.01	92.01
25	91.44	90.12	91.49	91.20	91.35	91.56	91.69	91.85	91.81
10	90.26	89.83	91.23	89.83	91.28	91.42	91.53	91.65	91.52
5	89.93	89.11	90.82	89.62	91.24	91.35	91.45	91.54	91.29

Table B-13. Estimated Avoidance Temperatures at Selected Ambient/Acclimation Water Temperatures for DNS RIS for Which Avoidance Test Data are Available.

	Avoidance Temperature (°F)						
Acclimation Temperature (°F)	80.0	86.0	87.0	88.0	91.4	93.2	95.0
Gizzard shad	90.5	93.1	93.5	93.9	95.4	96.1	97
Channel catfish	95	95.6	96	96.4	97.9	98.6	99.4
Largemouth bass	92.5	95.5	95.9	96.3	98.1	98.9	99.8
Smallmouth bass	91.5	93	93.2	93.4	94.3	94.6	95
Bluegill	90.7	94.1	94.8	95.2	97.2	98.2	99.3

Table B-14. Temperature Range for Optimum Growth and Upper and Lower Zero Growth Temperatures for DNS RIS.

	Upper Zero-Growth		Otpimum Growth Range		Lower Zero-Growth	
	°C	°F	°C	°F	°C	°F
Gizzard shad	34	93.2	29-32	84.2-89.6	--	--
Emerald shiner	34	93.2	24-31	75.2-87.8	7	44.6
Common Carp	35	95	14.5-32	58.1-89.6	10-13.8	50.0-56.8
Golden redhorse	--	--	--	--	--	--
White sucker	29.6	85.3	16-27	60.8-80.6	12	53.6
Channel catfish	34.7	94.5	20-32	68.0-89.6	10	50
Largemouth bass	36	96.8	23-31	73.4-87.8	10	50
Smallmouth bass	34	93.2	16-31	60.8-87.8	--	
Bluegill	32.8	91	23-31	73.4-87.8	13	55.4
Black crappie	30.5	86.9	13-25	55.4-77.0	11	51.8
Logperch	--	--	--	--	--	--
Freshwater drum	32.6	90.7	22-31	71.6-87.8	10	50

APPENDIX C

Information Supporting Biotic Category Rationales:
Protection of Balanced Indigenous Community – Retrospective Demonstration

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1.0 INTRODUCTION

1.1 Section 316(a) Evaluation Criteria

This appendix provides a retrospective evaluation that supports approval of the proposed Alternate Thermal Limits (ATLs) by demonstrating that prior Dresden Nuclear Station (DNS) operations have not caused appreciable harm to the balanced indigenous community (BIC) in the Des Plaines, Kankakee, and Illinois Rivers. The prospective evaluation of the effects of future DNS operations with the proposed ATLs in place is provided in Appendix B. Both evaluations demonstrate that the proposed ATLs will "assure the protection and propagation of a balanced, indigenous community (BIC)) of shellfish, fish, and wildlife in and on the body of water [Des Plaines, Kankakee, and Illinois Rivers]", which is the standard for granting ATLs under §316(a) of the Clean Water Act. Like the prospective evaluation for this Demonstration, the retrospective evaluation generally follows the Draft *Interagency Technical Guidance Manual* (USEPA and NRC 1977).

2.0 RETROSPECTIVE EVALUATION

2.1 Approach

In performing the retrospective evaluation, the biotic categories analyzed were: (1) phytoplankton, (2) habitat formers, (3) zooplankton, (4) mussels and macroinvertebrates, (5) fish, and (6) other vertebrate wildlife.

The analysis focused on the Illinois River in the vicinity of the thermal discharge for the DNS. Located in Northern Illinois, approximately 15 miles southwest of Joliet, DNS is situated at the confluence of the Des Plaines and Kankakee Rivers where they join to form the Illinois River.

The retrospective evaluation was conducted in two parts. First, the condition of each biotic category as a whole was analyzed by comparing available information on its abundance and species composition to what would be expected without the operation of DNS. Second, the long-term trends in abundance for each of the biotic categories within the river community were analyzed to determine whether a change in population abundance has occurred that can be attributed to the DNS's operations. Taken together, the biotic category and long-term trend analyses provide a thorough and technically sound assessment of the status of the biological community in the Illinois River near DNS, consistent with §316(a) guidance and practice.

Over the years that §316(a) studies have been conducted, it has become evident that certain biological communities require more detailed study and evaluation than do others. For example, as a rule the fish community always requires detailed evaluation due to recreational fisheries and the key role of many fish species in the aquatic food web. Depending on the nature of the receiving waters, some of the lower trophic level communities, e.g. phytoplankton and zooplankton, may not require detailed investigation due to heterogeneity of distribution, short regeneration times, and seasonality. In addition, these communities function as the source of food for various life stages of populations that comprise the fish community. Thus, permanent adverse effects on these lower trophic level communities would be reflected in an adverse shift (imbalance) in the fish community. For these reasons, the primary emphasis for this Demonstration has been on the fish community.

2.2 Water Quality Changes

While excess heat is the primary concern of §316(a), a number of other factors influence water quality and thereby influence the biological function of aquatic systems. These factors may interact with other pollutants in the water body, interact with the heat and chemical discharges, or interact with other uses of the water body. Accordingly, this Demonstration identifies some of the numerous factors that may influence water quality, and considers those factors in connection with DNS's discharge of heat.

2.2.1 Nutrients

Power plants, including DNS, are not significant sources of nutrients. Organic carbon, phosphorus, and nitrogen are the elements most often associated with nutrient richness. The current status of each of these in the Illinois River is discussed in the subsections that follow.

2.2.1.1 Organic Carbon

Organic carbon is not identified by the USEPA as a cause of impairment for the Des Plaines River. There is limited organic carbon data available on the Kankakee River, Des Plaines River, and Illinois River systems. For the most part, dissolved carbon is unavailable to aquatic organisms other than bacteria. The reintroduction of organic carbon into the food web through bacteria results in additional energy to higher trophic levels (e.g., fish). The energy contributed by the DNS thermal plume may increase bacterial growth rates but there is no indication of any harm caused by this potential interaction and there is no reason to expect that the small amount of additional heat that would be permitted to be discharged under the proposed ATLs would cause a harmful interaction (USEPA 1998)

2.2.1.2 Total Phosphorus

Phosphorus is a naturally occurring element in the environment, and is an essential nutrient for plant and animal growth in normal amounts, but is harmful in excess. Along with nitrogen, it is among the most common water pollutants nationally, degrading over 100,000 river and stream miles and over 3.5 million acres of lakes, reservoirs and ponds (USEPA 1998).

Agricultural watersheds contributing high concentrations of sediment are especially important sources of phosphorus pollution because of the widespread use of commercial and animal-manure fertilizers containing phosphorus, which is easily bound to sediment particles. Phosphorus occurs in relatively high concentrations in the upper Illinois Waterway (UIW) because of these factors. Total phosphorus is identified by the USEPA as a cause of impairment for the Des Plaines River. There are no nutrients added to the once-through cooling water during passage through DNS.

The most likely result of an interaction between the thermal plume and phosphorous would be an increase in the rate of algal growth during warm periods. However, this would be a localized effect in the less than 10% of the Dresden Pool occupied by the thermal plume, and no difference in algal abundance or growth has been observed in the plume. Given that there has been no evidence of a synergistic effect between total phosphorous and the station's thermal discharge in the past, there is no reason to expect that the small amount of additional heat that would be permitted to be discharged under the proposed ATLs would cause any such effect.

2.2.1.3 Total Nitrogen

Nitrogen is used in agricultural fertilizers to stimulate the production of crops, especially corn. Runoff from areas with intensive cultivation or large livestock densities are important sources of nitrogen. In addition, certain industrial discharges and municipal wastewater effluents may contain high concentrations of inorganic nitrogen, especially ammonia or nitrate nitrogen. Nitrogen concentrations throughout the river increased in the 1990s, compared to concentrations observed during 1985-1989. For the upper river, this response may have been partly associated with changes in municipal wastewater treatment technology (nitrification). Changes in precipitation and river flow are additional factors associated with river-wide increases in nitrogen concentrations. The drought conditions of the late 1980s reduced non-point source runoff and increased utilization of inorganic nitrogen within the riverine pools. Increased non- point source runoff in the 1990s likely favored mobilization of nitrogen from agricultural watersheds, resulting in high nitrogen concentrations in the river during this period. The large amount of agricultural sources of nitrogen in the area suggests that the small amount discharged from the DNS treatment plant is negligible by comparison. While nitrogen concentrations have increased during the recent decades for the reasons stated above, the DNS's thermal discharge and treatment plant effluent have not contributed to this increase.

Total nitrogen is identified by the USEPA as a cause of impairment for the Des Plaines River. The most likely result of an interaction between the thermal plume and nitrogen would be an increase in the rate of algal growth during warm periods. However, this would be a localized effect in the less than 10% of the Dresden Pool occupied by the thermal plume, and no difference in algal abundance or growth has been observed in the plume. Given that there has been no evidence of a synergistic effect between total nitrogen and the thermal discharge in the past, there is no reason to expect that the small amount of additional heat that would be permitted to be discharged under the proposed ATL would cause any such effect (USEPA 1998).

2.2.2 Biocides

To control biofouling organisms in cooling water systems, power plants generally need to apply some type of biocide. Biocides are typically halogenated (i.e., chlorinated and brominated) substances used specifically to control the growth of micro-fouling organisms within the cooling system of the power plant. The most common method of micro-fouling control is periodic bulk treatment with sodium hypochlorite.

Historically, DNS has treated its cooling water system with sodium hypochlorite. Sodium hypochlorite is normally used as the sole biocide for treatment of the circulating water system (*See Section 4.2 in Appendix D of this Demonstration for additional details about biocide application at DNS*.). Sodium bisulfite is used as a neutralizing agent prior to discharge to the river to ensure compliance with the Total Residual Chlorine/Total Residual Oxidants limit of 0.05 ppm. The detection limit is 0.05 ppm, an order of magnitude lower than the levels that cause fish mortality. Therefore, the DNS discharge of chlorine is well below levels that would cause harm to fish and DNS's use of biocides cannot reasonably be expected to alter or cause harm to fish communities in the Des Plaines, Kankakee, and Illinois River, nor does it pose any risk of harm to the BIC. Any potential interaction of the thermal discharge with the biocides is similarly harmless.

2.2.3 Heavy Metals

Metals in the Illinois River come from natural as well as artificial sources. Some of these metals are essential in low concentrations for proper metabolism in all living organisms yet toxic at high concentrations; other metals currently thought of as non-essential are toxic even at relatively low concentrations. Heavy metals can be harmful to fish at low concentrations, by altering prey availability via shifts in community structure (USEPA 1998).

Heavy metals are released to the Illinois River from numerous sources. Typical sources are municipal wastewater-treatment plants, manufacturing facilities, mining, and rural agricultural practices including cultivation and fertilization. Heavy metals are transported as either dissolved species in water or as an integral part of suspended sediments. Heavy metals may be volatilized to the atmosphere or stored in riverbed sediments (see Appendix A for more information).

Mercury and silver are identified by the USEPA as two sources of impairment for the Des Plaines River. Although most of the heavy metals in the river are associated with sediment, the majority of the previous studies have focused on the dissolved metals. Even for the dissolved metals, comparisons are difficult to draw between earlier and more recent data because analytical laboratory techniques have become markedly more sensitive in the last decade and field sampling techniques have not been adequately standardized. Those heavy metals that are found in the sediments are typically chemically bound to colloidal materials such as clay particles. The strength of this chemical bond is affected by the pH; as pH decreases (becomes more acidic), the surficial charge will eventually reverse allowing the cation exchange which frees the heavy metal to go into solution in the water. However, the pH of the Illinois, Des Plaines, and Kankakee Rivers ranges from about 7.0 to about 9.0 which is basic rather than acidic, thus inhibiting the process. Because movement of metals from the sediments into the water column is mediated principally by pH and pH is not affected by temperature, the thermal discharge has not caused the release of heavy metals from the sediments and the proposed change in the thermal standard will also not affect this process. Thus, the heavy metals bound in the sediments can be expected to remain there and not interact with the biota.

Therefore, there has not been and should not be any potential for interactive impacts between the thermal plume, heavy metals and the biotic community.

2.2.4 Potability, Odors, and Aesthetics

There is no evidence of an unnatural odor or an unaesthetic appearance in the Illinois River in the vicinity of the DNS in general, and none associated with DNS operations in particular. Given the small incremental change in the proposed ATL, there is no reason to expect it will have any effect on potability, odors or aesthetics of the Illinois, Des Plaines, and Kankakee Rivers (USEPA 1998).

2.2.5 Other Thermal Discharges

Three power plants with thermal discharges are located upstream of DNS in the UIW. Generating stations operated by NRG/Midwest Generation are located at RM 295.6 (Will County Station), RM 284.9 (Joliet Station #9), and RM 284.6 (Joliet Station #29). These plants are 12-23 miles upstream of DNS. The NRG/Midwest Generation plants operate under NPDES permits issued by the IEPA. The thermal component of the discharges from these three coal fired power plants is diluted and dissipated to ambient conditions by the time it reaches DNS, hence, they are too far upstream to be able to interact with the DNS's thermal discharge.

2.2.6 Summary

There is no evidence of harmful interactions between the DNS's thermal discharge and other pollutants, including dissolved organic carbon, total phosphorus, total nitrogen, biocides, heavy metals, and other thermal discharges located upstream. There is also no evidence suggesting that the small amount of additional heat that would be permitted to be discharged under the proposed ATL would cause such interactions.

2.3 Phytoplankton Biotic Category Analysis

2.3.1 Background

Phytoplankton are free-floating microscopic plants that are transported by the water currents; are generally broadly distributed and abundant; have high reproductive and growth rates; and short generation times. Rapid dispersal by water currents and prolific rates of reproduction enable phytoplankton to recover rapidly from localized stresses within the environment.

Numerous studies of power plant thermal discharges were conducted during the 1960s and 1970s. In general, those studies showed that adverse effects on the phytoplankton populations from power plant thermal discharges are rare and occurred, if at all, in a small area in the immediate vicinity of the discharge. Such effects were limited to periods of maximum discharge temperatures during the summer and during those hours when the circulating water was chlorinated to control biofouling of the condensers (Jensen 1974, 1978; EA 1978; UWAG 1978).

2.3.2 Site Specific Studies

Phytoplankton sampling was conducted on a quarterly basis in the river system near DNS from 1969 to 1976. Sampling was also conducted in the cooling pond in 1972-73 and 1977. Phytoplankton studies of the UIW were conducted in 1991 and 1993 that included locations in Dresden Pool and downstream of the Dresden Island Lock and Dam.

The 1970s studies showed there was no adverse influence on phytoplankton populations in the Illinois River from indirect open-cycle operation of DNS. While there were minor annual shifts in species composition and abundance, there were no substantial changes in the community structure and no unusually large shifts in abundance among the algal divisions during the years studied. Data collected during indirect open-cycle operation indicated that the composition of the phytoplankton community at the cooling water intake was similar to the discharge location during the months studied. Except for slight shifts in algal densities, the operation of DNS in an indirect open-cycle mode was projected to not result in any adverse effects to the phytoplankton community in the Illinois River (ComEd 1996).

Phytoplankton surveys conducted in the UIW and its tributaries in 1991 and 1993 evaluated chlorophyll and phytoplankton abundance along the waterway from the Chicago Locks downstream to below Dresden Island Lock and Dam. Results from that study indicated that total phytoplankton density increased with distance downstream in the UIW. Since nearly all of the phytoplankton community originated as components of the periphyton, improved and expanded periphyton habitat in the Brandon and Dresden Pools resulted in Dresden Pool having the highest total density of phytoplankton (ComEd 1996).

The 1991 and 1993 studies also showed that phytoplankton populations in the UIW are in a state of flux associated with changes in physical and chemical factors. Species in the UIW and its tributaries are those adapted to eutrophic (nutrient rich, warmwater) systems. Warmwater effluents stimulated production of the most abundant species and inhibited a few minor contributors to the total phytoplankton population. A majority of those individuals that appeared to be inhibited were not eliminated from the waterway, but appeared at other sites in the system (ComEd 1996).

Observations made by EA field staff during fish and benthic monitoring efforts in 1994 through 2014 indicate that phytoplankton blooms typically begin in the backwater areas of the UIW during late June and are often seen throughout the main channel areas by mid to late July. These blooms typically occur until about late September. These blooms do not appear to be dominated by nuisance algae.

2.3.3 Summary

Based on the studies conducted at other facilities and data collected as part of the operational studies at DNS, the DNS thermal discharge has not caused appreciable harm to the phytoplankton community. Hence, the proposed, relatively small, incremental changes in the DNS’s thermal limits are not expected to have any detectable effect on the phytoplankton community in the Dresden Pool.

2.4 Aquatic Habitat

The kinds and numbers of riverine or stream fishes and aquatic macroinvertebrates are strongly related to the physical and chemical characteristics of a stream or river (Gorman and Karr 1978;

Schlosser 1982; Rankin 1989; Gibson 1994). Similarly, resource agencies recognize that the physical habitat (i.e., the place where aquatic organisms live) directly affects the abundance and diversity of the aquatic biota. For example, Ohio EPA (1989) found that rivers and streams with good habitat support more diverse fish and macroinvertebrate communities than waterways in which the habitat has been degraded. Because it is clear that habitat quality, diversity, and quantity affect the aquatic biota, it is appropriate to assess habitat quality in the UIW. Such an assessment is particularly appropriate given the morphology, history, and evolution of the UIW.

Because Illinois does not have a method of habitat evaluation established for large rivers, habitats in the UIW have historically been evaluated using the Qualitative Habitat Evaluation Index (QHEI) developed by Ohio EPA (Rankin 1989; OEPA 2006). Ohio EPA uses the QHEI to determine what quality biota can reasonably be expected in various waterbodies (i.e., what aquatic life "use" can be attained). According to Rankin (1989), the QHEI was designed to provide a measure of habitat that generally corresponds to those physical factors that affect fish communities and which are generally important to other aquatic life (e.g., invertebrates). The QHEI is based on six interrelated metrics: substrate, instream cover, channel morphology, riparian and bank condition, pool and riffle quality, and gradient, each of which has been shown to be correlated with stream fish communities (ComEd 1996). General narrative ranges assigned to QHEI scores are as follows:

Narrative Rating	QHEI Range	
	Headwaters	Larger Streams
Excellent	> 70	> 75
Good	55 to 69	60 to 74
Fair	43 to 54	45 to 59
Poor	30 to 42	30 to 44
Very Poor	< 30	0

2.4.1 Aquatic Habitat Types

In 1993 and 1994, habitat quality at individual fish and benthic macroinvertebrate sampling locations on the UIW was assessed using the QHEI to determine the extent that habitat is limiting the aquatic biota of the UIW. QHEI scores varied depending on mesohabitat type. Mean QHEI scores were lowest in main channel habitats, the dominant mesohabitat in the UIW. Conversely, mean QHEI scores were best in tailwaters, one of the least available mesohabitats in the UIW. Mean QHEI scores in the Dresden Pool were less than 60 at all but two sampling locations (Tables C-1 through C-3; see Figure 1, Appendix G). Thus, habitat generally was poor to fair. The low QHEI scores were the result of a lack of riffle/run habitat, lack of clean, hard substrates (i.e., gravel/cobble), excessive siltation, channelization, poor quality riparian and floodplain areas, and lack of cover. The sampling locations with the lowest QHEI scores were in the Lower Des Plaines River and downstream of the Dresden Island Lock and Dam.

In order to evaluate aquatic habitat changes that may have occurred in the Des Plaines, Kankakee, and Illinois Rivers since the mid-1990s, a habitat assessment was performed at electrofishing locations in the vicinity of DNS during 2014 (Appendix G; Figure G-1). QHEIs were completed during early July and early September, before and after aquatic macrophytes had matured. These data were supplemented with substrate characterization data collected during the 2014 mussel survey (Appendix H). In both July and September, habitat ranged from poor to fair (Tables C-1 and C-2), and mean QHEI scores were again less than 60 at all sampling locations (Table C-3). The two highest mean scores were found at locations 501 and 506, while the lowest were found at 507A and 513 (Table C-3).

As seen in the 1993 and 1994 habitat assessments, the low 2014 QHEI scores are the result of many factors, including a lack of riffle/run habitat, lack of clean, hard substrates, excessive siltation, channelization, poor quality riparian and floodplain areas, and lack of cover. Most notably, the mesohabitat least desirable to riverine fishes, main channel, dominates the surface area of the Dresden Pool, as well as the majority of the entire UIW. Conversely, the habitat favored by most riverine species (i.e., dam tail waters) constitutes a very small amount of the surface area (ComEd 1996). While aquatic macrophyte growth in the Dresden Pool may offer some habitat to fish and benthic macroinvertebrates, it is reasonable to conclude that given the dominance of a single habitat type, particularly downstream of the DNS discharge, low habitat quality and the lack of habitat complexity are limiting factors for the biota in Dresden Pool near DNS (Figure C-1).

2.5 Nuisance Species

Aquatic nuisance species (ANS) are aquatic and terrestrial organisms, which are introduced into new habitats and produce harmful impacts on aquatic natural resources in the ecosystems into which they are introduced. Of the ANS that have been introduced in Illinois, many are found throughout the UIW, including in the Des Plaines, Kankakee, and Illinois Rivers. The following table lists the ANS found in Illinois waterways (Aquatic Nuisance Task Force 1999).

Aquatic Nuisance Species found in Illinois near DNS

Aquatic Nuisance Species	**Encountered during Sampling Near DNS**
Eurasian watermilfoil (*Myriophyllum spicatum*)	
Alewife (Alosa pseudoharengus)	
Grass carp (*Ctenopharyngodon idella*)	X
Ruffe (*Gymnocephalus cermus*)	
Silver carp (*Hypophthalmichthys molitrix*)	X
Bighead carp (*Hypophthalmichthys nobilis*)	
White perch (*Morone americana*)	X
Striped bass (*Morone saxatilis*)	
Round goby (*Neogobius melanostomus*)	X
Rainbow smelt (*Osmerus mordax*)	
Sea lamprey (*Petromyzon marinus*)	
Tubenose goby (*Proterorhinus marmoratus*)	
European rudd (*Scardinius erythrophthalmus*)	
Spiny waterflea (*Bythotrephes cedestroemi*)	
Zebra mussel (*Dreissena polymorpha*)	X
Rusty crayfish (*Orconectes rusticus*)	X

Of the ANS found in Illinois, 6 were collected or observed during the 2013 (Appendix F) and 2014 (Appendix G) sampling events.

ANS are a significant threat to the integrity of marine and freshwater ecosystems of the United States, and are recognized as a serious problem in Illinois. They affect food webs, nutrient dynamics and biodiversity of the aquatic ecosystems that they invade (Aquatic Nuisance Task Force 1999). To combat the ANS problem in Illinois, a State Comprehensive Management Plan for Aquatic Species was developed to address ANS from the perspective of industrial and municipal water users. The goals of the Management Plan have been to: prevent new introductions of nonindigenous aquatic nuisance species into the Great Lakes and Mississippi Basin waters of Illinois; limit the spread of established populations of nonindigenous aquatic nuisance species into unaffected waters of the state; and abate harmful ecological, economic, social, and public health impacts resulting from infestations of nonindigenous aquatic nuisance species (Aquatic Nuisance Task Force 1999). Since the time this management plan has been in place, a somewhat better understanding of the current ANS established in Illinois has developed. Many state and federal agencies have become very involved and collaborative in addressing and managing the ANS in Illinois.

DNS operations have not been responsible for past introductions of ANS to the DNS vicinity and are unlikely to be a vector of introduction in the future. Further, there is no evidence to suggest that DNS operations have contributed to the spread of ANS or created conditions that allow ANS to flourish within the vicinity of DNS.

2.6 Zooplankton Biotic Category Analysis

2.6.1 Background

Zooplankters are animal microorganisms that live freely in the water column, have relatively limited powers of locomotion, and drift with currents. Zooplankton may eat phytoplankton, other zooplankton, or suspended organic matter; in fact, many are omnivores and consume particles of suitable size regardless of origin.

Zooplankton generally are not expected to be adversely impacted by thermal discharges. First, because they spend their entire life in a variable environment, they have evolved broad physiological tolerances and behavioral patterns that allow them to survive changing conditions. Second, zooplankton are rapidly transported and dispersed by currents, such that no organism would spend any significant amount of time (conservatively less than 10 minutes) in the immediate discharge zone. Third, they have short generation times and high reproductive capacities, allowing populations to readily offset the loss of individuals and to recover rapidly from local perturbations. With optimum temperature (25.6° to 30°C [78° to 86°F]) and food supply, zooplankton such as rotifers and cladocerans can double their numbers up to five times per day (Edmondson et al., 1962; Hall 1964). Accordingly, the probability is low that there could be any meaningful change (positive or negative) in growth or reproduction of zooplankters transported through the DNS thermal plume.

Numerous studies during the 1970s and 1980s of power plant thermal discharges support the conclusion that zooplankton are a low potential impact category. Effects on zooplankton populations were limited to a small area in the immediate vicinity of the discharge, occurring with maximum discharge temperatures in the summer and during those hours when the circulating water was chlorinated to control fouling of the condensers (EA 1978; Tetra Tech 1978; UWAG 1978).

2.6.2 Site Specific Studies

Zooplankton studies at the DNS were conducted during indirect open-cycle operation from 1971 to 1974. Samples were collected at several locations upstream and downstream of the DNS discharge to the Illinois River, in the area of the DNS discharge, in the area of the DNS intake on the Kankakee River, and in the lower Des Plaines River. These studies suggested a difference in the zooplankton assemblage between the Kankakee and Des Plaines Rivers and the assemblage leaving the DNS cooling pond. Total zooplankton abundance was much higher while diversity was lower in the Des Plaines River than in the Kankakee River, which was likely a reflection of differences in hydrology and morphology of the two rivers. The Des Plaines River study area is very similar to lake habitat as compared to the Kankakee River, with increased residence time and higher fertility that allows for reproduction to dramatically increase zooplankton abundance. The zooplankton communities observed in samples consisted mostly of Copepoda, Cladocera, and Rotifera (ComEd 1980).

Typically, the zooplankton assemblage downstream of the discharge on the north shore of Dresden Pool was very similar to that upstream of the DNS discharge along the north shore of the Des Plaines River. Zooplankton densities and species composition downstream of the discharge on the south side of the Dresden Pool were intermediate to that between the Kankakee and Des Plaines Rivers, which reflects mixing of the two rivers. Species composition and abundance downstream of the discharge was very similar to that upstream of the discharge on the south shore of the Illinois River. The zooplankton communities observed in samples across all areas consisted mostly of Copepoda, Cladocera, and Rotifera (ComEd 1980).

2.6.3 Summary

The zooplankton studies in general reflect the community differences between waters leaving the DNS cooling pond, and the community in the Des Plaines and Kankakee Rivers. Because of the difference between the two rivers, it was not possible to document the extent to which indirect open-cycle affects the zooplankton assemblage in Dresden Pool. It appeared that zooplankton abundance and species composition in the cooling pond discharge was masked when the cooling pond discharge was diluted in Dresden Pool, mixing with communities transported and dispersed downstream from the Des Plaines and Kankakee Rivers. Therefore, it was concluded that the DNS discharge had no measurable effect on the downstream zooplankton assemblage (ComEd 1980). Given that these operating conditions remain essentially unchanged and community structure of higher trophic levels such as benthic macroinvertebrates and fish (see Sections 2.7 and 2.8) have remained similar or improved, it is concluded that DNS has no measurable effect on the zooplankton assemblage.

2.7 Freshwater Mussels and Macroinvertebrates Biotic Category Analysis

2.7.1 Benthic Macroinvertebrates

The aquatic macroinvertebrate community in the vicinity of DNS was sampled from both natural and artificial substrates. Natural substrates were sampled from 1972 through 1976 in the immediate vicinity of the DNS intake and discharge canals and locations downstream of the DNS's discharge to the Illinois River. Artificial substrates were sampled from 1974 through 1977 and most years from 1999 through 2014, in essentially the same areas as the natural substrates as well as in the DNS's discharge canal system for Unit 1 (now retired) and Units 2/3. Data from the benthic macroinvertebrate monitoring program conducted from 1972 through 1977 (Hazelton 1979), as summarized in the 1980 Demonstration (ComEd 1980), formed the basis for previous thermal evaluation of the potential effects of indirect open cycle operation of DNS. Monitoring of the benthic macroinvertebrate community was subsequently conducted in 1993 in association with a study of the UIW (ESE 1994) and 12 years between 1999 and 2014 using Ponar grab samples and Hester-Dendy (HD) samplers (see Appendices F and G).

From 1972 through September 1974, benthic macroinvertebrate data were collected during the period when DNS was operating in indirect open-cycle cooling mode (15 June through 30 September). These data showed a greater tubificid worm abundance in Dresden Pool downstream of the cooling pond discharge than upstream of it (ComEd 1980). However, it was ultimately concluded that the greater downstream abundance in tubificids was a function of substrate characteristics rather than higher water temperatures due to DNS operation. This conclusion was drawn from the fact that artificial substrate samples, even from within the discharge, showed higher insect density and diversity when compared to natural substrate samples. Thus, the lower availability of good quality natural substrates, rather than temperature, appeared to be the main factor limiting benthic macroinvertebrate diversity downstream of DNS.

Tubificidae (worms) and Chironomidae (midges) were the major families represented on the natural substrates with Tubificidae dominating the assemblage. The tubificid *Limnodrilus hoffmeisteri*, which is tolerant of organic enrichment and low quality substrates, was the most common identifiable tubificid species. Upstream of the DNS discharge, the composition of the benthic community during the 1974 through 1976 studies consisted primarily of Tubificidae (worms) and Chironomidae (midges) taxa with Ephemeroptera (mayflies) of secondary abundance.

The 1993 UIW macroinvertebrate study included five locations within the DNS study area (ESE 1994). Samples were collected using petite Ponar grabs and HD samplers. Results of this study suggested some level of environmental stress in the vicinity of DNS based on lower taxa richness, lower diversity, and higher densities among Ponar samples downstream of the DNS discharge than upstream of it. Among the HD results, greater densities, higher biotic index (BI) scores, and lower diversity was also evident downstream of the DNS. However, it was reported that HD sample densities in the DNS discharge had the highest invertebrate community index (ICI) score of any location sampled, indicating a good community condition in the DNS discharge canal. It was concluded that spatial differences observed in the macroinvertebrate community was influenced by several factors, including flow, flow-induced sampling variation, and differences in water quality, in addition to temperature (ESE 1994).

Macroinvertebrate data collected by Ponar grab and HD artificial substrate samplers from 1999 through 2014 have confirmed the expected results projected from the 1970s studies. The current data indicate that a poor benthic community exists in Dresden Pool and in the Illinois River downstream of the Dresden Island Lock and Dam. The fauna at all locations in the DNS study area included primarily tolerant or facultative taxa. The Ponar samples indicated that the highly tolerant Oligochaeta dominated at most locations. With a few exceptions, intolerant groups such as EPT taxa (Ephemeroptera, Plecoptera, and Trichoptera) generally were not well represented and when present were collected in relatively low numbers. The number of EPT taxa was lower than expected for a waterway of this size (DeWalt and Webb 1998). However, the artificial substrate samples typically had higher total taxa richness, higher EPT taxa richness, and a more even distribution of abundance among the taxa than did Ponar samples in natural substrate from the same locations.

No significant upstream/downstream differences were observed among the historically examined parameters, which include total density (all taxa), densities of Oligochaeta, Chironomidae, and Pelecypoda, and taxa richness in the Ponar samples (Appendix F). Comparisons among the Ponar data collected from Dresden Pool since 1999 showed there were no annual significant differences in the mean densities of Ephemeroptera for areas combined or the two areas individually. In addition, no significant annual differences were observed among the upstream densities of Chironomidae and taxa richness. Total density (all taxa) and Oligochaeta densities upstream of DNS were statistically similar among all years except 2008 when the lowest density was recorded. Downstream of DNS, total density, Oligochaeta density, Chironomidae density, and taxa richness were statistically similar except between years with the lowest and highest densities.

Artificial substrate results generally showed that the relative abundance of Chironomidae and Oligochaeta was higher upstream of DNS, whereas Trichoptera relative abundance was higher downstream of DNS. Ephemeroptera was a minor component upstream and downstream of DNS. As was observed for Chironomidae, relative abundance, Chironomidae densities were higher upstream of DNS than downstream of DNS; however, the opposite was the case for Oligochaeta. The total number of taxa was higher upstream of DNS while the number of EPT taxa was similar between areas. Mean Ephemeroptera densities among years were not significantly different. In addition, results were statistically similar among the majority of study years for all parameters. However, there were some inter-year significant differences in mean densities for all taxa, Oligochaeta, Chironomidae, and Trichoptera. These annual differences could be the result of a number of factors including natural annual variation, stream flow conditions, food availability, predator abundance, and legacy pollutants.

The more pollution tolerant taxa typically observed in the Dresden Pool Ponar samples such as *Nanocladius distinctus*, *Dicrotendipes simpsoni*, and *Glyptotendipes* were typically absent from the Ponar samples downstream of the Dresden Island Lock and Dam, but were present in the artificial substrate samples. The variability observed in this area and the lack of relationship to trends observed upstream are likely artifacts of the unstable conditions below the Dam and to the substantial differences in habitat between the Dresden Pool and the area downstream of the Dam.

2.7.2 Freshwater Mussels

A survey was conducted October 2014 in the vicinity of DNS to describe the mussel community upstream and downstream of the DNS's discharge (Appendix H). It employed systematic sampling design employing semi-quantitative transect sampling and timed visual searches. Mussel data included species, age, and size (length and height). Habitat information was also collected concurrent with transect mussel sampling that consisted of observations of substrate type, unique conditions (e.g., scour, deposition, and debris), and depth.

A total of 3,349 individuals representing 25 species were collected within the survey area from the semi-quantitative and qualitative sampling efforts; 928 individuals representing 20 species were collected downstream of the Dresden Island Lock and Dam and 2,421 individuals representing 24 species were collected upstream of the Dam. The most abundant species was the threeridge (*Amblema plicata*) that represented nearly 58 percent of the total number collected followed by mucket (*Actinonaias ligamentina*) and pink heelsplitter (*Potamilus alatus*), each contributing about 8 percent of the total. Each of the other 22 species comprised less than seven percent and collectively comprised about a quarter of the total abundance. The three most abundant species upstream were also the most abundant encountered downstream of the Dam, representing nearly 36 percent, 18 percent, and 9 percent, respectively, and 66 percent, 4 percent, and 8 percent of the total upstream, respectively. Fragile papershell (*Leptodea fragilis*) and mapleleaf (*Quadrula quadrula*) were also common upstream, comprising 7 and 4 percent of the total. *Quadrula quadrula*, *L. fragilis* and pimpleback (*Quadrula pustulosa* were the only other species to comprise more than seven percent of the mussels encountered downstream of the Dam. One species, yellow sandshell (*Lampsilis teres*), was only encountered downstream of the dam. Five species were only encountered upstream of the dam: rock pocketbook (*Arcidens confragosus*), pink papershell (*Potamilus ohiensis*), giant floater (*Pyganodon grandis*), lilliput (*Toxolasma parvum*), and paper pondshell (*Utterbackia imbecilis*).

Two state threatened species were encountered during the survey, purple wartyback (*Cyclonaias tuberculata*) and black sandshell (*Ligumia recta*). Both species were present upstream and downstream of the Dam. Five adult *C. tuberculata* (mean age = 9.6 years) were collected, including four downstream and one upstream. Four adult *L. recta* (mean age = 9.3 years) were collected, including three downstream and one upstream.

The mussel survey showed the presence of a diverse mussel assemblage upstream and downstream of the Dresden Island Lock and Dam. Recruitment was evident throughout the study area although the downstream assemblage had a greater proportion of adult mussels than upstream. Substrate and depth varied between upstream and downstream of the Dresden Island Lock and Dam but also varied within the upstream study reach. The study reach downstream of the Dam was generally shallower (mean depth of approximately five feet) and substrates were coarser (i.e., gravel, sand and cobble). The study reach upstream of the Dam was typical of an impounded river channel with a mean depth of approximately 13 feet and substrates with a generally larger proportion of finer sediments such as silt, sand, and clay in addition to gravel. Depth does not appear to be a contributing factor to density in the study area due to the presence of similarly high mussel densities located in both deep (upstream) and shallow (downstream) habitats. Mussel distribution appears largely based on substrate composition with the highest densities of mussels occurring in areas with substrates composed primarily of gravel mixed with sand and/or silt.

Downstream of the DNS discharge to the Dresden Island Lock and Dam, mussel densities were high along the right descending bank and low along the left descending bank. The largest concentration and highest densities of mussels encountered during the survey occurred along the right descending bank within the flow path of the elevated temperatures in the thermal plume (Figure C-2). Of the transects located immediately downstream of the discharge along the left descending bank (Transects 23 through 30), the transect located within the warmest portion of the plume (Transect 23) contained the greatest number of mussels. Mussel densities upstream of the DNS discharge were variable with the lowest average densities encountered during the survey occurring along the right descending bank and the third highest average densities along the left descending bank.

2.8 Fish Biotic Category Analysis

2.8.1 Threatened and Endangered Species

Federally endangered or threatened (T&E) fish species have not been collected in Dresden Pool or adjacent study areas in the upstream Des Plaines and Kankakee Rivers, or downstream of Dresden Island Lock and Dam (Appendix A). Pallid sturgeon (*Scaphirhynchus albus*) is the only federally listed fish species known to occur in Illinois; it listed in seven southwestern Illinois counties that border the Mississippi River (USFWS 2014), not in the vicinity of DNS.

Five T&E fish species listed by Illinois have been collected during the DNS long-term monitoring program. The threatened river redhorse (*Moxostoma carinatum*) and endangered greater redhorse (*M. valenciennesi*) were collected infrequently and in low numbers. Only four greater redhorse were collected over that same period. Modification of the Illinois River flow, bathymetry, and habitat has eliminated much of the historical redhorse habitat

The state-endangered western sand darter (*Ammocrypta clara*) were collected downstream of the Dresden Island Lock and Dam infrequently and in low numbers. Habitat downstream of the Dam is more suitable for darters than in Dresden Pool where the river channel is flooded by the impounded UIW.

Pallid shiner (*Hybopsis amnis*), listed as endangered in Illinois, was first collected from the DNS study area in 2001 and has been collected each year since. Once thought to have been extirpated from Illinois, it was discovered in the Kankakee River in 1983 (Kasprowicz et al. 1985). Although occasionally caught throughout the DNS study area, most pallid shiner were collected primarily upstream of DNS in the Kankakee River (Appendix G). The occurrence of pallid shiner 30 some years following the start-up and operation of DNS indicates the plant operations had not impacted that population.

The state-threatened banded killifish (*Fundulus diaphanus*) was first collected as part of the DNS monitoring program in 2013 and again in 2014 after 36 years of monitoring the UIW upstream of the Dresden Island Lock and Dam (Appendix G). Two specimens were collected in 2013, both from upstream of DNS, whereas all 10 specimens collected in 2014 were taken downstream of the DNS discharge. This species is typically associated with slow shallow water with extensive aquatic vegetation (EA 2014).

2.8.2 Ichthyoplankton

Ichthyoplankton consists of early life stages of fish (i.e., eggs, larvae, and early juveniles) that occur in the water column. Appendix A summarizes available information regarding the species of ichthyoplankton collected in Dresden Pool, at the DNS intake, and in the Kankakee River. Based on entrainment characterization studies at DNS (EA 2007), icthyoplankton occurred in the drift in 2005 and 2006 when ambient river temperatures ranged from 10.5 to 31.4°C (51 to 88.5°F), which suggest that ichthyoplankton are not exposed to temperatures high enough or for sufficient duration to cause thermally-induced mortality during the 2005 and 2006 study (Figures C-3 and C-4). Early life stages frequently have higher thermal tolerance than adults. Eggs and larvae of several RIS (common carp, channel catfish, and bluegill; Appendix B) acclimated to temperatures of 10-33°C (50-91.4°F) tolerate acute exposure to temperatures of 31-41°C (87.8-105.8°F) and chronic exposure up to 38.8°C (101.8°F).

The majority of the eggs and larvae collected from the Kankakee River upstream of DNS were freshwater drum, gizzard shad, Cyprinidae, sunfish (*Lepomis* spp.), and carpsucker (*Carpiodes* spp.) in 2005 and 2006 (Tables C-4 and C-5). Freshwater drum eggs accounted for 72 to 76 percent of the drift; of the other taxa collected, only gizzard shad accounted for more than three percent of the annual total except in 2006 when *Carpiodes* yolk-sac larvae accounted for 17 percent of the ichthyoplankton compared to less than one percent in 2005. The abundance of both freshwater drum and gizzard shad in the drift is indicative of their open water spawning habits and the high relative abundance of freshwater drum eggs in the drift is because their eggs are semi-buoyant. Overall, the above five taxa accounted for over 90 percent of the total ichthyoplankton drift in 2005 and 2006. Taxa with more specialized spawning behavior such as nest builders that provide parental care (e.g., channel catfish and sunfish) were infrequently collected and in low numbers.

Entrainment during closed cycle operations from April through 14 June (i.e., based on abundance in the Kankakee River upstream of the intake canal) and indirect open cycle from 15 June through August (i.e., based on abundance in the intake canal) in 2005 and 2006 was dominated by five taxa. Four taxa accounted for nearly 90 percent of the 2005 entrainment estimate of which nearly 59 percent were freshwater drum eggs. Early life stages of *Lepomis* (20 percent) ranked second, and gizzard shad and cyprinid group A (both 5 percent) each ranked third for the most entrained taxa in 2005. Freshwater drum eggs accounted for 60 percent of the 2006 entrainment estimate. Early life stages of gizzard shad (9 percent), unidentified cyprinid (8 percent), unidentified *Carpiodes* (6 percent), and *Lepomis* (3 percent) ranked two through five in 2006.

Results of the DNS 2005-2006 entrainment characterization study indicated that ichthyoplankton impacted by entrainment at DNS represented primarily forage and other fish that have high reproductive potentials and high natural mortality rates. The most commonly entrained species represent fishes that have been the most abundant in Dresden Pool, Des Plaines River, and Kankakee River over the operating history of DNS.

The 2005-2006 study also showed that there was a 71 to 78 percent reduction in entrainment when the facility operates as permitted compared to operating open cycle from April through August (EA 2007). Of the fish eggs, larvae, and juveniles estimated to be in the drift in 2005, 82.5 percent passed the intake by 15 June during closed cycle cooling (Figure C-3). Most of remaining drift during 2005 occurred during indirect open cycle cooling operations from mid-June through late August. In 2006, 86.5 percent of the drift passed the intake by mid-June (closed-cycle operations) and 13.5 percent occurred in the river during indirect open cycle operations after 15 June (Figure C-4).

2.8.3 Juvenile and Adult Fish

2.8.3.1 Species Composition

Studies conducted since 1991 in Dresden Pool (including upstream of DNS in the lower Des Plaines and Kankakee Rivers) and downstream of Dresden Island Lock and Dam, documented the occurrence of 86 fish species including 80 native species and six introduced/exotic species (Table C-6). Native species have dominated the catch since the beginning of the long term monitoring program in 1971. Twenty-one of the total 90 native species were collected each of the 20 years monitored from 1991 through 2014. Common carp was the only non-native species collected each year. The common native species represented several trophic levels including forage species (gizzard shad, emerald shiner, bluntnose minnow, and bullhead minnow), omnivores (e.g., channel catfish, rock bass, green sunfish, and bluegill), and top predators (e.g., smallmouth bass and largemouth bass). Other native species were collected each year included two cyprinids (spotfin shiner and spottail shiner), five suckers (river carpsucker, quillback, shorthead redhorse, smallmouth buffalo, and golden redhorse), orangespotted sunfish, logperch, and freshwater drum. In total, 28 species were collected during all or nearly all the years monitored upstream of Dresden Island Lock and Dam in the vicinity of DNS.

Monitoring of the fish community in Dresden Pool from 1991 through 2014 yielded annual species (native + exotic) counts of 36 to 70 species with an average of 54 species:

YEAR	SPECIES COUNT	YEAR	SPECIES COUNT
1991	60	2002	56
1992	60	2003	63
1993	59	2004	56
1994	47	2005	54
1995	45	2006	55
1997	44	2007	58
1998	41	2008	62
1999	36	2011	49
2000	53	2013	50
2001	54	2014	70

Except for a declining trend between 1993 and 2000, species counts generally increased with the highest count (70) in 2014. However, statistical analyses have shown that these differences are not significant (Table C-7). Lower total species counts in 2011 and 2013 reflect a 60 percent reduction in the sampling program those two years.

Native species richness in the DNS study area was statistically similar ($P>0.05$) among most years (Table C-7). The 2014 mean (15.3) was statistically higher than eight other years, but the lowest mean in 1994 (7.1) was statistically lower than only four of the other 16 years. These two measures of species diversity indicate that a diverse fishery has been maintained in the vicinity of DNS since 1994. As discussed in Appendix A, the only species not collected most years have been incidental, occasional, or exotic species. The Representative Important Species (RIS) selected for the predictive assessment (Appendix B) were almost always collected each year that monitoring was conducted. Exceptions were white sucker and black crappie that were always minor components of the fish community.

Native species richness in the electrofishing catch was higher upstream of DNS compared to downstream of the discharge from 1999 through 2014 for trips combined (all seasonal surveys) and the July/August surveys when water temperatures are highest in the study area (Figure C-5). However, those differences were relatively small, averaging less than three species and were rarely statistically significant. For trips combined, native species richness was statistically ($P<0.05$) lower downstream of DNS only four of the 13 years compared. Spatial differences for the July/August surveys were statistically similar except in 2014 when the upstream native species richness was the highest for the 13 years compared. Differences in native species richness between areas upstream and downstream of DNS primarily reflect the presence or absence of uncommon species and differences in habitats. Better habitat quality in the Kankakee River compared to the other sampling locations in the study area contributes to the higher native species richness values upstream of DNS. With the exception of white sucker and black crappie, the RIS were collected from both areas over the 13-year period compared. White sucker were not collected by electrofishing during the 1999-2014 study period and black crappie were either not collected or collected at very low rates.

Surveys downstream of the Dresden Island Lock and Dam from 1991 through 2014 yielded 86 species, 78 that were also collected upstream of the Dam (Table C-3). As in Dresden Pool, native species and common carp dominated the annual catches downstream of the Dam. Thirty of the total 86 species were collected downstream of the Dam during five or fewer of the surveys years.

2.8.3.2 Abundance

Total summer (15 June through August) electrofishing catch rates of native species ranged from 47.8 to 299.0 fish per km (Figure C-6). The 2011 and 2013 CPEs were below the long-term average because of the reduced sampling effort in July, August, and September as sampling was conducted monthly those years compared to twice monthly during the standard monitoring program, which increased the likelihood that young-of-year fishes would be recruited to the catch. Except in 2011 and 2013, sampling was conducted twice in July and August. The 2014 total CPE (273.3 fish/km) was exceeded only by the highest rate in 2003. Total CPE of native species in 1994 was significantly ($P<0.05$) lower compared to all years except 1995, but CPEs were statistically similar among 15 of the 17 years compared (Table C-7). Catch rates for the RIS followed the same trend as the total CPE, accounting about three-quarters of the total native species CPE (Figure C-6).

Summer RIS electrofishing catch rates during the period compared fall into three categories: highly variable, stable, or rarely collected. Gizzard shad, emerald shiner, bluegill, and largemouth bass CPE were the most variable of the RIS, whereas CPEs of common carp, golden redhorse, channel catfish, smallmouth bass, logperch, and freshwater drum were stable in comparison (Table C-8). White sucker and black crappie were rarely collected in Dresden Pool and always at low rates. Catch rates of gizzard shad, emerald shiner, and golden redhorse exhibited cyclical trends, whereas catch rates of bluegill and largemouth bass generally increased over the 1994-2014 monitoring period. Catch rates of channel catfish were stable except in 1998 and 1999, when rates were lowest. Catch rates reached their highest levels in 2000 and 2003 and remained well above the lowest rates through 2014. Smallmouth bass catch rates were stable, except for higher CPEs in 2003 and 2008. Logperch catch rates average less than 2 per km except in 2014 when record catches were recorded. Except for high catch rates in 1994 and 2003, freshwater drum were caught in low numbers and have been caught at less than 2 fish per km since 2004.

Total summer (15 June through August) electrofishing catch rates of native species at locations downstream of the Dresden Island Lock and Dam ranged from 86.0 to 340.5 fish per km (Table C-9). The 2011 and 2013 CPEs were below the long-term average but were statistically ($P<0.05$) comparable to all other (Table C-9).

2.8.3.3 Fish Community Well Being

The modified Index of Well-Being (IWBmod), which uses the number of fish, weight, and diversity evaluation criteria, was applied to the electrofishing data as an indicator of fish health in Dresden Pool. IWBmod is sensitive to an array of environmental disturbances, particularly those that result in shifts in community composition without large reductions in species richness, numbers, and/or biomass (Ohio EPA 1987). That modification calls for the exclusion of 13 highly tolerant species, all hybrids, and all exotic species from the number and weight calculations. However, these taxa are included in the two Shannon index calculations, which eliminate the “undesired” effect caused by a high abundance of tolerant species but retains their influence on the Shannon diversity indices.

Mean IWBmod scores for the 15 June through August monitoring period ranged from 5.3 to 7.4 (Table C-7). Those scores were statistically similar 13 of the 17 years compared and the highest score in 2003 was statistically higher than only four of the 17 years monitored. Ohio EPA (1987, 1989 updated 2006) uses IWBmod scores to assign streams or stream segments to the following classifications: Exceptional = ≥9.6; Very Good = 9.1-9.5; Good = 8.5-9.0; Marginally Good = 8.0-8.4; Fair = 6.4-7.9; Poor = 5.0-6.3; and Very Poor = <5.0. According to the Ohio EPA classification, the fish community in Dresden Pool during the mid-June through August time period would be considered poor in 2001 and fair all other years (Figure C-7).

Mean IWBmod scores upstream of DNS averaged 0.3 higher than downstream, but lowered the ratings from fair to poor only once, in 2001 (Figure C-7). The upstream/downstream differences for the 15 June through August period were statistically ($P>0.05$) similar 15 of the 17 years monitored, suggesting that operation of DNS had little effect on the wellbeing of the fish community in Dresden Pool. It is more likely that environmental conditions in the UIW resulting from impoundment of the Illinois River, operation of the navigation system, and use of the system for wastewater treatment (See Appendix A) has a greater effect on the fishery and prevents it from meeting higher ratings that are indicative of a natural river system.

Mean IWBmod scores for the 15 June through August monitoring period downstream of the Dresden Island Lock and Dam ranged from 6.7 to 7.9 (Table C-9). Those scores were statistically similar among all 15 years compared. Based on the Ohio EPA classification outlined above, the fish community downstream of the Dresden Island Lock and Dam during the mid-June through August time period would be considered fair each of the 15 years monitored.

2.8.3.4 Fish Condition

The relative weight (*Wr*) of fish and incidence of DELT anomalies (deformities, erosions, lesions, and tumors; Ohio EPA 1987, 1989) were used to evaluate the condition of individual species collected from Dresden Pool.

Relative Weight

Relative weight (*Wr*) is a measure of fish condition and indicates whether fish are growing and gaining weight at normal rates. Species collected in adequate numbers and that met minimum length requirements were used in for this evaluation. Lack of food, poor water quality, water temperatures, or disease are stresses that can cause poor growth. While growth may be difficult to measure, condition or plumpness of fish is easy to measure and indicates if fish are under stress. *Wr* is the ratio of the actual weight of a fish to what a healthy fish of the same length should weigh (i.e., standard weight, *Ws* as provided in Anderson and Gutreuter (1983)**.** Fish with high relative weights are close to normal weight while those with low relative weights are thin. A W*r* range of 90-100 is a typical objective for most fish species. When mean *Wr* values are well below 90, problems may exist in food and feeding relationships.

Mean *Wr* of species for which sample sizes were adequate to calculate relative weights ranged from 96 to 112 during the summer, indicating the fish in Dresden Pool were generally in good condition (Table C-10). Of the six RIS collected in adequate numbers and length to assess annual trends, summer mean *Wr* ranged from 93 for smallmouth bass to 108 for bluegill (Table C-10). Summer mean *Wr* for the RIS exceeded 90 most of the time (89 percent) and 53 percent of the summer means were greater than 100. In contrast, 40 percent of the mean *Wr* of four sucker species were less than 90 (Table C-10).

Annual mean *Wr* of species collected downstream of the Dresden Island Lock and Dam ranged from 96 to 106 indicating the fish in downstream of Dresden Pool were generally in good condition (Table C-11). Of the six RIS collected in adequate numbers and length to assess annual trends downstream of the Dam, mean *Wr* ranged from 90 for smallmouth bass to 109 for bluegill (Table C-8). Mean summer *Wr* for the RIS exceeded 90 most of the time (81 percent) and 47 percent of the summer means were greater than 100. In contrast, 51 percent of the summer means of three sucker species were less than 90 (Table C-8). As a group, sucker species occasionally had marginal *Wr* less than 90, which suggest health, food availability, and/or feeding relationship problems, although most summer means approached 90. Lower W*r* of these bottom feeding species suggest there may be as affect from the legacy of contaminated sediments in the UIW (see Section 3.2.7 of Appendices F and G).

Based on relative weight (*Wr*) results, fishes collected from Dresden Pool and downstream of Dresden Island Lock and Dam since 1994 were consistently in good condition, especially the six RIS for which relative weights were calculated.

<u>DELT Incidence Rate</u>

Inter-year comparisons of DELT anomalies during the summer (15 June through August) show that summer affliction rates in Dresden Pool decreased steadily from 13.6 percent in 1995 to 1.6 percent in 1999 and with few have been consistently near two percent during the last 14 study years (Appendix G). The lowest affliction rate occurred in 2011 (0.9) and rates were less than two percent four other years. Annual DELT affliction rates downstream of Dresden Island Lock and Dam varied were widely over the same period. Bottom feeders such as common carp, golden redhorse, shorthead redhorse, smallmouth buffalo, and channel catfish have typically exhibited the highest DELT anomaly affliction rates in Dresden Pool and downstream of Dresden Island Lock and Dam. Clupeidae (primarily the RIS gizzard shad), Cyprinidae, Centrarchidae, and Percidae had low incidence rates that averaged less than 5.0 percent over the 1994-2014 monitoring period both upstream and downstream of the Dam:

Family	Dresden Pool			Downstream Dresden Island L&D		
	# DELT	# Examined	% DELT	# DELT	# Examined	% DELT
Clupeidae	22	8,081	0.3%	5	1,280	0.4%
Cyprinidae	82	7,533	1.1%	2	1,868	0.1%
Catostomidae	169	1,479	11.4%	84	1,502	5.6%
Ictaluridae	200	427	46.8%	164	252	65.1%
Centrarchidae	198	8,649	2.3%	81	1,827	4.4%
Percidae	0	325	0.0%	1	123	0.8%

Only one of the percids examined had DELT anomalies and, and excluding common carp, less than 0.2 percent of the cyprinids had anomalies. Similarly, excluding smallmouth bass and largemouth bass, less than 0.5 percent of sunfish species had DELT anomalies. Of the RIS, common carp, golden redhorse, channel catfish, and freshwater drum had incidence rates that averaged greater than 10 percent over the 1994-2014 monitoring period both upstream and downstream of the Dam:

RIS	Dresden Pool			Downstream Dresden Island L&D		
	# DELT	# Examined	% DELT	# DELT	# Examined	% DELT
Gizzard shad	22	7,591	0.3%	5	1,109	0.5%
Common carp	69	373	18.5%	49	145	33.8%
Emerald shiner	1	2,853	0.0%	0	3,603	0.0%
White sucker	0	2	0.0%	1	1	100.0%
Golden redhorse	87	850	10.2%	14	239	5.9%
Channel catfish	192	355	54.1%	162	241	67.2%
Bluegill	45	3,670	1.2%	25	617	4.1%
Smallmouth bass	18	759	2.4%	11	293	3.8%
Largemouth bass	83	1,350	6.1%	32	291	11.0%
Black crappie	1	8	12.5%	2	13	15.4%
Logperch	0	279	0.0%	1	103	1.0%
Freshwater drum	42	337	12.5%	69	284	24.3%
Total RIS	560	18,427	3.0%	371	6,939	5.3%

Overall, 3.0 percent of the RIS examined from Dresden Pool had DELT anomalies compared to 5.3 percent downstream of the Dresden Island Lock and Dam. Differences between the two areas largely reflect higher incident rate of channel catfish downstream of the Dam.

A high incidence of DELT anomalies is an indicator of stress or contamination, which may be caused by a variety of environmental factors, including chemically contaminated substrates (Ohio EPA 1989). Disproportionately higher affliction rates among bottom feeders suggest that substrates within the DNS study area, like other upstream areas in the UIW, contain contaminants that are responsible for many of the DELT anomalies observed on these species (Bertrand and Sallee 1992; Burton 1995; EA 1996).

The Ohio EPA (1987) uses percent DELT anomalies as one of the metrics for their Index of Biotic Integrity (IBI). For large river sites like the UIW, the Ohio IBI scoring criteria is as follows: percent DELT anomalies <0.5 = 5 (good), 0.5-3.0 = 3 (fair), and >3.0 = 1 (poor). Based on the overall (all species combined) incidence rates observed for the 15 June through August period, fish in Dresden Pool were in the fair category with a few exceptions:

Dresden Pool		Downstream Dresden Island Lock & Dam	
Year	% DELT	Year	% DELT
1994	4.1	1994	5.6
1995	13.6	1995	5.4
1997	4.9	--	--
1998	2.1	--	--
1999	1.6	1999	8.2
2000	5.1	2000	3.2
2001	1.7	2001	3.4
2002	2.3	2002	3.5
2003	2.5	2003	6.7
2004	5.4	2004	7.6
2005	2.6	2005	4.0
2006	2.4	2006	5.5
2007	1.7	2007	2.4
2008	2.1	2008	3.6
2011	0.9	2011	7.7
2013	2.8	2013	5.0
2014	1.9	2014	2.8

Annual incidence rates of DELT anomalies downstream of Dresden Island Lock and Dam were in the poor range (>3.0 percent) 13 of the 15 years monitored. The rates varied widely and generally exhibited a cyclical trend. Higher rates were associated with the number of suckers and channel catfish collected.

2.9 Other Vertebrate Wildlife Biotic Category Analysis

The waters and shoreline of the UIW and Dresden Pool is used by various resident mammals (e.g., muskrat, white-tailed deer, and wild turkey), song birds (e.g., black-capped chickadee and tufted titmice), reptiles (e.g., northern water snake and red-eared slider), and amphibians (e.g., northern leopard frog and American bullfrog). Wildlife use the DNS study area for nesting, nursery, and foraging grounds, and in the case of migratory birds (e.g., waterfowl and American white pelicans), for resting areas. Water birds commonly seen in the area include local and migratory waterfowl and wading birds (e.g. Canada geese and great-blue heron). Bald eagle have been observed along the UIW and in the vicinity of Dresden Pool during monitoring studies at DNS. They overwinter along the Illinois River and have recently nested in northeast Illinois in Cook, Kane, and Will counties. Nesting sites are not known to exist along the Dresden Pool shoreline.

Activity of other vertebrate wildlife has not been limited by the thermal limits that DNS has operated under since 1981 and are not expected to be affected by the proposed ATL. The thermally-influenced area is relatively small and higher water temperatures occur in the summer when migratory waterfowl use is at its lowest.

3.0 CONCLUSIONS REGARDING PROTECTION AND PROPAGATION OF A BALANCED INDIGENOUS COMMUNITY

In a 316(a) Demonstration, the standard used in the assessment of the thermal component of power plant discharges is whether a balanced, indigenous community (BIC) of shellfish, fish, and wildlife has been and will be maintained in or on the receiving water body despite the thermal discharge. That standard -- protection of the BIC-- is satisfied if the following criteria are met:

- No substantial increase in abundance or distribution of any nuisance species or heat tolerant community;
- No substantial decreases of formerly abundant indigenous species or community structure to resemble a simpler successional stage than is natural for the locality and season, other than nuisance species;
- No unaesthetic appearance, odor, or taste of the water;
- No elimination of an established or potential economic or recreational use of the waters;
- No reduction in the successful completion of life cycles of indigenous species;
- No substantial reduction of community heterogeneity or trophic structure;
- No adverse impact on threatened or endangered species;
- No destruction of unique or rare habitat;
- No detrimental interaction with other pollutants, discharges, or water-use activities;
- Because this Demonstration is focused on a request for a change in the thermal limits, the demonstration must show that these conditions will be satisfied in the future if the proposed limits are adopted.

For the reasons summarized below, the retrospective and prospective evaluations of the DNS thermal discharge demonstrate that the above criteria will be satisfied if the proposed ATLs are adopted.

✓ **No substantial increases in abundance or distribution of any nuisance species or heat tolerant community**

To date, no substantial changes in abundance of nuisance species have been observed. The retrospective analysis indicates there have been changes in the non-thermal components of the system, but the DNS thermal discharge was not a contributing factor. Based on these observations, the relatively small amount of additional heat that will be discharged if the proposed ATLs are authorized is not expected to cause changes in abundance or distribution of nuisance species**.**

- ✓ **No substantial decreases of formerly abundant indigenous species other than nuisance species**

Based on results reported by the monitoring programs described in Appendix A, abundance of most indigenous species in the vicinity of DNS has either been unchanged or increased during the period of indirect open cycle cooling. Overall, the retrospective analysis indicates that any trends in abundance are apparent at locations both upstream and downstream of the DNS discharge, indicating that the thermal discharge is not a significant contributing factor. The prospective analysis concludes that the proposed ATLs will not cause any appreciable harm to the indigenous fish species.

A special mussel study conducted in 2014 shows that, in beds that have similar habitat, unionid mussels are similar in species composition and abundance upstream and downstream of the DNS discharge. This indicates that the thermal discharge has not caused any appreciable harm to the unionid mussel community in the Illinois River upstream of the Dresden Island Lock and Dam and that the proposed ATLs will adequately protect the balanced, indigenous unionid community in the DNS receiving waters.

The demonstration of no retrospective effects on benthic macroinvertebrate, shellfish, and fish communities supports the conclusion that the lower trophic levels on which they are dependent for food have been similarly unaffected and that no appreciable harm will result from the small increment in added heat that may be released if the proposed ATLs are authorized.

- ✓ **No unaesthetic appearance, odor, or taste of the water**

There is no evidence of an unnatural odor or an unaesthetic appearance in the DNS receiving waters and implementation of the proposed ATLs is not expected to cause any such impacts.

- ✓ **No elimination of an established or potential economic or recreational use of the waters**

No economic or recreational uses of the upper Illinois River have been eliminated or minimized as a result of the DNS thermal discharge. To the extent recreational fisheries are depressed, this is because of the fish consumption advisories for the UIW, due to PCB contamination that is unrelated to operation of DNS. The prospective demonstration for the RIS indicates the small increment in additional heat that may be released if the proposed ATLs are authorized will not affect these conditions.

- ✓ **No reductions in the successful completion of life cycles of indigenous species, including those of migratory species**

Retrospective analyses of the long-term monitoring program and the historical biological analyses indicate that thermal effects have not compromised the overall success of indigenous species in completing their life cycles. These observations, combined with the prospective demonstration for RIS, indicate that the small increment in added heat that could be released if the proposed ATLs are authorized will not cause any change in these conditions.

- ✓ **No substantial reductions of community heterogeneity or trophic structure**

Data collected during the long-term monitoring program conducted at DNS since the 1970s indicate that the number of species collected has remained reasonably constant across years. Any long-term changes in the fish community can be attributed to changes in the UIW unrelated to the operation of DNS. These changes are seen system wide in the UIW and there is no evidence that the DNS thermal discharge has contributed to these changes. Similarly, the proposed, relatively small, change in the ATLs is not expected to contribute to any such changes.

- ✓ **No adverse impacts on threatened or endangered species**

The retrospective analysis identified five state-listed fish species and two state-listed mussel species, but no federally listed threatened or endangered species. These state-listed species have not been impacted by the DNS thermal discharge and are not expected to be impacted if the proposed ATLs are authorized.

- ✓ **No destruction of unique or rare habitat, without a detailed and convincing justification of why the destruction should not constitute a basis of denial**

There are no unique habitats downstream of the DNS discharge that could potentially be affected by the thermal discharge.

- ✓ **No detrimental interactions with other pollutants, discharges, or water-use activities.**

Operation of DNS has not had a detrimental effect on recreational (e.g. boating and fishing) or commercial (e.g. shipping and fishing) water-use activities in the upper Illinois, Des Plaines, or Kankakee River. Cumulative effects of thermal additions discharged by industries upstream have not occurred. As discussed above, no harmful interactions with other pollutants such as organic carbon, phosphorus, and nitrogen are expected if the proposed ATLs are adopted.

4.0 REFERENCES CITED

Anderson, R.O., and S.J. Gutreuter. 1983. Length, weight, and associated structural indices, In Fisheries Techniques (Nielson L.A. and D.L. Johnson, eds.), p. 283-300. Southern Printing Company, Inc. Blacksburg, BV.

Aquatic Nuisance Task Force. 1999. Illinois State Comprehensive Management Plan for Aquatic Nuisance Species. http://www.anstaskforce.gov/illinois_state_plan.htm. October.

Berg, D.J., and D.W. Garton. 1988. Seasonal abundance of the exotic predatory cladoceran, *Bythotrephes cederstroemi*, in western Lake Erie. Journal of Great Lakes Research 14(4):479-488.

Bertrand and Sallee. 1992. Results and analysis of fish monitoring by the Department of Conservation at seven locations on the Upper Illinois Waterway.

Burke, J. S., D. R. Bayne et al. 1986. Impact of silver and bighead carps on plankton communities of channel catfish ponds. Aquaculture 55:59-68.

Burton, G.A. 1995. Upper Illinois Waterway Study Interim Report: 1994-1995 Sediment

Contamination Assessment. Prepared for Commonwealth Edison Company. Prepared by The Institute for Environmental Quality, Wright State University, Dayton, OH.

Calkins, H.A., S.J. Tripp, and J.E. Garvey. 2012. Linking silver carp habitat selection to flow and phytoplankton in the Mississippi River. Biological Invasions 14:949-958. http://link.springer.com/article/10.1007%2Fs10530-011-0128-2.

Commonwealth Edison Company and the Upper Illinois Waterway Ecological Study Task Force (ComEd). 1996. Final Report. Aquatic Ecological Study of the Upper Illinois Waterway Volumes 1 and 2. Commonwealth Edison Company, Chicago, Illinois.

Commonwealth Edison Company (ComEd). 1980. §316(a)-410(c) Demonstration for The Dresden Nuclear Generating Station. December.

DeWalt, R.E. and D.W. Webb. 1998. Summer Ephemeroptera, Plecoptera, and Tricoptera (EPT) Species Richness and Hilsenhoff Biotic Index at Eight Stream Segments in the Lower Illinois River Basin. Tech. Report 1998 (9). Illinois Natural History Survey, Center for Biodiversity.

Ecological Analysts (EA). 1978. Final report. Hudson River thermal effects studies for representative species. Prepared for Central Hudson Gas and Electric Corp., Consolidated Edison Company of NY, Inc., and Orange and Rockland Utilities, Inc.

EA Engineering, Science, and Technology, Inc. (EA). 2007. Entrainment Characterization

Study, 2005 – 2007, Dresden Station. Prepared for Exelon Nuclear, Warrenville, IL.

_____________. 2014. 2013 Upper Illinois Waterway Fisheries Investigation RM 274.4-296.0. Prepared for NRG Midwest Generation, LLC. Romeoville, IL.

Edmondson, U.T., G.W. Comita, and G.C. Anderson. 1962. Reproductive rates of copepods in nature and its relation to phytoplankton population. Ecology 43(4):625-634

Environmental Science & Technology, In. (ESE). 1994. The Upper Illinois Waterway Study. Interim Report. 1993 Benthic Macroinvertebrate Investigation and Habitat Assessment RM 272.0-323.0. Prepared for Commonwealth Edison Company, Chicago, IL.

Evans, M.S. 1988. *Bythotrephes cederstroemi*: its new appearance in Lake Michigan. Journal of Great Lakes Research 14(2):234-240.

Freedman, J.A., S.E. Butler, and D.H. Wahl. 2012. Impacts of Invasive Asian Carps on Native Food Webs. Final Project Report. Kaskaskia Biological Station, Illinois Natural History Survey, University of Illinois at Urbana-Champaign. 18pp.

Gibson, G. R. (ed.). 1994. Biological Criteria: Technical guidance for stream and small rivers. USEPA Report 822-B-94.001. Washington, D.C.

Gorman, O.T. and J.R. Karr. 1978. Habitat structure and stream fish communities. Ecology 59:507-515.

Hall, D.J. 1964. An experimental approach to the dynamics of a natural population of Daphnia *galeata mendotae*. Ecology 45(1): 94-112.

Hazleton Environmental Science & Corporation. 1979. Environmental studies of the Des Plaines, Kankakee, and Illinois rivers' near the Dresden Station, January through December, 1977. Annual report to Commonwealth Edison Company, Chicago, IL.

HDR Engineering, Inc. 2011. Presentation of 2010 Aquatic Program Results at Annual Steering Committee Meeting. March 2011.

Jensen, L.D. 1974. Entrainment and intake screening: proceedings of the Second Entrainment and Intake Screening Workshop. Electric Power Research Institute, Palo Alto, CA.

Jensen, L.D. 1978. Fourth National Workshop on Entrainment and Impingement. EA Ecological Analysts, Inc., Sparks, Maryland.

Kasprowicz, J.M., M.J. Wetzel, K.S. Cummings, and W.U. Brigham. 1985. Survey of Kankakee River Fishes and Mussels at Illinois Route 53 Bridge in Wilmington, Will County, Illinois. IDOT Job Number P-91-051-79. Illinois Natural History Survey, Section of Faunistic Surveys and Insect Identification Technical Report 1985(4).

Lu, M., P. Xie, H. Tang, Z. Shao, and L. Xie. 2002. Experimental study of trophic cascade effect of silver carp (Hypophthalmichthys molitrix) in a subtropical lake, Lake Donghu: on plankton community and underlying mechanisms of changes of crustacean community. Hydrobiologia 487(1):19-31.

Ohio Environmental Protection Agency (OEPA). 1987. Biological criteria for the protection of aquatic life: Vol. II. Users manual for biological field assessment of Ohio surface waters. Div. Water Quality Monitoring and Assess., Surface Water Sect. Columbus, OH.

______________. 1989. Biological criteria for the protection of aquatic life: Vol. III. Standardized field and laboratory methods for assessing fish and macroinvertebrate communities. Div. Water Quality Planning and Assess., Ecological Assess. Sect., Columbus, OH.

______________. 2006. Methods for Assessing Habitat in Flowing Waters: Using the Qualitative Habitat Evaluation Index (QHEI). Div. of Surface Water, Groveport, OH.

Pflieger, W. L. 1997. The fishes of Missouri. Missouri Department of Conservation, Jefferson City, MO. 372 pp.

Rankin, E.T. 1989. The qualitative habitat evaluation index (QHEI). Rationale, methods, and applications. Ohio EPA, Div. Water Quality Planning and Assess., Ecological Analysis Sect., Columbus, OH.

Schlosser, I.J. 1982. Fish community structure and function along two habitat gradients in a headwater stream. Ecological Monograph 52:395-414.

Tetra Tech, Inc. 1978. Biological Effects of Once-Through Cooling on the Marine Environments. Prepared for the Utility Water Act Group. June.

U.S. Environmental Protection Agency (USEPA) and Nuclear Regulatory Commission (NRC). 1977. Interagency 316(a) Technical Guidance Manual and Guide for Thermal Effects Sections of Nuclear Facilities Environmental Impact Statements. Office of Water Enforcement, Industrial Permits Branch, Washington, D.C.

U.S. Environmental Protection Agency. 1998. National Strategy for the Development of Regional Nutrient Criteria Office of Water, USEPA EPA-822-F-98-002. Washington, DC.

U.S. Fish and Wildlife Service (USFWS). 2014. Illinois County Distribution: Federally Endangered, Threatened, and Candidate Species. http://www.fws.gov/midwest/endangered/lists/illinois-cty.html. December.

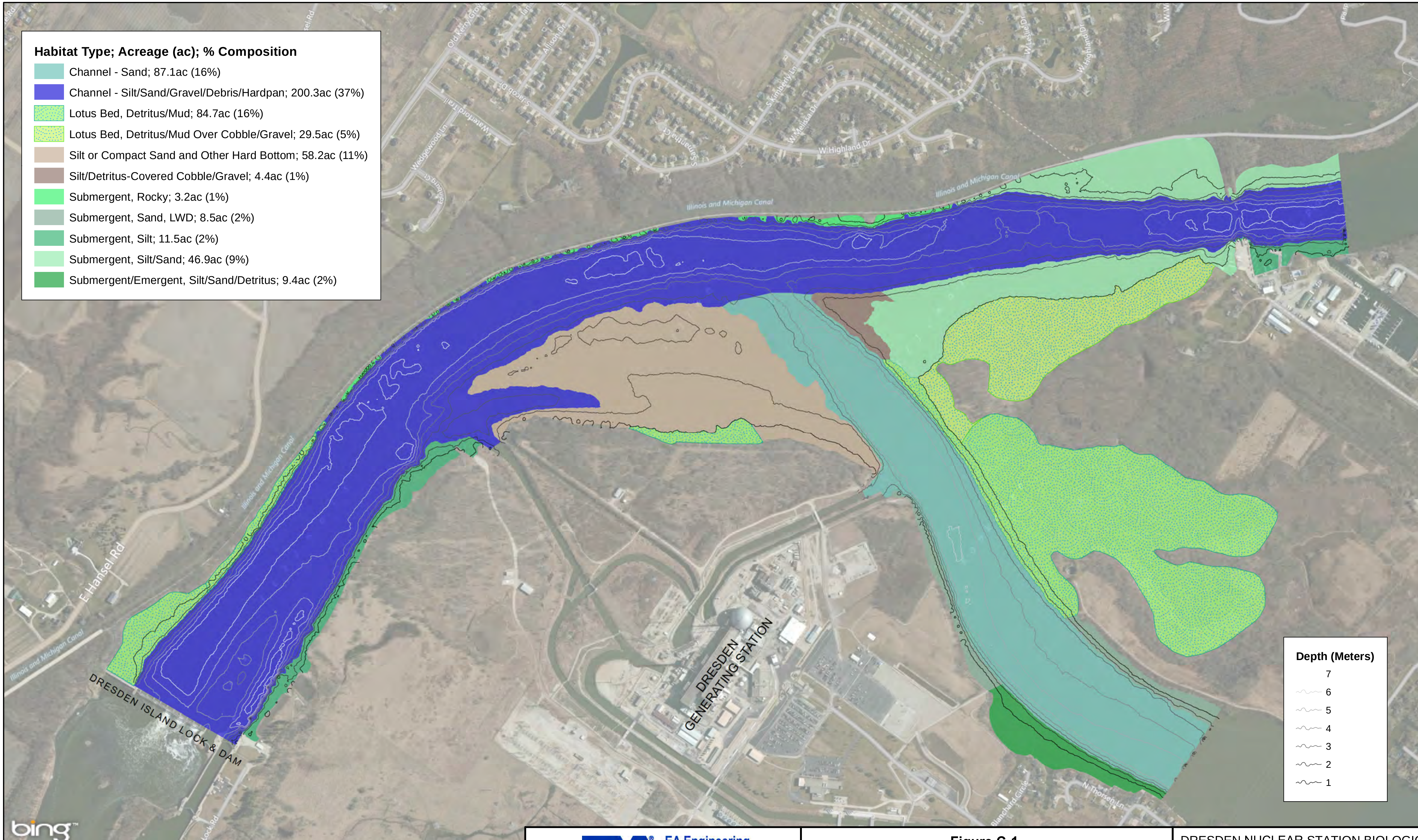
U. S. Geological Survey (USGS). 2013. Nonindigenous Aquatic Species. http://nas.er.usgs.gov/queries/SpeciesList.aspx?Group=Fishes

UWAG. (Utility Water Act Group). 1978. Biological Effects of Once-Through Cooling, Volume 4, Rivers and Reservoirs. Submitted to the U.S. Environmental Protection Agency by the Utility Water Act Group. June.

Vanderploeg, H.A., J.R. Liebig, and M. Omair. 1993. Bythotrephes predation on Great Lakes zooplankton measured by an in situ method: implications for zooplankton community structure. Archiv für Hydrobiologie 127:1-8.

FIGURES

SOURCE: Bing Maps Hybrid ©2010 Microsoft Corporation and its data suppliers



0 800 1,600 2,400 3,200 Feet

EA Engineering, Science, and Technology, Inc.

DRAWN BY	PROJECT NO	DATE
BJO	1500404	12/5/2014

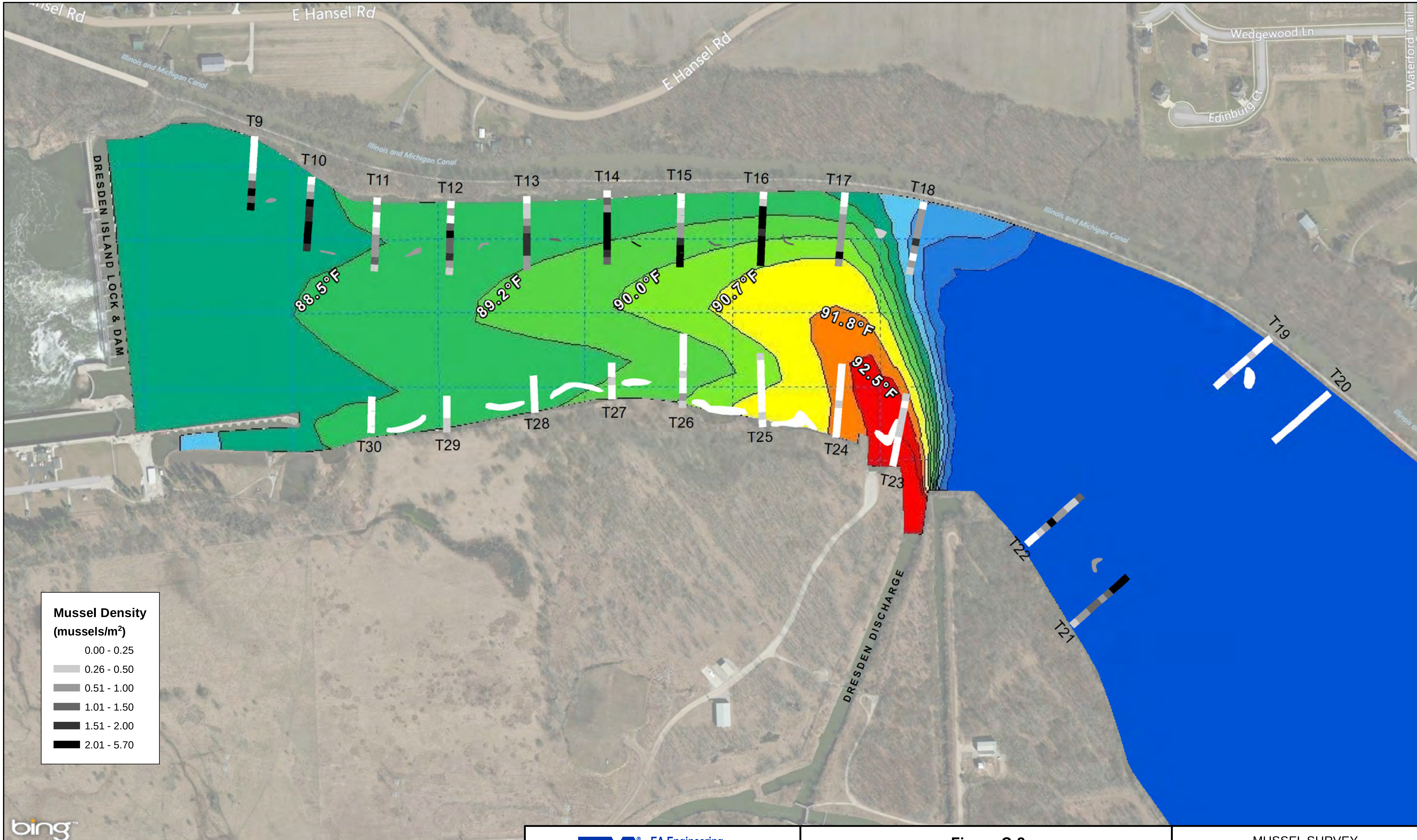
Figure C-1
Distribution of habitat in the Illinois, Des Plaines, and Kankakee Rivers within the area bounded by the hydrothermal model for the DNS cooling water discharge.

DRESDEN NUCLEAR STATION BIOLOGICAL MONITORING: MUSSEL SURVEY GRUNDY COUNTY, ILLINOIS

SCALE	FIGURE
1 inch = 800 feet	1

2014.12.05 C:\Users\bonelli\Desktop\Exelon\Dresden_Biological.mxd EA-Deerfield bonelli

SOURCE: Bing Maps Hybrid ©2010 Microsoft Corporation and its data suppliers



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EA Engineering, Science, and Technology, Inc., PBC

DRAWN BY	PROJECT NO	DATE
BJO	15004.04	1/28/2015

Figure C-2

MUSSEL SURVEY RESULTS AND THERMAL PLUME UNDER MEDIAN JULY RIVER CONDITIONS

MUSSEL SURVEY
DRESDEN GENERATING STATION
GRUNDY COUNTY, ILLINOIS

SCALE	FIGURE
1 inch = 400 feet	

Figure C-3. Cumulative Percentages of Kankakee River Ichthyoplankton Drift, 3 April - 27 August 2005.

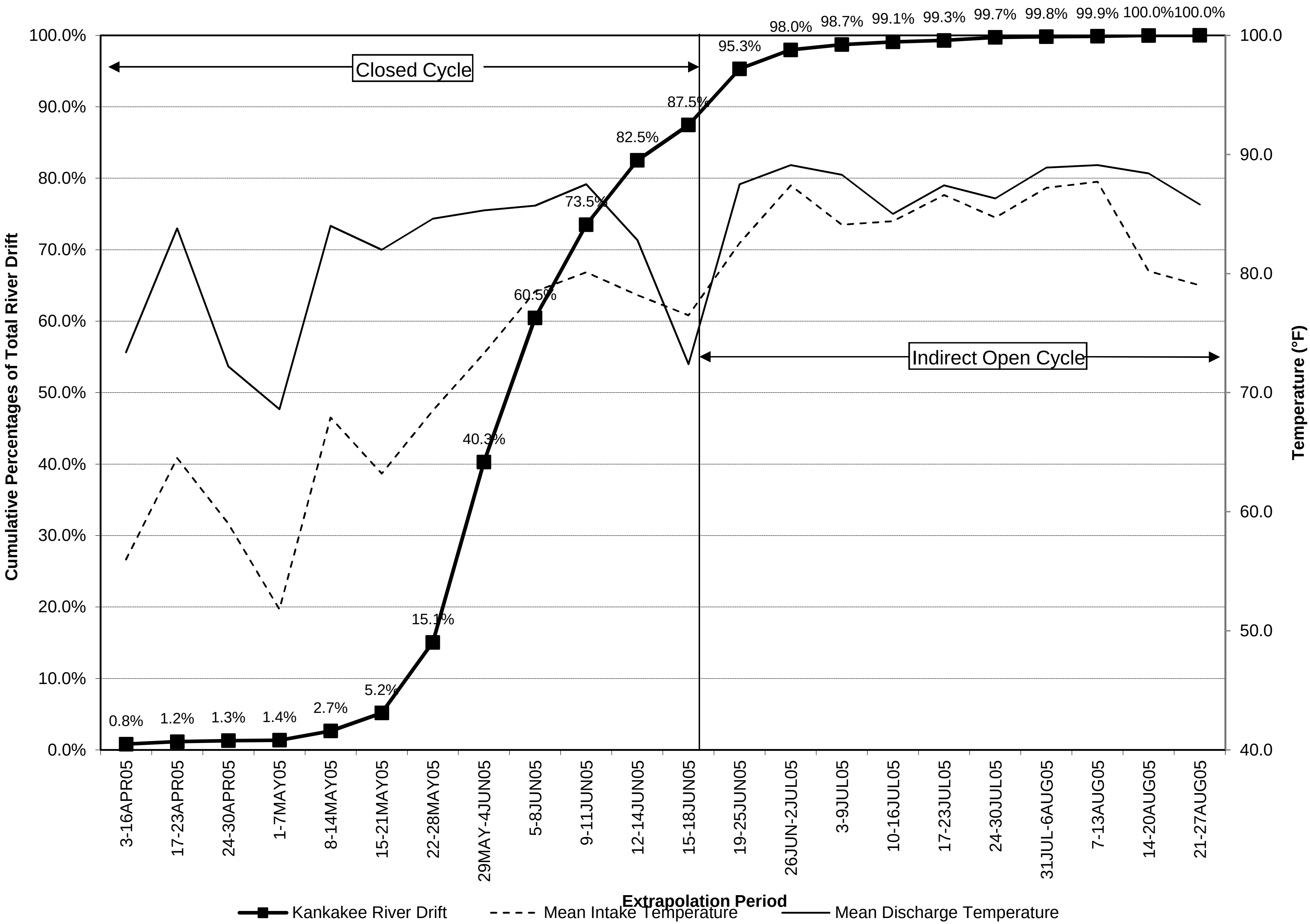


Figure C-4. Cumulative Percentages of Kankakee River Ichthyoplankton Drift, 2 April - 26 August 2006.

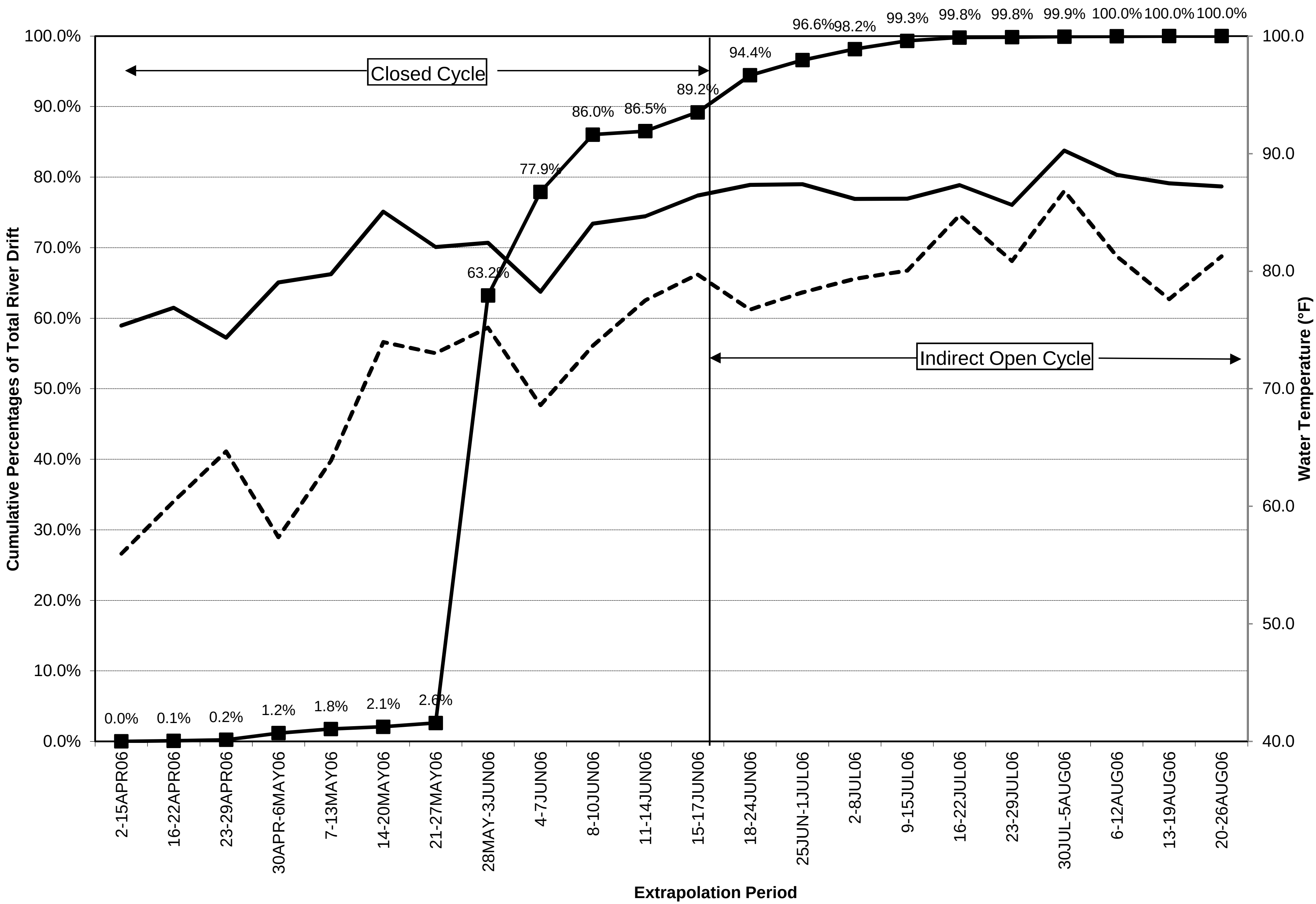


Figure C-5. Mean Number of Native Species in Electrofishing Catches Upstream and Downstream of DNS, 15 June-August, 1999-2014.

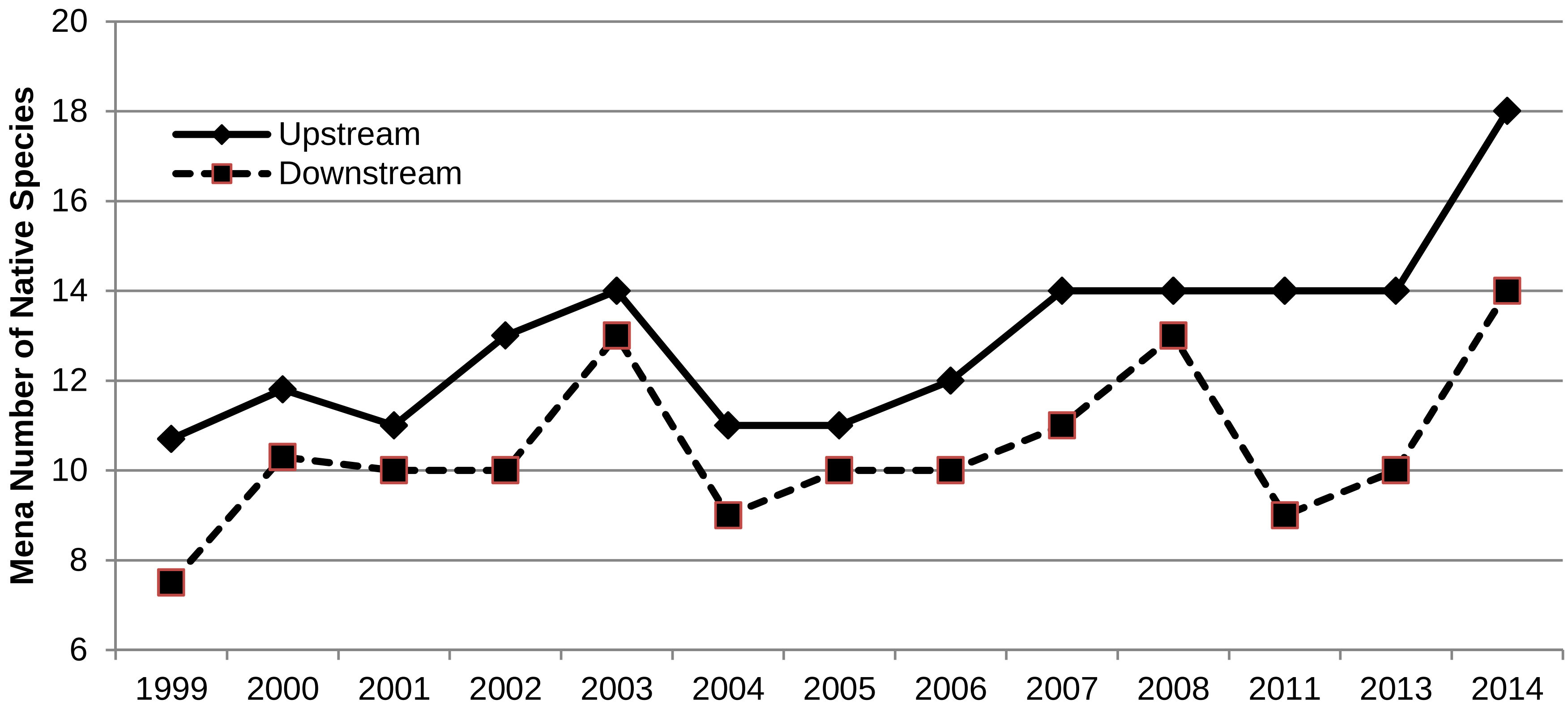


Figure C-6. Summer Total Native Species and RIS Electrofishing Catch Rates from Dresden Pool, 15 June through August, 1994-2014.

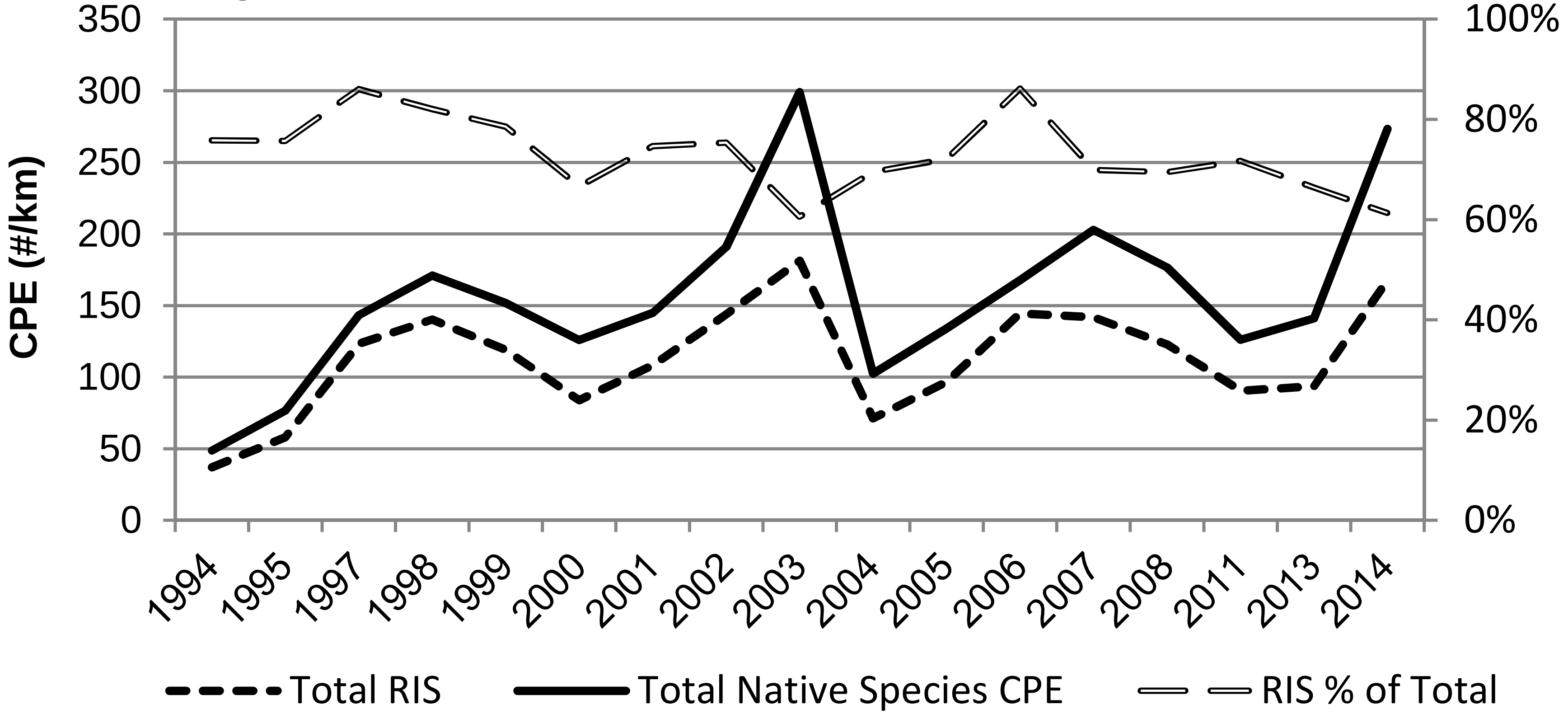
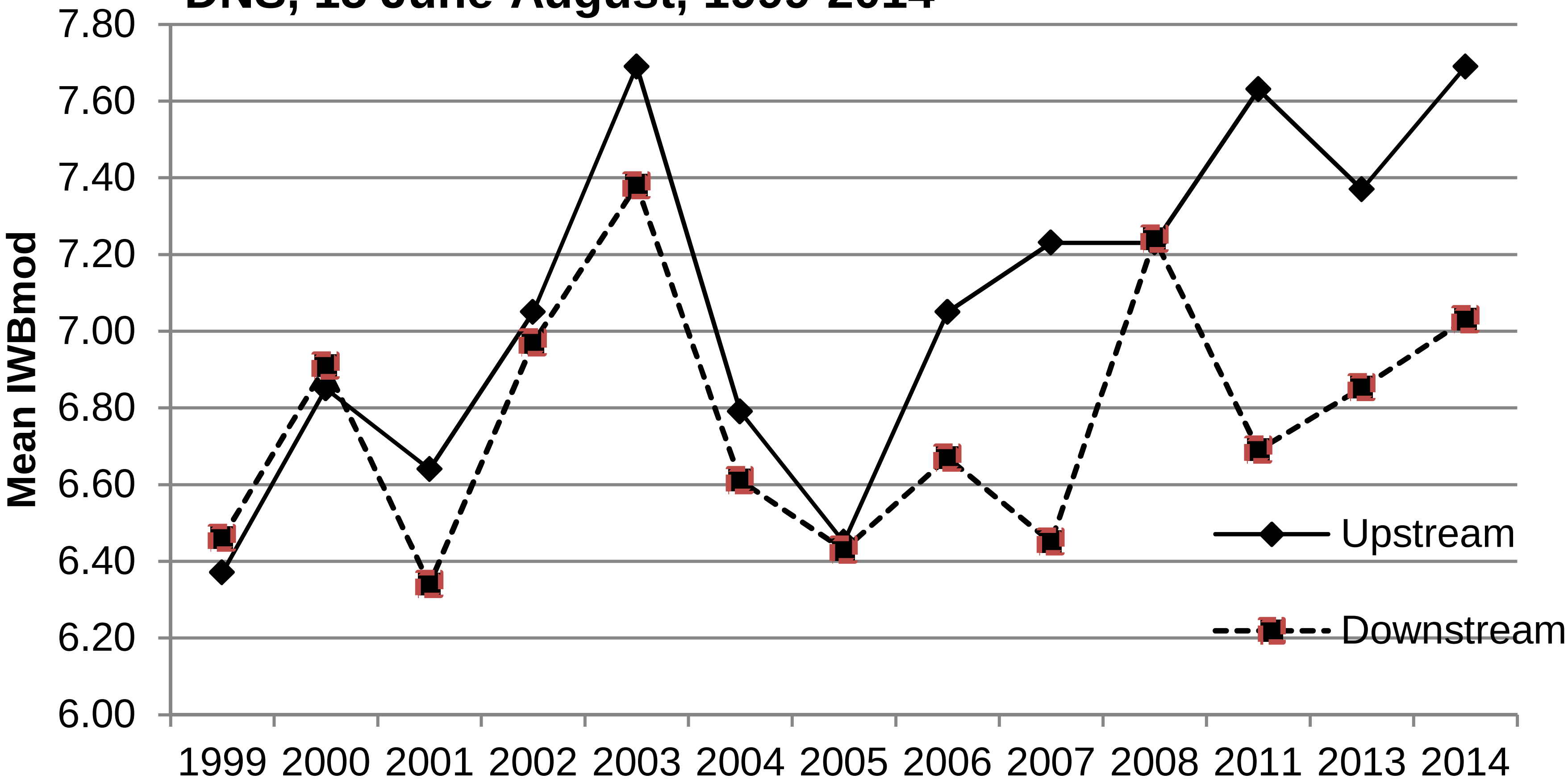


Figure C-7. Mean IWBmod Scores from Electrofishing Catch Data Collected Upstream and Downstream of DNS, 15 June-August, 1999-2014



TABLES

Table C-1. Summary of QHEI Metric Scores for the Dresden Nuclear Station Sampling Stations, July 2014.

Waterbody	Location	Substrate	Cover	Channel	Riparian	Pool/Current	Riffle/Run	Gradient	QHEI Score	Narrative	1993/1994 Mean QHEI Score
Des Plaines River	501	16.00	12.00	9.00	5.00	8.00	0.00	6.00	56.00	Fair	45.00
Kankakee River	502	8.00	11.00	11.00	4.00	8.00	0.00	6.00	48.00	Fair	56.50
Kankakee River	503	1.00	15.00	11.00	8.00	8.00	0.00	6.00	49.00	Fair	58.50
Illinois River	506	16.00	12.00	9.00	3.50	11.00	0.00	6.00	57.50	Fair	64.00
Illinois River	507A	0.00	10.00	9.00	7.50	8.00	0.00	6.00	40.50	Poor	53.00
Illinois River	510	10.50	11.00	9.00	6.00	8.00	0.00	6.00	50.50	Fair	56.00
Illinois River	512	8.00	5.00	9.00	6.50	11.00	0.00	6.00	45.50	Fair	66.50
Illinois River	513	4.00	5.00	9.00	8.00	8.00	0.00	6.00	40.00	Poor	56.00
Illinois River	514	13.00	7.00	9.00	8.00	9.00	0.00	6.00	52.00	Fair	44.50
Illinois River	515	10.00	6.00	9.00	7.00	8.00	0.00	6.00	46.00	Fair	56.30

Table C-2. Summary of QHEI Metric Scores for the Dresden Nuclear Station Sampling Stations, September 2014.

Waterbody	Location	Substrate	Cover	Channel	Riparian	Pool/Current	Riffle/Run	Gradient	QHEI Score	Narrative	1993/1994 Mean QHEI Score
Des Plaines River	501	16.00	12.00	9.00	5.00	8.00	0.00	6.00	56.00	Fair	45.00
Kankakee River	502	7.00	13.00	11.00	4.00	8.00	0.00	6.00	49.00	Fair	56.50
Kankakee River	503	1.00	15.00	11.00	8.00	8.00	0.00	6.00	49.00	Fair	58.50
Illinois River	506	16.00	10.00	9.00	3.50	10.00	0.00	6.00	54.50	Fair	64.00
Illinois River	507A	0.00	10.00	9.00	7.50	8.00	0.00	6.00	40.50	Poor	53.00
Illinois River	510	8.50	10.00	9.00	6.00	8.00	0.00	6.00	47.50	Fair	56.00
Illinois River	512	8.00	5.00	9.00	6.00	12.00	0.00	6.00	46.00	Fair	66.50
Illinois River	513	4.00	11.00	9.00	8.00	10.00	0.00	6.00	48.00	Fair	56.00
Illinois River	514	13.00	9.00	9.00	8.00	10.00	0.00	6.00	55.00	Fair	44.50
Illinois River	515	9.50	10.00	9.00	6.50	10.00	0.00	6.00	51.00	Fair	56.30

Table C-3. Summary of Average QHEI Metric Scores for the Dresden Nuclear Station Sampling Stations, July/September, 2014.

Waterbody	Location	Substrate	Cover	Channel	Riparian	Pool/Current	Riffle/Run	Gradient	QHEI Score	Narrative	1993/1994 Mean QHEI Score
Des Plaines River	501	16.00	12.00	9.00	5.00	8.00	0.00	6.00	56.00	Fair	45.00
Kankakee River	502	7.50	12.00	11.00	4.00	8.00	0.00	6.00	48.50	Fair	56.50
Kankakee River	503	1.00	15.00	11.00	8.00	8.00	0.00	6.00	49.00	Fair	58.50
Illinois River	506	16.00	11.00	9.00	3.50	10.50	0.00	6.00	56.00	Fair	64.00
Illinois River	507A	0.00	10.00	9.00	7.50	8.00	0.00	6.00	40.50	Poor	53.00
Illinois River	510	9.50	10.50	9.00	6.00	8.00	0.00	6.00	49.00	Fair	56.00
Illinois River	512	8.00	5.00	9.00	6.25	11.50	0.00	6.00	45.75	Fair	66.50
Illinois River	513	4.00	8.00	9.00	8.00	9.00	0.00	6.00	44.00	Poor	56.00
Illinois River	514	13.00	8.00	9.00	8.00	9.50	0.00	6.00	53.50	Fair	44.50
Illinois River	515	9.75	8.00	9.00	6.75	9.00	0.00	6.00	48.50	Fair	56.30

Table C-4. Number and Relative Abundance of Ichthyoplankton Collected Near Dresden Nuclear Station, April - August 2005.

Taxa	Life Stage	Kankakee River No.	Kankakee River %	Intake No.	Intake %	Discharge No.	Discharge %	Sites Combined No.	Sites Combined %
UNID CLUPEIDAE type	EGG	11	0.03	--	--	1	0.07	12	0.03
UNID CLUPEIDAE	EGG	1	0.00	--	--	--	--	1	0.00
	YOLK-SAC	83	0.20	--	--	--	--	83	0.18
	POST YOLK-SAC	476	1.13	45	1.68	--	--	521	1.13
	LARVAE	24	0.06	2	0.07	--	--	26	0.06
UNID *ALOSA*	YOLK-SAC	1	0.00	--	--	--	--	1	0.00
	POST YOLK-SAC	1	0.00	--	--	--	--	1	0.00
GIZZARD SHAD	EGG	1	0.00	--	--	--	--	1	0.00
	YOLK-SAC	2,001	4.77	6	0.22	--	--	2,007	4.36
	POST YOLK-SAC	1,415	3.37	157	5.87	--	--	1,572	3.42
	JUVENILE	35	0.08	10	0.37	--	--	45	0.10
	LARVAE	8	0.02	--	--	--	--	8	0.02
THREADFIN SHAD	POST YOLK-SAC	33	0.08	3	0.11	--	--	36	0.08
	JUVENILE	4	0.01	--	--	--	--	4	0.01
COMMON CARP	YOLK-SAC	153	0.36	--	--	5	0.37	158	0.34
	POST YOLK-SAC	36	0.09	23	0.86	--	--	59	0.13
SHOAL CHUB	JUVENILE	1	0.00	--	--	--	--	1	0.00
EMERALD SHINER	JUVENILE	1	0.00	3	0.11	--	--	4	0.01
EMERALD SHINER type	YOLK-SAC	2	0.00	--	--	--	--	2	0.00
	POST YOLK-SAC	8	0.02	--	--	--	--	8	0.02
GHOST SHINER	JUVENILE	13	0.03	--	--	--	--	13	0.03
SPOTTAIL SHINER	JUVENILE	1	0.00	--	--	--	--	1	0.00
BLUNTNOSE MINNOW	JUVENILE	6	0.01	--	--	--	--	6	0.01
CYPRINID GROUP A	YOLK-SAC	450	1.07	120	4.49	65	4.79	635	1.38
	POST YOLK-SAC	101	0.24	33	1.23	11	0.81	145	0.32
	JUVENILE	35	0.08	--	--	--	--	35	0.08
	LARVAE	2	0.00	--	--	1	0.07	3	0.01
UNID CYPRINID	YOLK-SAC	353	0.84	18	0.67	--	--	371	0.81
	POST YOLK-SAC	55	0.13	22	0.82	--	--	77	0.17
	JUVENILE	123	0.29	--	--	--	--	123	0.27
	LARVAE	29	0.07	4	0.15	--	--	33	0.07
CYPRINID/CATOSTOMID type	EGG	3	0.01	1	0.04	291	21.44	295	0.64
UNID *CARPIODES* type	YOLK-SAC	229	0.55	--	--	29	2.14	258	0.56
	POST YOLK-SAC	9	0.02	--	--	--	--	9	0.02
UNID *CARPIODES*	JUVENILE	1	0.00	--	--	--	--	1	0.00
WHITE SUCKER	POST YOLK-SAC	8	0.02	--	--	--	--	8	0.02
NORTHERN HOG SUCKER	JUVENILE	1	0.00	--	--	--	--	1	0.00
UNID *ICTIOBUS*	YOLK-SAC	10	0.02	--	--	--	--	10	0.02
	POST YOLK-SAC	6	0.01	--	--	--	--	6	0.01
UNID ICTIOBINAE	YOLK-SAC	67	0.16	--	--	29	2.14	96	0.21
	POST YOLK-SAC	1	0.00	--	--	--	--	1	0.00
SPOTTED SUCKER	POST YOLK-SAC	4	0.01	--	--	--	--	4	0.01
MOXOSTOMA /NORTHERN HOG SUCKER	YOLK-SAC	4	0.01	--	--	--	--	4	0.01
	POST YOLK-SAC	1	0.00	--	--	--	--	1	0.00
MOXOSTOMA /SPOTTED SUCKER	YOLK-SAC	1	0.00	--	--	--	--	1	0.00
	POST YOLK-SAC	11	0.03	--	--	--	--	11	0.02
	JUVENILE	1	0.00	--	--	--	--	1	0.00
UNID *MOXOSTOMA*	YOLK-SAC	3	0.01	--	--	--	--	3	0.01
	JUVENILE	2	0.00	--	--	--	--	2	0.00
UNID CATOSTOMINAE	POST YOLK-SAC	45	0.11	--	--	--	--	45	0.10
CHANNEL CATFISH	YOLK-SAC	2	0.00	2	0.07	32	2.36	36	0.08
	JUVENILE	184	0.44	7	0.26	27	1.99	218	0.47
TROUT-PERCH	YOLK-SAC	8	0.02	--	--	--	--	8	0.02
	POST YOLK-SAC	1	0.00	--	--	--	--	1	0.00
	JUVENILE	4	0.01	--	--	--	--	4	0.01
BROOK SILVERSIDE	POST YOLK-SAC	1	0.00	--	--	--	--	1	0.00
	JUVENILE	1	0.00	--	--	--	--	1	0.00
WHITE BASS	YOLK-SAC	26	0.06	--	--	--	--	26	0.06

Table C-4 (Continued)

Taxa	Life Stage	Kankakee River No.	Kankakee River %	Intake No.	Intake %	Discharge No.	Discharge %	Sites Combined No.	Sites Combined %
ROCK BASS	POST YOLK-SAC	1	0.00	--	--	--	--	1	0.00
UNID *LEPOMIS*	YOLK-SAC	72	0.17	85	3.18	159	11.72	316	0.69
	POST YOLK-SAC	1,190	2.84	410	15.34	639	47.09	2,239	4.87
	JUVENILE	159	0.38	66	2.47	7	0.52	232	0.50
	LARVAE	1	0.00	--	--	2	0.15	3	0.01
LARGEMOUTH BASS	JUVENILE	2	0.00	--	--	--	--	2	0.00
BLACK CRAPPIE	POST YOLK-SAC	1	0.00	--	--	--	--	1	0.00
UNID *POMOXIS*	YOLK-SAC	3	0.01	2	0.07	--	--	5	0.01
	POST YOLK-SAC	13	0.03	--	--	--	--	13	0.03
JOHNNY DARTER type	POST YOLK-SAC	1	0.00	--	--	--	--	1	0.00
	JUVENILE	6	0.01	--	--	--	--	6	0.01
YELLOW PERCH	YOLK-SAC	1	0.00	--	--	--	--	1	0.00
LOGPERCH	POST YOLK-SAC	1	0.00	--	--	--	--	1	0.00
	JUVENILE	21	0.05	--	--	--	--	21	0.05
SLENDERHEAD DARTER	POST YOLK-SAC	4	0.01	--	--	--	--	4	0.01
	JUVENILE	5	0.01	--	--	--	--	5	0.01
PERCINA type	YOLK-SAC	143	0.34	--	--	--	--	143	0.31
	POST YOLK-SAC	234	0.56	2	0.07	--	--	236	0.51
	LARVAE	1	0.00	--	--	--	--	1	0.00
WALLEYE	YOLK-SAC	6	0.01	--	--	--	--	6	0.01
UNID DARTERS	YOLK-SAC	32	0.08	1	0.04	--	--	33	0.07
	POST YOLK-SAC	32	0.08	1	0.04	--	--	33	0.07
	JUVENILE	3	0.01	--	--	--	--	3	0.01
	LARVAE	1	0.00	--	--	--	--	1	0.00
FRESHWATER DRUM	EGG	31,474	75.01	1,451	54.28	22	1.62	32,947	71.64
	YOLK-SAC	1,817	4.33	104	3.89	21	1.55	1,942	4.22
	POST YOLK-SAC	4	0.01	2	0.07	--	--	6	0.01
ROUND GOBY	YOLK-SAC	1	0.00	1	0.04	--	--	2	0.00
	JUVENILE	204	0.49	12	0.45	--	--	216	0.47
	LARVAE	3	0.01	--	--	--	--	3	0.01
UNIDENTIFIED	EGG	397	0.95	79	2.96	13	0.96	489	1.06
	LARVAE	27	0.06	1	0.04	3	0.22	31	0.07
Total Ichthyoplankton		41,957	100.00	2,673	100.00	1,357	100.00	45,987	100.00
Total Taxa		30		11		6		30	

Note: 0.00 denotes values less than 0.005.

Table C-5. Number and Relative Abundance of Ichthyoplankton Collected Near Dresden Nuclear Station, April - August 2006.

Taxa	Life Stage	Kankakee River		Intake		Discharge		Sites Combined	
		No.	%	No.	%	No.	%	No.	%
UNID CLUPEIDAE	YOLK-SAC	4	0.01	1	0.02	--	--	5	0.01
	POST YOLK-SAC	111	0.25	42	1.01	1	0.14	154	0.31
	LARVAE	47	0.11	29	0.70	1	0.14	77	0.16
UNID *ALOSA*	YOLK-SAC	1	0.00	1	0.02	--	--	2	0.00
GIZZARD SHAD	YOLK-SAC	645	1.46	105	2.52	1	0.14	751	1.54
	POST YOLK-SAC	1,056	2.40	215	5.15	13	1.88	1,284	2.63
	JUVENILE	16	0.04	3	0.07	--	--	19	0.04
	LARVAE	31	0.07	28	0.67	--	--	59	0.12
THREADFIN SHAD	POST YOLK-SAC	39	0.09	12	0.29	--	--	51	0.10
	LARVAE	--	--	1	0.02	--	--	1	0.00
UNID *DOROSOMA*	YOLK-SAC	1	0.00	--	--	--	--	1	0.00
	POST YOLK-SAC	1	0.00	2	0.05	--	--	3	0.01
UNID *ESOX*	POST YOLK-SAC	1	0.00	--	--	--	--	1	0.00
CENTRAL STONEROLLER type	POST YOLK-SAC	2	0.00	--	--	--	--	2	0.00
COMMON CARP	EGG	3	0.01	--	--	--	--	3	0.01
	YOLK-SAC	123	0.28	3	0.07	3	0.43	129	0.26
	POST YOLK-SAC	4	0.01	2	0.05	1	0.14	7	0.01
	LARVAE	1	0.00	--	--	1	0.14	2	0.00
EMERALD SHINER	JUVENILE	1	0.00	--	--	--	--	1	0.00
GHOST SHINER	JUVENILE	2	0.00	--	--	--	--	2	0.00
BLUNTNOSE MINNOW	JUVENILE	1	0.00	--	--	--	--	1	0.00
UNID *PIMEPHALES*	JUVENILE	1	0.00	--	--	--	--	1	0.00
CREEK CHUB type	YOLK-SAC	1	0.00	--	--	--	--	1	0.00
CYPRINID GROUP A	YOLK-SAC	191	0.43	56	1.34	79	11.43	326	0.67
	POST YOLK-SAC	41	0.09	15	0.36	25	3.62	81	0.17
	JUVENILE	--	--	--	--	1	0.14	1	0.00
	LARVAE	9	0.02	--	--	1	0.14	10	0.02
UNID CYPRINID	YOLK-SAC	121	0.27	122	2.92	--	--	243	0.50
	POST YOLK-SAC	228	0.52	180	4.31	--	--	408	0.83
	JUVENILE	7	0.02	--	--	--	--	7	0.01
	LARVAE	26	0.06	40	0.96	4	0.58	70	0.14
CYPRINID/CATOSTOMID type	EGG	28	0.06	13	0.31	194	28.08	235	0.48
QUILLBACK	YOLK-SAC	1	0.00	--	--	--	--	1	0.00
UNID *CARPIODES*	YOLK-SAC	7,570	17.19	2	0.05	139	20.12	7,711	15.77
	POST YOLK-SAC	2	0.00	1	0.02	1	0.14	4	0.01
	LARVAE	2	0.00	--	--	5	0.72	7	0.01
UNID *ICTIOBUS*	YOLK-SAC	2	0.00	--	--	--	--	2	0.00
	POST YOLK-SAC	2	0.00	--	--	--	--	2	0.00
SPOTTED SUCKER	POST YOLK-SAC	3	0.01	--	--	--	--	3	0.01
GOLDEN REDHORSE	JUVENILE	1	0.00	--	--	--	--	1	0.00
MOXOSTOMA /NORTHERN HOG SUCKER	YOLK-SAC	9	0.02	--	--	--	--	9	0.02
	POST YOLK-SAC	6	0.01	2	0.05	--	--	8	0.02
MOXOSTOMA /SPOTTED SUCKER	YOLK-SAC	1	0.00	--	--	--	--	1	0.00
	POST YOLK-SAC	1	0.00	--	--	--	--	1	0.00
UNID *MOXOSTOMA*	YOLK-SAC	24	0.05	--	--	--	--	24	0.05
	POST YOLK-SAC	1	0.00	--	--	--	--	1	0.00
UNID CATOSTOMINAE	YOLK-SAC	2	0.00	--	--	--	--	2	0.00
	POST YOLK-SAC	9	0.02	--	--	--	--	9	0.02
	LARVAE	1	0.00	--	--	--	--	1	0.00
UNID ICTIOBINAE	EGG	--	--	--	--	23	3.33	23	0.05
	YOLK-SAC	208	0.47	--	--	2	0.29	210	0.43
	POST YOLK-SAC	2	0.00	--	--	--	--	2	0.00
	LARVAE	6	0.01	--	--	--	--	6	0.01
UNID CATOSTOMID	POST YOLK-SAC	--	--	1	0.02	--	--	1	0.00
	LARVAE	1	0.00	--	--	--	--	1	0.00
CHANNEL CATFISH	JUVENILE	24	0.05	10	0.24	34	4.92	68	0.14
UNID *NOTURUS*	JUVENILE	2	0.00	1	0.02	1	0.14	4	0.01
FLATHEAD CATFISH	JUVENILE	2	0.00	--	--	--	--	2	0.00

TableC-5 (Continued)

Taxa	Life Stage	Kankakee River No.	Kankakee River %	Intake No.	Intake %	Discharge No.	Discharge %	Sites Combined No.	Sites Combined %
PIRATE PERCH	POST YOLK-SAC	2	0.00	--	--	--	--	2	0.00
BROOK SILVERSIDE	POST YOLK-SAC	--	--	1	0.02	--	--	1	0.00
UNID SILVERSIDE	YOLK-SAC	1	0.00	--	--	--	--	1	0.00
WHITE BASS	YOLK-SAC	48	0.11	--	--	--	--	48	0.10
YELLOW BASS	YOLK-SAC	1	0.00	1	0.02	--	--	2	0.00
ROCK BASS	POST YOLK-SAC	4	0.01	--	--	--	--	4	0.01
UNID *LEPOMIS*	YOLK-SAC	28	0.06	16	0.38	37	5.35	81	0.17
	POST YOLK-SAC	251	0.57	105	2.52	70	10.13	426	0.87
	LARVAE	1	0.00	4	0.10	1	0.14	6	0.01
UNID *POMOXIS*	POST YOLK-SAC	5	0.01	--	--	--	--	5	0.01
UNID *ETHEOSTOMA*	YOLK-SAC	12	0.03	--	--	--	--	12	0.02
	POST YOLK-SAC	2	0.00	--	--	--	--	2	0.00
PERCINA type	YOLK-SAC	123	0.28	--	--	--	--	123	0.25
	POST YOLK-SAC	54	0.12	19	0.46	--	--	73	0.15
	LARVAE	4	0.01	--	--	--	--	4	0.01
UNID *PERCINA*	POST YOLK-SAC	1	0.00	--	--	--	--	1	0.00
WALLEYE	YOLK-SAC	1	0.00	--	--	--	--	1	0.00
	POST YOLK-SAC	1	0.00	--	--	--	--	1	0.00
UNID DARTERS	YOLK-SAC	91	0.21	4	0.10	--	--	95	0.19
	POST YOLK-SAC	196	0.45	34	0.81	--	--	230	0.47
	LARVAE	1	0.00	--	--	--	--	1	0.00
FRESHWATER DRUM	EGG	31,523	71.57	2,862	68.60	4	0.58	34,389	70.32
	YOLK-SAC	659	1.50	123	2.95	7	1.01	789	1.61
	POST YOLK-SAC	1	0.00	--	--	8	1.16	9	0.02
	LARVAE	56	0.13	50	1.20	--	--	106	0.22
ROUND GOBY	YOLK-SAC	4	0.01	--	--	--	--	4	0.01
	JUVENILE	28	0.06	1	0.02	--	--	29	0.06
UNIDENTIFIED	EGG	295	0.67	55	1.32	32	4.63	382	0.78
	YOLK-SAC	1	0.00	--	--	--	--	1	0.00
	LARVAE	24	0.05	10	0.24	2	0.29	36	0.07
Total Ichthyoplankton		44,043	100.00	4,172	100.00	691	100.00	48,906	100.00
Total Taxa		29		16		9		29	

Note: 0.00 denotes values less than 0.005.

Table C-6. Checklist of Fish Species Collected near Dresden Nuclear Station from Dresden Pool and Downstream of Dresden Island Lock and Dam (DDD), 1991-2014.

Common Name	Scientific Name	Number of Years Collected	
		Dresden Pool[1]	DDD[2]
SPOTTED GAR	*Lepisosteus oculatus*	--	1
LONGNOSE GAR	*Lepisosteus osseus*	17	17
SHORTNOSE GAR	*Lepisosteus platostomus*	2	5
SKIPJACK HERRING	*Alosa chrysochloris*	17	14
GIZZARD SHAD	*Dorosoma cepedianum*	20	18
THREADFIN SHAD	*Dorosoma petenense*	13	13
GOLDEYE	*Hiodon alosoides*	6	5
MOONEYE	*Hiodon tergisus*	--	1
RAINBOW SMELT	*Osmerus mordax*	--	1
CHINOOK SALMON	*Oncorhynchus tshawytscha*	1	--
NORTHERN PIKE	*Esox lucius*	4	3
GRASS PICKEREL	*Esox niger*	5	2
CENTRAL STONEROLLER	*Campostoma anomalum*	13	4
GOLDFISH	*Carassius auratus*	6	4
GRASS CARP	*Ctenopharyngodon idella*	1	3
RED SHINER	*Cyprinella lutrensis*	8	9
SPOTFIN SHINER	*Cyprinella spiloptera*	20	18
COMMON CARP	*Cyprinus carpio*	20	18
SHOAL CHUB	*Macrhybopsis hyostoma*	--	2
SILVER CHUB	*Macrhybopsis storeriana*	--	2
SILVERJAW MINNOW	*Notropis buccatus*	1	--
HORNYHEAD CHUB	*Nocomis biguttatus*	10	3
GOLDEN SHINER	*Notemigonus crysoleucas*	15	5
PALLID SHINER	*Hybopsis amnis*	11	5
SILVER CARP	*Hypophthalmichthys molitrix*	1	2
EMERALD SHINER	*Notropis atherinoides*	20	18
GHOST SHINER	*Notropis buchanani*	16	14
STRIPED SHINER	*Luxilus chrysocephalus*	20	12
REDFIN SHINER	*Lythrurus umbratilis*	12	7
SPOTTAIL SHINER	*Notropis hudsonius*	20	17
ROSYFACE SHINER	*Notropis rubellus*	5	6
SAND SHINER	*Notropis stramineus*	19	18
MIMIC SHINER	*Notropis volucellus*	13	15
PUGNOSE MINNOW	*Opsopoeodus emiliae*	1	--
CHANNEL SHINER	*Notropis wickliffi*	1	--
SUCKERMOUTH MINNOW	*Phenacobius mirabilis*	6	4
BLUNTNOSE MINNOW	*Pimephales notatus*	20	18
FATHEAD MINNOW	*Pimephales promelas*	5	5
BULLHEAD MINNOW	*Pimephales vigilax*	20	18
CREEK CHUB	*Semotilus atromaculatus*	1	1

Table C-6 (Continued)

Common Name	Scientific Name	Number of Years Collected	
		Dresden Pool	DDD
RIVER CARPSUCKER	*Carpiodes carpio*	20	17
QUILLBACK	*Carpiodes cyprinus*	19	17
HIGHFIN CARPSUCKER	*Carpiodes velifer*	2	5
WHITE SUCKER	*Catostomus commersonii*	8	4
NORTHERN HOG SUCKER	*Hypentelium nigricans*	5	8
SMALLMOUTH BUFFALO	*Ictiobus bubalus*	20	1
BIGMOUTH BUFFALO	*Ictiobus cyprinellus*	5	5
BLACK BUFFALO	*Ictiobus niger*	10	5
SPOTTED SUCKER	*Minytrema melanops*	8	--
SILVER REDHORSE	*Moxostoma anisurum*	18	17
RIVER REDHORSE	*Moxostoma carinatum*	5	6
BLACK REDHORSE	*Moxostoma duquesnei*	1	1
GOLDEN REDHORSE	*Moxostoma erythrurum*	20	18
SHORTHEAD REDHORSE	*Moxostoma macrolepidotum*	20	18
GREATER REDHORSE	*Moxostoma valenciennesi*	1	3
BLACK BULLHEAD	*Ameiurus melas*	1	1
YELLOW BULLHEAD	*Ameiurus natalis*	9	1
CHANNEL CATFISH	*Ictalurus punctatus*	20	18
STONECAT	*Noturus flavus*	1	--
TADPOLE MADTOM	*Noturus gyrinus*	5	1
FLATHEAD CATFISH	*Pylodictis olivaris*	18	10
TROUT-PERCH	*Percopsis omiscomaycus*	13	5
BANDED KILLIFISH	*Fundulus diaphanus*	2	1
BLACKSTRIPE TOPMINNOW	*Fundulus notatus*	13	11
WESTERN MOSQUITOFISH	*Gambusia affinis*	4	11
BROOK SILVERSIDE	*Labidesthes sicculus*	20	17
WHITE PERCH	*Morone americana*	5	10
WHITE BASS	*Morone chrysops*	12	15
YELLOW BASS	*Morone mississippiensis*	5	8
STRIPED BASS	*Morone saxatilis*	1	2
ROCK BASS	*Ambloplites rupestris*	20	7
GREEN SUNFISH	*Lepomis cyanellus*	20	18
PUMPKINSEED	*Lepomis gibbosus*	9	3
WARMOUTH	*Lepomis gulosus*	7	--
ORANGESPOTTED SUNFISH	*Lepomis humilis*	20	16
BLUEGILL	*Lepomis macrochirus*	20	18
REDEAR SUNFISH	*Lepomis microlophus*	5	--
NORTHERN SUNFISH	*Lepomis peltastes*	19	15
SMALLMOUTH BASS	*Micropterus dolomieu*	20	18
LARGEMOUTH BASS	*Micropterus salmoides*	20	18
WHITE CRAPPIE	*Pomoxis annularis*	9	10
BLACK CRAPPIE	*Pomoxis nigromaculatus*	19	15
WESTERN SAND DARTER	*Ammocrypta clara*	--	3
RAINBOW DARTER	*Etheostoma caeruleum*	2	--
BLUNTNOSE DARTER	*Etheostoma chlorosoma*	1	--

Table C-6 (Continued)

Common Name	Scientific Name	Number of Years Collected	
		Dresden Pool	DDD
JOHNNY DARTER	*Etheostoma nigrum*	17	8
BANDED DARTER	*Etheostoma zonale*	5	3
YELLOW PERCH	*Perca flavescens*	3	1
LOGPERCH	*Percina caprodes*	20	18
BLACKSIDE DARTER	*Percina maculata*	8	3
SLENDERHEAD DARTER	*Percina phoxocephala*	15	10
RIVER DARTER	*Percina shumardi*	--	1
SAUGER	*Sander canadensis*	--	4
WALLEYE	*Sander vitreus*	12	7
FRESHWATER DRUM	*Aplodinotus grunniens*	20	18
ROUND GOBY	*Neogobius melanostomus*	9	6
TOTAL SPECIES		**88**	**86**

[1]Surveys in Dresden Pool conducted 20 years from 1991 through 2014.

[2]Surveys in downstream of Dresden Island Lock and Dam conducted 18 years from 1991 through 2014.

Table C-7. Results of Statistical Comparisons Among Years for Electrofishing Data Collected From Dresden Pool for the Period of 15 June through August, 1994, 1995, 1997-2008, 2011, 2013, and 2014.

Catch Parameter	2014	2013	2011	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998	1997	1995	1994	Significant Difference[a]	F Value	P Value
CPEs-all native fish[b]	273.3	141.1	126.2	176.7	202.9	167.7	133.9	102.4	299.0	191.0	145.0	125.9	151.7	170.9	143.2	76.6	47.8	Yes	4.22	<0.01
	A	AB	AB	AB	A	AB	AB	AB	A	AB	AB	AB	AB	AB	AB	BC	C[c]			
IWBmod[d]	7.24	6.98	6.92	7.14	6.63	6.76	6.46	6.65	7.45	7.00	6.36	6.88	6.09	6.51	6.83	6.31	5.30	Yes	4.65	<0.01
	AB	AB	ABCD	AB	ABCD	ABCD	ABCD	ABCD	A	ABC	BCD	ABC	CD	ABCD	ABC	BCD	D			
Native Species Richness[d]	15.3	10.7	10.2	12.6	11.6	10.2	9.9	9.6	12.6	10.8	9.7	11.0	8.4	10.2	10.6	9.2	7.1	Yes	4.26	<0.01
	A	ABC	BC	AB	AB	BC	BC	BC	AB	ABC	BC	ABC	BC	ABC	ABC	BC	C			

(a) Results of one-factor parametric Analysis of Variance tests (alpha=0.05).
(b) Log transformed data used for statistical analyses because they are normally distributed.
(c) Results of Tukey's Studentized Range Test; values with the same letters are not significantly different (alpha=0.05).
(d) Data ranks used for statistical analyses because raw data and log transformed data are not normally distributed.

Table C-8 Inter-Year comparisons of Dresden Pool Summer (15 June through August) RIS Electrofishing Catch Rates (#/km), 1994-2014.

RIS	1994	1995	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2011	2013	2014
Gizzard shad	11.9	25.1	42	54	58.4	26.4	45.7	45.8	61.6	23.6	48.9	47.6	56.1	50.9	33.8	27.3	100.9
Common carp	3.7	5.2	4	2.8	1.9	1.9	2.1	1.4	1.2	0.9	1.6	1.5	2.1	2.5	1.5	2.6	2.6
Emerald shiner	1.5	--	42.8	46.5	23	3	28.5	48.8	16	3.6	7.2	39.6	37.3	12	3	1.3	4.8
White sucker	--	0.2	--	0.1	--	--	--	--	--	--	--	--	--	--	--	--	--
Golden redhorse	0.2	10.2	4.1	4.3	1.2	4.3	1	5.5	12.4	4.8	1.5	5.7	6.5	7.9	2.8	0.9	1.4
Channel catfish	1.5	1.9	2.8	0.6	0.4	3.6	2.1	3	3.8	3	3	2.2	1.7	1.7	2.4	2.2	1.6
Bluegill	1.5	3.7	13.1	18.2	24	33.2	18	26.8	57.1	21.2	18.6	33	20.2	28.9	28.1	38.1	11.6
Smallmouth bass	4.1	5.6	6.4	5.8	3.4	4.3	2.9	4.7	11.1	5.7	3	3.6	3.9	7.4	3	3.9	5.6
Largemouth bass	2.6	2.8	4.1	3.7	6.1	4.6	6.2	5	11.7	6.3	11.2	9.3	11.1	9.2	14.7	13.6	28.7
black crappie	0.2	0.2	0.1	--	--	--	--	0.1	--	--	0.1	--	--	--	--	--	0.2
Logperch	0.2	0.4	0.6	2.3	0.6	1.6	0.6	0.4	0.9	0.2	0.8	0.6	1.6	1.6	0.4	2.6	8.8
Freshwater drum	9.5	2.6	3.2	1.8	0.1	1	1.4	2.4	5.3	1.9	0.7	1.5	1.3	0.8	0.6	1.3	1.6

Table C-9. Statistical Results Among Years for Electrofishing Data Collected Downstream of Dresden Island Lock and Dam During the Period of 15 June through August, 1994, 1995, 1999-2008, 2011, 2013, and 2014.

Catch Parameter	2014	2013	2011	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1995	1994	Significant Difference[a]	F Value	P Value
CPEs-all native fish[b]	195.3	90.0	99.0	170.8	340.5	141.3	206.3	176.0	196.3	247.5	152.8	105.5	118.0	242.5	86.0	No	1.37	0.19
IWBmod[c]	7.56	7.14	7.49	7.46	7.17	7.22	7.25	7.11	7.93	7.94	7.10	6.73	6.92	7.75	7.26	No	1.39	0.17
Native Species Richness	17.5 A	13.0 BCD	14.5 ABCD	15.5 AB	14.4 ABCD	12.9 BCD	14.6 ABCD	11.6 BCD	14.9 ABCD	15.1 ABC	13.9 ABCD	11.8 BCD	11.2 D	14.3 ABCD	11.5 CD[d]	Yes	1.85	0.04

(a) Results of one-factor parametric Analysis of Variance tests (alpha=0.05).
(b) Log transformed data used for statistical analyses because they are normally distributed.
(c) Data ranks used for statistical analyses because raw data and log transformed data are not normally distributed.
(d) Results of Fisher's Least-Squares-Difference Test; values with the same letters are not significantly different (alpha=0.05).

Table C-10. Annual Mean Relative Weights (*Wr*) for Selected Species Collected from Dresden Pool, 15 June-August, 1994-2014.

RIS	1994	1995	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2011	2013	2014	Years Combined
Species Combined	106	107	109	107	108	100	106	112	100	96	106	104	106	105	108	99	104	104
REPRESENTATIVE IMPORTANT SPECIES																		
Gizzard shad	--	112	108	101	104	90	102	114	87	88	100	96	97	100	101	85	--	97
Channel catfish	119	103	99	98	100	97	100	103	100	98	101	106	99	108	103	99	98	102
Bluegill	99	113	116	112	110	102	111	113	104	100	111	116	108	108	115	109	110	108
Smallmouth bass	93	95	91	88	90	86	95	104	90	89	98	96	95	97	90	82	95	93
Largemouth bass	100	104	105	100	99	97	108	104	99	95	108	103	106	104	107	97	103	103
Freshwater drum	114	109	114	115	--	113	108	104	103	102	109	98	102	106	98	98	98	106
CATOSTOMIDAE																		
River carpsucker	88	94	100	79	102	--	86	103	--	116	90	92	94	98	97	92	97	94
Smallmouth buffalo	88	90	92	88	87	86	87	90	88	82	85	84	87	85	84	91	90	87
Bigmouth buffalo	--	--	97	--	--	--	--	--	--	--	--	--	--	--	--	--	106	101
Shorthead redhorse	98	102	94	83	103	80	98	97	89	--	--	87	--	93	104	93	--	95

Table C-11. Annual Mean Relative Weights (*Wr*) for Selected Species Collected Downstream of Dresden Island Lock & Dam, 15 June-August 1994-2014.

RIS	1994	1995	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2011	2013	2014	Years Combined
Species Combined	96	98	106	95	97	103	96	96	101	106	100	102	97	99	100	99
REPRESENTATIVE IMPORTANT SPECIES																
Gizzard shad	95	97	109	84	96	94	80	79	89	81	85	97	81	82	92	91
Channel catfish	106	101	104	102	100	101	95	98	100	102	95	97	97	93	101	99
Bluegill	--	125	106	104	103	119	106	101	108	124	107	108	111	107	111	109
Smallmouth bass	91	96	85	82	80	88	84	85	101	106	92	97	83	85	92	90
Largemouth bass	107	93	100	98	102	106	99	97	108	100	99	102	102	96	99	101
Freshwater drum	103	108	107	104	99	109	103	101	111	105	105	104	98	90	103	105
CATOSTOMIDAE																
River carpsucker	91	100	90	93	88	96	95	85	93	88	96	99	--	84	105	93
Smallmouth buffalo	87	95	89	77	84	85	87	81	92	87	82	87	87	82	82	85
Shorthead redhorse	91	77	106	--	92	93	83	93	96	94	91	94	84	89	101	91