TVA

Tennessee Valley Authority, 1101 Market Street, Chattanooga, Tennessee 37402

CNL-16-075

April 22, 2016

10 CFR 50.90

ATTN: Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Browns Ferry Nuclear Plant, Units 1, 2, and 3
Renewed Facility Operating License Nos. DPR-33, DPR-52, and DPR-68
NRC Docket Nos. 50-259, 50-260, and 50-296

Subject: **Proposed Technical Specifications (TS) Change TS-505 - Request for License Amendments - Extended Power Uprate (EPU) - Supplement 13, Responses to Requests for Additional Information**

References:

1. Letter from TVA to NRC, CNL-15-169, "Proposed Technical Specifications (TS) Change TS-505 - Request for License Amendments - Extended Power Uprate (EPU)," dated September 21, 2015 (ML15282A152)

2. Letter from NRC to TVA, "Browns Ferry Nuclear Plant, Units 1, 2, and 3 - Request for Additional Information Related to License Amendment Request Regarding Extended Power Uprate (CAC Nos. MF6741, MF6742, and MF6743)," dated April 4, 2016 (ML16064A286)

By the Reference 1 letter, Tennessee Valley Authority (TVA) submitted a license amendment request (LAR) for the Extended Power Uprate (EPU) of Browns Ferry Nuclear Plant (BFN) Units 1, 2 and 3. The proposed LAR modifies the renewed operating licenses to increase the maximum authorized core thermal power level from the current licensed thermal power of 3458 megawatts to 3952 megawatts. During their technical review of the LAR, the Nuclear Regulatory Commission (NRC) identified the need for additional information. The Reference 2 letter provided NRC Requests for Additional Information (RAI) related to the environmental review of the BFN EPU LAR. The due date for the responses to the NRC RAIs provided by the Reference 2 letter is April 22, 2016. The enclosure to this letter provides the responses to the RAIs included in the Reference 2 letter, with the exception of the responses to NRC RAIs RERP-GE-RAI 2 and

A001
NRR

RERP-GE-RAI 4. NRC RAIs RERP-GE-RAI 2 and RERP-GE-RAI 4 involve providing environmental information associated with transmission system upgrades. However, due to changes in the modifications associated with these transmission system upgrades, the due date for the responses to NRC RAIs RERP-GE-RAI 2 and RERP-GE-RAI 4 was extended to May 27, 2016, per communication with the NRC Project Manager.

TVA has reviewed the information supporting a finding of no significant hazards consideration and the environmental consideration provided to the NRC in the Reference 1 letter. The supplemental information provided in this submittal does not affect the bases for concluding that the proposed license amendment does not involve a significant hazards consideration. In addition, the supplemental information in this submittal does not affect the bases for concluding that neither an environmental impact statement nor an environmental assessment needs to be prepared in connection with the proposed license amendment. Additionally, in accordance with 10 CFR 50.91(b)(1), TVA is sending a copy of this letter to the Alabama State Department of Public Health.

There are no new regulatory commitments associated with this submittal. If there are any questions or if additional information is needed, please contact Mr. Edward D. Schrull at (423) 751-3850.

I declare under penalty of perjury that the foregoing is true and correct. Executed on the 22nd day of April 2016.

Respectfully,

J.W. Shea

J. W. Shea
Vice President, Nuclear Licensing

Enclosure: Responses to NRC Requests for Additional Information Related to the Browns Ferry Nuclear Plant Extended Power Uprate Environmental Review

cc:

NRC Regional Administrator - Region II
NRC Senior Resident Inspector - Browns Ferry Nuclear Plant
State Health Officer, Alabama Department of Public Health

ENCLOSURE

Responses to NRC Requests for Additional Information Related to Browns Ferry Nuclear Plant Extended Power Uprate Environmental Review

Enclosure Contains Responses to the Following Environmental Review RAIs

General (GE)

RERP-GE-RAI 1

RERP-GE-RAI 3

Visual Resources (VR)

RERP-VR-RAI 1

Noise (NO)

RERP-NO-RAI 1

Surface Water Resources (SW)

RERP-SW-RAI 1 (includes Attachment 1)

RERP-SW-RAI 2 (includes Attachments 2 and 3)

RERP-SW-RAI 3

RERP-SW-RAI 4

RERP-SW-RAI 5 (includes Attachment 4)

RERP-SW-RAI 6 (includes Attachments 5 and 6)

Aquatic Resources (AQ)

RERP-AQ-RAI 1

RERP-AQ-RAI 2 (includes Attachments 7 through 12)

Protected Species and Habitats (PS)

RERP-PS-RAI 1

ENCLOSURE

RERP-GE-RAI 1

The NRC issued a final Environmental Assessment (EA) and Finding of No Significant Impact (FONSI) related to the BFN, Units 1, 2, and 3 previously proposed extended power uprate (EPU) LARs in February 2007 (ADAMS Accession No. ML070190246). Describe any new and significant information regarding an impact on the human environment because of the currently proposed EPU LAR dated September 21, 2015, and its supplements. Also, describe any environmental impact that has arisen since the publication of the final EA and FONSI in February 2007.

TVA Response:

New and significant information related to the proposed Browns Ferry Nuclear Plant (BFN) extended power uprate (EPU) since the NRC publication of the environmental assessment (EA) and finding of no significant impact (FONSI) is described below.

- Hydrothermal conditions: TVA updated the hydrothermal analysis on September 21, 2015, in the BFN EPU License Amendment Request (LAR), Attachment 42, Supplemental Environmental Report, Section 7.2.3, Impact on Discharge.
- Cooling Towers: TVA replaced all but two of the original cooling towers, and constructed one additional new cooling tower. As described in the BFN EPU LAR, Attachment 42, Supplemental Environmental Report, Section 2.2, Related Power Uprate Submittals and NEPA Documentation, TVA prepared EAs for the cooling tower replacements and construction of the new cooling tower and issued associated FONSIs.
- Transmission System Upgrades: TVA transmission system upgrades will be required for EPU that are not discussed in, or bounded by, the assessment documented in the BFN EPU LAR, Attachment 42, Supplemental Environmental Report. The environmental information associated with these upgrades will be provided in response to RERP-GE-RAI-2.

ENCLOSURE

RERP-GE-RAI 3

On page 12 of the Interconnection System Impact Study, TVA estimates that transmission-related upgrades and modifications would be completed 7 to 10 years after TVA receives authorization to begin work. Given this timeline and assuming the EPU is approved, would BFN be able to operate at EPU levels prior to the transmission upgrades being completed? If not, please provide revised estimates of when each unit would begin operating at EPU levels, included revisions to the EPU outage schedules, if applicable.

TVA Response:

a. The interconnection system impact study (SIS) identified six breaker failure relays requiring upgrade. Installation of relay upgrades will not preclude or delay the BFN operating at EPU conditions. All six relays will be replaced prior to the first unit uprate (Unit 3) in the Spring of 2018. Therefore, the relay replacement schedule will not affect the EPU schedule.

b. The SIS determined that the TVA transmission system would require incremental installation of 774 mega volt amp reactive (MVAR) capacitor banks in four locations throughout the TVA transmission system. The proposed locations are the Clayton Village Substation located in Oktibbeha County Mississippi, Holly Springs Substation located in Marshall County Mississippi, Corinth Substation located in Alcorn County Mississippi, and the Wilson Substation located in Wilson County Tennessee. The preliminary estimated completion of the final capacitor bank is Spring of 2019. TVA Transmission Operation and Power Supply does not preclude BFN operating at EPU levels during the capacitor bank installations. Therefore, the MVAR capacitor bank installation schedule will not affect the EPU schedule.

c. The SIS determined that the TVA transmission system would require a new 500 kV transmission line to support the EPU of all three BFN units. The new line mitigates a transient stability issue that could arise if a 3-phase fault develops while one of the four 500 kV lines specified in the SIS is out of service and BFN is operating at EPU conditions. Until the new transmission line is constructed, TVA will issue a detailed temporary operating guide to eliminate these issues during 500 kV line outages; otherwise, BFN will operate at EPU levels. Therefore, the new transmission line construction schedule will not affect the EPU schedule.

ENCLOSURE

RERP-VR-RAI 1

The NRC's 2005 final supplemental environmental impact statement (SEIS) for license renewal of BFN (ADAMS Accession No. ML051730443) describes the BFN viewshed as the following: "There are no homes within foreground viewing distance to the north and east. Adjacent to the site however, is a small residential development located to the northwest. Another residential development is located across Wheeler Reservoir to the southwest, and the Mallard Creek public use area is directly across the reservoir. These developments have at least partial views of the plant site. A berm, graded during the initial construction of the plant and containing approximately 2.5 million cubic meter (3.3 million cubic yard) of earth excavated to make cooling water channels, lies adjacent to the cooling tower complex and blocks views of the northern and eastern plant area (TVA 2003a)."

Confirm that this description continues to accurately depict the BFN viewshed.

TVA Response:

This description of the viewshed has changed since the 2005 final supplemental environmental impact statement (SEIS). The first three sentences remain correct as written, however the remainder of the quote requires some modification.

In 2012, a larger but architecturally similar cooling tower (CT 7) was constructed north of the original six CTs. Construction of CT 7, required relocation of part of the berm to the north side of CT 7 where it continues to block views of the northern and eastern plant area. In addition, a portion of Shaw Road near the entrance to the BFN was relocated to facilitate construction of CT 7. Portions of CTs 1 through 6, and CT 7 continue to be visible to motorists traveling on Shaw Road. Construction of CT 7 and relocation of Shaw Road altered the viewscape such that the view on this stretch of road is now dominated by CT 7. Because the viewscape is similar, the direct, indirect, and cumulative effects on the viewshed are insignificant. The paragraph from the NRC's 2005 supplemental environmental impact statement should be revised for use in the BFN extended power uprate environmental assessment as follows.

> "There are no homes within foreground viewing distance to the north and east. Adjacent to the site however, is a small residential development located to the northwest. Another residential development is located across Wheeler Reservoir to the southwest, and the Mallard Creek public use area is directly across the reservoir. These developments have at least partial views of the plant site. Two earthen berms lie adjacent to the cooling tower complex. These berms block views of the northern and eastern plant areas. The berms, as well as portions of the cooling tower complex, are visible to motorists traveling on Shaw Road."

ENCLOSURE

RERP-NO-RAI 1

Section 7.1.5 of the Supplemental Environmental Report (ER) summarizes a 2012 environmental sound pressure level assessment that found the ambient noise level in the Paradise Shores community located 1,500 feet from the BFN property boundary to be 59.7 decibels in the absence of cooling tower operation and 61.9 decibels with six cooling towers in operation. Previously, a 2001 background noise survey (described on page 8 of NRC's 2007 Final EA and page 2-67 (Section 2.2.8.4) of NRC's 2005 license renewal SEIS) found that the noise level in the Paradise Shores community with six cooling towers operating was 52 decibels. Explain the increase in background noise levels between the 2001 and 2011 assessments.

TVA Response:

A number of factors may account for differences in the background noise levels between the 2001 and the 2012 noise surveys. Background noise surveys were taken in the Paradise Shores residential community in June 2001 without cooling towers operating, and again in July 2001 with three cooling towers in operation. The BFN cooling tower contribution to the background noise was estimated to be 1 to 2 decibels (dBA). Noise surveys were again taken in the Paradise Shores residential community in August 2012 with six cooling towers in service, and again in September 2012 without cooling towers operating. The BFN cooling tower contribution to the background noise was estimated to be 2.2 decibels. The NRC final supplemental environmental impact statement (SEIS), June 2005, states that the dominant contributors to the background noise were traffic, lawn mowers, home air conditioners, fauna (insects and frogs), and family activities. It should be noted that the data collection represents a single 24-hour period for each date. The background noise level in these surveys is influenced by several factors that can vary significantly from day to day, season to season, and year to year. Specific differences between the 2001 and 2012 surveys, and the effect of those differences, cannot be quantified. The general differences in local conditions between the 2001 and 2012 surveys are described below.

- The Paradise Shores residential community has undergone some demographic changes. According to 2000 and 2010 census profile information, the number of housing units increased from 56 to 72. The number of households increased from 39 to 46 and the total population increased from 93 to 101. The change in the demographics results in changes in the number of operating air conditioning units, automobiles, lawn mowers, boats, and other noise generating devices.
- The July 2001 survey was conducted with three cooling towers actually in service. The September 2012 survey was conducted with six cooling towers actually in service.
- There are seasonal variations between the two surveys. The 2001 surveys were conducted entirely in the summer months. The 2012 surveys began in the summer and were concluded in the fall. Fauna, flora, agricultural equipment use, social activities, river activities (recreational and commercial), and traffic patterns are some factors that exhibit seasonal variation. The specific day(s) of the week when the 2001 survey data was collected are not known, however the day of the week also influences traffic patterns, lawn mower use, and river activities.
- Weather factors also influence background noise level. Specifically, wind velocity and rain would affect noise generation while wind direction, wind gradient, air temperature, and relative humidity would affect noise propagation. However, the meteorological conditions on the dates of data collection for either survey year were not documented.

ENCLOSURE

RERP-SW-RAI 1

TVA indicates in Sections 7.1.6 and 7.2.3 of the Supplemental ER that the proposed EPU would not increase temperature or flow rates of discharged water beyond permitted National Pollutant Discharge Elimination System (NPDES) limits. Clarify whether implementation of the EPU will change the volume or quality of effluents discharged to the Tennessee River, including usage of cooling water treatment chemicals. If so, quantify the changes in discharge characteristics and specify whether an NPDES permit modification will be required or whether notification to Alabama Department of Environmental Management (ADEM) has been made. Additionally, provide relevant documentation of correspondence to/from the State.

TVA Response:

Most of the water withdrawn at the plant intake is returned to the river. As noted in the BFN EPU license amendment request (LAR), Attachment 42, Supplemental Environmental Report, Section 7.2.3, Impact on Discharge, water losses from evaporation and drift will occur for the condenser circulating water (CCW) system when cooling towers are in operation (helper mode). For other systems, water loss would be comparatively negligible, unquantifiable amounts. Operating at EPU conditions will not change the CCW flow entering and leaving the main condenser. In the open mode of operation, essentially all of the water that enters the forebay is subsequently discharged back to the Tennessee River. Therefore, EPU operation does not affect the volume of water discharged to the Tennessee River in the open mode of operation. Operating at EPU conditions is expected to increase the number of days that the cooling towers are operated in the helper mode by about 22 days per year. Therefore, for an average of 22 additional days per year, BFN discharge volume to the Tennessee River will be reduced due to cooling tower evaporation and drift. No modification is required for the Alabama Department of Environmental Management (ADEM), National Pollutant Discharge Elimination (NPDES) permit.

Page Att 42-46 of the BFN EPU LAR, Attachment 42, Section 7.2.3, Impact on Discharge, states "For years with warm summers, the number of days of helper mode operation, on the average, is expected to increase by about 13 days at 120 percent [original licensed thermal power (OLTP)] as compared to 105 percent OLTP." Table 7.2-3, Summary of BFN Hydrothermal Impacts for Warm, Summer Meteorology, under Helper Mode Operation, indicates the model predicted average number of days of cooling tower operation per year for 105 percent OLTP and 120 percent OLTP to be 66 days and 89 days respectively. The change from 105 percent OLTP to 120 percent OLTP is given as +13 days. These numbers contain a typographical error and a mathematical error. The actual model predicted average number of days of cooling tower operation at 120 percent OLTP is 88 days resulting in a change of +22 days. See the Attachment 1 mark-up for changes to BFN EPU LAR, Attachment 42, Supplemental Environmental Report, Section 7.2.3, Impact on Discharge, and Table 7.2-3, Summary of BFN Hydrothermal Impacts for Warm, Summer Meteorology.

As noted in the BFN EPU LAR, Attachment 42, Supplemental Environmental Report, Table 7.2-3, both the Diffuser Discharge Temperature, Flow-Weighted and the Temperature at Downstream End of Mixing Zone at Compliance Depth will change under EPU conditions. These changes however, remain within the temperature limitations contained in the NPDES Permit for the plant and will not require a modification to the NPDES permit.

The types, frequency, and amounts of cooling water treatment chemicals used in the raw water chemical treatment system are not affected by EPU. The hydrothermal impact on water quality is discussed in detail in the BFN EPU LAR, Attachment 42, Section 7.2.3, Impact on Discharge.

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There will be no change in the volume or quality of effluents discharged to the Tennessee River associated with the EPU. All monitored effluents will remain within current NPDES limits. Operation at EPU will not affect the water quality discharge to the Tennessee River. An NPDES permit modification is not required and notification to the ADEM is not required. Because no changes to the NPDES permit have been identified, there is no applicable correspondence to/from the State of Alabama.

ENCLOSURE

RERP-SW-RAI 2

Please provide a copy of BFN's current ADEM-issued NPDES permit and most recent NPDES permit renewal application.

TVA Response:

The BFN NPDES permit issued by the ADEM, dated July 3, 2012 is included as Attachment 2. The most recent BFN permit renewal application from March 2011 is provided as Attachment 3 of this response. Development of the BFN 2017 NPDES permit renewal application will begin during the summer of 2016.

Table 7.2-3: Summary of BFN Hydrothermal Impacts for Warm, Summer Meteorology

Parameter [(1)]		0% OLTP [(2)]	105% OLTP	120% OLTP	Change 105%→120% OLTP
Water Temperature (°F)					
Ambient River Temperature at Compliance Depth	Average	66.5	66.5	66.5	0
	Hourly Max	94.3	94.3	94.3	0
	Hourly Min	37.6	37.6	37.6	0
	24-hr Avg Max	91.5	91.5	91.5	0
	24-hr Avg Min	38.4	38.4	38.4	0
Diffuser Discharge Temperature, Flow-Weighted	Average	NA [(4)]	86.9	89.5	+2.6 F°
	Hourly Max	NA	112.5	117.2	+4.7 F°
	Hourly Min	NA	60.3	58.0	-2.3 F°
	24-hr Avg Max	NA	107.1	110.5	+3.5 F°
	24-hr Avg Min	NA	60.8	64.3	+3.5 F°
Temperature at Downstream End of Mixing Zone at Compliance Depth	Average	66.5 [(3)]	70.8	71.4	+0.6 F°
	Hourly Max	94.3 [(3)]	92.1	92.0	-0.1 F°
	Hourly Min	37.6 [(3)]	39.8	40.3	+0.5 F°
	24-hr Avg Max	91.5 [(3)]	89.4	89.3	-0.1 F°
	24-hr Avg Min	38.4 [(3)]	40.4	41.2	+0.8 F°
Helper Mode Operation					
Max No. days of cooling tower operation per year		NA	82	121	+39
Avg No. days of cooling tower operation per year		NA	66	~~89~~ 88	~~+13~~ +22
Hydrothermal Derate Operation					
Percent of Summers with Derates		NA	1 in 6	1 in 6	unchanged
Max No. Hours of Derate for Summers with Derate		NA	185	207	+28
Max Derate MWH for Summers with Derate		NA	81065	101850	+20785
Avg Derate MWe for Summers with Derate		NA	438	492	54
Changes in Net Generation (10^6 MWH)					
Maximum Annual Net Generation		NA	29.6	34.5	+4.9
Minimum Annual Net Generation		NA	29.2	34.1	+4.9
Average Annual Net Generation		NA	29.4	34.3	+4.9

Notes:
1. Based on simulations with historical hydrology and meteorology for years 2007-2012.
2. 0% OLTP = no withdrawal from or discharge to the river from BFN.
3. Value assumed to be the same as ambient (i.e., neglects any heat exchange between the reservoir and the atmosphere/riverbed in the reach between the ambient measurement at TRM 297.8 and the downstream end of mixing zone at TRM 293.5).

NA=not applicable.

For the simulations summarized herein, the results at 105 percent OLTP assume the configuration of cooling towers is the same as that summarized in Table 7.2-1. Results at 120 percent OLTP assume that CTs 1 and 2 are replaced with new cooling towers with design characteristics the same as those for CT 5.

Presented in Table 7.2-3 are the results comparing plant operation at 120 percent OLTP with plant operation at 105 percent OLTP. The table includes four sections: the first summarizes impacts on water temperature, the second summarizes impacts on helper mode operation (i.e., cooling tower operation), the third and fourth summarize impacts on plant electrical generation (i.e., derates and net generation). Notable observations include the following:

- For years with warm summers, the temperature of water exiting the diffusers at 120 percent OLTP, on the average, will be about 2.6 F° warmer than the temperature of water at 105 percent OLTP. For the maximum hourly value, as well as the maximum 24-hour average value, the model results imply a change in the temperature of water exiting the diffusers of 4.7 F° warmer and 3.4 F° warmer, respectively.
- For years with warm summers, the temperature of the river at the compliance depth at the downstream end of the mixing zone at 120 percent OLTP, on the average, will be about 0.6 F° warmer than the temperature at 105 percent OLTP. For the maximum hourly value, as well as the maximum 24-hour average value, the model results imply very subtle changes in the temperature of the river at the compliance depth at the downstream end of the mixing zone (only 0.1 F° cooler). This primarily is due to additional helper mode operation.
- For years with warm summers, the number of days of helper mode operation, on the average, is expected to increase by about ~~13~~ 22 days at 120 percent OLTP as compared to 105 percent OLTP. At 120 percent OLTP, the most extreme years are expected to include about 121 days of helper mode operation.
- For years with warm summers the number of summers containing derates is expected to remain at 1 in 6 at EPU conditions. For warm summers containing derates, the maximum number of hours of derate per year is expected to increase by about 28 at 120 percent OLTP with a maximum overall increase in annual hydrothermal derate energy loss of about 20,785 MWh. In derate events, the average amount of derate power loss is expected to increase by about 54 MW at 120 percent OLTP.
- The average annual net generation with the uprate from 105 percent OLTP to 120 percent OLTP is expected to increase by about 4.9×10^6 MWh.

At both 105 percent and 120 percent OLTP, the derate predictions summarized in Table 7.2-3 occurred only for 2010, the warmest summer of record (see Figure 7.2-1). Other notable observations from the hydrothermal simulations include the following:

- In helper mode operation, the model results indicate a water loss due to cooling tower evaporation of about 2.7 percent of the cooling tower flow on average. Berger (1995) suggests that manufacturers strive to limit cooling tower drift to about 0.2 percent of the flow. Thus, during helper mode operation, the combined loss due to evaporation and drift is expected to be roughly 3 percent of the cooling tower flow. If all seven cooling towers

ATTACHMENT 1

Markup of Changes to BFN EPU LAR
Attachment 42, Supplemental Environmental Report

ENCLOSURE

References

1. Letter from United States Department of the Interior Fish and Wildlife Service to TVA, "Browns Ferry Nuclear Plant - Proposed Extended Power Uprate - Updated list of threatened and endangered species that may occur in your proposed project location, and/or may be affected by your proposed project," dated February 1, 2016 (ML16032A044).

2. Ortmann 1925. The American Midland Naturalist, Volume IX, Number 7, The Naiad-Fauna of the Tennessee River System Below Walden Gorge; dated March 1925.

p. Fleshy-fruit gladecress (*Leavenworthia crassa*):
Fleshy-fruit gladecress (*Leavenworthia crassa*) has a narrow global range and is currently known from seven locations in Lawrence and Morgan County, Alabama. The nearest occurrence is approximately 8 miles southwest of the BFN site. While native habitat for the species consists of limestone glades and other areas with thin soils and limestone outcrops, fleshy-fruit glade cress can also persist in areas of disturbed soil adjacent to suitable native habitat. Limestone glade habitat does not occur on or adjacent to the BFN site and proposed BFN EPU project areas where work would occur do not receive the type of disturbance necessary to support a population of the species. The proposed BFN EPU would have no effect on fleshy-fruit gladecress.

q. Kral's water-plantain (*Sagittaria secundifolia*):
Kral's water-plantain (*Sagittaria secundifolia*) is a diminutive, perennial that grows in cracks of bedrock located in stream channels with shallow water. Extant populations are only known from the Little River drainage of northeast Alabama and northwest Georgia, the Sipsey Fork of the Black Warrior River, and Hatchet Creek. The nearest population of Kral's water-plantain is located in Winston County, Alabama, over 35 miles south - southwest of the BFN site. No suitable habitat occurs on or near the BFN site and the species would not be affected by the proposed BFN EPU project.

r. Leafy prairie-clover (*Dalea foliosa*):
Leafy prairie-clover (*Dalea foliosa*) occurs in high quality barren remnants and in wet, limestone glades. The nearest populations of leafy prairie-clover are more than 20 miles to the south and west of the BFN site. Construction, operation, and maintenance of the BFN has drastically altered the physical landscape on-site. The highly-disturbed, anthropogenic plant communities currently on the BFN site are not capable of supporting leafy prairie-clover. The species would not be affected by the proposed BFN EPU project.

s. Lyrate bladderpod (*Lesquerella lyrata*):
Lyrate bladderpod (*Lesquerella lyrata*) occurs in association with limestone glades. The species has only been documented south of the Tennessee River. The nearest extant populations of lyrate bladderpod are about 25 miles southwest of the BFN site. Suitable habitat does not occur on or adjacent to the BFN site and lyrate bladderpod would not be affected by the proposed BFN EPU project.

t. Price's potato-bean (*Apios priceana*):
Price's potato-bean (*Apios priceana*) requires plant habitats that are found relatively frequently on the landscape. Rich forested slopes and forest edges underlain by limestone are not uncommon, but those habitats are not found on the BFN site. Price's potato-bean does not occur at the BFN site and would not be affected by the proposed BFN EPU project.

u. Flattened musk turtle (*Sternotherus depressus*):
Flattened musk turtles are restricted to the Black Warrior River drainage. They are found above the Fall Line (the juncture of the coastal plain and upland provinces) within the Black Warrior River Basin. This species appears to prefer large creeks or small rivers where vegetation grows in shallow areas. Pools within these bodies of water typically have an abundance of submerged rocks where crevices are plentiful. The BFN site is not located in the Black Warrior River drainage, therefore no habitat for this species would be affected by the proposed BFN EPU project. Flattened musk turtles would not be affected by the proposed BFN EPU project.

USFWS final DCH for this species does not overlap with the potential action area of the proposed BFN EPU project. Therefore, the proposed BFN EPU project would not affect DCH for the triangular kidneyshell.

l. Alabama streak-sorus fern (*Thelypteris pilosa var. alabamensis*):
The Alabama streak-sorus fern is a rare endemic restricted to semi-shaded crevices of sandstone rock faces along a 4.25 miles section of the Sipsey Fork. The nearest known extant occurrence of Alabama streak-sorus fern is about 35 miles south - southwest of BFN. The highly specialized habitat required by this fern does not occur on or near the BFN site and the proposed BFN EPU would have no effect on the species.

m. Boulder darter (*Etheostoma wapiti*):
The boulder darter was federally listed on September 1, 1988, along with a non-essential, experimental population designated between Shoal Creek miles 41.7 and 14. This small fish inhabits streams and medium rivers with moderate to high gradient in areas with boulder/rubble substrate. The closest records of this species to the BFN site are well upstream of the mainstem Tennessee River in the Elk River and Shoal Creek tributaries. Given the lack of evidence that the boulder darter inhabits the Tennessee River, particularly near the BFN site, TVA has concluded that it would not occur at the BFN site and, thus, would not be affected by the proposed BFN EPU project. The USFWS has not published DCH for the boulder darter, therefore, the proposed BFN EPU would not affect DCH for this species.

n. Rush darter (*Etheostoma phytophilum*):
The rush darter was federally listed as endangered on August 9, 2011. The biology of this small fish species is not well-known, but is likely similar to the goldstripe darter. It lives along the benthic (bottom) habitat of springs and spring-fed streams with very shallow depths. This species is known only in Etowah, Jefferson, and Winston Counties in Alabama, which fall within the upper Mobile River basin. Because the rush darter does not occur in the Tennessee River basin, and no habitat for this species occurs in the BFN EPU project area, the proposed BFN EPU project would not affect this species. The USFWS final DCH for this species does not overlap with the potential action area of the proposed BFN EPU project. Therefore, the proposed BFN EPU project would not affect DCH for the rush darter.

o. Slackwater darter (*Etheostoma boschungi*):
The slackwater darter was federally listed as threatened on October 11, 1977. It is known only in streams in Lauderdale, Limestone, and Madison Counties within the Alabama portion of its range. This small fish species is a benthic (bottom) dweller in low to moderate grade creeks and small to medium-sized streams, where it utilizes various habitats and aquatic vegetation for spawning habitat. While it is known in Swan Creek, a tributary to the Tennessee River (Wheeler Reservoir), this species has not been found in the mainstem Tennessee River. Given the lack of appropriate habitat and lack of records in the Tennessee River near BFN, TVA has concluded that the slackwater darter would not be found in the BFN EPU project area or affected by the proposed BFN EPU project. The USFWS final DCH for this species does not overlap with the potential action area of the proposed BFN EPU project. Therefore, the proposed BFN EPU project would not affect DCH for the slackwater darter.

River basin and is not found near the BFN site. TVA has determined that the proposed BFN EPU project would have no effect on the orangenacre mucket. The USFWS final DCH for this species does not overlap with the potential action area of the proposed BFN EPU project. Therefore, the propose BFN EPU project would not affect DCH for the orangenacre mucket.

h. Ovate clubshell (*Pleurobema perovatum*):
The ovate clubshell was federally listed on March 17, 1993. This small to medium sized freshwater mussel inhabits sand/gravel mixtures of shoal and run habitat in large streams and small rivers. Its range falls completely within streams of the Mobile River basin and does not exist within the Tennessee River basin. Therefore, the ovate clubshell is not found near the BFN site and would not be affected by the proposed BFN EPU project. The USFWS final DCH for this species does not overlap with the potential action area of the proposed BFN EPU project. Therefore, the proposed BFN EPU project would not affect DCH for the ovate clubshell.

i. Sheepnose mussel (*Plethobasus cyphyus*):
The sheepnose was federally listed as endangered on April 12, 2012. This medium-sized freshwater mussel is typically found in low to moderate gradient reaches of medium and large rivers. It occurs throughout much of the Mississippi River basin, including portions of the Tennessee River. The sheepnose is currently found in the riverine portions of Pickwick Reservoir (i.e., Wilson Dam tailwater) and Wheeler Reservoir (i.e., Guntersville Dam tailwater). Sheepnose records in Wheeler Reservoir closest to the BFN site at TRM 294 occur approximately 15 miles upstream near TRM 309. The closest records of this species downstream of BFN are recorded at TRM 259 (approximately 30 miles away). Given the void of records for sheepnose in the Tennessee River near the BFN site, TVA has determined that this species does not occur within the proposed BFN EPU project area and would not be affected by the proposed BFN EPU project. The USFWS has not published DCH for the sheepnose.

j. Snuffbox mussel (*Epioblasma triquetra*):
The snuffbox was federally listed as endangered on March 15, 2012. This small to medium sized, triangular-shaped freshwater mussel is typically found in riffles of medium and large rivers in swift currents. This species is widely distributed throughout the Mississippi River basin and is known to occur in five counties within Alabama, including Lauderdale County. Snuffbox was recorded in the Tennessee River near Wilson Dam (TRM 259) in 1939, recently in the Elk River (a tributary of Wheeler Reservoir) near Elk River Mile (ERM) 34, and recently in the Tennessee River well upstream of the BFN site near TRM 334. Given the vast distances between the BFN site and known records of the snuffbox, in conjunction with the lack of preferable habitat at the site, TVA has determined that this species does not occur near the BFN site and would not be affected by the proposed BRN EPU project. The USFWS has not published DCH for the snuffbox, therefore, the proposed BFN EPU would not affect DCH for this species.

k. Triangular kidneyshell (*Ptychobranchus greenii*):
The triangular kidneyshell was federally listed on March 17, 1993. This freshwater mussel is most commonly found in reaches of creeks and medium-sized to large rivers with moderate current and coarse gravel / sand mixtures of substrate. This species is known from five counties in Alabama, including Lawrence County; however, it is known only from the upper watershed of the Mobile River. Therefore, the triangular kidneyshell does not occur in the Tennessee River basin and would not be affected by the proposed BFN EPU project. The

designated critical habitat for the cracking pearlymussel, therefore, the proposed BFN EPU would not affect DCH for this species.

d. Dark pigtoe (*Pleurobema furvum*):
The dark pigtoe was federally listed as endangered on March 17, 1993. This freshwater mussel is known to occur in three drainages (Sipsey Fork, Rush Creek, and North River) within the upper Black Warrior River drainage of Alabama, which is part of the Mobile River basin that flows into the Gulf of Mexico. The dark pigtoe does not occur in the Tennessee River basin and therefore would not be affected by the proposed BFN EPU. The USFWS final DCH for this species does not overlap with the potential action area of the proposed BFN EPU project. Therefore, the proposed BFN EPU would not affect the dark pigtoe or its DCH.

e. Fanshell (*Cyprogenia stegaria*):
The fanshell was federally listed as endangered on June 21, 1990 with non-essential, experimental population designation listed for portions of the French Broad and Holston Rivers (which meet to form the head of the Tennessee River) in 2007. This medium-sized freshwater mussel occurs in gravel substrates of medium to large rivers in locations with moderate to strong current. The fanshell was historically found throughout the Tennessee, Cumberland, and Ohio River systems, but its distribution has been reduced dramatically in recent decades, presumably due to habitat changes caused by impoundment and water quality problems. The fanshell has been recorded from Lauderdale and Colbert Counties in Alabama, but not Limestone or Lawrence Counties adjacent the BFN site. More specifically, records indicate the fanshell occurs in the mainstem Tennessee River throughout much of Pickwick Reservoir and in the upstream-most portion of Wheeler Reservoir (i.e., Guntersville Dam tailwater), where it was found most recently as 1978. Given the closest record of this species relative to the BFN site is approximately 50 miles upstream within Wheeler Reservoir, TVA has determined that this species does not exist within the BFN EPU project area and therefore would not be affected by the proposed BFN EPU project. The USFWS has not designated critical habitat for the fanshell, therefore, the proposed BFN EPU would not affect DCH for this species.

f. Littlewing pearlymussel (*Pegias fabula*):
The littlewing pearlymussel was federally listed as endangered on November 14, 1988. This very small freshwater mussel species is most common near the upstream and downstream margins of riffles in sand and gravel substrates, sometimes containing cobble-size particles within creeks and medium-sized rivers. Although the littlewing pearlymussel was historically known in Lauderdale and Limestone Counties in Alabama, the most recently published USFWS five-year review of this species reported that existing populations currently occur only in portions of the Cumberland River drainage and Tennessee River drainage outside of Alabama. This species is presumed extirpated from the state of Alabama. Consequently, TVA has determined that the littlewing pearlymussel does not occur at the BFN site and would not be affected by the proposed BFN EPU project. The USFWS has not published DCH for the littlewing pearlymussel, therefore, the proposed BFN EPU would not affect DCH for this species.

g. Orangenacre mucket (*Hamiota* [formerly *Lampsilis*] *perovalis*):
The orangenacre mucket was federally listed as threatened on March 17, 1993. This species is a medium sized freshwater mussel typically found in creeks to medium-sized rivers near riffles. The orangenacre mucket inhabits streams of Mississippi and Alabama that are only within the Mobile River system. This species does not occur in the Tennessee

would not be relevant to an environmental review of the proposed BFN site action are provided below for each species. In addition, nonessential experimental populations listed in Reference 1 have been discounted from environmental review of the proposed BFN EPU as allowed under Section 10 of the Endangered Species Act.

It should be noted that this examination of species does not include those associated with the proposed transmission system upgrades. Site specific environmental review of transmission system upgrades will occur once the proposed scope of work has been sufficiently defined for upgrade actions. Potential effects to each of the relevant species will be assessed during that review.

a. Black warrior waterdog (*Necturus alabamensis*):
The Black Warrior waterdog is a large, aquatic salamander that permanently retains its external gills throughout its adult life. The Black Warrior waterdog inhabits streams above the Fall Line (the juncture of the coastal plain and upland provinces) within the Black Warrior River Basin. This also includes parts of the North River, Locust Fork, Mulberry Fork, and Sipsey Fork drainages and their tributaries. BFN is not located in these river drainages, nor would this habitat be affected by the proposed BFN EPU project. Therefore, the Black Warrior waterdog would not be affected by the proposed BFN EPU project.

b. Alabama moccasinshell (*Medionidus acutissimus*):
The Alabama moccasinshell was federally listed as threatened on March 17, 1993. This species is a small freshwater mussel averaging about one inch in length that is typically found in sand or sand/gravel mixtures in clear streams with moderate flows but also can be found in small and large rivers. This species is restricted to the Mobile River basin, which drains into the Gulf of Mexico adjacent Alabama. The upstream-most reaches of the Mobile River basin includes headwater streams in the southern portion of Lawrence County, Alabama. The Alabama moccasinshell does not occur in the Tennessee River or its watershed and therefore does not occur on or near the BFN site. The USFWS final Designated Critical Habitat (DCH) for this species does not overlap with the potential action area of the proposed BFN EPU project. Therefore, the proposed BFN EPU would not affect the Alabama moccasinshell.

c. Cracking pearlymussel (*Hemistena lata*):
The cracking pearlymussel was federally listed as endangered on September 28, 1989 with non-essential, experimental populations designated in the French Broad and Holston Rivers (headwater tributaries of the Tennessee River) in 2007 and in the free-flowing reach of the Tennessee River from Wilson Dam downstream to the backwaters of Pickwick Reservoir in 2001. This relatively small species of freshwater mussel prefers habitat in sand, gravel, cobble mixtures within swift currents but can be found in mud and sand substrate in slower currents from medium-sized creeks to large rivers. Although this species is reported from the mainstem Tennessee River, records show it occurred downstream of Wheeler Dam in the Wilson Reservoir. The closest historical record of cracking pearlymussel relative to the BFN site, Tennessee River Mile (TRM) 294, is at the mouth of the Elk River, which enters Wheeler Reservoir at TRM 285; however, this collection was reported by Ortmann in 1925 (Reference 2). The cracking pearlymussel is known to currently inhabit the Elk River. Recent surveys by TVA and the Alabama Department of Conservation and Natural Resources indicate that there is no reported evidence that this species recently inhabited the Wheeler Reservoir reach of the Tennessee River. Therefore, TVA has concluded that this species would not be affected by the proposed BFN EPU. The USFWS has not

ENCLOSURE

RERP-PS-RAI 1

In an Information for Planning and Conservation Report dated February 1, 2016 (ADAMS Accession No. ML16032A044), the U.S. Fish and Wildlife identified a number of Federally listed species that are not addressed in the Supplemental ER. Provide any available information on potential habitat, occurrence, or sightings of the following species as well as an assessment of impacts of the proposed EPU on each species, as applicable.

a. *black warrior waterdog (Necturus alabamensis)*

b. *Alabama moccasinshell (Medionidus acutissimus)*

c. *cracking pearlymussel (Hemistena lata)*

d. *dark pigtoe (Pleurobema furvum)*

e. *fanshell (Cyprogenia stegaria)*

f. *littlewing pearlymussel (Pegias fabula)*

g. *orangenacre mucket (Lampsilis perovalis)*

h. *ovate clubshell (Pleurobema perovatum)*

i. *sheepnose mussel (Plethobasus cyphyus)*

j. *snuffbox mussel (Epioblasma triquetra)*

k. *triangular kidneyshell (Ptychobranchus greenii)*

l. *Alabama streak-sorus fern (Thelypteris pilosa var. alabamensis)*

m. *boulder darter (Etheostoma wapiti)*

n. *rush darter (Etheostoma phytophilum)*

o. *slackwater darter (Etheostoma boschungi)*

p. *fleshy-fruit gladecress (Leavenworthia crassa)*

q. *Kral's water-plantain (Sagittaria secundifolia)*

r. *leafy prairie-clover (Dalea foliosa)*

s. *lyrate bladderpod (Lesquerella lyrata)*

t. *Price's potato-bean (Apios priceana)*

u. *flattened musk turtle (Sternotherus depressus)*

TVA Response:

In an Information for Planning and Conservation (IPaC) Report dated February 1, 2016 (Reference 1), the U.S. Fish and Wildlife Service (USFWS) identified a number of federally listed species that were not addressed in the Supplemental Environmental Report (ER) for the proposed BFN EPU LAR. Discrepancies between the species addressed in the Supplemental ER and those identified in Reference 1 are primarily due to differences in search boundaries for species' records used in development of the list reviewed in the Supplemental ER and those listed in Reference 1. An explanation of why each additional species identified in Reference 1

RERP-AQ-RAI 2

Provide copies of the following references cited in the Supplemental ER.

a. *TVA. 2010. Fish impingement at Browns Ferry Nuclear Plant, September 2007 through September 2009. TVA Environmental Stewardship and Policy.*

b. *TVA. 2012a. Biological Monitoring of the Tennessee River Near Browns Ferry Nuclear Plant Discharge, Autumn 2011. TVA Biological and Water Resources, Chattanooga, Tennessee.*

c. *TVA. 2012b. Entrainment of Ichthyoplankton at Browns Ferry Nuclear Plant During 2008–2009. Knoxville, Tennessee: TVA Biological and Water Resources.*

d. *TVA. 2013. Biological Monitoring of the Tennessee River Near Browns Ferry Nuclear Plant Discharge, Autumn 2013.*

e. *TVA. 2014. Biological Monitoring of the Tennessee River Near Browns Ferry Nuclear Power Plant Discharge, Autumn 2014. Knoxville, Tennessee: River and Reservoir Compliance Monitoring Program.*

TVA Response:

Copies of the following references cited in the BFN EPU LAR, Attachment 42, Supplemental Environmental Report, are attached to this response. In addition to the requested documents, the report for Biological Monitoring of the Tennessee River Near Browns Ferry Nuclear Plant Discharge, Autumn 2015, has become available and is attached to this response.

a. TVA. 2010. Fish Impingement at Browns Ferry Nuclear Plant, September 2007 Through September 2009. TVA Environmental Stewardship and Policy. (Attachment 7 to this response)

b. TVA. 2012a. Biological Monitoring of the Tennessee River Near Browns Ferry Nuclear Plant Discharge, Autumn 2011. TVA Biological and Water Resources, Chattanooga, Tennessee. (Attachment 8 to this response)

c. TVA. 2012b. Entrainment of Ichthyoplankton at Browns Ferry Nuclear Plant During 2008–2009. Knoxville, Tennessee: TVA Biological and Water Resources. (Attachment 9 to this response)

d. TVA. 2013. Biological Monitoring of the Tennessee River Near Browns Ferry Nuclear Plant Discharge, Autumn 2013. (Attachment 10 to this response)

e. TVA. 2014. Biological Monitoring of the Tennessee River Near Browns Ferry Nuclear Plant Discharge, Autumn 2013. Knoxville, Tennessee: River and Reservoir Compliance Monitoring Program. (Attachment 11 to this response)

f. Biological Monitoring of the Tennessee River Near Browns Ferry Nuclear Plant Discharge, Autumn 2015. (Attachment 12 to this response)

RERP-AQ-RAI 1

Section 2.1.3 of the NRC's 2005 license renewal SEIS states that when the intake forebay gates are in a full-open position and the plant is operating in either open or helper modes, the average flow velocity through the openings is about 0.2 meters per second (m/s) (0.6 feet per second (fps)) for the operation of one unit, 0.34 m/s (1.1 fps) for the operation of two units, and 0.52 m/s (1.7 fps) for the operation of all three units. Confirm that these flow rates would continue to describe the inflow of cooling water under EPU conditions.

TVA Response:

The average flow velocities referenced in the NRC's 2005 Supplemental Environmental Impact Statement (SEIS) assumes the BFN total intake water withdrawal of approximately 734,000 gallons per minute (gpm) for each unit. The 2015 average intake water withdrawal was approximately 664,000 gpm for each unit. TVA is making no physical or operational modifications to the circulating water systems, residual heat removal service water system, emergency equipment cooling water system, raw cooling water, or raw water systems for EPU operation. Therefore, no changes are expected in the volume flow rate of water through the intake forebay. The physical parameters of the forebay have not changed. Therefore, the velocities stated in the NRC's 2005 SEIS bound intake flow velocities for the BFN units at EPU conditions.

RERP-SW-RAI 6

Provide a copy of BFN's current Alabama Department of Economic and Community Affairs Water Withdrawal/Use Permit.

TVA Response:

As a federal agency with statutory authority to manage, control, and use water resources, TVA voluntarily cooperates with the State of Alabama in its water management programs under the Alabama Water Resource Act. The BFN Certificate Of Use (COU) from the Alabama Department of Economic and Community Affairs (ADECA)/Office of Water Resources (OWR), dated December 1, 2005, is maintained on file with the ADECA/OWR and is provided as Attachment 5 to this response. TVA periodically applies to renew the certificate and updates the OWR of any changes in facility data by submitting a Declaration of Beneficial Use to ADECA/OWR. The most recent application for renewal and Declaration of Beneficial Use, dated September 23, 2015, is provided as Attachment 6 of this response. The ADECA/OWR updates facility data and maintains the COU but has not reissued the COU for each renewal application. The ADECA/OWR has received the most recent BFN application for renewal and is processing the application in accordance with ADECA/OWR administrative rules.

RERP-SW-RAI 5

Please provide the volume (in million gallons per day (mgd)) of surface water withdrawn annually by BFN from the Tennessee River (covering the last 5 years). Provide copies of relevant reports submitted to the State.

TVA Response:

The BFN average annual volume flow rate, in million gallons per day (mgd), for the last five years (2011-2015) is summarized in Table SW-5 below. The BFN average and peak volume of surface water withdrawn, in mgd, from the Tennessee River, by month for the last five years is provided in Attachment 4 to this response. The reports provided in Attachment 4 were previously submitted to the State of Alabama.

Table SW-5

2011 Annual Average (mgd)	2012 Annual Average (mgd)	2013 Annual Average (mgd)	2014 Annual Average (mgd)	2015 Annual Average (mgd)
2567.6	2607.8	2639.3	2621.8	2867.3

RERP-SW-RAI 4

TVA indicates in Section 7.2.2 of the Supplemental ER that the proposed EPU will not impact the current volume of water withdrawn from the Tennessee River. Clarify and confirm whether TVA projects any incremental increase in the volume of water withdrawn from the Tennessee River upon implementation of the EPU. If any increase is projected, quantify the increase.

TVA Response:

BFN is making no modifications to the circulating water systems, residual heat removal service water system, emergency equipment cooling water system, raw cooling water, or raw water systems for EPU operation. Therefore, no changes are expected in the volume of water withdrawn from the Tennessee River upon implementation of EPU.

RERP-SW-RAI 3

In Section 7.2-3 of the Supplemental ER, TVA summarizes modeling results that compare plant operation at the existing 105 percent original licensed thermal power (OLTP) versus 120 percent OLTP that include projected impacts on water temperature, cooling tower (helper mode) operations, and other parameters. To clarify and to provide context for some of the results presented, please provide a summary of the actual hours of cooling tower operation as well as derate hours experienced over the last five years of operations.

TVA Response:

Operation of the cooling towers (CTs) and unit derate information for the years 2011 through 2015 is summarized in Table SW-3 below. The CT operation data is based upon review of operator logs during the time period. The data represents periods where at least one BFN unit was operating with at least one CT in service. River temperature (inlet temperature or delta between upstream and downstream temperature) is the primary reason for CT operation.

Note that the response to NRC request for additional information RERP-SW-RAI-1 describes corrections to the BFN EPU LAR, Attachment 42, Supplemental Environmental Report, Section 7.2.3, Impact on Discharge, and to Table 7.2-3, Summary of BFN Hydrothermal Impacts for Warm, Summer Meteorology. These corrections relate to the model prediction for the average annual number of days of CT operation at 120 percent original licensed thermal power.

Table SW-3

Year	CT Operation (Hrs)	CT Operation (Days)	Derates (Hrs)		
2011	1889	81	U1 = 182.5	U2 = 99.4	U3 = 63.5
2012	1940	84	0		
2013	1207	52	0		
2014	1865	85	0		
2015	1438	65	U1 =0	U2 = 2.7	U3 = 3.4

ATTACHMENT 2

Browns Ferry Nuclear Plant National Pollutant Discharge Elimination System (NPDES) Permit Issued by the Alabama Department of Environmental Management, dated July 3, 2012

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM PERMIT

PERMITTEE: TENNESSEE VALLEY AUTHORITY
BROWNS FERRY NUCLEAR PLANT

FACILITY LOCATION: 10835 SHAW ROAD
ATHENS, AL 35611

PERMIT NUMBER: AL0022080

RECEIVING WATERS: DSN001, DSN005, DSN012, DSN013, DSN018, DSN019, DSN024: TENNESSEE RIVER

In accordance with and subject to the provisions of the Federal Water Pollution Control Act, as amended, 33 U.S.C. §§1251-1378 (the "FWPCA"), the Alabama Water Pollution Control Act, as amended, ***Code of Alabama 1975****, §§ 22-22-1 to 22-22-14 (the "AWPCA"), the Alabama Environmental Management Act, as amended,* ***Code of Alabama 1975****, §§22-22A-1 to 22-22A-15, and rules and regulations adopted thereunder, and subject further to the terms and conditions set forth in this permit, the Permittee is hereby authorized to discharge into the above-named receiving waters.*

ISSUANCE DATE: JULY 03,2012

EFFECTIVE DATE: JULY 03,2012

EXPIRATION DATE: JULY 02,2017

Glenda L. Dean
Alabama Department of Environmental Management

INDUSTRIAL SECTION
NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES) PERMIT

TABLE OF CONTENTS

PART I DISCHARGE LIMITATIONS, CONDITIONS, AND REQUIREMENTS

A. DISCHARGE LIMITATIONS AND MONITORING REQUIREMENTS

During the period beginning on the effective date of this permit and lasting through the expiration date of this permit, the permittee is authorized to discharge from the following point source(s) outfall(s), described more fully in the permittee's application:

DSN0011:Once-through cooling water from the Condenser Circulating Water (CCW), Raw Cooling Water (RCW), Turbine building station sump effluent, intake building sump effluent, and Liquid Radwaste System via DSN001B through the diffuser outfall to the Tennessee River (Normal River Conditions – See DSN0012 for Cooling Anomaly Conditions **11/**). **12/**

Such discharge shall be limited and monitored by the permittee as specified below:

	DISCHARGE LIMITATIONS					MONITORING REQUIREMENTS 1/		
EFFLUENT CHARACTERISTIC	**Daily Maximum**	**Monthly Average**	**Daily Minimum**	**Daily Maximum**	**Daily Average**	**Measurement Frequency 2/**	**Sample Type**	**Seasonal**
Temperature, Water Deg. Fahrenheit **4/**	-	-	-	-	REPORT F	Daily	Recorder	-
Temperature, Water Deg. Fahrenheit **10/**	-	-	-	REPORT F	REPORT F	Daily	Recorder	-
Temperature, Water Deg. Fahrenheit **5/**	-	-	-	93 F **7/**	90 F **8/**	Daily	Recorder	-
pH **9/**	-	-	6.0 S.U.	8.5 S.U.	-	Weekly	Grab	-
Temp Diff Between Up/Down Stream Deg F **6/**	-	-	-	REPORT F	10 F	Daily	Recorder	-
Flow, In Conduit or Thru Treatment Plant	REPORT MGD	REPORT MGD	-	-	-	Daily	Pump Log **3/**	-

THE DISCHARGE SHALL HAVE NO SHEEN, AND THERE SHALL BE NO DISCHARGE OF VISIBLE OIL, FLOATING SOLIDS OR VISIBLE FOAM IN OTHER THAN TRACE AMOUNTS.

1/ Samples collected to comply with the monitoring requirements specified above shall be collected at the following location: At the nearest accessible location just prior to discharge and after final treatment. Unless otherwise specified, composite samples shall be time composite samples collected using automatic sampling equipment or a minimum of eight (8) equal volume grab samples collected over equal time intervals. All composite samples shall be collected for the total period of discharge not to exceed 24 hours.

2/ If only one sampling event occurs during a month, the sample result shall be reported on the discharge monitoring report as both the monthly average and daily maximum value for all parameters with a monthly average limitation.

3/ Pump log verified by annual dye testing or diffuser head measurement.

4/ The Ambient Upstream River Temperature (Deg F) shall be determined by an upstream monitor located in the main channel at about river mile 297.8. In the event of a failure of this monitor, the five-foot depth temperature at the monitor located at river mile 296.1 will serve as the measured ambient temperature. Measurements shall be every 15 minutes at 3, 5, and 7 foot depths and averaged to obtain a 5 foot depth measurement. The temperatures shall be averaged and reported on a 24-hour calendar day basis.

5/ See Part IV.F. for downstream monitoring requirements.

6/ Temp Diff Between Up/Down Stream (Deg F) shall be determined by subtracting the ambient temperature values monitored in 4/ from the downstream river temperature monitored in 5/.

7/ The hourly average of the three downstream temperature monitors. See Part IV.F.

8/ When the 24-hour ambient average upstream temperature exceeds 90°F, the downstream temperature may equal but not exceed the upstream value.

9/ The pH shall not be less than 6.0 s.u. nor greater than 8.5 s.u. unless ambient river conditions prevent compliance at that range. Upstream monitoring by the permittee within one hour of a non-complying pH value will serve to demonstrate that ambient river conditions are preventing compliance.

10/ Effluent Temperature (Deg F).

11/ When weather or other events cause cooling of the Ambient Upstream River Temperature (Deg F) at a rate of $\geq$ 0.5°F per day (based on a 6-hour trend) a cooling anomaly condition exists and the requirements of DSN0012 shall apply for that 24 hour calendar day.

12/ When cooling water anomaly (see footnote 11/) conditions exist, NODI=9 shall be reported for all parameters associated with DSN0011.

During the period beginning on the effective date of this permit and lasting through the expiration date of this permit, the permittee is authorized to discharge from the following point source(s) outfall(s), described more fully in the permittee's application:

DSN0012: Once-through cooling water from the Condenser Circulating Water (CCW), Raw Cooling Water (RCW), Turbine building station sump effluent, intake building sump effluent, and Liquid Radwaste System via DSN001B through the diffuse (Cooling Anomaly Conditions 5/). 11/

Such discharge shall be limited and monitored by the permittee as specified below:

EFFLUENT CHARACTERISTIC	DISCHARGE LIMITATIONS Daily Maximum	Monthly Average	Daily Minimum	Daily Maximum	Daily Average	MONITORING REQUIREMENTS 1/ Measurement Frequency 2/	Sample Type	Seasonal
Temperature, Water Deg. Fahrenheit 4/ 5/	-	-	-	-	REPORT F	Daily	Recorder	-
Temperature, Water Deg. Fahrenheit 10/	-	-	-	REPORT F	REPORT F	Daily	Recorder	-
Temperature, Water Deg. Fahrenheit 5/ 6/	-	-	-	93 F 8/	90 F	Daily	Recorder	-
pH 9/	-	-	6.0 S.U.	8.5 S.U.	-	Weekly	Grab	-
Temp Diff Between Up/Down Stream Deg F6/ 7/	-	-	-	REPORT F	REPORT F	Daily	Recorder	-
Flow, In Conduit or Thru Treatment Plant	REPORT MGD	REPORT MGD	-	-	-	Daily	Pump Log 3/	-

THE DISCHARGE SHALL HAVE NO SHEEN, AND THERE SHALL BE NO DISCHARGE OF VISIBLE OIL, FLOATING SOLIDS OR VISIBLE FOAM IN OTHER THAN TRACE AMOUNTS.

1/ Samples collected to comply with the monitoring requirements specified above shall be collected at the following location: At the nearest accessible location just prior to discharge and after final treatment. Unless otherwise specified, composite samples shall be time composite samples collected using automatic sampling equipment or a minimum of eight (8) equal volume grab samples collected over equal time intervals. All composite samples shall be collected for the total period of discharge not to exceed 24 hours.

2/ If only one sampling event occurs during a month, the sample result shall be reported on the discharge monitoring report as both the monthly average and daily maximum value for all parameters with a monthly average limitation.

3/ Pump log verified by annual dye testing or diffuser head measurement.

4/ The Ambient Upstream River Temperature (Deg F) shall be determined by an upstream monitor located in the main channel at about river mile 297.8. In the event of a failure of this monitor, the five-foot depth temperature at the monitor located at river mile 296.1 will serve as the measured ambient temperature. Measurements shall be every 15 minutes at 3, 5, and 7 foot depths and averaged to obtain a 5 foot depth measurement. The temperatures shall be averaged and reported on a 24-hour calendar day basis.

5/ When weather or other events cause cooling of the Ambient Upstream River Temperature (Deg F) at a rate of $\geq$ 0.5°F per day (based on a 6-hour trend) a cooling anomaly condition exists and the requirements of DSN0012 shall apply for that 24 hour calendar day.

6/ See Part IV.F. for downstream monitoring requirements.

7/ Temp Diff Between Up/Down Stream (Deg F) shall be determined by subtracting the ambient temperature values monitored in 4/ from the downstream river temperature monitored in 5/.

8/ The hourly average of the three downstream temperature monitors. See Part IV.F.

9/ The pH shall not be less than 6.0 s.u. nor greater than 8.5 s.u. unless ambient river conditions prevent compliance at that range. Upstream monitoring by the permittee within one hour of a non-complying pH value will serve to demonstrate that ambient river conditions are preventing compliance.

10/ Effluent Temperature (Deg F).

11/ When cooling water anomaly (see footnote 5/) conditions do not exist, NODI=9 shall be reported for all parameters associated with DSN0012.

During the period beginning on the effective date of this permit and lasting through the expiration date of this permit, the permittee is authorized to discharge from the following point source(s) outfall(s), described more fully in the permittee's application:

DSN001Q: Once-through cooling water from the Condenser Circulating Water (CCW), Raw Cooling Water (RCW), Turbine building station sump effluent, intake building sump effluent, and Liquid Radwaste System via DSN001B through the diffuser outfall to the Tennessee River.

Such discharge shall be limited and monitored by the permittee as specified below:

EFFLUENT CHARACTERISTIC	DISCHARGE LIMITATIONS					MONITORING REQUIREMENTS 1/		
	Monthly Average	Daily Maximum	Daily Minimum	Monthly Average	Daily Maximum	Measurement Frequency 2/	Sample Type	Seasonal
Chlorine, Total Residual	-	-	-	0.034 mg/l	0.044 mg/l	Quarterly	Grab	-

THE DISCHARGE SHALL HAVE NO SHEEN, AND THERE SHALL BE NO DISCHARGE OF VISIBLE OIL, FLOATING SOLIDS OR VISIBLE FOAM IN OTHER THAN TRACE AMOUNTS.

1/ Samples collected to comply with the monitoring requirements specified above shall be collected at the following location: At the nearest accessible location just prior to discharge and after final treatment. Unless otherwise specified, composite samples shall be time composite samples collected using automatic sampling equipment or a minimum of eight (8) equal volume grab samples collected over equal time intervals. All composite samples shall be collected for the total period of discharge not to exceed 24 hours.

2/ If only one sampling event occurs during a month, the sample result shall be reported on the discharge monitoring report as both the monthly average and daily maximum value for all parameters with a monthly average limitation.

3/ Total residual chlorine (TRC) and free available chlorine (FAC) may not be discharged from any single generating unit for more than 2 hours per day unless the permittee demonstrates (with records retained on-site) to ADEM that discharge for more than 2 hours is required for macro invertebrate control.

During the period beginning on the effective date of this permit and lasting through the expiration date of this permit, the permittee is authorized to discharge from the following point source(s) outfall(s), described more fully in the permittee's application:

DSN001Y: Once-through cooling water from the Condenser Circulating Water (CCW), Raw Cooling Water (RCW), Turbine building station sump effluent, intake building sump effluent, and Liquid Radwaste System via DSN001B through the diffuser outfall to the Tennessee River.

Such discharge shall be limited and monitored by the permittee as specified below:

	DISCHARGE LIMITATIONS					MONITORING REQUIREMENTS 1/		
EFFLUENT CHARACTERISTIC	**Monthly Average**	**Daily Maximum**	**Daily Minimum**	**Monthly Average**	**Daily Maximum**	**Measurement Frequency 2/**	**Sample Type**	**Seasonal**
Toxicity, Ceriodaphnia Chronic 3/	-	0 pass(0) /fail(1)	-	-	-	Annually	24-Hr Composite	-
Toxicity, Pimephales Chronic 3/	-	0 pass(0) /fail(1)	-	-	-	Annually	24-Hr Composite	-

THE DISCHARGE SHALL HAVE NO SHEEN, AND THERE SHALL BE NO DISCHARGE OF VISIBLE OIL, FLOATING SOLIDS OR VISIBLE FOAM IN OTHER THAN TRACE AMOUNTS.

1/ Samples collected to comply with the monitoring requirements specified above shall be collected at the following location: At the nearest accessible location just prior to discharge and after final treatment. Unless otherwise specified, composite samples shall be time composite samples collected using automatic sampling equipment or a minimum of eight (8) equal volume grab samples collected over equal time intervals. All composite samples shall be collected for the total period of discharge not to exceed 24 hours.

2/ If only one sampling event occurs during a month, the sample result shall be reported on the discharge monitoring report as both the monthly average and daily maximum value for all parameters with a monthly average limitation.

3/ See Part IV.C for Effluent Toxicity Requirements.

During the period beginning on the effective date of this permit and lasting through the expiration date of this permit, the permittee is authorized to discharge from the following point source(s) outfall(s), described more fully in the permittee's application:

DSN0051: Residual Heat Removal Service Water (RHRSW) System

Such discharge shall be limited and monitored by the permittee as specified below:

	DISCHARGE LIMITATIONS					MONITORING REQUIREMENTS 1/		
EFFLUENT CHARACTERISTIC	Monthly Average	Daily Maximum	Daily Minimum	Monthly Average	Daily Maximum	Measurement Frequency 2/	Sample Type	Seasonal
Temperature, Water Deg. Fahrenheit	-	-	-	REPORT F	REPORT F	Bi-Weekly	Grab	-
pH	-	-	6.0 S.U.	-	8.5 S.U.	Bi-Weekly	Grab	-
Flow, In Conduit or Thru Treatment Plant	REPORT MGD	-	-	-	-	Bi-Weekly	Estimate	-

THE DISCHARGE SHALL HAVE NO SHEEN, AND THERE SHALL BE NO DISCHARGE OF VISIBLE OIL, FLOATING SOLIDS OR VISIBLE FOAM IN OTHER THAN TRACE AMOUNTS.

1/ Samples collected to comply with the monitoring requirements specified above shall be collected at the following location: At the nearest accessible location just prior to discharge and after final treatment. Unless otherwise specified, composite samples shall be time composite samples collected using automatic sampling equipment or a minimum of eight (8) equal volume grab samples collected over equal time intervals. All composite samples shall be collected for the total period of discharge not to exceed 24 hours.

2/ If only one sampling event occurs during a month, the sample result shall be reported on the discharge monitoring report as both the monthly average and daily maximum value for all parameters with a monthly average limitation.

During the period beginning on the effective date of this permit and lasting through the expiration date of this permit, the permittee is authorized to discharge from the following point source(s) outfall(s), described more fully in the permittee's application:

DSN013Y: Storm water from the toxicity testing laboratory parking lot, northeast corner of the Training Center's parking lot, storm drain at sedimentation pond, area south of the toxicity testing lab, DSN013A, DSN013B, and DSN013C. 3/ 4/

Such discharge shall be limited and monitored by the permittee as specified below:

	DISCHARGE LIMITATIONS					MONITORING REQUIREMENTS 1/		
EFFLUENT CHARACTERISTIC	Monthly Average	Daily Maximum	Daily Minimum	Monthly Average	Daily Maximum	Measurement Frequency 2/	Sample Type	Seasonal
pH	-	-	REPORT S.U.	-	REPORT S.U.	Annually	Grab	-
Solids, Total Suspended	-	-	-	-	REPORT mg/l	Annually	Grab	-
Oil & Grease	-	-	-	-	15.0 mg/l	Annually	Grab	-
Flow, In Conduit or Thru Treatment Plant	-	REPORT MGD	-	-	-	Annually	Estimate	-

THE DISCHARGE SHALL HAVE NO SHEEN, AND THERE SHALL BE NO DISCHARGE OF VISIBLE OIL, FLOATING SOLIDS OR VISIBLE FOAM IN OTHER THAN TRACE AMOUNTS.

1/ Samples collected to comply with the monitoring requirements specified above shall be collected at the following location: At the nearest accessible location just prior to discharge and after final treatment. Unless otherwise specified, composite samples shall be time composite samples collected using automatic sampling equipment or a minimum of eight (8) equal volume grab samples collected over equal time intervals. All composite samples shall be collected for the total period of discharge not to exceed 24 hours.

2/ If only one sampling event occurs during a month, the sample result shall be reported on the discharge monitoring report as both the monthly average and daily maximum value for all parameters with a monthly average limitation.

3/ See Part IV.A for Best Management Practices (BMP) Plan Requirements.

4/ See Part IV.B for Stormwater Measurement and Sampling Requirements.

During the period beginning on the effective date of this permit and lasting through the expiration date of this permit, the permittee is authorized to discharge from the following point source(s) outfall(s), described more fully in the permittee's application:

DSN018Y: Stormwater from Materials and Procurement Complex parking lot, the firing range parking lot, the Facilities Maintenance area, the vehicle fuel dispensing area, and adjacent grass area. 3/ 4/

Such discharge shall be limited and monitored by the permittee as specified below:

	DISCHARGE LIMITATIONS					MONITORING REQUIREMENTS 1/		
EFFLUENT CHARACTERISTIC	Monthly Average	Daily Maximum	Daily Minimum	Monthly Average	Daily Maximum	Measurement Frequency 2/	Sample Type	Seasonal
pH	-	-	REPORT S.U.	-	REPORT S.U.	Annually	Grab	-
Solids, Total Suspended	-	-	-	-	REPORT mg/l	Annually	Grab	-
Oil & Grease	-	-	-	-	15.0 mg/l	Annually	Grab	-
Benzene, Ethylbenzenetoulene, Xylene Combn	-	-	-	-	15.47 ug/l	Annually	Grab	-
Naphthalene	-	-	-	-	600.0 ug/l	Annually	Grab	-
Flow, In Conduit or Thru Treatment Plant	-	REPORT MGD	-	-	-	Annually	Estimate	-

THE DISCHARGE SHALL HAVE NO SHEEN, AND THERE SHALL BE NO DISCHARGE OF VISIBLE OIL, FLOATING SOLIDS OR VISIBLE FOAM IN OTHER THAN TRACE AMOUNTS.

1/ Samples collected to comply with the monitoring requirements specified above shall be collected at the following location: At the nearest accessible location just prior to discharge and after final treatment. Unless otherwise specified, composite samples shall be time composite samples collected using automatic sampling equipment or a minimum of eight (8) equal volume grab samples collected over equal time intervals. All composite samples shall be collected for the total period of discharge not to exceed 24 hours.

2/ If only one sampling event occurs during a month, the sample result shall be reported on the discharge monitoring report as both the monthly average and daily maximum value for all parameters with a monthly average limitation.

3/ See Part IV.A for Best Management Practices (BMP) Plan Requirements.

4/ See Part IV.B for Stormwater Measurement and Sampling Requirements.

During the period beginning on the effective date of this permit and lasting through the expiration date of this permit, the permittee is authorized to discharge from the following point source(s) outfall(s), described more fully in the permittee's application:

DSN019Y: Storm water from the east side of plant which includes the Fire Training area, the Low Level Radwaste storage facility, the inert landfill, and the Hazardous Waste storage area. 3/ 4/

Such discharge shall be limited and monitored by the permittee as specified below:

	DISCHARGE LIMITATIONS					MONITORING REQUIREMENTS 1/		
EFFLUENT CHARACTERISTIC	**Monthly Average**	**Daily Maximum**	**Daily Minimum**	**Monthly Average**	**Daily Maximum**	**Measurement Frequency 2/**	**Sample Type**	**Seasonal**
pH	-	-	REPORT S.U.	-	REPORT S.U.	Annually	Grab	-
Solids, Total Suspended	-	-	-	-	REPORT mg/l	Annually	Grab	-
Oil & Grease	-	-	-	-	15.0 mg/l	Annually	Grab	-
Flow, In Conduit or Thru Treatment Plant	-	REPORT MGD	-	-	-	Annually	Estimate	-
Chemical Oxygen Demand (COD)	-	-	-	-	REPORT mg/l	Annually	Grab	-

THE DISCHARGE SHALL HAVE NO SHEEN, AND THERE SHALL BE NO DISCHARGE OF VISIBLE OIL, FLOATING SOLIDS OR VISIBLE FOAM IN OTHER THAN TRACE AMOUNTS.

1/ Samples collected to comply with the monitoring requirements specified above shall be collected at the following location: At the nearest accessible location just prior to discharge and after final treatment. Unless otherwise specified, composite samples shall be time composite samples collected using automatic sampling equipment or a minimum of eight (8) equal volume grab samples collected over equal time intervals. All composite samples shall be collected for the total period of discharge not to exceed 24 hours.

2/ If only one sampling event occurs during a month, the sample result shall be reported on the discharge monitoring report as both the monthly average and daily maximum value for all parameters with a monthly average limitation.

3/ See Part IV.A for Best Management Practices (BMP) Plan Requirements.

4/ See Part IV.B for Stormwater Measurement and Sampling Requirements.

During the period beginning on the effective date of this permit and lasting through the expiration date of this permit, the permittee is authorized to discharge from the following point source(s) outfall(s), described more fully in the permittee's application:

DSN01B1: Liquid Radwaste System (Low Volume Waste Water).

Such discharge shall be limited and monitored by the permittee as specified below:

	DISCHARGE LIMITATIONS					MONITORING REQUIREMENTS 1/		
EFFLUENT CHARACTERISTIC	**Monthly Average**	**Daily Maximum**	**Daily Minimum**	**Monthly Average**	**Daily Maximum**	**Measurement Frequency 2/**	**Sample Type**	**Seasonal**
pH	-	-	6.0 S.U.	-	9.0 S.U.	Monthly	Grab	-
Solids, Total Suspended	-	-	-	30.0 mg/l	100.0 mg/l	Monthly	Grab	-
Oil & Grease	-	-	-	15.0 mg/l	20.0 mg/l	Monthly	Grab	-
Flow, In Conduit or Thru Treatment Plant	-	REPORT MGD	-	-	-	Monthly	Estimate	-

THE DISCHARGE SHALL HAVE NO SHEEN, AND THERE SHALL BE NO DISCHARGE OF VISIBLE OIL, FLOATING SOLIDS OR VISIBLE FOAM IN OTHER THAN TRACE AMOUNTS.

1/ Samples collected to comply with the monitoring requirements specified above shall be collected at the following location: At the nearest accessible location just prior to discharge and after final treatment. Unless otherwise specified, composite samples shall be time composite samples collected using automatic sampling equipment or a minimum of eight (8) equal volume grab samples collected over equal time intervals. All composite samples shall be collected for the total period of discharge not to exceed 24 hours.

2/ If only one sampling event occurs during a month, the sample result shall be reported on the discharge monitoring report as both the monthly average and daily maximum value for all parameters with a monthly average limitation.

During the period beginning on the effective date of this permit and lasting through the expiration date of this permit, the permittee is authorized to discharge from the following point source(s) outfall(s), described more fully in the permittee's application:

DSN024Y: Storm water from the northeast and east perimeters which include the adjacent farmland, vehicle service shop, and mechanic shop. 3/ 4/

Such discharge shall be limited and monitored by the permittee as specified below:

EFFLUENT CHARACTERISTIC	DISCHARGE LIMITATIONS Monthly Average	Daily Maximum	Daily Minimum	Monthly Average	Daily Maximum	MONITORING REQUIREMENTS 1/ Measurement Frequency 2/	Sample Type	Seasonal
pH	-	-	REPORT S.U.	-	REPORT S.U.	Annually	Grab	-
Solids, Total Suspended	-	-	-	-	REPORT mg/l	Annually	Grab	-
Oil & Grease	-	-	-	-	15.0 mg/l	Annually	Grab	-
Flow, In Conduit or Thru Treatment Plant	-	REPORT MGD	-	-	-	Annually	Estimate	-

THE DISCHARGE SHALL HAVE NO SHEEN, AND THERE SHALL BE NO DISCHARGE OF VISIBLE OIL, FLOATING SOLIDS OR VISIBLE FOAM IN OTHER THAN TRACE AMOUNTS.

1/ Samples collected to comply with the monitoring requirements specified above shall be collected at the following location: At the nearest accessible location just prior to discharge and after final treatment. Unless otherwise specified, composite samples shall be time composite samples collected using automatic sampling equipment or a minimum of eight (8) equal volume grab samples collected over equal time intervals. All composite samples shall be collected for the total period of discharge not to exceed 24 hours.

2/ If only one sampling event occurs during a month, the sample result shall be reported on the discharge monitoring report as both the monthly average and daily maximum value for all parameters with a monthly average limitation.

3/ See Part IV.A for Best Management Practices (BMP) Plan Requirements.

4/ See Part IV.B for Stormwater Measurement and Sampling Requirements.

During the period beginning on the effective date of this permit and lasting through the expiration date of this permit, the permittee is authorized to discharge from the following point source(s) outfall(s), described more fully in the permittee's application:

DSN13AY: Storm water runoff from the switchyard drainage ditch (including the 4 kV operator yard), the main plant transformer yard, the switchyard, the east parking lot, and the grassland north of the east parking lot. 3/ 4/

Such discharge shall be limited and monitored by the permittee as specified below:

	DISCHARGE LIMITATIONS					MONITORING REQUIREMENTS 1/		
EFFLUENT CHARACTERISTIC	**Monthly Average**	**Daily Maximum**	**Daily Minimum**	**Monthly Average**	**Daily Maximum**	**Measurement Frequency 2/**	**Sample Type**	**Seasonal**
pH	-	-	REPORT S.U.	-	REPORT S.U.	Annually	Grab	-
Solids, Total Suspended	-	-	-	-	REPORT mg/l	Annually	Grab	-
Oil & Grease	-	-	-	-	15.0 mg/l	Annually	Grab	-
Flow, In Conduit or Thru Treatment Plant	-	REPORT MGD	-	-	-	Annually	Estimate	-

THE DISCHARGE SHALL HAVE NO SHEEN, AND THERE SHALL BE NO DISCHARGE OF VISIBLE OIL, FLOATING SOLIDS OR VISIBLE FOAM IN OTHER THAN TRACE AMOUNTS.

1/ Samples collected to comply with the monitoring requirements specified above shall be collected at the following location: At the nearest accessible location just prior to discharge and after final treatment. Unless otherwise specified, composite samples shall be time composite samples collected using automatic sampling equipment or a minimum of eight (8) equal volume grab samples collected over equal time intervals. All composite samples shall be collected for the total period of discharge not to exceed 24 hours.

2/ If only one sampling event occurs during a month, the sample result shall be reported on the discharge monitoring report as both the monthly average and daily maximum value for all parameters with a monthly average limitation.

3/ See Part IV.A for Best Management Practices (BMP) Plan Requirements.

4/ See Part IV.B for Stormwater Measurement and Sampling Requirements.

During the period beginning on the effective date of this permit and lasting through the expiration date of this permit, the permittee is authorized to discharge from the following point source(s) outfall(s), described more fully in the permittee's application:

DSN13B1: Sedimentation pond discharge. 3/ 4/

Such discharge shall be limited and monitored by the permittee as specified below:

	DISCHARGE LIMITATIONS					MONITORING REQUIREMENTS 1/		
EFFLUENT CHARACTERISTIC	**Monthly Average**	**Daily Maximum**	**Daily Minimum**	**Monthly Average**	**Daily Maximum**	**Measurement Frequency 2/**	**Sample Type**	**Seasonal**
pH	-	-	6.0 S.U.	-	9.0 S.U.	Once per batch	Grab	-
Solids, Total Suspended	-	-	-	30.0 mg/l	100.0 mg/l	Once per batch	Grab	-
Oil & Grease	-	-	-	15.0 mg/l	20.0 mg/l	Once per batch	Grab	-
Flow, In Conduit or Thru Treatment Plant	REPORT MGD	REPORT MGD	-	-	-	Once per batch	Measured	-

THE DISCHARGE SHALL HAVE NO SHEEN, AND THERE SHALL BE NO DISCHARGE OF VISIBLE OIL, FLOATING SOLIDS OR VISIBLE FOAM IN OTHER THAN TRACE AMOUNTS.

1/ Samples collected to comply with the monitoring requirements specified above shall be collected at the following location: At the nearest accessible location just prior to discharge and after final treatment. Unless otherwise specified, composite samples shall be time composite samples collected using automatic sampling equipment or a minimum of eight (8) equal volume grab samples collected over equal time intervals. All composite samples shall be collected for the total period of discharge not to exceed 24 hours.

2/ If only one sampling event occurs during a month, the sample result shall be reported on the discharge monitoring report as both the monthly average and daily maximum value for all parameters with a monthly average limitation.

3/ See Part IV.A for Best Management Practices (BMP) Plan Requirements.

4/ See Part IV.B for Stormwater Measurement and Sampling Requirements.

During the period beginning on the effective date of this permit and lasting through the expiration date of this permit, the permittee is authorized to discharge from the following point source(s) outfall(s), described more fully in the permittee's application:

DSN13C1:Treated domestic wastewater, medical lab photo developing waste, blowdown from the Training Center's chiller system, flush water from the stand-by liquid control system, flush water from cooler/air compressor cleaning, filtered waste from insulator showers used by personnel involved in the periodic asbestos stripping and handling operations, and rainwater. 4/

Such discharge shall be limited and monitored by the permittee as specified below:

	DISCHARGE LIMITATIONS					MONITORING REQUIREMENTS 1/		
EFFLUENT CHARACTERISTIC	Monthly Average	Daily Maximum	Daily Minimum	Monthly Average	Daily Maximum	Measurement Frequency 2/	Sample Type	Seasonal
BOD, 5-Day (20 Deg. C)	-	-	-	30.0 mg/l	45.0 mg/l	Bi-Weekly	Grab	-
pH	-	-	6.0 S.U.	-	9.0 S.U.	Bi-Weekly	Grab	-
Solids, Total Suspended	-	-	-	90.0 mg/l	135.0 mg/l	Bi-Weekly	Grab	-
Flow, In Conduit or Thru Treatment Plant	REPORT MGD	REPORT MGD	-	-	-	Bi-Weekly	Instantaneous	-

THE DISCHARGE SHALL HAVE NO SHEEN, AND THERE SHALL BE NO DISCHARGE OF VISIBLE OIL, FLOATING SOLIDS OR VISIBLE FOAM IN OTHER THAN TRACE AMOUNTS.

1/ Samples collected to comply with the monitoring requirements specified above shall be collected at the following location: At the nearest accessible location just prior to discharge and after final treatment. Unless otherwise specified, composite samples shall be time composite samples collected using automatic sampling equipment or a minimum of eight (8) equal volume grab samples collected over equal time intervals. All composite samples shall be collected for the total period of discharge not to exceed 24 hours.

2/ If only one sampling event occurs during a month, the sample result shall be reported on the discharge monitoring report as both the monthly average and daily maximum value for all parameters with a monthly average limitation.

3/ See Part IV.A for Best Management Practices (BMP) Plan Requirements.

4/ Sampling location for BOD, TSS, and pH is at the end of DSN13AY and samples must be taken during dry weather with no storm water runoff.

B. DISCHARGE MONITORING AND RECORD KEEPING REQUIREMENTS

1. Representative Sampling

Samples and measurements taken as required herein shall be representative of the volume and nature of the monitored discharge and shall be in accordance with the provisions of this permit.

2. Test Procedures

For the purpose of reporting and compliance, permittees shall use one of the following procedures:

a. For parameters with an EPA established Minimum Level (ML), report the measured value if the analytical result is at or above the ML and report "0" for values below the ML. Test procedures for the analysis of pollutants shall conform to 40 CFR Part 136 and guidelines published pursuant to Section 304(h) of the FWPCA, 33 U.S.C. Section 1314(h). If more than one method for analysis of a substance is approved for use, a method having a minimum level lower than the permit limit shall be used. If the minimum level of all methods is higher than the permit limit, the method having the lowest minimum level shall be used and a report of less than the minimum level shall be reported as zero and will constitute compliance; however, should EPA approve a method with a lower minimum level during the term of this permit the permittee shall use the newly approved method.

b. For pollutants parameters without an established ML, an interim ML may be utilized. The interim ML shall be calculated as 3.18 times the Method Detection Level (MDL) calculated pursuant to 40 CFR Part 136, Appendix B.

Permittees may develop an effluent matrix-specific ML, where an effluent matrix prevents attainment of the established ML. However, a matrix specific ML shall be based upon proper laboratory method and technique. Matrix-specific MLs must be approved by the Department, and may be developed by the permittee during permit issuance, reissuance, modification, or during compliance schedule.

In either case the measured value should be reported if the analytical result is at or above the ML and "0" reported for values below the ML.

c. For parameters without an EPA established ML, interim ML, or matrix-specific ML, a report of less than the detection limit shall constitute compliance if the detection limit of all analytical methods is higher than the permit limit using the most sensitive EPA approved method. For the purpose of calculating a monthly average, "0" shall be used for values reported less than the detection limit.

The Minimum Level utilized for procedures A and B above shall be reported on the permittee's DMR. When an EPA approved test procedure for analysis of a pollutant does not exist, the Director shall approve the procedure to be used.

3. Recording of Results

For each measurement or sample taken pursuant to the requirements of this permit, the permittee shall record the following information:

a. The facility name and location, point source number, date, time and exact place of sampling;

b. The name(s) of person(s) who obtained the samples or measurements;

c. The dates and times the analyses were performed;

d. The name(s) of the person(s) who performed the analyses;

e. The analytical techniques or methods used, including source of method and method number; and

f. The results of all required analyses.

4. Records Retention and Production

The permittee shall retain records of all monitoring information, including all calibration and maintenance records and all original strip chart recordings for continuous monitoring instrumentation, copies of all reports required by the permit, and records of all data used to complete the above reports or the application for this permit, for a period of at least three years from the date of the sample measurement, report or application. This period may be extended by request of the Director at any time. If litigation or other enforcement action, under the AWPCA and/or the FWPCA, is ongoing which involves any of the above records, the records shall be kept until the litigation is resolved. Upon the written request of the Director or his designee, the permittee shall provide the Director with a copy of any record required to be retained by this paragraph. Copies of these records shall not be submitted unless requested.

All records required to be kept for a period of three years shall be kept at the permitted facility or an alternate location approved by the Department in writing and shall be available for inspection.

5. Monitoring Equipment and Instrumentation

All equipment and instrumentation used to determine compliance with the requirements of this permit shall be installed, maintained, and calibrated in accordance with the manufacturer's instructions or, in the absence of manufacturer's instructions, in accordance with accepted practices. The permittee shall develop and maintain quality assurance procedures to ensure proper operation and maintenance of all equipment and instrumentation. The quality assurance procedures shall include the proper use, maintenance, and installation, when appropriate, of monitoring equipment at the plant site.

C. DISCHARGE REPORTING REQUIREMENTS

1. Reporting of Monitoring Requirements

a. The permittee shall conduct the required monitoring in accordance with the following schedule:

MONITORING REQUIRED MORE FREQUENTLY THAN MONTHLY AND MONTHLY shall be conducted during the first full month following the effective date of coverage under this permit and every month thereafter.

QUARTERLY MONITORING shall be conducted at least once during each calendar quarter. Calendar quarters are the periods of January through March, April through June, July through September, and October through December. The permittee shall conduct the quarterly monitoring during the first complete calendar quarter following the effective date of this permit and is then required to monitor once during each quarter thereafter. Quarterly monitoring may be done anytime during the quarter, unless restricted elsewhere in this permit, but it should be submitted with the last DMR due for the quarter, i.e. (March, June, September and December DMRs).

SEMIANNUAL MONITORING shall be conducted at least once during the period of January through June and at least once during the period of July through December. The permittee shall conduct the semiannual monitoring during the first complete calendar semiannual period following the effective date of this permit and is then required to monitor once during each semiannual period thereafter. Semiannual monitoring may be done anytime during the semiannual period, unless restricted elsewhere in this permit, but it should be submitted with the last DMR due for the month of the semiannual period, i.e. (June and December DMRs).

ANNUAL MONITORING shall be conducted at least once during the period of January through December. The permittee shall conduct the annual monitoring during the first complete calendar annual period following the effective date of this permit and is then required to monitor once during each annual period thereafter. Annual monitoring may be done anytime during the year, unless restricted elsewhere in this permit, but it should be submitted with the December DMR.

b. The permittee shall submit discharge monitoring reports (DMRs) on the forms provided by the Department and in accordance with the following schedule:

REPORTS OF MORE FREQUENTLY THAN MONTHLY AND MONTHLY TESTING shall be submitted on a **monthly** basis. The first report is due on the **28th** day of **August, 2012**. The reports shall be submitted so that they are received by the Department no later than the 28th day of the month following the reporting period.

REPORTS OF QUARTERLY TESTING shall be submitted on a quarterly basis. The first report is due on the 28th day of **28th** day of **October, 2012**. The reports shall be submitted so that they are received by the Department no later than the 28th day of the month following the reporting period.

REPORTS OF SEMIANNUAL TESTING shall be submitted on a semiannual basis. The reports are due on the 28th day of JANUARY and the 28th day of JULY. The reports shall be submitted so that they are received by the Department no later than the 28th day of the month following the reporting period.

REPORTS OF ANNUAL TESTING shall be submitted on an annual basis. The first report is due on the 28th day of JANUARY. The reports shall be submitted so that they are received by the Department no later than the 28th day of the month following the reporting period.

c. The Department is utilizing a web-based electronic environmental (E2) reporting system for submittal of DMRs. The E2 DMR system allows ADEM to electronically validate, acknowledge receipt, and upload data to the state's central wastewater database. This improves the accuracy of reported compliance data and reduces costs to both the regulated community and ADEM. **If the permittee is not already participating in the e-DMR system, within 180 days of coverage under this permit, permittee must apply for participation in the e-DMR system unless the facility submits in writing valid justification as to why they cannot participate and the Department approves in writing utilization of hard copy DMR submittals.** To participate in this program, the Permittee Participation Package may be downloaded online at **https://e2.adem.alabama.gov/npdes**. If the electronic environmental (E2) reporting system is down (i.e. electronic submittal of DMR data is unable to be completed due to technical problems originating with the

Department's system: this could include entry/submittal issues with an entire set of DMRs or individual parameters), permittee is not relieved of their obligation to submit DMR data to the Department by the required submittal date. However, if the E2 system is down on the 28th day of the month or is down for an extended period f time as determined by the Department when a DMR is required to be submitted, the facility may submit the data in an alternate manner and format acceptable to the Department. Preapproved alternate acceptable methods include faxing, e-mailing, mailing, or hand-delivery of data such that they are received by the required reporting date. Within five calendar days of the E2 system resuming operation, the permittee shall enter the data into the E2 reporting system, unless an alternate timeframe is approved by the Department. An attachment should be included with the E2 DMR submittal verifying the original submittal date (date of the fax, copy of dated e-mail, or hand-delivery stamped date). If a permittee is allowed to submit via the US Postal Service, the DMR must be legible and bear an original signature. Photo and electronic copies of the signature are not acceptable and shall not satisfy the reporting requirements of this permit. If the permittee, using approved analytical methods as specified in Provision I.B.2 monitors any discharge from a point source for a limited substance identified in Provision I.A of this permit more frequently than required by this permit, the results of such monitoring shall be included in the calculation and reporting of values on the DMR form and the increased frequency shall be indicated on the DMR form. In the event no discharge from a point source identified in Provision I.A of this permit and described more fully in the permittee's application occurs during a monitoring period, the permittee shall report "No Discharge" for such period on the appropriate DMR form.

d. All reports and forms required to be submitted by this permit, the AWPCA and the Department's Rules and Regulations, shall be electronically signed (or, if allowed by the Department, traditionally signed) by a "responsible official" of the permittee as defined in ADEM Administrative Code Rule 335-6-6-.09 or a "duly authorized representative" of such official as defined in ADEM Administrative Code Rule 335-6-6-.09 and shall bear the following certification:

"I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

e. The permittee may certify in writing that a discharge will not occur for an extended period of time and after such certification shall not be required to submit monitoring reports. Written notification of a planned resumption of discharge shall be submitted at least 30 days prior to resumption of the discharge. If an unplanned resumption of discharge occurs, written notification shall be submitted within 7 days of the resumption. In any case, all discharges shall comply with all provisions of this permit.

f. All Discharge Monitoring Report forms required to be submitted by this permit, the AWPCA, and the Department's Rules shall be addressed to:

Alabama Department of Environmental Management
Permits and Services Division
Environmental Data Section
Post Office Box 301463
Montgomery, Alabama 36130-1463

Certified and Registered Mail containing Discharge Monitoring Reports shall be addressed to:

Alabama Department of Environmental Management
Permits and Services Division
Environmental Data Section
1400 Coliseum Boulevard
Montgomery, Alabama 36110-2059

g. All other correspondence and reports required to be submitted by this permit, the AWPCA, and the Department's Rules shall be addressed to:

Alabama Department of Environmental Management
Water Division
Post Office Box 301463
Montgomery, Alabama 36130-1463

Certified and Registered Mail shall be addressed to:

Alabama Department of Environmental Management
Water Division
1400 Coliseum Boulevard
Montgomery, Alabama 36110-2059

h. If this permit is a reissuance, then the permittee shall continue to submit DMRs in accordance with the requirements of their previous permit until such time as DMRs are due as discussed in Part I.C.1.b. above.

2. Noncompliance Notification

a. 24-Hour Noncompliance Reporting

The permittee shall report to the Director, within 24-hours of becoming aware of the noncompliance, any noncompliance which may endanger health or the environment. This shall include but is not limited to the following circumstances:

(1) does not comply with any daily minimum or maximum discharge limitation for an effluent characteristic specified in Provision I. A. of this permit which is denoted by an "(X)";

(2) threatens human health or welfare, fish or aquatic life, or water quality standards;

(3) does not comply with an applicable toxic pollutant effluent standard or prohibition established under Section 307(a) of the FWPCA, 33 U.S.C. Section 1317(a);

(4) contains a quantity of a hazardous substance which has been determined may be harmful to public health or welfare under Section 311(b)(4) of the FWPCA, 33 U.S.C. Section 1321(b)(4);

(5) exceeds any discharge limitation for an effluent characteristic as a result of an unanticipated bypass or upset; and

(6) is an unpermitted direct or indirect discharge of a pollutant to a water of the state (unpermitted discharges properly reported to the Department under any other requirement are not required to be reported under this provision).

The permittee shall orally report the occurrence and circumstances of such discharge to the Director within 24-hours after the permittee becomes aware of the occurrence of such discharge. In addition to the oral report, the permittee shall submit to the Director or Designee a written report as provided in Part I.C.2.c no later than five (5) days after becoming aware of the occurrence of such discharge.

b. If for any reason, the permittee's discharge does not comply with any limitation of this permit, the permittee shall submit to the Director or Designee a written report as provided in Part I.C.2.c below, such report shall be submitted with the next Discharge Monitoring Report required to be submitted by Part I.C.1 of this permit after becoming aware of the occurrence of such noncompliance.

c. Any written report required to be submitted to the Director or Designee by Part I.C.2 a. or b. shall be submitted using a copy of the Noncompliance Notification Form provided with this permit and shall include the following information:

(1) A description of the discharge and cause of noncompliance;

(2) The period of noncompliance, including exact dates and times or, if not corrected, the anticipated time the noncompliance is expected to continue; and

(3) A description of the steps taken and/or being taken to reduce or eliminate the noncomplying discharge and to prevent its recurrence.

D. OTHER REPORTING AND NOTIFICATION REQUIREMENTS

1. Anticipated Noncompliance

The permittee shall give the Director written advance notice of any planned changes or other circumstances regarding a facility which may result in noncompliance with permit requirements.

2. Termination of Discharge

The permittee shall notify the Director, in writing, when all discharges from any point source(s) identified in Provision I. A. of this permit have permanently ceased. This notification shall serve as sufficient cause for instituting procedures for modification or termination of the permit.

3. Updating Information

   a. The permittee shall inform the Director of any change in the permittee's mailing address, telephone number or in the permittee's designation of a facility contact or office having the authority and responsibility to prevent and abate violations of the AWPCA, the Department's Rules, and the terms and conditions of this permit, in writing, no later than ten (10) days after such change. Upon request of the Director or his designee, the permittee shall furnish the Director with an update of any information provided in the permit application.

   b. If the permittee becomes aware that it failed to submit any relevant facts in a permit application, or submitted incorrect information in a permit application or in any report to the Director, it shall promptly submit such facts or information with a written explanation for the mistake and/or omission.

4. Duty to Provide Information

   The permittee shall furnish to the Director, within a reasonable time, any information which the Director or his designee may request to determine whether cause exists for modifying, revoking and re-issuing, suspending, or terminating this permit, in whole or in part, or to determine compliance with this permit.

5. Cooling Water and Boiler Water Additives

   a. The permittee shall notify the Director in writing not later than thirty (30) days prior to instituting the use of any biocide corrosion inhibitor or chemical additive in a cooling or boiler system, not identified in the application for this permit, from which discharge is allowed by this permit. Notification is not required for additives that do not contain a heavy metal(s) as an active ingredient and that pass through a wastewater treatment system prior to discharge nor is notification required for additives that should not reasonably be expected to cause the cooling water or boiler water to exhibit toxicity as determined by analysis of manufacturer's data or testing by the permittee. Such notification shall include:

      (1) name and general composition of biocide or chemical;

      (2) 96-hour median tolerance limit data for organisms representative of the biota of the waterway into which the discharge will ultimately reach;

      (2) quantities to be used;

      (3) frequencies of use;

      (4) proposed discharge concentrations; and

      (6) EPA registration number, if applicable.

   b. The use of a biocide or additive containing tributyl tin, tributyl tin oxide, zinc, chromium or related compounds in cooling or boiler system(s), from which a discharge regulated by this permit occurs, is prohibited except as exempted below. The use of a biocide or additive containing zinc, chromium or related compounds may be used in special circumstances if (1) the permit contains limits for these substances, or (2) the applicant demonstrates during the application process that the use of zinc, chromium or related compounds as a biocide or additive will not pose a reasonable potential to violate the applicable State water quality standards for these substances. The use of any additive, not identified in this permit or in the application for this permit or not exempted from notification under this permit is prohibited, prior to a determination by the Department that permit modification to control discharge of the additive is not required or prior to issuance of a permit modification controlling discharge of the additive.

6. Permit Issued Based On Estimated Characteristics

   a. If this permit was issued based on estimates of the characteristics of a process discharge reported on an EPA NPDES Application Form 2D (EPA Form 3510-2D), the permittee shall complete and submit an EPA NPDES Application Form 2C (EPA Form 3510-2C) no later than two years after the date that discharge begins. Sampling required for completion of the Form 2C shall occur when a discharge(s) from the process(s) causing the new or increased discharge is occurring. If this permit was issued based on estimates concerning the composition of a stormwater discharge(s), the permittee shall perform the sampling required by EPA NPDES Application Form 2F (EPA Form 3510-2F) no later than one year after the industrial activity generating the stormwater discharge has been fully initiated.

   b. This permit shall be reopened if required to address any new information resulting from the completion and submittal of the Form 2C and or 2F.

E. SCHEDULE OF COMPLIANCE

1. The permittee shall achieve compliance with the discharge limitations specified in Provision I. A. in accordance with the following schedule:

COMPLIANCE SHALL BE ATTAINED ON THE EFFECTIVE DATE OF THIS PERMIT

2. No later than 14 calendar days following a date identified in the above schedule of compliance, the permittee shall submit either a report of progress or, in the case of specific actions being required by identified dates, a written notice of compliance or noncompliance. In the latter case, the notice shall include the cause of noncompliance, any remedial actions taken, and the probability of meeting the next scheduled requirement.

PART II OTHER REQUIREMENTS, RESPONSIBILITIES, AND DUTIES

A. OPERATIONAL AND MANAGEMENT REQUIREMENTS

1. Facilities Operation and Maintenance

The permittee shall at all times properly operate and maintain all facilities and systems of treatment and control (and related appurtenances) which are installed or used by the permittee to achieve compliance with the conditions of the permit. Proper operation and maintenance includes effective performance, adequate funding, adequate operator staffing and training, and adequate laboratory and process controls, including appropriate quality assurance procedures. This provision requires the operation of backup or auxiliary facilities only when necessary to achieve compliance with the conditions of the permit.

2. Best Management Practices

a. Dilution water shall not be added to achieve compliance with discharge limitations except when the Director or his designee has granted prior written authorization for dilution to meet water quality requirements.

b. The permittee shall prepare, implement, and maintain a Spill Prevention, Control and Countermeasures (SPCC) Plan in accordance with 40 C.F.R. Section 112 if required thereby.

c. The permittee shall prepare, submit for approval and implement a Best Management Practices (BMP) Plan for containment of any or all process liquids or solids, in a manner such that these materials do not present a significant potential for discharge, if so required by the Director or his designee. When submitted and approved, the BMP Plan shall become a part of this permit and all requirements of the BMP Plan shall become requirements of this permit.

3. Spill Prevention, Control, and Management

The permittee shall provide spill prevention, control, and/or management sufficient to prevent any spills of pollutants from entering a water of the state or a publicly or privately owned treatment works. Any containment system used to implement this requirement shall be constructed of materials compatible with the substance(s) contained and which shall prevent the contamination of groundwater and such containment system shall be capable of retaining a volume equal to 110 percent of the capacity of the largest tank for which containment is provided.

B. OTHER RESPONSIBILITIES

1. Duty to Mitigate Adverse Impacts

The permittee shall promptly take all reasonable steps to mitigate and minimize or prevent any adverse impact on human health or the environment resulting from noncompliance with any discharge limitation specified in Provision I. A. of this permit, including such accelerated or additional monitoring of the discharge and/or the receiving waterbody as necessary to determine the nature and impact of the noncomplying discharge.

2. Right of Entry and Inspection

The permittee shall allow the Director, or an authorized representative, upon the presentation of proper credentials and other documents as may be required by law to:

a. enter upon the permittee's premises where a regulated facility or activity or point source is located or conducted, or where records must be kept under the conditions of the permit;

b. have access to and copy, at reasonable times, any records that must be kept under the conditions of the permit;

c. inspect any facilities, equipment (including monitoring and control equipment), practices, or operations regulated or required under the permit; and

d. sample or monitor, for the purposes of assuring permit compliance or as otherwise authorized by the AWPCA, any substances or parameters at any location.

C. BYPASS AND UPSET

1. Bypass

a. Any bypass is prohibited except as provided in b. and c. below:

b. A bypass is not prohibited if:

(1) It does not cause any discharge limitation specified in Provision I. A. of this permit to be exceeded;

(2) It enters the same receiving stream as the permitted outfall; and

(3) It is necessary for essential maintenance of a treatment or control facility or system to assure efficient operation of such facility or system.

c. A bypass is not prohibited and need not meet the discharge limitations specified in Provision I. A. of this permit if:

(1) It is unavoidable to prevent loss of life, personal injury, or severe property damage;

(2) There are no feasible alternatives to the bypass, such as the use of auxiliary treatment facilities, retention of untreated wastes, or maintenance during normal periods of equipment downtime (this condition is not satisfied if adequate back-up equipment should have been installed in the exercise of reasonable engineering judgment to prevent a bypass which occurred during normal periods of equipment downtime or preventive maintenance); and

(3) The permittee submits a written request for authorization to bypass to the Director at least ten (10) days prior to the anticipated bypass (if possible), the permittee is granted such authorization, and the permittee complies with any conditions imposed by the Director to minimize any adverse impact on human health or the environment resulting from the bypass.

d. The permittee has the burden of establishing that each of the conditions of Provision II.C.1.b. or c. have been met to qualify for an exception to the general prohibition against bypassing contained in a. and an exemption, where applicable, from the discharge limitations specified in Provision I. A. of this permit.

2. Upset

a. A discharge which results from an upset need not meet the discharge limitations specified in Provision I. A. of this permit if:

(1) No later than 24-hours after becoming aware of the occurrence of the upset, the permittee orally reports the occurrence and circumstances of the upset to the Director or his designee; and

(2) No later than five (5) days after becoming aware of the occurrence of the upset, the permittee furnishes the Director with evidence, including properly signed, contemporaneous operating logs, or other relevant evidence, demonstrating that (i) an upset occurred; (ii) the permittee can identify the specific cause(s) of the upset; (iii) the permittee's facility was being properly operated at the time of the upset; and (iv) the permittee promptly took all reasonable steps to minimize any adverse impact on human health or the environment resulting from the upset.

b. The permittee has the burden of establishing that each of the conditions of Provision II. C.2.a. of this permit have been met to qualify for an exemption from the discharge limitations specified in Provision I.A. of this permit.

D. DUTY TO COMPLY WITH PERMIT, RULES, AND STATUTES

1. Duty to Comply

a. The permittee must comply with all conditions of this permit. Any permit noncompliance constitutes a violation of the AWPCA and the FWPCA and is grounds for enforcement action, for permit termination, revocation and reissuance, suspension, modification; or denial of a permit renewal application.

b. The necessity to halt or reduce production or other activities in order to maintain compliance with the conditions of the permit shall not be a defense for a permittee in an enforcement action.

c. The discharge of a pollutant from a source not specifically identified in the permit application for this permit and not specifically included in the description of an outfall in this permit is not authorized and shall constitute noncompliance with this permit.

d. The permittee shall take all reasonable steps, including cessation of production or other activities, to minimize or prevent any violation of this permit or to minimize or prevent any adverse impact of any permit violation.

e. Nothing in this permit shall be construed to preclude and negate the permittee's responsibility or liability to apply for, obtain, or comply with other ADEM, Federal, State, or Local Government permits, certifications, licenses, or other approvals.

2. Removed Substances

Solids, sludges, filter backwash, or any other pollutant or other waste removed in the course of treatment or control of wastewaters shall be disposed of in a manner that complies with all applicable Department Rules.

3. Loss or Failure of Treatment Facilities

Upon the loss or failure of any treatment facilities, including but not limited to the loss or failure of the primary source of power of the treatment facility, the permittee shall, where necessary to maintain compliance with the discharge limitations specified in Provision I. A. of this permit, or any other terms or conditions of this permit, cease, reduce, or otherwise control production and/or all discharges until treatment is restored. If control of discharge during loss or failure of the primary source of power is to be accomplished by means of alternate power sources, standby generators, or retention of inadequately treated effluent, the permittee must furnish to the Director within six months a certification that such control mechanisms have been installed.

4. Compliance with Statutes and Rules

a. This permit has been issued under ADEM Administrative Code, Chapter 335-6-6. All provisions of this chapter, that are applicable to this permit, are hereby made a part of this permit. A copy of this chapter may be obtained for a small charge from the Office of General Counsel, Alabama Department of Environmental Management, 1400 Coliseum Blvd., Montgomery, AL 36130.

b. This permit does not authorize the noncompliance with or violation of any Laws of the State of Alabama or the United States of America or any regulations or rules implementing such laws. FWPCA, 33 U.S.C. Section 1319, and Code of Alabama 1975, Section 22-22-14.

E. PERMIT TRANSFER, MODIFICATION, SUSPENSION, REVOCATION, AND REISSUANCE

1. Duty to Reapply or Notify of Intent to Cease Discharge

a. If the permittee intends to continue to discharge beyond the expiration date of this permit, the permittee shall file a complete permit application for reissuance of this permit at least 180 days prior to its expiration. If the permittee does not intend to continue discharge beyond the expiration of this permit, the permittee shall submit written notification of this intent which shall be signed by an individual meeting the signatory requirements for a permit application as set forth in ADEM Administrative Code Rule 335-6-6-.09.

b. Failure of the permittee to apply for reissuance at least 180 days prior to permit expiration will void the automatic continuation of the expiring permit provided by ADEM Administrative Code Rule 335-6-6-.06 and should the permit not be reissued for any reason any discharge after expiration of this permit will be an unpermitted discharge.

2. Change in Discharge

a. The permittee shall apply for a permit modification at least 180 days in advance of any facility expansion, production increase, process change, or other action that could result in the discharge of additional pollutants or increase the quantity of a discharged pollutant such that existing permit limitations would be exceeded or that could result in an additional discharge point. This requirement applies to pollutants that are or that are not subject to discharge limitations in this permit. No new or increased discharge may begin until the Director has authorized it by issuance of a permit modification or a reissued permit.

b. The permittee shall notify the Director as soon as it is known or there is reason to believe:

(1) That any activity has occurred or will occur which would result in the discharge on a routine or frequent basis, of any toxic pollutant which is not limited in this permit, if that discharge will exceed the highest of the following notification levels:

(a) one hundred micrograms per liter;

(b) two hundred micrograms per liter for acrolein and acrylonitrile; five hundred micrograms per liter for 2,4-dinitrophenol and for 2-methyl-4,6-dini-trophenol; and one milligram per liter for antimony;

(c) five times the maximum concentration value reported for that pollutant in the permit application; or

(2) That any activity has occurred or will occur which would result in any discharge, on a non-routine or infrequent basis, of a toxic pollutant which is not limited in the permit, if that discharge will exceed the highest of the following notification levels:

(a) five hundred micrograms per liter;

(b) one milligram per liter for antimony;

(c) ten times the maximum concentration value reported for that pollutant in the permit application.

3. Transfer of Permit

This permit may not be transferred or the name of the permittee changed without notice to the Director and subsequent modification or revocation and reissuance of the permit to identify the new permittee and to incorporate any other changes as may be required under the FWPCA or AWPCA. In the case of a change in name, ownership or control of the permittee's premises only, a request for permit modification in a format acceptable to the Director is required at least 30 days prior to the change. In the case of a change in name, ownership or control of the permittee's premises accompanied by a change or proposed change in effluent characteristics, a complete permit application is required to be submitted to the Director at least 180 days prior to the change. Whenever the Director is notified of a change in name, ownership or control, he may decide not to modify the existing permit and require the submission of a new permit application.

4. Permit Modification and Revocation

a. This permit may be modified or revoked and reissued, in whole or in part, during its term for cause, including but not limited to, the following:

(1) If cause for termination under Provision II. E. 5. of this permit exists, the Director may choose to revoke and reissue this permit instead of terminating the permit;

(2) If a request to transfer this permit has been received, the Director may decide to revoke and reissue or to modify the permit; or

(3) If modification or revocation and reissuance is requested by the permittee and cause exists, the Director may grant the request.

b. This permit may be modified during its term for cause, including but not limited to, the following:

(1) If cause for termination under Provision II. E. 5. of this permit exists, the Director may choose to modify this permit instead of terminating this permit;

(2) There are material and substantial alterations or additions to the facility or activity generating wastewater which occurred after permit issuance which justify the application of permit conditions that are different or absent in the existing permit;

(3) The Director has received new information that was not available at the time of permit issuance and that would have justified the application of different permit conditions at the time of issuance;

(4) A new or revised requirement(s) of any applicable standard or limitation is promulgated under Sections 301(b)(2)(C), (D), (E), and (F), and 307(a)(2) of the FWPCA;

(5) Errors in calculation of discharge limitations or typographical or clerical errors were made;

(6) To the extent allowed by ADEM Administrative Code, Rule 335-6-6-.17, when the standards or regulations on which the permit was based have been changed by promulgation of amended standards or regulations or by judicial decision after the permit was issued;

(7) To the extent allowed by ADEM Administrative Code, Rule 335-6-6-.17, permits may be modified to change compliance schedules;

(8) To agree with a granted variance under 301(c), 301(g), 301(h), 301(k), or 316(a) of the FWPCA or for fundamentally different factors;

(9) To incorporate an applicable 307(a) FWPCA toxic effluent standard or prohibition;

(10) When required by the reopener conditions in this permit;

(11) When required under 40 CFR 403.8(e) (compliance schedule for development of pretreatment program);

(12) Upon failure of the state to notify, as required by Section 402(b)(3) of the FWPCA, another state whose waters may be affected by a discharge permitted by this permit;

(13) When required to correct technical mistakes, such as errors in calculation, or mistaken interpretations of law made in determining permit conditions; or

(14) When requested by the permittee and the Director determines that the modification has cause and will not result in a violation of federal or state law, regulations or rules.

5. Permit Termination

This permit may be terminated during its term for cause, including but not limited to, the following:

a. Violation of any term or condition of this permit;

b. The permittee's misrepresentation or failure to disclose fully all relevant facts in the permit application or during the permit issuance process or the permittee's misrepresentation of any relevant facts at any time;

c. Materially false or inaccurate statements or information in the permit application or the permit;

d. A change in any condition that requires either a temporary or permanent reduction or elimination of the permitted discharge;

e. The permittee's discharge threatens human life or welfare or the maintenance of water quality standards;

f. Permanent closure of the facility generating the wastewater permitted to be discharged by this permit or permanent cessation of wastewater discharge;

g. New or revised requirements of any applicable standard or limitation that is promulgated under Sections 301(b)(2)(C), (D), (E), and (F), and 307(a)(2) of the FWPCA that the Director determines cannot be complied with by the permittee; or

h. Any other cause allowed by the ADEM Administrative Code, Chapter 335-6-6.

6. Permit Suspension

This permit may be suspended during its term for noncompliance until the permittee has taken action(s) necessary to achieve compliance.

7. Request for Permit Action Does Not Stay Any Permit Requirement

The filing of a request by the permittee for modification, suspension or revocation of this permit, in whole or in part, does not stay any permit term or condition.

F. COMPLIANCE WITH TOXIC POLLUTANT STANDARD OR PROHIBITION

If any applicable effluent standard or prohibition (including any schedule of compliance specified in such effluent standard or prohibition) is established under Section 307(a) of the FWPCA, 33 U.S.C. Section 1317(a), for a toxic pollutant discharged by the permittee and such standard or prohibition is more stringent than any discharge limitation on the pollutant specified in Provision I. A. of this permit, or controls a pollutant not limited in Provision I. A. of this permit, this permit shall be modified to conform to the toxic pollutant effluent standard or prohibition and the permittee shall be notified of such modification. If this permit has not been modified to conform to the toxic pollutant effluent standard or prohibition before the effective date of such standard or prohibition, the permittee shall attain compliance with the requirements of the standard or prohibition within the time period required by the standard or prohibition and shall continue to comply with the standard or prohibition until this permit is modified or reissued.

G. DISCHARGE OF WASTEWATER GENERATED BY OTHERS

The discharge of wastewater, generated by any process, facility, or by any other means not under the operational control of the permittee or not identified in the application for this permit or not identified specifically in the description of an outfall in this permit is not authorized by this permit.

PART III OTHER PERMIT CONDITIONS

A. CIVIL AND CRIMINAL LIABILITY

1. Tampering

Any person who falsifies, tampers with, or knowingly renders inaccurate any monitoring device or method required to be maintained or performed under the permit shall, upon conviction, be subject to penalties as provided by the AWPCA.

2. False Statements

Any person who knowingly makes any false statement, representation, or certification in any record or other document submitted or required to be maintained under this permit, including monitoring reports or reports of compliance or noncompliance shall, upon conviction, be subject to penalties as provided by the AWPCA.

3. Permit Enforcement

a. Any NPDES permit issued or reissued by the Department is a permit for the purpose of the AWPCA and the FWPCA and as such any terms, conditions, or limitations of the permit are enforceable under state and federal law.

b. Any person required to have a NPDES permit pursuant to ADEM Administrative Code Chapter 335-6-6 and who discharges pollutants without said permit, who violates the conditions of said permit, who discharges pollutants in a manner not authorized by the permit, or who violates applicable orders of the Department or any applicable rule or standard of the Department. is subject to any one or combination of the following enforcement actions under applicable state statutes.

(1) An administrative order requiring abatement, compliance, mitigation, cessation, clean-up, and/or penalties;

(2) An action for damages;

(3) An action for injunctive relief; or

(4) An action for penalties.

c. If the permittee is not in compliance with the conditions of an expiring or expired permit the Director may choose to do any or all of the following provided the permittee has made a timely and complete application for reissuance of the permit:

(1) initiate enforcement action based upon the permit which has been continued;

(2) issue a notice of intent to deny the permit reissuance. If the permit is denied, the owner or operator would then be required to cease the activities authorized by the continued permit or be subject to enforcement action for operating without a permit;

(3) reissue the new permit with appropriate conditions; or

(4) take other actions authorized by these rules and AWPCA.

4. Relief from Liability

Except as provided in Provision II.C.1 (Bypass) and Provision II.C.2 (Upset), nothing in this permit shall be construed to relieve the permittee of civil or criminal liability under the AWPCA or FWPCA for noncompliance with any term or condition of this permit.

B. OIL AND HAZARDOUS SUBSTANCE LIABILITY

Nothing in this permit shall be construed to preclude the institution of any legal action or relieve the permittee from any responsibilities, liabilities or penalties to which the permittee is or may be subject under Section 311 of the FWPCA, 33 U.S.C. Section 1321.

C. PROPERTY AND OTHER RIGHTS

This permit does not convey any property rights in either real or personal property, or any exclusive privileges, nor does it authorize any injury to persons or property or invasion of other private rights, trespass, or any infringement of federal, state, or local laws or regulations, nor does it authorize or approve the construction of any physical structures or facilities or the undertaking of any work in any waters of the state or of the United States.

D. AVAILABILITY OF REPORTS

Except for data determined to be confidential under Code of Alabama 1975, Section 22-22-9(c), all reports prepared in accordance with the terms of this permit shall be available for public inspection at the offices of the Department. Effluent data shall not be considered confidential.

E. EXPIRATION OF PERMITS FOR NEW OR INCREASED DISCHARGES

1. If this permit was issued for a new discharger or new source, this permit shall expire eighteen months after the issuance date if construction of the facility has not begun during the eighteen-month period.

2. If this permit was issued or modified to allow the discharge of increased quantities of pollutants to accommodate the modification of an existing facility and if construction of this modification has not begun during the eighteen month period after issuance of this permit or permit modification, this permit shall be modified to reduce the quantities of pollutants allowed to be discharged to those levels that would have been allowed if the modification of the facility had not been planned.

3. Construction has begun when the owner or operator has:

   a. begun, or caused to begin as part of a continuous on-site construction program:

      (1) any placement, assembly, or installation of facilities or equipment; or

      (2) significant site preparation work including clearing, excavation, or removal of existing buildings, structures, or facilities which is necessary for the placement, assembly, or installation of new source facilities or equipment; or

   b. entered into a binding contractual obligation for the purpose of placement, assembly, or installation of facilities or equipment which are intended to be used in its operation within a reasonable time. Options to purchase or contracts which can be terminated or modified without substantial loss, and contracts for feasibility, engineering, and design studies do not constitute a contractual obligation under the paragraph. The entering into a lease with the State of Alabama for exploration and production of hydrocarbons shall also be considered beginning construction.

F. COMPLIANCE WITH WATER QUALITY STANDARDS

1. On the basis of the permittee's application, plans, or other available information, the Department has determined that compliance with the terms and conditions of this permit should assure compliance with the applicable water quality standards.

2. Compliance with permit terms and conditions notwithstanding, if the permittee's discharge(s) from point sources identified in Provision I. A. of this permit cause or contribute to a condition in contravention of state water quality standards, the Department may require abatement action to be taken by the permittee in emergency situations or modify the permit pursuant to the Department's Rules, or both.

3. If the Department determines, on the basis of a notice provided pursuant to this permit or any investigation, inspection or sampling, that a modification of this permit is necessary to assure maintenance of water quality standards or compliance with other provisions of the AWPCA or FWPCA, the Department may require such modification and, in cases of emergency, the Director may prohibit the discharge until the permit has been modified.

G. GROUNDWATER

Unless specifically authorized by a permit issued by the Department, the discharge of pollutants to groundwater is prohibited. Should a threat of groundwater contamination occur, the Director may require groundwater monitoring to properly assess the degree of the problem and the Director may require that the permittee undertake measures to abate any such discharge and/or contamination.

H. DEFINITIONS

1. Average monthly discharge limitation - means the highest allowable average of "daily discharges" over a calendar month, calculated as the sum of all "daily discharges" measured during a calendar month divided by the number of "daily discharges" measured during that month (zero discharge days shall not be included in the number of "daily discharges" measured and a less than detectable test result shall be treated as a concentration of zero if the most sensitive EPA approved method was used).

2. Average weekly discharge limitation - means the highest allowable average of "daily discharges" over a calendar week, calculated as the sum of all "daily discharges" measured during a calendar week divided by the number of "daily discharges" measured during that week (zero discharge days shall not be included in the number of "daily discharges" measured and a less than detectable test result shall be treated as a concentration of zero if the most sensitive EPA approved method was used).

3. Arithmetic Mean – means the summation of the individual values of any set of values divided by the number of individual values.

4. AWPCA - means the Alabama Water Pollution Control Act.

5. BOD – means the five-day measure of the pollutant parameter biochemical oxygen demand.

6. Bypass - means the intentional diversion of waste streams from any portion of a treatment facility.

7. CBOD – means the five-day measure of the pollutant parameter carbonaceous biochemical oxygen demand.

8. Daily discharge - means the discharge of a pollutant measured during any consecutive 24-hour period in accordance with the sample type and analytical methodology specified by the discharge permit.

9. Daily maximum - means the highest value of any individual sample result obtained during a day.

10. Daily minimum - means the lowest value of any individual sample result obtained during a day.

11. Day - means any consecutive 24-hour period.

12. Department - means the Alabama Department of Environmental Management.

13. Director - means the Director of the Department.

14. Discharge - means "[t]he addition, introduction, leaking, spilling or emitting of any sewage, industrial waste, pollutant or other wastes into waters of the state". Code of Alabama 1975, Section 22-22-1(b)(8).

15. Discharge Monitoring Report (DMR) - means the form approved by the Director to accomplish reporting requirements of an NPDES permit.

16. DO – means dissolved oxygen.

17. 8HC – means 8-hour composite sample, including any of the following:

    a. The mixing of at least 5 equal volume samples collected at constant time intervals of not more than 2 hours over a period of not less than 8 hours between the hours of 6:00 a.m. and 6:00 p.m. If the sampling period exceeds 8 hours, sampling may be conducted beyond the 6:00 a.m. to 6:00 p.m. period.

    b. A sample continuously collected at a constant rate over period of not less than 8 hours between the hours of 6:00 a.m. and 6:00 p.m. If the sampling period exceeds 8 hours, sampling may be conducted beyond the 6:00 a.m. to 6:00 p.m. period.

18. EPA - means the United States Environmental Protection Agency.

19. FC – means the pollutant parameter fecal coliform.

20. Flow – means the total volume of discharge in a 24-hour period.

21. FWPCA - means the Federal Water Pollution Control Act.

22. Geometric Mean – means the Nth root of the product of the individual values of any set of values where N is equal to the number of individual values. The geometric mean is equivalent to the antilog of the arithmetic mean of the logarithms of the individual values. For purposes of calculating the geometric mean, values of zero (0) shall be considered one (1).

23. Grab Sample – means a single influent or effluent portion which is not a composite sample. The sample(s) shall be collected at the period(s) most representative of the discharge.

24. Indirect Discharger – means a nondomestic discharger who discharges pollutants to a publicly owned treatment works or a privately owned treatment facility operated by another person.

25. Industrial User – means those industries identified in the Standard Industrial Classification manual, Bureau of the Budget 1967, as amended and supplemented, under the category "Division D – Manufacturing" and such other classes of significant waste producers as, by regulation, the Director deems appropriate.

26. MGD – means million gallons per day.

27. Monthly Average – means, other than for fecal coliform bacteria, the arithmetic mean of the entire composite or grab samples taken for the daily discharges collected in one month period. The monthly average for fecal coliform bacteria is the geometric

mean of daily discharge samples collected in a one month period. The monthly average for flow is the arithmetic mean of all flow measurements taken in a one month period.

28. New Discharger – means a person, owning or operating any building, structure, facility or installation:

    a. from which there is or may be a discharge of pollutants;

    b. that did not commence the discharge of pollutants prior to August 13, 1979, and which is not a new source; and

    c. which has never received a final effective NPDES permit for dischargers at that site.

29. NH3-N – means the pollutant parameter ammonia, measured as nitrogen.

30. Permit application - means forms and additional information that is required by ADEM Administrative Code Rule 335-6-6-.08 and applicable permit fees.

31. Point source - means "any discernible, confined and discrete conveyance, including but not limited to any pipe, channel, ditch, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, . . . from which pollutants are or may be discharged." Section 502(14) of the FWPCA, 33 U.S.C. Section 1362(14).

32. Pollutant - includes for purposes of this permit, but is not limited to, those pollutants specified in Code of Alabama 1975, Section 22-22-1(b)(3) and those effluent characteristics specified in Provision I. A. of this permit.

33. Privately Owned Treatment Works – means any devices or system which is used to treat wastes from any facility whose operator is not the operator of the treatment works, and which is not a "POTW".

34. Publicly Owned Treatment Works – means a wastewater collection and treatment facility owned by the State, municipality, regional entity composed of two or more municipalities, or another entity created by the State or local authority for the purpose of collecting and treating municipal wastewater.

35. Receiving Stream – means the "waters" receiving a "discharge" from a "point source".

36. Severe property damage - means substantial physical damage to property, damage to the treatment facilities which causes them to become inoperable, or substantial and permanent loss of natural resources which can reasonably be expected to occur in the absence of a bypass. Severe property damage does not mean economic loss caused by delays in production.

37. Significant Source – means a source which discharges 0.025 MGD or more to a POTW or greater than five percent of the treatment work's capacity, or a source which is a primary industry as defined by the U.S. EPA or which discharges a priority or toxic pollutant.

38. TKN – means the pollutant parameter Total Kjeldahl Nitrogen.

39. TON – means the pollutant parameter Total Organic Nitrogen.

40. TRC – means Total Residual Chlorine.

41. TSS – means the pollutant parameter Total Suspended Solids.

42. 24HC – means 24-hour composite sample, including any of the following:

    a. the mixing of at least 12 equal volume samples collected at constant time intervals of not more than 2 hours over a period of 24 hours;

    b. a sample collected over a consecutive 24-hour period using an automatic sampler composite to one sample. As a minimum, samples shall be collected hourly and each shall be no more than one twenty-fourth (1/24) of the total sample volume collected; or

    c. a sample collected over a consecutive 24-hour period using an automatic composite sampler composited proportional to flow.

43. Upset - means an exceptional incident in which there is an unintentional and temporary noncompliance with technology-based permit discharge limitations because of factors beyond the reasonable control of the permittee. An upset does not include noncompliance to the extent caused by operational error, improperly designed treatment facilities, inadequate treatment facilities, lack of preventive maintenance, or careless or improper operation.

44. Waters - means "[a]ll waters of any river, stream, watercourse, pond, lake, coastal, ground or surface water, wholly or partially within the state, natural or artificial. This does not include waters which are entirely confined and retained completely upon the

property of a single individual, partnership or corporation unless such waters are used in interstate commerce." Code of Alabama 1975, Section 22-22-1(b)(2). Waters "include all navigable waters" as defined in Section 502(7) of the FWPCA, 22 U.S.C. Section 1362(7), which are within the State of Alabama.

45. Week - means the period beginning at twelve midnight Saturday and ending at twelve midnight the following Saturday.

46. Weekly (7-day and calendar week) Average – is the arithmetic mean of all samples collected during a consecutive 7-day period or calendar week, whichever is applicable. The calendar week is defined as beginning on Sunday and ending on Saturday. Weekly averages shall be calculated for all calendar weeks with Saturdays in the month. If a calendar week overlaps two months (i.e., the Sunday is in one month and the Saturday in the following month), the weekly average calculated for the calendar week shall be included in the data for the month that contains the Saturday.

SEVERABILITY

The provisions of this permit are severable, and if any provision of this permit or the application of any provision of this permit to any circumstance is held invalid, the application of such provision to other circumstances, and the remainder of this permit shall not be affected thereby.

PART IV ADDITIONAL REQUIREMENTS, CONDITIONS, AND LIMITATIONS

A. BEST MANAGEMENT PRACTICES (BMP) PLAN REQUIREMENTS

1. BMP Plan

The permittee shall develop and implement a Best Management Practices (BMP) Plan which prevents, or minimizes the potential for, the release of pollutants from ancillary activities, including material storage areas; plant site runoff; in-plant transfer, process and material handling areas; loading and unloading operations, and sludge and waste disposal areas, to the waters of the State through plant site runoff; spillage or leaks; sludge or waste disposal; or drainage from raw material storage.

2. Plan Content

The permittee shall prepare and implement a best management practices (BMP) plan, which shall:

a. Establish specific objectives for the control of pollutants:

(1) Each facility component or system shall be examined for its potential for causing a release of significant amounts of pollutants to waters of the State due to equipment failure, improper operation, natural phenomena such as rain or snowfall, etc.

(2) Where experience indicates a reasonable potential for equipment failure (e.g., a tank overflow or leakage), natural condition (e.g. precipitation), or circumstances to result in significant amounts of pollutants reaching surface waters, the plan should include a prediction of the direction, rate of flow, and total quantity of pollutants which could be discharged from the facility as a result of each condition or circumstance.

b. Establish specific best management practices to meet the objectives identified under paragraph a. of this section, addressing each component or system capable of causing a release of significant amounts of pollutants to the waters of the State, and identifying specific preventative or remedial measures to be implemented;

c. Establish a program to identify and repair leaking equipment items and damaged containment structures, which may contribute to contaminated stormwater runoff. This program must include regular visual inspections of equipment, containment structures and of the facility in general to ensure that the BMP is continually implemented and effective:

d. Prevent the spillage or loss of fluids, oil, grease, gasoline, etc. from vehicle and equipment maintenance activities and thereby prevent the contamination of stormwater from these substances;

e. Prevent or minimize stormwater contact with material stored on site;

f. Designate by position or name the person or persons responsible for the day to day implementation of the BMP:

g. Provide for routine inspections, on days during which the facility is manned, of any structures that function to prevent stormwater pollution or to remove pollutants from stormwater and of the facility in general to ensure that the BMP is continually implemented and effective;

h. Provide for the use and disposal of any material used to absorb spilled fluids that could contaminate stormwater;

i. Develop a solvent management plan, if solvents are used on site. The solvent management plan shall include as a minimum lists of the total organic compounds on site; the method of disposal used instead of dumping, such as reclamation, contract hauling; and the procedures for assuring that toxic organics do not routinely spill or leak into the stormwater;

j. Provide for the disposal of all used oils, hydraulic fluids, solvent degreasing material, etc. in accordance with good management practices and any applicable state or federal regulations;

k. Include a diagram of the facility showing the locations where stormwater exits the facility, the locations of any structure or other mechanisms intended to prevent pollution of stormwater or to remove pollutants from stormwater, the locations of any collection and handling systems;

l. Provide control sufficient to prevent or control pollution of stormwater by soil particles to the degree required to maintain compliance with the water quality standard for turbidity applicable to the waterbody(s) receiving discharge(s) under this permit;

m. Provide spill prevention, control, and/or management sufficient to prevent or minimize contaminated stormwater runoff. Any containment system used to implement this requirement shall be constructed of materials compatible with the substance(s) contained and shall prevent the contamination of groundwater. The containment system shall also be

capable of retaining a volume equal to 110 percent of the capacity of the largest tank for which containment is provided;

n. Provide and maintain curbing, diking or other means of isolating process areas to the extent necessary to allow segregation and collection for treatment of contaminated stormwater from process areas;

o. Be reviewed by plant engineering staff and the plant manager; and

p. Bear the signature of the plant manager.

3. Compliance Schedule

The permittee shall have reviewed (and revised if necessary) and fully implemented the BMP plan as soon as practicable but no later than six months after the effective date of this permit.

4. Department Review

a. When requested by the Director or his designee, the permittee shall make the BMP available for Department review.

b. The Director or his designee may notify the permittee at any time that the BMP is deficient and require correction of the deficiency.

c. The permittee shall correct any BMP deficiency identified by the Director or his designee within 30 days of receipt of notification and shall certify to the Department that the correction has been made and implemented.

5. Administrative Procedures

a. A copy of the BMP shall be maintained at the facility and shall be available for inspection by representatives of the Department.

b. A log of the routine inspection required above shall be maintained at the facility and shall be available for inspection by representatives of the Department. The log shall contain records of all inspections performed for the last three years and each entry shall be signed by the person performing the inspection.

c. The permittee shall provide training for any personnel required to implement the BMP and shall retain documentation of such training at the facility. This documentation shall be available for inspection by representatives of the Department. Training shall be performed prior to the date that implementation of the BMP is required.

d. BMP Plan Modification. The permittee shall amend the BMP plan whenever there is a change in the facility or change in operation of the facility which materially increases the potential for the ancillary activities to result in a discharge of significant amounts of pollutants.

e. BMP Plan Review. The permittee shall complete a review and evaluation of the BMP plan at least once every three years from the date of preparation of the BMP plan. Documentation of the BMP Plan review and evaluation shall be signed and dated by the Plant Manager.

B. STORMWATER FLOW MEASUREMENT AND SAMPLING REQUIREMENTS

1. Stormwater Flow Measurement

a. All stormwater samples shall be collected from the discharge resulting from a storm event that is greater than 0.1 inches.

b. The total volume of stormwater discharged for the event must be monitored, including the date and duration (in hours) and rainfall (in inches) for storm event(s) sampled. The duration between the storm event sampled and the end of the previous measurable (greater than 0.1 inch rainfall) storm event must be a minimum of 72 hours. This information must be recorded as part of the sampling procedure and records retained according to Part I.B. of this permit.

c. The volume may be measured using flow measuring devices, or estimated based on a modification of the Rational Method using total depth of rainfall, the size of the drainage area serving a stormwater outfall, and an estimate of the runoff coefficient of the drainage area. This information must be recorded as part of the sampling procedure and records retained according to Part I.B. of this permit.

2. Stormwater Sampling

a. A grab sample, if required by this permit, shall be taken during the first thirty minutes of the discharge (or as soon thereafter as practicable); and a flow-weighted composite sample, if required by this permit, shall be taken for the entire event or for the first three hours of the event.

b. All test procedures will be in accordance with part I.B. of this permit.

C. EFFLUENT TOXICITY LIMITATIONS AND BIOMONITORING REQUIREMENTS

1. The permittee shall perform short-term chronic toxicity tests on the wastewater discharges required to be tested for chronic toxicity by Part I of this permit.

a. Test Requirements (Definitive Test)

(1) The effluent shall be tested with appropriate replicates of 49% effluent, a control and a minimum of four serial dilutions of 13, 25, 49, 75, and 100% effluent.

(2) Any test result that shows a statistically significant reduction in survival, growth or reproduction between the control and the test at the 95% confidence level indicate chronic toxicity and constitute noncompliance with this permit.

b. General Test Requirements

(1) A minimum of three (3) 24-hour composite samples shall be obtained for use in the above biomonitoring tests and collected every other day so that the laboratory receives water samples on the first, third and fifth day of the seven-day test period. The holding time for each composite sample shall not exceed 36 hours. The control water shall be a water prepared in the laboratory in accordance with the EPA procedure described in EPA 821-R-02-013 or the most current edition or another control water selected by the permittee and approved by the Department.

(2) Effluent toxicity tests in which the control survival is less than 80%, *P. promelas* dry weight per surviving control organism is less than 0.25 mg, Ceriodaphnia number of young per surviving control organism is less than 15, Ceriodaphnia reproduction where less than 60% of surviving control females produce three broods or in which the other requirements of the EPA Test Procedure are not met shall be unacceptable and the permittee shall rerun the tests as soon as practical within the monitoring period.

(3) In the event of an invalid test, upon subsequent completion of a valid test, the results of all tests, valid and invalid, are reported with an explanation of the tests performed and results.

c. Reporting Requirements

(1) The permittee shall notify the Department in writing within 48 hours after toxicity has been demonstrated by the scheduled test(s).

(2) Biomonitoring test results obtained during each monitoring period shall be summarized and reported using the appropriate Discharge Monitoring Report (DMR) form approved by the Department. In accordance with Section 2. of this part, an effluent toxicity report containing the information in Section 2. shall be included with the DMR. Two copies of the test results must be submitted to the Department no later than 28 days after the month in which the tests were performed.

d. Additional Testing Requirements

(1) If chronic toxicity is indicated (noncompliance with permit limit), the permittee shall perform two additional valid chronic toxicity tests in accordance with these procedures to determine the extent and duration of the toxic condition. The toxicity tests shall run consecutively beginning on the first calendar week following the date on which the permittee became aware of the permit noncompliance and the results of these tests shall be submitted no later than 28 days following the month in which the tests were performed.

(2) After evaluation of the results of the follow-up tests, the Department will determine if additional action is appropriate and may require additional testing and/or toxicity reduction measures. The permittee may be required to perform a Toxicity Identification Evaluation (TIE) and/or a Toxicity Reduction Evaluation (TRE). The TIE/TRE shall be performed in accordance with the most recent protocols/guidance outlined by EPA (e.g., EPA/600/2-88/062, EPA/600/R-92/080, EPA/600/R-91-003, EPA/600/R-92/081, EPA/833/B-99/022 and/or EPA/600/6-91/005F,etc.)

e. Test Methods

(1) The tests shall be performed in accordance with the latest edition of the "EPA Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms." The Larval Survival and Growth Test, Methods 1000.0, shall be used for the fathead minnow (*Pimephales promelas*) test and the Survival and Reproduction Test, Method 1002.0, shall be used for the cladoceran (*Ceriodaphnia dubia*) test.

2. EFFLUENT TOXICITY TESTING REPORTS

The following information shall be submitted with each discharge monitoring report unless otherwise directed by the Department. The Department may at any times suspend or reinstate this requirement or may decrease or increase the frequency of submittals.

a. Introduction

(1) Facility name, location and county
(2) Permit number
(3) Toxicity testing requirements of permit
(4) Name of receiving water body
(5) Contract laboratory information (if tests are performed under contract)

(a) Name of firm
(b) Telephone number
(c) Address

(6) Objective of test

b. Plant Operations

(1) Discharge Operating schedule (if other than continuous)
(2) Volume of discharge during sample collection to include Mean daily discharge on sample collection dates (MGD, CFS, GPM)
(3) Design flow of treatment facility at time of sampling

c. Source of Effluent and Dilution Water

(1) Effluent samples

(a) Sampling point
(b) Sample collection dates and times (to include composite sample start and finish times)
(c) Sample collection method
(d) Physical and chemical data of undiluted effluent samples (water temperature, pH, alkalinity, hardness, specific conductance, total residual chlorine (if applicable), etc.)
(e) Lapsed time from sample collection to delivery
(f) Lapsed time from sample collection to test initiation
(g) Sample temperature when received at the laboratory

(2) Dilution Water

(a) Source
(b) Collection/preparation date(s) and time(s)
(c) Pretreatment (if applicable)
(d) Physical and chemical characteristics (water temperature, pH, alkalinity, hardness, specific conductance, etc.)

d. Test Conditions

(1) Toxicity test method utilized
(2) End point(s) of test
(3) Deviations from referenced method, if any, and reason(s)
(4) Date and time test started
(5) Date and time test terminated
(6) Type and volume of test chambers
(7) Volume of solution per chamber
(8) Number of organisms per test chamber
(9) Number of replicate test chambers per treatment

(10) Test temperature, pH and dissolved oxygen as recommended by the method (to include ranges)
(11) Specify if aeration was needed
(12) Feeding frequency, amount and type of food
(13) Specify if (and how) pH control measures were implemented
(14) Light intensity (mean)

e. Test Organisms

(1) Scientific name
(2) Life stage and age
(3) Source
(4) Disease(s) treatment (if applicable)

f. Quality Assurance

(1) Reference toxicant utilized and source
(2) Date and time of most recent chronic reference toxicant test(s), raw data and current control chart(s). The most recent chronic reference toxicant test shall be conducted within 30 days of the routine.
(3) Dilution water utilized in reference toxicant test
(4) Results of reference toxicant test(s) (NOEC, IC25, PASS/FAIL, etc.), report concentration-response relationship and evaluate test sensitivity
(5) Physical and chemical methods utilized

g. Results

(1) Provide raw toxicity data in tabular form, including daily records of affected organisms in each concentration (including controls) and replicate
(2) Provide table of endpoints: NOECs, IC25s, PASS/FAIL, etc. (as required in the applicable NPDES permit)
(3) Indicate statistical methods used to calculate endpoints
(4) Provide all physical and chemical data required by method
(5) Results of test(s) (NOEC, IC25, PASS/FAIL, etc.), report concentration-response relationship (definitive test only), report percent minimum significant difference (PMSD) calculated for sublethal endpoints determined by hypothesis testing.

h. Conclusions and Recommendations

(1) Relationship between test endpoints and permit limits
(2) Actions to be taken

1/ Adapted from "Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms", Fourth Edition, October 2002 (EPA 821-R-02-013), Section 10, Report Preparation

D. COOLING WATER INTAKE REQUIREMENTS

1. The cooling water intake structure used by the permittee has been evaluated using available information. At this time, the Department has determined that the cooling water intake structure represents the best technology available (BTA) to minimize adverse environmental impact in accordance with Section 316(b) of the federal Clean Water Act (33 U.S.C. section 1326).

2. The permittee shall submit the following information at least 180 days prior to permit expiration of this permit:

- design intake flow of the CWIS;
- percentage of intake flow , based on highest monthly average in last 5 years, used for cooling purposes;
- an estimate of the intake flow reduction at the facility based upon the use of a 100 percent (or some lesser percentage) closed-cycle re-circulating cooling water system compared to a conventional once-through cooling water system;
- through screen design intake flow velocity;
- any impingement and entrainment data that may have been collected based on the operation of the facility's CWIS, collected since the effective date of this NPDES permit; and,

- a detailed description of any changes in the operation of the CWIS, or changes in the type of technologies used at the CWIS such as screens or other technologies affecting the rates of impingement and/or entrainment of fish and shellfish.

3. The permittee is required to operate and maintain the CWIS in a manner that minimizes impingement and entrainment levels. The permittee is required to make advance notification to the Department of any planned changes to facility operation and/or maintenance activities which could have a significant impact on impingement and entrainment levels.

E. 316(a) DEMONSTRATION REQUIREMENTS

Permit Monitoring Program

Re-application Monitoring Program: Should the permittee wish a continuance of its 316(a) request beyond the term of this permit, re-application for such a continuance shall be submitted in accordance with 40 CFR Part 125.70 Subpart H-Criteria for Determining Alternative Effluent Limitations Under Section 316(a) of the Act and 40 CFR Part 122.21 (m)(6) Subpart B-Permit Application and Special NPDES Program Requirements, Variance Requests by Non-POTWs. Re-application must be received 180 days prior to permit expiration. Re-application shall include necessary technical data and relevant information to include data collected within the life of the permit to support a continuation of the variance.

Re-Opener Clause

This permit shall be modified, or revoked and re-issued in the event that the Department determines through biological and/or water quality monitoring that more stringent limitations and/or monitoring requirements are necessary to assure the protection and propagation of a balanced, indigenous population of shellfish, fish, and wildlife in and on the Tennessee River.

F. DOWNSTREAM MONITORING

Compliance with downstream river temperature and temperature rise limitations shall be applicable at the edge of the mixing zone which shall not exceed the following dimensions:

"(1) A maximum length of 2400 feet downstream of the diffusers, (2) a maximum width of 2,000 feet, and (3) a maximum length of 150 feet upstream of the diffusers to the top of the diffuser pipes and extends to the bottom downstream of the diffusers.

Downstream river temperature measurements shall be made by three monitors located in a line across the reservoir at approximate river mile 293.45. Temperature data shall be measured every 15 minutes at 3, 5, and 7 foot depths and averaged to obtain a 5 foot depth measurement. Temperatures at each monitor will be averaged using a 24-hour calendar day average. The temperatures from the monitors corresponding to the diffusers in operation will then be averaged to obtain a representative spatial mean.

ALABAMA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT
WATER DIVISION – INDUSTRIAL AND MUNICIPAL SECTIONS
NONCOMPLIANCE NOTIFICATION FORM

PERMITTEE NAME: ______________________ PERMIT NO: ______________________

FACILITY LOCATION: ______________________

DMR REPORTING PERIOD: ______________________

1. DESCRIPTION OF DISCHARGE: (Include outfall number (s))

2. DESCRIPTION OF NON-COMPLIANCE: (Attach additional pages if necessary):

LIST EFFLUENT VIOLATIONS (If applicable)			
Outfall Number (s)	NONCOMPLIANCE PARAMETER(S)	Result Reported (Include units)	Permit Limit (Include units)

LIST MONITORING / REPORTING VIOLATIONS (If applicable)		
Outfall Number (s)	NONCOMPLIANCE PARAMETER(S)	Monitoring / Reporting Violation (Provide description)

3. CAUSE OF NON-COMPLIANCE (Attach additional pages if necessary):

4. PERIOD OF NONCOMPLIANCE: (Include exact date(s) and time(s) or, if not corrected, the anticipated time the noncompliance is expected to continue):

5. DESCRIPTION OF STEPS TAKEN AND/OR BEING TAKEN TO REDUCE OR ELIMINATE THE NONCOMPLYING DISCHARGE AND TO PREVENT ITS RECURRENCE (attach additional pages if necessary):

"I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

____
NAME AND TITLE OF RESPONSIBLE OFFICIAL (type or print)

______________________ / ______________
SIGNATURE OF RESPONSIBLE OFFICIAL / DATE SIGNED

ADEM Form 421 09/05

ATTACHMENT 3

Most Recent Browns Ferry Nuclear Plant
National Pollutant Discharge Elimination System (NPDES)
Permit Renewal Application from March 2011

A60 110225 503
Env. Document Type: NPDES Permit Application

March 1, 2011

Mr. Eric Sanderson
Alabama Department of Environmental
Management
1400 Coliseum Boulevard
Montgomery, Alabama 36110-2059

Dear Mr. Sanderson:

TENNESSEE VALLEY AUTHORITY (TVA) – BROWNS FERRY NUCLEAR PLANT (BFN) – NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES) PERMIT NO. AL0022080 – NPDES PERMIT RENEWAL APPLICATION

Enclosed are three copies of an application for re-issuance of the subject permit. The permit renewal application package includes the Alabama Department of Environmental Management Form 187; EPA Form 1 and a site map, EPA Form 2C and a wastewater flow schematic, EPA Form 2E, and EPA Form 2F. Also enclosed is a check in the amount of $8,400.00 for the application fee. For completing the application forms, TVA elected to use a 12-month historical monitoring period between July 2009 and June 2010, to bracket the renewal sampling event.

TVA requests that the permit requirements for process outfalls be continued from the current requirements, with the exception of the items noted below.

DSN 001

1. TVA requests continuation of the alternative thermal limitations and associated monitoring requirements contained in the current NPDES permit. A copy of the report discussing the results of monitoring to support this request is enclosed.

2. A summary of the reasonable potential evaluation and toxicity test results for DSN 001 since the last permit renewal application is enclosed. TVA requests that the current annual frequency for toxicity monitoring be maintained.

3. TVA proposes to incorporate additional chemicals into its Raw Water Treatment Program as described in Attachment 4 to the enclosed ADEM Form 187. Specifically, TVA proposes the use of Zinc Sulfate/Orthophosphate (FLOWGARD MS6209) and a biodispersant (GE SPECTRUS BD1500). As discussed in the enclosure, TVA believes that the proposed use of FLOWGARD MS6209 will not pose a reasonable potential to violate the applicable water quality criteria for zinc. TVA requests ADEM's determination (per Part I.D.5.b of BFN's current permit) that a permit modification or renewal is not required to allow the use of zinc containing chemicals.

4. Herbicide Treatments at BFN are associated with grounds maintenance use and to control aquatic vegetation in the cold water and warm water channels. Several herbicides potentially could be used to control aquatic vegetation in the cold and warm water channels (see Table 1) depending on the species of aquatic plant and time of projected cooling tower usage. All herbicides used for grounds maintenance that are sprayed in or near ditches have approved aquatic labels by EPA. The herbicides that may be sprayed in or near ditches that flow to the Tennessee River include Rodeo® and Aqua Master® Herbicides. Herbicides that are applied for grass and weed controls away from ditches (e.g., switchyards and gravel parking lots) may not have aquatic labels. The main Herbicides used in the switchyard and parking lot areas are GLY - 4 - PLUS®, OUST® and Round-Up®. Regardless of the area of application, all herbicide applications are performed in accordance with the label instructions. MSDSs for all aquatic herbicides currently planned for use are enclosed.

BFN currently has six mechanical draft cooling towers (MDCT). These existing MDCT can only support approximately 80% of the heat rejection needs from the three operating units. During the hot summer months, this lack of cooling capacity has resulted in TVA having to make significant derates. During the summer of 2010, derates to below 50% of full power were made to meet NPDES permit requirements. As a result, TVA is currently constructing an additional 28-cell linear MDCT on the BFN site and is planning to replace four of BFN's existing MDCT. The four replacement MDCT (Towers 1, 2, 5, and 6) are to be rebuilt at a later date. No increase in the total BFN flow rate is proposed at this time.

TVA appreciates the consideration of the items requested with this NPDES renewal application. If you have any questions or require additional information, please contact Mike Stiefel in Chattanooga, Tennessee, at (423) 751-6844 or by email at mbstiefel@tva.gov.

Sincerely,

(Original signed by)

Lindy P. Johnson, Senior Specialist
Water Permits and Compliance
5D Lookout Place

cc: See page 3

MBS:SMF
Enclosures
cc (Enclosures):

C. R. Cooper, NAB 1G-BFN
J. G. Doyle, NAB 2A-BFN
J. E. Emens, SAB 2B-BFN
K. M. Hodges (EDMS), LP 2V-C
R. M. Krich, LP 3R-C
T. A. Marlow, NAB 1A-BFN
D. B. Nida, LP 5U-C
K. J. Polson, NAB 2A-BFN (w/o Enclosures)
G. R. Signer, WT 6A-K (w/o Enclosures)

U:\media files\water\npdes\bfn\bfn 2011 permit renewal application\bfn npdes renewal 2011 cover letter.doc

TVA

Tennessee Valley Authority, 1101 Market Street, Chattanooga, Tennessee 37402-2801

March 1, 2011

Mr. Eric Sanderson
Alabama Department of Environmental
Management
1400 Coliseum Boulevard
Montgomery, Alabama 36110-2059

Dear Mr. Sanderson:

TENNESSEE VALLEY AUTHORITY (TVA) – BROWNS FERRY NUCLEAR PLANT (BFN) – NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES) PERMIT NO. AL0022080 – NPDES PERMIT RENEWAL APPLICATION

Enclosed are three copies of an application for re-issuance of the subject permit. The permit renewal application package includes the Alabama Department of Environmental Management Form 187; EPA Form 1 and a site map, EPA Form 2C and a wastewater flow schematic, EPA Form 2E, and EPA Form 2F. Also enclosed is a check in the amount of $8,400.00 for the application fee. For completing the application forms, TVA elected to use a 12-month historical monitoring period between July 2009 and June 2010, to bracket the renewal sampling event.

TVA requests that the permit requirements for process outfalls be continued from the current requirements, with the exception of the items noted below.

DSN 001

1. TVA requests continuation of the alternative thermal limitations and associated monitoring requirements contained in the current NPDES permit. A copy of the report discussing the results of monitoring to support this request is enclosed.

2. A summary of the reasonable potential evaluation and toxicity test results for DSN 001 since the last permit renewal application is enclosed. TVA requests that the current annual frequency for toxicity monitoring be maintained.

3. TVA proposes to incorporate additional chemicals into its Raw Water Treatment Program as described in Attachment 4 to the enclosed ADEM Form 187. Specifically, TVA proposes the use of Zinc Sulfate/Orthophosphate (FLOWGARD MS6209) and a biodispersant (GE SPECTRUS BD1500). As discussed in the enclosure, TVA believes that the proposed use of FLOWGARD MS6209 will not pose a reasonable potential to violate the applicable water quality criteria for zinc. TVA requests ADEM's determination (per Part I.D.5.b of BFN's current permit) that a permit modification or renewal is not required to allow the use of zinc containing chemicals.

4. Herbicide Treatments at BFN are associated with grounds maintenance use and to control aquatic vegetation in the cold water and warm water channels. Several herbicides potentially could be used to control aquatic vegetation in the cold and warm water channels (see Table 1) depending on the species of aquatic plant and time of projected cooling tower usage. All herbicides used for grounds maintenance that are sprayed in or near ditches have approved aquatic labels by EPA. The herbicides that may be sprayed in or near ditches that flow to the Tennessee River include Rodeo® and Aqua Master® Herbicides. Herbicides that are applied for grass and weed controls away from ditches (e.g., switchyards and gravel parking lots) may not have aquatic labels. The main Herbicides used in the switchyard and parking lot areas are GLY - 4 - PLUS®, OUST® and Round-Up®. Regardless of the area of application, all herbicide applications are performed in accordance with the label instructions. MSDSs for all aquatic herbicides currently planned for use are enclosed.

BFN currently has six mechanical draft cooling towers (MDCT). These existing MDCT can only support approximately 80% of the heat rejection needs from the three operating units. During the hot summer months, this lack of cooling capacity has resulted in TVA having to make significant derates. During the summer of 2010, derates to below 50% of full power were made to meet NPDES permit requirements. As a result, TVA is currently constructing an additional 28-cell linear MDCT on the BFN site and is planning to replace four of BFN's existing MDCT. The four replacement MDCT (Towers 1, 2, 5, and 6) are to be rebuilt at a later date. No increase in the total BFN flow rate is proposed at this time.

TVA appreciates the consideration of the items requested with this NPDES renewal application. If you have any questions or require additional information, please contact Mike Stiefel in Chattanooga, Tennessee, at (423) 751-6844 or by email at mbstiefel@tva.gov.

Sincerely,

Lindy P. Johnson

Lindy P. Johnson, Senior Specialist
Water Permits and Compliance
5D Lookout Place

Enclosures

**TENNESSEE VALLEY AUTHORITY (TVA) – BROWNS FERRY NUCLEAR PLANT
NPDES PERMIT NO. AL0022080 - APPLICATION FOR RENEWAL**

Current Whole Effluent Toxicity (WET) Requirements:

DSN001 -	7-day *Pimephales promelas* and 3-brood *Ceriodaphnia dubia* IC_{25} = 49% effluent (2.04 TUc) Monitoring Frequency: 1/year

Proposed Whole Effluent (WET) Toxicity Requirements:

DSN001 -	7-day *Pimephales promelas* and 3-brood *Ceriodaphnia dubia* IC_{25} = 41% effluent (2.44 TUc) Monitoring Frequency: 1/year

DSN001:

In accordance with EPA's recommendation (Technical Support Document for Water Quality-based Toxics Control, EPA/505/2-90-001), BFN DSN001 would not be required to have a chronic WET limit based on a demonstration of no Reasonable Potential (RP) for excursions above the ambient water quality chronic (CCC) criterion using effluent data for current operating conditions. Following guidance in the Technical Support Document (TSD), where no RP exists, biomonitoring would be conducted at a frequency of only once every 5 years as part of the permit renewal process to document acceptable effluent toxicity, and toxicity at the instream wastewater concentration (IWC) would serve only as a hard trigger for accelerated toxicity biomonitoring.

Since, however, BFN might require modification of the chemical program for control of biofouling organisms, TVA requests maintaining the current annual testing schedule to demonstrate continuing compliance with WET permit limitations. TVA also requests continuation of testing of intake samples to identify and invalidate test results when effluent toxicity is attributable to toxicity in ambient intake water used for plant operations.

The following data summary and RP calculations utilize 20 years (29 studies) of WET biomonitoring data. The 6 most recent studies were conducted in accordance with Part IV of the current NPDES Permit AL0022080. At no time during this monitoring was the permit limit (2.04 TUc) exceeded. Table 1 summarizes BFN biomonitoring results, followed by the RP calculations.

BFN Documentation:

Summary of BFN DSN 001 WET Biomonitoring Results

		Acute Results (96-h Survival)		Chronic Results
		% Survival Undiluted Sample	Study Toxicity Units (TUa)	Study Toxicity Units (TUc)
Hypoth.-based NOEC:				
1. Sep 14-21, 1990	*Ceriodaphnia dubia*	100	<1.0	<1.0
	Pimephales promelas	98		
2. Feb 20-27, 1992*	*Ceriodaphnia dubia*	100	<1.0	<1.0
	Pimephales promelas	95		
3. Jul 23-30, 1992*	*Ceriodaphnia dubia*	100	<1.0	<1.0
	Pimephales promelas	100		
4. Oct 28-Nov 4, 1992*	*Ceriodaphnia dubia*	100	<1.0	<1.0
	Pimephales promelas	98		
5. May 20-27, 1993*	*Ceriodaphnia dubia*	100	<1.0	<1.0
	Pimephales promelas	98		
6. Mar 10-17, 1994	*Ceriodaphnia dubia*	100	<1.0	<1.0
	Pimephales promelas	100		
7. Jun 22-29, 1994	*Ceriodaphnia dubia*	100	<1.0	<1.0
	Pimephales promelas	100		
8. Dec 6-13, 1995	*Ceriodaphnia dubia*	100	<1.0	<1.0
	Pimephales promelas	100		
IC_{25}-based NOEC				
9. Jun 11-18, 1996	*Ceriodaphnia dubia*	100	<1.0	<1.0
	Pimephales promelas	100		
10. Nov 15-22, 1996	*Ceriodaphnia dubia*	100	<1.0	<1.0
	Pimephales promelas	100		
11. May 14-21, 1997	*Ceriodaphnia dubia*	100	<1.0	<1.0
	Pimephales promelas	100		
12. Nov 4-11, 1997	*Ceriodaphnia dubia*	100	<1.0	<1.0
	Pimephales promelas	98		
13. May 6-13, 1998	*Ceriodaphnia dubia*	100	<1.0	<1.0
	Pimephales promelas	100		
14. Oct 27-Nov 3, 1998	*Ceriodaphnia dubia*	100	<1.0	1.4
	Pimephales promelas	98		
15. May 18-25, 1999	*Ceriodaphnia dubia*	100	<1.0	
	Pimephales promelas	100		1.3
16. Nov 9-17, 1999	*Ceriodaphnia dubia*	90	<1.0	1.02
	Pimephales promelas	100		1.5
17. May 23-30, 2000	*Ceriodaphnia dubia*	100	<1.0	<1.0
	Pimephales promelas	100		
18. Nov 14-21, 2000	*Ceriodaphnia dubia*	100	<1.0	<1.0
	Pimephales promelas	100		

BFN Documentation:

Summary of BFN DSN 001 WET Biomonitoring Results- continued

		Acute Results (96-h Survival)		Chronic Results
		% Survival Undiluted Sample	Study Toxicity Units (TUa)	Study Toxicity Units (TUc)
19. Nov 6-13, 2001	*Ceriodaphnia dubia*	100	<1.0	<1.0
	Pimephales promelas	100		
20. Oct 22-29, 2002	*Ceriodaphnia dubia*	100	<1.0	<1.0
	Pimephales promelas	100		
21. Oct 7-14, 2003	*Ceriodaphnia dubia*	100	<1.0	<1.0
	Pimephales promelas	100		
22. Jul 13-20, 2004	*Ceriodaphnia dubia*	100	<1.0	<1.0
	Pimephales promelas	100		
23. Oct 19-26, 2005	*Ceriodaphnia dubia*	100	<1.0	<1.0
	Pimephales promelas	100		
24. Jun 13-20, 2006	*Ceriodaphnia dubia*	100	<1.0	<1.0
	Pimephales promelas	90		
25. May 8-15, 2007	*Ceriodaphnia dubia*	100	<1.0	<1.0
	Pimephales promelas	100		
Jun 10-17, 2008 §	*Ceriodaphnia dubia*	*100*	*<1.0*	*<1.0*
	Pimephales promelas	*100*		
26. Sep 11-18 2008	*Ceriodaphnia dubia*	100	<1.0	<1.0
	Pimephales promelas	100		
27. Apr 14-21, 2009	*Ceriodaphnia dubia*	100	<1.0	<1.0
	Pimephales promelas	100		
28. May 11-18, 2010	*Ceriodaphnia dubia*	100	<1.0	<1.0
	Pimephales promelas	100		
29. Oct 6-13, 2010	*Ceriodaphnia dubia*	100	<1.0	<1.0
	Pimephales promelas	100		
n		58	29	30
Maximum		100%	<1.0 TUa	1.5 TUc
Minimum		90%	<1.0 TUa	<1.0 TUc
Mean		99.4%	<1.0 TUa	1.04 TUc
CV		1.99%	0%	11.98%

* *Selenastrum capricornutum* tests were also conducted during these studies. No toxicity attributable to DSN001 occurred.

§ Test was invalidated because the COC was not correctly filled in.

Data collected under the current permit.

Dilution and Instream Waste Concentration Calculation

DSN001:

Maximum Discharge Flow = 2895 MGD (based on application schematic)

Tennessee River Flow (7Q10) = 7109 MGD (based on ADEM 1994 rationale)

Dilution Factor (DF): $DF = \frac{Qs}{Qw} = \frac{7109}{2895} = 2.46$

Instream Waste Concentration (IWC): $IWC = \frac{Qw}{Qs} \times 100 = \frac{2895}{7109} \text{ x } 100 = 41\%$

Reasonable Potential Determination:

Step 1 Total number of observations "n" for chronic effluent data = **30**; maximum value of the sample results is **1.5** TUc

Step 2 The value of the CV is 0.12 (minimum table value of **0.1** used)

Step 3 The value of the ratio for ≥ 20 pieces of data and a CV of 0.1 is **1.2** (99% Confidence Level and 99% Probability Basis)

Step 4 The value that exceeds the 99th percentile of the distribution (ratio times x_{max}) after dilution is calculated as:

[1.5 TUc x 1.2 x 0.41] = 0.74 TUc

Step 5 0.74 TUc is less than the ambient CCC of 1.0 TUc. There is no reasonable potential for this effluent to cause an excursion above the CCC.

Based on EPA's recommendation in the *Technical Support Document for Water Quality-based Toxics Control*, toxicity tests for DSN001 should be repeated at a frequency of at least once every 5 years as a part of the permit application.

cc (Enclosure - Electronic Distribution):

C. M. Anderson, LP 5D-C
W. A. Bruss, WCA 1A-STA
L. C. Diamond, LP 5U-C
S. W. Eslinger, LP 2G-C
K. M. Hodges (EDMS), LP 2V-C
J. D. Mullins, LP 5E-C
C. H. Reed, WCB 1A-STA
T. S. Rudder, WCA 1A-STA
G. R. Signer, WT 6A-K
M. G. Tritapoe, LP 5D-C

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Env. Document Type: NPDES Correspondence

March 18, 2011

Mr. Eric Sanderson
Water Division
Alabama Department of Environmental
Management
1400 Coliseum Boulevard
Montgomery, Alabama 36110-2059

Dear Mr. Sanderson:

TENNESSEE VALLEY AUTHORITY (TVA) - WIDOWS CREEK FOSSIL PLANT (WCF) - NPDES PERMIT NO AL0003875 - CONSENT ORDER NO. 10-002-CWP - PROGRESS AND UPDATED SCHEDULE FOR OPERATIONS AND MAINTENANCE MODIFICATION REPORT (O&M MODIFICATION PLAN)

This letter is to provide you with a formal progress update on the activities listed in the O&M Modification Plan. Enclosed is a revised schedule of activities for the O&M Modification Plan for your information.

The revised schedule was prepared in regard to TVA's commitment for a status report on the progress of the items listed in O&M Modification Plan. Some projects were delayed pending ADEM's approval of the O&M Modification Plan, which was provided by letter dated September 30, 2010. Since receiving approval, TVA has commenced scheduling Phase 1 engineering studies on that portion of the projects that were awaiting approval.

TVA appreciates the consideration and time ADEM has spent reviewing the O&M Modification Plan. The following summarizes the progress to date:

Stormwater Outfall Reroute.

TVA has commenced Phase 1 engineering studies to reroute the stormwater outfalls as proposed in the O&M Modification Plan. TVA has submitted the proposed modifications in an updated NPDES permit renewal application. TVA expects this will facilitate the modification of the permit when construction is complete and the outfalls are removed from the permit.

Cenosphere Management Plan

As part of the O&M Modification Plan, TVA implemented a cenospheres management plan. The plan is in place, and implementation is ongoing with successful minimization of cenospheres reaching the discharge to the receiving stream.

Red Water Pond Geotechnical Assessment

The geotechnical assessment for the Red Water Pond has been completed and submitted to TVA. Conclusions presented in the report stated that current stability projects already scheduled for the Ash Pond Complex will improve the stability factor of safety to satisfactory levels. The risk remediation projects that will improve stability in the Red Water Pond include lowering of the Main Ash Pond pool and the construction of a rock buttress with reverse-graded filter along the Main Ash Pond dike on one side of the Red Water Pond dike.

Stability Improvements

The first projects initiated for stability improvements include the reverse graded filter and rock buttress along the toe of slope at the Gypsum and Ash Pond dikes. The Gypsum Pond was higher priority for stability improvements as studies showed it having a lower factor of safety in some cross sections of the dike. The Gypsum Pond Buttress is complete with the exception of portions of the dike that abut wetlands; the buttress construction would encroach on the wetlands and was halted until necessary permits were issued. The wetlands permits (ADEM 401 certification and Department of Army Permit No. 2008-02174) have been issued as of February 15, and construction will be completed after remobilization.

If you have questions regarding this revised schedule or require more information, please contact Anna Brodie in Chattanooga, Tennessee, at (423) 751-3357 or by email at acbrodie@tva.gov

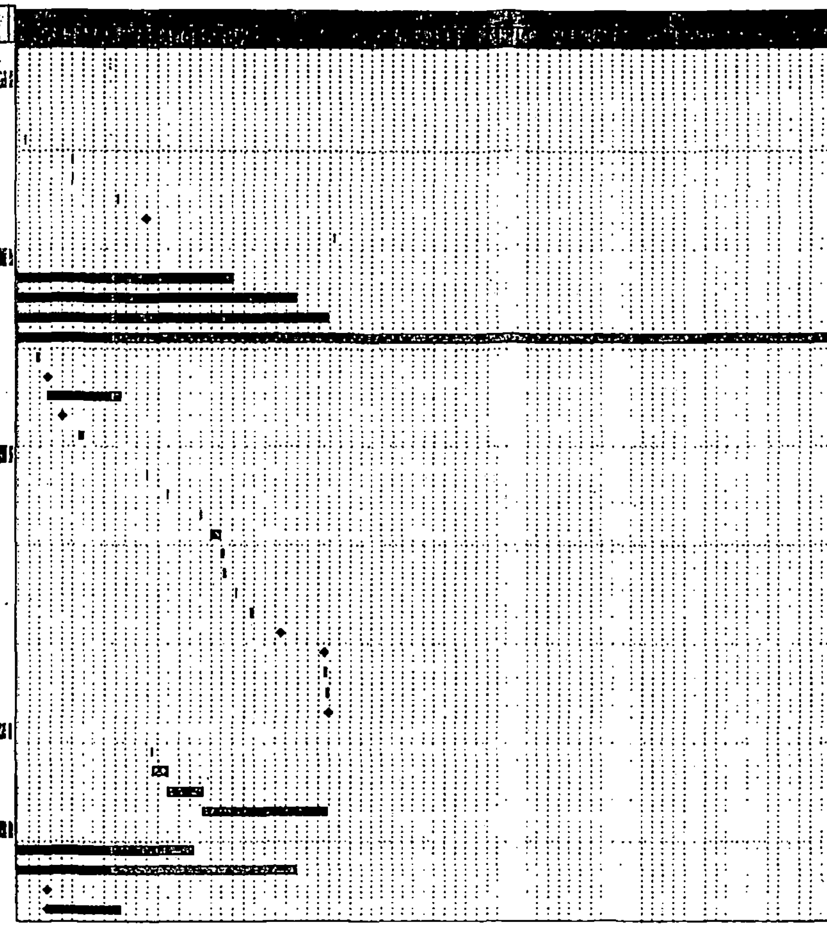
Sincerely,

(Original signed by)

Lindy Johnson, Senior Specialist
Water Permits and Compliance
Lookout Place 5D

ACB:SMF:VMG
Enclosure
cc: (see Page 3)

ID	Activity Name	TVA Dept	Start	Finish	Planned Date
WCFP ADEM Lvl 1 - Consent Order (TAO-1485)			08-Feb-10 A	30-Sep-16	
Common			08-Feb-10 A	15-Oct-12	
WCF-12000	Submit Consent Order Response to ADEM	EP&C	08-Feb-10 A	08-Feb-10 A	09FEB10
WCF-14000	TVA NEPA Review Initiated	EP&C	15-Apr-10 A	15-Apr-11 A	15APR10
WCF-13000	Schedule Mtg /ADEM to Review O&M Modifications Rpt	EP&C	20-May-10 A	20-May-10 A	26FEB10
WCF-11000	ADEM Approval or Modification Requested for O&M Mod Plan	EP&C	30-Sep-10 A	30-Sep-10 A	31MAR10
WCF-21000	TVA Discuss Modifications w/ADEM to Determine Permit Actions Needed	EP&C	30-Sep-10 A	30-Sep-10 A	15APR10
WCF-22000	Submit Proposed Modification To NPDES Permit Renewal Application	EP&C	07-Feb-11 A	07-Feb-11 A	
WCF-42110	TVA NEPA Approval Complete	EP&C		29-Apr-11*	30APR11
WCF-42350	Notify ADEM of O&M Mod Complete	EP&C	15-Oct-12	15-Oct-12	
Main Ash Pond			01-Apr-10 A	30-Sep-16	
WCF-42440	Stability Improvements		01-Apr-10 A	30-Dec-11	01OCT11
WCF-42400	Seepage Improvements		01-Apr-10 A	29-Jun-12	31OCT11
WCF-42420	Bottom Ash Stack Mitigation		01-Apr-10 A	28-Sep-12	01OCT11
WCF-42410	Dredge Cell Cap and Closure - Design & Construct		01-Apr-10 A	30-Sep-16	01OCT11
WCF-24000	Contractor Conduct Red Water Pond Geotechnical Assessment	CCPE	21-Jun-10 A	30-Jun-10 A	30JUN10
WCF-42470	Develop CBMPP			22-Jul-10 A	
WCF-42480	Obtain Construction and Wetlands Permits		22-Jul-10 A	15-Feb-11	
WCF-20000	Contractor Submit Red Water Pond Geotechnical Assessment to TVA	CCPE		01-Sep-10 A	01SEP10
WCF-40010	TVA Review Red Water Pond Report	CCPE/EP&C	18-Oct-10 A	29-Oct-10 A	31OCT10
Re-Route Storm Water Outfalls [illegible]			[illegible]	[illegible]	
WCF-23000	TVA Project Planning Document	FPGP	02-May-11*	02-May-11	23JUN10
WCF-40100	TVA Phase II 10% (Internal) Review Meeting	FPGP	01-Jul-11*	01-Jul-11	23AUG10
WCF-30000	TVA Phase II 50% (Internal) Review Meeting	FPGP	03-Oct-11*	03-Oct-11	03NOV10
WCF-42200	Prepare Construction CBMPP & Alert EP&C To Obtain Permit	FPGP	01-Nov-11*	30-Nov-11	30APR11
WCF-40200	TVA Develops Construction NOR	FPGP	01-Dec-11*	05-Dec-11	01DEC11
WCF-42000	TVA Obtain Construction Permit Coverage	EP&C	06-Dec-11*	12-Dec-11	30APR11
WCF-40000	TVA Phase II 100% (Internal) Review Meeting	FPGP	10-Jan-12*	10-Jan-12	23FEB11
WCF-42100	TVA Issues DCN Packages	FPGP	21-Feb-12*	27-Feb-12	01APR11
WCF-42310	Construction Starts	CCPOM	15-May-12*		
WCF-42320	Construction Complete	CCPOM		15-Sep-12*	15JUN12
WCF-42330	Close TVA DCN Package	FPGP	17-Sep-12*	21-Sep-12	
WCF-42340	TVA Work Order Closure	FPGP	24-Sep-12	28-Sep-12*	
WCF-42490	Notify ADEM of Reroute / Terminated Outfalls			28-Sep-12	31DEC12
Chemical Treatment Pond Interim Closure			17-May-11*	24-Sep-12	
WCF-41000	Submit Iron & Copper Pond Draft Interim Closure Plan to ADEM	CCPE	17-May-11*	17-May-11	23JAN11
WCF-42300	ADEM Approval of Copper & Iron Pond Interim Closure Plan by URS	EP&C	18-May-11*	01-Jul-11	30APR11
WCF-42370	Chemical Treatment Pond Interim Ph2 Design		01-Jul-11*	10-Oct-11	
WCF-42380	Chemical Treatment Pond Interim Ph3 Construction		11-Oct-11	24-Sep-12	
Gypsum Impoundment			01-Mar-10 A	29-Jun-12	
WCF-42390	Gypsum Impoundment - Stability Improvements Project **		01-Mar-10 A	12-Sep-11	
WCF-42430	Gypsum Impoundment - Seepage Improvements Project		01-Mar-10 A	29-Jun-12	
WCF-42450	Develop CBMPP			28-JUN-10	
WCF-42460	Obtain Construction and Wetlands Permits		22-Jul-10 A	15-FEB-11	



** Areas requiring individual Corps of Engineers permit were deferred until receipt of permits.

Actual Work Remaining Work Critical Remaining Work ◆ Milestone	Page 1 of 1 Data Date: 17-Jan-11 Run Date: 16-Mar-11	WCFP ADEM Lvl 1 - Consent Order (TAO-1485) Schedule/Version: WCFP ADEM © Primavera Systems, Inc.

Biological Monitoring of the Tennessee River Near Browns Ferry Nuclear Plant Discharge Autumn 2008

Jeffrey W. Simmons
Dennis S. Baxter

May 2009

Tennessee Valley Authority
Aquatic Monitoring and Management
Chattanooga, Tennessee

Table of Contents

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Acronyms and Abbreviations

ADEM	Alabama Department of Environmental Management
BIP	Balanced Indigenous Population
BFN	Browns Ferry Nuclear Plant
ERM	Elk River Mile
NPDES	National Pollutant Discharge Elimination System
PSD	Proportional Stock Density
QA	Quality Assurance
RBI	Reservoir Benthic Macroinvertebrate Index
RFAI	Reservoir Fish Assemblage Index
RSD	Relative Stock Density
RSDM	Relative Stock Density of Memorable-sized
RSDP	Relative Stock Density of Preferred-sized
RSDT	Relative Stock Density of Trophy-sized
SAHI	Shoreline Assessment Habitat Index
SSS	Spring Sport Fish Survey
TRM	Tennessee River Mile
TVA	Tennessee Valley Authority
USFWS	U.S. Fish and Wildlife Service
VS	Vital Signs
Wr	Relative weight

Introduction

Section 316(a) of the Clean Water Act (CWA) authorizes alternative thermal limits (ATL) for the control of the thermal component of a discharge from a point source so long as the limits will assure the protection of Balanced Indigenous Populations (BIP) of aquatic life. The term "balanced indigenous population," as defined in EPA's regulations implementing Section 316(a), means a biotic community that is typically characterized by:

(1) diversity appropriate to ecoregion;
(2) the capacity to sustain itself through cyclic seasonal changes;
(3) the presence of necessary food chain species; and
(4) lack of domination by pollution-tolerant species.

Prior to 2000, the Tennessee Valley Authority's (TVA) Browns Ferry Nuclear Plant (BFN) was operating under a 316(a) ATL that had been continued with each permit renewal based on studies conducted in the mid-1970s. In 1999, EPA Region IV began requesting additional data in conjunction with NPDES permit renewal applications to verify that BIP was being maintained at TVA's thermal plants with ATLs. TVA proposed that its existing Vital Signs (VS) monitoring program, supplemented with additional fish and benthic macroinvertebrate community monitoring upstream and downstream of thermal plants with ATLs, was appropriate for that purpose. The VS monitoring program began in 1990 in the Tennessee River System. This program was implemented to evaluate ecological health conditions in major reservoirs as part of TVA's stewardship role. One of the 5 indicators used in the VS program to evaluate reservoir health is the Reservoir Fish Assemblage Index (RFAI) methodology. RFAI has been thoroughly tested on TVA and other reservoirs and published in peer-reviewed literature (Jennings, et al., 1995; Hickman and McDonough, 1996; McDonough and Hickman, 1999). Fish communities are used to evaluate ecological conditions because of their importance in the aquatic food web and because fish life cycles are long enough to integrate conditions over time. Benthic macroinvertebrate populations are assessed using the Reservoir Benthic Index (RBI) methodology. Because benthic macroinvertebrates are relatively immobile, negative impacts to aquatic ecosystems can be detected earlier in benthic macroinvertebrate communities than in fish communities. These data are used to supplement RFAI results to provide a more thorough examination of differences in aquatic communities upstream and downstream of thermal discharges.

TVA initiated a study to evaluate fish and benthic macroinvertebrate communities in areas immediately upstream and downstream of BFN during 2000-2008 using RFAI and RBI multi-metric evaluation techniques. This report presents the results of autumn 2008 RFAI and RBI data collected upstream and downstream of BFN with comparisons to RFAI and RBI data collected at these sites during autumn 2000-2007.

TVA's Spring Sport Fish Survey (SSS) data from 2008 is also included as supplemental information on the overall health of sport fisheries in Wheeler Reservoir. The TVA SSS is conducted to evaluate the sport fish population of TVA Reservoirs. The results of the survey are used by state agencies to protect, improve and assess the quality of sport fisheries. Predominant habitat types in the reservoir are surveyed to determine sport fish abundance. In addition to

accommodating TVA and state databases, this surveying method aligns with TVA Watershed Team and TVA's Reservoir Operations Study objectives. Sample sites are selected using the shoreline habitat characteristics employed by the Watershed Teams. The survey predominantly targets three species of black bass (largemouth, smallmouth, and spotted bass) and black and white crappie. These species are the predominant sport fish sought after by fishermen.

Plant Description

BFN is a three-unit nuclear-fueled facility and as of June, 2007, all three units are operating. BFN is located on Wheeler Reservoir at Tennessee River Mile (TRM) 294 in Limestone County, Alabama (Figure 1). Current operation utilizes a once-through condenser cooling water (CCW) system, withdrawing water from the Tennessee River through an intake structure at TRM 294.3 and discharging the water through diffuser pipes located downstream from the plant at TRM 293.6 (Figure 2). Maximum flow rate of the CCW is about 3,468 million gallons per day.

Methods

Fish and Benthic Macroinvertebrate Sample Locations Upstream and Downstream of BFN

Two sample locations, one upstream and one downstream of the plant discharge channel, were selected in Wheeler Reservoir. The BFN discharge enters the Tennessee River TRM 293.6. For the fish community, the downstream site was centered at TRM 292.5 (Figure 3) and upstream sample site was centered at TRM 295.9 (Figure 4). For the benthic macroinvertebrate community, transects across the full width of the reservoir were established at TRM 291.7 (downstream) and TRM 295.9 (upstream).

Fish Community Sampling Methods and Data Analysis for Sites Upstream and Downstream of BFN

Fish sampling methods included boat electro-fishing and gill netting (Hubert, 1996; Reynolds, 1996). Electro-fishing methodology consisted of fifteen electro-fishing boat runs near the shoreline, each 300 meters long with a duration of approximately 10 minutes each. The total near-shore area sampled is approximately 4,500 meters (15,000 feet).

Experimental gill nets (so called because of their use for research as opposed to commercial fishing) are used as an additional gear type to collect fish from deeper habitats not effectively sampled by electro-fishing. Each experimental gill net consists of five-6.1 meter panels for a total length of 30.5 meters (100.1 feet). The distinguishing characteristic of experimental gill nets is mesh size that varies between panels. For this application, each net has panels with mesh sizes of 2.5, 5.1, 7.6, 10.2, and 12.7 cm. Experimental gill nets are typically set perpendicular to river flow extending from near-shore to the main channel of the reservoir. Ten overnight experimental gill net sets were used at each area.

Fish collected were identified by species, counted, and examined for anomalies (such as disease, deformations, or hybridization). The resulting data were analyzed using RFAI methodology.

The RFAI uses 12 fish community metrics from four general categories: Species Richness and Composition; Trophic Composition; Abundance; and Fish Health. Individual species can be

utilized for more than one metric. Together, these 12 metrics provide a balanced evaluation of fish community integrity. The individual metrics are shown below, grouped by category:

Species Richness and Composition

1. **Total number of species** -- Greater numbers of species are considered representative of healthier aquatic ecosystems. As conditions degrade, numbers of species at an area decline.
2. **Number of centrarchid species** -- Sunfish species (excluding black basses) are invertivores and a high diversity of this group is indicative of reduced siltation and suitable sediment quality in littoral areas.
3. **Number of benthic invertivore species** -- Due to the special dietary requirements of this species group and the limitations of their food source in degraded environments, numbers of benthic invertivore species increase with better environmental quality.
4. **Number of intolerant species** -- This group is made up of species that are particularly intolerant of physical, chemical, and thermal habitat degradation. Higher numbers of intolerant species suggest the presence of fewer environmental stressors.
5. **Percentage of tolerant individuals** (excluding Young-of-Year) -- This metric signifies poorer water quality with increasing proportions of individuals tolerant of degraded conditions.
6. **Percentage dominance by one species** -- Ecological quality is considered reduced if one species inordinately dominates the resident fish community.
7. **Percentage of non-native species** -- Based on the assumption that non-native species reduce the quality of resident fish communities.
8. **Number of top carnivore species** -- Higher diversity of piscivores is indicative of the availability of diverse and plentiful forage species and the presence of suitable habitat.

Trophic Composition

9. **Percent of individuals as top carnivores** -- A measure of the functional aspect of top carnivores which feed on major planktivore populations.
10. **Percentage of individuals as omnivores** -- Omnivores are less sensitive to environmental stresses due to their ability to vary their diets. As trophic links are disrupted due to degraded conditions, specialist species such as insectivores decline while opportunistic omnivorous species increase in relative abundance.

Abundance

11. **Average number per run** -- (number of individuals) -- This metric is based upon the assumption that high quality fish assemblages support large numbers of individuals.

Fish Health

12. **Percentage individuals with anomalies** -- Incidence of diseases, lesions, tumors, external parasites, deformities, blindness, and natural hybridization

are noted for all fish measured, with higher incidence indicating less favorable environmental conditions.

RFAI methodology addresses all four attributes or characteristics of a "balanced indigenous population" defined by the CWA, as described below:

(1) **A biotic community characterized by diversity appropriate to the ecoregion**: Diversity is addressed by the metrics in the Species Richness and Composition category, especially metric 1 – Total number of species. Determination of reference conditions based on the inflow zones of lower mainstem Tennessee River reservoirs (as described below) ensures appropriate species expectations for the ecoregion.
(2) **The capacity for the community to sustain itself through cyclic seasonal change**: TVA uses an autumn data collection period for biological indicators, both VS and upstream/downstream monitoring. Autumn monitoring is used to document condition or health after being subjected to the wide variety of stressors throughout the year. One of the main benefits of using biological indicators is their ability to integrate stressors through time. Examining the condition or health of a community at the end of the "biological year" (i.e., autumn) provides insights into how well the community has dealt with the stresses through an annual seasonal cycle. Likewise, evaluation of the condition of individuals in the community (in this case, individual fish as reflected in Metric 12) provides insights into how well the community can be expected to withstand stressors through winter. Further, multiple sampling years during the permit renewal cycle adds to the evidence of whether or not the autumn monitoring approach has correctly demonstrated the ability of the community to sustain itself through repeated seasonal changes.
(3) **The presence of necessary food chain species**: Integrity of the food chain is measured by the Trophic Composition metrics, with support from the Abundance metric and Species Richness and Composition metrics. Existence of a healthy fish community indicates presence of necessary food chain species because the fish community is comprised of species that utilize multiple feeding mechanisms that transcend various levels in the aquatic food web. Basing evaluations on a sound multi-metric system such as the RFAI enhances the ability to discern alterations in the aquatic food chain.
(4) **A lack of domination by pollution-tolerant species**: Domination by pollution-tolerant species is measured by metrics 3 (Number of benthic invertivore species), 4 (Number of intolerant species), 5 (Percentage of tolerant individuals), 6 (Percentage dominance by one species), and 10 (Percentage of individuals as omnivores).

Scoring categories are based on "expected" fish community characteristics in the absence of human-induced impacts other than impoundment of the reservoir. These categories were developed from historical fish assemblage data representative of transition zones from lower mainstem Tennessee River reservoirs (Hickman and McDonough, 1996). Attained values for each of the 12 metrics were compared to the scoring criteria and assigned scores to represent relative degrees of degradation: least degraded (5); intermediate degraded (3); and greatest degraded (1). Scoring criteria for lower mainstem Tennessee River reservoirs is shown in Table 1.

If a metric was calculated as a percentage (e.g., Percent tolerance individuals), the data from electro-fishing and gill netting were scored separately and allotted half the total score for that individual metric. Individual metric scores for a sampling area (i.e., upstream or downstream) are summed to obtain the RFAI score for the area.

TVA uses RFAI results to determine maintenance of BIP using 2 approaches. One is "absolute" in that it compares the RFAI scores and individual metrics to predetermined values. The other is "relative" in that it compares RFAI scores attained downstream to the upstream control site. The "absolute" approach is based on Jennings et al. (1995) who suggested that favorable comparisons of the attained RFAI score from the potential impact zone to a predetermined criterion can be used to identify the presence of normal community structure and function and hence existence of BIP. For multi-metric indices, TVA uses two criteria to ensure a conservative screening of BIP. First, if an RFAI score reaches 70% of the highest attainable score of 60 (adjusted upward to include sample variability as described below), and second, if fewer than half of RFAI metrics receive a low (1) or moderate (3) score, then normal community structure and function would be present indicating that BIP had been maintained, thus no further evaluation would be needed.

RFAI scores range from 12 to 60. Ecological health ratings (12-21 ["Very Poor"], 22-31 ["Poor"], 32-40 ["Fair"], 41-50 ["Good"], or 51-60 ["Excellent"]) are then applied to scores. As discussed in detail below, the average variation for RFAI scores in TVA reservoirs is 6 ($\pm$ 3). Therefore, any location that attains an RFAI score of 45 (42 plus the upward sample variation of 3) or higher would be considered to have BIP. It must be stressed that scores below this threshold do not necessarily reflect an adversely impacted fish community. The threshold is used to serve as a conservative screening level; i.e., any fish community that meets these criteria is obviously not adversely impacted. RFAI scores below this level would require a more in-depth look to determine if BIP exists. An inspection of individual RFAI metric results and species of fish used in each metric would be an initial step to help identify if operation of BFN is a contributing factor. This approach is appropriate because a validated multi-metric index is being used and scoring criteria applicable to the zone of study are available.

A difference in RFAI scores attained at the downstream area compared to the upstream (control) area is used as one basis for determining presence or absence of impacts on the resident fish community from BFN's operations. The definition of "similar" is integral to accepting the validity of these interpretations. The Quality Assurance (QA) component of the Vital Signs monitoring program deals with how well the RFAI scores can be repeated and is accomplished by collecting a second set of samples at 15%-20% of the areas each year. Comparison of paired-sample QA data collected over seven years shows that the difference in RFAI index scores ranges from 0 to 18 points. The mean difference between these 54 paired scores is 4.6 points with 95% confidence limits of 3.4 and 5.8. The 75th percentile of the sample differences is 6, and the 90th percentile is 12. Based on these results, a difference of 6 points or less in the overall RFAI scores is the value selected for defining "similar" scores between upstream and downstream fish communities. That is, if the downstream RFAI score is within 6 points of the upstream score and if there are no major differences in overall fish community composition, then the two locations are considered similar. It is important to bear in mind that differences greater than 6 points can be expected simply due to method variation (i.e., 25% of the QA paired sample sets exceeded a difference of 6). An examination of the 12 metrics (with emphases on fish

species used for each metric) is conducted to determine any difference in scores and the potential for the difference to be thermally related.

Benthic Macroinvertebrate Community Sampling Methods and Data Analysis for Sites Upstream and Downstream of BFN

Ten benthic grab samples were collected at equally spaced points along the upstream and downstream transects. A Ponar sampler was used for most samples but a Peterson sampler was used when heavier substrate was encountered. Collection and processing techniques followed standard VS procedures. Bottom sediments were washed on a 533μ screen; organisms were then picked from the screen and remaining substrate and identified in the field to Order or Family level without magnification. Benthic community results were evaluated using seven community characteristics or metrics. Results for each metric were assigned a rating of 1, 3, or 5 depending upon how they scored based on reference conditions developed for VS reservoir inflow sample sites. The ratings for the seven metrics were summed to produce a benthic score for each sample site. Potential scores ranged from 7 to 35. Ecological health ratings (7-12 "Very Poor", 13-18 "Poor", 19-23 "Fair", 24-29 "Good", or 30-35 "Excellent") are then applied to scores.

A similar or higher benthic index score at the downstream site compared to the upstream site is used as basis for determining absence of impact on the benthic macroinvertebrate community related to BFN's thermal discharge. The QA component of VS monitoring shows that the comparison of benthic index scores from 49 paired sample sets collected over the past seven years range from 0 to 14 points, the 75th percentile is 4, the 90th percentile is 6. The mean difference between these 49 paired scores is 3.1 points with 95% confidence limits of 2.2 and 4.1. Based on these results, a difference of 4 points or less is the value selected for defining "similar" scores between upstream and downstream benthic communities. That is, if the downstream benthic score is within 4 points of the upstream score, the communities will be considered similar and it will be concluded that BFN has had no effect. Once again, it is important to bear in mind that differences greater than 4 points can be expected simply due to method variation (25% of the QA paired sample sets exceeded that value). When such occurs, a metric-by-metric examination will be conducted to determine what caused the difference in scores and the potential for the difference to be thermally related.

Prior to 2001, a sampling site in the forebay zone of Wheeler Reservoir (TRM 277) was used as the downstream comparison site. Other factors unrelated to influence from BFN have kept benthic communities depressed, both at the forebay site and in the Elk River embayment (Wheeler Reservoir, Elk River Mile [ERM] 6 – between BFN and the forebay site). In order to more accurately assess the effects from BFN, a second transition zone site two miles downstream from the BFN diffuser at TRM 291.7 was created in 2000. Benthic scores and community composition from this site have been used since 2000 for downstream comparisons.

Spring Sport Fish Survey

Spring Sport Fish Surveys were conducted on Wheeler Reservoir during spring 2008. Sampling was conducted using boat mounted electrofishing gear at twelve sites in the Elk River, Second Creek, and First Creek. Sampling effort at each site consisted of thirty minutes of continuous electrofishing in the littoral zones of prominent habitat types present. After being stunned, fish were collected with dip nets, counted, weighed, measured, and then released unharmed.

Results of the SSS monitoring were calculated using Shoreline Assessment Habitat Index (SAHI), Relative Stock Density (RSD), Proportional Stock Density (PSD), and Relative Weight (Wr). Habitat type is evaluated using the SAHI metric and is a critical component incorporated into the SSS. The resultant habitat designations ("Good", "Fair", and "Poor") are correlated to black bass abundance (numbers/hour). RSD is the number of fish greater than a minimum preferred length in a stock divided by the number of fish greater than or equal to a minimum stock size. PSD is the number of fish greater than or equal to a minimum quality length in a sample divided by the number of fish greater than or equal to a minimum stock length. Wr is an index that quantifies fish condition and the preferred range value is 90%-105% for moderate density bass populations such as those found in the Tennessee Valley latitudes.

Results and Discussion

Fish Community

In 2008, fish community RFAI scores of 45 ("Good") and 42 ("Good") were observed at the downstream and upstream stations, respectively (Table 2). Both sites met BIP screening criteria, were within the 6 point range of acceptable variation, and are considered similar.

An examination of the autumn 2008 RFAI showed that portions of three metrics (gill net portion of percent tolerant individuals, gill net portion of percent non-native species, and the electrofishing and gill net portions of percent omnivores) scored lower at the upstream site while the downstream site scored lower for a portion of one metric (electrofishing portion of percent top carnivores) (Table 2).

A discussion of the individual metric scores follows (refer to Tables 2, 3, and 4):

1. Total number of Species: At both the downstream and upstream sampling areas, 28 native species were collected. Five native species (black redhorse, largescale stoneroller, black buffalo, golden redhorse, sauger) were collected at the downstream area that were not encountered at the upstream area, while five native species (longnose gar, golden shiner, white crappie, northern hogsucker, and bullhead minnow) and two non-native species (striped bass and Atlantic needlefish) were collected at the upstream area that were not encountered at the site downstream of BFN. Both sites received the mid-range score for this metric.

2. Number of Centrarchid Species (less Micropterus): Six centrarchid species were collected at the downstream site while seven centrarchid species were collected at the upstream site (3 white crappie were collected upstream but not downstream). Both sites received the highest score for this metric.

3. Number of benthic invertivore species: Five benthic invertivore species were collected downstream of BFN, while four benthic invertivore species were collected upstream. Black and golden redhorse were collected upstream but were not encountered downstream of BFN, while northern hogsucker was collected downstream but not encountered upstream of BFN. Both sites received the mid-range score for this metric.

4. Number of intolerant species: Five intolerant species were encountered at both the upstream and downstream sites and both sites received the highest score for this metric.

5. Percent tolerant individuals: The downstream site received a mid-range score for both the electrofishing and gill net portions of this metric. The upstream site had a considerably higher percentage of tolerant individuals in the electrofishing and gill net samples due to collection of more tolerant species. The upstream site received a mid-range score for the electrofishing portion and the lowest score for the gill net portion of this metric.

6. Percent dominance by one species: Inland silverside (non-native) was the dominant species in the electrofishing portion of the sample at the downstream site while gizzard shad was the dominant species at the upstream site. Both sites received the mid-range score for this portion of the metric. White bass was the dominant species at the downstream site for the gill net portion of this metric while channel catfish was the dominant species at the upstream site. Both sites received a mid-range score for the gill net portion of this metric.

7. Percent non-native fish: Both the upstream and downstream sites received the lowest score for the electrofishing portion of this metric due to a high percentage of inland silversides (52.7% of downstream sample, 29% of upstream sample). The downstream site received the highest score for the gillnet portion of this metric due to collection of 1 common carp while the upstream site received the mid-range score due to collection of 1 common carp and 2 striped bass.

8. Number of top carnivores: Eleven species of top carnivores were collected upstream of BFN while ten species were collected at the downstream site (white crappie and longnose gar were not collected downstream while sauger were not collected upstream). Both sites received the highest score for this metric.

9. Percent top carnivores: Electrofishing samples collected upstream of BFN resulted in a higher percentage of top carnivores compared to downstream samples. Conversely, gill net samples collected downstream of BFN had a much higher percentage of top carnivores than those collected upstream. Both sites received the highest score for the gill net portion of this metric, while the downstream site received a mid-range score for the electrofishing portion of this metric.

10. Percent of omnivore species: The downstream site had a much lower percentage of omnivores in both the electrofishing and gill net samples. The upstream site scored 1 point lower for each portion of this metric, predominately due to higher percentages of gizzard shad in the electrofishing portion and channel catfish in the gill net portion.

11. Overall fish abundance: This metric is measured by the average number of fish caught for each electro-fishing and gill net effort. Average catch per unit effort was low at both sites for the electrofishing portion of this metric; both received the lowest score. Gill net catch rates were similar; both sites received the mid-range score for this portion of the metric.

12. Percent anomalies: Both the upstream and downstream sites received the highest score for this metric due to a low percentage of observed anomalies (i.e. visible lesions, bacterial and

fungal infections parasites, muscular and skeletal deformities, and hybridization).

As discussed above, RFAI scores have an intrinsic variability of ±3 points. This variability comes from various sources, including annual variations in air temperature and stream flow; variations in pollutant loadings from nonpoint sources; changes in habitat, such as extent and density of aquatic vegetation; natural population cycles and movements of the species being measured (TWRC, 2006). Another source of variability arises from the fact that nearly any practical measurement, lethal or non-lethal, of a biological community is a sample rather than a measurement of the entire population. As long as the score is within the 6-point range, there is no certainty that any real change has taken place beyond method variability.

Over the nine sample years, both sites have averaged a score of 42 ("Good"). Both sites have been within the 6 point range of accepted variability each year, with the exception of 2005 when the upstream site scored 10 points higher, indicating the sites were similar annually and that the BFN heated effluent is not adversely affecting the fish community in the vicinity of the plant (Table 5). The "Fair" 2005 score at the downstream site was a result of a high percentage of tolerant individuals in the gill net samples and dominance by one species in both gill net and electrofishing samples (Appendices 1-C, 2-E). Individual metric scores and overall RFAI scores for the upstream and downstream sampling sites of BFN for sample years 2000-2007 are listed in Appendix 1 (A-H). Species collected and catch per effort during electrofishing at the upstream and downstream sampling sites of BFN for sample years 2000-2007 are listed in Appendix 2 (A-P).

RFAI scores are presented for the Wheeler Reservoir inflow site (TRM 348.0), the forebay site (TRM 277.0), and the Elk River embayment site (ERM 6.0) to provide additional information of the health of the fish community throughout the reservoir; however, aquatic communities at these sites are not affected by BFN temperature effects and are not used to determine BIP in relation to BFN (Table 5). The average RFAI scores at these three sites over all sampling years have remained in the "Good" range.

Benthic Macroinvertebrate Community

Benthic macroinvertebrate data collected during autumn 2008 from TRM 295.9 upstream from BFN and from TRM 291.7 downstream of BFN resulted in a RBI scores of 25 ("Good") and 29 ("Good"), respectively (Table 6). Both sites have scored in the "Good" to "Excellent" ecological health range for all sampling years (Table 7). A difference of 4 points or less between upstream and downstream stations is used to define "similar" conditions between the two sites. Scores for these two sites have not exceeded a difference of 4 points during any sampling year. Table 8 provides density by taxon from the 2008 samples at these sites. These data indicate that a healthy benthic macroinvertebrate community exists in both the upstream and downstream vicinity of BFN and that the plant is not adversely impacting this fauna.

RBI scores for the inflow, forebay, and Elk River embayment sites are included to provide additional data on the overall health of the benthic macroinvertebrate community in Wheeler Reservoir (Table 7). RBI scores in the "Good" to "Excellent" range have been observed 8 of the 11 sample years at the inflow site. Data collected in Wheeler Reservoir forebay (TRM 277) and the Elk River embayment (ERM 6.0) have consistently resulted in "Poor" RBI scores. The

forebay sampling site is located 17 river miles downstream of BFN. The Elk River embayment sampling site is located 6 river miles upstream of the confluence with the Tennessee River. The confluence of the Elk River is 10 river miles downstream of BFN. Because these sites are located considerable distances from BFN, poor sampling results should not be indicative of temperature effects from the plant. Furthermore, the benthic macroinvertebrate community closest to the discharge should be most affected by BFN thermal effects and sampling at this site has not indicated negative effects.

Spring Sport Fish Survey
A total of 18 hours of electrofishing effort resulted in 1,390 largemouth bass, 30 spotted bass, and 57 smallmouth bass; of these, 66.7% were harvestable size ($\geq$ 10 inches). Overall catch rate (82.0 fish/hour) was slightly higher than the previous year (76.1 fish/hour) (Table 9). The average weight of harvestable sized black bass was 1.5 pounds. The largest black bass collected was a 5.9 pound largemouth bass collected from First Creek. Large bass were well represented with 53 bass greater than three pounds, 14 greater than four pounds, and 5 over five pounds. All size classes up to 20 inches were represented in the population. Length frequency histograms illustrated a bimodal distribution with the 8 and 13 inch groups being the dominant size classes (Figure 5).

Habitat type is derived from the SAHI which was developed by TVA's Resource Stewardship Program. The resultant habitat designations (Good, Fair, and Poor) are correlated to black bass abundance (numbers/hour). Among the three areas sampled during 2008, individual sites showed a lot of variation in abundance to habitat types on Wheeler Reservoir with the exception of First Creek (Table 10). Overall reservoir catch rates were 101, 81, and 66 fish/hour at the Good, Fair, and Poor habitat types, respectively exhibiting a classic positive correlation of black bass density to habitat types.

The following results describe the quality and condition of black bass collected in Wheeler Reservoir during spring 2008: The RSD value (12) was within the desirable range (10-25) (Figure 6). The PSD value (55) was also within the preferred range (40-70) (Figure 7). Wr values shown in Figure 8 are designated by inch groups which reflect the classical categories, i.e., 0-7 = substock, 8-11 = stock, 12-14 = quality, 15-19 = preferred, 20-24 = memorable and 25+ = trophy. All categories, except trophy, fell within the desired range, which indicates a balanced population structure. Largemouth bass length frequency histograms illustrated a bimodal distribution with the 8-inch size class (age-2) and 12 and 13-inch class (age-3) being the dominant size classes (Figure 5).
A total of 34 crappie, 29 white and 5 black, were also collected during the survey. According to angler accounts, Wheeler Reservoir has a good crappie population; however, they were not in the shallow areas that coincided with our littoral zone sampling efforts.

Wheeler Reservoir Flow and BFN Temperature
A comparison of daily average flows from Guntersville Dam, October 2007 through November 2008, and historic daily flows from 1976-2007 are shown in Figure 9. Daily average flows were approximately 50% less than the historical daily average flows from 1976 through 2007.

Figure 10 illustrates the comparison of daily average water temperatures recorded upstream of

BFN intake and downstream of BFN discharge during October 2007 through November 2008. Despite 50% daily average flow past the plant, BFN operated within their NPDES permit limit and a Balanced Indigenous Population was maintained.

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Table 1. Scoring criteria (2002) for forebay, transition, and inflow sections of Lower Mainstream reservoirs in the Tennessee River system. Lower Mainstream reservoirs include Guntersville, Wheeler, Wilson, Pickwick, and Kentucky. Transition scoring criteria were used for sites upstream and downstream of Browns Ferry Nuclear Plant.

		Scoring Criteria								
		Forebay			Transition			Inflow		
Metric	Gear	1	3	5	1	3	5	1	3	5
1. Total species	Combined	<14	14-27	>27	<16	16-30	>30	<14	14-27	>27
2. Total Centrarchid species	Combined	<2	2-3	>3	<2	2-2	>2	<2	2-4	>4
3. Total benthic invertivores	Combined	<4	4-6	>6	<4	4-7	>7	<4	4-7	>7
4. Total intolerant species	Combined	<2	2-4	>4	<3	3-4	>4	<3	3-6	>6
5. Percent tolerant individuals	Electrofishing	>61%	30-61%	<30%	>54%	27-54%	<27%	>51%	26-51%	<26%
	Gill netting	>46%	22-46%	<22%	>30%	15-30%	<15%			
6. Percent dominance by 1 species	Electrofishing	>59%	30-59%	<30%	>58%	29-58%	<29%	>47%	24-47%	<24%
	Gill netting	>43%	21-43%	<21%	>34%	17-34%	<17%			
7. Percent non-native species	Electrofishing	>2%	2-2%	<2%	>2%	1-2%	<1%	>4%	2-4%	<2%
	Gill netting	>2%	1-2%	<1%	>2%	1-2%	<1%			
8. Total top carnivore species	Combined	<4	4-7	>7	<4	4-7	>7	<4	4-7	>7
9. Percent top carnivores	Electrofishing	<6%	6-12%	>12%	<5%	5-10%	>10%	<15%	15-29%	>29%
	Gill netting	<25%	25-49%	>49%	<20%	20-39%	>39%			
10. Percent omnivores	Electrofishing	>59%	30-59%	<30%	>48%	24-48%	<24%	>48%	24-48%	<24%
	Gill netting	>49%	24-49%	<24%	>33%	16-33%	<16%			
11. Average number per run	Electrofishing	<170	170-341	>341	<243	243-487	>487	<68	68-136	>136
	Gill netting	<20	20-40	>40	<11	11-22	>22			
12. Percent anomalies	Electrofishing	>5%	2-5%	<2%	>5%	2-5%	<2%	>5%	2-5%	<2%
	Gill netting	>5%	2-5%	<2%	>5%	2-5%	<2%			

Table 2 Individual Metric Scores and the Overall RFAI Scores Downstream (TRM 292.5) and Upstream (TRM 295.9) of Browns Ferry Nuclear Plant Discharge, Autumn 2008.

Autumn 2008	TRM 292.5		TRM 295.9	
Metric	Obs	Score	Obs	Score
A. Species richness and composition				
1. Number of species (Tables 3 and 4)	**28 species**	3	**28 species**	3
2. Number of centrarchid species (less Micropterus)	**6 species** Green sunfish Bluegill Longear sunfish Warmouth Black crappie Redear sunfish	5	**7 species** Green sunfish Bluegill Longear sunfish Warmouth Redear sunfish White crappie Black crappie	5
3. Number of benthic invertivore species	**5 species** Spotted sucker Black redhorse Golden redhorse Freshwater drum Logperch	3	**4 species** Spotted sucker Northern hog sucker Freshwater drum Logperch	3
4. Number of intolerant species	**5 species** Spotted sucker Skipjack herring Black redhorse Longear sunfish Smallmouth bass	5	**5 species** Spotted sucker Northern hog sucker Skipjack herring Longear sunfish Smallmouth bass	5

Table 2. (Continued)

Autumn 2008 Metric		TRM 292.5 Obs	Score	TRM 295.9 Obs	Score
5. Percent tolerant individuals	Electrofishing	**37.4%** Bluegill 10.3% Gizzard shad 19.3% Largemouth bass 7.2% Spotfin shiner 0.2% Green sunfish 0.3%	**1.5**	**50.6%** Bluegill 8.2% Gizzard shad 31.7% Common carp 0.3% Largemouth bass 9.4% Spotfin shiner 0.2% Golden shiner 0.2% Green sunfish 0.4%	**1.5**
	Gill Netting	**23.6%** Gizzard shad 14.1% Common carp 0.5% Bluegill 1.0% Largemouth bass 8.0%	**1.5**	**32.1%** Gizzard shad 12.3% Common carp 0.5% Bluegill 3.2% Largemouth bass 7.0% Longnose gar 4.8% Golden shiner 2.7% White crappie 1.6%	**0.5**
6. Percent dominance by one species	Electrofishing	**52.7%** Inland silverside	**1.5**	**31.7%** Gizzard shad	**1.5**
	Gill Netting	**28.6%** White bass	**1.5**	**19.8%** Channel catfish	**1.5**
7. Percent non-native species	Electrofishing	**52.7%** Inland silverside 52.7%	**0.5**	**29.5%** Inland silverside 29.0% Atlantic needlefish 0.1% Common carp 0.3%	**0.5**
	Gill Netting	**0.5%** Common carp 0.5%	**2.5**	**1.6%** Common carp 0.5% Striped bass 1.1%	**1.5**

Table 2. (Continued)

Autumn 2008 Metric		TRM 292.5 Obs	Score	TRM 295.9 Obs	Score
8. Number of top carnivore species		**10 species** Spotted gar Largemouth bass Spotted bass Smallmouth bass Skipjack herring Flathead catfish White bass Yellow bass Black crappie Sauger	5	**11 species** Longnose gar Spotted gar Largemouth bass Spotted bass Smallmouth bass Skipjack herring Flathead catfish White bass Yellow bass Black crappie White crappie	5
B. Trophic composition					
9. Percent top carnivores	Electrofishing	**8.5%** Largemouth bass 7.2% Spotted bass 0.2% Smallmouth bass 1.0% Flathead catfish 0.06%	1.5	**12.6%** Largemouth bass 9.4% Spotted bass 0.7% Smallmouth bass 0.7% Flathead catfish 0.3% White bass 0.2% Yellow bass 1.0% Spotted gar 0.2%	2.5
	Gill Netting	**61.3%** Spotted gar 0.5% Largemouth bass 8.0% Spotted bass 1.0% Skipjack herring 15.6% Flathead catfish 4.5% White bass 28.6% Yellow bass 1.5% Black crappie 0.5% Sauger 1.0%	2.5	**39.6%** Longnose gar 4.8% Largemouth bass 7.0% Spotted bass 1.6% Skipjack herring 1.6% Flathead catfish 2.1% White bass 14.0% Yellow bass 5.3% White crappie 1.6% Black crappie 0.5%	2.5

Table 2. (Continued)

Autumn 2008 Metric		TRM 292.5 Obs	Score	TRM 295.9 Obs	Score
10. Percent omnivores	Electrofishing	**20.7%** Gizzard shad 19.3% Channel catfish 1.2% Blue catfish 0.2%	**2.5**	**38.5%** Gizzard shad 31.7% Channel catfish 5.8% Smallmouth buffalo 0.4% Common carp 0.3% Golden shiner 0.2%	**1.5**
	Gill Netting	**26.6%** Gizzard shad 14.1% Blue catfish 6.0% Channel catfish 3.5% Smallmouth buffalo 2.0% Black buffalo 0.5% Common carp 0.5%	**1.5**	**44.4%** Gizzard shad 12.3% Blue catfish 5.3% Channel catfish 19.8% Golden shiner 2.7% Smallmouth buffalo 3.7% Common carp 0.5%	**0.5**
C. Fish abundance and health					
11. Average number per run	Electrofishing	**112.2**	**0.5**	**59.9**	**0.5**
	Gill Netting	**19.9**	**1.5**	**18.7**	**1.5**
12. Percent anomalies	Electrofishing	**0.4%**	**2.5**	**1%**	**2.5**
	Gill Netting	**0.5%**	**2.5**	**0.5%**	**2.5**
Overall RFAI Score			**45** **Good**		**42** **Good**

Table 3. Species Collected, Trophic level, Native and Tolerance Classification, Catch Per Effort During Electrofishing and Gill Netting at Areas Downstream of Browns Ferry Nuclear Plant Discharge, Autumn 2008.

Common Name	Scientific name	Trophic level	Sunfish species	Native species	Tolerance	Electrofishing Catch Rate Per Run	Electrofishing Catch Rate Per Hour	Total fish EF	Gill Netting Catch Rate Per Net Night	Total Gill net fish	Total fish Combined
Gizzard shad	*Dorosoma cepedianum*	OM	.	X	TOL	21.67	103.83	325	2.80	28	353
Common carp	*Cyprinus carpio*	OM	.	.	TOL	.	.	.	0.10	1	1
Spotfin shiner	*Cyprinella spiloptera*	IN	.	X	TOL	0.20	0.96	3	.	.	3
Green sunfish	*Lepomis cyanellus*	IN	X	X	TOL	0.33	1.60	5	.	.	5
Bluegill	*Lepomis macrochirus*	IN	X	X	TOL	11.60	55.59	174	0.20	2	176
Largemouth bass	*Micropterus salmoides*	TC	.	X	TOL	8.13	38.98	122	1.60	16	138
Skipjack herring	*Alosa chrysochloris*	TC	.	X	INT	.	.	.	3.10	31	31
Spotted sucker	*Minytrema melanops*	BI	.	X	INT	0.07	0.32	1	0.30	3	4
Black redhorse	*Moxostoma duquesnei*	BI	.	X	INT	0.07	0.32	1	.	.	1
Longear sunfish	*Lepomis megalotis*	IN	X	X	INT	5.60	26.84	84	.	.	84
Smallmouth bass	*Micropterus dolomieu*	TC	.	X	INT	1.13	5.43	17	.	.	17
Spotted gar	*Lepisosteus oculatus*	TC	.	X	.	.	.	.	0.10	1	1
Threadfin shad	*Dorosoma petenense*	PK	.	X	.	0.07	0.32	1	.	.	1
Largescale stoneroller	*Campostoma oligolepis*	HB	.	X	.	0.07	0.32	1	.	.	1
Smallmouth buffalo	*Ictiobus bubalus*	OM	.	X	.	.	.	.	0.40	4	4
Black buffalo	*Ictiobus niger*	OM	.	X	.	.	.	.	0.10	1	1
Golden redhorse	*Moxostoma erythrurum*	BI	.	X	.	0.13	0.64	2	0.10	1	3
Blue catfish	*Ictalurus furcatus*	OM	.	X	.	0.20	0.96	3	1.20	12	15
Channel catfish	*Ictalurus punctatus*	OM	.	X	.	1.33	6.39	20	0.70	7	27
Flathead catfish	*Pylodictis olivaris*	TC	.	X	.	0.07	0.32	1	0.90	9	10
White bass	*Morone chrysops*	TC	.	X	.	.	.	.	5.70	57	57
Yellow bass	*Morone mississippiensis*	TC	.	X	.	.	.	.	0.30	3	3
Warmouth	*Lepomis gulosus*	IN	X	X	.	0.07	0.32	1	.	.	1
Redear sunfish	*Lepomis microlophus*	IN	X	X	.	1.40	6.71	21	1.10	11	32
Spotted bass	*Micropterus punctulatus*	TC	.	X	.	0.20	0.96	3	0.20	2	5
Black crappie	*Pomoxis nigromaculatus*	TC	X	X	.	.	.	.	0.10	1	1
Logperch	*Percina caprodes*	BI	.	X	.	0.20	0.96	3	.	.	3
Sauger	*Sander canadensis*	TC	.	X	.	.	.	.	0.20	2	2
Freshwater drum	*Aplodinotus grunniens*	BI	.	X	.	0.53	2.56	8	0.70	7	15
Inland silverside	*Menidia beryllina*	IN	.	.	.	59.13	283.39	887	.	.	887
Total						112.20	537.72	1,683	93.90	19.90	199
Number Samples						15			10		
Species Collected						21			20		

Table 4. Species Collected, Trophic level, Native and Tolerance Classification, Catch Per Effort During Electrofishing and Gill Netting at Areas Upstream of Browns Ferry Nuclear Plant Discharge, Autumn 2008.

Common Name	Scientific name	Trophic level	Sunfish species	Native species	Tolerance	Electrofishing Catch Rate Per Run	Electrofishing Catch Rate Per Hour	Total fish EF	Gill Netting Catch Rate Per Net Night	Total Gill net fish	Total fish Combined
Longnose gar	*Lepisosteus osseus*	TC	.	X	TOL	.	.	.	0.90	9	9
Gizzard shad	*Dorosoma cepedianum*	OM	.	X	TOL	19.00	96.28	285	2.30	23	308
Common carp	*Cyprinus carpio*	OM	.	.	TOL	0.20	1.01	3	0.10	1	4
Golden shiner	*Notemigonus crysoleucas*	OM	.	X	TOL	0.13	0.68	2	0.50	5	7
Spotfin shiner	*Cyprinella spiloptera*	IN	.	X	TOL	0.13	0.68	2	.	.	2
Green sunfish	*Lepomis cyanellus*	IN	X	X	TOL	0.27	1.35	4	.	.	4
Bluegill	*Lepomis macrochirus*	IN	X	X	TOL	4.93	25.00	74	0.60	6	80
Largemouth bass	*Micropterus salmoides*	TC	.	X	TOL	5.60	28.38	84	1.30	13	97
White crappie	*Pomoxis annularis*	TC	X	X	TOL	.	.	.	0.30	3	3
Skipjack herring	*Alosa chrysochloris*	TC	.	X	INT	.	.	.	0.30	3	3
Northern hog sucker	*Hypentelium nigricans*	BI	.	X	INT	0.13	0.68	2	.	.	2
Spotted sucker	*Minytrema melanops*	BI	.	X	INT	0.60	3.04	9	.	.	9
Longear sunfish	*Lepomis megalotis*	IN	X	X	INT	1.53	7.77	23	.	.	23
Smallmouth bass	*Micropterus dolomieu*	TC	.	X	INT	0.40	2.03	6	.	.	6
Spotted gar	*Lepisosteus oculatus*	TC	.	X	.	0.13	0.68	2	.	.	2
Threadfin shad	*Dorosoma petenense*	PK	.	X	.	0.27	1.35	4	.	.	4
Bullhead minnow	*Pimephales vigilax*	IN	.	X	.	0.07	0.34	1	.	.	1
Smallmouth buffalo	*Ictiobus bubalus*	OM	.	X	.	0.27	1.35	4	0.70	7	11
Blue catfish	*Ictalurus furcatus*	OM	.	X	.	.	.	.	1.00	10	10
Channel catfish	*Ictalurus punctatus*	OM	.	X	.	3.47	17.57	52	3.70	37	89
Flathead catfish	*Pylodictis olivaris*	TC	.	X	.	0.20	1.01	3	0.40	4	7
White bass	*Morone chrysops*	TC	.	X	.	0.13	0.68	2	2.60	26	28
Yellow bass	*Morone mississippiensis*	TC	.	X	.	0.60	3.04	9	1.00	10	19
Striped bass	*Morone saxatilis*	TC	.	.	.	.	.	.	0.20	2	2
Warmouth	*Lepomis gulosus*	IN	X	X	.	0.07	0.34	1	.	.	1
Redear sunfish	*Lepomis microlophus*	IN	X	X	.	2.67	13.51	40	0.60	6	46
Spotted bass	*Micropterus punctulatus*	TC	.	X	.	0.40	2.03	6	0.30	3	9
Black crappie	*Pomoxis nigromaculatus*	TC	X	X	.	.	.	.	0.10	1	1
Logperch	*Percina caprodes*	BI	.	X	.	0.33	1.69	5	.	.	5
Freshwater drum	*Aplodinotus grunniens*	BI	.	X	.	0.87	4.39	13	1.80	18	31
Inland silverside	*Menidia beryllina*	IN	.	.	.	17.40	88.18	261	.	.	261
Atlantic needlefish	*Strongylura marina*	TC	.	.	.	0.07	0.34	1	.	.	1
Total						59.87	303.4	898	18.7	187	1085
Number Samples						15			10		
Species Collected						26			19		

Table 5. Summary of RFAI Scores from Sites Located Directly Upstream and Downstream of Browns Ferry Nuclear Plant as Well as Scores from Sampling Conducted During 1993-2008 as Part of the Vital Signs Monitoring Program in Wheeler Reservoir.

Station	Location	1993	1994	1995	1997	1999	1993-1999 Average	2000	2001	2002	2003	2004	2005	2006	2007	2008	2000-2008 Average
Inflow	TRM 348.0	46	48	42	48	36	44	-	38	46	40	44	46	46	38	38	42
Transition BFN Upstream	TRM 295.9	43	43	35	42	30	39	41	37	43	39	43	46	45	39	42	42
Transition BFN Downstream	TRM 292.5	-	-	-	-	-	N/A	43	40	41	43	43	36	44	42	45	42
Forebay	TRM 277.0	52	44	49	44	42	46	-	43	47	46	45	45	48	49	46	46
Elk River Embayment	ERM 6.0	43	46	36	-	49	44	-	51	-	44	51	47	-	39	-	46

Note: No data were collected for 1996 and 1998.
RFAI Scores: 12-21 ("Very Poor"), 22-31 ("Poor"), 32-40 ("Fair"), 41-50 ("Good"), or 51-60 ("Excellent").

Table 6. Individual Metric Ratings and the Overall RBI Field Scores for Upstream and Downstream Sampling Sites Near Browns Ferry Nuclear Plant, Wheeler Reservoir, Autumn 2008.

	Downstream TRM 291.7		Upstream TRM 295.9	
Metric	**Obs**	**Rating**	**Obs**	**Rating**
1. Average number of taxa	6.3	5	5.8	5
2. Proportion of samples with long-lived organisms	0.9	5	0.7	3
3. Average number of EPT taxa	1.1	5	0.5	3
4. Average proportion of oligochaete individuals	7.2	5	7.8	5
5. Average proportion of total abundance comprised by the two most abundant taxa	81.5	3	84.5	3
6. Average density excluding chironomids and oligochaetes	181.7	1	220	1
7. Zero-samples – proportion of samples containing no organisms	0	5	0	5
Benthic Index Score		**29**		**25**
		Good		**Good**

*TRM 295.9 and TRM 291.7 scored with transition criteria.
Reservoir Benthic Index Scores: 7-12 ("Very Poor"), 13-18 ("Poor"), 19-23 ("Fair"), 24-29 ("Good"), 30-35 ("Excellent")

Table 7. RBI Field Scores from Data Collected During 1994-2008 at Wheeler Reservoir Inflow, Transition, Embayment, and Forebay Sampling Sites.

Station	Location	1994	1995	1997	1999	1994-1999 Average	2000	2001	2002	2003	2004	2005	2006	2007	2008	2000-2008 Average
Inflow	TRM 347.0	31	21	25	23	25	-	21	25	31	31	31	33	33	-	29
Transition BFN Upstream	TRM 295.9	33	25	31	31	30	31	29	31	31	33	31	31	33	25	31
Transition BFN Downstream	TRM 291.7	-	-	-	-	N/A	27	31	27	35	33	31	31	29	29	30
Forebay	TRM 277.0	19	15	23	17	19	-	17	15	15	19	15	13	13	15	15
Elk River Embayment	ERM 6.0	15	13	15	15	15	-	15	-	15	-	17	-	13	-	15

Note: No data were collected for 1996 and 1998.
Reservoir Benthic Index Scores: 7-12 ("Very Poor"), 13-18 ("Poor"), 19-23 ("Fair"), 24-29 ("Good"), 30-35 ("Excellent")

Table 8. Average Mean Density Per Square Meter of Benthic Taxa Collected at Upstream and Downstream Sites Near Browns Ferry Nuclear Plant, Wheeler Reservoir, Autumn 2008.

Taxa	Downstream TRM 291.7	Upstream TRM 295.9
Tubellaria		
Tricladida		
Planariidae		
Oligocheata		
Oligochaetes	27	57
Hirudinea	5	2
Crustacea		
Amphipoda	57	12
Isopoda		
Insecta		
Ephemeroptera		
Mayflies other than Hexagenia		
Ephemeridae		
Hexagenia (≤10 mm)	3	27
Hexagenia (>10 mm)	40	17
Odonata		
Trichoptera		
Caddisflies	7	---
Plecotera		
Stoneflies		
Coeleoptera		
Diptera		
Ceratopogonidae	---	12
Chironomidae		
Chironomids	298	432
Gastropoda		
Snails	8	13
Basommatophora		
Ancylidae	2	---
Bivalvia		
Unionoida		
Unionidae		
Mussels		
Veneroida		
Corbiculidae		
Corbicula (≤10mm)	3	12
Corbicula (>10mm)	7	55
Sphaeriidae		
Fingernail clams	50	72
Dreissenidae		
Dreissena polymorpha		
Density of organisms per meter²	**507**	**711**
Number of samples	**10**	**10**
Total area sampled (meter²)	**0.6**	**0.6**

Table 9. **Electrofishing Catch Rates and Population Characteristics of Black Bass Collected During Spring Sport Fish Surveys on Wheeler Reservoir, 1995-2008.**

Year	EF Catch Rate (no./hr.)	Mean Weight (lbs.)	% Harvestable	Bass >4 lbs.	Bass >5 lbs.	Largest bass (lbs.)
2008	82.0	1.5	55.5	14	5	5.9
2007	76.1	1.6	53.8	31	7	6.5
2006	37.9	1.3	75.4	15	5	6.2
2005	60.7	1.7	69.9	36	11	6.8
2004	71.8	1.3	76.2	54	23	6.0
2003	55.7	1.3	51.4	20	7	6.4
2002	59.5	1.3	49.4	23	11	6.1
2001	62.7	1.2	41.0	1	0	4.2
2000	73.0	1.2	66.0	5	1	5.6
1999	33.2	1.2	58.3	0	0	4.7
1998	55.5	1.1	38.0	2	0	4.4
1997	47.8	1.0	69.2	5	2	6.1
1996	70.3	1.5	42.8	9	5	6.2
1995	36.8	1.2	68.0	12	5	6.3
Average	58.8	1.3	58.2	16.2	5.9	5.8

Table 10. **Black Bass Catch Per Hour Compared to Habitat Types by Location During Spring Sport Fish Surveys on Wheeler Reservoir, 2008.**

	Habitat Designation		
Wheeler Reservoir Site	**Good**	**Fair**	**Poor**
Elk River	45(1)	94(8)	47(3)
First Creek	126(2)	100(8)	65(2)
Second Creek	133(2)	50(8)	85(2)

Catch per hour = number of fish collected per hour
( ) = number of transects sampled at each location

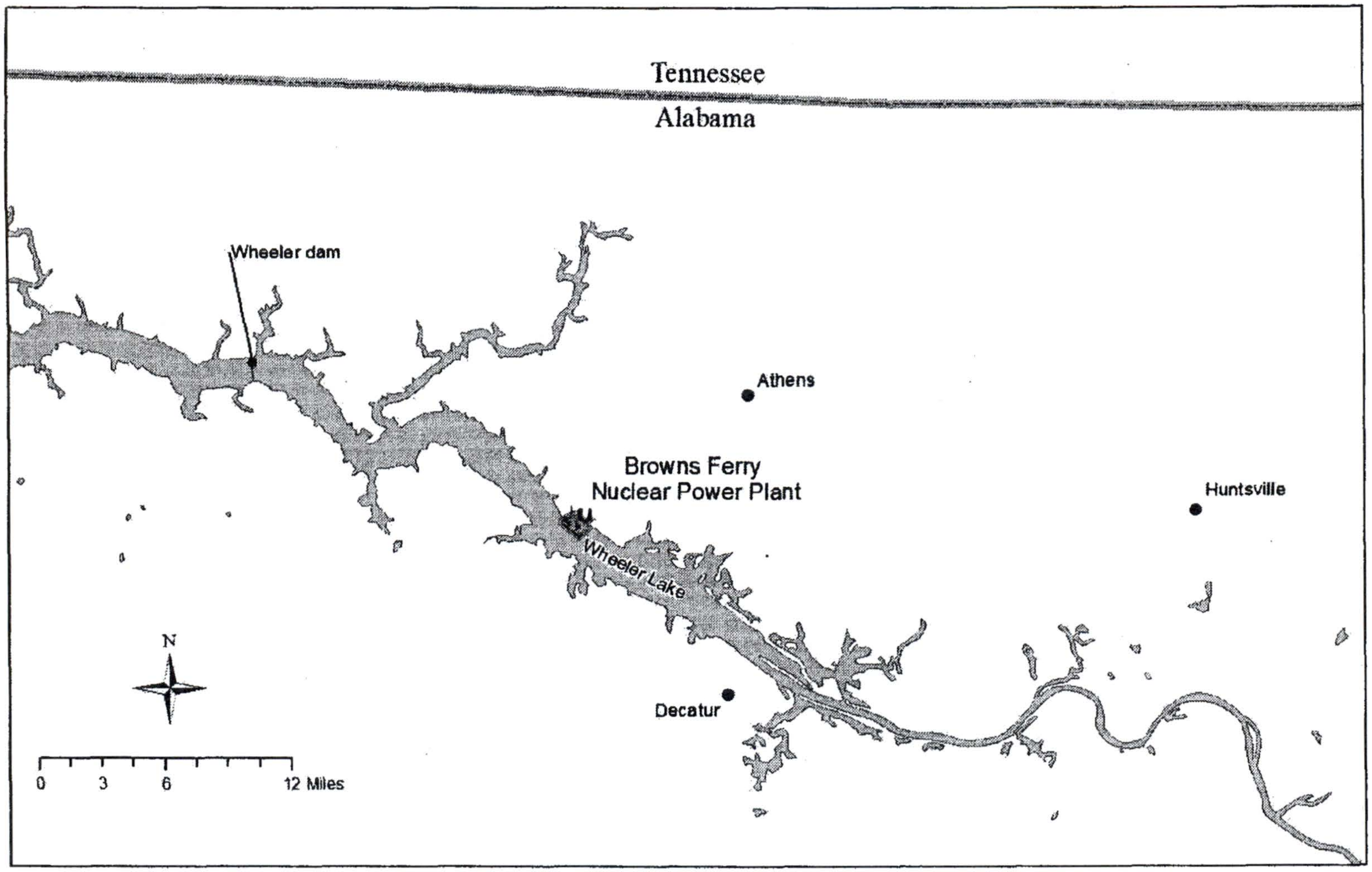


Figure 1. Browns Ferry Nuclear Power Plant is located on the north shore of Wheeler Reservoir at Tennessee River Mile 294.

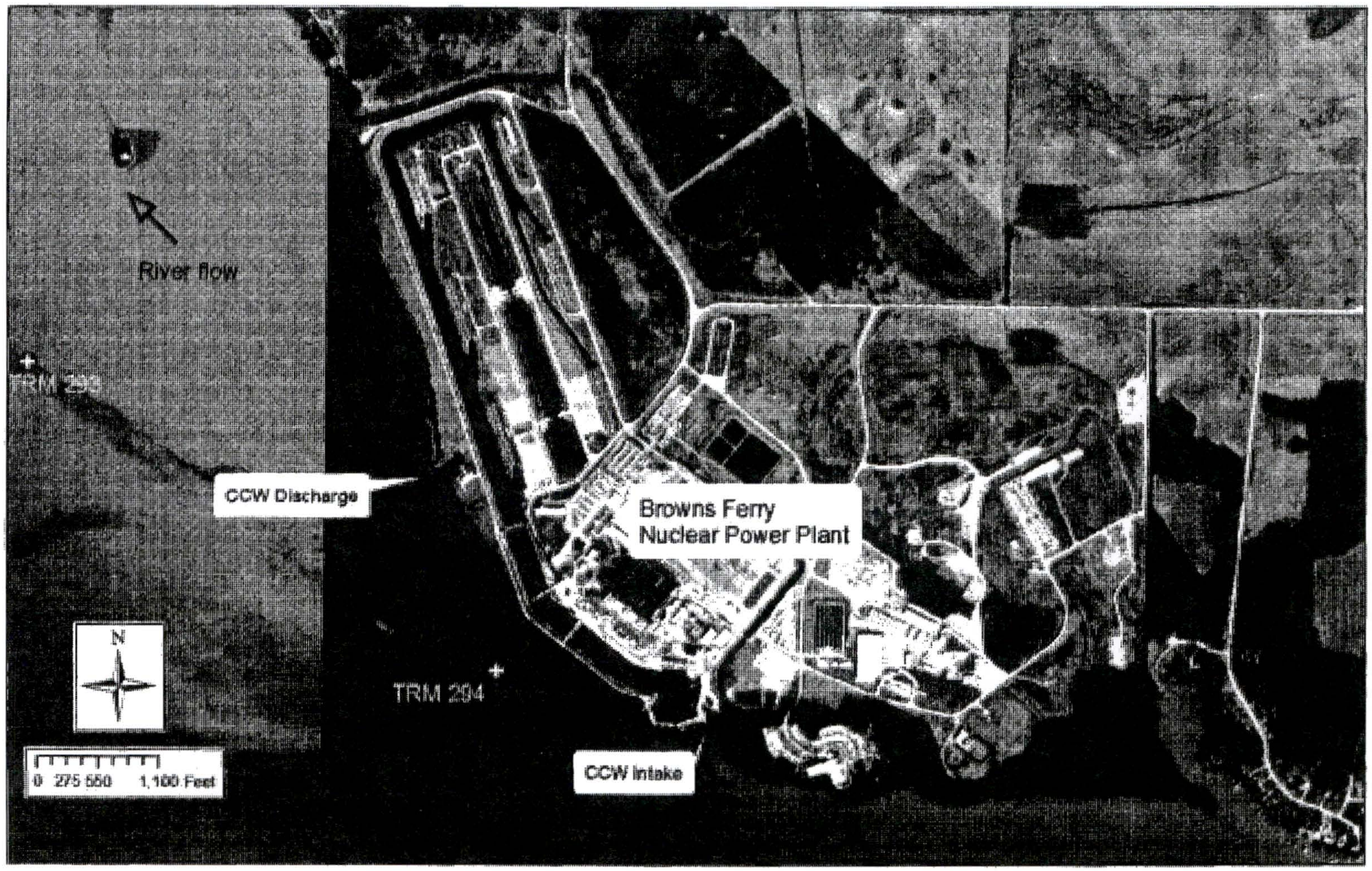
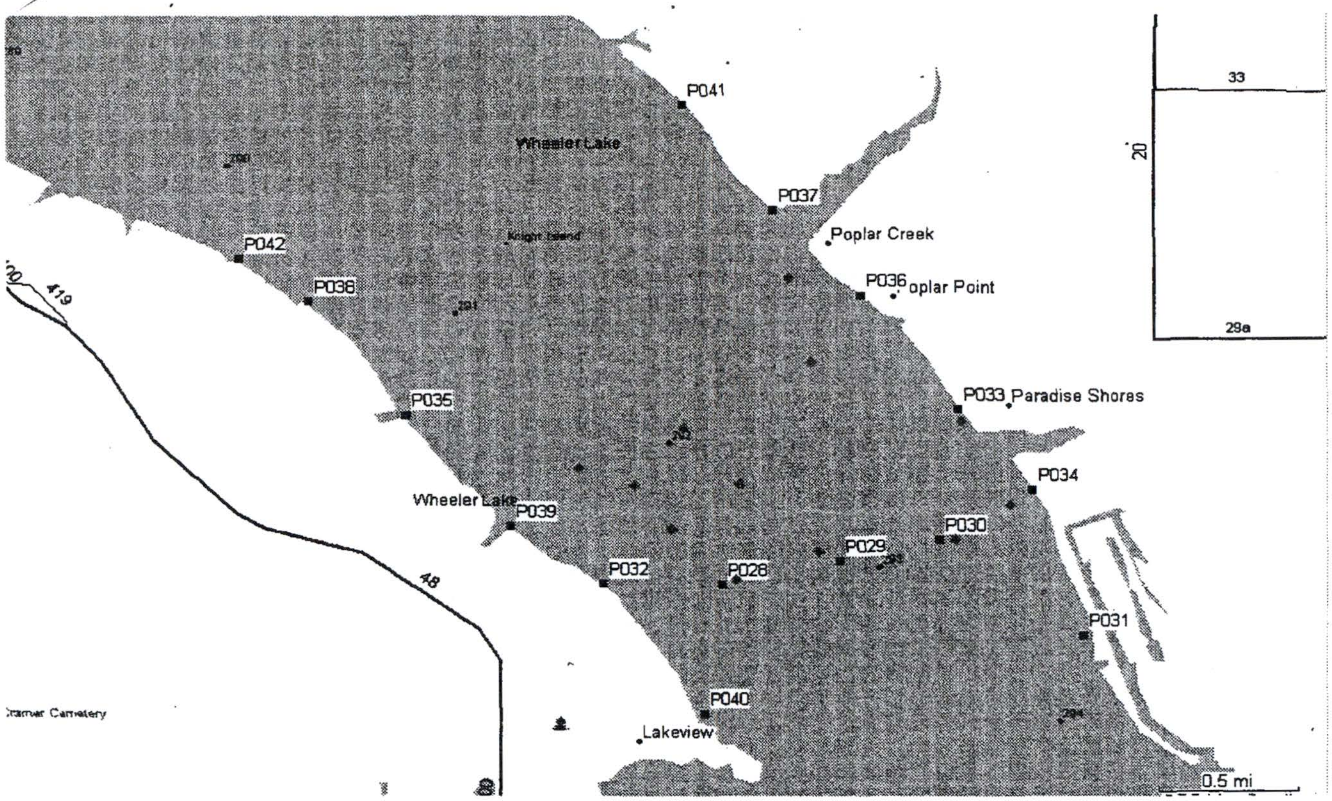
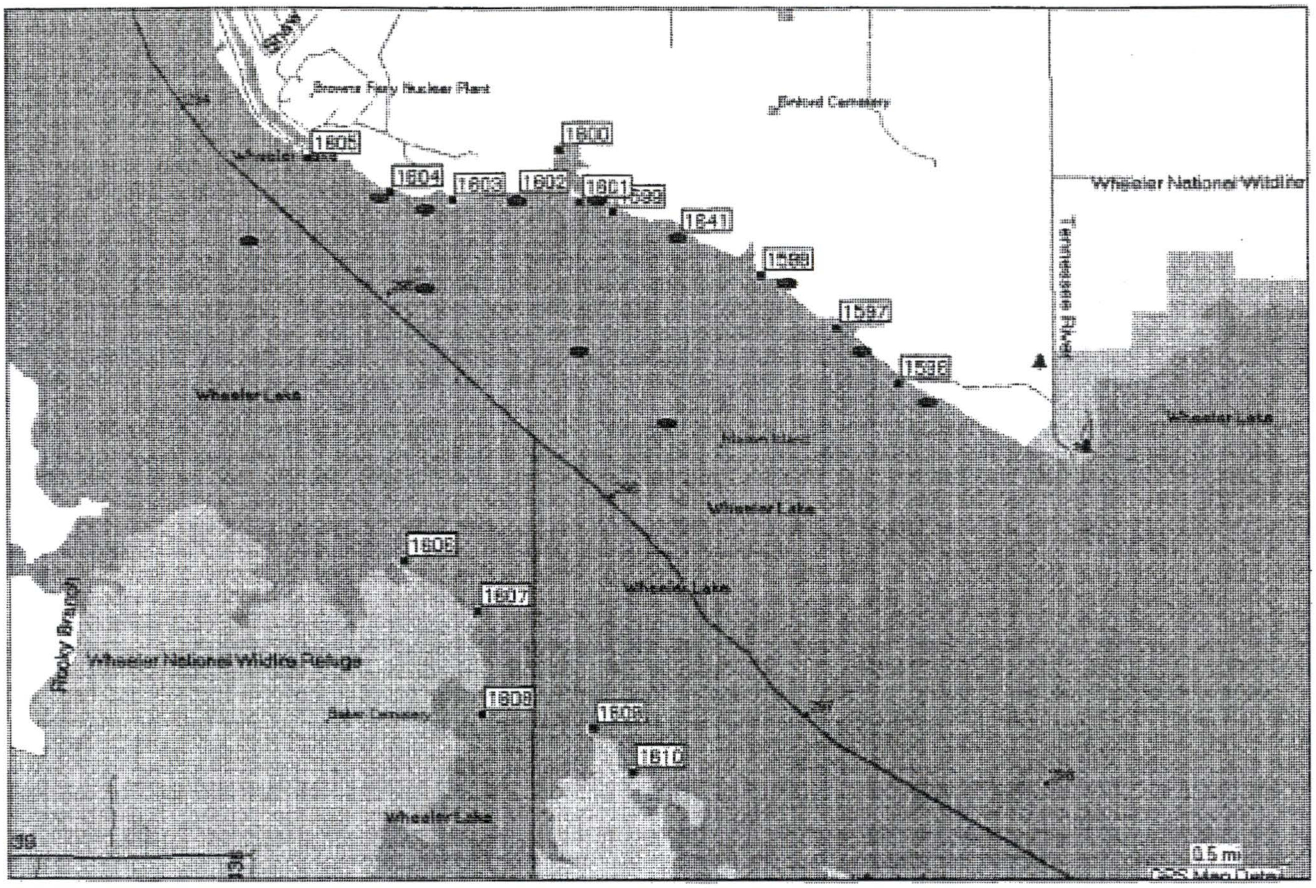


Figure 2. Location of Browns Ferry Nuclear Plant and Condenser Cooling Water (CCW) intake and discharge.



	Electrofishing locations			Gill net locations	
P028	N34 42.701	W87 08.909		N34 42.723	W87 08.858
P029	N34 42.785	W87 08.458		N34 42.816	W87 08.543
P030	N34 42.857	W87 08.076		N34 42.861	W87 08.021
P031	N34 42.522	W87 07.533		N34 42.977	W87 07.814
P032	N34 42.703	W87 09.375		N34 43.271	W87 07.998
P033	N34 43.310	W87 08.006		N34 43.776	W87 08.650
P034	N34 43.030	W87 07.728		N34 43.478	W87 08.568
P035	N34 43.290	W87 10.130		N34 43.247	W87 09.062
P036	N34 43.709	W87 08.377		N34 43.052	W87 08.843
P037	N34 44.012	W87 08.709		N34 42.896	W87 09.111
P038	N34 43.688	W87 10.498		N34 43.049	W87 09.256
P039	N34 42.903	W87 09.727		N34 43.176	W87 09.331
P040	N34 42.250	W87 08.981			
P041	N34 44.387	W87 09.062			
P042	N34 43.843	W87 10.763			

Figure 3. RFAI electrofishing and gill net locations downstream of Browns Ferry Nuclear Plant. Black squares represent electrofishing locations; red diamonds represent gill net locations.



Electrofishing locations				Gill net locations	
1596	N34 41.336	W87 04.933		N34 47.083	W87 20.788
1597	N34 41.513	W87 05.162		N34 47.250	W87 20.972
1598	N34 41.683	W87 05.447		N34 47.350	W87 21.448
1599	N34 41.887	W87 05.997		N34 47.480	W87 21.912
1600	N34 42.092	W87 06.198		N34 47.723	W87 22.407
1601	N34 41.917	W87 06.127		N34 49.002	W87 22.067
1602	N34 41.935	W87 06.365		N34 49.107	W87 22.028
1603	N34 41.926	W87 06.604		N34 48.927	W87 21.533
1604	N34 41.953	W87 06.840		N34 48.910	W87 21.080
1605	N34 42.060	W87 07.142		N34 48.740	W87 20.860
1606	N34 40.770	W87 06.793		N34 48.887	W87 20.585
1607	N34 40.610	W87 06.515		N34 48.682	W87 20.458
1608	N34 40.278	W87 06.503			
1609	N34 40.237	W87 06.083			
1610	N34 40.097	W87 05.930			

Figure 4. RFAI electrofishing and gill net locations upstream of Browns Ferry Nuclear Plant. Black squares represent electrofishing locations; red circles represent gill net locations.

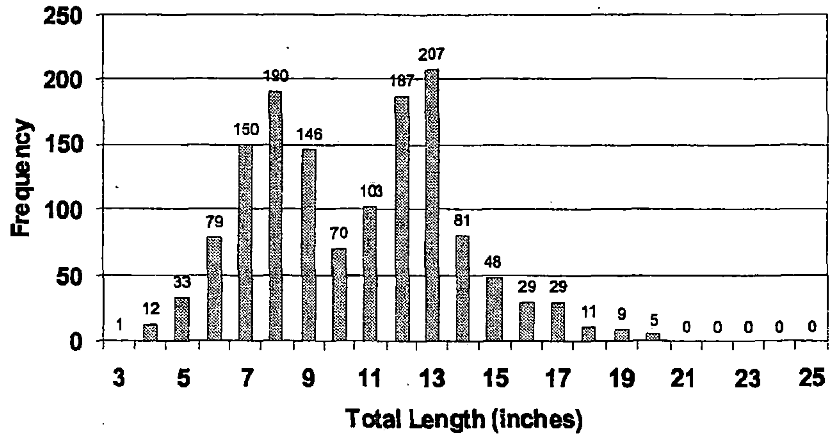


Figure 5. Length frequency distribution for largemouth bass collected from Wheeler Reservoir (all sites) during Spring Sport Fish Surveys, 2008.

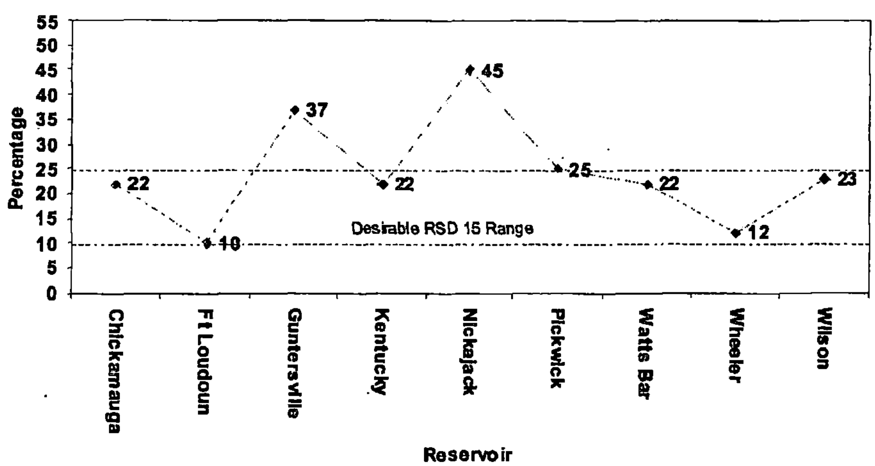


Figure 6. Relative stock density values for Tennessee River reservoirs calculated from 2008 Spring Sport Fish Survey samples.

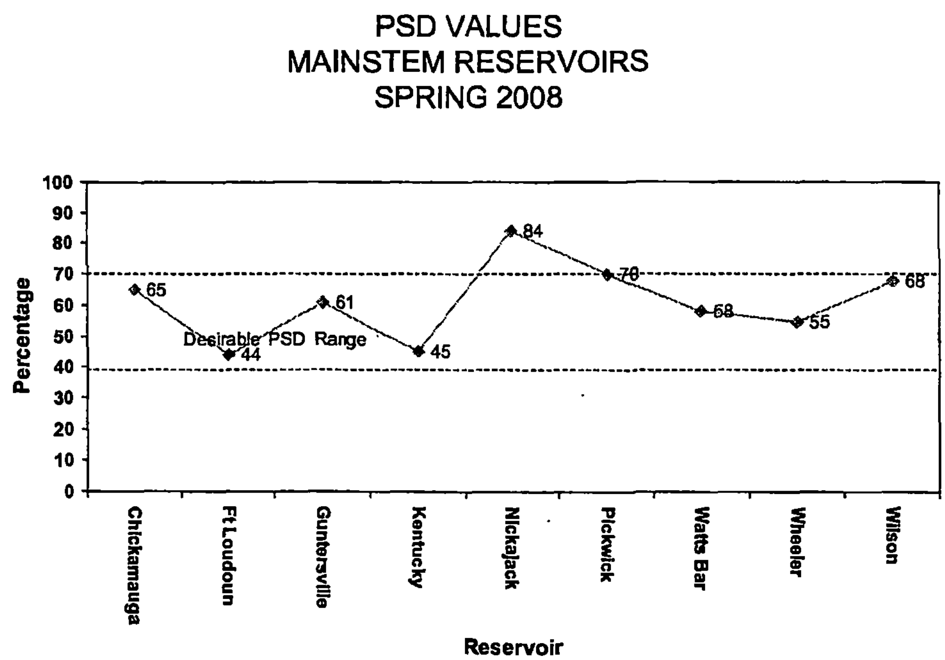


Figure 7. Proportional stock density values for Tennessee River reservoirs calculated from 2008 Spring Sport Fish Survey samples.

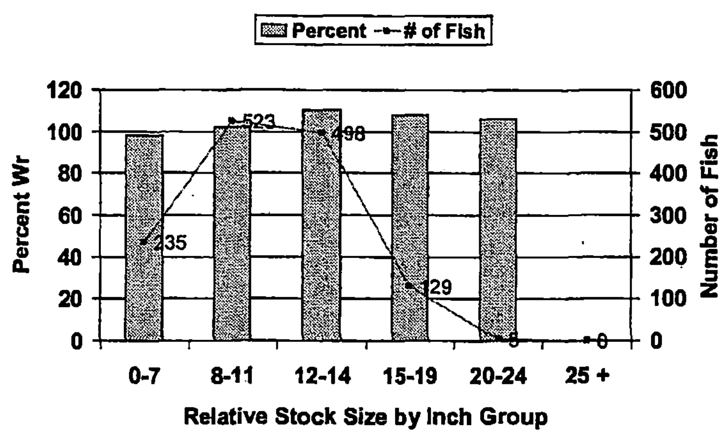


Figure 8. Wheeler Reservoir mean relative weights (Wr) for largemouth bass, calculated from 2008 Spring Sport Fish Survey samples.

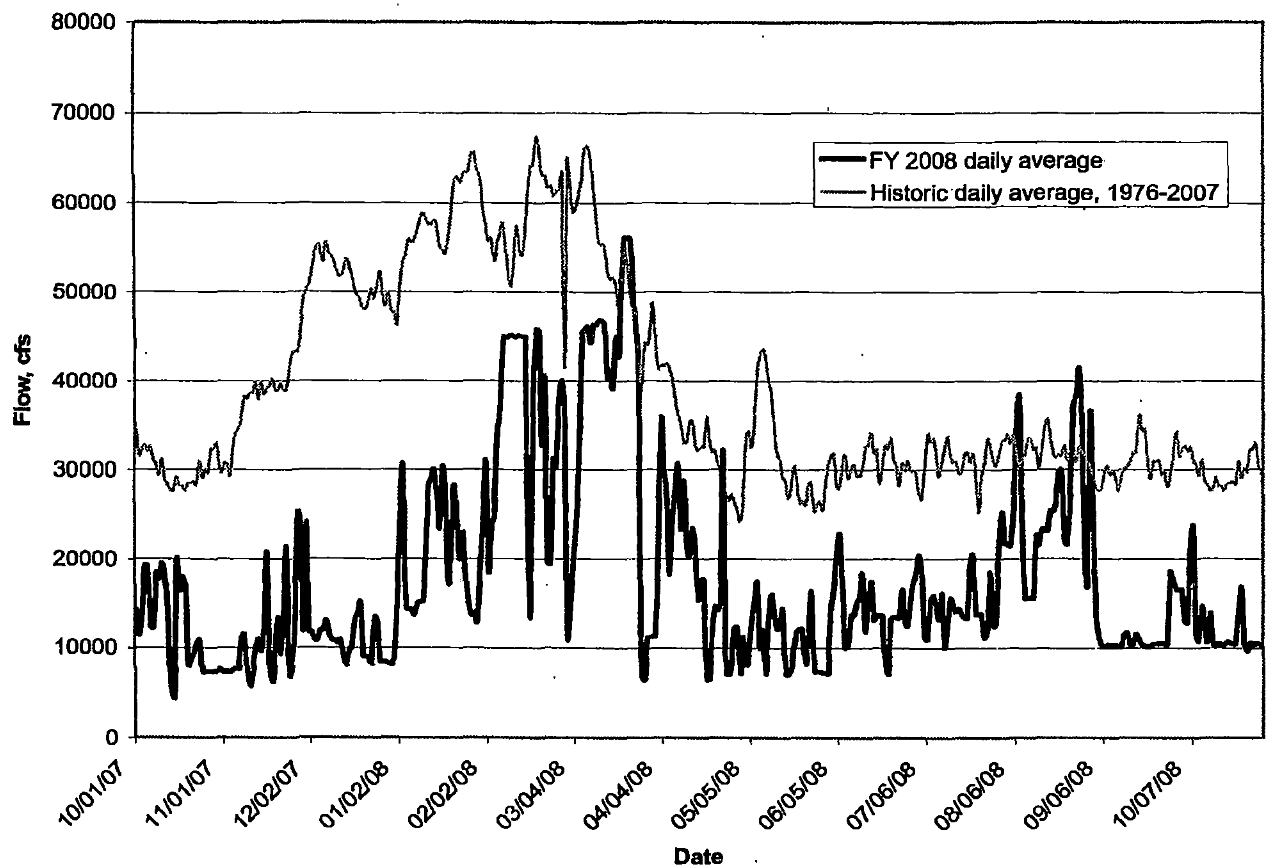


Figure 9. Daily average flows from Guntersville Dam, October 2007 through November 2008, and historic daily flows, averaged for the period 1976-2007.

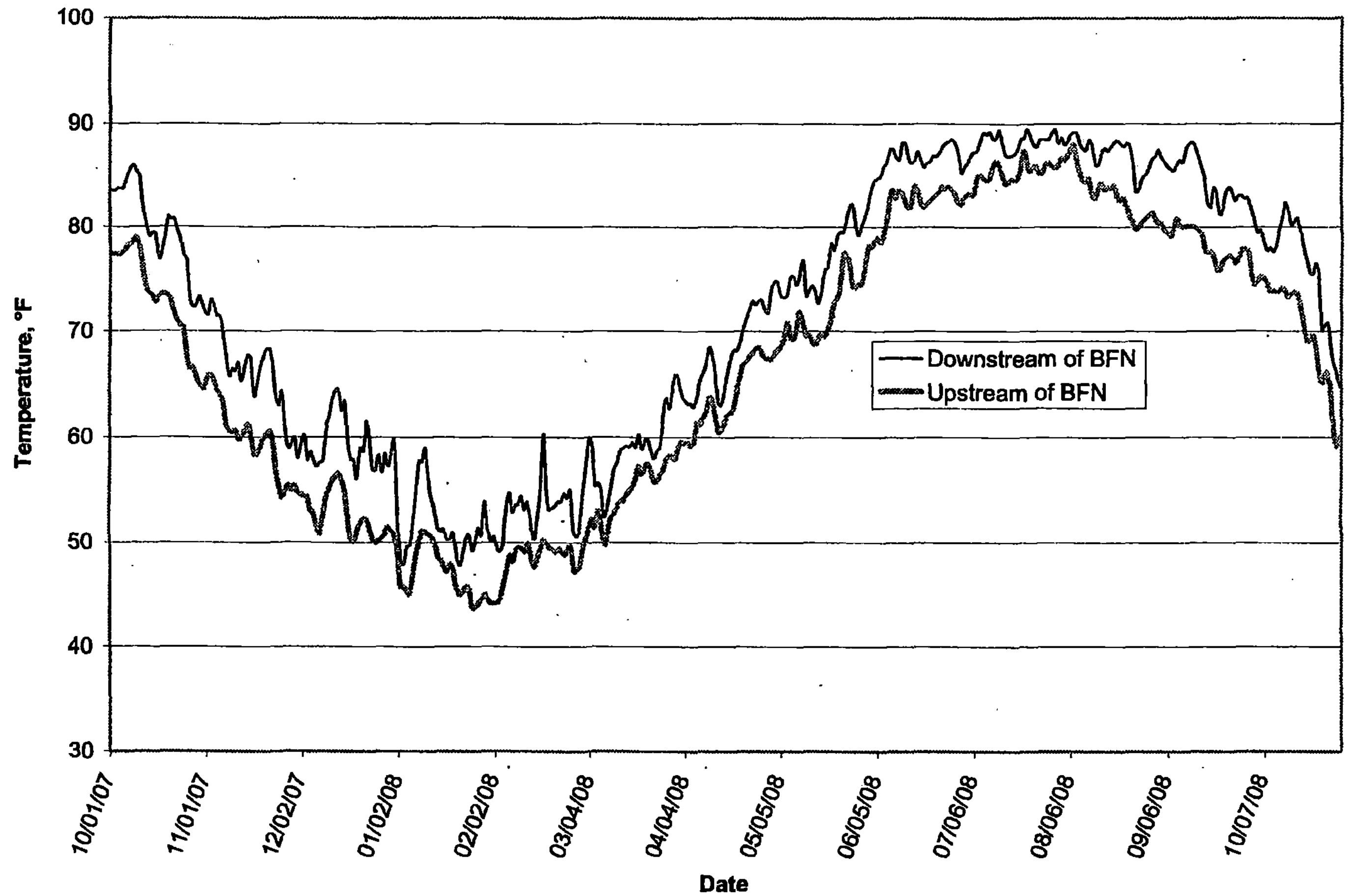


Figure 10. Daily average water temperatures at a depth of five feet, recorded upstream of BFN intake and downstream of BFN discharge, October 2007 through November 2008.

Appendix 1: Historical RFAI Scores

Historical Metric Scores and the Overall RFAI Scores for Areas Upstream and Downstream of Browns Ferry Nuclear Plant Discharge, 2000-2007.

Appendix 1-A. Individual Metric Scores and the Overall RFAI Scores for Sites Upstream and Downstream of Browns Ferry Nuclear Plant Discharge, Autumn 2007.

Autumn 2007		Downstream TRM 292.5		Upstream TRM 295.9	
Metric		**Obs**	**Score**	**Obs**	**Score**
A. Species richness and composition					
1. Number of species		26	3	26	3
2. Number of centrarchid species		5	5	7	5
3. Number of benthic invertivores		5	3	3	1
4. Number of intolerant species		5	5	5	5
5. Percent tolerant individuals	Electrofishing	48.1	1.5	64.7	0.5
	Gill Netting	23.5	1.5	30.9	0.5
6. Percent dominance by 1 species	Electrofishing	37.8	1.5	31.8	1.5
	Gill Netting	23.5	1.5	23.6	1.5
7. Percent non-native species	Electrofishing	34.2	0.5	16.9	0.5
	Gill Netting	0	2.5	0	2.5
8. Number of top carnivore species		9	5	8	5
B. Trophic composition					
9. Percent top carnivores	Electrofishing	4.8	0.5	16	2.5
	Gill Netting	56.3	2.5	54.5	2.5
10. Percent omnivores	Electrofishing	42.5	1.5	36.8	1.5
	Gill Netting	38.7	0.5	38.2	0.5
C. Fish abundance and health					
11. Average number per run	Electrofishing	60.3	0.5	36.3	0.5
	Gill Netting	11.9	1.5	5.5	0.5
12. Percent anomalies	Electrofishing	1.2	2.5	0.9	2.5
	Gill Netting	0	2.5	0	2.5
Overall RFAI Score			**42**		**39**
			Good		**Fair**

Appendix 1-B. Individual Metric Scores and the Overall RFAI Scores for Sites Upstream and Downstream of Browns Ferry Nuclear Plant Discharge, Autumn 2006.

Autumn 2006		Downstream TRM 292.5		Upstream TRM 295.9	
Metric		**Obs**	**Score**	**Obs**	**Score**
A. Species richness and composition					
1. Number of species		28	3	31	5
2. Number of centrarchid species		6	5	6	5
3. Number of benthic invertivores		4	3	4	3
4. Number of intolerant species		5	5	5	5
5. Percent tolerant individuals	Electrofishing	13.9	2.5	35.5	1.5
	Gill Netting	32.6	0.5	33	0.5
6. Percent dominance by 1 species	Electrofishing	67.4	0.5	47.5	1.5
	Gill Netting	25.3	1.5	30	1.5
7. Percent non-native species	Electrofishing	0.1	2.5	0.1	2.5
	Gill Netting	0	2.5	1	1.5
8. Number of top carnivore species		9	5	11	5
B. Trophic composition					
9. Percent top carnivores	Electrofishing	12.5	2.5	14.2	2.5
	Gill Netting	43.2	2.5	45	2.5
10. Percent omnivores	Electrofishing	10.2	2.5	21.8	2.5
	Gill Netting	53.7	0.5	47	0.5
C. Fish abundance and health					
11. Average number per run	Electrofishing	119.7	0.5	63.5	0.5
	Gill Netting	9.5	0.5	10	0.5
12. Percent anomalies	Electrofishing	0.3	2.5	0.6	2.5
	Gill Netting	2.1	1.5	2	1.5
Overall RFAI Score			**44**		**45**
			Good		**Good**

Appendix 1-C. Individual Metric Scores and the Overall RFAI Scores for Sites Upstream and Downstream of Browns Ferry Nuclear Plant Discharge, Autumn 2005.

Autumn 2005		Downstream TRM 292.5		Upstream TRM 295.9	
Metric		**Obs**	**Score**	**Obs**	**Score**
A. Species richness and composition					
1. Number of species		27	3	32	5
2. Number of centrarchid species		6	5	6	5
3. Number of benthic invertivores		5	3	7	3
4. Number of intolerant species		4	3	6	5
5. Percent tolerant individuals	Electrofishing	18.2	2.5	37.1	1.5
	Gill Netting	39	0.5	10	2.5
6. Percent dominance by 1 species	Electrofishing	64.1	0.5	49.1	1.5
	Gill Netting	36.4	0.5	20	1.5
7. Percent non-native species	Electrofishing	2.3	0.5	0.3	2.5
	Gill Netting	0	2.5	0	2.5
8. Number of top carnivore species		7	3	11	5
B. Trophic composition					
9. Percent top carnivores	Electrofishing	5.5	1.5	3	0.5
	Gill Netting	20.8	1.5	53.3	2.5
10. Percent omnivores	Electrofishing	16	2.5	33	1.5
	Gill Netting	59.7	0.5	35	0.5
C. Fish abundance and health					
11. Average number per run	Electrofishing	82.2	0.5	118.7	0.5
	Gill Netting	7.7	0.5	6	0.5
12. Percent anomalies	Electrofishing	0.2	2.5	0.1	2.5
	Gill Netting	0	2.5	0	2.5
Overall RFAI Score			**36**		**46**
			Fair		**Good**

Appendix 1-D. Individual Metric Scores and the Overall RFAI Scores for Sites Upstream and Downstream of Browns Ferry Nuclear Plant Discharge, Autumn 2004.

Autumn 2004		Downstream TRM 292.5		Upstream TRM 295.9	
Metric		Obs	Score	Obs	Score
A. Species richness and composition					
1. Number of species		28	3	30	3
2. Number of centrarchid species		5	5	7	5
3. Number of benthic invertivores		6	3	7	3
4. Number of intolerant species		5	5	7	5
5. Percent tolerant individuals	Electrofishing	26	2.5	54.6	0.5
	Gill Netting	0	2.5	12.6	2.5
6. Percent dominance by 1 species	Electrofishing	36	1.5	23.6	2.5
	Gill Netting	64.1	0.5	19.3	1.5
7. Percent non-native species	Electrofishing	20	0.5	8.8	0.5
	Gill Netting	2.6	0.5	7.6	0.5
8. Number of top carnivore species		8	5	11	5
B. Trophic composition					
9. Percent top carnivores	Electrofishing	9.3	1.5	19.1	2.5
	Gill Netting	84.6	2.5	61.3	2.5
10. Percent omnivores	Electrofishing	15.1	2.5	36	1.5
	Gill Netting	15.4	2.5	29.4	1.5
C. Fish abundance and health					
11. Average number per run	Electrofishing	65.7	0.5	31.1	0.5
	Gill Netting	3.9	0.5	11.9	1.5
12. Percent anomalies	Electrofishing	2	1.5	1.5	2.5
	Gill Netting	0	2.5	2.5	1.5
Overall RFAI Score			**43**		**43**
			Good		**Good**

Appendix 1-E. Individual Metric Scores and the Overall RFAI Scores for Sites Upstream and Downstream of Browns Ferry Nuclear Plant Discharge, Autumn 2003.

Autumn 2003		Downstream TRM 292.5		Upstream TRM 295.9	
Metric		Obs	Score	Obs	Score
A. Species richness and composition					
1. Number of species		28	3	28	3
2. Number of centrarchid species		7	5	6	5
3. Number of benthic invertivores		4	3	4	3
4. Number of intolerant species		4	3	5	5
5. Percent tolerant individuals	Electrofishing	48.7	1.5	66.8	0.5
	Gill Netting	6.3	2.5	16.9	1.5
6. Percent dominance by 1 species	Electrofishing	28.1	2.5	41.8	1.5
	Gill Netting	25.4	1.5	27.7	1.5
7. Percent non-native species	Electrofishing	7.1	0.5	8	0.5
	Gill Netting	0	2.5	0	2.5
8. Number of top carnivore species		10	5	10	5
B. Trophic composition					
9. Percent top carnivores	Electrofishing	12.4	2.5	9.7	1.5
	Gill Netting	63.5	2.5	36.9	1.5
10. Percent omnivores	Electrofishing	38.1	1.5	51.1	0.5
	Gill Netting	27	1.5	56.9	0.5
C. Fish abundance and health					
11. Average number per run	Electrofishing	40.4	0.5	23.5	0.5
	Gill Netting	6.3	0.5	6.5	0.5
12. Percent anomalies	Electrofishing	3	1.5	0.9	2.5
	Gill Netting	0	2.5	0	2.5
Overall RFAI Score			**43**		**39**
			Good		**Fair**

Appendix 1-F. Individual Metric Scores and the Overall RFAI Scores for Sites Upstream and Downstream of Browns Ferry Nuclear Plant Discharge, Autumn 2002.

Autumn 2002		Downstream TRM 292.5		Upstream TRM 295.9	
Metric		Obs	Score	Obs	Score
A. Species richness and composition					
1. Number of species		25	3	26	3
2. Number of centrarchid species		4	5	4	5
3. Number of benthic invertivores		5	3	4	3
4. Number of intolerant species		5	5	6	5
5. Percent tolerant individuals	Electrofishing	54.1	0.5	38.1	1.5
	Gill Netting	7.8	2.5	8.4	2.5
6. Percent dominance by 1 species	Electrofishing	25.7	2.5	30.3	1.5
	Gill Netting	36.7	0.5	25.3	1.5
7. Percent non-native species	Electrofishing	24.9	0.5	13.3	0.5
	Gill Netting	5.6	0.5	7.2	0.5
8. Number of top carnivore species		8	5	8	5
B. Trophic composition					
9. Percent top carnivores	Electrofishing	9.7	1.5	10.6	2.5
	Gill Netting	63.3	2.5	74.7	2.5
10. Percent omnivores	Electrofishing	28.6	1.5	19.2	2.5
	Gill Netting	26.7	1.5	21.7	1.5
C. Fish abundance and health					
11. Average number per run	Electrofishing	68.8	0.5	38.5	0.5
	Gill Netting	9	0.5	8.3	0.5
12. Percent anomalies	Electrofishing	1.3	2.5	2.1	1.5
	Gill Netting	0	2.5	1.2	2.5
Overall RFAI Score			**41**		**43**
			Good		**Good**

Appendix 1-G. Individual Metric Scores and the Overall RFAI Scores for Sites Upstream and Downstream of Browns Ferry Nuclear Plant Discharge, Autumn 2001.

Autumn 2001		Downstream TRM 292.5		Upstream TRM 295.9	
Metric		**Obs**	**Score**	**Obs**	**Score**
A. Species richness and composition					
1. Number of species		27	3	29	3
2. Number of centrarchid species		5	5	7	5
3. Number of benthic invertivores		5	3	3	1
4. Number of intolerant species		5	5	6	5
5. Percent tolerant individuals	Electrofishing	46	1.5	60.2	0.5
	Gill Netting	39.2	0.5	29.7	1.5
6. Percent dominance by 1 species	Electrofishing	25.8	2.5	49.2	1.5
	Gill Netting	29.4	1.5	28.1	1.5
7. Percent non-native species	Electrofishing	6.8	0.5	7.5	0.5
	Gill Netting	2	1.5	4.7	0.5
8. Number of top carnivore species		8	5	11	5
B. Trophic composition					
9. Percent top carnivores	Electrofishing	16.2	2.5	10.2	2.5
	Gill Netting	35.3	1.5	45.3	2.5
10. Percent omnivores	Electrofishing	31.6	1.5	55.7	0.5
	Gill Netting	54.9	0.5	46.9	0.5
C. Fish abundance and health					
11. Average number per run	Electrofishing	25.5	0.5	34	0.5
	Gill Netting	5.1	0.5	12.8	1.5
12. Percent anomalies	Electrofishing	1	2.5	1.4	2.5
	Gill Netting	3.9	1.5	3.1	1.5
Overall RFAI Score			**40**		**37**
			Fair		**Fair**

Appendix 1-H. Individual Metric Scores and the Overall RFAI Scores for Sites Upstream and Downstream of Browns Ferry Nuclear Plant Discharge, Autumn 2000.

Autumn 2000		Downstream TRM 292.5		Upstream TRM 295.9	
Metric		**Obs**	**Score**	**Obs**	**Score**
A. Species richness and composition					
1. Number of species		24	3	24	3
2. Number of centrarchid species		3	5	3	5
3. Number of benthic invertivores		6	3	6	3
4. Number of intolerant species		8	5	5	5
5. Percent tolerant individuals	Electrofishing	34.4	1.5	64.3	0.5
	Gill Netting	17	1.5	9.5	2.5
6. Percent dominance by 1 species	Electrofishing	30.9	1.5	48.2	1.5
	Gill Netting	56	0.5	55.8	0.5
7. Percent non-native species	Electrofishing	0	2.5	2.9	0.5
	Gill Netting	1	1.5	6.3	0.5
8. Number of top carnivore species		8	5	9	5
B. Trophic composition					
9. Percent top carnivores	Electrofishing	6.9	1.5	14.1	2.5
	Gill Netting	68	2.5	82.1	2.5
10. Percent omnivores	Electrofishing	37.1	1.5	52.1	0.5
	Gill Netting	27	1.5	14.7	2.5
C. Fish abundance and health					
11. Average number per run	Electrofishing	17.3	0.5	20.7	0.5
	Gill Netting	10	0.5	9.5	0.5
12. Percent anomalies	Electrofishing	0	2.5	0	2.5
	Gill Netting	0	2.5	0	2.5
Overall RFAI Score			**43**		**41**
			Good		**Good**

Appendix 2: Historical Fish Species List

Species Collected and Catch Per Unit Effort During Electrofishing at Areas Upstream and Downstream of Browns Ferry Nuclear Plant Discharge, 2000-2007.

Appendix 2-A. Species Collected, Trophic Level, Native and Tolerance Classification, and Catch Per Unit Effort During Electrofishing and Gill Netting Downstream (TRM 292.5) of Browns Ferry Nuclear Plant Discharge, Autumn 2007.

Common Name	Scientific name	Trophic level	Sunfish species	Native species	Tolerance	Electrofishing Catch Rate Per Run	Electrofishing Catch Rate Per Hour	Total fish EF	Gill Netting Catch Rate Per Net Night	Total Gill net fish	Total fish Combined
Gizzard shad	*Dorosoma cepedianum*	OM	.	X	TOL	22.80	119.58	342	2.50	25	367
Common carp	*Cyprinus carpio*	OM	.	.	TOL	0.07	0.35	1	.	.	1
Golden shiner	*Notemigonus crysoleucas*	OM	.	X	TOL	0.07	0.35	1	.	.	1
Spotfin shiner	*Cyprinella spiloptera*	IN	.	X	TOL	0.40	2.10	6	.	.	6
Green sunfish	*Lepomis cyanellus*	IN	X	X	TOL	0.40	2.10	6	.	.	6
Bluegill	*Lepomis macrochirus*	IN	X	X	TOL	4.00	20.98	60	.	.	60
Largemouth bass	*Micropterus salmoides*	TC	.	X	TOL	1.27	6.64	19	0.30	3	22
Skipjack herring	*Alosa chrysochloris*	TC	.	X	INT	.	.	.	2.80	28	28
Spotted sucker	*Minytrema melanops*	BI	.	X	INT	0.27	1.40	4	0.10	1	5
Black redhorse	*Moxostoma duquesnei*	BI	.	X	INT	0.07	0.35	1	.	.	1
Longear sunfish	*Lepomis megalotis*	IN	X	X	INT	2.00	10.49	30	.	.	30
Smallmouth bass	*Micropterus dolomieu*	TC	.	X	INT	0.93	4.90	14	.	.	14
Spotted gar	*Lepisosteus oculatus*	TC	.	X	.	.	.	.	0.40	4	4
Threadfin shad	*Dorosoma petenense*	PK	.	X	.	0.13	0.70	2	0.10	1	3
Smallmouth buffalo	*Ictiobus bubalus*	OM	.	X	.	0.53	2.80	8	0.90	9	17
Golden redhorse	*Moxostoma erythrurum*	BI	.	X	.	0.07	0.35	1	.	.	1
Blue catfish	*Ictalurus furcatus*	OM	.	X	.	.	.	.	0.70	7	7
Channel catfish	*Ictalurus punctatus*	OM	.	X	.	2.13	11.19	32	0.50	5	37
Flathead catfish	*Pylodictis olivaris*	TC	.	X	.	0.13	0.70	2	0.60	6	8
White bass	*Morone chrysops*	TC	.	X	.	.	.	.	0.10	1	1
Yellow bass	*Morone mississippiensis*	TC	.	X	.	0.33	1.75	5	2.30	23	28
Warmouth	*Lepomis gulosus*	IN	X	X	.	0.13	0.70	2	.	.	2
Redear sunfish	*Lepomis microlophus*	IN	X	X	.	1.27	6.64	19	.	.	19
Spotted bass	*Micropterus punctulatus*	TC	.	X	.	0.20	1.05	3	0.10	1	4
Logperch	*Percina caprodes*	BI	.	X	.	0.07	0.35	1	.	.	1
Sauger	*Sander canadensis*	TC	.	X	.	.	.	.	0.10	1	1
Freshwater drum	*Aplodinotus grunniens*	BI	.	X	.	2.47	12.94	37	0.40	4	41
Inland silverside	*Menidia beryllina*	IN	.	.	.	20.53	107.69	308	.	.	308
Total						60.27	316.10	904	11.90	119	1,023
Number Samples						15			10		
Species Collected						23			15		

Appendix 2-B. Species Collected, Trophic Level, Native and Tolerance Classification, and Catch Per Unit Effort During Electrofishing and Gill Netting Upstream (TRM 295.9) of Browns Ferry Nuclear Plant Discharge, Autumn 2007.

Common Name	Scientific name	Trophic level	Sunfish species	Native species	Tolerance	Electrofishing Catch Rate Per Run	Electrofishing Catch Rate Per Hour	Total fish EF	Gill Netting Catch Rate Per Net Night	Total Gill net fish	Total fish Combined
Gizzard shad	*Dorosoma cepedianum*	OM	.	X	TOL	11.53	57.86	173	1.30	13	186
Golden shiner	*Notemigonus crysoleucas*	OM	.	X	TOL	0.93	4.68	14	.	.	14
Spotfin shiner	*Cyprinella spiloptera*	IN	.	X	TOL	0.13	0.67	2	.	.	2
Redbreast sunfish	*Lepomis auritus*	IN	X	X	TOL	0.20	1.00	3	.	.	3
Green sunfish	*Lepomis cyanellus*	IN	X	X	TOL	0.20	1.00	3	.	.	3
Bluegill	*Lepomis macrochirus*	IN	X	X	TOL	5.60	28.09	84	.	.	84
Largemouth bass	*Micropterus salmoides*	TC	.	X	TOL	4.87	24.41	73	0.40	4	77
Skipjack herring	*Alosa chrysochloris*	TC	.	X	INT	.	.	.	1.10	11	11
Spotted sucker	*Minytrema melanops*	BI	.	X	INT	0.53	2.68	8	.	.	8
Black redhorse	*Moxostoma duquesnei*	BI	.	X	INT	0.07	0.33	1	.	.	1
Longear sunfish	*Lepomis megalotis*	IN	X	X	INT	1.53	7.69	23	.	.	23
Smallmouth bass	*Micropterus dolomieu*	TC	.	X	INT	0.13	0.67	2	.	.	2
Spotted gar	*Lepisosteus oculatus*	TC	.	X	.	.	.	.	0.30	3	3
Threadfin shad	*Dorosoma petenense*	PK	.	X	.	0.07	0.33	1	.	.	1
Emerald shiner	*Notropis atherinoides*	IN	.	X	.	0.13	0.67	2	.	.	2
Bullhead minnow	*Pimephales vigilax*	IN	.	X	.	0.07	0.33	1	.	.	1
Smallmouth buffalo	*Ictiobus bubalus*	OM	.	X	.	0.40	2.01	6	0.20	2	8
Blue catfish	*Ictalurus furcatus*	OM	.	X	.	.	.	.	0.20	2	2
Channel catfish	*Ictalurus punctatus*	OM	.	X	.	0.47	2.34	7	0.40	4	11
Flathead catfish	*Pylodictis olivaris*	TC	.	X	.	0.07	0.33	1	0.20	2	3
Yellow bass	*Morone mississippiensis*	TC	.	X	.	0.47	2.34	7	0.80	8	15
Warmouth	*Lepomis gulosus*	IN	X	X	.	0.07	0.33	1	.	.	1
Redear sunfish	*Lepomis microlophus*	IN	X	X	.	1.20	6.02	18	0.10	1	19
Spotted bass	*Micropterus punctulatus*	TC	.	X	.	0.20	1.00	3	0.10	1	4
Black crappie	*Pomoxis nigromaculatus*	TC	X	X	.	0.07	0.33	1	0.10	1	2
Yellow perch	*Perca flavescens*	IN	.	.	.	0.13	0.67	2	.	.	2
Freshwater drum	*Aplodinotus grunniens*	BI	.	X	.	1.20	6.02	18	0.30	3	21
Inland silverside	*Menidia beryllina*	IN	.	.	.	6.00	30.10	90	.	.	90
Total						36.27	181.90	544	5.50	55	599
Number Samples						15			10		
Species Collected						25			13		

Appendix 2-C. Species Collected, Trophic Level, Native and Tolerance Classification, and Catch Per Unit Effort During Electrofishing and Gill Netting Downstream (TRM 292.5) of Browns Ferry Nuclear Plant Discharge, Autumn 2006.

Common Name	Scientific name	Trophic level	Sunfish species	Native species	Tolerance	Electrofishing Catch Rate Per Run	Electrofishing Catch Rate Per Hour	Total fish EF	Gill Netting Catch Rate Per Net Night	Total Gill net fish	Total fish Combined
Gizzard shad	*Dorosoma cepedianum*	OM	.	X	TOL	7.13	30.14	107	2.40	24	131
Common carp	*Cyprinus carpio*	OM	.	.	TOL	0.07	0.28	1	.	.	1
Spotfin shiner	*Cyprinella spiloptera*	IN	.	X	TOL	0.93	3.94	14	.	.	14
Striped shiner	*Luxilus chrysocephalus*	OM	.	X	TOL	0.07	0.28	1	.	.	1
Green sunfish	*Lepomis cyanellus*	IN	X	X	TOL	0.87	3.66	13	.	.	13
Bluegill	*Lepomis macrochirus*	IN	X	X	TOL	2.87	12.11	43	0.10	1	44
Largemouth bass	*Micropterus salmoides*	TC	.	X	TOL	4.73	20.00	71	0.50	5	76
White crappie	*Pomoxis annularis*	TC	X	X	TOL	.	.	.	0.10	1	1
Skipjack herring	*Alosa chrysochloris*	TC	.	X	INT	.	.	.	1.60	16	16
Spotted sucker	*Minytrema melanops*	BI	.	X	INT	0.47	1.97	7	.	.	7
Black redhorse	*Moxostoma duquesnei*	BI	.	X	INT	0.13	0.56	2	.	.	2
Longear sunfish	*Lepomis megalotis*	IN	X	X	INT	3.80	16.06	57	.	.	57
Smallmouth bass	*Micropterus dolomieu*	TC	.	X	INT	3.93	16.62	59	.	.	59
Threadfin shad	*Dorosoma petenense*	PK	.	X	.	0.07	0.28	1	.	.	1
Emerald shiner	*Notropis atherinoides*	IN	.	X	.	0.33	1.41	5	.	.	5
Bullhead minnow	*Pimephales vigilax*	IN	.	X	.	0.13	0.56	2	.	.	2
Smallmouth buffalo	*Ictiobus bubalus*	OM	.	X	.	0.40	1.69	6	0.20	2	8
Blue catfish	*Ictalurus furcatus*	OM	.	X	.	.	.	.	1.50	15	15
Channel catfish	*Ictalurus punctatus*	OM	.	X	.	4.53	19.15	68	1.00	10	78
Flathead catfish	*Pylodictis olivaris*	TC	.	X	.	0.53	2.25	8	0.40	4	12
White bass	*Morone chrysops*	TC	.	X	.	2.80	11.83	42	0.20	2	44
Yellow bass	*Morone mississippiensis*	TC	.	X	.	0.33	1.41	5	0.20	2	7
Striped bass	*Morone saxatilis*	TC	.	.	.	.	.	.	.	.	0
Hybrid striped x white bass	*Hybrid morone (chrysops x sax)*	TC	.	.	.	0.07	0.28	1	.	.	1
Warmouth	*Lepomis gulosus*	IN	X	X	.	0.07	0.28	1	.	.	1
Redear sunfish	*Lepomis microlophus*	IN	X	X	.	0.40	1.69	6	.	.	6
Spotted bass	*Micropterus punctulatus*	TC	.	X	.	2.53	10.70	38	0.10	1	39
Logperch	*Percina caprodes*	BI	.	X	.	0.60	2.54	9	.	.	9
Sauger	*Sander canadensis*	TC	.	X	.	0.07	0.28	1	1.00	10	11
Freshwater drum	*Aplodinotus grunniens*	BI	.	X	.	1.13	4.79	17	0.20	2	19
Inland silverside	*Menidia beryllina*	IN	.	.	.	80.67	340.85	1210	.	.	1,210
Total						119.66	505.61	1,795	9.50	95	1,890
Number Samples						15			10		
Species Collected						27			14		

Appendix 2-D. Species Collected, Trophic Level, Native and Tolerance Classification, and Catch Per Unit Effort During Electrofishing and Gill Netting Upstream (TRM 295.9) of Browns Ferry Nuclear Plant Discharge, Autumn 2006.

Common Name	Scientific name	Trophic level	Sunfish species	Native species	Tolerance	Electrofishing Catch Rate Per Run	Electrofishing Catch Rate Per Hour	Total fish EF	Gill Netting Catch Rate Per Net Night	Total Gill net fish	Total fish Combined
Gizzard shad	*Dorosoma cepedianum*	OM	.	X	TOL	11.47	50.59	172	3.00	30	202
Golden shiner	*Notemigonus crysoleucas*	OM	.	X	TOL	0.80	3.53	12	.	.	12
Spotfin shiner	*Cyprinella spiloptera*	IN	.	X	TOL	0.20	0.88	3	.	.	3
Green sunfish	*Lepomis cyanellus*	IN	X	X	TOL	0.27	1.18	4	.	.	4
Bluegill	*Lepomis macrochirus*	IN	X	X	TOL	2.93	12.94	44	0.20	2	46
Largemouth bass	*Micropterus salmoides*	TC	.	X	TOL	6.87	30.29	103	0.10	1	104
Skipjack herring	*Alosa chrysochloris*	TC	.	X	INT	.	.	.	2.40	24	24
Spotted sucker	*Minytrema melanops*	BI	.	X	INT	1.80	7.94	27	.	.	27
Black redhorse	*Moxostoma duquesnei*	BI	.	X	INT	0.27	1.18	4	.	.	4
Longear sunfish	*Lepomis megalotis*	IN	X	X	INT	0.60	2.65	9	.	.	9
Smallmouth bass	*Micropterus dolomieu*	TC	.	X	INT	0.07	0.29	1	.	.	1
Spotted gar	*Lepisosteus oculatus*	TC	.	X	.	0.20	0.88	3	0.50	5	8
Bowfin	*Amia calva*	TC	.	X	.	0.07	0.29	1	.	.	1
Threadfin shad	*Dorosoma petenense*	PK	.	X	.	0.07	0.29	1	.	.	1
Emerald shiner	*Notropis atherinoides*	IN	.	X	.	1.13	5.00	17	.	.	17
Bullhead minnow	*Pimephales vigilax*	IN	.	X	.	0.20	0.88	3	.	.	3
Smallmouth buffalo	*Ictiobus bubalus*	OM	.	X	.	0.53	2.35	8	0.50	5	13
Bigmouth buffalo	*Ictiobus cyprinellus*	PK	.	X	.	0.07	0.29	1	.	.	1
Blue catfish	*Ictalurus furcatus*	OM	.	X	.	.	.	.	0.20	2	2
Channel catfish	*Ictalurus punctatus*	OM	.	X	.	1.07	4.71	16	1.00	10	26
Flathead catfish	*Pylodictis olivaris*	TC	.	X	.	0.13	0.59	2	0.20	2	4
Yellow bass	*Morone mississippiensis*	TC	.	X	.	0.53	2.35	8	0.70	7	15
Hybrid striped x white bass	*Hybrid morone (chrysops x sax)*	TC	.	.	.	.	.	.	0.10	1	1
Warmouth	*Lepomis gulosus*	IN	X	X	.	0.13	0.59	2	.	.	2
Redear sunfish	*Lepomis microlophus*	IN	X	X	.	1.27	5.59	19	0.40	4	23
Spotted bass	*Micropterus punctulatus*	TC	.	X	.	0.87	3.82	13	0.20	2	15
Hybrid bass	*Hybrid micropterus sp.*	TC	.	X	.	0.07	0.29	1	.	.	1
Black crappie	*Pomoxis nigromaculatus*	TC	X	X	.	0.07	0.29	1	0.10	1	2
Yellow perch	*Perca flavescens*	IN	.	.	.	0.07	0.29	1	.	.	1
Logperch	*Percina caprodes*	BI	.	X	.	0.53	2.35	8	.	.	8
Sauger	*Sander canadensis*	TC	.	X	.	0.13	0.59	2	0.10	1	3
Walleye	*Stizostedion vitreum*	TC	.	X	.	.	.	.	0.10	1	1
Freshwater drum	*Aplodinotus grunniens*	BI	.	X	.	0.93	4.12	14	0.20	2	16
Inland silverside	*Menidia beryllina*	IN	.	.	.	30.20	133.24	453	.	.	453
Total						63.55	280.27	953	10.00	100	1,053
Number Samples						15			10		
Species Collected						30			17		

Appendix 2-E. Species Collected, Trophic Level, Native and Tolerance Classification, and Catch Per Unit Effort During Electrofishing and Gill Netting Downstream (TRM 292.5) of Browns Ferry Nuclear Plant Discharge, Autumn 2005.

Common Name	Scientific name	Trophic level	Sunfish species	Native species	Tolerance	Electrofishing Catch Rate Per Run	Electrofishing Catch Rate Per Hour	Total fish EF	Gill Netting Catch Rate Per Net Night	Total Gill net fish	Total fish Combined
Gizzard shad	*Dorosoma cepedianum*	OM	.	X	TOL	9.60	54.75	144	2.80	28	172
Spotfin shiner	*Cyprinella spiloptera*	IN	.	X	TOL	0.80	4.56	12	.	.	12
Bluntnose minnow	*Pimephales notatus*	OM	.	X	TOL	0.13	0.76	2	.	.	2
Redbreast sunfish	*Lepomis auritus*	IN	X	X	TOL	0.07	0.38	1	.	.	1
Green sunfish	*Lepomis cyanellus*	IN	X	X	TOL	1.20	6.84	18	.	.	18
Bluegill	*Lepomis macrochirus*	IN	X	X	TOL	1.93	11.03	29	.	.	29
Largemouth bass	*Micropterus salmoides*	TC	.	X	TOL	1.27	7.22	19	0.20	2	21
Skipjack herring	*Alosa chrysochloris*	TC	.	X	INT	.	.	.	0.40	4	4
Spotted sucker	*Minytrema melanops*	BI	.	X	INT	0.53	3.04	8	0.10	1	9
Longear sunfish	*Lepomis megalotis*	IN	X	X	INT	1.20	6.84	18	.	.	18
Smallmouth bass	*Micropterus dolomieu*	TC	.	X	INT	0.80	4.56	12	.	.	12
Threadfin shad	*Dorosoma petenense*	PK	.	X	.	52.67	300.38	790	0.20	2	792
Largescale stoneroller	*Campostoma oligolepis*	HB	.	X	.	0.13	0.76	2	.	.	2
Emerald shiner	*Notropis atherinoides*	IN	.	X	.	0.73	4.18	11	.	.	11
Smallmouth buffalo	*Ictiobus bubalus*	OM	.	X	.	0.80	4.56	12	0.50	5	17
Silver redhorse	*Moxostoma anisurum*	BI	.	X	.	.	.	.	0.10	1	1
Golden redhorse	*Moxostoma erythrurum*	BI	.	X	.	.	.	.	0.40	4	4
Blue catfish	*Ictalurus furcatus*	OM	.	X	.	.	.	.	0.60	6	6
Channel catfish	*Ictalurus punctatus*	OM	.	X	.	2.60	14.83	39	0.70	7	46
Flathead catfish	*Pylodictis olivaris*	TC	.	X	.	.	.	.	0.60	6	6
White bass	*Morone chrysops*	TC	.	X	.	2.13	12.17	32	.	.	32
Yellow bass	*Morone mississippiensis*	TC	.	X	.	.	.	.	0.20	2	2
Warmouth	*Lepomis gulosus*	IN	X	X	.	0.20	1.14	3	.	.	3
Redear sunfish	*Lepomis microlophus*	IN	X	X	.	0.60	3.42	9	0.40	4	13
Spotted bass	*Micropterus punctulatus*	TC	.	X	.	0.33	1.90	5	0.20	2	7
Logperch	*Percina caprodes*	BI	.	X	.	0.40	2.28	6	.	.	6
Freshwater drum	*Aplodinotus grunniens*	BI	.	X	.	2.20	12.55	33	0.30	3	36
Inland silverside	*Menidia beryllina*	IN	.	.	.	1.87	10.65	28	.	.	28
Total						82.19	468.80	1,233	7.70	77	1,310
Number Samples						15			10		
Species Collected						22			15		

Appendix 2-F. Species Collected, Trophic Level, Native and Tolerance Classification, and Catch Per Unit Effort During Electrofishing and Gill Netting Upstream (TRM 295.9) of Browns Ferry Nuclear Plant Discharge, Autumn 2005.

Common Name	Scientific name	Trophic level	Sunfish species	Native species	Tolerance	Electrofishing Catch Rate Per Run	Electrofishing Catch Rate Per Hour	Total fish EF	Gill Netting Catch Rate Per Net Night	Total Gill net fish	Total fish Combined
Gizzard shad	*Dorosoma cepedianum*	OM	.	X	TOL	38.53	228.46	578	0.30	3	581
Golden shiner	*Notemigonus crysoleucas*	OM	.	X	TOL	.	.	.	0.10	1	1
Green sunfish	*Lepomis cyanellus*	IN	X	X	TOL	0.07	0.40	1	.	.	1
Bluegill	*Lepomis macrochirus*	IN	X	X	TOL	4.40	26.09	66	.	.	66
Largemouth bass	*Micropterus salmoides*	TC	.	X	TOL	1.00	5.93	15	0.10	1	16
White crappie	*Pomoxis annularis*	TC	X	X	TOL	0.07	0.40	1	0.10	1	2
Skipjack herring	*Alosa chrysochloris*	TC	.	X	INT	0.07	0.40	1	0.70	7	8
Northern hog sucker	*Hypentelium nigricans*	BI	.	X	INT	0.27	1.58	4	.	.	4
Spotted sucker	*Minytrema melanops*	BI	.	X	INT	1.53	9.09	23	0.10	1	24
Black redhorse	*Moxostoma duquesnei*	BI	.	X	INT	.	.	.	0.10	1	1
Longear sunfish	*Lepomis megalotis*	IN	X	X	INT	1.13	6.72	17	0.10	1	18
Smallmouth bass	*Micropterus dolomieu*	TC	.	X	INT	0.20	1.19	3	.	.	3
Spotted gar	*Lepisosteus oculatus*	TC	.	X	.	0.20	1.19	3	.	.	3
Threadfin shad	*Dorosoma petenense*	PK	.	X	.	58.27	345.45	874	.	.	874
Largescale stoneroller	*Campostoma oligolepis*	HB	.	X	.	0.13	0.79	2	.	.	2
Emerald shiner	*Notropis atherinoides*	IN	.	X	.	6.93	41.11	104	.	.	104
Bullhead minnow	*Pimephales vigilax*	IN	.	X	.	0.07	0.40	1	.	.	1
Smallmouth buffalo	*Ictiobus bubalus*	OM	.	X	.	0.07	0.40	1	.	.	1
Silver redhorse	*Moxostoma anisurum*	BI	.	X	.	.	.	.	0.10	1	1
Golden redhorse	*Moxostoma erythrurum*	BI	.	X	.	.	.	.	0.10	1	1
Blue catfish	*Ictalurus furcatus*	OM	.	X	.	.	.	.	0.50	5	5
Channel catfish	*Ictalurus punctatus*	OM	.	X	.	0.53	3.16	8	1.20	12	20
Flathead catfish	*Pylodictis olivaris*	TC	.	X	.	0.20	1.19	3	0.20	2	5
White bass	*Morone chrysops*	TC	.	X	.	0.33	1.98	5	0.10	1	6
Yellow bass	*Morone mississippiensis*	TC	.	X	.	1.33	7.91	20	0.10	1	21
Warmouth	*Lepomis gulosus*	IN	X	X	.	0.20	1.19	3	.	.	3
Redear sunfish	*Lepomis microlophus*	IN	X	X	.	1.07	6.32	16	0.10	1	17
Spotted bass	*Micropterus punctulatus*	TC	.	X	.	0.13	0.79	2	1.00	10	12
Yellow perch	*Perca flavescens*	IN	.	.	.	0.13	0.79	2	.	.	2
Logperch	*Percina caprodes*	BI	.	X	.	0.27	1.58	4	.	.	4
Sauger	*Sander canadensis*	TC	.	X	.	0.07	0.40	1	0.80	8	9
Walleye	*Sander vitreus*	TC	.	X	.	.	.	.	0.10	1	1
Freshwater drum	*Aplodinotus grunniens*	BI	.	X	.	1.27	7.51	19	0.10	1	20
Inland silverside	*Menidia beryllina*	IN	.	.	.	0.20	1.19	3	.	.	3
Total						118.67	703.61	1,780	6.00	60	1,840
Number Samples						15			10		
Species Collected						28			20		

Appendix 2-G. Species Collected, Trophic Level, Native and Tolerance Classification, and Catch Per Unit Effort During Electrofishing and Gill Netting Downstream (TRM 292.5) of Browns Ferry Nuclear Plant Discharge, Autumn 2004.

Common Name	Scientific name	Trophic level	Sunfish species	Native species	Tolerance	Electrofishing Catch Rate Per Run	Electrofishing Catch Rate Per Hour	Total fish EF	Gill Netting Catch Rate Per Net Night	Total Gill net fish	Total fish Combined
Gizzard shad	*Dorosoma cepedianum*	OM	.	X	TOL	7.27	42.91	109	.	.	109
Spotfin shiner	*Cyprinella spiloptera*	IN	.	X	TOL	1.27	7.48	19	.	.	19
Redbreast sunfish	*Lepomis auritus*	IN	X	X	TOL	0.07	0.39	1	.	.	1
Green sunfish	*Lepomis cyanellus*	IN	X	X	TOL	0.27	1.57	4	.	.	4
Bluegill	*Lepomis macrochirus*	IN	X	X	TOL	5.20	30.71	78	.	.	78
Largemouth bass	*Micropterus salmoides*	TC	.	X	TOL	3.00	17.72	45	.	.	45
Skipjack herring	*Alosa chrysochloris*	TC	.	X	INT	.	.	.	2.50	25	25
Spotted sucker	*Minytrema melanops*	BI	.	X	INT	0.07	0.39	1	.	.	1
Black redhorse	*Moxostoma duquesnei*	BI	.	X	INT	0.13	0.79	2	.	.	2
Longear sunfish	*Lepomis megalotis*	IN	X	X	INT	2.60	15.35	39	.	.	39
Smallmouth bass	*Micropterus dolomieu*	TC	.	X	INT	1.40	8.27	21	.	.	21
Threadfin shad	*Dorosoma petenense*	PK	.	X	.	0.07	0.39	1	.	.	1
Emerald shiner	*Notropis atherinoides*	IN	.	X	.	23.67	139.76	355	.	.	355
Smallmouth buffalo	*Ictiobus bubalus*	OM	.	X	.	0.13	0.79	2	.	.	2
Black buffalo	*Ictiobus niger*	OM	.	X	.	0.07	0.39	1	.	.	1
Silver redhorse	*Moxostoma anisurum*	BI	.	X	.	0.07	0.39	1	.	.	1
Golden redhorse	*Moxostoma erythrurum*	BI	.	X	.	0.13	0.79	2	.	.	2
Blue catfish	*Ictalurus furcatus*	OM	.	X	.	.	.	.	0.50	5	5
Channel catfish	*Ictalurus punctatus*	OM	.	X	.	2.47	14.57	37	0.10	1	38
Flathead catfish	*Pylodictis olivaris*	TC	.	X	.	0.13	0.79	2	.	.	2
White bass	*Morone chrysops*	TC	.	X	.	0.07	0.39	1	.	.	1
Yellow bass	*Morone mississippiensis*	TC	.	X	.	.	.	.	0.20	2	2
Striped bass	*Morone saxatilis*	TC	.	.	.	.	.	.	0.10	1	1
Redear sunfish	*Lepomis microlophus*	IN	X	X	.	0.20	1.18	3	.	.	3
Spotted bass	*Micropterus punctulatus*	TC	.	X	.	1.53	9.06	23	0.20	2	25
Logperch	*Percina caprodes*	BI	.	X	.	1.07	6.30	16	.	.	16
Sauger	*Sander canadensis*	TC	.	X	.	.	.	.	0.30	3	3
Freshwater drum	*Aplodinotus grunniens*	BI	.	X	.	1.67	9.84	25	.	.	25
Inland silverside	*Menidia beryllina*	IN	.	.	.	13.13	77.56	197	.	.	197
Chestnut lamprey	*Ichthyomyzon castaneus*	PS	.	X	.	0.07	0.39	1	.	.	1
Total						65.76	388.17	986	3.90	39	1,025
Number Samples						15			10		
Species Collected						25			7		

Appendix 2-H. Species Collected, Trophic Level, Native and Tolerance Classification, and Catch Per Unit Effort During Electrofishing and Gill Netting Upstream (TRM 295.9) of Browns Ferry Nuclear Plant Discharge, Autumn 2004.

Common Name	Scientific name	Trophic level	Sunfish species	Native species	Tolerance	Electrofishing Catch Rate Per Run	Electrofishing Catch Rate Per Hour	Total fish EF	Gill Netting Catch Rate Per Net Night	Total Gill net fish	Total fish Combined
Gizzard shad	*Dorosoma cepedianum*	OM	.	X	TOL	7.33	40.59	110	0.80	8	118
Common carp	*Cyprinus carpio*	OM	.	.	TOL	0.07	0.37	1	.	.	1
Golden shiner	*Notemigonus crysoleucas*	OM	.	X	TOL	0.53	2.95	8	0.10	1	9
Bluntnose minnow	*Pimephales notatus*	OM	.	X	TOL	0.13	0.74	2	.	.	2
Green sunfish	*Lepomis cyanellus*	IN	X	X	TOL	0.13	0.74	2	.	.	2
Bluegill	*Lepomis macrochirus*	IN	X	X	TOL	4.20	23.25	63	0.10	1	64
Largemouth bass	*Micropterus salmoides*	TC	.	X	TOL	4.60	25.46	69	0.30	3	72
White crappie	*Pomoxis annularis*	TC	X	X	TOL	.	.	.	0.20	2	2
Skipjack herring	*Alosa chrysochloris*	TC	.	X	INT	.	.	.	0.40	4	4
Silver chub	*Macrhybopsis storeriana*	BI	.	X	INT	0.07	0.37	1	.	.	1
Northern hog sucker	*Hypentelium nigricans*	BI	.	X	INT	0.07	0.37	1	.	.	1
Spotted sucker	*Minytrema melanops*	BI	.	X	INT	2.73	15.13	41	.	.	41
Black redhorse	*Moxostoma duquesnei*	BI	.	X	INT	.	.	.	0.20	2	2
Longear sunfish	*Lepomis megalotis*	IN	X	X	INT	0.60	3.32	9	.	.	9
Smallmouth bass	*Micropterus dolomieu*	TC	.	X	INT	0.27	1.48	4	.	.	4
Spotted gar	*Lepisosteus oculatus*	TC	.	X	.	0.13	0.74	2	0.10	1	3
Emerald shiner	*Notropis atherinoides*	IN	.	X	.	1.87	10.33	28	.	.	28
Smallmouth buffalo	*Ictiobus bubalus*	OM	.	X	.	0.47	2.58	7	0.10	1	8
Golden redhorse	*Moxostoma erythrurum*	BI	.	X	.	0.13	0.74	2	0.10	1	3
Blue catfish	*Ictalurus furcatus*	OM	.	X	.	.	.	.	1.90	19	19
Channel catfish	*Ictalurus punctatus*	OM	.	X	.	2.67	14.76	40	0.60	6	46
Flathead catfish	*Pylodictis olivaris*	TC	.	X	.	0.07	0.37	1	0.20	2	3
White bass	*Morone chrysops*	TC	.	X	.	.	.	.	0.90	9	9
Yellow bass	*Morone mississippiensis*	TC	.	X	.	0.33	1.85	5	1.80	18	23
Striped bass	*Morone saxatilis*	TC	.	.	.	.	.	.	0.90	9	9
Warmouth	*Lepomis gulosus*	IN	X	X	.	0.07	0.37	1	.	.	1
Redear sunfish	*Lepomis microlophus*	IN	X	X	.	1.27	7.01	19	0.20	2	21
Spotted bass	*Micropterus punctulatus*	TC	.	X	.	0.47	2.58	7	0.10	1	8
Black crappie	*Pomoxis nigromaculatus*	TC	X	X	.	0.07	0.37	1	0.10	1	2
Yellow perch	*Perca flavescens*	IN	.	.	.	0.13	0.74	2	.	.	2
Logperch	*Percina caprodes*	BI	.	X	.	0.13	0.74	2	.	.	2
Sauger	*Sander canadensis*	TC	.	X	.	.	.	.	2.30	23	23
Freshwater drum	*Aplodinotus grunniens*	BI	.	X	.	0.07	0.37	1	0.50	5	6
Inland silverside	*Menidia beryllina*	IN	.	.	.	2.53	14.02	38	.	.	38
Total						31.14	172.34	467	11.90	119	586
Number Samples						15			10		
Species Collected						27			21		

Appendix 2-I. Species Collected, Trophic Level, Native and Tolerance Classification, and Catch Per Unit Effort During Electrofishing and Gill Netting Downstream (TRM 292.5) of Browns Ferry Nuclear Plant Discharge, Autumn 2003.

Common Name	Scientific name	Trophic level	Sunfish species	Native species	Tolerance	Electrofishing Catch Rate Per Run	Electrofishing Catch Rate Per Hour	Total fish EF	Gill Netting Catch Rate Per Net Night	Total Gill net fish	Total fish Combined
Gizzard shad	*Dorosoma cepedianum*	OM	.	X	TOL	11.33	67.73	170	0.30	3	173
Common carp	*Cyprinus carpio*	OM	.	.	TOL	0.13	0.80	2	.	.	2
Spotfin shiner	*Cyprinella spiloptera*	IN	.	X	TOL	0.13	0.80	2	.	.	2
Bluntnose minnow	*Pimephales notatus*	OM	.	X	TOL	0.13	0.80	2	.	.	2
Green sunfish	*Lepomis cyanellus*	IN	X	X	TOL	0.20	1.20	3	.	.	3
Bluegill	*Lepomis macrochirus*	IN	X	X	TOL	5.80	34.66	87	.	.	87
Largemouth bass	*Micropterus salmoides*	TC	.	X	TOL	1.87	11.16	28	0.10	1	29
White crappie	*Pomoxis annularis*	TC	X	X	TOL	0.07	0.40	1	.	.	1
Skipjack herring	*Alosa chrysochloris*	TC	.	X	INT	1.67	9.96	25	1.50	15	40
Spotted sucker	*Minytrema melanops*	BI	.	X	INT	0.67	3.98	10	0.10	1	11
Longear sunfish	*Lepomis megalotis*	IN	X	X	INT	2.47	14.74	37	.	.	37
Smallmouth bass	*Micropterus dolomieu*	TC	.	X	INT	1.07	6.37	16	.	.	16
Threadfin shad	*Dorosoma petenense*	PK	.	X	.	0.07	0.40	1	.	.	1
Largescale stoneroller	*Campostoma oligolepis*	HB	.	X	.	0.07	0.40	1	.	.	1
Emerald shiner	*Notropis atherinoides*	IN	.	X	.	6.33	37.85	95	.	.	95
Bullhead minnow	*Pimephales vigilax*	IN	.	X	.	0.07	0.40	1	.	.	1
Golden redhorse	*Moxostoma erythrurum*	BI	.	X	.	.	.	.	0.10	1	1
Blue catfish	*Ictalurus furcatus*	OM	.	X	.	0.20	1.20	3	0.20	2	5
Channel catfish	*Ictalurus punctatus*	OM	.	X	.	3.60	21.51	54	1.20	12	66
Flathead catfish	*Pylodictis olivaris*	TC	.	X	.	0.07	0.40	1	0.10	1	2
White bass	*Morone chrysops*	TC	.	X	.	.	.	.	0.20	2	2
Yellow bass	*Morone mississippiensis*	TC	.	X	.	0.07	0.40	1	0.30	3	4
Warmouth	*Lepomis gulosus*	IN	X	X	.	0.07	0.40	1	.	.	1
Redear sunfish	*Lepomis microlophus*	IN	X	X	.	0.33	1.99	5	0.10	1	6
Spotted bass	*Micropterus punctulatus*	TC	.	X	.	0.07	0.40	1	0.20	2	3
Black crappie	*Pomoxis nigromaculatus*	TC	X	X	.	0.07	0.40	1	.	.	1
Logperch	*Percina caprodes*	BI	.	X	.	0.27	1.59	4	.	.	4
Sauger	*Sander canadensis*	TC	.	X	.	0.07	0.40	1	1.60	16	17
Freshwater drum	*Aplodinotus grunniens*	BI	.	X	.	0.80	4.78	12	0.30	3	15
Inland silverside	*Menidia beryllina*	IN	.	.	.	2.73	16.33	41	.	.	41
Total						40.43	241.45	606	6.30	63	669
Number Samples						15			10		
Species Collected						28			14		

Appendix 2-J. Species Collected, Trophic Level, Native and Tolerance Classification, and Catch Per Unit Effort During Electrofishing and Gill Netting Upstream (TRM 295.9) of Browns Ferry Nuclear Plant Discharge, Autumn 2003.

Common Name	Scientific name	Trophic level	Sunfish species	Native species	Tolerance	Electrofishing Catch Rate Per Run	Electrofishing Catch Rate Per Hour	Total fish EF	Gill Netting Catch Rate Per Net Night	Total Gill net fish	Total fish Combined
Gizzard shad	*Dorosoma cepedianum*	OM	.	X	TOL	9.80	54.65	147	1.00	10	157
Common carp	*Cyprinus carpio*	OM	.	.	TOL	0.20	1.12	3	.	.	3
Green sunfish	*Lepomis cyanellus*	IN	X	X	TOL	0.20	1.12	3	.	.	3
Bluegill	*Lepomis macrochirus*	IN	X	X	TOL	3.87	21.56	58	.	.	58
Largemouth bass	*Micropterus salmoides*	TC	.	X	TOL	1.53	8.55	23	0.10	1	24
White crappie	*Pomoxis annularis*	TC	X	X	TOL	0.07	0.37	1	.	.	1
Skipjack herring	*Alosa chrysochloris*	TC	.	X	INT	0.13	0.74	2	0.50	5	7
Silver chub	*Macrhybopsis storeriana*	BI	.	X	INT	0.07	0.37	1	.	.	1
Spotted sucker	*Minytrema melanops*	BI	.	X	INT	0.80	4.46	12	.	.	12
Longear sunfish	*Lepomis megalotis*	IN	X	X	INT	0.20	1.12	3	.	.	3
Smallmouth bass	*Micropterus dolomieu*	TC	.	X	INT	0.20	1.12	3	.	.	3
Spotted gar	*Lepisosteus oculatus*	TC	.	X	.	0.07	0.37	1	.	.	1
Threadfin shad	*Dorosoma petenense*	PK	.	X	.	0.07	0.37	1	.	.	1
Emerald shiner	*Notropis atherinoides*	IN	.	X	.	0.60	3.35	9	.	.	9
Bullhead minnow	*Pimephales vigilax*	IN	.	X	.	0.13	0.74	2	.	.	2
Quillback	*Carpiodes cyprinus*	OM	.	X	.	.	.	.	0.10	1	1
Smallmouth buffalo	*Ictiobus bubalus*	OM	.	X	.	0.07	0.37	1	.	.	1
Bigmouth buffalo	*Ictiobus cyprinellus*	PK	.	X	.	0.07	0.37	1	.	.	1
Golden redhorse	*Moxostoma erythrurum*	BI	.	X	.	.	.	.	0.10	1	1
Blue catfish	*Ictalurus furcatus*	OM	.	X	.	.	.	.	1.80	18	18
Channel catfish	*Ictalurus punctatus*	OM	.	X	.	1.93	10.78	29	0.80	8	37
Flathead catfish	*Pylodictis olivaris*	TC	.	X	.	0.13	0.74	2	.	.	2
White bass	*Morone chrysops*	TC	.	X	.	0.07	0.37	1	0.10	1	2
Yellow bass	*Morone mississippiensis*	TC	.	X	.	0.07	0.37	1	0.40	4	5
Warmouth	*Lepomis gulosus*	IN	X	X	.	0.20	1.12	3	.	.	3
Redear sunfish	*Lepomis microlophus*	IN	X	X	.	0.93	5.20	14	0.20	2	16
Spotted bass	*Micropterus punctulatus*	TC	.	X	.	.	.	.	0.60	6	6
Yellow perch	*Perca flavescens*	IN	.	.	.	0.07	0.37	1	.	.	1
Sauger	*Sander canadensis*	TC	.	X	.	.	.	.	0.70	7	7
Freshwater drum	*Aplodinotus grunniens*	BI	.	X	.	0.40	2.23	6	0.10	1	7
Inland silverside	*Menidia beryllina*	IN	.	.	.	1.60	8.92	24	.	.	24
Total						23.48	130.85	352	6.50	65	417
Number Samples						15			10		
Species Collected						26			13		

Appendix 2-K. Species Collected, Trophic Level, Native and Tolerance Classification, and Catch Per Unit Effort During Electrofishing and Gill Netting Downstream (TRM 292.5) of Browns Ferry Nuclear Plant Discharge, Autumn 2002.

Common Name	Scientific name	Trophic level	Sunfish species	Native species	Tolerance	Electrofishing Catch Rate Per Run	Electrofishing Catch Rate Per Hour	Total fish EF	Gill Netting Catch Rate Per Net Night	Total Gill net fish	Total fish Combined
Gizzard shad	*Dorosoma cepedianum*	OM	.	X	TOL	17.67	104.33	265	0.20	2	267
Golden shiner	*Notemigonus crysoleucas*	OM	.	X	TOL	0.07	0.39	1	.	.	1
Spotfin shiner	*Cyprinella spiloptera*	IN	.	X	TOL	0.60	3.54	9	.	.	9
Green sunfish	*Lepomis cyanellus*	IN	X	X	TOL	0.13	0.79	2	.	.	2
Bluegill	*Lepomis macrochirus*	IN	X	X	TOL	15.87	93.70	238	0.10	1	239
Largemouth bass	*Micropterus salmoides*	TC	.	X	TOL	2.87	16.93	43	0.40	4	47
Skipjack herring	*Alosa chrysochloris*	TC	.	X	INT	0.07	0.39	1	3.30	33	34
Spotted sucker	*Minytrema melanops*	BI	.	X	INT	0.13	0.79	2	.	.	2
Black redhorse	*Moxostoma duquesnei*	BI	.	X	INT	0.13	0.79	2	.	.	2
Longear sunfish	*Lepomis megalotis*	IN	X	X	INT	3.20	18.90	48	.	.	48
Smallmouth bass	*Micropterus dolomieu*	TC	.	X	INT	2.60	15.35	39	.	.	39
Threadfin shad	*Dorosoma petenense*	PK	.	X	.	2.87	16.93	43	.	.	43
Emerald shiner	*Notropis atherinoides*	IN	.	X	.	0.20	1.18	3	.	.	3
Quillback	*Carpiodes cyprinus*	OM	.	X	.	.	.	.	0.10	1	1
Silver redhorse	*Moxostoma anisurum*	BI	.	X	.	0.07	0.39	1	.	.	1
Blue catfish	*Ictalurus furcatus*	OM	.	X	.	.	.	.	1.10	11	11
Channel catfish	*Ictalurus punctatus*	OM	.	X	.	1.93	11.42	29	1.00	10	39
Flathead catfish	*Pylodictis olivaris*	TC	.	X	.	0.07	0.39	1	0.20	2	3
White bass	*Morone chrysops*	TC	.	X	.	.	.	.	0.20	2	2
Yellow bass	*Morone mississippiensis*	TC	.	X	.	0.07	0.39	1	0.10	1	2
Striped bass	*Morone saxatilis*	TC	.	.	.	.	.	.	0.50	5	5
Redear sunfish	*Lepomis microlophus*	IN	X	X	.	1.07	6.30	16	0.30	3	19
Spotted bass	*Micropterus punctulatus*	TC	.	X	.	0.93	5.51	14	0.40	4	18
Hybrid bass	*Hybrid micropterus sp.*	TC	.	X	.	0.07	0.39	1	.	.	1
Logperch	*Percina caprodes*	BI	.	X	.	0.60	3.54	9	.	.	9
Sauger	*Sander canadensis*	TC	.	X	.	.	.	.	0.60	6	6
Freshwater drum	*Aplodinotus grunniens*	BI	.	X	.	0.47	2.76	7	0.50	5	12
Inland silverside	*Menidia beryllina*	IN	.	.	.	17.13	101.18	257	.	.	257
Total						68.82	406.28	1,032	9.00	90	1,122
Number Samples						15			10		
Species Collected						23			15		

Appendix 2-L. Species Collected, Trophic Level, Native and Tolerance Classification, and Catch Per Unit Effort During Electrofishing and Gill Netting Upstream (TRM 295.9) of Browns Ferry Nuclear Plant Discharge, Autumn 2002.

Common Name	Scientific name	Trophic level	Sunfish species	Native species	Tolerance	Electrofishing Catch Rate Per Run	Electrofishing Catch Rate Per Hour	Total fish EF	Gill Netting Catch Rate Per Net Night	Total Gill net fish	Total fish Combined
Gizzard shad	*Dorosoma cepedianum*	OM	.	X	TOL	3.73	23.14	56	0.60	6	62
Common carp	*Cyprinus carpio*	OM	.	.	TOL	0.13	0.83	2	.	.	2
Golden shiner	*Notemigonus crysoleucas*	OM	.	X	TOL	0.73	4.55	11	.	.	11
Green sunfish	*Lepomis cyanellus*	IN	X	X	TOL	0.13	0.83	2	.	.	2
Bluegill	*Lepomis macrochirus*	IN	X	X	TOL	6.60	40.91	99	0.10	1	100
Largemouth bass	*Micropterus salmoides*	TC	.	X	TOL	3.33	20.66	50	.	.	50
Skipjack herring	*Alosa chrysochloris*	TC	.	X	INT	.	.	.	2.10	21	21
Northern hog sucker	*Hypentelium nigricans*	BI	.	X	INT	0.07	0.41	1	.	.	1
Spotted sucker	*Minytrema melanops*	BI	.	X	INT	0.73	4.55	11	.	.	11
Black redhorse	*Moxostoma duquesnei*	BI	.	X	INT	0.20	1.24	3	.	.	3
Longear sunfish	*Lepomis megalotis*	IN	X	X	INT	0.27	1.65	4	.	.	4
Smallmouth bass	*Micropterus dolomieu*	TC	.	X	INT	0.07	0.41	1	.	.	1
Threadfin shad	*Dorosoma petenense*	PK	.	X	.	11.67	72.31	175	.	.	175
Emerald shiner	*Notropis atherinoides*	IN	.	X	.	0.13	0.83	2	.	.	2
Bullhead minnow	*Pimephales vigilax*	IN	.	X	.	0.13	0.83	2	.	.	2
Smallmouth buffalo	*Ictiobus bubalus*	OM	.	X	.	0.07	0.41	1	.	.	1
Bigmouth buffalo	*Ictiobus cyprinellus*	PK	.	X	.	0.07	0.41	1	.	.	1
Black buffalo	*Ictiobus niger*	OM	.	X	.	0.13	0.83	2	.	.	2
Blue catfish	*Ictalurus furcatus*	OM	.	X	.	.	.	.	0.80	8	8
Channel catfish	*Ictalurus punctatus*	OM	.	X	.	2.60	16.12	39	0.40	4	43
Flathead catfish	*Pylodictis olivaris*	TC	.	X	.	.	.	.	0.20	2	2
White bass	*Morone chrysops*	TC	.	X	.	.	.	.	0.50	5	5
Yellow bass	*Morone mississippiensis*	TC	.	X	.	.	.	.	0.40	4	4
Striped bass	*Morone saxatilis*	TC	.	.	.	0.07	0.41	1	0.10	1	2
Hybrid striped x white bass	*Hybrid morone (chrysops x sax)*	TC	.	.	.	.	.	.	0.50	5	5
Redear sunfish	*Lepomis microlophus*	IN	X	X	.	1.87	11.57	28	.	.	28
Spotted bass	*Micropterus punctulatus*	TC	.	X	.	0.53	3.31	8	1.80	18	26
Sauger	*Sander canadensis*	TC	.	X	.	0.07	0.41	1	0.60	6	7
Freshwater drum	*Aplodinotus grunniens*	BI	.	X	.	0.20	1.24	3	0.20	2	5
Inland silverside	*Menidia beryllina*	IN	.	.	.	4.93	30.58	74	.	.	74
Total						38.46	238.44	577	8.30	83	660
Number Samples						15			10		
Species Collected						24			13		

Appendix 2-M. Species Collected, Trophic Level, Native and Tolerance Classification, and Catch Per Unit Effort During Electrofishing and Gill Netting Downstream (TRM 292.5) of Browns Ferry Nuclear Plant Discharge, Autumn 2001.

Common Name	Scientific name	Trophic level	Sunfish species	Native species	Tolerance	Electrofishing Catch Rate Per Run	Electrofishing Catch Rate Per Hour	Total fish EF	Gill Netting Catch Rate Per Net Night	Total Gill net fish	Total fish Combined
Gizzard shad	*Dorosoma cepedianum*	OM	.	X	TOL	6.60	39.76	99	1.50	15	114
Central stoneroller	*Campostoma anomalum*	HB	.	X	TOL	0.07	0.40	1	.	.	1
Common carp	*Cyprinus carpio*	OM	.	.	TOL	0.13	0.80	2	.	.	2
Golden shiner	*Notemigonus crysoleucas*	OM	.	X	TOL	0.07	0.40	1	.	.	1
Spotfin shiner	*Cyprinella spiloptera*	IN	.	X	TOL	0.27	1.61	4	.	.	4
Green sunfish	*Lepomis cyanellus*	IN	X	X	TOL	0.07	0.40	1	.	.	1
Bluegill	*Lepomis macrochirus*	IN	X	X	TOL	2.80	16.87	42	0.30	3	45
Largemouth bass	*Micropterus salmoides*	TC	.	X	TOL	1.73	10.44	26	0.10	1	27
White crappie	*Pomoxis annularis*	TC	X	X	TOL	.	.	.	0.10	1	1
Skipjack herring	*Alosa chrysochloris*	TC	.	X	INT	0.13	0.80	2	0.20	2	4
Spotted sucker	*Minytrema melanops*	BI	.	X	INT	0.20	1.20	3	0.10	1	4
Black redhorse	*Moxostoma duquesnei*	BI	.	X	INT	0.13	0.80	2	.	.	2
Longear sunfish	*Lepomis megalotis*	IN	X	X	INT	2.60	15.66	39	.	.	39
Smallmouth bass	*Micropterus dolomieu*	TC	.	X	INT	0.87	5.22	13	.	.	13
Threadfin shad	*Dorosoma petenense*	PK	.	X	.	0.13	0.80	2	.	.	2
Emerald shiner	*Notropis atherinoides*	IN	.	X	.	2.13	12.85	32	.	.	32
Bullhead minnow	*Pimephales vigilax*	IN	.	X	.	0.07	0.40	1	.	.	1
Smallmouth buffalo	*Ictiobus bubalus*	OM	.	X	.	0.33	2.01	5	.	.	5
Golden redhorse	*Moxostoma erythrurum*	BI	.	X	.	0.13	0.80	2	.	.	2
Blue catfish	*Ictalurus furcatus*	OM	.	X	.	.	.	.	0.30	3	3
Channel catfish	*Ictalurus punctatus*	OM	.	X	.	0.93	5.62	14	1.00	10	24
Flathead catfish	*Pylodictis olivaris*	TC	.	X	.	0.27	1.61	4	0.10	1	5
Yellow bass	*Morone mississippiensis*	TC	.	X	.	.	.	.	0.60	6	6
Striped bass	*Morone saxatilis*	TC	.	.	.	.	.	.	0.10	1	1
Redear sunfish	*Lepomis microlophus*	IN	X	X	.	0.40	2.41	6	.	.	6
Hybrid sunfish	*Hybrid lepomis spp.*	IN	X	X	.	0.07	0.40	1	.	.	1
Spotted bass	*Micropterus punctulatus*	TC	.	X	.	1.07	6.43	16	0.20	2	18
Logperch	*Percina caprodes*	BI	.	X	.	1.60	9.64	24	.	.	24
Sauger	*Sander canadensis*	TC	.	X	.	0.07	0.40	1	0.40	4	5
Freshwater drum	*Aplodinotus grunniens*	BI	.	X	.	1.07	6.43	16	0.10	1	17
Inland silverside	*Menidia beryllina*	IN	.	.	.	1.60	9.64	24	.	.	24
Total						25.54	153.80	383	5.10	51	434
Number Samples						15			10		
Species Collected						27			14		

Appendix 2-N. Species Collected, Trophic Level, Native and Tolerance Classification, and Catch Per Unit Effort During Electrofishing and Gill Netting Upstream (TRM 295.9) of Browns Ferry Nuclear Plant Discharge, Autumn 2001.

Common Name	Scientific name	Trophic level	Sunfish species	Native species	Tolerance	Electrofishing Catch Rate Per Run	Electrofishing Catch Rate Per Hour	Total fish EF	Gill Netting Catch Rate Per Net Night	Total Gill net fish	Total fish Combined
Gizzard shad	*Dorosoma cepedianum*	OM	.	X	TOL	16.73	99.60	251	3.60	36	287
Common carp	*Cyprinus carpio*	OM	.	.	TOL	0.33	1.98	5	.	.	5
Golden shiner	*Notemigonus crysoleucas*	OM	.	X	TOL	0.80	4.76	12	.	.	12
Bluntnose minnow	*Pimephales notatus*	OM	.	X	TOL	0.07	0.40	1	.	.	1
Green sunfish	*Lepomis cyanellus*	IN	X	X	TOL	0.07	0.40	1	.	.	1
Bluegill	*Lepomis macrochirus*	IN	X	X	TOL	1.53	9.13	23	.	.	23
Largemouth bass	*Micropterus salmoides*	TC	.	X	TOL	0.93	5.56	14	0.10	1	15
White crappie	*Pomoxis annularis*	TC	X	X	TOL	.	.	.	0.10	1	1
Skipjack herring	*Alosa chrysochloris*	TC	.	X	INT	.	.	.	1.50	15	15
Mooneye	*Hiodon tergisus*	IN	.	X	INT	.	.	.	0.10	1	1
Mimic shiner	*Notropis volucellus*	SP	.	X	INT	0.07	0.40	1	.	.	1
Spotted sucker	*Minytrema melanops*	BI	.	X	INT	1.87	11.11	28	0.20	2	30
Longear sunfish	*Lepomis megalotis*	IN	X	X	INT	0.27	1.59	4	.	.	4
Smallmouth bass	*Micropterus dolomieu*	TC	.	X	INT	0.07	0.40	1	.	.	1
Spotted gar	*Lepisosteus oculatus*	TC	.	X	.	1.20	7.14	18	0.10	1	19
Threadfin shad	*Dorosoma petenense*	PK	.	X	.	0.73	4.37	11	0.20	2	13
Emerald shiner	*Notropis atherinoides*	IN	.	X	.	3.20	19.05	48	.	.	48
Smallmouth buffalo	*Ictiobus bubalus*	OM	.	X	.	0.53	3.17	8	0.40	4	12
Blue catfish	*Ictalurus furcatus*	OM	.	X	.	.	.	.	1.20	12	12
Channel catfish	*Ictalurus punctatus*	OM	.	X	.	0.47	2.78	7	0.80	8	15
Flathead catfish	*Pylodictis olivaris*	TC	.	X	.	0.13	0.79	2	0.20	2	4
White bass	*Morone chrysops*	TC	.	X	.	0.13	0.79	2	0.30	3	5
Yellow bass	*Morone mississippiensis*	TC	.	X	.	0.20	1.19	3	2.00	20	23
Striped bass	*Morone saxatilis*	TC	.	.	.	.	.	.	0.30	3	3
Hybrid striped x white bass	*Hybrid morone (chrysops x sax)*	TC	.	.	.	.	.	.	0.30	3	3
Warmouth	*Lepomis gulosus*	IN	X	X	.	0.07	0.40	1	.	.	1
Redear sunfish	*Lepomis microlophus*	IN	X	X	.	0.33	1.98	5	0.20	2	7
Spotted bass	*Micropterus punctulatus*	TC	.	X	.	0.53	3.17	8	0.50	5	13
Black crappie	*Pomoxis nigromaculatus*	TC	X	X	.	0.07	0.40	1	.	.	1
Logperch	*Percina caprodes*	BI	.	X	.	0.87	5.16	13	.	.	13
Sauger	*Sander canadensis*	TC	.	X	.	0.13	0.79	2	0.40	4	6
Hybrid walleye x sauger	*Hybrid Sander*	TC	.	.	.	0.07	0.40	1	.	.	1
Freshwater drum	*Aplodinotus grunniens*	BI	.	X	.	0.47	2.78	7	0.30	3	10
Inland silverside	*Menidia beryllina*	IN	.	.	.	2.13	12.70	32	.	.	32
Total						34.00	202.39	510	12.80	128	638
Number Samples						15			10		
Species Collected						28			20		

Appendix 2-O. Species Collected, Trophic Level, Native and Tolerance Classification, and Catch Per Unit Effort During Electrofishing and Gill Netting Downstream (TRM 292.5) of Browns Ferry Nuclear Plant Discharge, Autumn 2000.

Common Name	Scientific name	Trophic level	Sunfish species	Native species	Tolerance	Electrofishing Catch Rate Per Run	Electrofishing Catch Rate Per Hour	Total fish EF	Gill Netting Catch Rate Per Net Night	Total Gill net fish	Total fish Combined
Gizzard shad	*Dorosoma cepedianum*	OM	.	X	TOL	5.33	33.61	80	1.60	16	96
Bluegill	*Lepomis macrochirus*	IN	X	X	TOL	0.13	0.84	2	0.10	1	3
Largemouth bass	*Micropterus salmoides*	TC	.	X	TOL	0.47	2.94	7	.	.	7
Skipjack herring	*Alosa chrysochloris*	TC	.	X	INT	.	.	.	5.60	56	56
Northern hog sucker	*Hypentelium nigricans*	BI	.	X	INT	0.07	0.42	1	.	.	1
Spotted sucker	*Minytrema melanops*	BI	.	X	INT	0.47	2.94	7	.	.	7
River redhorse	*Moxostoma carinatum*	BI	.	X	INT	0.20	1.26	3	.	.	3
Black redhorse	*Moxostoma duquesnei*	BI	.	X	INT	.	.	.	0.10	1	1
Longear sunfish	*Lepomis megalotis*	IN	X	X	INT	0.67	4.20	10	.	.	10
Smallmouth bass	*Micropterus dolomieu*	TC	.	X	INT	0.53	3.36	8	.	.	8
Brook silverside	*Labidesthes sicculus*	IN	.	X	INT	3.80	23.95	57	.	.	57
Threadfin shad	*Dorosoma petenense*	PK	.	X	.	.	.	.	.	.	0
Emerald shiner	*Notropis atherinoides*	IN	.	X	.	3.40	21.43	51	.	.	51
Smallmouth buffalo	*Ictiobus bubalus*	OM	.	X	.	0.53	3.36	8	0.10	1	9
Blue catfish	*Ictalurus furcatus*	OM	.	X	.	.	.	.	0.50	5	5
Channel catfish	*Ictalurus punctatus*	OM	.	X	.	0.53	3.36	8	0.50	5	13
Flathead catfish	*Pylodictis olivaris*	TC	.	X	.	.	.	.	0.10	1	1
White bass	*Morone chrysops*	TC	.	X	.	.	.	.	0.60	6	6
Yellow bass	*Morone mississippiensis*	TC	.	X	.	.	.	.	0.20	2	2
Striped bass	*Morone saxatilis*	TC	.	.	.	.	.	.	0.10	1	1
Redear sunfish	*Lepomis microlophus*	IN	X	X	.	0.27	1.68	4	0.10	1	5
Spotted bass	*Micropterus punctulatus*	TC	.	X	.	0.13	0.84	2	.	.	2
Logperch	*Percina caprodes*	BI	.	X	.	0.20	1.26	3	.	.	3
Sauger	*Sander canadensis*	TC	.	X	.	0.07	0.42	1	0.20	2	3
Freshwater drum	*Aplodinotus grunniens*	BI	.	X	.	0.47	2.94	7	0.20	2	9
Total						17.27	108.81	259	10.00	100	359
Number Samples						15			10		
Species Collected						17			14		

Appendix 2-P. Species Collected, Trophic Level, Native and Tolerance Classification, and Catch Per Unit Effort During Electrofishing and Gill Netting Upstream (TRM 295.9) of Browns Ferry Nuclear Plant Discharge, Autumn 2000.

Common Name	Scientific name	Trophic level	Sunfish species	Native species	Tolerance	Electrofishing Catch Rate Per Run	Electrofishing Catch Rate Per Hour	Total fish EF	Gill Netting Catch Rate Per Net Night	Total Gill net fish	Total fish Combined
Gizzard shad	*Dorosoma cepedianum*	OM	.	X	TOL	10.00	60.48	150	0.10	1	151
Common carp	*Cyprinus carpio*	OM	.	.	TOL	0.47	2.82	7	.	.	7
Bluegill	*Lepomis macrochirus*	IN	X	X	TOL	0.80	4.84	12	0.10	1	13
Largemouth bass	*Micropterus salmoides*	TC	.	X	TOL	2.07	12.50	31	0.70	7	38
Skipjack herring	*Alosa chrysochloris*	TC	.	X	INT	.	.	.	5.30	53	53
Northern hog sucker	*Hypentelium nigricans*	BI	.	X	INT	0.07	0.40	1	.	.	1
Spotted sucker	*Minytrema melanops*	BI	.	X	INT	0.33	2.02	5	.	.	5
River redhorse	*Moxostoma carinatum*	BI	.	X	INT	0.07	0.40	1	.	.	1
Smallmouth bass	*Micropterus dolomieu*	TC	.	X	INT	0.20	1.21	3	.	.	3
Spotted gar	*Lepisosteus oculatus*	TC	.	X	.	0.27	1.61	4	0.10	1	5
Threadfin shad	*Dorosoma petenense*	PK	.	X	.	.	.	.	.	.	0
Emerald shiner	*Notropis atherinoides*	IN	.	X	.	4.33	26.21	65	.	.	65
Grass carp	*Ctenopharyngodon idella*	HB	.	.	.	0.07	0.40	1	.	.	1
Smallmouth buffalo	*Ictiobus bubalus*	OM	.	X	.	0.07	0.40	1	0.10	1	2
Golden redhorse	*Moxostoma erythrurum*	BI	.	X	.	0.07	0.40	1	.	.	1
Blue catfish	*Ictalurus furcatus*	OM	.	X	.	.	.	.	0.50	5	5
Channel catfish	*Ictalurus punctatus*	OM	.	X	.	0.27	1.61	4	0.70	7	11
Flathead catfish	*Pylodictis olivaris*	TC	.	X	.	0.07	0.40	1	0.20	2	3
White bass	*Morone chrysops*	TC	.	X	.	0.00	0.00	0	0.40	4	4
Yellow bass	*Morone mississippiensis*	TC	.	X	.	.	.	.	0.10	1	1
Hybrid striped x white bass	*Hybrid morone (chrysops x sax)*	TC	.	.	.	.	.	.	0.60	6	6
Warmouth	*Lepomis gulosus*	IN	X	X	.	0.07	0.40	1	.	.	1
Redear sunfish	*Lepomis microlophus*	IN	X	X	.	0.80	4.84	12	0.20	2	14
Spotted bass	*Micropterus punctulatus*	TC	.	X	.	0.07	0.40	1	0.20	2	3
Yellow perch	*Perca flavescens*	IN	.	.	.	0.07	0.40	1	.	.	1
Logperch	*Percina caprodes*	BI	.	X	.	0.07	0.40	1	.	.	1
Sauger	*Sander canadensis*	TC	.	X	.	0.27	1.61	4	0.20	2	6
Freshwater drum	*Aplodinotus grunniens*	BI	.	X	.	0.27	1.61	4	.	.	4
Total						20.78	125.36	311	9.50	95	406
Number Samples						15			10		
Species Collected						22			15		

Table 1. - List of Herbicides for Potential Use in the Brown's Ferry Cooling Channels

Active Ingredient[1]	Brand Name Examples[2]	Classification[3]	Type	Plant Type[4]	Typical Degradation Half-life[5]	Notes
Copper (chelated) - ethanolamines	Cutrine Plus	Contact	Liquid	Submersed	Hours to 1+ day	Can be used for algal control
Copper (chelated) - ethanolamines	Cutrine Plus	Contact	Granule	Submersed	Hours to 1+ day	Can be used for algal control
Copper (chelated) - ethylene diamine	Komeen, Current	Contact	Liquid	Submersed	Hours to 1+ day	Often mixed with diquat to enhance control of vascular plants; also provides algal control
Diquat	Reward	Contact	Liquid	Submersed	0.5 to 7 days	Some deactivation if used in muddy water; commonly used with Komeen in TVA reservoirs to control several species of vascular plants
Endothall - Potassium salt	Aquathol K	Contact	Liquid	Submersed	2 to 14+ days	With a few day contact time, provides control of several vascular plants
Endothall - Potassium salt	Aquathol Super K	Contact	Granule	Submersed	2 to 14+ days	With a few day contact time, provides control of several vascular plants
Endothall - Amine salt	Hydrothol	Contact	Liquid	Submersed	2 to 14+ days	High fish toxicity if used at high label rates; controls various vascular species
Flumioxazin	Clipper	Contact	Water dispersable granule	Submersed	1+ day	Recently approved by EPA; not deactivated in muddy water; controls various species
			Page 1			

Table 1. - List of Herbicides for Potential Use in the Brown's Ferry Cooling Channels (continued)

Active Ingredient[1]	Brand Name	Classification[2]	Type	Plant Type[3]	Typical Degradation Half-life[4]	Notes
Fluridone	Sonar AS	Systemic	Liquid	Submersed	7 to 30+ days	Controls a wide range of vascular plants; previously used in BFN cooling channels
Fluridone	Sonar Q	Systemic	Granule	Submersed	7 to 30+ days	Controls a wide range of vascular plants; previously used in BFN cooling channels
Glyphosate	Rodeo, Aqua Master	Systemic	Liquid	Emergent	Hours to 1+ day	Controls herbaceous and woody species along shoreline
Imazapyr	Habitat	Systemic	Liquid	Emergent	7 to 14+ days	Controls herbaceous and woody species along shoreline
Sodium carbonate peroxyhydrate	PAK 27 Algaecide, Green Clean Pro	Contact	Granule	Submersed	Hours	Controls some species of algae
2,4-D - amine	Weedar 64	Systemic	Liquid	Submersed/ Emergent	4 to 21+ days	Primarily used to control milfoil in reservoirs; ineffective on naiads & pondweeds
2,4-D - butoxy-ethyl ester	Navigate	Systemic	Granule	Submersed	4 to 21+ days	Used primarily for milfoil control and a few other species

Active Ingredient[1] - the chemical that has the herbicidal acitivity for controlling a plant

Table 1. - List of Herbicides for Potential Use in the Brown's Ferry Cooling Channels (continued)

Brand Name Examples[2] - herbicide active ingredients are often marketed under several brand names by different companies; brand names listed in this table are examples and other brand names may be used in treatments at Brown's Ferry Nuclear Plant

Classification[3] - **Contact** - a herbicide that is not translocated by vascular tissues of a plant; **Systemic** - a herbicide that is translocated or moved to other parts of the plant by its vascular tissues

Plant Type[4] - **Submersed** - an aquatic plant whose vegetative parts are primarily below the surface of the water, used here to also include plants with floating leaves; **Emergent** - an aquatic or wetland plant that has most of its vegetative parts (i.e., stems and leaves) above the surface of the water

Typical Degradation Half-life[5] - typical time required for the concentration of a chemical to be reduced by one-half; information in this chart taken primarily from Getty *et al., Biology and Control of Aquatic Plants - A Best Management Handbook* (2009)

DHW/TVA-2/2011

Material Safety Data Sheet

Clipper™ Herbicide

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

PRODUCT NAME:	Clipper™ Herbicide
VC NUMBER(S):	1420
PRODUCT CODE:	Not Established.
EPA REGISTRATION NUMBER:	59639-161
PRODUCT DESCRIPTION:	Herbicide

MANUFACTURER/DISTRIBUTOR
VALENT U.S.A. CORPORATION
P.O. Box 8025
1600 Riviera Avenue, Suite 200
Walnut Creek, CA 94596-8025.

EMERGENCY TELEPHONE NUMBERS
HEALTH EMERGENCY OR SPILL (24 hr):
(800) 892-0099
TRANSPORTATION (24 hr.): CHEMTREC
(800) 424-9300 or (202) 483-7616.

PRODUCT INFORMATION
PROFESSIONAL PRODUCTS: (800) 898-2536 .

The current MSDS is available through our website (www.valent.com), or by calling the product information numbers listed above.

2. HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW.

CAUTION

- Harmful if inhaled or absorbed through skin.
- Avoid breathing dust or spray mist
- Avoid contact with eyes, skin and clothing
- May cause moderate eye irritation
- Keep out of reach of children

POTENTIAL HEALTH EFFECTS

Acute Toxicity (Primary Routes of Exposure): None known.

Acute Eye Contact: Based on an evaluation of the ingredients and/or similar products, this product may cause brief and/or minor eye irritation. The expected adverse health effects resulting from an exposure may include redness and possible swelling.

Acute Skin Contact: Based on an evaluation of the ingredients and/or similar products, this product may cause brief and/or minor skin irritation. The expected adverse health effects resulting from an exposure may include redness and possibly some minor swelling. This product may be slightly toxic when absorbed through the skin. This product is not expected to cause allergic skin reactions.

Acute Ingestion: Based on an evaluation of the ingredients and/or similar products, this product may be minimally toxic when ingested.

Acute Inhalation: Based on an evaluation of the ingredients and/or similar products, this product is expected to be slightly toxic when inhaled. Exposure to high concentrations of dust may result in respiratory irritation. Signs and symptoms may include, but not be limited to, nasal discharge, sore throat, coughing and difficulty in breathing.

Chronic Toxicity (including cancer): Repeated exposures to Flumioxazin Technical in animals have produced anemia and other blood formation changes, organ weight changes and changes in blood chemistry. Flumioxazin Technical did not produce cancer in life-time feeding studies in laboratory animals.

Developmental Toxicity (birth defects): Birth defects were produced in the offspring of female rats exposed to Flumioxazin Technical. No effects were observed in rabbits.

Reproductive Toxicity: Reproductive effects were observed in rats exposed to Flumioxazin Technical.

Signs and Symptoms of Systemic Effects: No signs or symptoms occured in animals exposed to high oral or dermal doses of Flumioxazin Technical. Exposure to very high concentrations of Flumioxazin Technical in the air resulted in breathing difficulties, decreased activity and some changes in the tissues of the respiratory system.

Potentially Aggravated Medical Conditions: Individuals with anemia or preexisting diseases of the blood may have increased susceptibility to the toxicity of excessive exposures.

For complete discussion of the toxicology data from which this evaluation was made, refer to Section 11. For Ecotox/Environmental Information, refer to Section 12. For Regulatory Information, refer to Section 15.

3. COMPOSITION/INFORMATION ON INGREDIENTS

Chemical Name	CAS Number	Weight/ Percent	Purpose
Flumioxazin (2-[7-fluoro-3,4-dihydro-3-oxo-4-(2-propynyl)-2H-1,4-benzoxazin-6-yl]-4,5,6,7-tetrahydro-1H-isoindole-1,3(2H)-dione).	103361-09-7	45 - 55	Active Ingredient
Kaolin clay.	1332-58-7	11 - 21	Carrier
Others (including particulates not otherwise classified).	No CAS#	24 - 40	-.

Other ingredients, which are maintained as trade secrets, are any substances other than an active ingredient contained in this product. Some of these may be hazardous, but their identities are withheld because they are considered trade secrets. The hazards associated with the other ingredients are addressed in this document. Specific information on other ingredients for the management of exposures, spills, or safety assessments can be obtained by a treating physician or nurse by calling **(800) 892-0099** at any time.

4. FIRST AID MEASURES

EMERGENCY NUMBER (800) 892-0099

Have the product container or label with you when calling a poison control center or doctor, or going for treatment. You may also contact **1-800-892-0099** for emergency medical treatment information.

EYE CONTACT:
Hold eye open and rinse slowly and gently with water for 15-20 minutes. Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye. Call a poison control center or doctor for treatment advice.

SKIN CONTACT:
Take off contaminated clothing. Rinse skin immediately with plenty of water for 15-20 minutes. Call a poison control center or doctor for treatment advice.

INGESTION:
Call a poison control center or doctor immediately for treatment advice. Have person sip a glass of water if able to swallow. DO NOT induce vomiting unless told to do so by the poison control center or doctor. Do not give anything by mouth to an unconscious person.

INHALATION:
Move person to fresh air. If person is not breathing, call 911 or an ambulance, then give artificial respiration, if possible. Call a poison control center or doctor for further treatment advice.

NOTES TO PHYSICIAN:
None.

5. FIRE FIGHTING MEASURES

FLASH POINT:	Not applicable.
AUTOIGNITION:	No data available
EXTINGUISHING MEDIA:	Water fog, carbon dioxide, foam, dry chemical
FLAMMABLE LIMITS IN AIR - LOWER (%):	Not applicable
FLAMMABLE LIMITS IN AIR - UPPER (%):	Not applicable

NFPA RATING:

Health:	1
Flammability:	1
Reactivity:	0
Special:	None

(Least-0, Slight-1, Moderate-2, High-3, Extreme-4). These values are obtained using professional judgement. Values were not available in the guidelines or published evaluations prepared by the National Fire Protection Association, NFPA.

FIRE FIGHTING INSTRUCTIONS: Products of combustion from fires involving this material may be toxic. Avoid breathing smoke and mists. Avoid personnel and equipment contact with fallout and runoff. Minimize the amount of water used for fire fighting. Do not enter any enclosed area without full protective equipment, including self-contained breathing equipment. Contain and isolate runoff and debris for proper disposal. Decontaminate personal protective equipment and fire fighting equipment before reuse.

HAZARDOUS DECOMPOSITION PRODUCTS: Normal combustion forms carbon dioxide, water vapor and may produce: Oxides of nitrogen . Combustion may produce toxic gases of: Nitrogen compounds, Fluorine compounds. Incomplete combustion can produce carbon monoxide.

6. ACCIDENTAL RELEASE MEASURES

VALENT EMERGENCY PHONE NUMBER: (800) 892-0099
CHEMTREC EMERGENCY PHONE NUMBER: (800) 424-9300
OBSERVE PRECAUTIONS IN SECTION 8: PERSONAL PROTECTION
Stop the source of the spill if safe to do so. Contain the spill to prevent further contamination of the soil, surface water, or ground water. For additional spill response information refer to the North American Emergency Response Guidebook.

UN/NA NUMBER: Not applicable. **EMERGENCY RESPONSE GUIDEBOOK NO.:** Not applicable.

FOR SPILLS ON LAND:

CONTAINMENT: Reduce airborne dust. Avoid runoff into storm sewers or other bodies of water.

CLEANUP: Clean up spill immediately. Vacuum or sweep up material and place in a chemical waste container. Wash area with soap and water. Pick up wash liquid with additional absorbent and place in a chemical waste container.

FOR SPILLS IN WATER:

CONTAINMENT: This material will disperse or dissolve in water. Stop the source of the release. Contain and isolate to prevent further release into soil, surface water and ground water.

CLEANUP: Clean up spill immediately. Absorb spill with inert material. Remove contaminated water for treatment or disposal.

7. HANDLING AND STORAGE

END USER MUST READ AND OBSERVE ALL PRECAUTIONS ON PRODUCT LABEL.

HANDLING:

Users should wash hands before eating, drinking, chewing gum, using tobacco or using the toilet. Remove contaminated clothing and shoes immediately. Then wash thoroughly and put on clean clothing.

STORAGE:

Do not contaminate water, food or feed by storage, disposal or cleaning of equipment. Keep pesticide in original container only. Store in a cool, dry place. Do not put formulation or dilute spray solution into food or drink containers. Do not store or transport near food or feed. Do not contaminate food or foodstuffs. Not for use or storage in or around the home.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

END USER MUST READ AND OBSERVE ALL PRECAUTIONS ON PRODUCT LABEL.

EYES & FACE: Do not get this material in your eyes. Eye contact can be avoided by wearing protective eyewear.

RESPIRATORY PROTECTION: Use this material only in well ventilated areas. Unless ventilation is adequate to keep airborne concentrations below recommended exposure standards, approved respiratory protection should be worn.

This material may be a respiratory irritant and, unless ventilation is adequate, the use of approved respiratory protection is recommended. Use this material only in well ventilated areas.

SKIN & HAND PROTECTION: Avoid contact with skin or clothing. Skin contact should be minimized by wearing protective clothing including gloves.

EXPOSURE LIMITS

Chemical Name	ACGIH Exposure Limits	OSHA Exposure Limits	Manufacturer's Exposure Limits
Flumioxazin (2-[7-fluoro-3,4-dihydro-3-oxo-4-(2-propynyl)-2H-1,4-benzoxazin-6-yl]-4,5,6,7-tetrahydro-1H-isoindole-1,3(2H)-dione).	None.	None.	None.
Kaolin clay.	2 mg/m^3 TWA (respirable fraction)	15 mg/m^3 TWA 5 mg/m^3 TWA	None
Others (including particulates not otherwise classified).	None.	None.	None.

9. PHYSICAL AND CHEMICAL PROPERTIES

PHYSICAL FORM:	Granule
COLOR:	Light brown
ODOR:	Slight
FLASH POINT:	Not applicable.
MELTING POINT:	Not applicable
BULK DENSITY:	0.49 g/cc (30.8 lb./cu. ft.)
pH:	5.4 @ 25°C (1% suspension)
CORROSION CHARACTERISTICS:	Not corrosive to containers.
SOLUBILITY:	Dispersible in water

10. STABILITY AND REACTIVITY

CHEMICAL STABILITY:	This material is considered chemically and thermally stable.
INCOMPATIBILITY:	May react with strong oxidizing agents, such as chlorates, nitrates, peroxides, etc.

10. STABILITY AND REACTIVITY

OXIDATION/REDUCTION PROPERTIES:	Not an oxidizing or reducing agent.
EXPLODABILITY:	Not expected to be explosive.
HAZARDOUS DECOMPOSITION PRODUCTS:	Normal combustion forms carbon dioxide, water vapor and may produce: Oxides of nitrogen . Combustion may produce toxic gases of: Nitrogen compounds, Fluorine compounds. Incomplete combustion can produce carbon monoxide.

11. TOXICOLOGICAL INFORMATION

ACUTE TOXICITY:

Oral Toxicity LD_{50} (rats).	> 5,000 mg/kg	EPA Tox Category	IV
Dermal Toxicity LD_{50} (rabbits).	> 2,000 mg/kg	EPA Tox Category	III
Inhalation Toxicity LC_{50} (rats).	0.969 mg/L	EPA Tox Category	III
Eye Irritation (rabbits).	Brief and/or minor irritation	EPA Tox Category	III
Skin Irritation (rabbits).	Brief and/or minor irritation	EPA Tox Category	IV
Skin Sensitization (guinea pigs).	Non-sensitizer	EPA Tox Category	Not applicable

CARCINOGEN CLASSIFICATION

TOXICITY OF FLUMIOXAZIN TECHNICAL

SUBCHRONIC: Compound related effects of Flumioxazin Technical noted in rats following subchronic exposures at high dose levels were hematotoxicity including anemia, and increases in liver, spleen, heart, kidney and thyroid weights. In dogs, the effects produced at high dose levels included a slight prolongation in activated partial thromboplastin time, increased cholesterol and phospholipid, elevated alkaline phosphatase, increased liver weights and histological changes in the liver. The lowest no-observable-effect-level (NOEL) in subchronic studies was 30 ppm in the three-month toxicity study in rats.

CHRONIC/CARCINOGENICITY: In a one year dog feeding study, Flumioxazin Technical produced treatment-related changes in blood chemistry and increased liver weights at 100 and 1000 mg/kg/day. Minimal treatment-related histological changes were noted in the livers of animals in the 1000 mg/kg/day group. Based on these data the NOEL is 10 mg/kg/day. Dietary administration of Flumioxazin Technical for 18 months produced liver changes in mice of the 3000 and 7000 ppm groups. There was no evidence of any treatment-related oncogenic effect. The NOEL for this study is 300 ppm. Dietary administration of Flumioxazin Technical for 24 months produced anemia and chronic nephropathy in rats of the 500 and 1000 ppm groups. The anemia lasted throughout the treatment period, however, it was not progressive nor aplastic in nature. No evidence of an oncogenic effect was observed. The NOEL for this study is 50 ppm.

DEVELOPMENTAL TOXICITY: Flumioxazin Technical produces developmental toxicity in rats in the absence of maternal toxicity at doses of 30 mg/kg/day by the oral route and 300 mg/kg/day by the dermal route. The developmental effects noted consisted primarily of decreased number of live fetuses and fetal weights, cardiovascular abnormalities, wavy ribs and decreased number of ossified sacrococcygeal vertebral bodies. The developmental NOEL in the rat oral and dermal developmental toxicity studies were 10 and 100 mg/kg/day, respectively. The response in rabbits was very different from that in rats. No developmental toxicity was noted in rabbits at doses up to 3000 mg/kg/day, a dose well above the maternal NOEL of 1000 mg/kg/day.

REPRODUCTION: Reproductive toxicity was observed in F1 males, P1 females and F1 females at 300 ppm Flumioxazin Technical, the highest dose tested and a dose that also produced signs of systemic toxicity. Toxicity was also observed in the F1 and F2 offspring at doses of 200 ppm and greater.

MUTAGENICITY: Flumioxazin Technical was not mutagenic in most *in vitro* assays: gene mutation and a chromosome aberration assay in the absence of metabolic activation. In three *in vivo* assays, chromosome aberration, unscheduled DNA synthesis and micronucleus assay, Flumioxazin Technical was not mutagenic. The only positive response was observed in the *in vitro* chromosome aberration assay in the presence of metabolic activation. Overall, Flumioxazin Technical does not present a genetic hazard.

For a summary of the potential for adverse health effects from exposure to this product, refer to Section 2. For information regarding regulations pertaining to this product, refer to Section 15.

12. ECOLOGICAL INFORMATION

AVIAN TOXICITY:

Based upon EPA designation, Flumioxazin Technical is practically non-toxic to avian species. The following results were obtained from studies with Flumioxazin Technical:

Oral LD_{50} bobwhite quail: greater than 2250 mg/kg
Dietary LC_{50} bobwhite quail: greater than 5620 ppm
Dietary LC_{50} mallard duck: greater than 5620 ppm.

Flumioxazin Technical in the diet. In mallard ducks, a slight, but not statistically significant reduction in hatchlings and 14-day old survivors was observed. Based on a possible, slight effect on egg production at 500 ppm, the NOEL for this study was 250 ppm. No reproductive effects were observed in bobwhite quail exposed to 500 ppm of Flumioxazin technical in the diet.

AQUATIC ORGANISM TOXICITY:

Based upon EPA designation, Flumioxazin Technical is slightly to moderately toxic to freshwater fish; moderately toxic to freshwater invertebrates; moderately toxic to estuarine/marine fish and moderately to highly toxic estuarine/marine invertebrates, based on the following tests:

96-hour LC_{50} rainbow trout: 2.3 mg/L
96-hour LC_{50} bluegill sunfish: greater than 21 mg/L
48-hour LC_{50} Daphnia magna: 5.5 mg/L
96-hour LC_{50} sheepshead minnow: greater than 4.7 mg/L
96-hour (shell deposition) EC_{50} eastern oyster: 2.8 mg/L
96-hour LC_{50} mysid shrimp: 0.23 mg/L
Fish early life-stage (rainbow trout): NOEC >7.7 µg/L, <16 µg/L
Chronic toxicity (mysid shrimp): NOEC >15 µg/L, <27 µg/L
Chronic toxicity (Daphnia magna): NOEC >52 µg/L, <99 µg/L.

OTHER NON-TARGET ORGANISM TOXICITY:

Flumioxazin Technical is practically non-toxic to bees. The acute contact LC50 in bees was greater than 105 µg/bee.

13. DISPOSAL CONSIDERATIONS

END USERS MUST DISPOSE OF ANY UNUSED PRODUCT AS PER THE LABEL RECOMMENDATIONS.

PRODUCT DISPOSAL: Wastes resulting from the use of this product may be disposed of on site or at an approved waste disposal facility.

CONTAINER DISPOSAL: Non-refillable container. Do not reuse or refill this container. Offer for recycling if available. Triple rinse as follows: Empty the remaining contents into mix tank. Fill the container 1/4 full with water. Replace and tighten closures. Tip container on its side and roll it back and forth, ensuring at least one complete revolution for 30 seconds. Stand the container on its end and tip it back and forth several times. Empty the rinsate into application equipment or a mix tank or store rinsate for later use or disposal. Repeat this procedure two more times.

DISPOSAL METHODS: Check government regulations and local authorities for approved disposal of this material. Dispose in accordance with applicable laws and regulations.

14. TRANSPORT INFORMATION

UN/NA NUMBER:	Not applicable.
DOT (ground) SHIPPING NAME:	Herbicide, solid, non-regulated
TECHNICAL NAME (hazardous material):	Not applicable.
HAZARD CLASS:	Not applicable.
PACKING GROUP:	Not applicable.
DOT REPORTABLE QUANTITY (RQ):	None
REMARKS:	None
EXEMPTION REQUIREMENT:	None.
EMERGENCY RESPONSE GUIDEBOOK NO.:	Not applicable.
MARINE POLLUTANT:	Not applicable.

15. REGULATORY INFORMATION

PESTICIDE REGULATIONS: All pesticides are governed under FIFRA (Federal Insecticide, Fungicide, and Rodenticide Act). Therefore, the regulations presented below are pertinent only when handled outside of the normal use and applications of pesticides. This includes waste streams resulting from manufacturing/formulation facilities, spills or misuse of products, and storage of large quantities of products containing hazardous or extremely hazardous substances.

U.S. FEDERAL REGULATIONS:

Ingredients in this product are reviewed against an inclusive list of federal regulations. Therefore, the user should consult appropriate authorities. The federal regulations reviewed include: Clean Water Act, SARA, CERCLA, RCRA, DOT, TSCA and OSHA. If no components or information is listed in the space below this paragraph, then none of the regulations reviewed are applicable.

SARA (311, 312):

Immediate Health:	Yes.
Chronic Health:	Yes.
Fire:	No
Sudden Pressure:	No
Reactivity:	No

STATE REGULATIONS:
Each state may promulgate standards more stringent than the federal government. This section cannot encompass an inclusive list of all state regulations. Therefore, the user should consult state or local authorities. The state regulations reviewed include: California Proposition 65, California Directors List of Hazardous Substances, Massachusetts Right to Know, Michigan Critical Materials List, New Jersey Right to Know, Pennsylvania Right to Know, Rhode Island Right to Know and the Minnesota Hazardous Substance list. For Washington State Right to Know, see Section 8 for Exposure Limit information. For Louisiana Right to Know refer to SARA information listed under U.S. Regulations above. If no components or information is listed in the space below this paragraph, then none of the regulations reviewed are applicable.

Flumioxazin (2-[7-fluoro-3,4-dihydro-3-oxo-4-(2-propynyl)-2H-1,4-benzoxazin-6-yl]-4,5,6,7-tetrahydro-1H-isoindole-1,3(2H)-dione).

California Proposition 65	Not Listed
NJ Right To Know	Listed

Kaolin clay.

MA Right To Know	Listed
PA Right To Know	Listed
RI Right To Know	Listed
MN Hazardous Substance	Listed

For information regarding potential adverse health effects from exposure to this product, refer to Sections 2 and 11.

16. OTHER INFORMATION

REASON FOR ISSUE:	Added the EPA registration number. Added container disposal information.
MSDS NO.:	0381
EPA REGISTRATION NUMBER:	59639-161
REVISION NUMBER:	3
REVISION DATE:	11/11/2010
SUPERCEDES DATE:	March 4, 2009
RESPONSIBLE PERSON(S):	Valent U.S.A. Corporation, Corporate EH&S, (925) 256-2803.

This Material Safety Data Sheet (MSDS) serves different purposes than and DOES NOT REPLACE OR MODIFY THE EPA-APPROVED PRODUCT LABELING (attached to and accompanying the product container). This MSDS provides important health, safety, and environmental information for employers, employees, emergency responders and others handling large quantities of the product in activities generally other than product use, while the labeling provides that information specifically for product use in the ordinary course.

Use, storage and disposal of pesticide products is regulated by the EPA under the authority of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) through the product labeling. All necessary and appropriate precautionary, use, storage, and disposal information is set forth on that labeling. It is a violation of federal law to use a pesticide product in any manner not prescribed on the EPA-approved label.

The information in this MSDS is based on data available to us as of the revision date given herein, and believed to be correct. Contact Valent U.S.A. Corporaton to confirm if you have the most current MSDS.

Judgements as to the suitability of information herein for the individual's own use or purposes are necessarily the individual's own responsibility. Although reasonable care has been taken in the preparation of such information, Valent extends no warranties, makes no representations, and assumes no responsibility as to the accuracy or suitability of such information for application to the individual's purposes or the consequences of its use.

MONSANTO COMPANY

Material Safety Data Sheet
Commercial Product

1. PRODUCT AND COMPANY IDENTIFICATION

Product name
AquaMaster® Herbicide

EPA Reg. No.
524-343
Product use
Herbicide
Chemical name
Not applicable.
Synonyms
None.
Company
MONSANTO COMPANY, 800 N. Lindbergh Blvd., St. Louis, MO, 63167
Telephone: 800-332-3111, **Fax:** 314-694-5557
Emergency numbers
FOR CHEMICAL EMERGENCY, SPILL LEAK, FIRE, EXPOSURE, OR ACCIDENT Call CHEMTREC - Day or Night: 1-800-424-9300 toll free in the continental U.S., Puerto Rico, Canada, or Virgin Islands. For calls originating elsewhere: 703-527-3887 (collect calls accepted).
FOR MEDICAL EMERGENCY - Day or Night: +1 (314) 694-4000 (collect calls accepted).

2. COMPOSITION/INFORMATION ON INGREDIENTS

Active ingredient
Isopropylamine salt of N-(phosphonomethyl)glycine; {Isopropylamine salt of glyphosate}

Composition

COMPONENT	CAS No.	% by weight (approximate)
Isopropylamine salt of glyphosate	38641-94-0	53.8
Water	7732-18-5	46.2

OSHA Status
This product is not hazardous according to the OSHA Hazard Communication Standard, 29 CFR 1910.1200.

3. HAZARDS IDENTIFICATION

Emergency overview
Appearance and odour (colour/form/odour): Colourless - Amber / Liquid, (viscous) / Odourless

CAUTION!

Potential health effects
Likely routes of exposure
Skin contact, eye contact, inhalation
Eye contact, short term
Not expected to produce significant adverse effects when recommended use instructions are followed.
Skin contact, short term
Not expected to produce significant adverse effects when recommended use instructions are followed.
Inhalation, short term

Not expected to produce significant adverse effects when recommended use instructions are followed.

Refer to section 11 for toxicological and section 12 for environmental information.

4. FIRST AID MEASURES

Eye contact
Immediately flush with plenty of water.
If easy to do, remove contact lenses.

Skin contact
Take off contaminated clothing, wristwatch, jewellery.
Wash affected skin with plenty of water.
Wash clothes and clean shoes before re-use.

Inhalation
Remove to fresh air.

Ingestion
Immediately offer water to drink.
Do NOT induce vomiting unless directed by medical personnel.
If symptoms occur, get medical attention.

Advice to doctors
This product is not an inhibitor of cholinesterase.

Antidote
Treatment with atropine and oximes is not indicated.

5. FIRE-FIGHTING MEASURES

Flash point
none

Extinguishing media
Recommended: Water, foam, dry chemical, carbon dioxide (CO2)

Unusual fire and explosion hazards
None.
Environmental precautions: see section 6.

Hazardous products of combustion
Carbon monoxide (CO), phosphorus oxides (PxOy), nitrogen oxides (NOx)

Fire fighting equipment
Self-contained breathing apparatus.
Equipment should be thoroughly decontaminated after use.

6. ACCIDENTAL RELEASE MEASURES

Personal precautions
Use personal protection recommended in section 8.

Environmental precautions
SMALL QUANTITIES:
Low environmental hazard.

LARGE QUANTITIES:
Minimise spread.
Keep out of drains, sewers, ditches and water ways.
Notify authorities.

Methods for cleaning up
SMALL QUANTITIES:
Flush spill area with water.
LARGE QUANTITIES:
Absorb in earth, sand or absorbent material.
Dig up heavily contaminated soil.
Collect in containers for disposal.
Refer to section 7 for types of containers.
Flush residues with small quantities of water.
Minimise use of water to prevent environmental contamination.

Refer to section 13 for disposal of spilled material.

7. HANDLING AND STORAGE

Good industrial practice in housekeeping and personal hygiene should be followed.

Handling
Avoid contact with skin and eyes.
When using do not eat, drink or smoke.
Wash hands thoroughly after handling or contact.
Thoroughly clean equipment after use.
Do not contaminate drains, sewers and water ways when disposing of equipment rinse water.
Refer to section 13 for disposal of rinse water.
Emptied containers retain vapour and product residue.

Storage
Minimum storage temperature: -15 °C
Maximum storage temperature: 50 °C
Compatible materials for storage: stainless steel, aluminium, fibreglass, plastic, glass lining
Incompatible materials for storage: galvanised steel, unlined mild steel, see section 10.
Keep out of reach of children.
Keep away from food, drink and animal feed.
Keep only in the original container.
Partial crystallization may occur on prolonged storage below the minimum storage temperature.
If frozen, place in warm room and shake frequently to put back into solution.
Minimum shelf life: 5 years.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Airborne exposure limits

Components	Exposure Guidelines
Isopropylamine salt of glyphosate	No specific occupational exposure limit has been established.
Water	No specific occupational exposure limit has been established.

Engineering controls
No special requirement when used as recommended.

Eye protection

No special requirement when used as recommended.

Skin protection
No special requirement when used as recommended.

Respiratory protection
No special requirement when used as recommended.

When recommended, consult manufacturer of personal protective equipment for the appropriate type of equipment for a given application.

9. PHYSICAL AND CHEMICAL PROPERTIES

These physical data are typical values based on material tested but may vary from sample to sample. Typical values should not be construed as a guaranteed analysis of any specific lot or as specifications for the product.

Colour/colour range:	Colourless - Amber
Form:	Liquid, (viscous)
Odour:	Odourless
Flash point:	none
Specific gravity:	1.206 @ 20 °C / 15.6 °C
Solubility:	Water: Completely miscible.
pH:	4.6 - 4.8 @ 63 g/l
Partition coefficient (log Pow):	< 0.000 (active ingredient)

10. STABILITY AND REACTIVITY

Stability
Stable under normal conditions of handling and storage.

Hazardous decomposition
Thermal decomposition: Hazardous products of combustion: see section 5.

Materials to avoid/Reactivity
Reacts with galvanised steel or unlined mild steel to produce hydrogen, a highly flammable gas that could explode.

11. TOXICOLOGICAL INFORMATION

This section is intended for use by toxicologists and other health professionals.

Data obtained on product, similar products and on components are summarized below.

<u>Mutagenicity</u>
Micronucleus test(s):
Not mutagenic.
Ames test(s):
Not mutagenic with and without metabolic activation.

<u>Isopropylamine salt of glyphosate (62%)</u>

<u>Acute oral toxicity</u>
Rat, LD50 (limit test): > 5,000 mg/kg body weight
Practically non-toxic.
FIFRA category IV.
No mortality.

Mouse, LD50 (limit test): > 5,000 mg/kg body weight
Practically non-toxic.
FIFRA category IV.
No mortality.

Acute dermal toxicity

Rabbit, LD50 (limit test): > 5,000 mg/kg body weight
Practically non-toxic.
FIFRA category IV.
No mortality.

Skin irritation

Rabbit, 6 animals, Draize test:
Days to heal: 3
Primary Irritation Index (PII): 0.0/8.0
Essentially non irritating.
FIFRA category IV.

Acute inhalation toxicity

Rat, LC50, 4 hours, aerosol: > 4.24 mg/L
Practically non-toxic.
FIFRA category IV.
No mortality. Maximum attainable concentration.

Skin sensitization

Guinea pig, Buehler test:
Positive incidence: 0 %

N-(phosphonomethyl)glycine; {glyphosate}

Mutagenicity

In vitro and in vivo mutagenicity test(s):
Not mutagenic.

Repeated dose toxicity

Rabbit, dermal, 21 days:
NOAEL toxicity: > 5,000 mg/kg body weight/day
Target organs/systems: none
Other effects: none

Rat, oral, 3 months:
NOAEL toxicity: > 20,000 mg/kg diet
Target organs/systems: none
Other effects: none

Chronic effects/carcinogenicity

Mouse, oral, 24 months:
NOEL tumour: > 30,000 mg/kg diet
NOAEL toxicity: ~ 5,000 mg/kg diet
Tumours: none
Target organs/systems: liver
Other effects: decrease of body weight gain, histopathologic effects

Rat, oral, 24 months:
NOEL tumour: > 20,000 mg/kg diet
NOAEL toxicity: ~ 8,000 mg/kg diet
Tumours: none
Target organs/systems: eyes
Other effects: decrease of body weight gain, histopathologic effects

Toxicity to reproduction/fertility

Rat, oral, 3 generations:
NOAEL toxicity: > 30 mg/kg body weight
NOAEL reproduction: > 30 mg/kg body weight
Target organs/systems in parents: none
Other effects in parents: none

Target organs/systems in pups: none
Other effects in pups: none

Developmental toxicity/teratogenicity

Rat, oral, 6 - 19 days of gestation:
NOAEL toxicity: 1,000 mg/kg body weight
NOAEL development: 1,000 mg/kg body weight
Other effects in mother animal: decrease of body weight gain, decrease of survival
Developmental effects: weight loss, post-implantation loss, delayed ossification
Effects on offspring only observed with maternal toxicity.

Rabbit, oral, 6 - 27 days of gestation:
NOAEL toxicity: 175 mg/kg body weight
NOAEL development: 175 mg/kg body weight
Target organs/systems in mother animal: none
Other effects in mother animal: decrease of survival
Developmental effects: none

12. ECOLOGICAL INFORMATION

This section is intended for use by ecotoxicologists and other environmental specialists.

Data obtained on components are summarized below.

Isopropylamine salt of glyphosate (62%)

Aquatic toxicity, fish

Bluegill sunfish (Lepomis macrochirus):
Acute toxicity, 96 hours, static, LC50: > 1,000 mg/L
Practically non-toxic.

Rainbow trout (Oncorhynchus mykiss):
Acute toxicity, 96 hours, static, LC50: > 1,000 mg/L
Practically non-toxic.

Aquatic toxicity, invertebrates

Water flea (Daphnia magna):
Acute toxicity, 48 hours, static, EC50: 930 mg/L
Practically non-toxic.

Aquatic toxicity, algae/aquatic plants

Green algae (Scenedesmus subspicatus):
Acute toxicity, 72 hours, static, ErC50 (growth rate): 166 mg/L
Practically non-toxic.

Soil organism toxicity, invertebrates

Earthworm (Eisenia foetida):
Acute toxicity, 14 days, LC50: > 5,000 mg/kg dry soil
Practically non-toxic.

N-(phosphonomethyl)glycine; {glyphosate}

Avian toxicity

Bobwhite quail (Colinus virginianus):
Dietary toxicity, 5 days, LC50: > 4,640 mg/kg diet
No more than slightly toxic.

Mallard duck (Anas platyrhynchos):
Dietary toxicity, 5 days, LC50: > 4,640 mg/kg diet
No more than slightly toxic.

Bobwhite quail (Colinus virginianus):
Acute oral toxicity, single dose, LD50: > 3,851 mg/kg body weight
Practically non-toxic.

Arthropod toxicity

Honey bee (Apis mellifera):
Oral, 48 hours, LD50: 100 μg/bee

Honey bee (Apis mellifera):
Contact, 48 hours, LD50: > 100 μg/bee
Practically non-toxic.

Bioaccumulation

Bluegill sunfish (Lepomis macrochirus):
Whole fish: BCF: < 1
No significant bioaccumulation is expected.

Dissipation

Soil, field:
Half life: 2 - 174 days
Koc: 884 - 60,000 L/kg
Adsorbs strongly to soil.

Water, aerobic:
Half life: < 7 days

13. DISPOSAL CONSIDERATIONS

Product

Not classified as hazardous waste by the Resource, Conservation and Recovery Act (RCRA), 40 CFR 261.
Recycle if appropriate facilities/equipment available.
Burn in special, controlled high temperature incinerator.
Keep out of drains, sewers, ditches and water ways.
Follow all local/regional/national/international regulations.
Consult your attorney or appropriate regulatory officials for information on disposal.

Container

Triple or pressure rinse empty containers.
Pour rinse water into spray tank.
Store for collection by approved waste disposal service.
Dispose of as non hazardous industrial waste.
Do NOT re-use containers.
Follow all local/regional/national/international regulations.

14. TRANSPORT INFORMATION

The data provided in this section is for information only. Please apply the appropriate regulations to properly classify your shipment for transportation.

Not hazardous under the applicable DOT, ICAO/IATA, IMO, TDG and Mexican regulations.

15. REGULATORY INFORMATION

TSCA Inventory

All components are on the US EPA's TSCA Inventory

SARA Title III Rules

Section 311/312 Hazard Categories
Not applicable.
Section 302 Extremely Hazardous Substances
Not applicable.
Section 313 Toxic Chemical(s)
Not applicable.

CERCLA Reportable quantity
Not applicable.

16. OTHER INFORMATION

The information given here is not necessarily exhaustive but is representative of relevant, reliable data.
Follow all local/regional/national/international regulations.
Please consult supplier if further information is needed.
For more information refer to product label.
Please consult Monsanto if further information is needed.
In this document the British spelling was applied.
® Registered trademark of Monsanto Company or its subsidiaries.

	Health	Flammability	Instability	Additional Markings
NFPA	0	1	1	

0 = Minimal hazard, 1 = Slight hazard, 2 = Moderate hazard, 3 = Severe hazard, 4 = Extreme hazard

Full denomination of most frequently used acronyms. BCF (Bioconcentration Factor), BOD (Biochemical Oxygen Demand), COD (Chemical Oxygen Demand), EC50 (50% effect concentration), ED50 (50% effect dose), I.M. (intramuscular), I.P. (intraperitoneal), I.V. (intravenous), Koc (Soil adsorption coefficient), LC50 (50% lethality concentration), LD50 (50% lethality dose), LDLo (Lower limit of lethal dosage), LEL (Lower Explosion Limit), LOAEC (Lowest Observed Adverse Effect Concentration), LOAEL (Lowest Observed Adverse Effect Level), LOEC (Lowest Observed Effect Concentration), LOEL (Lowest Observed Effect Level), MEL (Maximum Exposure limit), MTD (Maximum Tolerated Dose), NOAEC (No Observed Adverse Effect Concentration), NOAEL (No Observed Adverse Effect Level), NOEC (No Observed Effect Concentration), NOEL (No Observed Effect Level), OEL (Occupational Exposure Limit), PEL (Permissible Exposure Limit), PII (Primary Irritation Index), Pow (Partition coefficient n-octanol/water), S.C. (subcutaneous), STEL (Short-Term Exposure Limit), TLV-C (Threshold Limit Value-Ceiling), TLV-TWA (Threshold Limit Value - Time Weighted Average), UEL (Upper Explosion Limit)

This Material Safety Data Sheet (MSDS) serves different purposes than and DOES NOT REPLACE OR MODIFY THE EPA-APPROVED PRODUCT LABELING (attached to and accompanying the product container). This MSDS provides important health, safety, and environmental information for employers, employees, emergency responders and others handling large quantities of the product in activities generally other than product use, while the labeling provides that information specifically for product use in the ordinary course. Use, storage and disposal of pesticide products are regulated by the EPA under the authority of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) through the product labeling, and all necessary and appropriate precautionary, use, storage, and disposal information is set forth on that labeling. It is a violation of federal law to use a pesticide product in any manner not prescribed on the EPA-approved label.

cerexagri

AQUATHOL K Aquatic Herbicide

Material Safety Data Sheet

Cerexagri, Inc.

1 PRODUCT AND COMPANY IDENTIFICATION

Agrichemicals Group
Cerexagri, Inc.
630 Freedom Business Center, Suite 402
King of Prussia, PA 19406

EMERGENCY PHONE NUMBERS:
Chemtrec: (800) 424-9300 (24hrs) or (703) 527-3887
Medical: Rocky Mountain Poison Control Center
(866) 767-5089 (24Hrs)

Information Telephone Numbers	Phone Number	Available Hrs
R&D Technical Service	610-878-6100	8:00am to 5:00pm EST
Customer Service	1-800-438-6071	8:00am - 5:00 pm EST

Product Name	AQUATHOL K Aquatic Herbicide
Product Synonym(s)	

Chemical Family	Dicarboxylic Acid
Chemical Formula	C8H8O5K2
Chemical Name	Dipotassium Endothall
EPA Reg Num	4581-204
Product Use	Contact killer for submerged aquatic weeds

2 COMPOSITION / INFORMATION ON INGREDIENTS

Ingredient Name	CAS RegistryNumber	Typical Wt. %	OSHA
Endothal-potassium	2164-07-0	40.3	Y

The substance(s) marked with a "Y" in the OSHA column, are identified as hazardous chemicals according to the criteria of the OSHA Hazard Communication Standard (29 CFR 1910.1200)

3 HAZARDS IDENTIFICATION

Emergency Overview
Yellow brown liquid, very faint chlorine odor.
KEEP OUT OF REACH OF CHILDREN.

DANGER!

Causes irreversible eye damage
MAY BE FATAL IF SWALLOWED.
MAY BE FATAL IF INHALED.

HARMFUL IF ABSORBED THROUGH SKIN.

Do not get in eyes, on skin or on clothing.
Do not breathe vapor.

Potential Health Effects

Inhalation and skin contact are expected to be the primary routes of occupational exposure to this material. Based on single exposure animal tests, this material is considered to be moderately toxic if swallowed, slightly toxic if absorbed through skin or inhaled, non-irritating to skin and causes irreversible eye damage.

4 FIRST AID MEASURES

IF IN EYES,
-Hold eye open and rinse slowly and gently with water for 15-20 minutes. Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye.
-Call a poison control center or doctor for treatment advice.

IF ON SKIN, immediately wash with cool/cold water. If irritation develops, immediately obtain medical attention.

IF SWALLOWED,
-Call a poison control center or doctor immediately for treatment advice.
-Have person sip a glass of water if able to swallow.
-Do not induce vomiting unless told to do so by a poison control center or doctor.
-Do not give anything by mouth to an unconscious person.

IF INHALED,
-Move person to fresh air.
-If person is not breathing, call 911 or an ambulance, then give artificial respiration, preferably mouth-to-mouth if possible.
-Call a poison control center or doctor for further treatment advice.

NOTE TO PHYSICIANS, Measures against circulatory shock, respiratory depression, and convulsion may be needed.

5 FIRE FIGHTING MEASURES

Fire and Explosive Properties

Auto-Ignition Temperature	N/A	
Flash Point	N/A	Flash Point Method
Flammable Limits- Upper	N/A	
Lower	N/A	

Extinguishing Media

Use water spray, carbon dioxide, foam or dry chemical.

Fire Fighting Instructions

Fire fighters and others who may be exposed to products of combustion should wear full fire fighting turn out gear (full Bunker Gear) and self-contained breathing apparatus (pressure demand NIOSH approved or equivalent). Fire fighting equipment should be thoroughly decontaminated after use.

Fire and Explosion Hazards

None known.

6 ACCIDENTAL RELEASE MEASURES

In Case of Spill or Leak

Stop the leak, if possible. Shut off or remove all ignition sources.
Ventilate the space involved. Avoid generation of vapors.
Prevent waterway contamination. Construct a dike to prevent spreading.
Use non-sparking equipment to clean up spill.
Absorb, sweep up, place in appropriate containers for recovery or disposal.
Collect run-off water and transfer to drums or tanks for later disposal.
After removal, clean area with soap and water, collect rinsate. Remove from spill location.
Consult a regulatory specialist to determine appropriate state or local reporting requirements, for assistance in waste characterization and/or hazardous waste disposal and other requirements listed in pertinent environmental permits.

7 HANDLING AND STORAGE

Handling

Do not breathe vapor. Do not breathe mist.
Wash thoroughly after handling. Keep container closed.

Empty container may contain hazardous residues.
KEEP OUT OF REACH OF CHILDREN.

Use only with adequate ventilation.

Storage

Do not store in a manner where cross-contamination with pesticides, fertilizers, food or feed could occur.

8 EXPOSURE CONTROLS / PERSONAL PROTECTION

Engineering Controls

Investigate engineering techniques to reduce exposures. Provide ventilation if necessary to minimize exposure. Dilution ventilation is acceptable, but local mechanical exhaust ventilation preferred, if practical, at sources of air contamination such as open process equipment. Consult ACGIH ventilation manual or NFPA Standard 91 for design of exhaust systems.

Eye / Face Protection

Where there is potential for eye contact, wear chemical goggles and have eye flushing equipment immediately available.

Skin Protection

Minimize skin contamination by following good industrial hygiene practice. Wearing rubber gloves is recommended. Wash hands and contaminated skin thoroughly after handling.

Respiratory Protection

Where airborne exposure is likely, use NIOSH approved respiratory protection equipment appropriate to the material and/or its components. If exposures cannot be kept at a minimum with engineering controls, consult respirator manufacturer to determine appropriate type equipment for a given application. Observe respirator use limitations specified by NIOSH or the manufacturer. For emergency and other conditions where there may be a potential for significant exposure, use an approved full face positive-pressure, self-contained breathing apparatus or positive-pressure airline with auxiliary self-contained air supply. Respiratory protection programs must comply with 29 CFR § 1910.134.

Airborne Exposure Guidelines for Ingredients

The components of this product have no established Airborne Exposure Guidelines

-Only those components with exposure limits are printed in this section.
-Skin contact limits designated with a "Y" above have skin contact effect. Air sampling alone is insufficient to accurately quantitate exposure. Measures to prevent significant cutaneous absorption may be required.
-ACGIH Sensitizer designator with a value of "Y" above means that exposure to this material may cause allergic reactions.
-WEEL-AIHA Sensitizer designator with a value of "Y" above means that exposure to this material may cause allergic skin reactions.

9 PHYSICAL AND CHEMICAL PROPERTIES

Appearance/Odor	Yellow brown liquid, very faint chlorine odor.
pH	7.4 (nominal)
Specific Gravity	1.285 (H2O=1)
Vapor Pressure	negligible
Vapor Density	NE
Melting Point	NA
Freezing Point	NA
Boiling Point	>100 deg C
Solubility In Water	Miscible
Percent Volatile	59.7

10 STABILITY AND REACTIVITY

Stability

This material is chemically stable under normal and anticipated storage and handling conditions.

Hazardous Polymerization

Does not occur.

Incompatibility

Materials that react with water.

Hazardous Decomposition Products

Elevated temperatures may convert endothall to anhydride, a strong vesicant, causing blistering of eyes, mucous membranes, and skin.(*See section 16)

11 TOXICOLOGICAL INFORMATION

Toxicological Information

Data on this material and/or its components are summarized below.

Endothal-potassium

Although no allergic skin reactions were observed in guinea pigs following exposure to this material in water, allergic skin reactions were observed following exposure to this material in ethanol. Repeated application to the skin of rats produced severe skin irritation, liver and kidney effects considered to be secondary to irritation, and increased mortality. Long-term dietary administration produced no adverse effects in rats.

11 TOXICOLOGICAL INFORMATION

Single exposure (acute) studies indicate:
Oral - Moderately Toxic to Rats [LD50 99.5 mg/kg (Category II)]
Dermal - Slightly Toxic to Rabbits [LD50 2,000 mg/kg (Category III)]
Inhalation - Slightly Toxic to Rats [4-hr LC50 0.83 mg/l; aerosol (Category II)]
Eye Irritation - Causes irreversible eye damage in rabbits (Category I)
Skin Irritation - Non-irritating to Rabbits (Category IV)

7-Oxabicyclo[2.2.1]heptane-2,3-dicarboxylic acid
Intentional swallowing of 40 ml of endothall led to death within 12-hours. Skin allergy was observed in guinea pigs following repeated exposure. Repeated dietary administration (via gelatin capsules) produced vomiting, diarrhea, sluggish movements, and liver, kidney and blood effects in dogs. Long-term dietary administration to rats and mice produced effects in the glandular stomach. High mortality rates and intestinal tumors considered to be secondary to the effects in the stomach were observed in mice. Long-term application to the skin of mice produced no tumors. No birth defects were observed in the offspring of rats given endothall orally during pregnancy, even at dosages which produced adverse effects on the mothers. Skeletal anomalies were observed in the offspring of rabbits and mice given endothall orally during pregnancy, but only a dosages which produced adverse effects in the mothers. Endothall produced no genetic changes in standard tests using bacterial and animal cells or animals.

12 ECOLOGICAL INFORMATION

Ecotoxicological Information

Data on this material and/or its components are summarized below.
Endothal-potassium
This material is practically non-toxic to bluegill sunfish (LC50 316-501.2 mg/l), rainbow trout (LC50 107-528.7 mg/l), eastern oysters (LC50 117 mg/l), largemouth bass (LC50 130 mg/l), fiddler crab (LC50 752.4 mg/l) and sheepshead minnow (LC50 340 mg/l), and slightly toxic to mysid shrimp (LC50 79 mg/l) and smallmouth bass (LC50 47 mg/l). It is practically non-toxic to slightly toxic to Daphnia magna (EC50 72-319.5 mg/l) and no more than moderately toxic to freshwater blue-green algae (LC50 >4.8 mg/l), freshwater diatoms (LC50 >3.6 mg/l), freshwater green algae (LC50 >4.8 mg/l) and marine diatoms (LC50 >9.0 mg/l).

The 8-day LC50 for bobwhite quail and mallard ducklings is >5,000 ppm, the 21-day LD50 for mallard ducks is 344 mg/kg, the 14-day EC50 for duckweed is 0.84 mg/l and the 14-day LC50 for juvenile chinook salmon is 62.5 ppm.

Chemical Fate Information

Data on this material and/or its components are summarized below.

Endothal-potassium
This material is rapidly degraded in aqeuous systems by the indigenous microbial population to CO_2 and other non-toxic natural products.

13 DISPOSAL CONSIDERATIONS

Waste Disposal

Pesticide wastes are acutely hazardous. Improper disposal of excess pesticide or rinsate is a violation of Federal law. If these wastes cannot be disposed of by use according to label instructions, contact your State Pesticide or Environmental Control Agency, or the Hazardous Waste representative at the nearest EPA Regional Office for guidance.

14 TRANSPORT INFORMATION

DOT Name	Pesticides, liquid, toxic, n.o.s.
DOT Technical Name	Endothall
DOT Hazard Class	6.1
UN Number	2902
DOT Packing Group	PG III
RQ	1000 lbs.
DOT Special Information	DOT HM215C= The Keep Away From Foodstuffs (KAFF) label is authorized until October 2003. During the transition period the KAFF or the Toxic label may be used. After October 2003 only the Toxic label is authorized.

15 REGULATORY INFORMATION

Hazard Categories Under Criteria of SARA Title III Rules (40 CFR Part 370)

Immediate (Acute) Health	Y	Fire	N
Delayed (Chronic) Health	N	Reactive	N
		Sudden Release of Pressure	N

Ingredient Related Regulatory Information:

SARA Reportable Quantities	CERCLA RQ	SARA TPQ
Endothal-potassium	NE	

SARA Title III, Section 313

This product does contain chemical(s) which are defined as toxic chemicals under and subject to the reporting requirements of, Section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 and 40 CFR Part 372. See Section 2

Endothal-potassium

16 OTHER INFORMATION

Revision Information

Revision Date	28 JUL 2003	Revision Number 7
Supercedes Revision Dated	08-JUL-2002	

Revision Summary

Update section 4 add skin statement

Key

NE= Not Established NA= Not Applicable (R) = Registered Trademark

Miscellaneous
Proper PPE and vetnilation should be used when using high heat, such as welding or oxy-acetylene torch cutting, on machinery that may have endothal residue.

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Cerexagri, Inc. is a wholly owned subsidiary of ATOFINA Chemicals, Inc.

1 PRODUCT AND COMPANY IDENTIFICATION

Pre-Harvest Division
Cerexagri-Nisso LLC
630 Freedom Business Center, Suite 402
King of Prussia, PA 19406

EMERGENCY PHONE NUMBERS:
Chemtrec: (800) 424-9300 (24hrs) or (703) 527-3887
Medical: Rocky Mountain Poison Control Center
(866) 767-5089 (24Hrs)

Information Telephone Numbers	Phone Number	Available Hrs
R&D Technical Service	610-878-6100	8:00am to 5:00pm EST
Customer Service	1-800-438-6071	8:00am - 5:00 pm EST

Product Name	AQUATHOL (R) SUPER K
Product Synonym(s)	

Chemical Family	Dicarboxylic acid
Chemical Formula	C8H8O5K2
Chemical Name	Dipotassium endothall
EPA Reg Num	4581-388-82695
Product Use	Aquatic herbicide

2 COMPOSITION / INFORMATION ON INGREDIENTS

Ingredient Name	CAS RegistryNumber	Typical Wt. %	OSHA
Endothal-potassium	2164-07-0	63.0 %	Y
2-Propenamide, polymer with potassium	31212-13-2	27.5%	Y

The substance(s) marked with a "Y" in the OSHA column, are identified as hazardous chemicals according to the criteria of the OSHA Hazard Communication Standard (29 CFR 1910.1200)

3 HAZARDS IDENTIFICATION

Emergency Overview
Beige granular material, odorless.
KEEP OUT OF REACH OF CHILDREN.
DANGER!
Causes irreversible eye damage
MAY BE FATAL IF SWALLOWED.
HARMFUL IF ABSORBED THROUGH SKIN.

Do not get in eyes, on skin or on clothing.
Avoid breathing dust.

Potential Health Effects

Inhalation and skin contact are expected to be the primary routes of occupational exposure to this material. Based on single exposure animal tests, it is considered to be moderately toxic if swallowed, no more than slightly toxic if absorbed through skin, severely irritating to eyes and slightly irritating to skin.

4 FIRST AID MEASURES

IF IN EYES,
-Hold eye open and rinse slowly and gently with water for 15-20 minutes. Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye.
-Call a poison control center or doctor for treatment advice.

IF ON SKIN, immediately wash with cool/cold water. If irritation develops, immediately obtain medical attention.

IF SWALLOWED,
-Call a poison control center or doctor immediately for treatment advice.
-Have person sip a glass of water if able to swallow.
-Do not induce vomiting unless told to do so by a poison control center or doctor.
-Do not give anything by mouth to an unconscious person.

IF INHALED,
-Move person to fresh air.
-If person is not breathing, call 911 or an ambulance, then give artificial respiration, preferably mouth-to-mouth if possible.
-Call a poison control center or doctor for further treatment advice.

5 FIRE FIGHTING MEASURES

Fire and Explosive Properties

Auto-Ignition Temperature	NE	
Flash Point	NE	Flash Point Method
Flammable Limits- Upper	NE	
Lower	NE	

Extinguishing Media

Use water spray, carbon dioxide, foam or dry chemical.

Fire Fighting Instructions

Fire fighters and others who may be exposed to products of combustion should wear full fire fighting turn out gear (full Bunker Gear) and self-contained breathing apparatus (pressure demand NIOSH approved or equivalent). Fire fighting equipment should be thoroughly decontaminated after use.

Fire and Explosion Hazards

None known.

6 ACCIDENTAL RELEASE MEASURES

In Case of Spill or Leak

Contain spill. Sweep or scoop up and remove to suitable container. Flush with water. Prevent spilled product from entering sewers or natural water. Consult a regulatory specialist to determine appropriate state or local reporting requirements, for assistance in waste characterization and/or hazardous waste disposal and other requirements listed in pertinent environmental permits.

7 HANDLING AND STORAGE

7 HANDLING AND STORAGE

Handling

Do not breathe dust. Avoid contact with eyes, skin and clothing.
Wash thoroughly after handling. Keep container closed.
Empty container may contain hazardous residues.
KEEP OUT OF REACH OF CHILDREN.

Storage

Do not store in a manner where cross-contamination with pesticides, fertilizers, food or feed could occur.

8 EXPOSURE CONTROLS / PERSONAL PROTECTION

Engineering Controls

Investigate engineering techniques to reduce exposures. Provide ventilation if necessary to minimize exposure. Dilution ventilation is acceptable, but local mechanical exhaust ventilation preferred, if practical, at sources of air contamination such as open process equipment. Consult ACGIH ventilation manual or NFPA Standard 91 for design of exhaust systems.

Eye / Face Protection

Where there is potential for eye contact, wear chemical goggles and have eye flushing equipment immediately available.

Skin Protection

Minimize skin contamination by following good industrial hygiene practice. Wearing rubber gloves is recommended. Wash hands and contaminated skin thoroughly after handling.

Respiratory Protection

Where airborne exposure is likely, use NIOSH approved respiratory protection equipment appropriate to the material and/or its components. If exposures cannot be kept at a minimum with engineering controls, consult respirator manufacturer to determine appropriate type equipment for a given application. Observe respirator use limitations specified by NIOSH or the manufacturer. For emergency and other conditions where there may be a potential for significant exposure, use an approved full face positive-pressure, self-contained breathing apparatus or positive-pressure airline with auxiliary self-contained air supply. Respiratory protection programs must comply with 29 CFR § 1910.134.

Airborne Exposure Guidelines for Ingredients

The components of this product have no established Airborne Exposure Guidelines

-Only those components with exposure limits are printed in this section.
-Skin contact limits designated with a "Y" above have skin contact effect. Air sampling alone is insufficient to accurately quantitate exposure. Measures to prevent significant cutaneous absorption may be required.
-ACGIH Sensitizer designator with a value of "Y" above means that exposure to this material may cause allergic reactions.
-WEEL-AIHA Sensitizer designator with a value of "Y" above means that exposure to this material may cause allergic skin reactions.

9 PHYSICAL AND CHEMICAL PROPERTIES

Appearance/Odor	Beige granular material, odorless.
pH	6.9 (1% aqueous soln)
Specific Gravity	0.607 g/cm3
Vapor Pressure	Negligible
Vapor Density	N/A
Melting Point	N/A
Freezing Point	N/A
Boiling Point	N/A
Solubility In Water	>65 g/100ml
Evaporation Rate	N/A
Percent Volatile	N/A

10 STABILITY AND REACTIVITY

Stability

This material is chemically stable under normal and anticipated storage and handling conditions.

Hazardous Polymerization

Does not occur.

Incompatibility

None known.

Hazardous Decomposition Products

Elevated temperatures convert endothall to anhydride, a strong vessicant, causing blisters of eyes, mucous membranes, and skin.

11 TOXICOLOGICAL INFORMATION

Toxicological Information

Data on this material and/or its components are summarized below.
Single exposure (acute) studies indicate:
Oral - Moderately Toxic to Rats (LD50 98 mg/kg)
Dermal - No More than Slightly Toxic to Rabbits (LD50 >2,000 mg/kg)
Eye Irritation - Severely Irritating to Rabbits
Skin Irritation - Slightly Irritating to Rabbits
No skin allergy was observed in guinea pigs following repeated exposure.

Endothal-potassium (technical active ingredient)
Although no allergic skin reactions were observed in guinea pigs following exposure to this material in water, allergic skin reactions were observed following exposure to this material in ethanol. Repeated application to the skin of rats produced severe skin irritation, liver and kidney effects considered to be secondary to irritation, and increased mortality. Long-term dietary administration produced no adverse effects in rats.

12 ECOLOGICAL INFORMATION

12 ECOLOGICAL INFORMATION

Ecotoxicological Information

Data on this material and/or its components are summarized below.
Endothal-potassium (technical active ingredient)
This material is practically non-toxic to bluegill sunfish (LC50 316-501.2 mg/l), rainbow trout (LC50 107-528.7 mg/l), eastern oysters (LC50 117 mg/l), largemouth bass (LC50 130 mg/l), fiddler crab (LC50 752.4 mg/l) and sheepshead minnow (LC50 340 mg/l), and slightly toxic to mysid shrimp (LC50 79 mg/l) and smallmouth bass (LC50 47 mg/l). It is practically non-toxic to slightly toxic to Daphnia magna (EC50 72-319.5 mg/l) and no more than moderately toxic to freshwater blue-green algae (LC50 >4.8 mg/l), freshwater diatoms (LC50 >3.6 mg/l), freshwater green algae (LC50 >4.8 mg/l) and marine diatoms (LC50 >9.0 mg/l).

The 8-day LC50 for bobwhite quail and mallard ducklings is >5,000 ppm, the 21-day LD50 for mallard ducks is 344 mg/kg, the 14-day EC50 for duckweed is 0.84 mg/l and the 14-day LC50 for juvenile chinook salmon is 62.5 ppm.

Endothall
This material is slightly toxic to bluegill sunfish (96-hr LC50 77 mg/l), rainbow trout (96-hr LC50 49 mg/l), Daphnia magna (48-hr LC50 92 mg/l), eastern oysters (96-hr LC50 54 mg/l), mysid shrimp (96-hr LC50 39 mg/l) and fiddler crab (96-hr LC50 85.1 mg/l). It is practically non-toxic to sheepshead minnow (96-hr LC50 110 mg/l) and common mummichog (96-hr LC50 213.9 mg/l).

This material has an 8-day LC50 of >5,000 ppm (bobwhite quail and mallard ducklings), a 21-day LD50 of 111 mg/kg (mallard ducks), a 30-day MATC of 19 mg/l (fathead minnows) and a 21-day MATC of 6.7 mg/l (Daphnia magna). No adverse effects were observed in mallard ducks and bobwhite quail following repeated (20-weeks) administration in the diet.

Chemical Fate Information

Data on this material and/or its components are summarized below.
Endothal-potassium (technical active ingredient)
This material is rapidly degraded in aqeuous systems by the indigenous microbial population to CO2 and other non-toxic natural products.

13 DISPOSAL CONSIDERATIONS

Waste Disposal

Pesticide wastes are acutely hazardous. Improper disposal of excess pesticide or rinsate is a violation of Federal law. If these wastes cannot be disposed of by use according to label instructions, contact your State Pesticide or Environmental Control Agency, or the Hazardous Waste representative at the nearest EPA Regional Office for guidance.

14 TRANSPORT INFORMATION

DOT Name	Pesticides, solid, toxic, n.o.s.
DOT Technical Name	Endothall
DOT Hazard Class	6.1
UN Number	2588
DOT Packing Group	PG III
RQ	1,000 POUNDS

15 REGULATORY INFORMATION

Hazard Categories Under Criteria of SARA Title III Rules (40 CFR Part 370)

Immediate (Acute) Health	Y	Fire	N
Delayed (Chronic) Health	N	Reactive	N
		Sudden Release of Pressure	N

Ingredient Related Regulatory Information:

SARA Reportable Quantities	CERCLA RQ	SARA TPQ
Endothal-potassium	NE	
2-Propenamide, polymer with potassium	NE	

SARA Title III, Section 313

This product does contain chemical(s) which are defined as toxic chemicals under and subject to the reporting requirements of, Section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 and 40 CFR Part 372. See Section 2

Endothal-potassium

16 OTHER INFORMATION

Revision Information

Revision Date	05 JAN 2006	Revision Number 11
Supercedes Revision Dated	03-JAN-2006	

Revision Summary

Update section 1

Key

NE= Not Established NA= Not Applicable (R) = Registered Trademark

Miscellaneous

Aquathol (R) is a registered trademark of Cerexagri, Inc.

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MATERIAL SAFETY DATA SHEET

AB Cutrine Plus Granular

1. Product And Company Identification

Supplier
Applied Biochemists (WI)
A division of Advantis Technologies, Inc.
W175 N11163 Stonewood Drive, Suite 234
Germantown, WI 53022

Telephone Number: (262) 255-4449
FAX Number: (262) 255-4268
Web Site: www.appliedbiochemists.com

Manufacturer
Advantis Technologies, Inc.
1400 Bluegrass Lakes Parkway
Alpharetta, GA 30004 United States

Telephone Number: (770) 521-5999
FAX Number: (770) 521-5959
Web Site: www.poolspacare.com

Supplier Emergency Contacts & Phone Number
CHEMTREC - DAY OR NIGHT: (800) 424-9300

Manufacturer Emergency Contacts & Phone Number
CHEMTREC - DAY OR NIGHT: (800) 424-9300

Issue Date: 02/15/2007

Product Name: AB Cutrine Plus Granular
Chemical Name: Chelated Elemental Copper
CAS Number: Not Established
Chemical Family: Granular Copper Algaecide
Chemical Formula: Proprietary Mixture
MSDS Number: 377

2. Composition/Information On Ingredients

Ingredient Name	CAS Number		Percent Of Total Weight
COPPERCARBONATE	12069-69-1		
CRYSTALLINE SILICA	14808-60-7		
MONOETHANOLAMINE	141-43-5		

Ingredients listed in this section have been determined to be hazardous as defined in 29CFR 1910.1200. Materials determined to be health hazards are listed if they comprise 1% or more of the composition. Materials identified as carcinogens are listed if they comprise 0.1% or more of the composition. Information on proprietary materials is available in 29CFR 1910.1200(i)(1).

3. Hazards Identification

Primary Routes(s) Of Entry
Eye Contact, Skin Contact

Eye Hazards
Can cause eye irritation.

Skin Hazards
May be irritating to skin.

Ingestion Hazards
May be harmful if swallowed.

Inhalation Hazards
Inhaled dust may be irritating to mucous membranes.

Chronic/Carcinogenicity Effects
This product contains clay. IARC has classified crystalline silica (a component of clay) as a probable human carcinogen. Prolonged contact may cause liver damage, kidney damage, and/or chronic muscle damage.

3. Hazards Identification - Continued

Signs And Symptoms

Contact with skin and eyes may be irritating.

Conditions Aggravated By Exposure

May cause skin sensitization.

First Aid (Pictograms)

4. First Aid Measures

Eye

Call a physician or a poison control center immediately. In case of contact, hold eyelids apart and immediately flush eyes with plenty of water for at least 15 minutes. DO NOT let the victim rub his eye(s).

Skin

In case of contact, immediately flush skin with plenty of water for at least 15 minutes. Remove contaminated clothing and shoes. Thoroughly clean shoes before reuse. Wash clothing before reuse.

Ingestion

Get medical attention immediately.

Inhalation

Get medical attention immediately. If breathing is difficult, give oxygen. If inhaled, remove to fresh air.

5. Fire Fighting Measures

Flammability Class: Not flammable

Fire And Explosion Hazards

Decomposition of wet chemical may cause auto-ignition above 150F.

Extinguishing Media

Use CO2 (Carbon Dioxide), dry chemical, water fog, or foam.

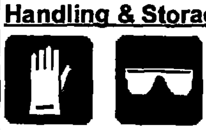
Fire Fighting Instructions

Avoid breathing vapors, gases and fumes. Firefighters should wear self-contained breathing apparatus and full protective gear. Water can be used to cool and protect exposed material.

6. Accidental Release Measures

Clean up spill immediately. Sweep up and remove immediately. Avoid rinsing into sewer. Use appropriate containers to avoid environmental contamination.

Handling & Storage (Pictograms)



7. Handling And Storage

Handling And Storage Precautions

Keep out of reach of children. Use only with adequate ventilation. Wash thoroughly after handling.

Handling Precautions

Avoid contact with eyes. Avoid contact with skin and clothing. Avoid contact with strong acids and nitrates

7. Handling And Storage - Continued

Storage Precautions
Keep out of reach of children. Store in a cool, dry place. Do not stack wet material.

Work/Hygienic Practices
Wash thoroughly with soap and water after handling. Use safe chemical handling procedures suitable for the hazards presented by this material.

8. Exposure Controls/Personal Protection

Engineering Controls
Local exhaust recommended.

Eye/Face Protection
Safety glasses with side shields or goggles.

Skin Protection
Chemical-resistant gloves (rubber or plastic).

Respiratory Protection
None normally required. If needed, use NIOSH approved respirator for dusts.

Ingredient(s) - Exposure Limits
COPPER CARBONATE
PEL = 1 mg/m3 (as copper dusts and mists - CAS# 7440-50-8)
TLV = 1 mg/m3 (as copper dusts and mists - CAS# 7440-50-8)
CRYSTALLINE SILICA
PEL = 0.1 mg/m3
TLV = 0.05 mg/m3
MONOETHANOLAMINE
PEL = 3ppm
TLV = 3 ppm

9. Physical And Chemical Properties

Appearance
Blue/Green granules

Odor
Amine, slight

Chemical Type: Mixture
Physical State: Solid
Melting Point: N/A °F
Boiling Point: Not Determined °F
Percent Volitales: Not Determined
Packing Density: 1.2-1.3
Vapor Pressure: Not Determined
Solubility: Granules are insoluble; Chemical soluble
Evaporation Rate: Not Determined

10. Stability And Reactivity

Stability: Stable
Hazardous Polymerization: Will not occur

Conditions To Avoid (Stability)
Temperatures above 150F, especially if the material is damp.

MATERIAL SAFETY DATA SHEET

AB Cutrine Plus Granular

10. Stability And Reactivity - Continued

Incompatible Materials

Strong acids and nitrates.

Hazardous Decomposition Products

Oxides of Nitrogen and Carbon.

11. Toxicological Information

Acute Inhalation Effects

Acute Inhalation LC50 > 2.59 mg/L (Male and female rats)

12. Ecological Information

Ecotoxicological Information

13. Disposal Considerations

Dispose in accordance with applicable federal, state and local government regulations.

14. Transport Information

Proper Shipping Name

Not regulated

Hazard Class

Not regulated

DOT Identification Number

NONE

15. Regulatory Information

No Data Available...

NFPA

HMIS

HEALTH	1
FLAMMABILITY	0
REACTIVITY	0
PERSONAL PROTECTION	B

16. Other Information

Revision/Preparer Information

MSDS Preparer: JHW

This MSDS Superceeds A Previous MSDS Dated: 11/15/2006

Disclaimer

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Applied Biochemists (WI)

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MATERIAL SAFETY DATA SHEET

AB Cutrine Plus

1. Product And Company Identification

Supplier	Manufacturer
Applied Biochemists (WI) A division of Advantis Technologies, Inc. W175 N11163 Stonewood Drive, Suite 234 Germantown, WI 53022 **Telephone Number:** (262) 255-4449 **FAX Number:** (262) 255-4268 **Web Site:** www.appliedbiochemists.com	Advantis Technologies 1400 Bluegrass Lakes Parkway Alpharetta, GA 30004 United States **Telephone Number:** (770) 521-5999 **FAX Number:** (770) 521-5959 **Web Site:** www.poolspacare.com
Supplier Emergency Contacts & Phone Number CHEMTREC - DAY OR NIGHT: (800) 424-9300 ACEAN - DAY OR NIGHT: (800) 654-6911	**Manufacturer Emergency Contacts & Phone Number** CHEMTREC - DAY OR NIGHT: (800) 424-9300 ACEAN - DAY OR NIGHT: (800) 654-6911

Issue Date: 02/19/2010

Product Name: AB Cutrine Plus
Chemical Name: Chelated Elemental Copper
Chemical Family: Copper Algaecide
Chemical Formula: Proprietary Mixture
MSDS Number: 366

2. Composition/Information On Ingredients

Ingredient Name	CAS Number		Percent Of Total Weight
COPPER CARBONATE	12069-69-1		
MONOETHANOLAMINE	141-43-5		
TRIETHANOLAMINE	102-71-6		

Ingredients listed in this section have been determined to be hazardous as defined in 29CFR 1910.1200. Materials determined to be health hazards are listed if they comprise 1% or more of the composition. Materials identified as carcinogens are listed if they comprise 0.1% or more of the composition. Information on proprietary materials is available in 29CFR 1910.1200(i)(1).

3. Hazards Identification

Primary Routes(s) Of Entry
Eye Contact, Skin Contact

Eye Hazards
Corrosive to eyes.

Skin Hazards
May be corrosive to skin.

Ingestion Hazards
Harmful if swallowed. May cause burning of the mouth, throat and stomach.

Inhalation Hazards
Inhalation may cause dizziness, drowsiness, euphoria, loss of coordination, headache and nausea.

Signs And Symptoms
Contact with skin and eyes may be irritating.

Conditions Aggravated By Exposure
May cause skin sensitization.

First Aid (Pictograms)

4. First Aid Measures

Eye

Call a physician or a poison control center immediately.In case of contact, hold eyelids apart and immediately flush eyes with plenty of water for at least 15 minutes.DO NOT let the victim rub his eye(s).

Skin

In case of contact, immediately flush skin with plenty of water for at least 15 minutes. Remove contaminated clothing and shoes. Thoroughly clean shoes before reuse. Wash clothing before reuse.

Ingestion

Give two glasses of water. Never give anything by mouth to an unconscious victim. DO NOT INDUCE VOMITING, unless directed to do so by medical personnel. Get medical attention immediately.

Inhalation

Get medical attention immediately. If breathing is difficult, give oxygen. If inhaled, remove to fresh air.

5. Fire Fighting Measures

Flash Point: ND °F

Extinguishing Media

Use CO2 (Carbon Dioxide), dry chemical, or foam.

Fire Fighting Instructions

Avoid breathing vapors, gases and fumes. Firefighters should wear self-contained breathing apparatus and full protective gear. Water can be used to cool and protect exposed material.

6. Accidental Release Measures

Clean up spill immediately. Contain and/or absorb spill with ground corn cob. Avoid rinsing into sewer. Use appropriate containers to avoid environmental contamination.

Handling & Storage (Pictograms)

7. Handling And Storage

Handling And Storage Precautions

Keep out of reach of children. Use only with adequate ventilation. Wash thoroughly after handling.

Handling Precautions

Avoid contact with eyes. Avoid contact with skin and clothing. Avoid contact with strong acids and nitrates

Storage Precautions

Keep out of reach of children.

Work/Hygienic Practices

Wash thoroughly with soap and water after handling. Use safe chemical handling procedures suitable for the hazards presented by this material.

8. Exposure Controls/Personal Protection

No Data Available...

8. Exposure Controls/Personal Protection - Continued

Engineering Controls
Local exhaust recommended.

Eye/Face Protection
Safety glasses with side shields or goggles.

Skin Protection
Chemical-resistant gloves.

Respiratory Protection
None normally required. If needed, use NIOSH approved respirator for organic vapors and mists.

9. Physical And Chemical Properties

Appearance
Blue viscous liquid

Odor
Slight

Chemical Type: Mixture
Physical State: Liquid
Melting Point: N/A °F
Boiling Point: Not Determined °F
Specific Gravity: 1.220-1.230 @ 24 deg C
Percent Volitales: Not Determined
Vapor Pressure: Not Determined
Vapor Density: >1 (air = 1)
pH Factor: 10.3-10.5
Solubility: Miscible in water
Evaporation Rate: Not Determined

10. Stability And Reactivity

Stability: Stable
Hazardous Polymerization: Will not occur

Conditions To Avoid (Stability)
Excessive heat. Thermal decomposition may cause oxides of carbon/nitrogen.

Incompatible Materials
Strong acids and nitrates.

Hazardous Decomposition Products
Oxides of Nitrogen and Carbon.

11. Toxicological Information

Acute Studies
Oral LD50 = 650-2420 mg/kg Rat*

Subacute Dietary LC50 = >2,500 ppm Leghorn Chicken*
Subacute Dietary LC50 = >1,000 ppm Ring-necked Pheasant**
Subacute Dietary LC50 = >1,000 ppm Mallard Duck**
*Data from 9% copper mixed ethanolamine complexes (Cutrine Plus).
**Data from 7.1% copper triethanolamine complexes (Cutrine).

12. Ecological Information

No Data Available...

AB Cutrine Plus

12. Ecological Information - Continued

Ecotoxicological Information

96 Hour LC50 = <3.0 mg/ Rainbow Trout (44ppm Total Hardness)**
96 Hour LC50 = 56 mg/l Rainbow Trout (290 ppm Total Hardness)**
96 Hour LC50 = 13.3 mg/l Bluegill (48 ppm Total Hardness)*
96 Hour LC50 = 83 mg/l Bluegill (200 ppm Total Hardness)*
96 Hour LC50 = 67 mg/l Channel Catfish**
96 Hour LC50 = 211 mg/l Blue Shrimp (Juvenile)*
96 Hour LC50 = 68 mg/l Grass Shrimp**
96 Hour LC50 = 2,200 mg/l Fiddler Crab**

*Data from 9% copper mixed ethanolamine complexes (Cutrine Plus).
**Data from 7.1% copper triethanolamine complexes (Cutrine).

13. Disposal Considerations

Dispose in accordance with applicable federal, state and local government regulations.

14. Transport Information

Proper Shipping Name
CORROSIVE LIQUID, NOS (Copper Triethanolamine Complexes)

Hazard Class
8,PG III (<4L Consumer Commodity ORM-D)

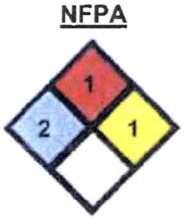
DOT Identification Number
UN1760

DOT (Pictograms)

15. Regulatory Information

No Data Available...

NFPA



HMIS

HEALTH	2
FLAMMABILITY	1
REACTIVITY	1
PERSONAL PROTECTION	D

16. Other Information

Revision/Preparer Information
MSDS Preparer: JHW3
MSDS Preparer Phone Number: 770-521-5999
This MSDS Superceeds A Previous MSDS Dated: 10/21/2004

Disclaimer

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Disclaimer - Continued

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Applied Biochemists (WI)

GreenClean® PRO
Granular Algaecide

Specimen Label and MSDS

• Algaecide

ACTIVE INGREDIENT:
Sodium Carbonate Peroxyhydrate* ... 85%
OTHER INGREDIENTS 15%
TOTAL 100%
* Contains 27.6% Hydrogen Dioxide by weight.

KEEP OUT OF REACH OF CHILDREN
DANGER – PELIGRO
Si usted no entiende la etiqueta, busque a alguien para que se la explique a usted en detalle.

(If you do not understand this label, find someone to explain it to you in detail.)

EPA Registration No.: 70299-6
EPA Establishment No.: 68660-TX-001

FIRST AID

If in eyes
- Hold eye open and rinse slowly and gently with water for 15 – 20 minutes.
- Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye.
- Call a poison control center or doctor for treatment advice.

If on skin or clothing
- Take off contaminated clothing.
- Rinse skin immediately with plenty of water for 15 – 20 minutes.
- Call a poison control center or doctor for treatment advice.

If swallowed
- Call poison control center or doctor immediately for treatment advice.
- Have person sip a glass of water if able to swallow.
- Do not induce vomiting unless told to do so by the poison control center or doctor.
- Do not give anything by mouth to an unconscious person.

If inhaled
- Move person to fresh air.
- If person is not breathing, call 911 or an ambulance, then give artificial respiration, preferably by mouth-to-mouth, if possible.
- Call a poison control center or doctor for treatment advice.

Have the product container or label with you when calling a poison control center or doctor, or going for treatment. You may also contact 1-800-858-7378 for emergency medical treatment information.

NOTE TO PHYSICIAN
Probable mucosal damage may contraindicate the use of gastric lavage.

PRECAUTIONARY STATEMENTS:
HAZARDS TO HUMAN AND DOMESTIC ANIMALS – DANGER: Corrosive. Causes irreversible eye damage. Harmful if swallowed, inhaled or absorbed through skin. Do not get in eyes, on skin or on clothing. Wash thoroughly with soap and water after handling.

PERSONAL PROTECTIVE EQUIPMENT (PPE):
When handling wear protective eyewear (goggles or face shield) and chemical resistant gloves. Applicators and handlers must wear coveralls over longsleeved shirt, long pants, and chemical resistant footwear plus socks. Follow manufacturer's instructions for cleaning/maintaining PPE. If no such instructions exist for washables, use detergent and hot water. Keep and wash PPE separately from other laundry.

USER SAFETY RECOMMENDATIONS:
Users should wash hands thoroughly with soap and water before eating, drinking, chewing gum, using tobacco or using the toilet. Users should remove clothing immediately if pesticide gets inside. Then wash thoroughly and put on clean clothing. Remove PPE immediately after handling this product. Wash the outside of gloves before removing. As soon as possible, wash thoroughly and change into clean clothing.

ENVIRONMENTAL HAZARDS:
This pesticide is toxic to birds. Do not contaminate water when cleaning equipment or disposing of equipment washwaters. Do not apply to treated, finished drinking water reservoirs or drinking water receptacles. This product is highly toxic to bees and other beneficial insects exposed to direct contact on blooming crops or weeds. Do not apply this product or allow it to drift to blooming crops or weeds while bees are actively visiting the treatment area. Do not apply this product or allow it to drift to crops where beneficials are part of an integrated pest management strategy.

PHYSICAL AND CHEMICAL HAZARDS:
Strong oxidizing agent. **Corrosive.** Do not bring in contact with other pesticides, cleaners or oxidative agents.

DIRECTIONS FOR USE:
It is a violation of Federal law to use this product in a manner inconsistent with its labeling. For any requirements specific to your State or Tribe, consult the agency responsible for pesticide regulation. Do not apply this product in a way that will contact workers or other persons, either directly or through drift. Only protected handlers may be in the area during application.

Agricultural Use Requirements
Use this product only in accordance with its labeling and with the Worker Protection Standard, 40 CFR Part 170. This standard contains requirements for the protection of agricultural workers on farms, forests, nurseries and greenhouses, and handlers of agricultural pesticides. It contains requirements for training, decontamination, notification, and emergency assistance. It also contains specific instructions and exceptions pertaining to the statements on this label about personal protective equipment (PPE), notification to workers, and restricted entry intervals (REI). The requirements in this box apply to uses of this product that are covered by the Worker Protection Standard.

For enclosed environments:
There is a restricted entry of one (1) hour for this product when applied via spraying or foaming on hard surfaces in enclosed environments. PPE requirement for early entry to treated areas that is permitted under the Worker Protection Standard and that involves contact with anything that has been treated, such as plants, soil or water, is coveralls, waterproof gloves and shoes plus socks.

There is a restricted entry of zero (0) hours for spreading, broadcasting, spot treatment, injection or other non-spraying or non-foaming application methods when used in enclosed environments.

For water treatment and applications in non-enclosed environments:
Keep unprotected persons out of treated areas until sprays have dried or dusts have settled.

Non-Agricultural Use Requirements
The requirements in this box apply to uses of this product that are **not** within the scope of the Worker Protection Standard for agricultural pesticides (40 CFR Part 170). The WPS applies when this product is used to produce agricultural plants on farms, forests, nurseries or greenhouses.

Keep unprotected persons out of treated areas until sprays have dried or dusts have settled.

WATER APPLICATION RATES

1 lb = 2 Cups

Applications Rates	Heavy Algae Growth	Low Algae Growth / Maintenance
Granular: Large Volume For example: Lakes, Ponds, Lagoons.	**20-90 pounds** of GreenClean Pro Granular Algaecide per acre-foot of water -or- **50-250 pounds** of GreenClean Pro Granular Algaecide per million gallons of water.	**2-9 pounds** of GreenClean Pro Granular Algaecide per acre-foot of water -or- **5-25 pounds** of GreenClean Pro Granular Algaecide per million gallons of water.
Granular: Small Volume For example: water gardens, fountains, ornamental waterfalls.	**2-10 Tablespoons** of GreenClean Pro Granular Algaecide per 1000 gallons of water.	**1-3 teaspoons** of GreenClean Pro Granular Algaecide per 1000 gallons of water.
Granular: Ground/Surface: For use on non-painted surfaces to control algae, moss, slime molds and their spores.	**1-2 pounds** of GreenClean Pro Granular Algaecide per 1000 square feet of area. Make granular applications over a wet surface or activate with water immediately following application.	**0.5-1 pounds** of GreenClean Pro Granular Algaecide per 1000 square feet of area. Make granular applications over a wet surface or activate with water immediately following application.
Liquid Applications: For Ground/Surface or Water applications.	**Solution Preparation:** Due to solubility limitations, use at least 1 gallon of water to fully dissolve each 0.5 pounds of GreenClean Pro Granular Algaecide. Dissolution in cold water takes approximately 5 minutes. **Treatment Rates:** Use same rates at the granular application above.	
Foam Applications: For Ground/Surface applications.	**Solution Preparation:** Follow the liquid solution preparation instructions above. Add 2.0 - 5.0 fluid ounces of an alkaline-based foam, such as BioSafe Systems "BioFoaming Agent®", per gallon of finished solution.	

Apply GreenClean Pro Granular Algaecide to any listed non-food water or surface sites except treated, finished drinking water reservoirs or drinking water receptacles.

Application sites include:
Sod Farms, Greenhouses, Nurseries, Golf Courses, Amusement Parks, Water Parks, Aquariums, Zoos, Botanical Gardens, Parks, Recreational Areas, Non-Chlorinated Swimming Areas, Raceways, Sports Facilities, Business Parks, Residential Developments, Indoor/Interiors, Malls, Hotels, Kennels, Cemeteries, Carwashes, Marinas, Boats, Docks, Garden Centers, Power Washing, Water Gardens, Landscapes, Municipalities, Waterways, Storm Waters, Drainage Systems, Impounded Waters, and Wastewater.

Application surfaces include:
WATER SURFACES
Ponds, Lakes, Lagoons, Golf Course Ponds, Impounded Waters, Industrial/Commercial Ponds, Standing Water, Bilge Water, Non-Potable Water Reservoirs, Waterways, Canals, Laterals, Conveyance Ditches, Drainage Systems, Catch Basins, Flooded Areas, Sewage Systems, Drain Fields, Fire Ponds, Watering Tanks (Non-Potable Water), Storage Tanks, Water Collectors and Domestic/Commercial Non-Potable Waters.

NON-PAINTED SURFACES
Floors, Walkways, Storage Areas, Patios, Decks, Railings, Roofs, Asphalt Shingles, Siding, Fiberglass, Boats, Piers, Docks, Stairs, Ramps, Ground Cover Mats, Weed Control Mats, Concrete, Brick, Tile, Slate, Granite, Outdoor Furniture, Statues/Monuments, Tennis Courts (non-grass), Nursery Yards, Shorelines, Gravel, Dirt Floors, Under Benches, and Other Non-Painted Surfaces.

WATER TREATMENT
Use GreenClean Pro Granular Algaecide to treat, control, and prevent a broad spectrum of algae. Effects of treatment are immediately apparent (bubbling, bleaching/discoloration of algae). Waters treated with GreenClean Pro Granular Algaecide are permissible to be used without interruption.

SURFACE TREATMENT
Use GreenClean Pro Granular Algaecide on all listed non-painted surfaces, to prevent and control algae, moss, slime molds and their spores, and the odors and conditions that these organisms cause (such as the breeding grounds for pests such as shore flies and fungus gnats).

APPLICATION METHODS
- SPREADING / BROADCASTING: Broadcast GreenClean Pro Granular Algaecide with a mechanical spreader or by hand, directly on the surface. A lawn spreader or any othe applicator that will ensure uniform coverag is acceptable.
- SPOT TREATMENT: Apply GreenClean Granular Algaecide directly over the in

area. Re-treatment is required when heavy growth occurs.

- LIQUID: Make a solution with GreenClean Pro Granular Algaecide (refer to liquid application rates). Spray this solution on the desired treatment surface. If using a slurry, agitate constantly.
- FOAM: Make a solution with GreenClean Pro Granular Algaecide (refer to foam application rates). Spray this solution on the desired treatment surface. Use a foamer, such as the BioSafe BioFoamer™, to apply.
- INJECTION: Make a solution with GreenClean Pro Granular Algaecide (refer to liquid application rates). Inject this solution into the water via a piping system.
- SUBSURFACE: Place GreenClean Pro Granular Algaecide in burlap bags and drag through the water by means of a boat. Use granular application rates. Begin treatment along the shoreline, and proceed outward. The path of the boat shall ensure an even distribution. Continue dragging until all GreenClean Pro Granular Algaecide is dissolved.

DETERMINING WATER VOLUME

Measure length (L), width (W), and average depth (D) in feet (ft) or meters (m) and calculate volume using one of the following formulas:

1 acre-foot of water =
208.7 ft long x 208.7 ft. wide x 1 ft. deep
43,560 ft.^{3} = 325,851 gal. = 2,780,000 lbs.

$$\frac{\text{Avg. L (ft)} \times \text{Avg. W (ft)} \times \text{Avg. D (ft)}}{43{,}560} = \text{acre-feet of water}$$

GENERAL TREATMENT NOTES

- Control is most easily achieved when algae are not yet well established. Treat when growth first begins to appear.
- GreenClean Granular is water activated.
- When applying GreenClean Granular to soil, gravel or other similar media, incorporate the product into the first inch of substrate for optimum effectiveness.
- Apply early in the day under calm, sunny conditions, and when water temperatures are warm. Sunlight and higher temperatures both enhance GreenClean activity.
- Apply in a manner that will ensure even distribution of GreenClean Granular within the treatment area.
- Break up any heavy algae before or during application.
- Skim dead algae and organic matter that rises to the water's surface after treatment. Allowing dead organics to sink and decay will provide a food source and additional nutrients that stimulate algae re-growth and further blooms.
- If using in conjunction with other water additives (such as bacteria or enzymes), always apply GreenClean Granular first and wait several hours before adding other products.
- Re-treat areas if re-growth begins to appear. Allow 48 hours between consecutive treatments.
- Maintain with maintenance rates at a frequency appropriate for your environmental conditions.
- In regions where water freezes in the winter, treatment with GreenClean Granular (including skimming) 6-8 weeks before expected freeze will help prevent masses of decaying algae under the ice cover.
- After application, do not allow undiluted granules to remain in an area where humans or animals are exposed.
- Non-target plants will suffer contact burn if undiluted granules are accidentally spilled on them. Do not apply in such a way that the concentrated product comes in contact with grass, ornamentals and other foliage.
- Do not tank mix with aquatic herbicides or algaecides containing copper or bromides.

EFFECTIVENESS FACTORS

- Effects of GreenClean Pro Granular Algaecide treatment are immediately apparent (bubbling, bleaching/discoloration of algae).
- **GreenClean Pro Granular Algaecide treatments are successful when contact of the pesticide is made with the algae.**
- Liquid applications will not sink through the water column as readily as a granular application.
- When treating surface mats and blooms, it is possible that GreenClean Pro Granular Algaecide will not penetrate the water column below the infested area, and a second application is then required for treating any bottom growing algae.
- Apply more frequently during the summer months when water consumption and temperatures are high.

STORAGE AND DISPOSAL

Do not contaminate water, food, or feed by storage or disposal.

PESTICIDE STORAGE:

Store in original containers in a cool, well-vented area, away from direct sunlight. Do not allow product to become overheated in storage. This may cause increased degradation of the product, which will decrease product effectiveness. In case of spill, flood area with large quantities of water. Do not store in a manner where cross-contamination with other pesticides or fertilizers could occur.

PESTICIDE DISPOSAL:

Wastes resulting from the use of this product may be disposed of on site or at an approved waste disposal facility. Open dumping is prohibited. If wastes cannot be disposed of according to label directions, contact your State Pesticide or Environmental Control Agency, or the Hazardous Waste Representative at the nearest EPA Regional Office for guidance.

CONTAINER DISPOSAL: Triple rinse (or equivalent). Then offer for recycling or dispose of in a sanitary landfill, or incineration, or if allowed by state and local authorities by burning. If burned, stay out of smoke.

WARRANTY

This material conforms to the description on the label and is reasonably fit for the purposes referred to in the directions for use. Timing, unfavorable temperatures, water conditions, presence of other materials, method of application, weather, watering practices, nature of soil, disease problem, condition of crop, incompatibility with other chemicals, pre-existing conditions and other conditions influencing the use of this product are beyond the control of the seller. Buyer assumes all risks associated with the use, storage, or handling of this material not in strict accordance with directions given herewith. NO OTHER EXPRESS OR IMPLIED WARRANTY OF FITNESS OR MERCHANTIBILITY IS MADE.

A Product of:
BioSafe Systems LLC
Glastonbury, CT 06033
888.273.3088
www.biosafesystems.com

3000-7 6/2004

BASF

The Chemical Company

Safety Data Sheet
HABITAT HERBICIDE

1. Product and Company Identification

Company
BASF CORPORATION
100 Campus Drive
Florham Park, NJ 07932, USA

24 Hour Emergency Response Information
CHEMTREC: 1-800-424-9300
BASF HOTLINE: 1-800-832-HELP

Substance number:	000000063383
Molecular formula:	C(13) H(15) N(3) O(3). C(3) H(9) N
Chemical family:	imidazole derivative
Synonyms:	Isopropylamine salt of imazapyr

2. Hazards Identification

Emergency overview

CAUTION:
KEEP OUT OF REACH OF CHILDREN.
Avoid contact with the skin, eyes and clothing.
Avoid inhalation of mists/vapours.

See Product Label for additional precautionary statements.

State of matter: liquid
Colour: blue, clear
Odour: ammonia-like

Potential health effects

Primary routes of exposure:
Routes of entry for solids and liquids include eye and skin contact, ingestion and inhalation. Routes of entry for gases include inhalation and eye contact. Skin contact may be a route of entry for liquified gases.

Acute toxicity:
Relatively nontoxic after single ingestion. Slightly toxic after short-term skin contact. Relatively nontoxic after short-term inhalation.

Irritation / corrosion:
May cause slight but temporary irritation to the eyes. May cause slight irritation to the skin.

Sensitization:
Skin sensitizing effects were not observed in animal studies.

Chronic toxicity:

Repeated dose toxicity: No other known chronic effects.

Potential environmental effects

Aquatic toxicity:
There is a high probability that the product is not acutely harmful to fish. There is a high probability that the product is not acutely harmful to aquatic invertebrates. Acutely harmful for aquatic plants.

Terrestrial toxicity:
With high probability not acutely harmful to terrestrial organisms.

3. Composition / Information on Ingredients

CAS Number	Content (W/W)	Chemical name
81510-83-0	28.7 %	Isopropylamine salt of imazapyr
	71.3 %	Proprietary ingredients

4. First-Aid Measures

General advice:
First aid providers should wear personal protective equipment to prevent exposure. Remove contaminated clothing. Move person to fresh air. If person is not breathing, call 911 or ambulance, then give artificial respiration, preferably mouth-to-mouth if possible. Call a poison control center or physician for treatment advice. Have the product container or label with you when calling a poison control center or doctor or going for treatment.

If inhaled:
Remove the affected individual into fresh air and keep the person calm. Assist in breathing if necessary.

If on skin:
Rinse skin immediately with plenty of water for 15 - 20 minutes.

If in eyes:
Hold eyes open and rinse slowly and gently with water for 15 to 20 minutes. Remove contact lenses, if present, after first 5 minutes, then continue rinsing.

If swallowed:
Have person sip a glass of water if able to swallow. Do not induce vomiting unless told to by a poison control center or doctor. Never induce vomiting or give anything by mouth if the victim is unconscious or having convulsions.

Note to physician

Antidote:	No known specific antidote.
Treatment:	Treat symptomatically.

5. Fire-Fighting Measures

Flash point:	Non-flammable.
Self-ignition temperature:	not self-igniting

Suitable extinguishing media:
foam, dry extinguishing media, carbon dioxide, water spray

Hazards during fire-fighting:
carbon monoxide, carbon dioxide, nitrogen oxide, nitrogen dioxide, Hydrocarbons,
If product is heated above decomposition temperature, toxic vapours will be released. The substances/groups of substances mentioned can be released if the product is involved in a fire.

Protective equipment for fire-fighting:
Firefighters should be equipped with self-contained breathing apparatus and turn-out gear.

Further information:
Evacuate area of all unnecessary personnel. Contain contaminated water/firefighting water. Do not allow to enter drains or waterways.

6. Accidental release measures

Personal precautions:
Take appropriate protective measures. Clear area. Shut off source of leak only under safe conditions. Extinguish sources of ignition nearby and downwind. Ensure adequate ventilation. Wear suitable personal protective clothing and equipment.

Environmental precautions:
Do not discharge into the subsoil/soil. Do not discharge into drains/surface waters/groundwater. Contain contaminated water/firefighting water.

Cleanup:
Dike spillage. Pick up with suitable absorbent material. Place into suitable containers for reuse or disposal in a licensed facility. Spilled substance/product should be recovered and applied according to label rates whenever possible. If application of spilled substance/product is not possible, then spills should be contained, solidified, and placed in suitable containers for disposal. After decontamination, spill area can be washed with water. Collect wash water for approved disposal.

7. Handling and Storage

Handling

General advice:
RECOMMENDATIONS ARE FOR MANUFACTURING, COMMERCIAL BLENDING, AND PACKAGING WORKERS. PESTICIDE APPLICATORS & WORKERS must refer to the Product Label and Directions for Use attached to the product for Agricultural Use Requirements in accordance with the EPA Worker Protection Standard 40 CFR part 170. Ensure adequate ventilation. Provide good ventilation of working area (local exhaust ventilation if necessary). Keep away from sources of ignition - No smoking. Keep container tightly sealed. Protect contents from the effects of light. Protect against heat. Protect from air. Handle and open container with care. Do not open until ready to use. Once container is opened, content should be used as soon as possible. Avoid aerosol formation. Avoid dust formation. Provide means for controlling leaks and spills. Do not return residues to the storage containers. Follow label warnings even after container is emptied. The substance/ product may be handled only by appropriately trained personnel. Avoid all direct contact with the substance/product. Avoid contact with the skin, eyes and clothing. Avoid inhalation of dusts/mists/vapours. Wear suitable personal protective clothing and equipment.

Protection against fire and explosion:
The relevant fire protection measures should be noted. Fire extinguishers should be kept handy. Avoid all sources of ignition: heat, sparks, open flame. Sources of ignition should be kept well clear. Avoid extreme heat. Keep away from oxidizable substances. Electrical equipment should conform to national electric code. Ground all transfer equipment properly to prevent electrostatic discharge. Electrostatic discharge may cause ignition.

Storage

General advice:
Keep only in the original container in a cool, dry, well-ventilated place away from ignition sources, heat or flame. Protect containers from physical damage. Protect against contamination. The authority permits and storage regulations must be observed.

Storage incompatibility:
General advice: Segregate from incompatible substances. Segregate from foods and animal feeds. Segregate from textiles and similar materials.

Temperature tolerance
Protect from temperatures below: 0 °C

Changes in the properties of the product may occur if substance/product is stored below indicated temperature for extended periods of time.
Protect from temperatures above: 40 °C
Changes in the properties of the product may occur if substance/product is stored above indicated temperature for extended periods of time.

8. Exposure Controls and Personal Protection

Users of a pesticidal product should refer to the product label for personal protective equipment requirements.

Advice on system design:
Whenever possible, engineering controls should be used to minimize the need for personal protective equipment.

Personal protective equipment

RECOMMENDATIONS FOR MANUFACTURING, COMMERCIAL BLENDING, AND PACKAGING WORKERS:

Respiratory protection:
Wear respiratory protection if ventilation is inadequate. Wear a NIOSH-certified (or equivalent) TC23C Chemical/Mechanical type filter system to remove a combination of particles, gas and vapours. For situations where the airborne concentrations may exceed the level for which an air purifying respirator is effective, or where the levels are unknown or Immediately Dangerous to Life or Health (IDLH), use NIOSH-certified full facepiece pressure demand self-contained breathing apparatus (SCBA) or a full facepiece pressure demand supplied-air respirator (SAR) with escape provisions.

Hand protection:
Chemical resistant protective gloves, Protective glove selection must be based on the user's assessment of the workplace hazards.

Eye protection:
Safety glasses with side-shields. Tightly fitting safety goggles (chemical goggles). Wear face shield if splashing hazard exists.

Body protection:
Body protection must be chosen depending on activity and possible exposure, e.g. head protection, apron, protective boots, chemical-protection suit.

General safety and hygiene measures:
Wear long sleeved work shirt and long work pants in addition to other stated personal protective equipment. Work place should be equipped with a shower and an eye wash. Handle in accordance with good industrial hygiene and safety practice. Personal protective equipment should be decontaminated prior to reuse. Gloves must be inspected regularly and prior to each use. Replace if necessary (e.g. pinhole leaks). Take off immediately all contaminated clothing. Store work clothing separately. Hands and/or face should be washed before breaks and at the end of the shift. No eating, drinking, smoking or tobacco use at the place of work. Keep away from food, drink and animal feeding stuffs.

9. Physical and Chemical Properties

Form:	liquid	
Odour:	ammonia-like, faint odour	
Colour:	blue, clear	
pH value:	6.6 - 7.2	
Freezing point:	approx. 0 °C	(1,013.3 hPa) Information applies to the solvent.
Boiling point:	approx. 100 °C	(1,013.3 hPa) Information applies to the solvent.
Vapour pressure:	approx. 23.3 hPa	(20 °C) Information applies to the solvent.
Density:	1.04 - 1.09 g/ml	

Bulk density:		not applicable
Viscosity, dynamic:	approx. > 1 mPa.s	(20 °C)
Solubility in water:		miscible
Molar mass:	320.4 g/mol	

10. Stability and Reactivity

Conditions to avoid:
Avoid all sources of ignition: heat, sparks, open flame. Avoid extreme temperatures. Avoid prolonged exposure to extreme heat. Avoid contamination. Avoid electro-static discharge. Avoid prolonged storage.

Substances to avoid:
oxidizing agents, reducing agents

Hazardous reactions:
The product is chemically stable.

Decomposition products:
Hazardous decomposition products: No hazardous decomposition products if stored and handled as prescribed/indicated., Prolonged thermal loading can result in products of degradation being given off.

Thermal decomposition:
Possible thermal decomposition products:
carbon monoxide, carbon dioxide, nitrogen oxide
Stable at ambient temperature. If product is heated above decomposition temperature toxic vapours may be released. If product is heated above decomposition temperature hazardous fumes may be released.

Corrosion to metals:
Corrosive effect on: mild steel brass

Oxidizing properties:
not fire-propagating
Not an oxidizer.

11. Toxicological information

Acute toxicity

Oral:
Type of value: LD50
Species: rat (male/female)
Value: > 5,000 mg/kg

Inhalation:
Type of value: LC50
Species: rat (male/female)
Value: > 5.3 mg/l (OECD Guideline 403)
Exposure time: 4 h
An aerosol was tested.

Dermal:
Type of value: LD50
Species: rabbit (male/female)
Value: > 2,000 mg/kg

Irritation / corrosion

Skin:
Species: rabbit
Result: mildly irritating

Method: Primary skin irritation test

Eye:
Species: rabbit
Result: non-irritant

Sensitization:
Skin sensitization test
Species: guinea pig
Result: Skin sensitizing effects were not observed in animal studies.

Genetic toxicity

Information on: imazapyr
No mutagenic effect was found in various tests with microorganisms and mammals.

Carcinogenicity

Information on: imazapyr
In long-term studies in rats and mice in which the substance was given by feed, a carcinogenic effect was not observed.

Reproductive toxicity

Information on: imazapyr
The results of animal studies gave no indication of a fertility impairing effect.

Development:

Information on: imazapyr
No indications of a developmental toxic / teratogenic effect were seen in animal studies.

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12. Ecological Information

Fish

Information on: imazapyr
Acute:
Oncorhynchus mykiss/LC50 (96 h): > 100 mg/l

Aquatic invertebrates

Information on: imazapyr
Acute:
Daphnia magna/EC50 (48 h): > 100 mg/l

Aquatic plants

Toxicity to aquatic plants:
other swollen duckweed/EC50 (14 d): 0.0228 mg/l
The product has not been tested. The statement has been derived from products of a similar structure and composition.

Non-Mammals

Information on: imazapyr

Other terrestrial non-mammals:
mallard duck/LC50: > 5,000 ppm
With high probability not acutely harmful to terrestrial organisms.
Honey bee/LD50: > 100 ug/bee
With high probability not acutely harmful to terrestrial organisms.

Degradability / Persistence
Biological / Abiological Degradation

Evaluation: Not readily biodegradable (by OECD criteria).

Other adverse effects:

The ecological data given are those of the active ingredient. Do not release untreated into natural waters.

13. Disposal considerations

Waste disposal of substance:
Pesticide wastes are regulated. Improper disposal of excess pesticide, spray mix or rinsate is a violation of federal law. If pesticide wastes cannot be disposed of according to label instructions, contact the State Pesticide or Environmental Control Agency or the Hazardous Waste representative at the nearest EPA Regional Office for guidance.

Container disposal:
Rinse thoroughly at least three times (triple rinse) in accordance with EPA recommendations. Consult state or local disposal authorities for approved alternative procedures such as container recycling. Recommend crushing, puncturing or other means to prevent unauthorized use of used containers.

RCRA:
This product is not regulated by RCRA.

14. Transport Information

Reference Bill of Lading

15. Regulatory Information

Federal Regulations

Registration status:

Crop Protection	TSCA, US	released / exempt
Chemical	TSCA, US	blocked / not listed

EPCRA 311/312 (Hazard categories): Acute;

State regulations

CA Prop. 65:
There are no listed chemicals in this product.

16. Other Information

Refer to product label for EPA registration number.

Recommended use: herbicide

BASF supports worldwide Responsible Care® initiatives. We value the health and safety of our employees, customers, suppliers and neighbors, and the protection of the environment. Our commitment to Responsible Care is integral to conducting our business and operating our facilities in a safe and environmentally responsible fashion, supporting our customers and suppliers in ensuring the safe and environmentally sound handling of our products, and minimizing the impact of our operations on society and the environment during production, storage, transport, use and disposal of our products.

Local Contact Information
Product Stewardship
919 547-2000

END OF DATA SHEET

1 PRODUCT AND COMPANY IDENTIFICATION

Pre-Harvest Division
Cerexagri-Nisso LLC
630 Freedom Business Center, Suite 402
King of Prussia, PA 19406

EMERGENCY PHONE NUMBERS:
Chemtrec: (800) 424-9300 (24hrs) or (703) 527-3887
Medical: Rocky Mountain Poison Control Center
(866) 767-5089 (24Hrs)

Information Telephone Numbers	Phone Number	Available Hrs
R&D Technical Service	610-878-6100	8:00am to 5:00pm EST
Customer Service	1-800-438-6071	8:00am - 5:00 pm EST

Product Name	HYDROTHOL (R) 191 Aquatic algicide and herbicide
Product Synonym(s)	

Chemical Family	Dicarboxylic Acid- Monoamine Salt
Chemical Formula	C8H9O5 + HN(CH3)2 R, (where R is C8-C18)
Chemical Name	Endothall Mono (N, N-Dimethylalkylamine) Salt
EPA Reg Num	4581-174-82695
Product Use	Aquatic herbicide and algicide

2 COMPOSITION / INFORMATION ON INGREDIENTS

Ingredient Name	CAS RegistryNumber	Typical Wt. %	OSHA
Mono(N,N-dimethylalkylamine) salt of endothall	66330-88-9	53.0	Y

The substance(s) marked with a "Y" in the OSHA column, are identified as hazardous chemicals according to the criteria of the OSHA Hazard Communication Standard (29 CFR 1910.1200)

3 HAZARDS IDENTIFICATION

Emergency Overview
Yellowish brown liquid with very faint chlorine odor.
KEEP OUT OF REACH OF CHILDREN.
DANGER!
Causes irreversible eye damage
MAY BE FATAL IF ABSORBED THROUGH SKIN.
MAY BE FATAL IF SWALLOWED.
CAUSES SKIN BURNS.
HARMFUL IF INHALED.
Do not get in eyes, on skin or on clothing.

Potential Health Effects

Inhalation and skin contact are expected to be the primary routes of occupational exposure to this material. Based on single exposure animal tests, it is considered to be moderately toxic if swallowed or absorbed through skin, slightly toxic if inhaled and severely irritating to eyes and skin.

4 FIRST AID MEASURES

IF IN EYES,
-Hold eye open and rinse slowly and gently with water for 15-20 minutes. Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye.
-Call a poison control center or doctor for treatment advice.

IF ON SKIN, immediately wash with cool/cold water. If irritation develops, immediately obtain medical attention.

IF SWALLOWED,
-Call a poison control center or doctor immediately for treatment advice.
-Have person sip a glass of water if able to swallow.
-Do not induce vomiting unless told to do so by a poison control center or doctor.
-Do not give anything by mouth to an unconscious person.

IF INHALED,
-Move person to fresh air.
-If person is not breathing, call 911 or an ambulance, then give artificial respiration, preferably mouth-to-mouth if possible.
-Call a poison control center or doctor for further treatment advice.

5 FIRE FIGHTING MEASURES

Fire and Explosive Properties

Auto-Ignition Temperature	NE		
Flash Point	>100 deg C	Flash Point Method	
Flammable Limits- Upper	N/A		
Lower	N/A		

Extinguishing Media

Use water spray, carbon dioxide, foam or dry chemical.

Fire Fighting Instructions

Fire fighters and others who may be exposed to products of combustion should wear full fire fighting turn out gear (full Bunker Gear) and self-contained breathing apparatus (pressure demand NIOSH approved or equivalent). Fire fighting equipment should be thoroughly decontaminated after use.

Fire and Explosion Hazards

None known.

6 ACCIDENTAL RELEASE MEASURES

In Case of Spill or Leak

Small spills: soak up with an inert absorbent. Scoop up and place in a clean, dry container. Consult with environmental engineer or professional to determine if neutralization is appropriate and for handling procedures for residual materials.
Large spills: Pump into marked containers for disposal or reclamation. Consult a regulatory specialist to determine appropriate state or local reporting requirements, for assistance in waste characterization and/or hazardous waste disposal and other requirements listed in pertinent environmental permits.

7 HANDLING AND STORAGE

7 HANDLING AND STORAGE

Handling

Use only with adequate ventilation.
Do not get in eyes, on skin or on clothing. Do not breathe mist.
Empty container may contain hazardous residues. Keep container closed. Wash thoroughly after handling.

Storage

Keep from freezing; material may coagulate.

8 EXPOSURE CONTROLS / PERSONAL PROTECTION

Engineering Controls

Investigate engineering techniques to reduce exposures. Provide ventilation if necessary to minimize exposure. Dilution ventilation is acceptable, but local mechanical exhaust ventilation preferred, if practical, at sources of air contamination such as open process equipment. Consult ACGIH ventilation manual or NFPA Standard 91 for design of exhaust systems.

Eye / Face Protection

Where there is potential for eye contact, wear chemical goggles and have eye flushing equipment immediately available.

Skin Protection

Minimize skin contamination by following good industrial hygiene practice. Wearing rubber gloves is recommended. Wash hands and contaminated skin thoroughly after handling.

Respiratory Protection

Avoid breathing vapor or mist. Where airborne exposure is likely, use NIOSH approved respirator with a N 95 particulate filter. If exposures cannot be kept at a minimum with engineering controls, use NIOSH approved respiratory protection equipment as noted above. Observe respirator use limitations specified by NIOSH or the manufacturer. For emergency and other conditions where there may be a potential for significant exposure, use an approved full face positive-pressure, self-contained breathing apparatus or positive-pressure airline with auxiliary self-contained air supply. Respiratory protection programs must comply with 29 CFR § 1910.134.

Airborne Exposure Guidelines for Ingredients

The components of this product have no established Airborne Exposure Guidelines

-Only those components with exposure limits are printed in this section.
-Skin contact limits designated with a "Y" above have skin contact effect. Air sampling alone is insufficient to accurately quantitate exposure. Measures to prevent significant cutaneous absorption may be required.
-ACGIH Sensitizer designator with a value of "Y" above means that exposure to this material may cause allergic reactions.
-WEEL-AIHA Sensitizer designator with a value of "Y" above means that exposure to this material may cause allergic skin reactions.

9 PHYSICAL AND CHEMICAL PROPERTIES

Appearance/Odor	Yellowish brown liquid with very faint chlorine odor.
pH	NA
Specific Gravity	1.044 @ 25 deg C
Vapor Pressure	9.45 X 10-6 Torr (endothal amine salt)
Vapor Density	NA
Melting Point	N/A
Freezing Point	<0 deg C
Boiling Point	100 deg C
Solubility In Water	>50 g/100ml (amine salt)
Percent Volatile	47.0
Viscosity	100 cps @ 25 C

10 STABILITY AND REACTIVITY

Stability

This material is chemically stable under normal and anticipated storage and handling conditions.

Hazardous Polymerization

Does not occur.

Incompatibility

Materials that react with water.

Hazardous Decomposition Products

Extreme temperatures may convert endothall product to endothall anhydride, a strong vesiccant, causing blistering of eyes, mucous membranes, and skin. (See Section 16)

11 TOXICOLOGICAL INFORMATION

Toxicological Information

Data on this material and/or its components are summarized below.
Hydrothol 191
Single exposure (acute) studies indicate that this material is moderately toxic if swallowed (rat LD50 233.4 mg/kg) or absorbed through skin (rabbit LD50 480.9 mg/kg), slightly toxic if inhaled (rat 4-hr LC50 0.7 mg/l) and severely irritating to rabbit eyes and skin. No skin allergy was observed in guinea pigs following repeated exposure.

7-Oxabicyclo[2.2.1]heptane-2,3-dicarboxylic acid (technical active ingredient)
Intentional swallowing of 40 ml led to death within 12-hours. Skin allergy was observed in guinea pigs following repeated exposure. Repeated dietary administration (via gelatin capsules) produced vomiting, diarrhea, sluggish movements, and liver, kidney and blood effects in dogs. Long-term dietary administration to rats and mice produced effects in the glandular stomach. High mortality rates and intestinal tumors considered to be secondary to the effects in the stomach were observed in mice. Long-term application to the skin of mice produced no tumors. No birth defects were observed in the offspring of rats exposed orally during pregnancy, even at dosages that produced adverse effects on the mothers. Skeletal anomalies were observed in the offspring of rabbits and mice exposed orally during pregnancy, but only at dosages that produced adverse effects in the mothers. No genetic changes were observed in tests using bacteria, animal cells or animals.

12 ECOLOGICAL INFORMATION

Ecotoxicological Information

Hydrothol 191
This material is highly toxic to Daphnia magna (48-hr LC50 0.36 mg/l), fathead minnow (96-hr LC50 0.94 mg/l), golden shiner (120-hr LC50 0.32 mg/l) and scud (96-hr TL50 0.48 mg/l). It is moderately toxic to mussels (48-hr LC50 4.85 mg/l) and rainbow trout (96-hr LC50 1.7 mg/l). The 7-day LC50 for Ceriodaphnia was 0.18-0.19 mg/l and 0.304 mg/l for fathead minnow.

7-Oxabicyclo[2.2.1]heptane-2,3-dicarboxylic acid (technical active ingredient)
This material is slightly toxic to bluegill sunfish (96-hr LC50 77 mg/l), rainbow trout (96-hr LC50 49 mg/l), Daphnia magna (48-hr LC50 92 mg/l), eastern oysters (96-hr LC50 54 mg/l), mysid shrimp (96-hr LC50 39 mg/l) and fiddler crab (96-hr LC50 85.1 mg/l). It is practically non-toxic to sheepshead minnow (96-hr LC50 110 mg/l) and common mummichog (96-hr LC50 213.9 mg/l).

This material has an 8-day LC50 of >5,000 ppm (bobwhite quail and mallard ducklings), a 21-day LD50 of 111 mg/kg (mallard ducks), a 30-day MATC of 19 mg/l (fathead minnows) and a 21-day MATC of 6.7 mg/l (Daphnia magna). No adverse effects were observed in mallard ducks and bobwhite quail following repeated (20-weeks) administration in the diet.

Chemical Fate Information

7-Oxabicyclo[2.2.1]heptane-2,3-dicarboxylic acid (technical active ingredient)
No degradation was observed in irradiated or dark water during a 30-day test period at pH 7 or 9. Rapid degradation was observed in irradiated, but not dark, water at pH 5 (half-life <24 hours). This material adsorbed readily from aqueous solution on to Crosby silt loam. It is not expected to bioccumulate with bioaccumulation factors (BCF) of 10 for mosquito fish and 0.003-0.008 for bluegills.

13 DISPOSAL CONSIDERATIONS

Waste Disposal

Pesticide wastes are acutely hazardous. Improper disposal of excess pesticide or rinsate is a violation of Federal law. If these wastes cannot be disposed of by use according to label instructions, contact your State Pesticide or Environmental Control Agency, or the Hazardous Waste representative at the nearest EPA Regional Office for guidance.

14 TRANSPORT INFORMATION

DOT Name	Pesticides, liquid, toxic,n.o.s.
DOT Technical Name	Endothall
DOT Hazard Class	6.1
UN Number	2902
DOT Packing Group	PG III
RQ	1000lbs.
DOT Special Information	DOT HM215C = The Keep away from foodstuffs (KAFF) label is authorized until October 2003. During this transition period the KAFF or Toxic label may be used. After October 2003, all 6.1- PG III materials must carry the Toxic label.

15 REGULATORY INFORMATION

Hazard Categories Under Criteria of SARA Title III Rules (40 CFR Part 370)

Immediate (Acute) Health	Y	Fire	N
Delayed (Chronic) Health	N	Reactive	N
		Sudden Release of Pressure	N

Ingredient Related Regulatory Information:

SARA Reportable Quantities	CERCLA RQ	SARA TPQ
Mono(N,N-dimethylalkylamine) salt of endothall	NE	NE

16 OTHER INFORMATION

Revision Information

Revision Date	05 JAN 2006	Revision Number 13
Supercedes Revision Dated	03-JAN-2006	

Revision Summary
Update section 1

Key
NE= Not Established NA= Not Applicable (R) = Registered Trademark

Miscellaneous
Proper PPE and ventilation should be used when suing high heat, such as welding or oxy-acetylene torch cutting, on machinery that may have endothal residue.

Hydrothol (R) is a registered trademark of Cerexagri, Inc.

Material Safety Data Sheet

SePRO

Komeen

1 . Product and company identification

Product name	:	Komeen
EPA Registration Number	:	67690-25
Material uses	:	Aquatic herbicide.
Supplier/Manufacturer	:	**SePRO Corporation** 11550 North Meridian Street Suite 600 Carmel, IN 46032 U.S.A. Tel: 317-580-8282 Toll free: 1-800-419-7779 Fax: 317-428-4577 Monday - Friday, 8am to 5pm E.S.T. **www.sepro.com**
Responsible name	:	Atrion Regulatory Services, Inc.
In case of emergency	:	**INFOTRAC - 24-hour service 1-800-535-5053**

2 . Hazards identification

Physical state	:	Liquid.
Odor	:	None
OSHA/HCS status	:	This material is considered hazardous by the OSHA Hazard Communication Standard (29 CFR 1910.1200).
Emergency overview	:	**DANGER!** **CAUSES RESPIRATORY TRACT, EYE AND SKIN BURNS. MAY CAUSE SEVERE ALLERGIC RESPIRATORY AND SKIN REACTION. HARMFUL IF SWALLOWED. CONTAINS MATERIAL THAT CAN CAUSE TARGET ORGAN DAMAGE. CANCER HAZARD - CONTAINS MATERIAL WHICH CAN CAUSE CANCER.** Harmful if swallowed. Corrosive to the eyes, skin and respiratory system. Causes burns. May cause sensitization by inhalation and skin contact. Avoid exposure - obtain special instructions before use. Do not breathe vapor or mist. Do not ingest. Do not get in eyes or on skin or clothing. Contains material that can cause target organ damage. Contains material which can cause cancer. Risk of cancer depends on duration and level of exposure. Use only with adequate ventilation. Keep container tightly closed and sealed until ready for use. Wash thoroughly after handling.
Routes of entry	:	Dermal contact. Eye contact. Inhalation. Ingestion.
Potential acute health effects		
Inhalation	:	Corrosive to the respiratory system. May cause sensitization by inhalation. Exposure to decomposition products may cause a health hazard. Serious effects may be delayed following exposure.
Ingestion	:	Toxic if swallowed. May cause burns to mouth, throat and stomach.
Skin	:	Corrosive to the skin. Causes burns. May cause sensitization by skin contact.
Eyes	:	Corrosive to eyes. Causes burns.
Potential chronic health effects		
Chronic effects	:	Contains material that can cause target organ damage. Once sensitized, a severe allergic reaction may occur when subsequently exposed to very low levels.
Carcinogenicity	:	Contains material which can cause cancer. Risk of cancer depends on duration and level of exposure.
Mutagenicity	:	No known significant effects or critical hazards.
Teratogenicity	:	No known significant effects or critical hazards.
Developmental effects	:	No known significant effects or critical hazards.
Fertility effects	:	No known significant effects or critical hazards.
Target organs	:	Contains material which causes damage to the following organs: kidneys, liver, upper respiratory tract, skin, eye, lens or cornea.

Over-exposure signs/symptoms

Inhalation	: Adverse symptoms may include the following: respiratory tract irritation coughing wheezing and breathing difficulties asthma
Ingestion	: Adverse symptoms may include the following: stomach pains
Skin	: Adverse symptoms may include the following: pain or irritation redness blistering may occur
Eyes	: Adverse symptoms may include the following: pain watering redness
Medical conditions aggravated by over-exposure	: Pre-existing respiratory and skin disorders and disorders involving any other target organs mentioned in this MSDS as being at risk may be aggravated by over-exposure to this product.

See toxicological information (section 11)

3 . Composition/information on ingredients

United States		
Name	CAS number	%
Active ingredient:		
Copper sulphate pentahydrate	7758-98-7	30 - 60
Inert ingredient:		
Proprietary Amine	Proprietary	10 - 30

There are no additional ingredients present which, within the current knowledge of the supplier and in the concentrations applicable, are classified as hazardous to health or the environment and hence require reporting in this section.

4 . First aid measures

Eye contact	: Check for and remove any contact lenses. In case of contact, immediately flush eyes with plenty of water for at least 20 minutes. Get medical attention immediately.
Skin contact	: In case of contact, immediately flush skin with plenty of water for at least 20 minutes. Get medical attention immediately.
Inhalation	: If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention immediately.
Ingestion	: Do not induce vomiting. Never give anything by mouth to an unconscious person. Get medical attention immediately.
Protection of first-aiders	: No action shall be taken involving any personal risk or without suitable training. If it is suspected that fumes are still present, the rescuer should wear an appropriate mask or self-contained breathing apparatus. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation. Wash contaminated clothing thoroughly with water before removing it, or wear gloves.
Notes to physician	: In case of inhalation of decomposition products in a fire, symptoms may be delayed. The exposed person may need to be kept under medical surveillance for 48 hours.

5 . Fire-fighting measures

Flammability of the product	: May be combustible at high temperature.
Extinguishing media	
Suitable	: Use an extinguishing agent suitable for the surrounding fire.
Not suitable	: None known.
Special exposure hazards	: Promptly isolate the scene by removing all persons from the vicinity of the incident if there is a fire. No action shall be taken involving any personal risk or without suitable training. Fire water contaminated with this material must be contained and prevented from being discharged to any waterway, sewer or drain.

Hazardous thermal decomposition products	: Decomposition products may include the following materials: carbon dioxide carbon monoxide nitrogen oxides sulfur oxides metal oxide/oxides Decomposes above 200°C.
Special protective equipment for fire-fighters	: Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode.

6. Accidental release measures

Personal precautions	: No action shall be taken involving any personal risk or without suitable training. Evacuate surrounding areas. Keep unnecessary and unprotected personnel from entering. Do not touch or walk through spilled material. Do not breathe vapor or mist. Provide adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Put on appropriate personal protective equipment (see section 8).
Environmental precautions	: May be harmful to the environment if released in large quantities.
Methods for cleaning up	
Small spill	: Stop leak if without risk. Move containers from spill area. Dilute with water and mop up if water-soluble or absorb with an inert dry material and place in an appropriate waste disposal container. Dispose of via a licensed waste disposal contractor.
Large spill	: Stop leak if without risk. Move containers from spill area. Approach release from upwind. Prevent entry into sewers, water courses, basements or confined areas. Wash spillages into an effluent treatment plant or proceed as follows. Contain and collect spillage with non-combustible, absorbent material e.g. sand, earth, vermiculite or diatomaceous earth and place in container for disposal according to local regulations (see section 13). Dispose of via a licensed waste disposal contractor. Contaminated absorbent material may pose the same hazard as the spilled product. Note: see section 1 for emergency contact information and section 13 for waste disposal.

7. Handling and storage

Handling	: Put on appropriate personal protective equipment (see section 8). Eating, drinking and smoking should be prohibited in areas where this material is handled, stored and processed. Workers should wash hands and face before eating, drinking and smoking. Persons with a history of skin sensitization problems or asthma, allergies or chronic or recurrent respiratory disease should not be employed in any process in which this product is used. Do not get in eyes or on skin or clothing. Do not breathe vapor or mist. Do not ingest. Avoid release to the environment. Use only with adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Keep in the original container or an approved alternative made from a compatible material, kept tightly closed when not in use. Empty containers retain product residue and can be hazardous. Do not reuse container.
Storage	: Store in accordance with local regulations. Store in original container protected from direct sunlight in a dry, cool and well-ventilated area, away from incompatible materials (see section 10) and food and drink. Keep container tightly closed and sealed until ready for use. Containers that have been opened must be carefully resealed and kept upright to prevent leakage. Do not store in unlabeled containers. Use appropriate containment to avoid environmental contamination.

8. Exposure controls/personal protection

United States

Product name	Exposure limits
Copper sulphate pentahydrate	**ACGIH TLV (United States).** TWA: 1 mg/m³ 8 hour(s). Form: Copper dust. **OSHA PEL (United States).** TWA: 1 mg/m³ 8 hour(s). Form: Copper dust.
Proprietary Amine	**ACGIH TLV (United States, 1/2008). Absorbed through skin.** TWA: 25 mg/m³ 8 hour(s). TWA: 10 ppm 8 hour(s). **NIOSH REL (United States, 12/2001).** TWA: 25 mg/m³ 10 hour(s). TWA: 10 ppm 10 hour(s).

	OSHA PEL (United States, 11/2006). TWA: 25 mg/m^3 8 hour(s). TWA: 10 ppm 8 hour(s).

Consult local authorities for acceptable exposure limits.

Recommended monitoring procedures : If this product contains ingredients with exposure limits, personal, workplace atmosphere or biological monitoring may be required to determine the effectiveness of the ventilation or other control measures and/or the necessity to use respiratory protective equipment.
Applicators should refer to the product label for personal protective clothing and equipment.

Engineering measures : Use only with adequate ventilation. If user operations generate dust, fumes, gas, vapor or mist, use process enclosures, local exhaust ventilation or other engineering controls to keep worker exposure to airborne contaminants below any recommended or statutory limits.

Hygiene measures : Wash hands, forearms and face thoroughly after handling chemical products, before eating, smoking and using the lavatory and at the end of the working period. Appropriate techniques should be used to remove potentially contaminated clothing. Wash contaminated clothing before reusing. Ensure that eyewash stations and safety showers are close to the workstation location.

Personal protection

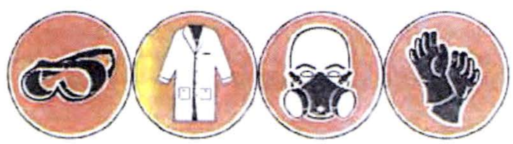
Eyes : Splash goggles.

Skin : Lab coat.

Respiratory : Vapor respirator.

Hands : Rubber gloves.

Personal protective equipment (Pictograms) :



HMIS Code/Personal protective equipment : G

Environmental exposure controls : Emissions from ventilation or work process equipment should be checked to ensure they comply with the requirements of environmental protection legislation. In some cases, fume scrubbers, filters or engineering modifications to the process equipment will be necessary to reduce emissions to acceptable levels.

9 . Physical and chemical properties

Physical state : Liquid.

Color : Purple. [Dark]

Odor : None

pH : 9.62

Relative density : 1.22 g/cm^3 (20°C).

Vapor pressure : No appreciable vapor pressure. Open containers can lose small amounts of water by volatilization.

Solubility : Soluble in water and alcohols.

10 . Stability and reactivity

Stability : The product is stable.

Hazardous polymerization : Under normal conditions of storage and use, hazardous polymerization will not occur.

Conditions to avoid : Avoid exposure - obtain special instructions before use.

Materials to avoid : Reactive or incompatible with the following materials: oxidizing materials and acids. (Specific materials to avoid) Do not use where water is below 6. Copper chelate may dissociate and release copper ions which could subsequently be precipitated as insoluble copper salts. Should not be applied when water temperature is below 60°F.

Hazardous decomposition products : Under normal conditions of storage and use, hazardous decomposition products should not be produced.

Highly flammable in the presence of the following materials or conditions: open flames, sparks and static discharge.
Flammable in the presence of the following materials or conditions: heat.

11 . Toxicological information

Acute toxicity

Product/ingredient name	Species	Dose	Result	Exposure
Copper sulphate pentahydrate	Rat	20 mg/kg	LD50 Intraperitoneal	-
	Rat	48900 ug/kg	LD50 Intravenous	-
	Rat - Female	300 mg/kg	LD50 Oral	-
	Rat	960 mg/kg	LD50 Oral	-
Proprietary Amine	Rabbit	730 uL/kg	LD50 Dermal	-
	Rat	1200 mg/kg	LD50 Oral	-

Inhalation : Corrosive to the respiratory system. May cause sensitization by inhalation. Exposure to decomposition products may cause a health hazard. Serious effects may be delayed following exposure.

Ingestion : Toxic if swallowed. May cause burns to mouth, throat and stomach.

Skin : Corrosive to the skin. Causes burns. May cause sensitization by skin contact.

Eyes : Corrosive to eyes. Causes burns.

Carcinogenicity

Classification

Product/ingredient name	ACGIH	IARC	EPA	NIOSH	NTP	OSHA
Proprietary Amine	A4	-	-	-	-	-

12 . Ecological information

Environmental effects : May be harmful to the environment if released in large quantities.

Aquatic ecotoxicity

Product/ingredient name	Test	Species	Exposure	Result
Proprietary Amine	-	Fish	96 hours	Acute LC50 115700 to 131600 ug/L
	-	Daphnia	48 hours	Acute LC50 26500 to 34400 ug/L

13 . Disposal considerations

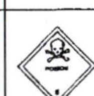
Waste disposal : The generation of waste should be avoided or minimized wherever possible. Empty containers or liners may retain some product residues. This material and its container must be disposed of in a safe way. Dispose of surplus and non-recyclable products via a licensed waste disposal contractor. Disposal of this product, solutions and any by-products should at all times comply with the requirements of environmental protection and waste disposal legislation and any regional local authority requirements. Avoid dispersal spilled material and runoff and contact with soil, waterways, drains and sewers.

Disposal should be in accordance with applicable regional, national and local laws and regulations.

Refer to Section 7: HANDLING AND STORAGE and Section 8: EXPOSURE CONTROLS/PERSONAL PROTECTION for additional handling information and protection of employees.

14 . Transport information

AERG : 151

Regulatory information	UN number	Proper shipping name	Classes	PG*	Label	Additional information
DOT Classification	UN3010	COPPER BASED PESTICIDES, LIQUID, TOXIC	6.1	III		

IMDG Class	UN3010	COPPER BASED PESTICIDES, LIQUID, TOXIC	6.1	III		
IATA-DGR Class	UN3010	COPPER BASED PESTICIDES, LIQUID, TOXIC	6.1	III		-

PG* : Packing group

15 . Regulatory information

United States

HCS Classification : Toxic material
Corrosive material
Sensitizing material
Carcinogen
Target organ effects

U.S. Federal regulations : **United States inventory (TSCA 8b):** All components are listed or exempted.

SARA 302/304/311/312 extremely hazardous substances : Proprietary Amine
SARA 302/304 emergency planning and notification : Proprietary Amine
SARA 302/304/311/312 hazardous chemicals : Copper sulphate pentahydrate; Proprietary Amine
SARA 311/312 MSDS distribution - chemical inventory - hazard identification : Copper sulphate pentahydrate: Immediate (acute) health hazard, Delayed (chronic) health hazard; Proprietary Amine: Fire hazard, Immediate (acute) health hazard, Delayed (chronic) health hazard

Clean Water Act (CWA) 307: Copper sulphate pentahydrate

Clean Water Act (CWA) 311: Copper sulphate pentahydrate; Proprietary Amine; Proprietary Acid

Clean Air Act (CAA) 112 accidental release prevention : Proprietary Amine

Clean Air Act (CAA) 112 regulated flammable substances : No products were found.

Clean Air Act (CAA) 112 regulated toxic substances : Proprietary Amine

SARA 313

	Product name	CAS number	Concentration
Form R - Reporting requirements	: Copper sulphate pentahydrate	7758-98-7	30 - 60
Supplier notification	: Copper sulphate pentahydrate	7758-98-7	30 - 60

SARA 313 notifications must not be detached from the MSDS and any copying and redistribution of the MSDS shall include copying and redistribution of the notice attached to copies of the MSDS subsequently redistributed.

State regulations : **Connecticut Carcinogen Reporting:** None of the components are listed.
Connecticut Hazardous Material Survey: None of the components are listed.
Florida substances: None of the components are listed.
Illinois Chemical Safety Act: None of the components are listed.
Illinois Toxic Substances Disclosure to Employee Act: None of the components are listed.
Louisiana Reporting: None of the components are listed.
Louisiana Spill: None of the components are listed.
Massachusetts Spill: None of the components are listed.
Massachusetts Substances: The following components are listed: Copper sulphate pentahydrate; Proprietary Amine
Michigan Critical Material: None of the components are listed.
Minnesota Hazardous Substances: None of the components are listed.
New Jersey Hazardous Substances: The following components are listed: Copper sulphate pentahydrate; Proprietary Amine; Proprietary Acid
New Jersey Spill: None of the components are listed.
New Jersey Toxic Catastrophe Prevention Act: None of the components are listed.
New York Acutely Hazardous Substances: The following components are listed: Copper sulphate pentahydrate; Proprietary Amine; Proprietary Acid
New York Toxic Chemical Release Reporting: None of the components are listed.
Pennsylvania RTK Hazardous Substances: The following components are listed: Copper sulphate pentahydrate; Proprietary Amine; Proprietary Acid
Rhode Island Hazardous Substances: None of the components are listed.

California Prop. 65 : **WARNING:** This product contains a chemical known to the State of California to cause cancer.

Ingredient name	Cancer	Reproductive	No significant risk level	Maximum acceptable dosage level
Sulfuric acid	Yes.	No.	No.	No.

International regulations

International lists : This product, (and its ingredients) is (are) listed on national inventories, or is (are) exempted from being listed, in Australia (AICS), in Europe (EINECS/ELINCS), in Korea (TCCL), in Japan (METI), in the Philippines (RA6969).

16 . Other information

Label requirements : **CAUSES RESPIRATORY TRACT, EYE AND SKIN BURNS. MAY CAUSE SEVERE ALLERGIC RESPIRATORY AND SKIN REACTION. HARMFUL IF SWALLOWED. CONTAINS MATERIAL THAT CAN CAUSE TARGET ORGAN DAMAGE. CANCER HAZARD - CONTAINS MATERIAL WHICH CAN CAUSE CANCER.**

Hazardous Material Information System (U.S.A.) :

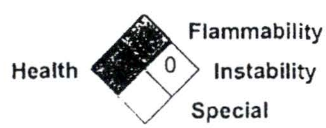
Health	*	3
Fire hazard		0
Physical Hazard		0
Personal protection		G

HAZARD RATINGS

4- Extreme
3- Serious
2- Moderate
1- Slight
0- Minimal
See section 8 for more detailed information on personal protection.

The customer is responsible for determining the PPE code for this material.

National Fire Protection Association (U.S.A.) :



References : ANSI Z400.1, MSDS Standard, 2004. - Manufacturer's Material Safety Data Sheet. - 29CFR Part1910.1200 OSHA MSDS Requirements. - 49CFR Table List of Hazardous Materials, UN#, Proper Shipping Names, PG.

Date of issue : 03/15/2009

Version : 1

Notice to reader

To the best of our knowledge, the information contained herein is accurate. However, neither the above named supplier nor any of its subsidiaries assumes any liability whatsoever for the accuracy or completeness of the information contained herein. Final determination of suitability of any material is the sole responsibility of the user. All materials may present unknown hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards that exist. The data in this MSDS relates only to the specific material designated herein. Possible adverse effects (see Section 2, 11 and 12) may occur if this material is not handled in the recommended manner.

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MATERIAL SAFETY DATA SHEET

AB Navigate

1. Product And Company Identification

Supplier	**Manufacturer**
Applied Biochemists (WI) **A division of Advantis Technologies, Inc.** **W175 N11163 Stonewood Drive, Suite 234** **Germantown, WI 53022**	**Advantis Technologies, Inc.** **1400 Bluegrass Lakes Parkway** **Alpharetta, GA 30004 United States**
Telephone Number: (262) 255-4449 FAX Number: (262) 255-4268 Web Site: www.appliedbiochemists.com	Telephone Number: (770) 521-5999 FAX Number: (770) 521-5959 Web Site: www.poolspacare.com
Supplier Emergency Contacts & Phone Number **CHEMTREC - DAY OR NIGHT: (800) 424-9300**	**Manufacturer Emergency Contacts & Phone Number** **CHEMTREC - DAY OR NIGHT: (800) 424-9300**

Issue Date: 02/15/2007

Product Name: AB Navigate
Chemical Name: 2,4-D: 2,4-Dichlorophenoxyacetic Acid, Butoxyethyl Ester
CAS Number: Not Established
Chemical Family: Aquatic Herbicide
MSDS Number: 379

2. Composition/Information On Ingredients

Ingredient Name	CAS Number		Percent Of Total Weight
2-BUTOXYETHYL-2,4-DICHLOROPHENOXYACETATE	1929-73-3		
CRYSTALLINE SILICA	14808-60-7		

Ingredients listed in this section have been determined to be hazardous as defined in 29CFR 1910.1200. Materials determined to be health hazards are listed if they comprise 1% or more of the composition. Materials identified as carcinogens are listed if they comprise 0.1% or more of the composition. Information on proprietary materials is available in 29CFR 1910.1200(i)(1).

EMERGENCY OVERVIEW

Harmful if swallowed, inhaled, or absorbed throught the skin. It is anticipated to be slightly to moderately toxic if swallowed and slightly toxic if inhaled.

3. Hazards Identification

Eye Hazards
Causes eye irritation.

Skin Hazards
May be irritating to skin.

Ingestion Hazards
It is anticipated to be slightly to moderately toxic if swallowed.

Inhalation Hazards
It is anticipated to be slightly toxic if inhaled.

Chronic/Carcinogenicity Effects
This product contains clay. IARC has classified cystalline silica (a component of clay) as a probably human carcinogen. Prolonged contact may cause lover damage, kidney damage, and/or chronic muscle damage.

Signs And Symptoms
Repeated and prolonged inhalation of this material may cause a form of disabling lung disease (commonly known as

3. Hazards Identification - Continued

Signs And Symptoms - Continued

silicosis). Clinical signs and symptoms fo silicosis include cough, shortness of breath, wheezing and impairment of lung function. Impairment of lung function may be progressive. In the usual case of silicosis, there is a slow deterioration of capacity for physical effort, decreased chest expansion, and an increased susceptibility to tuberculosis and other respiratory infections. Short term, extrememly heavy exposure to dust of this material (particularly small sized particles) can result in acute silicosis. Individuals with acute silicosis may suffer an abrupt onset of violent coughing, labored breathing, and weight loss; death has been known to occu within one to two years

Conditions Aggravated By Exposure

None known.

First Aid (Pictograms)

4. First Aid Measures

Eye

In case of contact, hold eyelids apart and immediately flush eyes with plenty of water for at least 15 minutes. Get medical attention immediately if irritation develops and persists.

Skin

In case of contact, immediately flush skin with soap and plenty of water. Get medical attention immediately if irritation (redness, rash, blistering) develops and persists.

Ingestion

Call a physician or a poison control center immediately. Drink 1 or 2 glasses of water and induce vomiting. Never give anything by mouth to an unconscious victim.

Inhalation

If inhaled, remove to fresh air. If not breathing, give artificial respiration.

Fire Fighting (Pictograms)

5. Fire Fighting Measures

Flammability Class: Not flammable

Fire And Explosion Hazards

Thermal decomposition products include oxides of carbon, sulfur dioxides and hydrochloric acid.

Extinguishing Media

Water fog, carbon dioxide, dry chemical, or foam.

Fire Fighting Instructions

Firefighters should wear self-contained breathing apparatus and full protective gear. Dike to prevent contamination of water sources.

6. Accidental Release Measures

Clean up spill immediately. Use appropriate containers to avoid environmental contamination. Prevent release to the environment. Do not flush area with water as it can cause contamination of sewer system.

MATERIAL SAFETY DATA SHEET

AB Navigate

Handling & Storage (Pictograms)

7. Handling And Storage

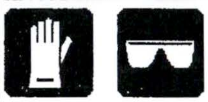
Handling And Storage Precautions

Do not swallow, breath dust, store near food, contaminate water, food, or feed, apply to waters used for irrigation, agricultural sprays, watering dairy animals or domestic water supplies. **Keep out of reach of children.**

Handling Precautions

Wash hands before eating, drinking, or smoking.

Protective Clothing (Pictograms)



8. Exposure Controls/Personal Protection

Engineering Controls

Not normally required.

Eye/Face Protection

Safety glasses or splash goggles.

Skin Protection

Wear protective clothing to minimize contact. Wear chemical resistant gloves.

Respiratory Protection

Not normally required. If needed, use NIOSH approved respirator for dusts.

Other/General Protection

Use safe chemical handling procedures suitable for the hazards presented by this material.

9. Physical And Chemical Properties

Appearance

Gray/Tan granules.

Odor

Mild, phenolic odor.

Chemical Type: Mixture
Physical State: Solid
Percent Volitales: Not Determined
Packing Density: Not Determined
Solubility: Insoluble
Evaporation Rate: Not Determined

10. Stability And Reactivity

Stability: Stable
Hazardous Polymerization: Will not occur

Conditions To Avoid (Stability)

None known.

MATERIAL SAFETY DATA SHEET

AB Navigate

10. Stability And Reactivity - Continued

Incompatible Materials

Acids, bases, and oxidizers.

Hazardous Decomposition Products

Thermal decomposition products include oxides of carbon, sulfur dioxides and hydrochloric acid.

11. Toxicological Information

Acute Studies

None available.

12. Ecological Information

Ecotoxicological Information

None available.

13. Disposal Considerations

Dispose in accordance with applicable federal, state and local government regulations. RQ for 2-Butoxyethy 2,4-dichlorophenoxy acetate (CAS# 1929-73-3) is 100 lbs.

14. Transport Information

Proper Shipping Name

Not regulated

Hazard Class

Not regulated

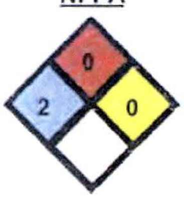
DOT Identification Number

NONE

15. Regulatory Information

No Data Available...

NFPA



HMIS

HEALTH	2
FLAMMABILITY	0
REACTIVITY	0
PERSONAL PROTECTION	F

16. Other Information

Revision/Preparer Information

MSDS Preparer: JHW

Disclaimer

Although reasonable care has been taken in the preparation of this document, we extend no warranties and make no representations as to the accuracy or completeness of the information contained therein, and assume no responsibility regarding the suitablility of this information for the user's intended purposes or for the consequences of its use. Each individual should make a determination as to the suitability of the information for their particular purposes(s).

Applied Biochemists (WI)

MATERIAL SAFETY DATA SHEET
North American Version

PAK™27 Algaecide

It is a violation of State and Federal law to use this product in a manner inconsistent with its labeling. The labeling must be in possession of the user at the time of pesticide use or application.

1. PRODUCT AND COMPANY IDENTIFICATION

1.1. Identification of the substance/preparation

Product Name	:	PAK™27 Algaecide
Chemical Name	:	Sodium carbonate peroxyhydrate
Synonyms	:	Sodium Percarbonate, PCS, Sodium Carbonate Peroxide, PAK™27
Chemical Formula	:	$2Na_2CO_3 \cdot 3H_2O_2$
Molecular Weight	:	314.06 g/mol
CAS Number	:	15630-89-4
Grades/Trade Names	:	PAK™27 Algaecide

1.2. Use of the Substance/Preparation

Recommended use : End-use Algaecide (pesticide)
- Use in accordance with label instructions
- EPA Reg. # 68660-9

1.3. Company/Undertaking Identification

Address : Solvay Chemicals, Inc.
PO BOX 27328 Houston, TX 77227-7328
3333 Richmond Ave. Houston, Texas 77098

1.4. Emergency telephone numbers

General: 1-800-765-8292 (Solvay Chemicals, Inc.,)
All Emergencies (USA): 1-800-424-9300 (CHEMTREC•)
Transportation Emergencies (INTERNATIONAL/MARITIME): 1-703-527-3887 (CHEMTREC•)
Transportation Emergencies (CANADA): 1-613-996-6666 (CANUTEC)
Transportation Emergencies (MEXICO-SETIQ): 01-800-00-214-00 (MEX. REPUBLIC)
525-559-1588 (Mexico City and metro area)

2. HAZARDS IDENTIFICATION

2.1. Emergency Overview:

General Information

Appearance	:	Granular solid
Color	:	White
Odor	:	Odorless/odorless

Main effects
- Irritating to mucous membranes, eyes and skin.
- Risk of serious damage to eyes.

2.2. Potential Health Effects:

Inhalation

Solvay Chemicals

SOLVAY

- Nose and throat irritation.
- At high concentrations, cough.
- In case of repeated or prolonged exposure: risk of sore throat, nose bleeds, chronic bronchitis.

Eye contact
- Severe eye irritation, watering and redness.
- Risk of serious or permanent eye lesions.

Skin contact
- Slight irritation
- In case of repeated contact: risk of dermatitis.

Ingestion
- Severe irritation of the mouth, throat, esophagus and stomach.
- Bloating of stomach, belching.
- Nausea, vomiting and diarrhea.

Other toxicity effects
See section 11: Toxicological Information

2.3. Environmental Effects:
See section 12: Ecological Information

3. COMPOSITION OF/INFORMATION ON INGREDIENTS

Sodium Carbonate Peroxyhydrate		
CAS-No.	:	15630-89-4
Concentration	:	> 85.0 %
Sodium Carbonate		
CAS-No.	:	497-19-8
Concentration	:	ca. 13 %
Sodium Metasilicate		
CAS-No.	:	6843-92-0
Concentration	:	ca. 1.5 %
Sodium Chloride		
CAS-No.	:	7647-14-5
Concentration	:	ca. 1 %

Note: Oxyper S141 and S142 may contain up to 0.5% Boron.

4. FIRST AID MEASURES

4.1. Inhalation
- Remove the subject from dusty environment and let him blow his nose.
- Consult with a physician in case of respiratory symptoms.

4.2. Eye contact
- Flush eyes as soon as possible with running water for 15 minutes, while keeping the eyelids wide open.
- In the case of difficulty of opening the lids, administer and analgesic eye wash (oxyburprocaine).
- Consult with an ophthalmologist immediately in all cases.

4.3. Skin contact
- Wash the affected skin with running water.
- Clean clothing
- Consult with a physician in case of persistent pain or redness.

4.4. Ingestion

The following actions are recommended:
- Consult with a physician in all cases.

If victim is conscious:
- Rinse mouth and administer fresh water.
- Do not induce vomiting.

If victim is unconscious but breathing:
- Not applicable

5. FIRE-FIGHTING MEASURES

5.1. Suitable extinguishing media
- Large quantities of water, water spray.
- In case of fire in close proximity, all means of extinguishing are acceptable (subject to section below).

5.2. Extinguishing media which must not be used for safety reasons
- No restrictions.

5.3. Special exposure hazards in a fire
- Oxidizer (see section 9).
- Oxygen released on exothermic decomposition may support combustion in case of surrounding fire.
- Pressure burst may occur due to decomposition in confined spaces/containers.
- Do not spray the dry product with water, except in case of fire.
- Wet product decomposes exothermically and may cause combustion of organic materials.

5.4. Special protective equipment for fire-fighters
- When intervention in close proximity, wear acid resistant over suit.

5.5. Other Information
- If safe to do so, remove the exposed containers.

6. ACCIDENTAL RELEASE MEASURES

6.1. Personal precautions
- Follow the protective measures given in sections 5 and 8.
- Keep away materials and products which are incompatible with the product (see section 10).
- Avoid direct contact of the product with water.

6.2. Environmental precautions
- Prevent discharges into the environment (sewers, rivers, soils, etc.).
- Immediately notify the appropriate authorities in case of significant discharge.

6.3. Methods for cleaning up
- Collect the product with suitable means avoiding dust formation.
- All receiving equipment should be clean, vented, dry, labeled and made of material that is compatible with the product.
- Because of the contamination risk, the collected material should be isolated in a safe place.
- Clean the area with large quantities of water.
- For disposal methods, refer to section 13.

7. HANDLING AND STORAGE

7.1. Handling
- Clean and dry piping circuits and equipment before any operations.
- Never return unused product to storage container.
- Keep away from incompatible products.
- Containers and equipment used to handle the product should be used exclusively for that product.
- Avoid any contact with water of humidity.

- For more information, consult the supplier.

Storage

- Keep in a dry place.
- Keep away from direct sunlight.
- Keep away from heat.
- Keep away from incompatible products
- Keep in container fitted with safety valve or vent.
- The container must be used exclusively for the product.
- Keep only in the original container at temperature not exceeding 40°C (104°F).

7.2. Packaging material

- Stainless steel
- Polyethylene
- Paper + PE coating.
- Glass
- Passivated aluminum

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

8.1 Exposure Limit Values	TLV® ACGIH® USA	OSHA PEL	SAEL
Sodium Carbonate Peroxyhydrate			5 mg/m^3
Particles not otherwise classified (PNOC)	3 mg/m^3 resp. dust 10 mg/m^3 inhalable dust	5 mg/m^3 resp. dust 15 mg/m^3 inhalable dust	

ACGIH® and TLV® are registered trademarks of the American Conference of Governmental Industrial Hygienists
SAEL is Solvay Acceptable Exposure Limit, Time Weighted Average for 8 hour workdays. No specific TLV-STEL (Short Term Exposure Level) has been set. Excursions in exposure level may exceed 3 times the TLV-TWA for no more than a total of 30 minutes during a workday and under no circumstances should they exceed 5 times the TLV-TWA.

8.2. Engineering controls

- Ensure adequate ventilation.
- Provide appropriate local ventilation for the emission risk.
- Refer to protective measures listed in section 7.

8.3. Personal protective equipment

8.3.1. Respiratory protection

- In case of dust clouds/fog/fumes, face mask with appropriate cartridge.

8.3.2. Hand protection

- Wear protective gloves.
- Recommended materials: PVC, neoprene, rubber

8.3.3. Eye protection

- Dust proof goggles, if very dusty.

8.3.4. Skin and body protection

- Wear suitable protective clothing.

8.3.5. Hygiene measures

- Shower and eye wash stations.
- Handle in accordance with good industrial hygiene and safety practice.
- Consult the industrial hygienist or the safety manager for the selection of personal protective equipment suitable for the working conditions.

9. PHYSICAL AND CHEMICAL PROPERTIES

9.1. General Information

Appearance	:	Granular solid
Color	:	White
Odor	:	Odorless

9.2. Important Health Safety and Environmental Information

pH	:	*From 10.4 – 10.6* *Concentration:* 1% solution
Boiling point/range	:	Remarks: Not applicable
Flash point	:	Remarks: Not applicable
Flammability (solid, gas)	:	Lower explosion limit: Remarks: Not applicable
Explosive properties	:	Remarks: Non-explosive
Oxidizing properties	:	Remarks: Oxidizer
Vapor pressure	:	Remarks: Not applicable
Relative density / Density	:	Remarks: No data
Partition coefficient (n-octanol/water)	:	Remarks: Not applicable
Viscosity	:	Remarks: Not applicable
Vapor density	:	Remarks: Not applicable
Bulk density	:	0.95-1.2 kg/m^3
Solubility	:	Water: 150 g/l *Temperature*: 20°C (68°F) Water: 175 g/l *Temperature*: 30°C (86°F)

9.3 Other information

Melting point/range	:	Remarks: Not applicable (before melting)
Decomposition temperature	:	Remarks: Self-accelerating decomposition with oxygen release starting from 50°C (122°F)

10. STABILITY AND REACTIVITY

10.1. Stability

- Potential for exothermic hazard.
- Stable under certain conditions with slow gas release.

10.2. Conditions to avoid

- Heat.
- Exposure to moisture.

10.3. Materials to avoid

- Water

- Acids
- Bases
- Heavy metal salts
- Reducing agents
- Organic materials
- Flammable materials

10.4. Hazardous decomposition products

- Oxygen

11. TOXICOLOGICAL INFORMATION

11.1 Toxicological data

Acute oral toxicity

- LD50, rat, 1,034 mg/kg

Acute inhalation toxicity

- LC0, 1 h, rat, > 4,580 mg/m3

Acute dermal irritation/corrosion

- LD lo, rabbit, > 2,000 mg/kg

Skin irritation

- rabbit, slightly irritant (skin)

Eye irritation

- rabbit, Risk of serious damage to eyes.

Sensitization

- No data

Chronic toxicity

- No data available

Remarks

- Harmful if swallowed.
- Risk of serious damage to eyes.

11.2 Chronic toxicity/ Carcinogenic Designation:

- None

12. ECOLOGICAL INFORMATION

12.1. Ecotoxicity effects

Acute toxicity

- Fishes, Pimephales promelas, LC50, 71 mg/l
- Fishes, Pimephales promelas, NOEC, 96 h, 7.4 mg/l
- Crustaceans, Daphnia pulex, EC50, 4.9 mg/l
- Crustaceans, Daphnia pulex, NOEC, 48 h, 2 mg/l

12.2. Mobility

- Air
  Remarks: not applicable
- Water
  Remarks: considerable solubility and mobility
- Soil/sediments, landfill leachate
  Remarks: non-significant adsorption

12.3. Persistence and degradability

Abiotic degradation

- Air
  Result: not applicable

- Soil, Hydrolysis
- Water
  Result: significant hydrolysis
  Degradation products: Sodium carbonate / carbonic acid/bicarbonate/carbonate / hydrogen peroxide (bio)degradable
-

Biodegradation
- Aerobic/anaerobic
  Remarks: no data available

12.4. Bioaccumulative potential
- Result: Does not bioaccumulate.

12.5. Remarks
- Toxic to aquatic organisms.
- Hazard for the aquatic environment is limited due to product properties:
- Does not bioaccumulate.
- abiotic degradability.
- low toxicity of degradation products.

13. DISPOSAL CONSIDERATIONS

13.1 Waste treatment: Sodium Percarbonate (sodium carbonate peroxyhydrate) is not a listed hazardous waste under 40 CFR 261. However, state and local regulations for waste disposal may be more restrictive. Spilled product should be disposed of in an EPA approved disposal facility in accordance with applicable national, state and local environmental laws and regulations.

13.2 Packaging treatment: To avoid treatment, use dedicated containers where possible. Rinse the empty containers and treat the effluent in the same way as waste. Consult current federal, state and local regulations regarding the proper disposal of emptied containers.

13.3 RCRA Hazardous Waste: D001 (ignitable)

14. TRANSPORT INFORMATION

Mode	DOT	IMDG	IATA
UN Number	3378	3378	3378
Class (Subsidiary)	5.1	5.1	5.1
Proper Shipping Name	Sodium Carbonate peroxyhydrate	Sodium Carbonate peroxyhydrate	Sodium Carbonate peroxyhydrate
Packing Group	III	III	III
Marine Pollutant	No	No	No
Hazard Label	Oxidizer (5.1)	Oxidizing Agent	Oxidizer
Placard	Oxidizer (5.1)	3378	Oxidizer
Emergency Information	ERG 140	EmS F-A; S-P	ERG Code 5L
Other	Consult with manufacturer before transporting in bulk		

15. REGULATORY INFORMATION

15.1 National Regulations (US)

TSCA Inventory 8(b): Yes

SARA Title III Sec. 302/303 Extremely Hazardous Substances (40 CFR355): No

SARA Title III Sec. 311/312 (40 CFR 370): Yes
Hazard Category: • Fire hazard
• Threshold planning quantity – 10,000 lbs.

SARA Title III Sec. 313 Toxic Chemical Emissions Reporting (40 CFR 372): No

CERCLA Hazardous Substance (40CFR Part 302)
Listed: No
Unlisted Substance: Yes, Reportable quantity 100 lbs.
Characteristic: D001 (Ignitability)

State Component Listing:

State	List
NJ	Right to Know Substance List

15.2 National Regulations (Canada):

Canadian NSN Registration: DSL

WHMIS Classification: **C** Oxidizing Material
D2B Poisonous and infectious material – other toxic effects.

This product has been classified in accordance with the hazard criteria of the ***Controlled Products Regulations*** and the MSDS contains all the information required by the ***Controlled Products Regulations.***

15.3 National Regulations (Europe)

EINECS / ELINCS # :

Labeling according to Directive 67/548/EEC.
Name of dangerous products-

Symbol(s)	**O**	Oxidizing
	Xi	Irritant.
	R 8	Contact with combustible material may cause fire.
	22	Irritating to skin.
	41	Risk of serious damage to eyes.
	S 3	Keep in a cool place.
	8	Keep container dry.
	17	Keep away from combustible material.
	24/25	Avoid contact with skin and eyes.
	26	In case of contact with eyes, rinse immediately with plenty of water and seek medical advice.

16. OTHER INFORMATION

16.1 Ratings:

NFPA (NATIONAL FIRE PROTECTION ASSOCIATION)
Health = 2 Fire = 0 Instability = 1 Special = OX

HMIS (HAZARDOUS MATERIAL INFORMATION SYSTEM)
Health = 2 Fire = 0 Reactivity = 1 PPE = Supplied by User; dependent on local conditions

16.2 Other Information:

To our actual knowledge, the information contained herein is accurate as of the date of this document. However, neither Solvay Chemicals, Inc., nor any of its affiliates makes any warranty, express or implied, or accepts any liability in connection with this information or its use. This information is for use by technically skilled persons at their own discretion and risk and does not relate to the use of this product in combination with any other substance or any other process. This is not a license under any patent or other proprietary right. The user alone must finally determine suitability of any information or material for any contemplated use, the manner of use and whether any patents are infringed. This information gives typical properties only and is not to be used for specification purposes. Solvay Chemicals, Inc. reserves the right to make additions, deletions or modifications to the information at any time without prior notification.

Material Safety Data Sheets contain country specific regulatory information; therefore, this MSDS is for use only by customers of Solvay Chemicals Inc. in the United States of America and, if specifically indicated, Canada and Mexico. If the user is located in a country other than the United States, please contact the Solvay Company serving your country for MSDS information applicable to your region.

The previous information is based upon our current knowledge and experience of our product and is not exhaustive. It applies to the product as defined by the specifications. In case of combinations of mixtures, one must confirm that no new hazards are likely to exist. In any case, the user is not exempt from observing all legal, administrative and regulatory procedures relating to the product, personal hygiene, and integrity of the work environment. (Unless noted to the contrary, the technical information applies only to pure product).

TRADEMARKS: All trade name of products referenced herein are either trademarks or registered trademarks of Solvay Chemicals, Inc. or its affiliates, unless otherwise identified.

16.3 Reason for revision:
Supersedes edition: Solvay Chemicals, Inc. MSDS PAK27-0105 dated: 03-10-05
Purpose of revision: Periodic review and update

syngenta

MATERIAL SAFETY DATA SHEET

Syngenta Crop Protection, Inc.
Post Office Box 18300
Greensboro, NC 27419

In Case of Emergency, Call
1-800-888-8372

1. PRODUCT IDENTIFICATION

Product Name:	**REWARD LANDSCAPE AND AQUATIC HERBICIDE**	Product No.:	A12872A
EPA Signal Word:	Warning		
Active Ingredient(%):	Diquat dibromide (37.3%)	CAS No.:	85-00-7
Chemical Name:	[6,7-dihydrodipyrido(1,2-a:2',1'-c)pyrazinediium dibromide]		
Chemical Class:	Bipyridilium (dipyridilium) contact herbicide		

EPA Registration Number(s): 100-1091 (formerly 10182-404) **Section(s) Revised: All sections**

2. COMPOSITION/INFORMATION ON INGREDIENTS

Material	OSHA PEL	ACGIH TLV	Other	NTP/IARC/OSHA Carcinogen
Diquat dibromide (37.3%)	Not Established	0.5 mg/m³ TWA (total dust); 0.08 mg/m³ TWA (respirable dust)	0.5 mg/m³ TWA**	No

** recommended by NIOSH

Ingredients not precisely identified are proprietary or non-hazardous. Values are not product specifications.

3. HAZARDS IDENTIFICATION

Symptoms of Acute Exposure

Harmful if inhaled or swallowed. Dust, mist or vapor irritating to eyes and respiratory tract. May cause skin irritation.

Hazardous Decomposition Products

Can decompose at high temperatures forming toxic gases.
Flammable hydrogen gas may be formed on contact with aluminum. See "Conditions to Avoid", Section 10.

Physical Properties

Appearance: Dark brown liquid
Odor: Odorless

Unusual Fire, Explosion and Reactivity Hazards

This product may form flammable and explosive hydrogen gas when in contact with aluminum.

4. FIRST AID MEASURES

Have the product container, label or Material Safety Data Sheet with you when calling Syngenta (800-888-8372), a poison contol center or doctor, or going for treatment.

Ingestion: If swallowed: Call Syngenta (800-888-8372), a poison control center or doctor immediately for treatment advice. Have the person sip a glass of water if able to swallow. Do not induce vomiting unless told to do so after calling 800-888-8372 or by a poison control center or doctor. Do not give anything by mouth to an unconscious person.

Eye Contact: If in eyes: Hold eye open and rinse slowly and gently with water for 15-20 minutes. Remove contact lenses, if present, after 5 minutes, then continue rinsing eye. Call Syngenta (800-888-8372), a poison control center or doctor for treatment advice.

Skin Contact: If on skin or clothing: Take off contaminated clothing. Rinse skin immediately with plenty of water for 15-20 minutes. Call Syngenta (800-888-8372), a poison control center or doctor for treatment advice.

Inhalation: If inhaled: Move person to fresh air. If person is not breathing, call 911 or an ambulance, then give artificial respiration, preferably mouth-to-mouth if possible. Call Syngenta (800-888-8372), a poison control center or doctor for further treatment advice.

Notes to Physician

There is no specific antidote if this product is ingested.

Treat symptomatically.

Medical Condition Likely to be Aggravated by Exposure

None known.

5. FIRE FIGHTING MEASURES

Fire and Explosion

Flash Point (Test Method):	Not Applicable	
Flammable Limits (% in Air):	Lower: % Not Applicable	Upper: % Not Applicable
Autoignition Temperature:	Not Applicable	
Flammability:	Not Applicable	

Unusual Fire, Explosion and Reactivity Hazards

This product may form flammable and explosive hydrogen gas when in contact with aluminum.

In Case of Fire

Use dry chemical, foam or CO2 extinguishing media. Wear full protective clothing and self-contained breathing apparatus. Evacuate nonessential personnel from the area to prevent human exposure to fire, smoke, fumes or products of combustion. Prevent use of contaminated buildings, area, and equipment until decontaminated. Water runoff can cause environmental damage. If water is used to fight fire, dike and collect runoff.

6. ACCIDENTAL RELEASE MEASURES

In Case of Spill or Leak

Control the spill at its source. Contain the spill to prevent it from spreading, contaminating soil, or entering sewage and drainage systems or any body of water. Clean up spills immediately, observing precautions outlined in Section 8. If a solid, sweep up material and place in a compatible disposal container. If a liquid, cover entire spill with absorbing material and place into compatible disposal container. Scrub area with hard water detergent (e.g. commercial products such as Tide, Joy, Spic and Span). Pick up wash liquid with additional absorbent and place into compatible disposal container. Once all material is cleaned up and placed in a disposal container, seal container and arrange for disposition.

7. HANDLING AND STORAGE

This product reacts with aluminum to produce flammable hydrogen gas. Do not mix or store in containers or systems made of aluminum or having aluminum fittings.

Store the material in a well-ventilated, secure area out of reach of children and domestic animals. Do not store food, beverages or tobacco products in the storage area. Prevent eating, drinking, tobacco use, and cosmetic application in areas where there is a potential for exposure to the material. Wash thoroughly with soap and water after handling.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

THE FOLLOWING RECOMMENDATIONS FOR EXPOSURE CONTROLS/PERSONAL PROTECTION ARE INTENDED FOR THE MANUFACTURE, FORMULATION AND PACKAGING OF THE PRODUCT.

FOR COMMERCIAL APPLICATIONS AND ON-FARM APPLICATIONS CONSULT THE PRODUCT LABEL.

Ingestion: Prevent eating, drinking, tobacco usage and cosmetic application in areas where there is a potential for exposure to the material. Wash thoroughly with soap and water after handling.

Eye Contact:	Where eye contact is likely, use chemical splash goggles. Facilities storing or utilizing this material should be equipped with an eyewash facility and a safety shower.
Skin Contact:	Where contact is likely, wear chemical-resistant (such as nitrile or butyl) gloves, coveralls, socks and chemical-resistant footwear. For overhead exposure, wear chemical-resistant headgear.
Inhalation:	Use process enclosures, local exhaust ventilation, or other engineering controls to keep airborne levels below exposure limits. A NIOSH-certified combination air-purifying respirator with an N, P or R 95 or HE class filter and an organic vapor cartridge may be permissible under certain circumstances where airborne concentrations are expected to exceed exposure limits. Protection provided by air-purifying respirators is limited. Use a pressure demand atmosphere-supplying respirator if there is any potential for uncontrolled release, exposure levels are not known, or under any other circumstances where air-purifying respirators may not provide adequate protection.

9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance:	Dark brown liquid
Odor:	Odorless
Melting Point:	Not Available
Boiling Point:	Not Available
Specific Gravity/Density:	1.20 g/mL @ 68°F (20°C)
pH:	4-6

Solubility in H2O

Diquat dibromide: 718,000 mg/L @ 68°F (20°C) and pH 7.2

Vapor Pressure

Diquat dibromide: <10(-8) mmHg @ 77°F (25°C)

10. STABILITY AND REACTIVITY

Stability:	Stable under normal use and storage conditions.
Hazardous Polymerization:	Will not occur.
Conditions to Avoid:	Concentrate should not be stored in aluminum containers. Spray solutions should not be mixed, stored or applied in containers other than plastic, plastic-lined steel, stainless steel or fiberglass.
Materials to Avoid:	Strong alkalis and anionic wetting agents (e.g., alkyl and alkylaryl sulfonates). Corrosive to aluminum.
Hazardous Decomposition Products:	Can decompose at high temperatures forming toxic gases. Flammable hydrogen gas may be formed on contact with aluminum. See "Conditions to Avoid", Section 10.

11. TOXICOLOGICAL INFORMATION

Acute Toxicity/Irritation Studies (Finished Product)

Ingestion:	Slightly Toxic	
	Oral (LD50 Rat) :	= 600 mg/kg body weight
Dermal:	Moderately Toxic	
	Dermal (LD50 Rabbit) :	= 260 mg/kg body weight
Inhalation:	Moderately Toxic	
	Inhalation (LC50 Rat) :	= 0.121 mg/l air - 4 hours
Eye Contact:	Irritant	
Skin Contact:	Not Available	
Skin Sensitization:	Not Available	

Neurotoxicity

Diquat dibromide: No evidence for neurotoxic effects in rats dosed up to 400 ppm ion in the diet for 13 weeks.

Reproductive Effects

Diquat dibromide: Mutagenicity: No evidence in in vivo assays.

Development Toxicity: In rabbit studies a small percentage of fetuses had minor defects at 3 and 10 mg ion/kg/d.

Chronic/Subchronic Toxicity Studies

Diquat dibromide: Kidney weight decreases and cataracts seen in dogs at 12.5 mg ion/kg/d.

Carcinogenicity

Diquat dibromide: No evidence of carcinogenicity in rat and mouse studies.

Other Toxicity Information

None.

Toxicity of Other Components

Not Applicable

Target Organs

Active Ingredients

Diquat dibromide: Eye, kidney

Inert Ingredients

: Not Applicable

12. ECOLOGICAL INFORMATION

Summary of Effects

Diquat dibromide:

This material is toxic to fish and wildlife.

Eco-Acute Toxicity

Diquat dibromide: Rainbow Trout 96-hour LC50 21 mg/L

Mirror Carp 96 hours LC50 67 mg/L

Eco-Chronic Toxicity

Diquat dibromide: Not Available

Environmental Fate

Diquat dibromide:

No data available for the formulation. The information presented here is for the active ingredient, diquat debromide.
Sorption: Extremely tightly adsorbed to (negatively-charged) soil particles due to its dicationic nature. Diquat is primarily adsorbed to clay, less so to OM. Diquat bound to soil is unavailable for plant uptake and is largely unavailable to soil microbes.
Koc: Average is 1,000,000 mL/g (estimated).
Photodegradation: Losses probably occur on sprayed leaf surfaces and on dead and decaying vegetation. Photochemical decomposition of diquat has been measured in the lab by irradiating thin layers of soil, but has not been unequivocally demonstrated under field conditions.
Other degradation: Certain microbe species in soil-less culture media decompose diquat. However, they degrade diquat bound to soil slowly or not at all.
Persistence: Typical half-life is 1000 d. Diquat is highly persistent due to strong binding to clay and unavailability to microbes. Diquat in soil is not taken up by plants, so any crop can be seeded at any time after application.
Mobility: Immobile in soil.
Volatilization: No losses.

13. DISPOSAL CONSIDERATIONS

Disposal

Do not reuse product containers. Dispose of product containers, waste containers, and residues according to local, state, and federal health and environmental regulations.

Characteristic Waste: Not Applicable

Listed Waste: Not Applicable

14. TRANSPORT INFORMATION

DOT Classification
Corrosive Liquid, N.O.S. (diquat dibromide, 37.3%), 8, UN1760, PGIII

B/L Freight Classification
Herbicides, NOIBN

Comments
International Transportation
Corrosive Liquid, N.O.S. (diquat dibromide, 37.3%), Class 8, UN1760, PGIII

15. REGULATORY INFORMATION

EPCRA SARA Title III Classification

Section 311/312 Hazard Classes:	Acute Health Hazard Chronic Health Hazard
Section 313 Toxic Chemicals:	Not Applicable

California Proposition 65
None

CERCLA/SARA 302 Reportable Quantity (RQ)
None

RCRA Hazardous Waste Classification (40 CFR 261)
Not Applicable

TSCA Status
Exempt from TSCA, subject to FIFRA

16. OTHER INFORMATION

NFPA Hazard Ratings		HMIS Hazard Ratings		
Health:	2	Health:	2	0 Minimal
Flammability:	1	Flammability:	1	1 Slight
Instability:	0	Reactivity:	0	2 Moderate
				3 Serious
				4 Extreme

For non-emergency questions about this product call:

1-800-334-9481

Original Issued Date: 04/11/2002
Revision Date: Replaces:

The information and recommendations contained herein are based upon data believed to be correct. However, no guarantee or warranty of any kind, expressed or implied, is made with respect to the information contained herein.

RSVP# : SCP-955-00349A

End of MSDS

MATERIAL SAFETY DATA SHEET

Dow AgroSciences

Emergency Phone: 800-992-5994
Dow AgroSciences LLC
Indianapolis, IN 46268

RODEO* HERBICIDE

Effective Date: 3/23/04
Product Code: 84825
MSDS: 006694

1. PRODUCT AND COMPANY IDENTIFICATION:

PRODUCT: Rodeo* Herbicide

COMPANY IDENTIFICATION:
Dow AgroSciences LLC
9330 Zionsville Road
Indianapolis, IN 46268-1189

2. COMPOSITION/INFORMATION ON INGREDIENTS:

Glyphosate IPA: N-(phosphono-methyl) glycine, Isopropylamine Salt	CAS # 038641-94-0	53.8%
Balance, Total		46.2%

3. HAZARDOUS IDENTIFICATIONS:

EMERGENCY OVERVIEW
Clear, pale yellow liquid. May cause eye irritation. Slightly toxic to aquatic organisms.
EMERGENCY PHONE NUMBER: 800-992-5994

4. FIRST AID:

EYE: Flush eyes thoroughly with water for several minutes. Remove contact lenses after initial 1-2 minutes and continue flushing for several additional minutes. If effects occur, consult a physician, preferably an ophthalmologist.

SKIN: Wash skin with plenty of water.

INGESTION: No emergency medical treatment necessary.

INHALATION: Remove person to fresh air; if effects occur, consult a physician.

NOTE TO PHYSICIAN: No specific antidote. Treatment of exposure should be directed at the control of symptoms and the clinical condition of the patient.

5. FIRE FIGHTING MEASURES:

FLASH POINT: >214°F (>101°C)
METHOD USED: Setaflash

FLAMMABLE LIMITS:
LFL: Not applicable
UFL: Not applicable

EXTINGUISHING MEDIA: Foam, CO_2, Dry Chemical

FIRE AND EXPLOSION HAZARDS: Foam fire extinguishing system is preferred because uncontrolled water can spread possible contamination. Toxic irritating gases may be formed under fire conditions.

FIRE-FIGHTING EQUIPMENT: Use positive-pressure, self-contained breathing apparatus and full protective equipment.

6. ACCIDENTAL RELEASE MEASURES:

ACTION TO TAKE FOR SPILLS: Absorb small spills with an inert absorbent material such as Hazorb, Zorball, sand, or dirt. Report large spills to Dow AgroSciences on 800-992-5994.

7. HANDLING AND STORAGE:

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE: Keep out of reach of children. Do not swallow. Avoid contact with eyes, skin, and clothing. Avoid breathing vapors and spray mist. Handle concentrate in ventilated area. Wash thoroughly with soap and water after handling and before eating, chewing gum, using tobacco, using the toilet or smoking. Keep away from food, feedstuffs, and water supplies. Store in original container with the lid tightly closed. Store above 10°F (-12°C) to keep from crystallizing.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION:

These precautions are suggested for conditions where the potential for exposure exists. Emergency conditions may require additional precautions.

EXPOSURE GUIDELINES: None established

ENGINEERING CONTROLS: Good general ventilation should be sufficient for most conditions. Local exhaust ventilation may be necessary for some operations.

RECOMMENDATIONS FOR MANUFACTURING, COMMERCIAL BLENDING, AND PACKAGING WORKERS:

EYE/FACE PROTECTION: Use safety glasses.

SKIN PROTECTION: No precautions other than clean body-covering clothing should be needed.

RESPIRATORY PROTECTION: For most conditions, no respiratory protection should be needed; however, if discomfort is experienced, use a NIOSH approved air-purifying respirator.

APPLICATIONS AND ALL OTHER HANDLERS: Please refer to the product label for personal protective clothing and equipment.

9. PHYSICAL AND CHEMICAL PROPERTIES:

APPEARANCE: Clear, pale yellow liquid
DENSITY: 10.0 - 10.5 lbs/gal
pH: 4.8 – 5.0
ODOR: None
SOLUBILITY IN WATER: Miscible
SPECIFIC GRAVITY: 1.21 gm/L
FREEZING POINT: -7°F - -10°F (-21°C - -25°C)

10. STABILITY AND REACTIVITY:

STABILITY: (CONDITIONS TO AVOID) Stable under normal storage conditions.

INCOMPATIBILITY: (SPECIFIC MATERIALS TO AVOID) Galvanized or unlined steel (except stainless steel) containers or spray tanks may produce hydrogen gas which may form a highly combustible gas mixture.

HAZARDOUS DECOMPOSITION PRODUCTS: None known.

HAZARDOUS POLYMERIZATION: Not known to occur.

11. TOXICOLOGICAL INFORMATION:

EYE: May cause slight temporary eye irritation. Corneal injury is unlikely.

SKIN: Essentially non-irritating to skin. Prolonged skin contact is unlikely to result in absorption of harmful amounts. The LD_{50} for skin absorption in rabbits is >5000 mg/kg. Did not cause allergic skin reactions when tested in guinea pigs.

INGESTION: Very low toxicity if swallowed. Harmful effects not anticipated from swallowing small amounts. The oral LD_{50} for rats is >5000 mg/kg.

INHALATION: Brief exposure (minutes) is not likely to cause adverse effects. The aerosol LC_{50} for rats is >6.37 mg/L for 4 hours.

SYSTEMIC (OTHER TARGET ORGAN) EFFECTS: For a similar material, glyphosate, in animals, effects have been reported on the following organ: liver.

CANCER INFORMATION: A similar material, glyphosate, did not cause cancer in laboratory animals.

TERATOLOGY (BIRTH DEFECTS): For glyphosate IPA, available data are inadequate for evaluation of potential to cause birth defects.

REPRODUCTIVE EFFECTS: For glyphosate IPA, available data are inadequate to determine effects on reproduction.

MUTAGENICITY: For a similar material, glyphosate, in-vitro and animal genetic toxicity studies were negative.

12. ECOLOGICAL INFORMATION:

ENVIRONMENTAL DATA:

ECOTOXICOLOGY:
Material is practically non-toxic to aquatic organisms on an acute basis (LC_{50} or EC_{50} is >100 mg/L in most sensitive species tested).
Acute LC_{50} for rainbow trout *(Oncorhynchus mykiss)* is >2500 mg/L.
Acute immobilization EC_{50} in water flea *(Daphnia magna)* is 918 mg/L.
Material is practically non-toxic to birds on an acute basis (LD_{50} is >2000 mg/kg).
Acute oral LD_{50} in bobwhite *(Colinus virginianus)* is >2000 mg/kg.
The LC_{50} in earthworm Eisenia foetida is >1000 mg/kg.
Acute contact LD_{50} in honey bee *(Apis mellifera)* is >100 µg/bee.
Acute oral LD_{50} in honey bee *(Apis mellifera)* is >100 µg/bee.
Growth inhibition EC_{50} in green alga *(Selenastrum capricornutum)* is 127 mg/L.
Growth inhibition EC_{50} in duckweed *(Lemna sp.)* is 24.4 mg/L.

13. DISPOSAL CONSIDERATIONS:

DISPOSAL METHOD: If wastes and/or containers cannot be disposed of according to the product label directions, disposal of this material must be in accordance with your local or area regulatory authorities.

MATERIAL SAFETY DATA SHEET

Emergency Phone: 800-992-5994
Dow AgroSciences LLC
Indianapolis, IN 46268

Dow AgroSciences

Effective Date: 3/23/04
Product Code: 84825
MSDS: 006694

RODEO* HERBICIDE

This information presented below only applies to the material as supplied. The identification based on characteristic(s) or listing may not apply if the material has been used or otherwise contaminated. It is the responsibility of the waste generator to determine the toxicity and physical properties of the material generated to determine the proper waste identification and disposal methods in compliance with applicable regulations.

If the material as supplied becomes a waste, follow all applicable regional, national and local laws and regulations.

14. TRANSPORT INFORMATION:

U.S. DEPARTMENT OF TRANSPORTATION (DOT) INFORMATION:

For all package sizes and modes of transportation:
This material is not regulated for transport.

15. REGULATORY INFORMATION:

NOTICE: The information herein is presented in good faith and believed to be accurate as of the effective date shown above. However, no warranty, express or implied, is given. Regulatory requirements are subject to change and may differ from one location to another; it is the buyer's responsibility to ensure that its activities comply with federal, state or provincial, and local laws. The following specific information is made for the purpose of complying with numerous federal, state or provincial, and local laws and regulations.

U.S. REGULATIONS

SARA 313 INFORMATION: To the best of our knowledge, this product contains no chemical subject to SARA Title III Section 313 supplier notification requirements.

SARA HAZARD CATEGORY: This product has been reviewed according to the EPA "Hazard Categories" promulgated under Sections 311 and 312 of the Superfund Amendment and Reauthorization Act of 1986 (SARA Title III) and is considered, under applicable definitions, to meet the following categories:

Not to have met any hazard category

TOXIC SUBSTANCES CONTROL ACT (TSCA): All ingredients are on the TSCA inventory or are not required to be listed on the TSCA inventory.

STATE RIGHT-TO-KNOW: This product is not known to contain any substances subject to the disclosure requirements of

New Jersey
Pennsylvania

OSHA HAZARD COMMUNICATION STANDARD: This product is a "Hazardous Chemical" as defined by the OSHA Hazard Communication Standard, 29 CFR 1910.1200.

COMPREHENSIVE ENVIRONMENTAL RESPONSE COMPENSATION AND LIABILITY ACT (CERCLA, or SUPERFUND): To the best of our knowledge, this product contains no chemical subject to reporting under CERCLA.

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA) RATINGS:

CATEGORY	RATING
Health	1
Flammability	1
Reactivity	0

16. OTHER INFORMATION:

MSDS STATUS: Revised Sections: 3,4,11,12,13,14 & 15
Reference: DR-0361-8028
Replaces MSDS Dated: 1/12/00
Document Code: D03-148-002
Replaces Document Code: D03-148-001

The Information Herein Is Given In Good Faith, But No Warranty, Express Or Implied, Is Made. Consult Dow AgroSciences For Further Information.

*Trademark of Dow AgroSciences LLC

Material Safety Data Sheet

SePRO

Sonar A.S.

1. Product and company identification

Product name	:	Sonar A.S.
EPA Registration Number	:	67690-4
Material uses	:	Herbicide.
Supplier/Manufacturer	:	**SePRO Corporation** 11550 North Meridian Street Suite 600 Carmel, IN 46032 U.S.A. Tel: 317-580-8282 Toll free: 1-800-419-7779 Fax: 317-428-4577 Monday - Friday, 8am to 5pm E.S.T. **www.sepro.com**
Responsible name	:	Atrion Regulatory Services, Inc.
In case of emergency	:	**INFOTRAC - 24-hour service 1-800-535-5053**

2. Hazards identification

Physical state	:	Liquid. [Opaque.]
Odor	:	Faint sweetness.
OSHA/HCS status	:	This material is considered hazardous by the OSHA Hazard Communication Standard (29 CFR 1910.1200).
Emergency overview	:	**WARNING!** **MAY CAUSE ALLERGIC SKIN REACTION. MAY BE HARMFUL IF SWALLOWED. MAY CAUSE EYE AND SKIN IRRITATION.** May be harmful if swallowed. Slightly irritating to the eyes and skin. May cause sensitization by skin contact. Do not breathe vapor or mist. Do not ingest. Do not get on skin or clothing. Avoid contact with eyes. Wash thoroughly after handling.
Routes of entry	:	Dermal contact. Eye contact. Inhalation. Ingestion.
Potential acute health effects		
Inhalation	:	Exposure to decomposition products may cause a health hazard. Serious effects may be delayed following exposure.
Ingestion	:	May be harmful if swallowed.
Skin	:	Slightly irritating to the skin. May cause sensitization by skin contact.
Eyes	:	Slightly irritating to the eyes.
Potential chronic health effects		
Chronic effects	:	Once sensitized, a severe allergic reaction may occur when subsequently exposed to very low levels.
Carcinogenicity	:	No known significant effects or critical hazards.
Mutagenicity	:	No known significant effects or critical hazards.
Teratogenicity	:	No known significant effects or critical hazards.
Developmental effects	:	No known significant effects or critical hazards.
Fertility effects	:	No known significant effects or critical hazards.
Over-exposure signs/symptoms		
Inhalation	:	No specific data.
Ingestion	:	No specific data.
Skin	:	Adverse symptoms may include the following: irritation redness
Eyes	:	Adverse symptoms may include the following: irritation watering redness

Medical conditions aggravated by over-exposure : Pre-existing skin disorders may be aggravated by over-exposure to this product.

See toxicological information (section 11)

3. Composition/information on ingredients

United States		
Name	**CAS number**	**%**
Active ingredient:		
4(1h)-pyridinone, 1-methyl-3-phenyl-5-[3-(trifluoromethyl)phenyl]-	59756-60-4	41.7
Inert Ingredient:		
Proprietary Alcohol	Proprietary	5 - 10
Proprietary Alcohol 2	Proprietary	1 - 5

There are no additional ingredients present which, within the current knowledge of the supplier and in the concentrations applicable, are classified as hazardous to health or the environment and hence require reporting in this section.

4. First aid measures

Eye contact : Check for and remove any contact lenses. In case of contact with eyes, rinse immediately with plenty of water. Get medical attention if symptoms occur.

Skin contact : Wash with soap and water. Get medical attention if symptoms occur.

Inhalation : If inhaled, remove to fresh air. If not breathing, give artificial respiration. Get medical attention if symptoms appear.

Ingestion : Do not induce vomiting. Never give anything by mouth to an unconscious person. Get medical attention if symptoms appear.

Protection of first-aiders : No action shall be taken involving any personal risk or without suitable training. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation. Wash contaminated clothing thoroughly with water before removing it, or wear gloves.

Notes to physician : In case of inhalation of decomposition products in a fire, symptoms may be delayed. The exposed person may need to be kept under medical surveillance for 48 hours.

5. Fire-fighting measures

Flammability of the product : May be combustible at high temperature.

Extinguishing media

Suitable : In case of fire, use water spray (fog), foam, dry chemical or CO_2

Not suitable : None known.

Hazardous thermal decomposition products : Decomposition products may include the following materials:
carbon dioxide
carbon monoxide
nitrogen oxides
halogenated compounds

Special protective equipment for fire-fighters : Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode.

6. Accidental release measures

Personal precautions : No action shall be taken involving any personal risk or without suitable training. Evacuate surrounding areas. Keep unnecessary and unprotected personnel from entering. Do not touch or walk through spilled material. Avoid breathing vapor or mist. Provide adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Put on appropriate personal protective equipment (see section 8).

Environmental precautions : Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers. Inform the relevant authorities if the product has caused environmental pollution (sewers, waterways, soil or air).

Methods for cleaning up

Small spill : Stop leak if without risk. Move containers from spill area. Dilute with water and mop up if water-soluble or absorb with an inert dry material and place in an appropriate waste disposal container. Dispose of via a licensed waste disposal contractor.

Large spill : Stop leak if without risk. Move containers from spill area. Approach release from upwind. Prevent entry into sewers, water courses, basements or confined areas. Wash spillages into an effluent treatment plant or proceed as follows. Contain and collect spillage with non-combustible, absorbent material e.g. sand, earth, vermiculite or diatomaceous earth and place in container for disposal according to local regulations (see section 13). Dispose of via a licensed waste disposal contractor. Contaminated absorbent material may pose the same hazard as the spilled product. Note: see section 1 for emergency contact information and section 13 for waste disposal.

7. Handling and storage

Handling : Put on appropriate personal protective equipment (see section 8). Eating, drinking and smoking should be prohibited in areas where this material is handled, stored and processed. Workers should wash hands and face before eating, drinking and smoking. Persons with a history of skin sensitization problems should not be employed in any process in which this product is used. Do not get in eyes or on skin or clothing. Do not ingest. Avoid breathing vapor or mist. Keep in the original container or an approved alternative made from a compatible material, kept tightly closed when not in use. Empty containers retain product residue and can be hazardous. Do not reuse container.

Storage : Avoid freezing. Store in accordance with local regulations. Store in original container protected from direct sunlight in a dry, cool and well-ventilated area, away from incompatible materials (see section 10) and food and drink. Keep container tightly closed and sealed until ready for use. Containers that have been opened must be carefully resealed and kept upright to prevent leakage. Do not store in unlabeled containers. Use appropriate containment to avoid environmental contamination.

8. Exposure controls/personal protection

United States	
Product name	**Exposure limits**
Proprietary Alcohol	**AIHA WEEL (United States, 1/2008).** TWA: 10 mg/m³ 8 hour(s).

Consult local authorities for acceptable exposure limits.

Recommended monitoring procedures : If this product contains ingredients with exposure limits, personal, workplace atmosphere or biological monitoring may be required to determine the effectiveness of the ventilation or other control measures and/or the necessity to use respiratory protective equipment.
Applicators should refer to the product label for personal protective clothing and equipment.

Engineering measures : No special ventilation requirements. Good general ventilation should be sufficient to control worker exposure to airborne contaminants. If this product contains ingredients with exposure limits, use process enclosures, local exhaust ventilation or other engineering controls to keep worker exposure below any recommended or statutory limits.

Hygiene measures : Wash hands, forearms and face thoroughly after handling chemical products, before eating, smoking and using the lavatory and at the end of the working period. Appropriate techniques should be used to remove potentially contaminated clothing. Wash contaminated clothing before reusing. Ensure that eyewash stations and safety showers are close to the workstation location.

Personal protection

Eyes : Safety glasses.

Skin : Lab coat.

Respiratory : A respirator is not needed under normal and intended conditions of product use.

Hands : Nitrile gloves.

Personal protective equipment (Pictograms) :

HMIS Code/Personal protective equipment : B

Environmental exposure controls	:	Emissions from ventilation or work process equipment should be checked to ensure they comply with the requirements of environmental protection legislation. In some cases, fume scrubbers, filters or engineering modifications to the process equipment will be necessary to reduce emissions to acceptable levels.

9 . Physical and chemical properties

Physical state	:	Liquid. [Opaque.]
Color	:	Off-white to tannish-gray.
Odor	:	Faint sweetness.
Flash point	:	Closed cup: >93.333°C (>200°F)
pH	:	5.6 to 7.6
Boiling/condensation point	:	100°C (212°F)
Relative density	:	1.15
Vapor pressure	:	0.31 kPa (2.3 mm Hg)
Solubility	:	Partially soluble in the following materials: cold water and hot water.

10 . Stability and reactivity

Stability	:	The product is stable.
Hazardous polymerization	:	Under normal conditions of storage and use, hazardous polymerization will not occur.
Conditions to avoid	:	Avoid freezing.
Materials to avoid	:	Reactive or incompatible with the following materials: oxidizing materials and acids.
Hazardous decomposition products	:	If water evaporates, residues may product harmful vapors under fire conditions.

Slightly flammable in the presence of the following materials or conditions: open flames, sparks and static discharge.
Non-flammable in the presence of the following materials or conditions: heat.

11 . Toxicological information

Acute toxicity

Product/ingredient name	Species	Dose	Result	Exposure
4(1h)-pyridinone, 1-methyl-3-phenyl-5-[3-(trifluoromethyl)phenyl]-	Rat	>10 g/kg	LD50 Oral	-
Proprietary Alcohol	Rabbit	20800 mg/kg	LD50 Dermal	-
	Rat	20 g/kg	LD50 Oral	-
Sonar A.S.	Rabbit	>2000 mg/kg	LD50 Dermal	-
	Rat	>500 mg/kg	LD50 Oral	-

Inhalation	:	Exposure to decomposition products may cause a health hazard. Serious effects may be delayed following exposure.
Ingestion	:	May be harmful if swallowed.
Skin	:	Slightly irritating to the skin. May cause sensitization by skin contact.
Eyes	:	Slightly irritating to the eyes.

12 . Ecological information

Environmental effects	:	No known significant effects or critical hazards.

Aquatic ecotoxicity

Product/ingredient name	Test	Species	Exposure	Result
Proprietary Alcohol	-	Daphnia	48 hours	Acute EC50 >10000000 ug/L
	-	Fish	96 hours	Acute LC50 710000 ug/L
	-	Daphnia	48 hours	Acute LC50 4919 mg/L
	-	Fish	96 hours	Chronic NOEC 600000 ug/L
	-	Daphnia	48 hours	Chronic NOEC 660000 ug/L

13 . Disposal considerations

Waste disposal	: The generation of waste should be avoided or minimized wherever possible. Empty containers or liners may retain some product residues. This material and its container must be disposed of in a safe way. Dispose of surplus and non-recyclable products via a licensed waste disposal contractor. Disposal of this product, solutions and any by-products should at all times comply with the requirements of environmental protection and waste disposal legislation and any regional local authority requirements. Avoid dispersal spilled material and runoff and contact with soil, waterways, drains and sewers.

Disposal should be in accordance with applicable regional, national and local laws and regulations.

Refer to Section 7: HANDLING AND STORAGE and Section 8: EXPOSURE CONTROLS/PERSONAL PROTECTION for additional handling information and protection of employees.

14 . Transport information

AERG : Not applicable.

Regulatory information

DOT/ IMDG/ IATA : Not regulated.

15 . Regulatory information

United States

HCS Classification : Sensitizing material

U.S. Federal regulations : **United States inventory (TSCA 8b):** All components are listed or exempted.

SARA 302/304/311/312 extremely hazardous substances : No products were found.
SARA 302/304 emergency planning and notification : No products were found.
SARA 302/304/311/312 hazardous chemicals : Proprietary Alcohol
SARA 311/312 MSDS distribution - chemical inventory - hazard identification: Proprietary Alcohol: Immediate (acute) health hazard, Delayed (chronic) health hazard

Clean Water Act (CWA) 307: No products were found.

Clean Water Act (CWA) 311: No products were found.

Clean Air Act (CAA) 112 accidental release prevention: No products were found.

Clean Air Act (CAA) 112 regulated flammable substances: No products were found.

Clean Air Act (CAA) 112 regulated toxic substances: No products were found.

State regulations : **Connecticut Carcinogen Reporting:** None of the components are listed.
Connecticut Hazardous Material Survey: None of the components are listed.
Florida substances: None of the components are listed.
Illinois Chemical Safety Act: None of the components are listed.
Illinois Toxic Substances Disclosure to Employee Act: None of the components are listed.
Louisiana Reporting: None of the components are listed.
Louisiana Spill: None of the components are listed.
Massachusetts Spill: None of the components are listed.
Massachusetts Substances: None of the components are listed.
Michigan Critical Material: None of the components are listed.
Minnesota Hazardous Substances: None of the components are listed.
New Jersey Hazardous Substances: None of the components are listed.
New Jersey Spill: None of the components are listed.
New Jersey Toxic Catastrophe Prevention Act: None of the components are listed.
New York Acutely Hazardous Substances: None of the components are listed.
New York Toxic Chemical Release Reporting: None of the components are listed.
Pennsylvania RTK Hazardous Substances: The following components are listed: Proprietary Alcohol
Rhode Island Hazardous Substances: None of the components are listed.

California Prop. 65 No products were found.

United States inventory (TSCA 8b) : All components are listed or exempted.

International regulations

International lists : This product, (and its ingredients) is (are) listed on national inventories, or is (are) exempted from being listed, in Australia (AICS), in Europe (EINECS/ELINCS), in Korea (TCCL), in Japan (METI), in the Philippines (RA6969).

16 . Other information

Label requirements : **MAY CAUSE ALLERGIC SKIN REACTION. MAY BE HARMFUL IF SWALLOWED. MAY CAUSE EYE AND SKIN IRRITATION.**

Hazardous Material Information System (U.S.A.) :

Health	1
Fire hazard	1
Physical Hazard	0
Personal protection	B

HAZARD RATINGS

4- Extreme
3- Serious
2- Moderate
1- Slight
0- Minimal
See section 8 for more detailed information on personal protection.

The customer is responsible for determining the PPE code for this material.

National Fire Protection Association (U.S.A.) :

References : ANSI Z400.1, MSDS Standard, 2004. - Manufacturer's Material Safety Data Sheet. - 29CFR Part1910.1200 OSHA MSDS Requirements. - 49CFR Table List of Hazardous Materials, UN#, Proper Shipping Names, PG.

Date of issue : 01/15/2009

Version : 1

Notice to reader

To the best of our knowledge, the information contained herein is accurate. However, neither the above named supplier nor any of its subsidiaries assumes any liability whatsoever for the accuracy or completeness of the information contained herein. Final determination of suitability of any material is the sole responsibility of the user. All materials may present unknown hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards that exist. The data in this MSDS relates only to the specific material designated herein. Possible adverse effects (see Section 2, 11 and 12) may occur if this material is not handled in the recommended manner.

Conforms to ANSI Z400.5-2004 Standard (United States).

Material Safety Data Sheet

SePRO

Sonar Q Aquatic Herbicide

1 . Product and company identification

Product name	:	Sonar Q Aquatic Herbicide
EPA Registration Number	:	67690-3
Material uses	:	Aquatic herbicide.
Supplier/Manufacturer	:	**SePRO Corporation** 11550 North Meridian Street Suite 600 Carmel, IN 46032 U.S.A. Tel: 317-580-8282 Toll free: 1-800-419-7779 Fax: 317-428-4577 Monday - Friday, 8am to 5pm E.S.T. **www.sepro.com**
Responsible name	:	Atrion Regulatory Services, Inc.
In case of emergency	:	**INFOTRAC - 24-hour service 1-800-535-5053**

2 . Hazards identification

Physical state	:	Solid. [Pellets.]
Odor	:	Faint earthy/musty.
OSHA/HCS status	:	This material is considered hazardous by the OSHA Hazard Communication Standard (29 CFR 1910.1200).
Emergency overview	:	**CAUTION!** **MAY CAUSE RESPIRATORY TRACT AND EYE IRRITATION. CONTAINS MATERIAL THAT CAN CAUSE TARGET ORGAN DAMAGE. CANCER HAZARD - CONTAINS MATERIAL WHICH CAN CAUSE CANCER.** Slightly irritating to the eyes and respiratory system. Avoid exposure - obtain special instructions before use. Avoid contact with eyes. Contains material that can cause target organ damage. Contains material which can cause cancer. Risk of cancer depends on duration and level of exposure. Use only with adequate ventilation. Keep container tightly closed and sealed until ready for use. Wash thoroughly after handling.
Routes of entry	:	Dermal contact. Eye contact. Inhalation. Ingestion.
Potential acute health effects		
Inhalation	:	Slightly irritating to the respiratory system. Exposure to decomposition products may cause a health hazard. Serious effects may be delayed following exposure.
Ingestion	:	No known significant effects or critical hazards.
Skin	:	No known significant effects or critical hazards.
Eyes	:	Slightly irritating to the eyes.
Potential chronic health effects		
Chronic effects	:	Contains material that can cause target organ damage.
Carcinogenicity	:	Contains material which can cause cancer. Risk of cancer depends on duration and level of exposure.
Mutagenicity	:	No known significant effects or critical hazards.
Teratogenicity	:	No known significant effects or critical hazards.
Developmental effects	:	No known significant effects or critical hazards.
Fertility effects	:	No known significant effects or critical hazards.
Target organs	:	Contains material which causes damage to the following organs: lungs, upper respiratory tract, eye, lens or cornea.
Over-exposure signs/symptoms		
Inhalation	:	Adverse symptoms may include the following: respiratory tract irritation coughing
Ingestion	:	No specific data.
Skin	:	No specific data.

Eyes	: Adverse symptoms may include the following: irritation watering redness
Medical conditions aggravated by over-exposure	: Pre-existing disorders involving any target organs mentioned in this MSDS as being at risk may be aggravated by over-exposure to this product.

See toxicological information (section 11)

3 . Composition/information on ingredients

United States		
Name	CAS number	%
Active Ingredient:		
4(1h)-pyridinone, 1-methyl-3-phenyl-5-[3-(trifluoromethyl)phenyl]-	59756-60-4	5 - 10
Inert Ingredient:		
Silica, Crystalline - Quartz	14808-60-7	1 - 5

There are no additional ingredients present which, within the current knowledge of the supplier and in the concentrations applicable, are classified as hazardous to health or the environment and hence require reporting in this section.

4 . First aid measures

Eye contact	: Check for and remove any contact lenses. In case of contact with eyes, rinse immediately with plenty of water. Get medical attention if symptoms occur.
Skin contact	: Wash with soap and water. Get medical attention if symptoms occur.
Inhalation	: If inhaled, remove to fresh air. If not breathing, give artificial respiration. Get medical attention if symptoms appear.
Ingestion	: Do not induce vomiting. Never give anything by mouth to an unconscious person. Get medical attention if symptoms appear.
Protection of first-aiders	: No action shall be taken involving any personal risk or without suitable training. If it is suspected that fumes are still present, the rescuer should wear an appropriate mask or self-contained breathing apparatus. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation. Wash contaminated clothing thoroughly with water before removing it, or wear gloves.
Notes to physician	: In case of inhalation of decomposition products in a fire, symptoms may be delayed. The exposed person may need to be kept under medical surveillance for 48 hours.

5 . Fire-fighting measures

Flammability of the product	: Non-flammable.
Extinguishing media	
Suitable	: Use an extinguishing agent suitable for the surrounding fire.
Not suitable	: None known.
Hazardous thermal decomposition products	: Decomposition products may include the following materials: carbon dioxide carbon monoxide nitrogen oxides halogenated compounds metal oxide/oxides
Special protective equipment for fire-fighters	: Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode.

6. Accidental release measures

Personal precautions : No action shall be taken involving any personal risk or without suitable training. Evacuate surrounding areas. Keep unnecessary and unprotected personnel from entering. Do not touch or walk through spilled material. Provide adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Put on appropriate personal protective equipment (see section 8).

Environmental precautions : Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers. Inform the relevant authorities if the product has caused environmental pollution (sewers, waterways, soil or air).

Methods for cleaning up

Small spill : Move containers from spill area. Vacuum or sweep up material and place in a designated, labeled waste container. Dispose of via a licensed waste disposal contractor.

Large spill : Move containers from spill area. Approach release from upwind. Prevent entry into sewers, water courses, basements or confined areas. Vacuum or sweep up material and place in a designated, labeled waste container. Dispose of via a licensed waste disposal contractor. Note: see section 1 for emergency contact information and section 13 for waste disposal.

7. Handling and storage

Handling : Put on appropriate personal protective equipment (see section 8). Eating, drinking and smoking should be prohibited in areas where this material is handled, stored and processed. Workers should wash hands and face before eating, drinking and smoking. Do not get in eyes or on skin or clothing. Do not ingest. Use only with adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Keep in the original container or an approved alternative made from a compatible material, kept tightly closed when not in use. Empty containers retain product residue and can be hazardous. Do not reuse container.

Storage : Store in accordance with local regulations. Store in original container protected from direct sunlight in a dry, cool and well-ventilated area, away from incompatible materials (see section 10) and food and drink. Keep container tightly closed and sealed until ready for use. Containers that have been opened must be carefully resealed and kept upright to prevent leakage. Do not store in unlabeled containers. Use appropriate containment to avoid environmental contamination.

8. Exposure controls/personal protection

	United States
Product name	**Exposure limits**
Silica, Crystalline - Quartz	**ACGIH TLV (United States, 1/2006).** TWA: 0.025 mg/m³ 8 hour(s). Form: Respirable fraction **NIOSH REL (United States, 12/2001).** TWA: 0.05 mg/m³ 10 hour(s). **OSHA PEL Z3 (United States, 9/2005).** TWA: 10 mg/m³ 8 hour(s). Form: Respirable

Consult local authorities for acceptable exposure limits.

Recommended monitoring procedures : If this product contains ingredients with exposure limits, personal, workplace atmosphere or biological monitoring may be required to determine the effectiveness of the ventilation or other control measures and/or the necessity to use respiratory protective equipment.

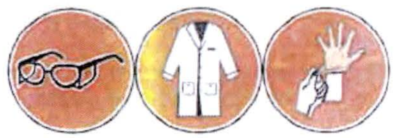
Applicators should refer to the product label for personal protective clothing and equipment.

Engineering measures : Use only with adequate ventilation. If user operations generate dust, fumes, gas, vapor or mist, use process enclosures, local exhaust ventilation or other engineering controls to keep worker exposure to airborne contaminants below any recommended or statutory limits.

Hygiene measures : Wash hands, forearms and face thoroughly after handling chemical products, before eating, smoking and using the lavatory and at the end of the working period. Appropriate techniques should be used to remove potentially contaminated clothing. Wash contaminated clothing before reusing. Ensure that eyewash stations and safety showers are close to the workstation location.

Personal protection

Eyes	: Safety glasses.
Skin	: Lab coat.
Respiratory	: A respirator is not needed under normal and intended conditions of product use
Hands	: Disposable vinyl gloves.
Personal protective equipment (Pictograms)	:



HMIS Code/Personal protective equipment	: A
Environmental exposure controls	: Emissions from ventilation or work process equipment should be checked to ensure they comply with the requirements of environmental protection legislation. In some cases, fume scrubbers, filters or engineering modifications to the process equipment will be necessary to reduce emissions to acceptable levels.

9 . Physical and chemical properties

Physical state	: Solid. [Pellets.]
Color	: Brown to gray. [Dark]
Odor	: Faint earthy/musty.
pH	: 8.2 [Conc. (% w/w): 31%]
Relative density	: 62 to 84 lbs/cu. Ft.(20C).
Solubility	: Insoluble; pellets disintegrates in water.

10 . Stability and reactivity

Stability	: The product is stable.
Hazardous polymerization	: Under normal conditions of storage and use, hazardous polymerization will not occur.
Conditions to avoid	: Avoid exposure - obtain special instructions before use.
Materials to avoid	: Reactive or incompatible with the following materials: oxidizing materials.
Hazardous decomposition products	: Under normal conditions of storage and use, hazardous decomposition products should not be produced.

11 . Toxicological information

Acute toxicity

Product/ingredient name	Species	Dose	Result	Exposure
4(1h)-pyridinone, 1-methyl-3-phenyl-5-[3-(trifluoromethyl)phenyl]-	Rat	>10 g/kg	LD50 Oral	-
Sonar Q Aquatic Herbicide	Rabbit	>2000 mg/kg	LD50 Dermal	-
	Rat	>5000 mg/kg	LD50 Oral	-

Inhalation	: Slightly irritating to the respiratory system. Exposure to decomposition products may cause a health hazard. Serious effects may be delayed following exposure.
Ingestion	: No known significant effects or critical hazards.
Skin	: No known significant effects or critical hazards.
Eyes	: Slightly irritating to the eyes.

Carcinogenicity

Classification

Product/ingredient name	ACGIH	IARC	EPA	NIOSH	NTP	OSHA
Silica, Crystalline - Quartz	A2	2A	-	+	Proven.	-

12 . Ecological information

Environmental effects : No known significant effects or critical hazards.

Aquatic ecotoxicity

Product/ingredient name	Test	Species	Exposure	Result
4(1h)-pyridinone, 1-methyl-3-phenyl-5-[3-(trifluoromethyl)phenyl]-	-	Daphnia	48 hours	Acute EC50 3.9 mg/L
	-	Daphnia	48 hours	Acute EC50 3.6 mg/L
	-	Fish	96 hours	Acute LC50 4.5 mg/L
	-	Fish	96 hours	Acute LC50 4.25 mg/L
	-	Fish	96 hours	Acute LC50 4.2 mg/L

13 . Disposal considerations

Waste disposal : The generation of waste should be avoided or minimized wherever possible. Empty containers or liners may retain some product residues. This material and its container must be disposed of in a safe way. Dispose of surplus and non-recyclable products via a licensed waste disposal contractor. Disposal of this product, solutions and any by-products should at all times comply with the requirements of environmental protection and waste disposal legislation and any regional local authority requirements. Avoid dispersal spilled material and runoff and contact with soil, waterways, drains and sewers.

Disposal should be in accordance with applicable regional, national and local laws and regulations.

Refer to Section 7: HANDLING AND STORAGE and Section 8: EXPOSURE CONTROLS/PERSONAL PROTECTION for additional handling information and protection of employees.

14 . Transport information

AERG : Not applicable.

Regulatory information

DOT/ IMDG/ IATA : Not regulated.

15 . Regulatory information

United States

HCS Classification : Carcinogen
Target organ effects

U.S. Federal regulations : **United States inventory (TSCA 8b):** All components are listed or exempted.

SARA 302/304/311/312 extremely hazardous substances : No products were found.
SARA 302/304 emergency planning and notification : No products were found.
SARA 302/304/311/312 hazardous chemicals : Silica, Crystalline - Quartz
SARA 311/312 MSDS distribution - chemical inventory - hazard identification: Silica, Crystalline - Quartz: Immediate (acute) health hazard, Delayed (chronic) health hazard

Clean Water Act (CWA) 307: No products were found.

Clean Water Act (CWA) 311: No products were found.

Clean Air Act (CAA) 112 accidental release prevention : No products were found.

Clean Air Act (CAA) 112 regulated flammable substances : No products were found.

Clean Air Act (CAA) 112 regulated toxic substances : No products were found.

State regulations : **Connecticut Carcinogen Reporting**: None of the components are listed.
Connecticut Hazardous Material Survey: None of the components are listed.
Florida substances: None of the components are listed.
Illinois Chemical Safety Act: None of the components are listed.
Illinois Toxic Substances Disclosure to Employee Act: None of the components are listed.
Louisiana Reporting: None of the components are listed.
Louisiana Spill: None of the components are listed.
Massachusetts Spill: None of the components are listed.
Massachusetts Substances : The following components are listed: Silica, Crystalline - Quartz
Michigan Critical Material: None of the components are listed.
Minnesota Hazardous Substances : None of the components are listed.
New Jersey Hazardous Substances : The following components are listed: Silica, Crystalline - Quartz

New Jersey Spill: None of the components are listed.
New Jersey Toxic Catastrophe Prevention Act: None of the components are listed.
New York Acutely Hazardous Substances: None of the components are listed.
New York Toxic Chemical Release Reporting: None of the components are listed.
Pennsylvania RTK Hazardous Substances: The following components are listed: Silica, Crystalline - Quartz
Rhode Island Hazardous Substances: None of the components are listed.

California Prop. 65 — **WARNING:** This product contains a chemical known to the State of California to cause cancer.

United States inventory (TSCA 8b) : **United States inventory (TSCA 8b):** All components are listed or exempted

International regulations

International lists : This product, (and its ingredients) is (are) listed on national inventories, or is (are) exempted from being listed, in Australia (AICS), in Europe (EINECS/ELINCS), in Korea (TCCL), in Japan (METI), in the Philippines (RA6969).

16 . Other information

Label requirements : **MAY CAUSE RESPIRATORY TRACT AND EYE IRRITATION. CONTAINS MATERIAL THAT CAN CAUSE TARGET ORGAN DAMAGE. CANCER HAZARD - CONTAINS MATERIAL WHICH CAN CAUSE CANCER.**

Hazardous Material Information System (U.S.A.) :

Health	*	1
Fire hazard		0
Physical Hazard		0
Personal protection		A

HAZARD RATINGS

4- Extreme
3- Serious
2- Moderate
1- Slight
0- Minimal
See section 8 for more detailed information on personal protection.

The customer is responsible for determining the PPE code for this material.

National Fire Protection Association (U.S.A.) :

References : ANSI Z400.1, MSDS Standard, 2004. - Manufacturer's Material Safety Data Sheet. - 29CFR Part1910.1200 OSHA MSDS Requirements. - 49CFR Table List of Hazardous Materials, UN#, Proper Shipping Names, PG.

Date of issue : 01/15/2009
Date of previous issue : 12/15/2008
Version : 2

Notice to reader

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Nufarm

WEEDAR® 64 BROADLEAF HERBICIDE

MATERIAL SAFETY DATA SHEET

1. CHEMICAL PRODUCT AND COMPANY DESCRIPTION

Product Name: Nufarm Weedar 64 Broadleaf Herbicide

Synonyms: 2,4-D DMA; 2,4-Dichlorophenoxyacetic acid, dimethylamine salt.

EPA Reg. No.: 71368-1

Company Name: Nufarm Americas, Inc.
Burr Ridge, IL 60521

Phone Numbers: **For Chemical Emergency, Spill, Leak, Fire, Exposure, Or Accident, Call CHEMTREC Day or Night: 1-800-424-9300.**
For Medical Emergencies Only, Call 877-325-1840.
For additional non-emergency information, call: 1-800-852-5234.

Date: March 12, 2002

Revisions: New or updated information in all sections.

Reasons for Revisions: General revision utilizing more specific data.

Supersedes: March 1, 2000

2. COMPOSITION/INFORMATION ON INGREDIENTS

COMPONENT	CAS REG. NO.	% BY WEIGHT
Acetic acid, (2,4-dichlorophenoxy)-, dimethylamine salt*	2008-39-1	46.8
Inert ingredients (trade secret)**		53.2

Note: The other major ingredient in this product is water.
*OSHA hazard
**Not OSHA hazard

3. HAZARDS IDENTIFICATION

Emergency Overview:

Appearance and Odor: Reddish brown liquid, phenolic-amine odor.
Warning Statements: DANGER. Keep out of reach of children. Corrosive. Causes irreversible eye damage. Harmful if swallowed. May be fatal if absorbed through the skin. Avoid breathing vapors or spray mist. Do not get in eyes, on skin or on clothing.

Potential Adverse Health Effects:

Likely Routes of Exposure: Inhalation, eye and skin contact.
Eye Contact: Causes corneal opacity, irreversible eye damage. Vapors and mist can cause irritation.
Skin Contact: May cause slight transient irritation. Overexposure by skin absorption may cause nausea, vomiting, abdominal pain, decreased blood pressure, muscle weakness, muscle spasms.
Inhalation: Harmful if inhaled. May cause upper respiratory tract irritation and symptoms similar to those from ingestion.
Ingestion: Harmful if swallowed. May cause nausea, vomiting, abdominal pain, decreased blood pressure, muscle weakness, muscle spasms.
Medical Conditions Possibly Aggravated By Exposure: Inhalation of product may aggravate existing chronic respiratory problems such as asthma, emphysema or bronchitis. Skin contact may aggravate existing skin disease.
Subchronic (Target Organ) Effects: (An adverse effect with symptoms that develop slowly over a long period of time): Repeated overexposure may cause effects to liver, kidneys, blood chemistry, and gross motor function. Rare cases of peripheral nerve damage have been reported, but extensive animal studies have failed to substantiate these observations, even at high doses for prolonged periods.
Chronic Effects/Carcinogenicity: Prolonged overexposure can cause liver, kidney and muscle damage. The International Agency for Research on Cancer (IARC) lists exposure to chlorophenoxy herbicides as a class 2B carcinogen, the category for limited evidence for carcinogenicity in humans. However, more current 2,4-D lifetime feeding studies in rats and mice did not show carcinogenic potential. The USEPA has given a class D classification (not classifiable as to human carcinogenicity).
Reproductive Toxicity: No impairment of reproductive function attributable to 2,4-D has been noted in laboratory animal studies.
Developmental Toxicity: Studies in laboratory animals with 2,4-D have shown decreased fetal body weights and delayed development in the offspring at doses toxic to mother animals.
Genotoxicity: There have been some positive and some negative studies, but the weight of evidence is that 2,4-D is not mutagenic.

4. FIRST AID MEASURES

If swallowed: If patient is conscious and alert, give 2 to 3 glasses of water or milk to drink. If available, give one tablespoon of Syrup of Ipecac to induce vomiting. Alternatively, induce vomiting by touching back of throat with finger. Do not make an unconscious person vomit. Get medical attention.
If on skin: Wash skin with plenty of soap and water. Remove contaminated clothing. Get medical attention.
If in eyes: Flush with water for at least 15 minutes. Get medical attention, PREFERABLY AN OPHTHALMOLOGIST.
If inhaled: Move to an uncontaminated area. Get medical attention.
Note to Physician: This product contains a phenoxy herbicidal chemical. There is no specific antidote. All treatments should be based on observed signs and symptoms of distress in the patient. Overexposure to materials other than this product may have occurred.
Myotonic effects may include muscle fibrillations, myotonia, and muscular weakness. Ingestion of massive doses may result in persistent fall of blood pressure. Myoglobin and hemoglobin may be found in urine. Elevations in lactate dehydrogenase (LDH), SGOT, SGPT and aldolase indicate the extent of muscle damage. It has been suggested that overexposure in humans may affect both the central and peripheral nervous systems. The acute effects on the central nervous system resemble those produced by alcohol or sedative drugs. In isolated cases, peripheral neuropathy and reduced nerve conduction velocities have been reported although these observations may be related to other factors. Gas-liquid chromatography for detecting and measuring chlorophenoxy compounds in blood and urine may be useful in confirming and assessing the magnitude of chlorophenoxy absorption.

5. FIRE FIGHTING MEASURES

Flash Point: >212° F (100° C) by Pensky-Martens closed cup method.
Autoignition Temperature: Not determined.
Flammability Limits: Not determined.
Extinguishing Media: Recommended (large fire): foam, water spray. Recommended (small fires): dry chemical, carbon dioxide.

Special Fire Fighting Procedures: Firefighters should wear NIOSH/MSHA approved self-contained breathing apparatus and full protective clothing. Dike area to prevent runoff and contamination of water sources. Dispose of fire control water later.
Unusual Fire and Explosion hazards: Under fire conditions, toxic, corrosive fumes are emitted. Containers will burst from internal pressure under extreme fire conditions.
Hazardous Decomposition Materials (Under Fire Conditions): Hydrogen chloride, oxides of nitrogen, and oxides of carbon.

6. ACCIDENTAL RELEASE MEASURES

Evacuation Procedures and Safety: Wear appropriate protective gear for the situation. See Personal Protection information in Section 8.
Containment of Spill: Dike spill using absorbent or impervious materials such as earth, sand or clay. Collect and contain contaminated absorbent and dike material for disposal.
Cleanup and Disposal of Spill: Pump any free liquid into an appropriate closed container. Collect washings for disposal. Decontaminate tools and equipment following cleanup. (See Section 13.)
Environmental and Regulatory Reporting: Prevent material from entering public sewer system or any waterways. Do not flush to drain. Large spills to soil or similar surfaces may necessitate removal of top soil. The affected area should be removed and placed in an appropriate container for disposal. Spills may be reportable to the National Response Center (800-424-8802) and to state and/or local agencies.

7. HANDLING AND STORAGE

Handling:
Handle containers carefully to avoid damage and spills.
Storage:
Store in original container in a dry secured storage area. Do not contaminate water, food or feed by storage or disposal. Avoid storage in close proximity to insecticides, fungicides, fertilizers and seeds. Keep container tightly closed when not in use.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

General:

These recommendations provide general guidance for handling this product. Because specific work environments and material handling practices vary, safety procedures should be developed for each intended usage, including maintenance and repair of equipment. Contact personal protective equipment manufacturers for assistance with selection, use and maintenance of such equipment.

Personal Protective Equipment:

Respiratory Protection: When respirators are required, select NIOSH/MSHA approved equipment based on actual or potential airborne concentrations and in accordance with the appropriate regulatory standards and/or industrial recommendations. Under normal conditions, in the absence of other airborne contaminants, the following devices should provide protection from this material up to the conditions specified by the appropriate OSHA or ANSI standard(s): Air-purifying (half-mask/full-face) respirator with cartridges/canister approved for use against pesticides. Under conditions immediately dangerous to life or health, or emergency conditions with unknown concentrations, use a full-face positive pressure air-supplied respirator equipped with an emergency escape air supply unit or use a self-contained breathing apparatus unit.

Eye/Face Protection: Eye and face protection requirements will vary dependent upon work environment conditions and material handling practices. Appropriate ANSI Z87 approved equipment should be selected for the particular use intended for this material. Eye contact should be prevented through use of protective eyewear such as chemical

safety glasses with side shields or splash proof goggles. An emergency eye wash should be readily accessible to the work area.

Skin Protection: Skin contact should be avoided through the use of permeation resistant clothing, gloves and footwear, selected with regard for use conditions and exposure potential. An emergency shower should be readily accessible to the work area. Consider both durability and permeation resistance of clothing.

Work Practice Controls: Personal hygiene is an important work practice exposure control measure and the following general measures should be taken when working with or handling this material: (1) Do not store, use, and/or consume foods, beverages, tobacco products, or cosmetics in areas where this material is stored. (2) Wash hands and face carefully before eating, drinking, using tobacco, applying cosmetics, or using the toilet.

Exposure Guidelines:

Exposure Limits:	OSHA PEL*	ACGIH TLV®*	STEL	Units
Acetic acid, (2,4-Dichlorophenoxy)-, dimethylamine salt	10**	10**	ND	mg/m^3

*8-hour TWA unless otherwise noted.
**Based on adopted limit for 2,4-D.

Ventilation:

Where engineering controls are indicated by specific use conditions or a potential for excessive exposure, use local exhaust ventilation at the point of generation.

9. PHYSICAL AND CHEMICAL PROPERTIES

NOTE: Physical data are typical values, but may vary from sample to sample. A typical value should not be construed as a guaranteed analysis or as a specification.

Physical Appearance:	Reddish brown to dark brown liquid.
Odor:	Characteristic organic amine and phenolic.
pH:	Approximately 7 to 9
Specific Gravity:	Approximately 1.155 @ 20°C
Water Solubility:	Soluble.
Melting Point Range:	Not Available.
Boiling Point Range:	Not Available. Expected to be similar to water: > 100°C
Vapor Pressure:	$<1 \times 10^{-7}$ mm Hg @ 26°C (data on 2,4-D dimethylamine salt)
Molecular Weight:	266.1 (data on 2,4-D dimethylamine salt)

10. STABILITY AND REACTIVITY

Chemical Stability: This material is stable under normal handling and storage conditions described in Section 7.
Conditions To Be Avoided: None known
Incompatibility With Other Materials: Strong oxidizing agents: bases, acids.
Hazardous Decomposition Products:
- **Decomposition Type:** Thermal
- **Decomposition Products:** Hydrogen chloride, oxides of carbon, nitrogen and sulfur.

Hazardous Polymerization: Does not occur.

11. TOXICOLOGICAL INFORMATION

Toxicological Data:
Except as noted, data from laboratory studies conducted on this product are summarized below.

Eye Irritation: Severely irritating (Rabbit).
Skin Irritation: Minimally irritating (Rabbit).
Dermal: Slightly toxic. (Rabbit LD_{50} 1544 mg/kg).
Inhalation: Slightly toxic. (Rat 4-hr LC_{50}: > 3.5 mg/L) (Data on similar product)
Oral: Slightly toxic. (Rat LD_{50} 1161 mg/kg).

This product contains substances that are considered to be probable or suspected human carcinogens as follows:

	Regulatory Agency Listing As Carcinogen			
Ingredients Name	**OSHA**	**IARC**	**NTP**	**ACGIH**
Chlorophenoxy herbicides	No	2B	No	No

(Also see Section 3.)

12. ECOLOGICAL INFORMATION

Aquatic Toxicity:
Data on 2,4-D dimethylamine salt:

96-hr LC_{50} Bluegill:	524 mg/l
96-hr LC_{50} Rainbow Trout:	250 mg/l
48-hr EC_{50} Daphnia:	184 mg/l

Avian Toxicity:
Data on 2,4-D dimethylamine salt:

Bobwhite Quail Oral LD_{50}:	500 mg/kg
Mallard Duck 8-day Dietary LC_{50}:	>5620 ppm

Environmental Fate:
In laboratory and field studies, 2,4-D DMA salt rapidly dissociated to parent acid in the environment. The typical half-life of the resultant 2,4-D acid ranged from a few days to a few weeks.

13. DISPOSAL CONSIDERATIONS

Waste Disposal Method:
Pesticide wastes are acutely hazardous. Improper disposal of excess pesticide is a violation of Federal Law and may contaminate ground water. If these wastes cannot be disposed of by use according to label instructions, contact your State Pesticide or Environmental Control Agency, or the Hazardous Waste representative at the nearest EPA Regional Office for guidance.

Container Handling and Disposal:
Do not reuse empty container. Triple rinse (or equivalent) adding rinsate to application equipment. Then offer empty container for recycling or reconditioning, or puncture and dispose of in a sanitary landfill or by incineration, or, if allowed by State and local authorities, by burning. If burned, stay out of smoke.

14. TRANSPORTATION INFORMATION

NOTE: Information is for surface transportation of package sizes generally offered and does not address regulatory variations due to changes in package size, mode of shipment or other conditions.

Packages containing less than 26.3 gallons of this product are generally not regulated. For packages containing 26.3 gallons or higher:

DOT Proper Shipping Name:	ENVIRONMENTALLY HAZARDOUS SUBSTANCE, LIQUID, N.O.S. (2,4-D SALTS), RQ (2,4-D SALTS)
DOT Hazard Class / I.D. No.:	9 / UN3082
DOT Label:	Class 9
U.S. Surface Freight Classification:	Weed killing compound, N.O.I.B.N.

15. REGULATORY INFORMATION

Federal Regulations:

TSCA Inventory: This product is excepted from TSCA because it is solely for FIFRA regulated use.

SARA Hazard Notification:
Hazard Categories Under Criteria of SARA Title III Rules (40 CFR Part 370):

Fire:	Reactive:	Release of Pressure:	Acute Health:	Chronic Health:
No	No	No	Yes	Yes

Section 313 Toxic Chemical(s):
ACETIC ACID, (2,4-DICHLOROPHENOXY)-, CAS NO. 94-75-7 (38.9% equivalent by weight in product)

Reportable Quantity (RQ) under U.S. CERCLA:

Ingredient	RQ
ACETIC ACID, (2,4-DICHLOROPHENOXY) -	100 lbs (approximately 26.3 gallons of this product)

Selected State Regulations:

This product contains the following components that are regulated under California Proposition 65:

Ingredient Name	Cancer List	Reproductive List	Risk Level (ug/day)	
			California	Nufarm
Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable

16. OTHER INFORMATION

National Fire Protection Association (NFPA®) Hazard Ratings:

Ratings for This Product		Key to Ratings	
2	Health Hazard	0	Minimal
1	Flammability	1	Slight
0	Instability	2	Moderate
		3	Serious
		4	Severe

Abbreviations and Acronyms Not Defined Elsewhere:

ACGIH	American Conference of Governmental Industrial Hygienists
ANSI	American National Standards Institute
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
DOT	Department of Transportation
FIFRA	Federal Insecticide, Fungicide and Rodenticide Act
IARC	International Agency for Research on Cancer
MSHA	Mine Safety and Health Administration
NIOSH	National Institute for Occupational Safety and Health
NTP	National Toxicology Program
OSHA	Occupational Safety and Health Administration

PEL	Permissible Exposure Limit
SARA	Superfund Amendments and Reauthorization Act of 1986
STEL	Short Term Exposure Limit
TLV	Threshold Limit Value
TSCA	Toxic Substances Control Act
TWA	Time Weighted Average
USEPA	U.S. Environmental Protection Agency

This Material Safety Data Sheet (MSDS) serves different purposes than and DOES NOT REPLACE OR MODIFY THE EPA-ACCEPTED PRODUCT LABELING (attached to and accompanying the product container). This MSDS provides important health, safety and environmental information for employers, employees, emergency responders and others handling large quantities of the product in activities generally other than product use, while the labeling provides that information specifically for product use in the ordinary course.

Use, storage and disposal of pesticide products are regulated by the EPA under the authority of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) through the product labeling, and all necessary and appropriate precautionary, use, storage, and disposal information is set forth on that labeling. It is a violation of federal law to use a pesticide product in any manner not prescribed on the EPA-accepted label.

Although the information and recommendations set forth herein (hereinafter "Information") are presented in good faith and believed to be correct as of the date hereof, Nufarm, Inc. makes no representations as to the completeness or accuracy thereof. Information is supplied upon the condition that the persons receiving same will make their own determination as to its suitability for their purposes prior to use. In no event will Nufarm, Inc. be responsible for damages of any nature whatsoever resulting from the use or of reliance upon Information. NO REPRESENTATIONS OR WARRANTIES, EITHER EXPRESS OR IMPLIED, OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR OF ANY OTHER NATURE ARE MADE HEREUNDER WITH RESPECT TO INFORMATION OR THE PRODUCT TO WHICH INFORMATION REFERS.

WEEDAR® is a registered trademark of Nufarm, Inc.

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES)
PERMIT APPLICATION SUPPLEMENTARY INFORMATION

ALABAMA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT
WATER DIVISION – INDUSTRIAL / MINING PERMIT SECTION
POST OFFICE BOX 301463
MONTGOMERY, ALABAMA 36130-1463

INSTRUCTIONS: APPLICATIONS SHOULD BE TYPED OR PRINTED IN INK AND SUBMITTED TO THE DEPARTMENT IN DUPLICATE. IF INSUFFICIENT SPACE IS AVAILABLE TO ADDRESS ANY ITEM, PLEASE CONTINUE ON AN ATTACHED SHEET OF PAPER. PLEASE MARK N/A IN THE APPROPRIATE BOX WHEN AN ITEM IS NON-APPLICABLE TO THE APPLICANT.

PURPOSE OF THIS APPLICATION

- ☐ INITIAL PERMIT APPLICATION FOR NEW FACILITY
- ☐ INITIAL PERMIT APPLICATION FOR EXISTING FACILITY
- ☐ MODIFICATION OF EXISTING PERMIT
- ☑ REISSUANCE OF EXISTING PERMIT
- ☐ REVOCATION & REISSUANCE OF EXISTING PERMIT

1. Facility Name: TVA Browns Ferry Nuclear Plant
   a. Operator Name: Tennessee Valley Authority
   b. Is the operator identified in 1.a., the owner of the facility? Yes ☑ No ☐
   If no, provide the name and address of the operator and submit information indicating the operator's scope of responsibility for the facility.
2. NPDES Permit Number AL 0 0 2 2 0 8 0
3. SID Permit Number (if applicable): IU __ __ - __ __ - __ __ __ __ __
4. NPDES General Permit Number (if applicable) ALG __ __ __ __ __ __ __
5. Facility Physical Location: (Attach a map with location marked; street, route no. or other specific identifier)
   Street: 10835 Shaw Road
   City: Athens County: Limestone State: Alabama Zip: 35611
   Facility (Front Gate) Latitude: 35° 42' 25.35" North Longitude: 87° 06' 50.02" West
6. Facility Mailing Address (Street or Post Office Box): P.O. Box 2000, WSP1A
   City: Decatur State: Alabama Zip: 35609

7. Responsible Official (as described on page 13 of this application):

Name and Title: K. J. Polson, Site Vice President

Address: P.O. Box 2000, NAB 2A

City: Decatur State: Alabama Zip: 35609

Phone Number: 256-729-3675

EMAIL Address: kjpolson@tva.gov

8. Designated Facility Contact:

Name and Title: Carroll R. (Rusty) Cooper, P.E.

Phone Number: 256-729-2681

EMAIL Address: crcooper@tva.gov

9. Designated Discharge Monitoring Report Contact:

Name and Title: Carroll R. (Rusty) Cooper, P.E.

Phone Number: 256-729-2681

EMAIL Address: crcooper@tva.gov

10. Type of Business Entity:

☐ Corporation ☐ General Partnership ☐ Limited Partnership

☐ Sole Proprietorship ☑ Other (Please Specify) Federal

11. Complete this section if the Applicant's business entity is a Corporation

a) Location of Incorporation:

Address: N/A

City: ____ County: ____ State: ____ Zip: ____

b) Parent Corporation of Applicant:

Name: N/A

Address: ____

City: ____ State: ____ Zip: ____

c) Subsidiary Corporation(s) of Applicant:

Name: N/A ______________________________

Address: ______________________________

City: ______________ State: ______________ Zip: ______________

d) Corporate Officers:

Name: N/A ______________________________

Address: ______________________________

City: ______________ State: ______________ Zip: ______________

Name: ______________________________

Address: ______________________________

City: ______________ State: ______________ Zip: ______________

e) Agent designated by the corporation for purposes of service:

Name: N/A ______________________________

Address: ______________________________

City: ______________ State: ______________ Zip: ______________

12. If the Applicant's business entity is a Partnership, please list the general partners.

Name: N/A ______________________________

Address: ______________________________

City: ______________ State: ______________ Zip: ______________

Name: ______________________________

Address: ______________________________

City: ______________ State: ______________ Zip: ______________

13. If the Applicant's business entity is a Proprietorship, please enter the proprietor's information.

Name: N/A

Address:

City: State: Zip:

14. Permit numbers for Applicant's previously issued NPDES Permits and identification of any other State of Alabama Environmental Permits presently held by the Applicant, its parent corporation, or subsidiary corporations within the State of Alabama:

Permit Name	Permit Number	Held By
See attachment 1		

15. Identify all Administrative Complaints, Notices of Violation, Directives, Administrative Orders, or Litigation concerning water pollution, if any, against the Applicant, its parent corporation or subsidiary corporations within the State of Alabama within the past five years (attach additional sheets if necessary):

Facility Name	Permit Number	Type of Action	Date of Action
See attachment 2			

SECTION B – BUSINESS ACTIVITY

1. Indicate applicable Standard Industrial Classification (SIC) Codes for all processes
   (If more than one applies, list in order of importance:

   a. 4911

   b.

   c.

   d.

   e.

2. If your facility conducts or will be conducting any of the processes listed below (regardless of whether they generate wastewater, waste sludge, or hazardous waste), place a check beside the category of business activity (check all that apply):

Industrial Categories

- [ ] Aluminum Forming
- [ ] Asbestos Manufacturing
- [ ] Battery Manufacturing
- [ ] Can Making
- [ ] Canned and Preserved Fruit and Vegetables
- [ ] Canned and Preserved Seafood
- [ ] Cement Manufacturing
- [ ] Centralized Waste Treatment
- [ ] Carbon Black
- [ ] Coal Mining
- [ ] Coil Coating
- [ ] Copper Forming
- [ ] Electric and Electronic Components Manufacturing
- [ ] Electroplating
- [ ] Explosives Manufacturing
- [ ] Feedlots
- [ ] Ferroalloy Manufacturing
- [ ] Fertilizer Manufacturing
- [ ] Foundries (Metal Molding and Casting)
- [ ] Glass Manufacturing
- [ ] Grain Mills
- [ ] Gum and Wood Chemicals Manufacturing
- [ ] Inorganic Chemicals
- [ ] Iron and Steel
- [ ] Leather Tanning and Finishing
- [ ] Metal Finishing
- [ ] Meat Products
- [ ] Metal Molding and Casting
- [ ] Metal Products
- [ ] Nonferrous Metals Forming
- [ ] Nonferrous Metals Manufacturing
- [ ] Oil and Gas Extraction
- [ ] Organic Chemicals Manufacturing
- [ ] Paint and Ink Formulating
- [ ] Paving and Roofing Manufacturing
- [ ] Pesticides Manufacturing
- [ ] Petroleum Refining
- [ ] Phosphate Manufacturing
- [ ] Photographic
- [ ] Pharmaceutical
- [ ] Plastic & Synthetic Materials
- [ ] Plastics Processing Manufacturing
- [ ] Porcelain Enamel
- [ ] Pulp, Paper, and Fiberboard Manufacturing
- [ ] Rubber
- [ ] Soap and Detergent Manufacturing
- [✓] Steam and Electric
- [ ] Sugar Processing
- [ ] Textile Mills
- [ ] Timber Products
- [ ] Transportation Equipment Cleaning
- [ ] Waste Combustion
- [ ] Other (specify)______________

A facility with processes inclusive in these business areas may be covered by Environmental Protection (EPA) categorical standards. These facilities are termed "categorical users" and should skip to question 2 of Section C.

3. Give a brief description of all operations at this facility including primary products or services (attach additional sheets if necessary):

TVA Browns Ferry Nuclear Plant operates three boiling water reactors for the purpose of generating electric power.

SECTION C – WASTEWATER DISCHARGE INFORMATION

Facilities that checked activities in question 2 of Section B and are considered Categorical Industrial Users should skip to question 2 of this section.

1. **For Non-Categorical Users Only:** Provide wastewater flows for each of the processes or proposed processes. Using the process flow schematic (Figure 1, pg 14), enter the description that corresponds to each process. [New facilities should provide estimates for each discharge.]

Process Description	Last 12 Months (gals/day) Highest Month Avg. Flow	Highest Flow Year of Last 5 (gals/day) Monthly Avg. Flow	Discharge Type (batch, continuous, intermittent)
N/A			

If batch discharge occurs or will occur, indicate: [New facilities may estimate.]

a. Number of batch discharges: ________ per day

b. Average discharge per batch: ________ (GPD)

c. Time of batch discharges ________ at ________
(days of week) (hours of day)

d. Flow rate: ________ gallons/minute

e. Percent of total discharge: ________

Non-Process Discharges (e.g. non-contact cooling water)	Last 12 Months (gals/day) Highest Month Avg. Flow	Highest Flow Year of Last 5 (gals/day) Monthly Avg. Flow

2. **Complete this Section only if you are subject to Categorical Standards and plan to directly discharge the associated wastewater to a water of the State.** If Categorical wastewater is discharged exclusively via an indirect discharge to a public or privately-owned treatment works, check "Yes" in the appropriate space below and proceed directly to part 2.c.

[ ] Yes

For Categorical Users: Provide the wastewater discharge flows or production (whichever is applicable by the effluent guidelines) for each of your processes or proposed processes. Using the process flow schematic (Figure 1, pg 14), enter the description that corresponds to each process. [New facilities should provide estimates for each discharge.]

2a.

Regulated Process	Applicable Category	Applicable Subpart	Type of Discharge Flow (batch, continuous, intermittent)
See attachment 3			

2b.

Process Description	Last 12 Months (gals/day) Highest Month Average*	Highest Flow Year of Last 5 (gals/day) Monthly Average*	Discharge Type (batch, continuous, intermittent)
See attachment 3			

*** Reported values should be expressed in units of the applicable Federal production-based standard. For example, flow (MGD), production (pounds per day), etc.**

If batch discharge occurs or will occur, indicate: [New facilities may estimate.]

a. Number of batch discharges: ________________ per day

b. Average discharge per batch: ________________ (GPD)

c. Time of batch discharges ________________ at ________________
(days of week) (hours of day)

d. Flow rate: ________________ gallons/minute

Percent of total discharge: ________________

2c.

Non categorical Process Description	Last 12 Months (gals/day) Highest Month Avg. Flow	Highest Flow Year of Last 5 (gals/day) Monthly Avg. Flow	Discharge Type (batch, continuous, intermittent)

If batch discharge occurs or will occur, indicate: [New facilities may estimate.]

a. Number of batch discharges: ________________ per day

b. Average discharge per batch: ________________ (GPD)

c. Time of batch discharges ________________ at ________________
(days of week) (hours of day)

d. Flow rate: ________________ gallons/minute

Percent of total discharge: ________________

2d.

Non-Process Discharges (e.g. non-contact cooling water)	Last 12 Months (gals/day) Highest Month Avg. Flow	Highest Flow Year of Last 5 (gals/day) Monthly Avg. Flow

All Applicants must complete Questions 3 – 5.

3. Do you have, or plan to have, automatic sampling equipment or continuous wastewater flow metering equipment at this facility?

Flow Metering	Yes ___	No ✓	N/A ___
Sampling Equipment	Yes ___	No ✓	N/A ___

If so, please indicate the present or future location of this equipment on the sewer schematic and describe the equipment below:

4. Are any process changes or expansions planned during the next three years that could alter wastewater volumes or characteristics? Yes ☐ No ☑ (If no, skip Question 5)

Briefly describe these changes and their anticipated effects on the wastewater volume and characteristics:

5. List the trade name and chemical composition of all biocides and corrosion inhibitors used:

Trade Name	Chemical Composition
See attachment 4	

For each biocide and/or corrosion inhibitor used, please include the following information:

(1) 96-hour median tolerance limit data for organisms representative of the biota of the waterway into which the discharge will ultimately reach,
(2) quantities to be used,
(3) frequencies of use,
(4) proposed discharge concentrations, and
(5) EPA registration number, if applicable

SECTION D – WATER SUPPLY

Water Sources (check as many as are applicable):

[ ] Private Well
[✓] Municipal Water Utility (Specify City):
[✓] Surface Water
[ ] Other (Specify): ____________

IF MORE THAN ONE WELL OR SURFACE INTAKE, PROVIDE DATA FOR EACH ON AN ATTACHMENT

City: 0.2003 *MGD Well: ____ *MGD Well Depth: ____ Ft. Latitude: ____________ Longitude: ____________

Surface Intake Volume: 2895 *MGD Intake Elevation in Relation to Bottom +1.0 Ft.

Intake Elevation: 518.0 Ft. Latitude: 34°42'04"N Longitude: 87°07'04"W

Name of Surface Water Source: Tennessee River

***MGD – Million Gallons per Day**

Cooling Water Intake Structure Information

Complete questions 1 and 2 if your water supply is provided by an outside source and not by an onsite water intake structure? (e.g., another industry, municipality, etc...)

1. Does the provider of your source water operate a surface water intake? Yes [ ] No [ ]
(If yes, continue, if no, go to Section E.)

   a) Name of Provider N/A b)Location of Provider ____________

   c) Latitude: ____________ Longitude: ____________

2. Is the provider a public water system (defined as a system which provides water to the public for human consumption or which provides only treated water, not raw water)? Yes [ ] No [ ]
(If yes, go to Section E, if no, continue.)

Only to be completed if you have a cooling water intake structure or the provider of your water supply uses an intake structure and does not treat the raw water.

3. Is any water withdrawn from the source water used for cooling? Yes [✓] No [ ]

4. Using the average monthly measurements over any 12-month period, approximately what percentage of water withdrawn is used exclusively for cooling purposes? 98 %

5. Does the cooling water consist of treated effluent that would otherwise be discharged? Yes [ ] No [✓]
(If yes, go to Section E, if no, complete questions 6 – 17.)

6. Is the cooling water used in a once-through or closed cycle cooling system? Yes [✓] No [ ]

7. When was the intake installed? Commercial operation began in 1974 (Unit 1), 1975 (Unit 2), and 1977 (Unit 3)
(Please provide dates for all major construction/installation of intake components including screens)

8. What is the maximum intake volume? 2895 MGD
(maximum pumping capacity in gallons per day)

9. What is the average intake volume? 2895 MGD
(average intake pump rate in gallons per day average in any 30-day period)

10. How is the intake operated? (e.g., continuously, intermittently, batch) Continuously

11. What is the mesh size of the screen on your intake? 3/8 inch

12. What is the intake screen flow-through area? 1,485 square feet at normal minimum pool

13. What is the through screen design intake flow velocity? 2.0 ft/sec

14. What is the mechanism for cleaning the screen? (e.g., does it rotate for cleaning) Rotating & backwashing

15. Do you have any additional fish detraction technology on your intake? Yes ☐ No ☑

16. Have there been any studies to determine the impact of the intake on aquatic organisms? Yes ☑ No ☐ (If yes please provide.)

17. Attach a site map showing the location of the water intake in relation to the facility, shoreline, water depth, etc.

SECTION E – WASTE STORAGE AND DISPOSAL INFORMATION

Provide a description of the location of all sites involved in the storage of solids or liquids that could be accidentally discharged to a water of the state, either directly or indirectly via such avenues as storm water drainage, municipal wastewater systems, etc., which are located at the facility for which the NPDES application is being made. Where possible, the location should be noted on a map and included with this application:

Description of Waste	Description of Storage Location
Low-level Radwaste, Haz/Mixed Waste, & Used Oil Waste	East side of plant property; within 1100 ft N-NW of DSN 024
Radwaste	SW of Service Building, adjacent to Turbine Building

Provide a description of the location of the ultimate disposal sites of solid or liquid waste by-products (such as sludges) from any wastewater treatment system located at the facility.

Description of Waste	Quantity (lbs/day)	Disposal Method*
N/A		

***Indicate which wastes identified above are disposed of at an off-site treatment facility and which are disposed of on-site. If any wastes are sent to an off-site centralized waste treatment facility, identify the waste and the facility.**

SECTION F – COASTAL ZONE INFORMATION

Is the discharge(s) located within 10-foot elevation of Mobile or Baldwin County?

Yes [ ] No [ ] If yes, then complete items A through M below:

		YES	NO
A.	Does the project require new construction?	[ ]	[ ]
B.	Will the project be a source of new air emissions?	[ ]	[ ]
C.	Does the project involve dredging and/or filling?	[ ]	[ ]
	Has the Corps of Engineers (COE) permit been received?	[ ]	[ ]
	Corps Project Number ____________		
D.	Does the project involve wetlands and/or submersed grassbeds?	[ ]	[ ]
E.	Are oyster reefs located near the project site? (Include a map showing project and discharge location with respect to oyster reefs)	[ ]	[ ]
F.	Does the project involve the siting, construction and operation of an energy facility as defined in ADEM Admin. Code R. 335-8-1-.02(bb)?	[ ]	[ ]
G.	Does the project involve shoreline erosion mitigation?	[ ]	[ ]
H.	Does the project involve construction on beaches and dunes?	[ ]	[ ]
I.	Will the project interfere with public access to coastal waters?	[ ]	[ ]
J.	Does the project lie within the 100-year floodplain?	[ ]	[ ]
K.	Does the project involve the registration, sale, use, or application of pesticides?	[ ]	[ ]
L.	Does the project propose to construct a new well or alter an existing well to pump more than 50 GPD?	[ ]	[ ]
M.	Has the applicable permit been obtained?	[ ]	[ ]

SECTION G – ANTI-DEGRADATION EVALUATION

In accordance with 40 CFR 131.12 and the Alabama Department of Environmental Management Administrative Code, Section 335-6-10-.04 for antidegradation, the following information must be provided, if applicable. It is the applicant's responsibility to demonstrate the social and economic importance of the proposed activity. If further information is required to make this demonstration, attach additional sheets to the application.

1. Is this a new or increased discharge that began after April 3, 1991? Yes [ ] No [✓]
   If yes, complete question 2 below. If no, go to Section H.

2. Has an Anti-Degradation Analysis been previously conducted and submitted to the Department for the new or increased discharge referenced in question 1? Yes [ ] No [ ]

   If yes, do not complete this section.

If no, and the discharge is to a Tier II waterbody as defined in ADEM Admin. Code r. 335-6-10-.12(4), complete questions A through F below and ADEM forms 311 and 313 (attached). Form 313 must be provided for each alternative considered technically viable.

Information required for new or increased discharges to high quality waters:

A. What environmental or public health problem will the discharger be correcting?

B. How much will the discharger be increasing employment (at its existing facility or as the result of locating a new facility)?

C. How much reduction in employment will the discharger be avoiding?

D. How much additional state or local taxes will the discharger be paying?

E. What public service to the community will the discharger be providing?

F. What economic or social benefit will the discharger be providing to the community?

SECTION H – EPA Application Forms

All Applicants must submit EPA permit application forms. More than one application form may be required from a facility depending on the number and types of discharges or outfalls found there. The EPA application forms are found on the Department's website at http://www.adem.state.al.us/. The EPA application forms must be submitted in duplicate as follows:

1. All applicants must submit Form 1.
2. Applicants for existing industrial facilities (including manufacturing facilities, commercial facilities, mining activities, and silvicultural activities) which discharge process wastewater must submit Form 2C.
3. Applicants for new industrial facilities which propose to discharge process wastewater must submit Form 2D.
4. Applicants for new and existing industrial facilities which discharge only non-process wastewater (i.e., non-contact cooling water and/or sanitary wastewater) must submit Form 2E.
5. Applicants for new and existing facilities whose discharge is composed entirely of storm water associated with industrial activity must submit Form 2F, unless exempted by § 122.26(c)(1)(ii). If the discharge is composed of storm water and non-storm water, the applicant must also submit Forms 2C, 2D, and/or 2E, as appropriate (in addition to Form 2F).

SECTION I – ENGINEERING REPORT/BMP PLAN REQUIREMENTS
See ADEM 335-6-6-.08(i) & (j)

SECTION J– RECEIVING WATERS

Receiving Water(s)	303(d) Segment? (Y / N)	Included in TMDL?* (Y / N)
Tennessee River	No	N/A

*If a TMDL Compliance Schedule is requested, the following should be attached as supporting documentation:
(1) Justification for the requested Compliance Schedule (e.g. time for design and installation of control equipment, etc.);
(2) Monitoring results for the pollutant(s) of concern which have not previously been submitted to the Department (sample collection dates, analytical results (mass and concentration), methods utilized, MDL/ML, etc. should be submitted as available);
(3) Requested interim limitations, if applicable;
(4) Date of final compliance with the TMDL limitations; and,
(5) Any other additional information available to support requested compliance schedule.

SECTION K – APPLICATION CERTIFICATION

THE INFORMATION CONTAINED IN THIS FORM MUST BE CERTIFIED BY A RESPONSIBLE OFFICIAL AS DEFINED IN ADEM ADMINISTRATIVE RULE 335-6-6-.09 "SIGNATORIES TO PERMIT APPLICATIONS AND REPORTS" (SEE BELOW).

"I CERTIFY UNDER PENALTY OF LAW THAT THIS DOCUMENT AND ALL ATTACHMENTS WERE PREPARED UNDER MY DIRECTION OR SUPERVISION IN ACCORDANCE WITH A SYSTEM DESIGNED TO ASSURE THAT QUALIFIED PERSONNEL PROPERLY GATHER AND EVALUATE THE INFORMATION SUBMITTED. BASED ON MY INQUIRY OF THE PERSON OR PERSONS WHO MANAGE THE SYSTEM, OR THOSE PERSONS DIRECTLY RESPONSIBLE FOR GATHERING THE INFORMATION, THE INFORMATION SUBMITTED IS, TO THE BEST OF MY KNOWLEDGE AND BELIEF, TRUE, ACCURATE, AND COMPLETE. I AM AWARE THAT THERE ARE SIGNIFICANT PENALTIES FOR SUBMITTING FALSE INFORMATION INCLUDING THE POSSIBILITY OF FINE AND IMPRISONMENT FOR KNOWING VIOLATIONS."

"I FURTHER CERTIFY UNDER PENALTY OF LAW THAT ALL ANALYSES REPORTED AS LESS THAN DETECTABLE IN THIS APPLICATION OR ATTACHMENTS THERETO WERE PERFORMED USING THE EPA APPROVED TEST METHOD HAVING THE LOWEST DETECTION LIMIT FOR THE SUBSTANCE TESTED."

SIGNATURE OF RESPONSIBLE OFFICIAL: [signature] DATE SIGNED: 2-26-11

(TYPE OR PRINT) NAME OF RESPONSIBLE OFFICIAL: K. J. Polson

TITLE OF RESPONSIBLE OFFICIAL: Site Vice President

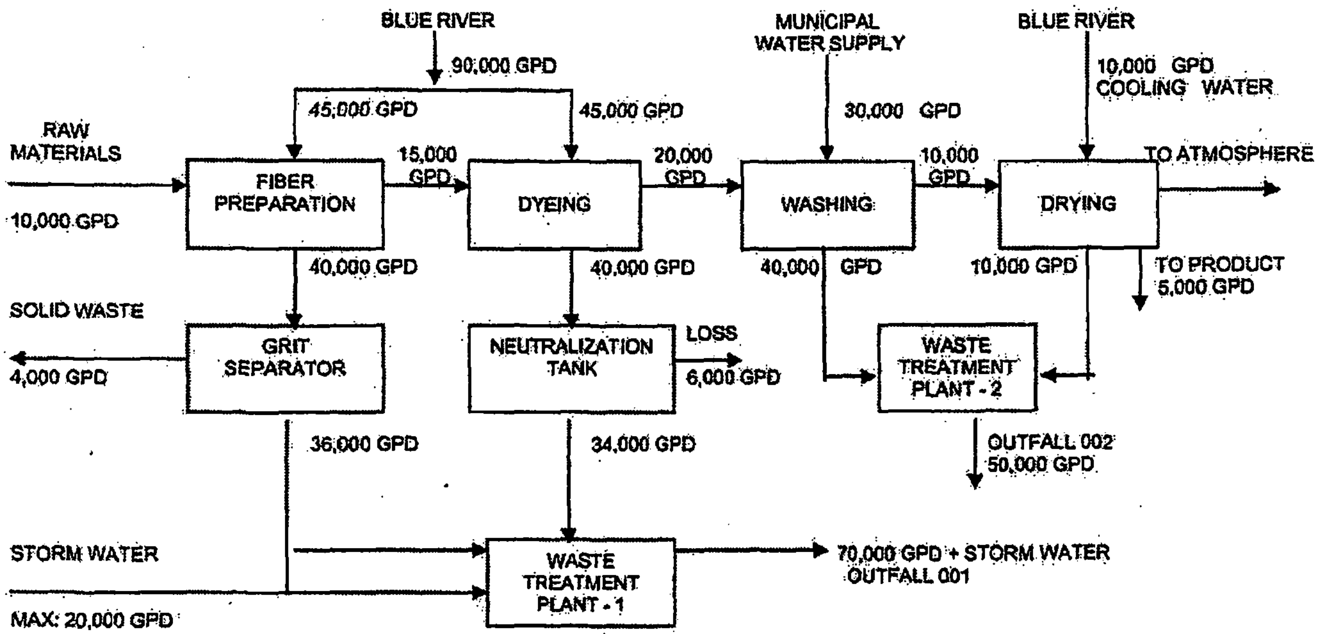
MAILING ADDRESS: P.O. Box 2000, NAB 2A

CITY, STATE, ZIP: Decatur, AL 35609 PHONE: (256) 729-3675

335-6-6-.09 SIGNATORIES TO PERMIT APPLICATIONS AND REPORTS.

(1) The application for an NPDES permit shall be signed by a responsible official, as indicated below:
(a) In the case of a corporation, by a principal executive officer of at least the level of vice president, or a manager assigned or delegated in accordance with corporate procedures, with such delegation submitted in writing if required by the Department, who is responsible for manufacturing, production, or operating facilities and is authorized to make management decisions which govern the operation of the regulated facility;
(b) In the case of a partnership, by a general partner;
(c) In the case of a sole proprietorship, by the proprietor; or
(d) In the case of a municipal, state, federal, or other public entity, by either a principal executive officer, or ranking elected official.

FIGURE 1



SCHEMATIC OF WATER FLOW
BROWN MILLS INC
CITY, COUNTY, STATE

ATTACHMENT 1 TO ADEM FORM 187
NPDES PERMIT RENEWAL APPLICATION
TVA BROWNS FERRY NUCLEAR PLANT - NPDES PERMIT NO. AL0022080

Permit Name	Permit Number	Held by
NPDES Permit	AL0024635	Bellefonte Nuclear Plant
RCRA ID	AL5640090002 (ID#)	Bellefonte Nuclear Plant
Synthetic Minor Operating Permit	705-0021-X004	Bellefonte Nuclear Plant
NPDES Permit	AL0022080	Browns Ferry Nuclear Plant
RCRA ID	AL8640015410 (ID#)	Browns Ferry Nuclear Plant
PSD Permit	708-0003-Z001	Browns Ferry Nuclear Plant
PSD Permit	708-0003-Z003	Browns Ferry Nuclear Plant
Inert Landfill Permit	42-02	Browns Ferry Nuclear Plant
Air Permits (U1-U8 turbines)	701-0010-Z001 through -Z008	Colbert Fossil Plant
Air Permits (U1-U5 boilers)	701-0010-Z009 through -Z013	Colbert Fossil Plant
NPDES Permit	AL0003867	Colbert Fossil Plant
NPDES Construction Storm Water Permit	ALHA00777	Colbert Fossil Plant
RCRA ID	AL7640006675 (ID#)	Colbert Fossil Plant
NPDES Permit	AL0003891	Environmental Research Center
General NPDES Permit	ALG360011	Guntersville Hydro Plant
RCRA ID	ALD982083461 (ID#)	M. S. Heavy Equipment Department
General NPDES Permit	ALG140643	M. S. Power Service Center
RCRA (Operating Permit)	AL2640 090 005	M. S. Power Service Center
General NPDES Permit	ALG340195	Scottsboro Power Svs. Ctr.
General NPDES Permit	ALG 36-0009	Wheeler Hydro Plant
NPDES Construction Storm Water Permit	ALHA02581	Widows Creek Fossil Plant
NPDES Permit	AL0003875	Widows Creek Fossil Plant
RCRA ID	AL8640006690 (ID#)	Widows Creek Fossil Plant
Solid Waste Disposal Permit	36-07	Widows Creek Fossil Plant
Title V Air Permit	705-0008	Widows Creek Fossil Plant
General NPDES Permit	ALG360012	Wilson Hydro Plant
General NPDES Permit	ALG610000	Various TVA Transmission Line & Substation Construction Projects

ATTACHMENT 2 TO ADEM FORM 187
NPDES PERMIT RENEWAL APPLICATION
TVA BROWNS FERRY NUCLEAR PLANT - NPDES PERMIT NO. AL0022080

Facility Name	Date of Issuance	Description of Action and Resolution	Date of Final Resolution
Widows Creek Fossil Plant - NPDES Permit No. AL0003875	10/13/2009	Consent Order 10-002-CWP was issued by ADEM in regard to a release of gypsum to Widows Creek (and other NPDES Permit issues which are described in the Order). TVA has submitted Engineering Reports and O&M Modification Plans which have been conceptually approved by ADEM. Also, TVA paid a civil penalty in the amount of $25,000.	Pending
Bellefonte Nuclear Plant - NPDES Permit AL0024635	07/31/2009	ADEM issued an NOV for late submittal of the NPDES permit renewal application. The permit was reissued prior to expiration.	11/24/2009
Widows Creek Fossil Plant	10/01/2008	EPA issued an NOV (settlement offer) for alleged failure to update the Risk Management Plan. Also, a civil penalty of $7,700 was paid. TVA submitted the revalidation of the plan and generated automatic notifications which are issued 6-months prior to the RMP re-validation anniversary date. In addition, RMP training is being conducted.	10/17/2008 (submittal to EPA)

ATTACHMENT 3 TO ADEM FORM 187
NPDES PERMIT RENEWAL APPLICATION
TVA BROWNS FERRY NUCLEAR PLANT - NPDES PERMIT NO. AL0022080

DSN	Regulated Process	Applicable Category and Subpart	Type of Discharge Flow (batch, continuous, intermittent)	Process Description	Last 12 Months (MGD) Highest Month Average	Highest Flow Year of Last 5 (MGD) Monthly Average
001	Once-through cooling water	40 CFR Part 423.13	Continuous	Removal of waste heat from process equipment	2925.4	2820.8
001b	Low volume wastes	40 CFR Part 423.13	Intermittent	Liquid rad-waste internal monitoring	0.037	0.032
005	Once-through cooling water	40 CFR Part 423.13	Intermittent	Residual heat removal system	6.72	4.96
013b	Low volume wastes	40 CFR Part 423.13	Intermittent	Water treatment plant wastewaters	0.282	0.259

DSN	Non-Categorical Process Description	Last 12 Months (MGD) Highest Month Average	Highest Flow Year of Last 5 (MGD) Monthly Average	Type of Discharge Flow (batch, continuous, intermittent)
013a(1)	Sanitary wastewater treatment system	0.264	0.199	Intermittent

DSN	Non-Process Discharge Description	Last 12 Months (MGD) Highest Month Average	Highest Flow Year of Last 5 (MGD) Monthly Average	Type of Discharge Flow (batch, continuous, intermittent)
012	Intake Screen Backwash	N/A	N/A	Intermittent

ATTACHMENT 4 TO ADEM FORM 187

BROWNS FERRY NUCLEAR PLANT
RAW WATER TREATMENT PROGRAM
MAXIMUM PROJECTED USAGE RATES

EMERGENCY EQUIPMENT COOLING WATER
(EECW) SYSTEM (8000 GPM AVERAGE FLOW)*

PRODUCTS	ACTIVE INGRED.	% ACTIVE INGRED.	PRODUCT FEED RATE (PPM)	ACTIVE FEED RATE (PPM)	FREQUENCY	DISCHARGE CONC. PRODUCT (PPM) (AT DSN001)	DISCHARGE CONC. ACTIVE (PPM) (AT DSN001)
Depositrol PY5200	Co-polymer	30	3.3	1.0	Continuous	0.02	0.006
Flogard MS6209	Zinc & Orthophosphate	12 52.3	8.3	1.0 4.4	Continuous	0.046	0.006
Flogard MS6235	Poly phosphate	29	10	2.9	Continuous	0.05	0.016
Flogard MS6201	Poly phosphate (pyro)	34.2	11.7	4.0	Continuous	0.06	0.022
Spectrus BD1500	Biodispersant	15	20	3	4/week	0.11	0.017
Spectrus OX1201	NaBr	40	17	6.8	28-56 hrs/wk(1)	NA	<0.1
NaOCl	NaOCl	10	51	5.1	28-56 hrs/wk(1)	NA	<0.1
Inhibitor AZ8100	Tolytriazole (TTA)	50	2	1	Continuous	0.01	0.006
EVAC	Amine	29.6	25	7.4	4/yr (72 hrs each)	0.14	0.04
Spectrus CT1300(2)	QUAT	50	5	2.5	4/yr (72 hrs each)	(3)	(3)
Bentonite Clay	Bentonite Clay	(3)	(3)	(3)	(3)	NA	NA

* EECW empties to the intake forebay through DSN 15a, 15b, and 15c, mixes with the forebay water and the condenser circulating water (CCW) flow (2106.1-3026.2 mgd dilution) and discharges to the Tennessee River through DSN001. The CCW flow of 3026.2 is typical with 3 Unit operation with all CCW pumps in service and would be considered normal operation. During outages the flow for CCW would be 2106.1 MGD. The discharge concentration is calculated based on what is considered to be two Unit CCW flow (2106.1).

The following molluscicide treatment regime and options should be in accordance with SPP-9.7/CHTP-108 and BFN Raw Water Team concurrence.

(1) 28-56 hours/week is normal operation for MIC control. Treatment time required varies due to seasonal demand. Continuous treatment (or some variation) may be used as an alternative to or in conjunction with non-oxidizing treatments, as required, for macrofouling (invertebrate) control.

(2) Treatment with Spectrus CT1300 is an alternative treatment plan (non-oxidizing biocide) in place of EVAC.

(3) Bentonite Clay is used to detoxify the Spectrus CT1300. It is applied at a 5:1 ratio of clay to CT1300 and is fed a minimum of 2 hours after CT1300 injection is completed.

RAW COOLING WATER/RAW SERVICE WATER
HIGH PRESSURE FIRE PROTECTION SYSTEMS
(58,000 GPM TOTAL AVERAGE FLOW)*

PRODUCTS	ACTIVE INGRED.	% ACTIVE INGRED.	PRODUCT FEED RATE (PPM)	ACTIVE FEED RATE (PPM)	FREQUENCY	DISCHARGE CONC. PRODUCT (PPM) (AT DSN001)	DISCHARGE CONC. ACTIVE (PPM) (AT DSN001)
Depositrol PY5200	Co-polymer	30	3.3	1.0	Continuous	0.13	0.04
Flogard MS6209	Zinc & Orthophosphate	12 52.3	8.3	1.0 4.4	Continuous	0.33	0.04
Flogard MS6235	Poly phosphate	29	10	2.9	Continuous	0.40	0.12
Flogard MS6201	Poly phosphate (pyro)	34.2	11.7	4.0	Continuous	0.47	0.16
Spectrus BD1500	Biodispersant	15	20	3	4/week	0.8	0.12
Spectrus OX1201	NaBr	40	17	6.8	28-56 hrs/wk(1)	NA	<0.1
NaOCl	NaOCl	10	51	5.1	28-56 hrs/wk(1)	NA	<0.1
Spectrus CT1300	QUAT	50	5	2.5	4/yr (72 hrs each)	(2)	(2)
Bentonite Clay	Bentonite Clay	(2)	(2)	(2)	(2)	NA	NA

*Portions of these systems empty to the intake forebay through DSN15 and 15d where they mix with forebay water and CCW before discharge to the Tennessee River through DSN001. The remainder discharges directly into the CCW and is discharged through DSN001 (2106.1-3026.2 mgd dilution). The CCW flow of 3026.2 is typical with 3 Unit operation with all CCW pumps in service and would be considered normal operation. During outages the flow for CCW would be 2106.1 MGD. The discharge concentration is calculated based on what is considered to be two Unit CCW flow (2106.1).

The following molluscicide treatment regime and options should be in accordance with SPP-9.7/RCTP-108 and BFN Raw Water Team concurrence.
(1) 28-56 hours/week is normal operation for MIC control. Treatment time required varies due to seasonal demand. Continuous treatment (or some variation) may be used as an alternative to or in conjunction with non-oxidizing treatments, as required, for macrofouling (invertebrate) control.
(2) Bentonite Clay is used to detoxify the Spectrus CT1300 not diluted by CCW (where dilution is acceptable). It is applied at a 5:1 ratio of clay to Spectrus CT1300. It is fed a minimum of 2 hours after Spectrus CT1300 injection is completed.

RHRSW SYSTEM-STAGNANT TREATMENT MODE
(2000 GPM AVERAGE FLOW)*

PRODUCTS	ACTIVE INGRED.	% ACTIVE INGRED.	PRODUCT FEED RATE (PPM)	ACTIVE FEED RATE (PPM)	FREQUENCY	DISCHARGE CONC. PRODUCT (PPM)	DISCHARGE CONC. ACTIVE (PPM)
Depositrol PY5200	Co-polymer	28.5	66.5	20	2/Quarter	66.5	20
Flogard MS6209	Zinc & Orthophosphate	12 52.3	8.3	1.0 4.4	2/Quarter	8.3	1.0 4.4
Flogard MS6235	Poly phosphate	29	106	30	2/Quarter	106	30
Spectrus BD1500	Biodispersant	15	20	3	2/Quarter	20	3
Spectrus NX1105	Gluteraldehyde	45	200	90	2/Quarter	200	90

* In the stagnant treatment mode, amounts are based on flushes twice per quarter for each of 10 heat exchangers (80 flushes per year). Each flush consists of 20 minutes at < 2000 gpm. Discharge is through DSN 005.

RHRSW SYSTEM-NORMAL TREATMENT MODE
(4500 GPM AVERAGE FLOW)*

PRODUCTS	ACTIVE INGRED.	% ACTIVE INGRED.	PRODUCT FEED RATE (PPM)	ACTIVE FEED RATE (PPM)	FREQUENCY	DISCHARGE CONC. PRODUCT (PPM)	DISCHARGE CONC. ACTIVE (PPM)
Depositrol PY5200	Co-polymer	30	3.3	1.0	Weekly(2)	3.3	1.0
Flogard MS6209	Zinc & Orthophosphate	12 52.3	8.3	1.0 4.4	Weekly(2)	8.3	1.0 4.4
Flogard MS6235	Poly phosphate	29	10	2.9	Weekly(2)	10	2.9
Flogard MS6201	Poly phosphate (pyro)	34.2	11.7	4.0	Weekly(2)	11.7	4
Spectrus BD1500	Biodispersant	15	20	3	Weekly(2)	20	3
Spectrus OX1201	NaBr	40	17	6.8	Weekly(2)	NA	<2.0
NaOCl	NaOCl	10	51	5.1	Weekly(2)	NA	<2.0
Inhibitor AZ8100(1)	Tolytriazole (TTA)	50	2	1	Weekly(2)	2.0.	1.0
EVAC(1)	Amine	29.6	25	7.4	Weekly(2)	25	7.4
Spectrus CT1300(1)	QUAT	50	5	2.5	Weekly(2)	5	2.5

* Discharge is through DSN 005. The 4500 gpm flow rate is typical; however, other flow rates may be used, if necessary or desired, as long as the discharge concentrations are not exceeded.
(1) These chemicals are not intended for treatment of this system, but may as a part of normal Plant operation (intermittent use of RHRSW pumps), be observed at the indicated concentrations. Reference use of these chemicals in previous Tables.
(2) The intended treatment schedule is weekly for approximately 30 minutes per heat exchanger, but as indicated in footnote 1, the system may receive treatment due to intermittent use of RHRSW pumps. Intermittent use is considered to be normal Plant operation of RHRSW pumps. During Unit Refueling Outages (~30 days average), RHRSW pumps are utilized in extended intervals for shutdown cooling and reactor coolant temperature control. Such outages typically occur every two years per unit with Units 1 and 3 scheduled during even numbered years and Unit 2 scheduled during odd numbered years.
GE Betz.doc

Evaluation of Proposed Zinc Addition:

It is proposed to treat the listed systems with a product containing zinc to be maintained at maximum total zinc concentration of 1.0 ppm . TVA plans to monitor at established internal points to ensure this maximum level is not exceeded.

The 7Q10 flow for the Tennessee River in the vicinity of BFN is 7,109 MGD per the 1994 NPDES permit rationale. Based on TVA's NPDES permit renewal monitoring, the background concentration of total zinc is <0.010 mg/L. Since the background concentration is less than the minimum detection limit (MDL), an actual ambient zinc concentration of 1/2 of MDL or 0.005 mg/L is assumed. Also, a total hardness of 100 mg/L for the receiving stream is assumed.

At an assumed hardness of 100 mg/L, the acute and chronic water quality criteria for zinc are both approximately 0.12 mg/L. At the 7Q10 river flow, the zinc load in the river could be (0.12 x 8.34 x 7,109) pounds per day or 7,115 pounds per day as dissolved zinc. Based on the background zinc concentration of < 0.010 mg/L, the assimilative capacity of the receiving stream at the 7Q10 flow ≈7,115 pounds per day - (0.010 x 8.34 x 7,109) or 6,522 pounds per day. The proposed zinc additions are:

Emergency Equipment Cooling Water:

(8,000 x 1440 x 10^{-6} x 8.34 x 1.0) lb/day or approximately 100 pounds per day as total zinc

Raw Cooling Water/Raw Service Water/High Pressure Fire Protection:

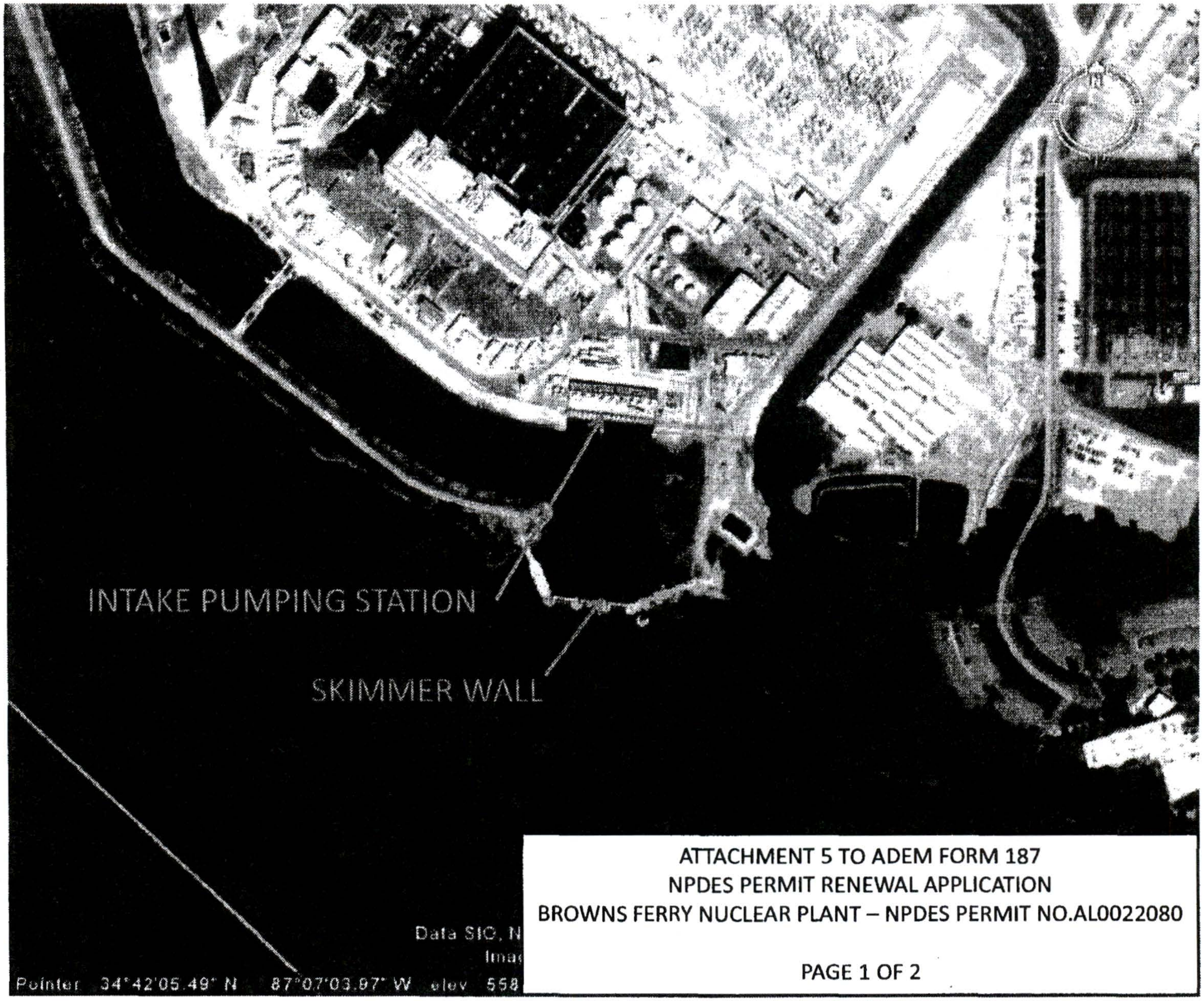
(58,000 x 1440 x 10^{-6} x 8.34 x 1.0) lb/day or approximately700 pounds per day as total zinc

Residual Heat Removal System:

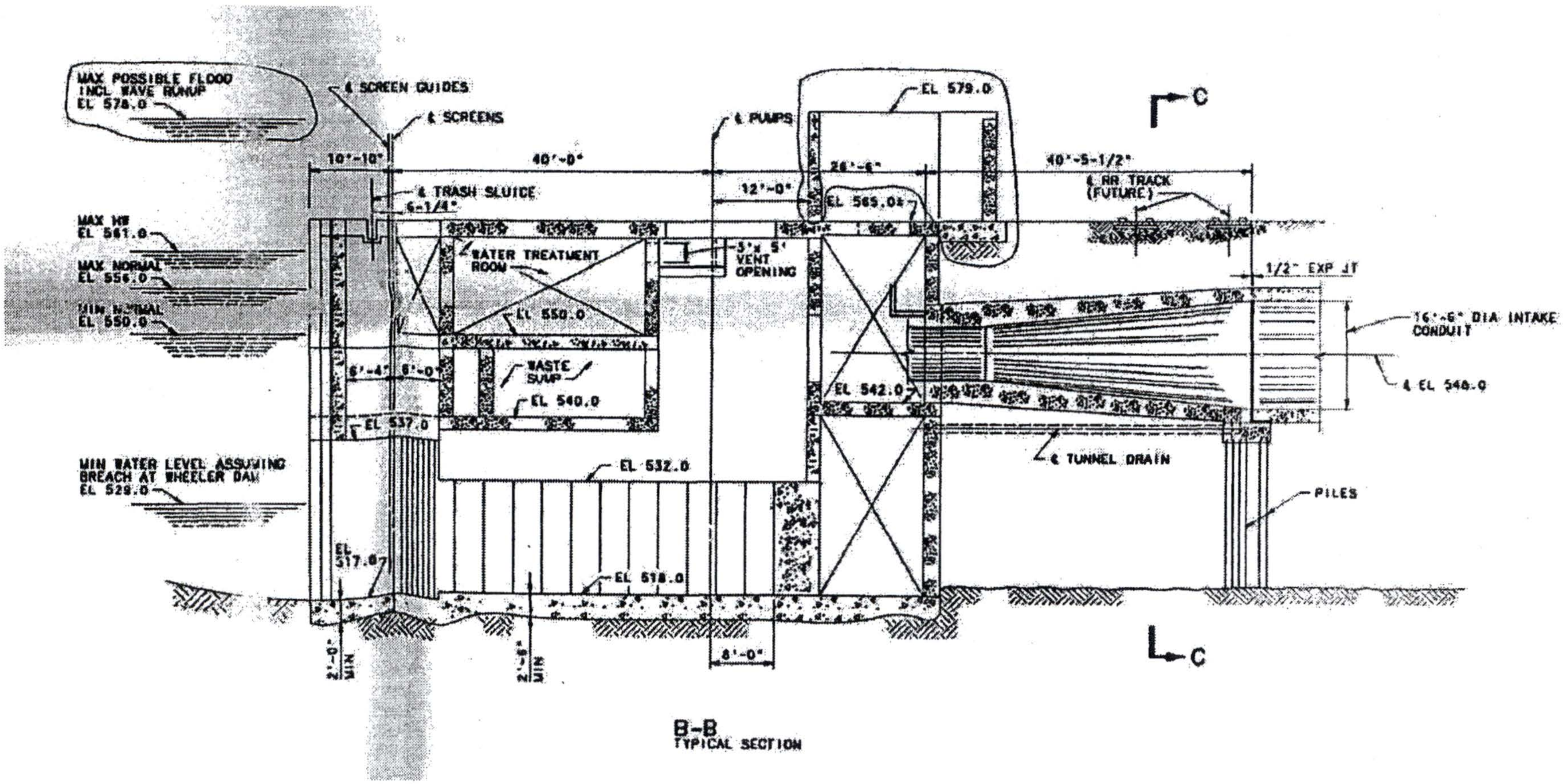
(4,500 x 1440 x 10^{-6} x 8.34 x 1.0) lb/day or approximately 54 pounds per day as total zinc

Total Proposed Zinc Addition:

(100 + 700 + 54) lb/day or 854 pounds per day which is significantly less than the assimilative capacity of the receiving stream



ATTACHMENT 5 TO ADEM FORM 187
NPDES PERMIT RENEWAL APPLICATION
BROWNS FERRY NUCLEAR PLANT – NPDES PERMIT NO.AL0022080



B-B
TYPICAL SECTION

ATTACHMENT 5 TO ADEM FORM 187
NPDES PERMIT RENEWAL APPLICATION
BROWNS FERRY NUCLEAR PLANT – NPDES PERMIT NO.AL0022080

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SOURCE DRAWING 0-31E201 R0

TENNESSEE VALLEY AUTHORITY

BROWNS FERRY NUCLEAR PLANT
NPDES PERMIT NO. AL0022080
316(b) MONITORING PROGRAM

FISH IMPINGEMENT AT BROWNS FERRY NUCLEAR PLANT SEPTEMBER 2007 THROUGH SEPTEMBER 2009

ENVIRONMENTAL STEWARDSHIP AND POLICY

APRIL 2010

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List of Acronyms and Abbreviations

AM&M	**Aquatic Monitoring and Management**
BFN	**Browns Ferry Nuclear Plant**
CCW	**Condenser Cooling Water**
CWA	**Clean Water Act**
EA	**Equivalent Adult**
EPA	**Environmental Protection Agency**
EPRI	**Formerly the Electric Power Research Institute**
GPM	**Gallons Per Minute**
MSL	**Mean Sea Level**
MW	**Megawatt**
PF	**Production Foregone**

Introduction

Browns Ferry Nuclear Plant (BFN) is a three unit nuclear-fueled facility located on Wheeler Reservoir in Limestone County, Alabama. Currently, all three units are in operation. Unit 1 was shutdown in 1985 and was returned to service in June 2007. Three condenser cooling water (CCW) pumps associated with Unit 1 are now in operation in addition to the CCW pumps used for Units 2 and 3. BFN's current operation utilizes a once-through CCW system, withdrawing water from the Tennessee River through an intake structure and discharging the water through diffuser pipes located downstream from the plant. This process is regulated by BFN's National Pollutant Discharge Elimination System permit, AL0022080, and is subject to compliance with the federal Clean Water Act (CWA). Section 316(b) of the CWA requires the location, design, construction, and capacity of cooling water intake structures to reflect the best technology available for minimizing adverse environmental impacts. A potential impact associated with cooling water intake structures is impingement of aquatic organisms. Impingement occurs when fish and shellfish are trapped against intake screens by the force of cooling water withdrawal. Impingement data related to the operation of Units 2 and 3 were collected during 2003 and 2004 to update baseline data so that potential impingement impacts from increased CCW demand after the restart of Unit 1 could be more accurately assessed (Baxter et al., 2006). Additional impingement data was collected to assess impingement rates associated with the CCW withdrawal for the operation of three units. Impingement monitoring began in September 2007 and continued weekly for two years. This report presents impingement data collected from the CCW intake screens during September 2007 through September 2009.

Plant Description

BFN is located at Tennessee River Kilometer 473 (Tennessee River Mile 294) on the north shore (right descending bank) of Wheeler Reservoir (Figure 1). The three units (boiling water reactors) each have a nameplate rating of 1,100 megawatts (MW). Units Two and Three were uprated in 1997 and 1998 and Unit One in 2007, resulting in an increase of 1280MW for each unit. The uprate was accomplished without additional increase in CCW demand. Six mechanical draft cooling towers enable BFN to operate in either open or helper mode.

The CCW intake channel extends approximately 152 m (500 ft) from the intake structure to the skimmer wall. The skimmer wall is a 66 m (218 ft) long concrete and steel structure positioned across the entrance of the intake channel. Water is drawn into the intake channel through the lower portion of the wall through three 12 m (40 ft) wide sections, enabling BFN to withdraw cooler water from the lower stratum. The three open sections have movable gates with bottom elevations that can vary between 161 m (527 ft) mean sea level (msl) and 167 m (547 ft) msl. Actual water depth in the channel varies based on reservoir elevations: the normal minimum pool elevation is 168 m (550 ft) msl and normal maximum pool elevation is 169 m (556 ft) msl.

The CCW pumping station is comprised of a concrete pumping structure 71 m (232 ft) long by 36 m (117 ft) wide and 14 m (47 ft) high. The bottom elevation of the pumping station is 158 m (517 ft) msl. Each unit has three CCW pumps. Each pump has a design flow rate of 220,000 gallons per minute (gpm), giving a design intake flow of 660,000 gpm per unit. The pumps are installed in separate pump bays that are each covered by two trashracks and two traveling screens. The screens are each 2.3 m (7.5 ft) wide with mesh openings of 9.5 mm (3/8 in). The

design through screen velocity is 2.0 feet per second at normal minimum pool and 1.64 feet per second at normal high pool. The CCW pumps can operate in parallel for each unit. However, if one pump is out of service, the two remaining pumps will deliver sufficient flow for full-load operation but with a higher turbine backpressure.

The traveling screens and screen wash system can be operated automatically or manually. Differential pressure across each pair of traveling screens for a given CCW pump is monitored. When operating the system in the automatic mode, the screen wash pump is started when a preset differential pressure of water is reached across any of the three pairs of screens. When a preset pressure is established at the screen wash nozzles, the screen motors are automatically started and the screens are washed. In either manual or automatic mode, the pump and screens run until manually stopped.

Methods

Impingement data presented in this report is from weekly samples collected from September 12, 2007 through September 9, 2009.

At BFN, a continuous backwash is utilized to remove fish and debris from the traveling screens. This backwash sends fish and debris back to Wheeler Reservoir through a sluice pipe. A catch basket constructed of 9.5 mm (3/8-in) mesh is located at the end of the sluice pipe and is moved into place to catch fish during sampling periods. Weekly, impingement sampling is conducted in six hour intervals during a twenty-four hour period to ensure that any diel variations in fish impingement could be detected. After the Aquatic Monitoring and Management (AM&M) crew removes the sample from the basket during each sampling period, fish are sorted from debris, identified, separated into 25 mm (1 in) length classes, enumerated, and weighed. Any fish collected alive are returned to the reservoir after processing. Incidental numbers of fish which appeared to have been dead for more than 24 hours (i.e., exhibiting pale gills, cloudy eyes, fungus, or partial decomposition) are not included in the sample. Data recorded by one member of the AM&M crew is checked and verified (signed) by the other for quality control. Quality Assurance/Quality Control procedures for impingement sampling (TVA 2004) are followed to ensure samples compare with historical impingement mortality data.

Data Analysis
Estimated annual impingement was calculated by extrapolating impingement rates from weekly samples (24-hr sample x 7 x 52).

To facilitate the implementation of and compliance with the Environmental Protection Agency (EPA) regulations for Section 316(b) of the CWA (Federal Register Vol. 69, No. 131; July 9, 2004), prior to its suspension by EPA, fish lost to impingement were evaluated by extrapolating the losses to equivalent reductions of adult fish, or of biomass production available to predators in the case of forage species. EPRI (formerly the Electric Power Research Institute) has identified two models for extrapolating losses of juvenile fish at intake structures to numbers or production of older fish (Barnthouse 2004). The Equivalent Adult (EA) model quantifies impingement losses in terms of the number of fish that would have survived to a given future age. The Production Foregone (PF) model was applied to forage fish species to quantify the loss

from impingement in terms of potential forage available for consumption by predators. These models were used to determine the "biological liability" of the CCW intake structure based on the EPA guidance developed under the suspended rule.

Fish Community Assessment

Prior to 2000, the Tennessee Valley Authority's (TVA) Browns Ferry Nuclear Plant (BFN) was operating under a 316(a) Alternative Thermal Limit (ATL) that had been continued with each permit renewal based on studies conducted in the mid-1970s. In 1999, EPA Region IV began requesting additional data in conjunction with NPDES permit renewal applications to verify that BIP was being maintained at TVA's thermal plants with ATLs. TVA proposed that its existing Vital Signs (VS) monitoring program, supplemented with additional fish and benthic macroinvertebrate community monitoring upstream and downstream of thermal plants with ATLs, was appropriate for that purpose. The VS monitoring program began in 1990 in the Tennessee River System. This program was implemented to evaluate ecological health conditions in major reservoirs as part of TVA's stewardship role. One of the 5 indicators used in the VS program to evaluate reservoir health is the Reservoir Fish Assemblage Index (RFAI) methodology. RFAI has been thoroughly tested on TVA and other reservoirs and published in peer-reviewed literature (Jennings, et al., 1995; Hickman and McDonough, 1996; McDonough and Hickman, 1999).

TVA initiated a study to evaluate fish communities in areas immediately upstream and downstream of BFN during 2000-2009 using RFAI and RBI multi-metric evaluation techniques. This report presents the results and comparisons of autumn RFAI data collected upstream and downstream of BFN during autumn 2000-2009 (Shaffer et al. 2010).

Results and Discussion

Weekly impingement sampling at BFN from September 12, 2007 through September 9, 2009, resulted in collection of 3,983,438 fish, comprising 46 species (Table 1). During Year One of the study (September 2007 through September 2008), 2,810,778 fish representing 46 species were collected. Of these, 2,731,184 threadfin shad were impinged representing 97% of the total fish collected. During Year Two (September 2008 through September 2009), samples included 1,172,660 fish (43 species) were collected and included 92% (1,074,676) threadfin shad. Threadfin shad were predominant in the samples (96%) for both years combined, followed by gizzard shad (2%), yellow bass, freshwater drum and bluegill (0.1% each). All other species contributed less than 1% of the total number of fish impinged. The rate of impingement was highest during November through January (87%) both years (Table 2, Figure 2). The sample collected on January 2 and 3, 2008 contained 1,684,003 fish (99.1% threadfin shad) and comprised 60% of the total fish collected during Year One. Low ambient water temperatures caused by a cold front during this period caused the high numbers of threadfin shad upstream of BFN to become lethargic from thermal shock to be drawn into the intake and impinged on the traveling screens. This extensive impingement resulted in damage to several traveling screens and a power reduction event which was documented in TVA's Performance Evaluation Report (PER) #135963. The second highest number impinged during Year One was 391,375 on week four of November 2007 (Table 3, Figure 2). Peak impingement during Year Two was recorded

during week three of November (208,051) and week two of December (206,874), 2007.

Annual extrapolated estimates of numbers impinged and corresponding biomass including the average for both years are compared by species and year in Table 4. Estimated impingement (numbers and biomass) during Year One (19,675,446 fish) was over twice that recorded for Year Two (8,208,620). The impingement of thermally shocked threadfin shad observed on January 2 and 3, 2008 was the primary reason for this difference between years. Relatively similar numbers of gizzard shad and freshwater drum were impinged both years.

Application of the EA and PF models to the estimated number impinged annually resulted in reduced numbers of fish (520,309 during Year One and 318,226 during Year Two) which would have been expected to survive to either harvestable size/age or to provide forage (Table 5). This reduced number is considered the "biological liability" resulting from plant CCW impingement mortality based on the guidance developed for the now suspended 316(b) regulations.

Historical impingement monitoring at BFN conducted during 2003 and 2004 with two units operating estimated an annual impingement of 8.1 million fish.

Fish Community Assessment - RFAI

In 2008, fish community RFAI scores of 45 ("Good") and 42 ("Good") were observed at the stations downstream and upstream of BFN respectively (Table 6). Both sites met BIP screening criteria, were within the 6 point range of acceptable variation and were therefore, considered similar. In 2009, fish community RFAI scores of 36 ("Fair") and 39 ("Fair") were observed at the downstream and upstream stations, respectively (Table 7). However, both sites were within the 6-point range of acceptable variation and were considered similar. Average scores for 2000-2009 were 41 for both the upstream and downstream sites (Table 8).

Summary and Conclusions

Impingement monitoring conducted at BFN during September 2007 through September 2009 collected 3,983,438 fish representing 46 species. Threadfin shad dominated the samples comprising 96% during the two years, combined. Gizzard shad (two percent) were next in abundance followed by yellow bass, freshwater drum and bluegill. Seasonal impingement was highest (87%) during November through January both years. Higher impingement during this period is attributed to large numbers of threadfin shad drawn into the plant CCW intake as a result of cold or thermal shock. Extrapolated estimates of numbers impinged were over twice as high (19,675,446) during the first year than estimated for Year Two (8,208,620). This difference was primarily the result of one sample in January, 2008 containing 1,684,003 fish (99.1% threadfin shad). Equivalent Adult and Production Foregone models were applied to the numbers impinged and resulted in reduced numbers of fish or "biological liability" of 520,309 during Year One and 318,226 during Year Two. When the models were applied a second time using an average number of threadfin shad impinged for the anomalous January 2008 sample, the resulting losses to impingement were reduced to 254,509 for Year One. The numbers of fish impinged at BFN are not considered detrimental to the fish community in Wheeler Reservoir.

Fish community or RFAI monitoring during autumn 2008 and 2009 upstream and downstream of BFN resulted in scores rated "Good" in 2008 and "Fair" during 2009. Scores between sites both years were within the acceptable range of variation and were therefore considered similar which suggests no effect from the operation of BFN to the downstream fish community.

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Table 1. List of Fish Species by Family, Scientific, and Common Name Including Numbers Collected in Impingement Samples During September 12, 2007 through September 3, 2008 and September 10, 2008 and September 9, 2009 at Browns Ferry Nuclear Plant.

Family	Scientific Name	Common Name	Total Number Impinged	
			Year One	Year Two
Petromyzontidae	*Ichthyomyzon castaneus*	Chestnut lamprey	4	2
Lepisosteidae	*Lepisosteus osseus*	Longnose gar	0	3
	Lepisosteus oculatus	Spotted gar	16	36
Hiodontidae	*Hiodon tergisus*	Mooneye	4	0
Clupeidae	*Dorosoma cepedianum*	Gizzard shad	34,015	54,678
	Alosa chrysochloris	Skipjack herring	54	21
	Dorosoma petenense	Threadfin shad	2,731,184	1,074,676
	Alosa pseudoharengus	Alewife	122	1,622
Cyprinidae	*Pimephales vigilax*	Bullhead minnow	1,622	197
	Pimephales notatus	Bluntnose minnow	10	0
	Notropis atherinoides	Emerald shiner	21	2
	Notemigonus crysoleucas	Golden Shiner	25	65
	Cyprinella spiloptera	Spotfin shiner	5	0
	Luxilus chrysocephalus	Striped shiner	5	2
	Cyprinus carpio	Common carp	23	74
Catostomidae	*Ictiobus bubalus*	Smallmouth buffalo	2	2
	Ictiobus niger	Black buffalo	4	0
	Moxostoma erythrurum	Golden redhorse	1	0
	Hypentelium nigricans	Northern hogsucker	6	23
	Carpiodes cyprinus	Quillback	0	3
	Minytrema melanops	Spotted sucker	516	735
Ictaluridae	*Ictalurus furcatus*	Blue catfish	516	735
	Ictalurus punctatus	Channel catfish	2,907	2,565
	Pylodictis olivaris	Flathead catfish	46	23
	Ameiurus nebulosus	Brown bullhead	0	13
	Ameiurus melas	Black bullhead	3	0
Atherinopsidae	*Labidesthes sicculus*	Brook silverside	13	0
	Menidia beryllina	Inland Silverside	40	1,798
Belonidae	*Strongylura marina*	Atlantic needlefish	38	11
Moronidae	*Morone chrysops*	White bass	535	255
	Morone mississippiensis	Yellow bass	9,280	15,657
	Morone saxatilis	Striped bass	7	8
	Morone saxatilis x M. chrysops	Hybrid striped bass	13	5
Centrarchidae	*Lepomis macrochirus*	Bluegill	15,132	5,565

Table 1. (continued)

Family	Scientific Name	Common Name	Total Number Impinged	
			Year One	Year Two
Centrarchidae	*Lepomis auritus*	Redbreast sunfish	0	58
	Lepomis microlophus	Redear sunfish	4,160	534
	Lepomis gulosus	Warmouth	14	106
	Lepomis humilis	Orangespotted sunfish	370	959
	Lepomis cyanellus	Green sunfish	35	270
	Lepomis megalotis	Longear sunfish	132	174
		Hybrid sunfish	1	0
	Micropterus dolomieu	Smallmouth bass	2	4
	Micropterus salmoides	Largemouth bass	78	73
	Micropterus punctulatus	Spotted bass	79	72
	Pomoxis annularis	White crappie	197	693
	Pomoxis nigromaculatus	Black crappie	20	2
Percidae	*Sander canadense*	Sauger	14	5
	Perca flavescens	Yellow perch	512	212
	Percina caprodes	Logperch	523	211
	Percina shumardi	River darter	0	3
Sciaenidae	*Aplodinotus grunniens*	Freshwater drum	9,483	11,426
		Total Number of Fish	**2,810,778**	**1,172,660**
		Total Number of Fish Species	**46**	**43**
		Number of Sample Days	**52**	**53**

Table 2. Number of fish impinged by month and percent of annual total during September, 2007 through September, 2009.

Month	Total Number of Fish Impinged 2007-2008 (Year 1)	Percent of Annual Total	Number of Fish Impinged 2008-2009 (Year 2)	Percent of Annual Total	Years 1 and 2 Combined	Percent of Two-Year Total
Jan	12,051,564	61	1,166,907	14	13,218,471	47
Feb	556,703	3	142,702	2	699,405	3
Mar	220,136	1	211,918	3	432,054	2
Apr	274,302	1	91,021	1	365,323	1
May	183,197	1	4,438	0	187,635	1
Jun	23,912	0	7,399	0	31,311	0
Jul	24,570	0	25,186	0	49,756	0
Aug	279,706	1	4,256	0	283,962	1
Sep	127,169	1	58,695	1	185,864	1
Oct	664,783	3	556,395	7	1,221,178	4
Nov	3,025,932	15	2,040,311	25	5,066,243	18
Dec	2,243,472	11	3,899,392	48	6,142,864	22
Total	**19,675,446**		**8,208,620**		**27,884,066**	

Table 3. Comparison of estimated weekly fish impingement at TVA's Browns Ferry Nuclear Plant during 2007 and 2008.

	Sept		Oct		Nov		Dec	
	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2
Week 1	-	-	9120	3881	4648	4304	72693	175411
Week 2	1050	2494	7900	34764	13330	6119	116023	206874
Week 3	2218	4012	23215	5892	22923	208051	84264	77367
Week 4	6144	1805	23334	3834	391375	72999	47516	97404
Week 5	-	-	31400	31114	-	-	-	-
	Jan		**Feb**		**March**		**April**	
	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2
Week 1	1684003	45658	4162	7478	5820	4121	7865	9810
Week 2	11410	89512	25196	5439	6506	5274	14337	1309
Week 3	12693	16101	26393	5216	7904	15571	5136	1718
Week 4	3995	5716	23778	2253	11218	5308	2905	166
Week 5	9551	9714	-	-	-	-	8943	0
	May		**June**		**July**		**Aug**	
	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2
Week 1	19708	141	1019	92	861	616	1824	23
Week 2	4006	345	807	280	612	0	1937	10
Week 3	1469	128	747	206	400	1322	1468	148
Week 4	988	20	843	479	519	475	34729	427
Week 5	-	-	-	-	1118	1185	-	-

Table 4. Annual extrapolated estimates of numbers and biomass of fish impinged by species and year at Watts Bar Nuclear Plant during September 2007 through September 2009.

	Estimated Number			Estimated Biomass (g)			
Species	9/12/2007 - 9/03/2008	9/10/2008 - 9/09/2009	Average	9/12/2007 - 9/03/2008	9/10/2008 - 9/09/2009	Average	Percent Composition by Number
Threadfin Shad	19,118,288	7,522,732	**13,320,510**	52,372,460	25,157,615	**38,765,038**	**96**
Gizzard Shad	238,105	382,746	**310,426**	8,348,508	7,366,639	**7,857,574**	**2**
Yellow Bass	64,960	109,599	**87,280**	1,528,870	2,181,942	**1,855,406**	**1**
Freshwater Drum	66,381	79,982	**73,182**	4,842,915	5,830,720	**5,336,818**	**1**
Bluegill	105,924	38,955	**72,440**	580,223	435,358	**507,791**	**1**
Channel Catfish	20,349	17,955	**19,152**	948,367	1,082,508	**1,015,438**	**T**
Redear Sunfish	29,120	3,738	**16,429**	183,232	140,707	**161,970**	**T**
Inland Silverside	280	12,586	**6,433**	1,218	66,010	**33,614**	**T**
Bullhead Minnow	11,354	1,379	**6,367**	67,130	5,369	**36,250**	**T**
Alewife	854	11,354	**6,104**	6,748	116,095	**61,422**	**T**
Orangespotted Sunfish	2,590	6,713	**4,652**	12,509	16,506	**14,508**	**T**
Blue Catfish	3,612	5,145	**4,379**	321,951	267,337	**294,644**	**T**
White Crappie	1,379	4,851	**3,115**	75,775	149,205	**112,490**	**T**
White Bass	3,745	1,785	**2,765**	713,489	462,112	**587,801**	**T**
Logperch	3,661	1,477	**2,569**	21,280	14,203	**17,742**	**T**
Longear Sunfish	924	1,218	**1,071**	8,834	11,004	**9,919**	**T**
Green Sunfish	245	1,890	**1,068**	3,570	7,630	**5,600**	**T**
Largemouth Bass	546	511	**529**	68,054	92,491	**80,273**	**T**
Spotted Bass	553	504	**529**	50,918	43,491	**47,205**	**T**
Warmouth	98	742	**420**	1,799	9,184	**5,492**	**T**
Common Carp	161	518	**340**	770	5,068	**2,919**	**T**
Golden Shiner	175	455	**315**	1,960	6,503	**4,232**	**T**
Skipjack Herring	378	147	**263**	183,015	30,254	**106,635**	**T**
Flathead Catfish	322	161	**242**	80,227	22,876	**51,552**	**T**
Redbreast Sunfish	0	406	**203**	0	2,513	**1,257**	**T**
Spotted Gar	112	252	**182**	215,719	354,508	**285,114**	**T**
Atlantic Needlefish	266	77	**172**	23,737	4,501	**14,119**	**T**
Northern Hog Sucker	42	161	**102**	441	4,879	**2,660**	**T**

Table 4. (continued)

Species	Estimated Number			Estimated Biomass (g)			Percent Composition by Number
	9/12/2007 - 9/03/2008	9/10/2008 - 9/09/2009	Average	9/12/2007 - 9/03/2008	9/10/2008 - 9/09/2009	Average	
Yellow Perch	84	84	**84**	728	1,323	**1,026**	**T**
Emerald Shiner	147	14	**81**	1,211	168	**690**	**T**
Black Crappie	140	14	**77**	8,834	252	**4,543**	**T**
Sauger	98	35	**67**	46,858	16,114	**31,486**	**T**
Hybrid Striped Bass	91	35	**63**	58,023	371	**29,197**	**T**
Spotted Sucker	0	126	**63**	0	41,503	**20,752**	**T**
Striped Bass	49	56	**53**	26,523	399	**13,461**	**T**
Brook Silverside	91	0	**46**	308	0	**154**	**T**
Brown Bullhead	0	91	**46**	0	525	**263**	**T**
Bluntnose Minnow	70	0	**35**	252	0	**126**	**T**
River Darter	35	14	**25**	35	56	**46**	**T**
Striped Shiner	35	14	**25**	294	56	**175**	**T**
Chestnut Lamprey	28	14	**21**	1,365	532	**949**	**T**
Smallmouth Bass	14	28	**21**	6,986	119	**3,553**	**T**
Spotfin Shiner	35	0	**18**	259	0	**130**	**T**
Black Buffalo	28	0	**14**	11,550	0	**5,775**	**T**
Mooneye	28	0	**14**	9,702	0	**4,851**	**T**
Smallmouth Buffalo	14	14	**14**	4,774	7,588	**6,181**	**T**
Black Bullhead	21	0	**11**	203	0	**102**	**T**
Longnose Gar	0	21	**11**	0	60,214	**30,107**	**T**
Quillback	0	21	**11**	0	27,727	**13,864**	**T**
Golden Redhorse	7	0	**4**	4,900	0	**2,450**	**T**
Hybrid Sunfish	7	0	**4**	7	0	**4**	**T**

Table 5. Extrapolated annual numbers of fish impinged at Browns Ferry Nuclear Plant September 2007 through August 2008 and September 2008 through August 2009. Also included are numbers of fish for which TVA is liable after EA and PF reduction.

	Year 1	Year 2
	2007-2008	**2008-2009**
Extrapolated Annual Number of fish Impinged	19,675,446	8,208,620
Number Liable for after EA & PF Reduction	520,309	318,226

Table 6. Individual Metric Scores and the Overall RFAI Scores Downstream (TRM 292.5) and Upstream (TRM 295.9) of Browns Ferry Nuclear Plant Discharge, Autumn 2008.

Autumn 2008	TRM 292.5		TRM 295.9	
Metric	Obs	Score	Obs	Score
A. Species richness and composition				
1. Number of indigenous species	28 species	3	28 species	3
2. Number of centrarchid species (less Micropterus)	6 species Green sunfish Bluegill Longear sunfish Warmouth Black crappie Redear sunfish	5	7 species Green sunfish Bluegill Longear sunfish Warmouth Redear sunfish White crappie Black crappie	5
3. Number of benthic invertivore species	5 species Spotted sucker Black redhorse Golden redhorse Freshwater drum Logperch	3	4 species Spotted sucker Northern hog sucker Freshwater drum Logperch	3
4. Number of intolerant species	5 species Spotted sucker Skipjack herring Black redhorse Longear sunfish Smallmouth bass	5	5 species Spotted sucker Northern hog sucker Skipjack herring Longear sunfish Smallmouth bass	5

Table 6. (Continued)

Autumn 2008		TRM 292.5		TRM 295.9	
Metric		Obs	Score	Obs	Score
5. Percent tolerant individuals	Electrofishing	37.4% Bluegill 10.3% Gizzard shad 19.3% Largemouth bass 7.2% Spotfin shiner 0.2% Green sunfish 0.3%	1.5	50.6% Bluegill 8.2% Gizzard shad 31.7% Common carp 0.3% Largemouth bass 9.4% Spotfin shiner 0.2% Golden shiner 0.2% Green sunfish 0.4%	1.5
	Gill Netting	23.6% Gizzard shad 14.1% Common carp 0.5% Bluegill 1.0% Largemouth bass 8.0%	1.5	32.1% Gizzard shad 12.3% Common carp 0.5% Bluegill 3.2% Largemouth bass 7.0% Longnose gar 4.8% Golden shiner 2.7% White crappie 1.6%	0.5
6. Percent dominance by one species	Electrofishing	52.7% Inland silverside	1.5	31.7% Gizzard shad	1.5
	Gill Netting	28.6% White bass	1.5	19.8% Channel catfish	1.5
7. Percent non-indigenous species	Electrofishing	52.7% Inland silverside 52.7%	0.5	29.5% Inland silverside 29.0% Atlantic needlefish 0.1% Common carp 0.3%	0.5
	Gill Netting	0.5% Common carp 0.5%	2.5	1.6% Common carp 0.5% Striped bass 1.1%	1.5

Table 6. (Continued)

Autumn 2008		TRM 292.5		TRM 295.9	
Metric		Obs	Score	Obs	Score
8. Number of top carnivore species		10 species Spotted gar Largemouth bass Spotted bass Smallmouth bass Skipjack herring Flathead catfish White bass Yellow bass Black crappie Sauger	5	11 species Longnose gar Spotted gar Largemouth bass Spotted bass Smallmouth bass Skipjack herring Flathead catfish White bass Yellow bass Black crappie White crappie	5
B. Trophic composition					
9. Percent top carnivores	Electrofishing	8.5% Largemouth bass 7.2% Spotted bass 0.2% Smallmouth bass 1.0% Flathead catfish 0.06%	1.5	12.6% Largemouth bass 9.4% Spotted bass 0.7% Smallmouth bass 0.7% Flathead catfish 0.3% White bass 0.2% Yellow bass 1.0% Spotted gar 0.2%	2.5
	Gill Netting	61.3% Spotted gar 0.5% Largemouth bass 8.0% Spotted bass 1.0% Skipjack herring 15.6% Flathead catfish 4.5% White bass 28.6% Yellow bass 1.5% Black crappie 0.5% Sauger 1.0%	2.5	39.6% Longnose gar 4.8% Largemouth bass 7.0% Spotted bass 1.6% Skipjack herring 1.6% Flathead catfish 2.1% White bass 14.0% Yellow bass 5.3% White crappie 1.6% Black crappie 0.5%	2.5

Table 6. (Continued)

Autumn 2008		TRM 292.5		TRM 295.9	
Metric		Obs	Score	Obs	Score
10. Percent omnivores	Electrofishing	20.7% Gizzard shad 19.3% Channel catfish 1.2% Blue catfish 0.2%	2.5	38.5% Gizzard shad 31.7% Channel catfish 5.8% Smallmouth buffalo 0.4% Common carp 0.3% Golden shiner 0.2%	1.5
	Gill Netting	26.6% Gizzard shad 14.1% Blue catfish 6.0% Channel catfish 3.5% Smallmouth buffalo 2.0% Black buffalo 0.5% Common carp 0.5%	1.5	44.4% Gizzard shad 12.3% Blue catfish 5.3% Channel catfish 19.8% Golden shiner 2.7% Smallmouth buffalo 3.7% Common carp 0.5%	0.5
C. Fish abundance and health					
11. Average number per run	Electrofishing	112.2	0.5	59.9	0.5
	Gill Netting	19.9	1.5	18.7	1.5
12. Percent anomalies	Electrofishing	0.4%	2.5	1%	2.5
	Gill Netting	0.5%	2.5	0.5%	2.5
Overall RFAI Score			**45**		**42**
			Good		**Good**

Table 7. Individual Metric Scores and the Overall RFAI Scores Downstream (TRM 292.5) and Upstream (TRM 295.9) of Browns Ferry Nuclear Plant Discharge, Autumn 2009.

Autumn 2009	TRM 292.5		TRM 295.9	
Metric	Obs	Score	Obs	Score
A. Species richness and composition				
1. Number of indigenous species (Tables 7 and 8)	27	3	26	3
2. Number of centrarchid species (less Micropterus)	7 Black crappie Bluegill Green sunfish Longear sunfish Redbreast sunfish Redear sunfish Warmouth	5	6 Black crappie Bluegill Green sunfish Longear sunfish Redear sunfish Warmouth	5
3. Number of benthic invertivore species	3 Freshwater drum Golden redhorse Logperch	1	4 Black redhorse Freshwater drum Golden redhorse Spotted sucker	3
4. Number of intolerant species	3 Longear sunfish Skipjack herring Smallmouth bass	3	5 Black redhorse Longear sunfish Skipjack herring Smallmouth bass Spotted sucker	5

Table 7. (Continued)

Autumn 2009		TRM 292.5		TRM 295.9	
Metric		Obs	Score	Obs	Score
5. Percent tolerant individuals	Electrofishing	40.9% Bluegill 5.67% Bluntnose minnow 0.07% Common carp 0.07% Gizzard shad 24.93% Golden shiner 0.07% Green sunfish 1.00% Largemouth bass 7.07% Redbreast sunfish 0.07% Spotfin shiner 1.93%	1.5	43.1% Bluegill 5.30% Common carp 0.18% Gizzard shad 26.97% Golden shiner 0.46% Green sunfish 0.73% Largemouth bass 9.05% Spotfin shiner 0.46%	1.5
	Gill Netting	45.7% Bluegill 4.35% Gizzard shad 39.13% Largemouth bass 2.17%	0.5	30.5% Common carp 3.39% Gizzard shad 23.73% White sucker 3.39%	0.5
6. Percent dominance by one species	Electrofishing	42.6% Inland silverside	1.5	35.6% Inland silverside	1.5
	Gill Netting	39.1% Gizzard shad	0.5	23.7% Gizzard shad	1.5

Table 7. (Continued)

Autumn 2009		TRM 292.5		TRM 295.9	
Metric		Obs	Score	Obs	Score
7. Percent non-indigenous species	Electrofishing	42.7% Common carp 0.07% Inland silverside 42.60%	0.5	35.8% Common carp 0.18% Inland silverside 35.56% Striped bass 0.09%	0.5
	Gill Netting	0.0%	2.5	3.4% Common carp 3.39%	0.5
8. Number of top carnivore species		9 Black crappie Flathead catfish Largemouth bass Skipjack herring Smallmouth bass Spotted bass Spotted gar White bass Yellow bass	5	9 Black crappie Flathead catfish Largemouth bass Skipjack herring Smallmouth bass Spotted bass Spotted gar White bass Yellow bass	5
B. Trophic composition					
9. Percent top carnivores	Electrofishing	11.5% Black crappie 0.07% Flathead catfish 0.27% Largemouth bass 7.07% Smallmouth bass 3.73% White bass 0.07% Yellow bass 0.27%	2.5	14.4% Black crappie 0.09% Flathead catfish 1.28% Largemouth bass 9.05% Smallmouth bass 0.18% Spotted bass 0.46% Spotted gar 0.46% Striped bass 0.09% Yellow bass 2.83%	2.5

Table 7. (Continued)

Autumn 2009		TRM 292.5		TRM 295.9	
Metric		Obs	Score	Obs	Score
	Gill Netting	32.6% Flathead catfish 6.52% Largemouth bass 2.17% Skipjack herring 2.17% Spotted bass 6.52% Spotted gar 8.70% White bass 4.35% Yellow bass 2.17%	1.5	30.5% Black crappie 1.69% Flathead catfish 1.69% Skipjack herring 8.47% Spotted bass 1.69% Spotted gar 1.69% White bass 6.78% Yellow bass 8.47%	1.5
10. Percent omnivores	Electrofishing	29.5% Bluntnose minnow 0.07% Channel catfish 4.20% Common carp 0.07% Gizzard shad 24.93% Golden shiner 0.07% Smallmouth buffalo 0.20%	1.5	36.8% Blue catfish 0.18% Channel catfish 8.96% Common carp 0.18% Gizzard shad 26.97% Golden shiner 0.46% Smallmouth buffalo 0.09%	1.5
	Gill Netting	56.5% Blue catfish 4.35% Channel catfish 6.52% Gizzard shad 39.13% Smallmouth buffalo 6.52%	0.5	54.2% Blue catfish 3.39% Channel catfish 20.34% Common carp 3.39% Gizzard shad 23.73% White sucker 3.39%	0.5

Table 8. Summary of RFAI Scores from Sites Located Directly Upstream and Downstream of Browns Ferry Nuclear Plant as Well as Scores from Sampling Conducted During 1993-2009 as Part of the Vital Signs Monitoring Program in Wheeler Reservoir.

Station	Location	1993	1994	1995	1997	1999	1993-1999 Average	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2000-2009 Average
Inflow	TRM 348.0	46	48	42	48	36	44	-	38	42	38	44	44	42	38	38	40	40
Transition BFN Upstream	TRM 295.9	43	43	35	40	30	38	41	37	43	39	43	46	41	39	42	39	41
Transition BFN Downstream	TRM 292.5	-	-	-	-	-	N/A	43	40	41	43	43	36	42	42	45	36	41
Forebay	TRM 277.0	52	44	49	45	42	46	-	41	45	44	43	45	46	49	46	47	45
Elk River Embayment	ERM 6.0	43	46	36	49	36	42	-	49	-	44	49	47	-	39	-	42	45

Note: No data were collected for 1996 and 1998.
RFAI Scores: 12-21 ("Very Poor"), 22-31 ("Poor"), 32-40 ("Fair"), 41-50 ("Good"), or 51-60 ("Excellent").

Table 8. Summary of RFAI Scores from Sites Located Directly Upstream and Downstream of Browns Ferry Nuclear Plant as Well as Scores from Sampling Conducted During 1993-2009 as Part of the Vital Signs Monitoring Program in Wheeler Reservoir.

Station	Location	1993	1994	1995	1997	1999	1993-1999 Average	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2000-2009 Average
Inflow	TRM 348.0	46	48	42	48	36	44	-	38	42	38	44	44	42	38	38	40	40
Transition BFN Upstream	TRM 295.9	43	43	35	40	30	38	41	37	43	39	43	46	41	39	42	39	41
Transition BFN Downstream	TRM 292.5	-	-	-	-	-	N/A	43	40	41	43	43	36	42	42	45	36	41
Forebay	TRM 277.0	52	44	49	45	42	46	-	41	45	44	43	45	46	49	46	47	45
Elk River Embayment	ERM 6.0	43	46	36	49	36	42	-	49	-	44	49	47	-	39	-	42	45

Note: No data were collected for 1996 and 1998.
RFAI Scores: 12-21 ("Very Poor"), 22-31 ("Poor"), 32-40 ("Fair"), 41-50 ("Good"), or 51-60 ("Excellent").

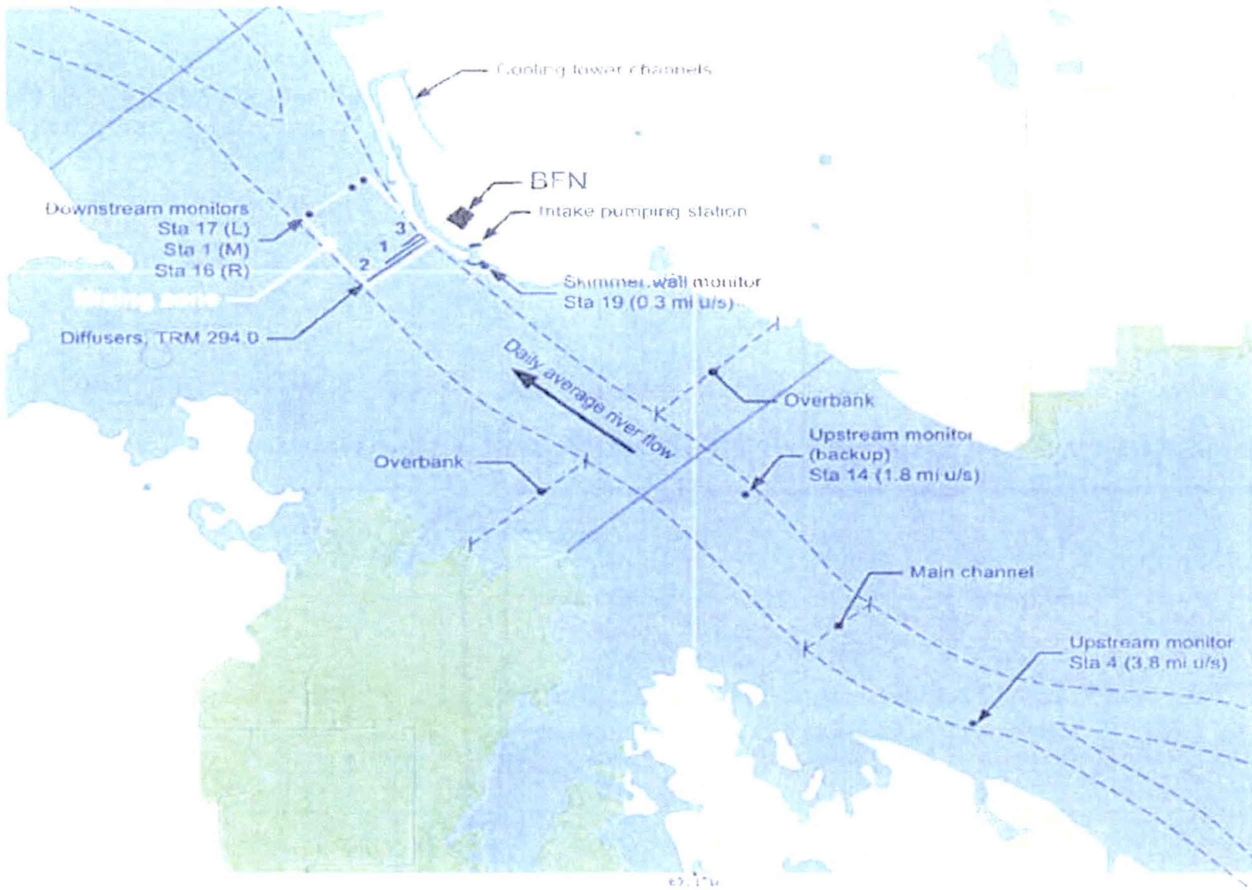

Figure 1. Location of Browns Ferry Nuclear Plant and Condenser Cooling Water (CCW) intake and discharge. Browns Ferry Nuclear Power Plant is located on the north shore of Wheeler Reservoir at Tennessee River Mile 294.

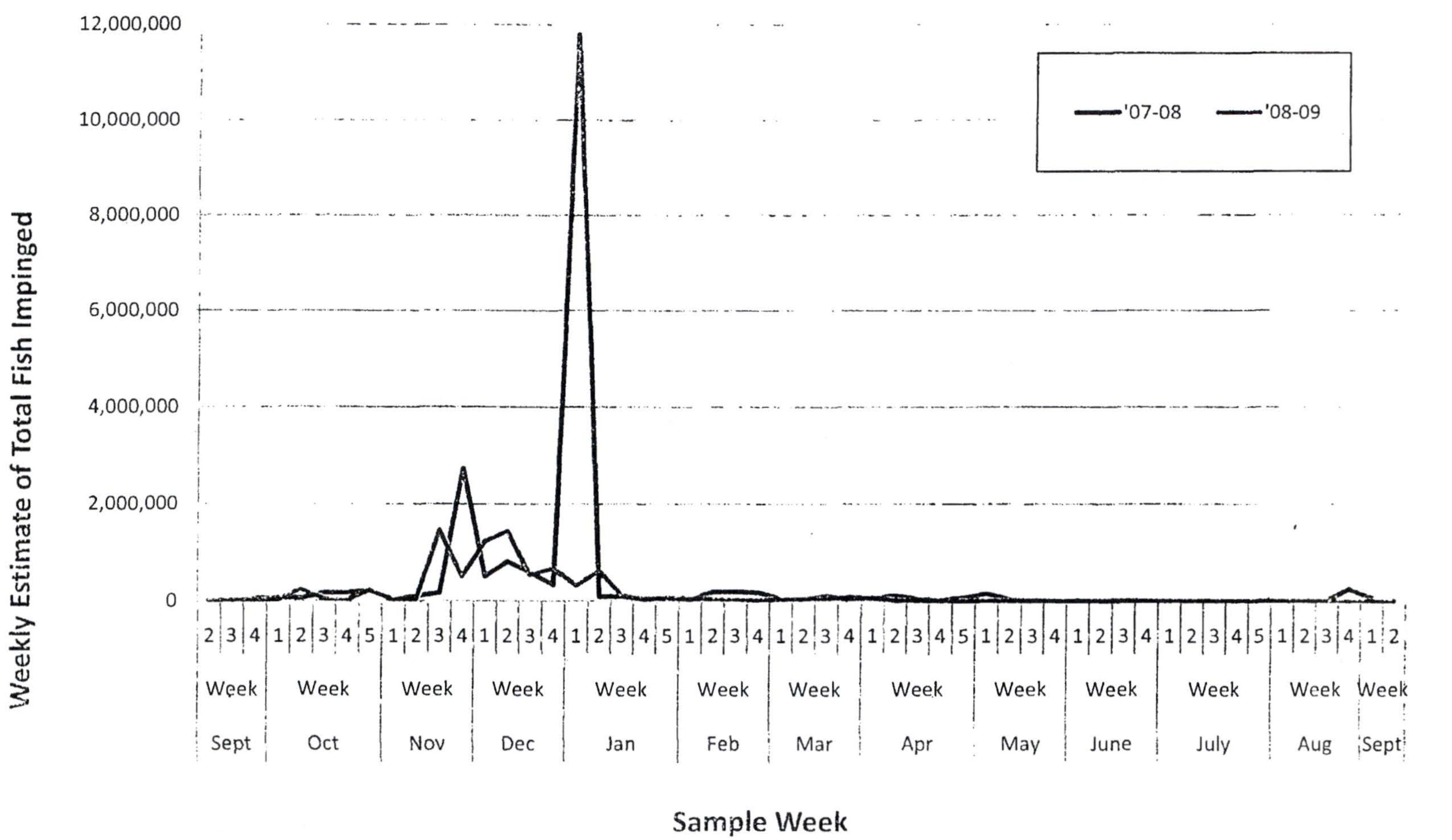

Figure 2. Weekly estimate of total fish impinged at Browns Ferry Nuclear Plant, September 2007 through August 2008 (Year 1) and September 2008 through August 2009 (Year 2).

Biological Assessment:
Effects of Condenser Cooling Water Withdrawal on the Fish Community Near the Browns Ferry Nuclear Plant Intake

by
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June 2006

Aquatic Monitoring and Management
Knoxville, Tennessee

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EXECUTIVE SUMMARY

The Tennessee Valley Authority (TVA) is pursuing the renewal of the operating license for the three-unit Browns Ferry Nuclear Plant (BFN). To meet future TVA power demands, the new license would extend the life of each unit twenty years and increase the generating capacity by twenty percent. Currently, Units 2 and 3 are in operation and recovery of Unit 1 is scheduled for completion in 2007. A consequence of the increased generation capacity is an increase in the quantity of condenser cooling water (CCW) required during normal operation. Prior to 1980, extensive biological and hydrological studies were conducted to assess the effects of CCW withdrawal on the aquatic community in Wheeler Reservoir. The historical studies demonstrated CCW demand for BFN had no significant effect on the aquatic community. TVA conducted a two year study in 2003 and 2004 to evaluate effects of the current two unit operation on the aquatic fish community and update baseline data prior to the restart of Unit 1.

CCW withdrawn from Wheeler Reservoir potentially effects the fish community by entrainment (small fish and eggs drawn through the intake screens) and impingement (fish trapped against screens by the intake water velocity). Densities of fish in the reservoir near the intake and daily volume of water transported past the BFN were compared to daily CCW demand and densities of fish at the intake skimmer wall to estimate percent entrainment. Fish were collected from the backwash process used in cleaning the traveling screens to estimate impingement rates.

Clupeids were the dominant fish taxon in both entrainment and impingement sampling. Expressed as percent composition, ninety-four percent of the fish eggs and ninety-five percent of the larvae collected in the entrainment samples were clupeids. Clupeids, primarily threadfin and gizzard shad, and freshwater drum were the dominant fish impinged; representing ninety-six percent of the total number of fish collected in the impingement samples. Composition in fish collected in the 2003 and 2004 study was similar to BFN historical baseline data.

Fish entrainment estimates were higher in 2004 (eggs – 18.8% and larvae – 18.7%) than observed in 2003 (eggs – 1.3% and larvae – 4.5%). The higher estimate in 2004 was attributed to the low flow conditions in Wheeler Reservoir near BFN. Average entrainment rate for the two year study was 7.6% for fish eggs and 10.8% for larvae, within the range found in the historical studies (2.3-8.2% for eggs and 4.5-11.7% for larvae).

The annual impingement rate, based on 2003 and 2004 data, was 8.1×10^5 fish weighing 1.18×10^4 kg. This is lower than observed historically, however, the 2003 and 2004 estimate was based on twenty-three samples and the historical estimates were based on data collected weekly for three years. Trends observed in the 2003 and 2004 data were similar to the historical assessments with highest numbers of fish impinged in winter and lower numbers impinged in summer.

Fluctuations in entrainment and impingement rates for BFN are common. Reservoir flow near BFN and the normal movement and cycles in year-class strength of the dominant fish taxa are factors contributing to these fluctuations. Although fluctuations in annual estimates do occur, the 2003 and 2004 316(b) assessment and recent Reservoir Fish Assemblage Index evaluations demonstrate Wheeler Reservoir near BFN supports a stable diverse indigenous fish community with no significant impacts from current plant operations.

INTRODUCTION

Browns Ferry Nuclear Plant (BFN) is a three-unit nuclear fueled facility located on Wheeler Reservoir in Limestone County, Alabama. At present, Units 2 and 3 are in operation and Unit 1 recovery is proceeding as scheduled. BFN's current operation utilizes a once-through condenser cooling water (CCW) system, withdrawing water from the Tennessee River through an intake structure and discharging the water through diffuser pipes located downstream from the plant. The procedure is regulated by BFN's National Pollutant Discharge Elimination System (NPDES) permit, AL0022080. This document provides current fishery data associated with the withdrawal of CCW, provides historical comparisons, and updates baseline data prior to the Unit 1 restart.

Background and Scope

The Tennessee Valley Authority (TVA) initiated an Integrated Resource Plan (IRP) in 1994 to assess the most cost effective approach to meeting future power demands. In response to the IRP, TVA is pursuing the renewal of the operating license for BFN's Units 1, 2, and 3. The scope of the renewal is to extend the operational license of each unit an additional twenty years beyond the current license and to uprate the units to 120 percent of their original licensed generating levels. After an extended shutdown, Unit 2 returned to service in 1991, Unit 3 in 1995; and restart of Unit 1 is scheduled for 2007. TVA prepared a Supplemental Environmental Impact Statement (SEIS) assessing the environmental impacts from the proposed license renewal. However, to more accurately assess potential entrainment and impingement impacts from increased CCW demand after the restart of Unit 1, TVA conducted studies in 2003 and 2004 to update baseline data.

Section 316(b) regulation of the Clean Water Act (CWA) provides standards for cooling water intake structures and procedures for assessing impacts. Compliance requires permittee to characterize the aquatic community in the vicinity of the intake structure prior to operation; monitoring during normal operation to assess impacts; and periodically review current operational demands, reservoir operation, and condition of the aquatic community to ensure no significant changes have occurred. Two potential impacts associated with cooling water intake structures are impingement and entrainment of fish eggs and larvae. Impingement occurs when aquatic organisms are trapped against the intake structure (traveling screens) by the force of cooling water withdrawal and entrainment occurs when small organisms are drawn through the intake structure into the plant cooling system.

BFN's preoperational baseline data include 18 years of standing stock surveys (1949-1961 and 1969-1973), gill and trap net surveys (1970-1973), and ichthyoplankton investigations (1971-1973). Aquatic monitoring continued until 1980 as part of BFN Technical Specifications issued by the Nuclear Regulatory Commission (NRC). In 1980, the NRC eliminated the aquatic monitoring requirement from the BFN's Technical Specifications. Since 1980, annual standing stock surveys (1980-1997) and Reservoir Fish Assemblage Index (RFAI) ratings (1993-2005) provide a minimum data base on the fish community in the vicinity of BFN.

RESERVOIR AND PLANT OPERATION DURING 2003 AND 2004

Wheeler Reservoir Operation

Surface elevation of Wheeler Reservoir and river flow past BFN is dependent on the rate water is released through Guntersville and Wheeler Dams. TVA's integrated approach to Wheeler Reservoir operation includes winter drawdown for flood control, minimum summer pools, and hydroelectric power generation. In 2003 and 2004, average daily surface elevation of Wheeler forebay ranged from 167.8 m above mean sea level (AMSL) to 169.5 m AMSL (Figure 1). Daily river flow past BFN ranged from 159 m^3/s to 2634 m^3/s in 2003 and 28 m^3/s to 2817 m^3/s in 2004 (Figure 2).

BFN Operation

BFN Units 2 and 3 were both in operation during the study period (Figure 3). The combined generation rate for Units 2 and 3 averaged 2096 megawatts (MW) in 2003 and 2191 MW in 2004. The average daily withdrawal rate of CCW from Wheeler Reservoir during the two year study was 87 m^3/s. In late February and March, a decrease in the demand for CCW was observed in both 2003 and 2004 as scheduled outages were performed on units (Figure 4). However, CCW demand during entrainment sampling (late March through early July) reflected normal operation, averaging 91 m^3/s in 2003 and 89 m^3/s in 2004.

METHODS

Entrainment

Sample Collection

To estimate BFN's plant entrainment rate, ichthyoplankton (fish eggs and larvae) samples were collected upstream at TRM 294.5 to estimate densities of fish eggs and larvae in the water column flowing past the plant and in the intake basin near the skimmer wall. Twenty samples were collected weekly from late March through early July in 2003 and 2004. Eight reservoir samples (four day and night) were collected at three stations; a full stratum sample on both left and right over banks; and two mid-channel stratified samples, surface to mid-depth and mid-depth to near bottom. Twelve samples (six day and night) were collected in the intake basin near the skimmer wall.

Samples were collected with a beam net 0.5 m square, 1.8 m long, with 505 micron "nitex" mesh netting. Nets were equipped with a large-vaned General Oceanics flowmeter® used to measure sample volume. Reservoir samples were ten-minute upstream oblique tows with a boat speed of 1 m/s, filtering approximately 150 m^3 of water. Intake samples were passive, collected in the inflow of the CCW under the skimmer wall gates, and volume filtered during the ten-minute sample was dependent on intake velocity.

Sample Processing

In the laboratory, all fish eggs and larvae were removed from each sample, identified to the lowest practical taxon, and enumerated. Taxonomic decisions were based on TVA's "Preliminary Guide to the Identification of Larval Fishes in the Tennessee River" (Hogue et al, 1976) and other pertinent literature. The term "unspecified" preceding a taxon indicates taxonomic resolution is not practical beyond this level and "unidentifiable" indicates the specimen(s) were mutilated. A minimum of 100 specimens of each taxon were measured to the nearest millimeter to obtain length frequency data.

Data Analysis

Data were summarized by type (eggs or larvae), family, number, composition, and relative abundance. Relative abundance of fish eggs and larvae is presented as numbers per 1000 m^3 of water sampled. Estimated entrainment is derived from the formula:

$$E = \frac{100\, D_i\, Q_i}{D_r\, Q_r}$$

Where D_i = mean density (N/1000 m^3) of eggs or larvae in intake samples
D_r = mean density (N/1000 m^3) of eggs or larvae in river
Q_i = plant intake water demands (m^3/day)
Q_r = river flow (m^3/day)

Temporal occurrence and relative abundance were evaluated for each significant taxon.

Impingement

Sample Collection

Historically, fish impingement rates at BFN were lowest in late spring (May-June) and peaked in winter. Weekly impingement samples were collected in the summer 2003 (July-early September) and winter 2003 and 2004 (December-March) to provide current impingement estimates. At BFN, a continuous backwash is utilized to clean the traveling screens. Fish trapped against the traveling screens were collected from the backwash, identified, separated into 25 mm TL size classes, enumerated, and weighed.

In summer, fish were collected in twenty-four hour periods and winter samples in twelve hour intervals. However, winter samples were staggered weekly (i.e., 12 noon to 12 midnight or 12 midnight to 12 noon) to ensure any diel variations in fish impingement would be recorded.

Data Analysis

Annual and daily impingement rates are expressed in total numbers and biomass (kg) for each species collected in samples.

RESULTS

Entrainment

Densities of fish eggs and larvae are expressed as numbers per volume of water sampled. Average volume (m^3) of water filtered in each intake sample was consistently less the volume filtered in reservoir samples; however, more samples were collected each sampling period in the intake. To evaluate volume filtered per sampling period in the intake and reservoir, the total volume of water filtered in the twelve intake samples was compared to the total volume filtered in the eight reservoir samples (Table 1). In 2003, an average of 1,137 m^3 of water was filtered per sampling period in the intake and 1,218 m^3 in the reservoir. Total water filtered in the 2004 intake sampling averaged 1,087 m^3 per sampling period and 1,277 m^3 in the reservoir. Therefore, densities of fish and eggs in the intake and reservoir were calculated based on similar sample volumes.

Tables 2 and 3 present scientific and common names of taxa collected in the 2003 and 2004 study and the taxonomic resolution used in processing samples. Although identification to subfamily, genus, or species was possible for some individuals, results are presented by family for comparative analysis.

Fish Eggs

A total of 25,364 fish eggs representing four families was collected during the two year project. Freshwater drum eggs comprised 94% of the eggs collected (Table 4). The only other taxon collected in significant numbers were clupeids, comprising 5.5% of total eggs collected.

Drum egg densities were higher in 2004, 577/1000 m^3 in the intake basin and 693/1000 m^3 in the reservoir, than observed in 2003, 76/1000 m^3 and 376/1000 m^3, respectively (Table 5). In 2003, drum eggs were collected May 1 through July 3 and April 23 through July 8 in 2004 (Figure 5). Peak density occurred on May 29 in 2003, 763/1000 m^3, and on May 20 in 2004, 3,771/1000 m^3.

Densities of shad eggs were similar in 2003 and 2004, 28/1000 m^3 and 26/1000 m^3, respectively. Although densities were similar, spatial distribution differed with abundance greater in the intake in 2003 and the reservoir in 2004 (Table 5). Shad eggs were collected April 17 through June 26 in 2003 with a peak density (124/1000 m^3) occurring May 1 (Figure 6). In 2004, shad eggs were collected from April 22 through July 8; however, 93% of the season total were collected on May 13, with a density of 880/1000 m^3.

Larval and Juvenile Fish

A total of 476,434 fish representing twelve families was collected in 2003 and 2004 entrainment sampling. In the reservoir samples, fish densities averaged 3,857/1000 m^3 and intake samples averaged 2,836/1000 m^3 (Table 5). Fish densities were higher in 2004 than observed in 2003, primarily a result of the high numbers of shad (Figure 7). Ninety-

five percent of the total number of fish collected were shad; other families contributing at least 1% of total composition were temperate basses 1.8%, sunfishes 1.0%, drum 1.1%, and silversides 1.0% (Table 4).

Shad densities were significantly higher in 2004, 3,656/1000 m^3, than observed in 2003, 2,671/1000 m^3. Shad were collected from early April to early July in both 2003 and 2004; however, peak densities occurred earlier in the season in 2004 (Figure 8). In 2003, densities peaked on June 12, 13,319/1000 m^3, and on May 13 in 2004, 35,282/1000 m^3.

Temperate basses in Wheeler Reservoir include three *Morone* species: striped bass, yellow bass, and white bass. *Morone* were collected during all sampling periods in both 2003 and 2004 averaging 122/1000 m^3. During the two year evaluation, densities ranged from 170/1000 m^3 in 2003 to 79/1000 m^3 in 2004. Typically, Morone are among the earlier spawners in Wheeler Reservoir; a trend reflected in this study. Densities were greater in April and early May in both 2003 and 2004 with peak density of 1,350/1000 m^3 occurring April 3, 2003 (Figure 9).

Centrarchids (sunfishes) averaged 22/1000 m^3 in 2003 and 100/1000 m^3 in 2004. In 2003, peak centrarchid densities occurred in June and in 2004 the peak occurred in May (Figure 10). Composition of the three genera of centrarchids collected in entrainment samples was crappie (5 %), black basses (4%), and lepomids (91%).

Average freshwater drum density was significantly higher in 2003 (138/1000 m^3) than observed in 2004 (14/1000 m^3). Freshwater drum larvae were collected late April through early July with peak density occurring on June 19 in 2003 (771/1000 m^3) and on May 27 in 2004 (70/1000 m^3) (Figure 11).

Silversides averaged 11/1000 m^3 in 2003 entrainment samples and 120/1000 m^3 in 2004. Silversides were collected early April through early July with peak densities occurring June 19 in 2003 (20/1000 m^3) and May 13 in 2004 (706/1000 m^3) (Figure 12). Both brook and inland silverside occur in Wheeler Reservoir; however, all late post yolk-sac larvae and juveniles collected were inland silversides.

Hydraulic Entrainment Estimates

The hydraulic entrainment estimate for all sampling periods, 2003 and 2004 combined, averaged 8.4%. In 2003, hydraulic entrainment estimate averaged 6.2% (range 4 to 27.6%) and in 2004 averaged 12.7% (range 5.9 to 42%) (Table 6). A decrease in river flow past BFN during most of the 2004 sampling season was the most significant contributing factor to the higher entrainment in 2004. Estimated daily CCW intake was consistent during entrainment sampling in 2003 and 2004; however, average daily volume transported past BFN was $1.3 \times 10^8 m^3$ in 2003 and decreased to $6.0 \times 10^7 m^3$ in 2004.

Fish Entrainment Estimates

Entrainment estimates for all numerically significant taxa of fish eggs and larvae were higher in 2004 (Table 7). The entrainment rate for fish eggs was 1.3% in 2003 and 18.8% in 2004. An estimated 4.5% of fish larvae transported past BFN were entrained in 2003 compared to 18.7% in 2004. The overall entrainment estimate based on the two year study averaged 7.6% for fish eggs and 10.8% for larval fish. Spatial-temporal distribution varied significantly between sampling periods and stations for both fish eggs (Figures 13 and 14) and larvae (Figures 15 and 16), demonstrating the heterogeneous distribution of individuals both vertically and horizontally in the water column. The unrealistically high entrainment estimate (18.8%) for shad eggs in 2004 is an example of this distribution pattern. In 2004, a total of 922 shad eggs was collected during the sampling season and 859 of these were collected May 13. The majority of these were found in intake samples and only two in samples collected in the reservoir immediately upstream from BFN intake structure. Similar events may have contributed to the fluctuations in entrainment estimates for other taxa.

Impingement

Thirty-seven species of fish representing eleven families were collected in the 2003 and 2004 impingement study (Table 8). The estimated daily impingement rate during the study was 2,218 fish per day weighing 32.2 kilograms (kg). Peak numbers of fish (12,125) were observed on December 11, 2003, and greatest biomass (141.1 kg) occurred on January 7, 2004 (Figures 17 and 18). Average impingement rates were higher in winter (2,581 fish, 41.7 kg) than observed in summer (1,388 fish with biomass of 10.3 kg). Seventeen species were impinged an average of at least one per day in either the summer or winter sampling (Table 9) and seven species contributed an average of one or more kilograms per day to the total biomass (Table 10).

Threadfin shad was the dominant species in numbers, 61% of total, and freshwater drum contributed the most biomass, 38% of total weight (Tables 11 and 12). Other species occurring in significant numbers were freshwater drum (21.2%), gizzard shad (7.8%), skipjack herring (4.8%), channel catfish (1.4%), and yellow bass (1.3%). In terms of biomass, other important species were gizzard shad (23.1%), threadfin shad (18.3%), channel catfish (6.4%), yellow bass (2.6%), and blue catfish (1.6%).

Three species were the primary drivers in the fluctuations in daily estimates observed in the 2003 and 2004 impingement study. The abundance of threadfin shad had the most significant affect on total numbers impinged (Figure 19) and was a major contributor to the total biomass. Gizzard shad and freshwater drum were also significant contributors to total biomass (Figure 20 and 21).

HISTORICAL COMPARISONS

Entrainment

The methodology used to estimate entrainment at BFN was changed in 1977. Prior to 1977, reservoir ichthyoplankton populations were estimated based on data collected at three transects in Wheeler Reservoir. Entrainment estimates were calculated by comparing reservoir populations with data collected in the BFN intake. Beginning in 1977, reservoir sampling was designed to estimate transport of fish eggs and larvae past BFN. Data collected across a single plant transect, located immediately upstream from BFN intake at TRM 294.5, provided estimates of fish transport past BFN and was compared to data collected in the intake to estimate entrainment. The 2003 and 2004 assessment used data collected at TRM 294.5 to estimate transport past BFN; therefore, historical comparisons were limited to baseline data collected in 1977 through 1979.

Hydraulic entrainment estimates in 2003 and 2004 were within the range observed in the historical evaluations; the 6.2% in 2003 was near historical lows and the 12.7% in 2004 near the historical high (Table 13). The 2003 and 2004 data demonstrate the significant effect of river flow on the entrainment estimates. The daily rate of entrainment for fish eggs and larvae was similar in 2003 and 2004; however, a significantly higher percentage of the total volume of water moving past BFN was entrained during the low flow conditions in 2004. Based on historical and 2003 and 2004 data, fluctuations in the annual entrainment estimates at BFN are common.

Impingement

Impingement at BFN was evaluated for a three-year period from 1974 through 1977 during various modes of operation; no units operating and minimal pump operation, one, two, or three units in operation. As expected, an increase in the number units in operation increases CCW demand and, consequently, increases the impingement rate. Estimated annual impingement was 2.69×10^6 fish with no units in operation, 5.26×10^6 with 1-2 units, and 6.67×10^6 with three units operating. Estimated total annual biomass impinged with three units operating was 6.3×10^4 kg. Historically, impingement was usually lowest in May and June and highest in winter.

The 2003 and 2004 impingement study was conducted during two time periods, July through early September and December through March. Two units were usually in operation during sample collection. Trends observed in the 2003 and 2004 assessment paralleled historical results; peak numbers of fish were impinged in winter (average 2,581 fish/day) and lower number in summer (average 1,388 fish/day). Based on the 2003 and 2004 data with two units operating, an estimated 8.1×10^5 fish having a biomass of 1.18×10^4 kg are impinged annually at BFN. These estimates are lower than reported in the 1974-1977 assessment with two units operating; however, the current estimates are based on twenty-three weekly samples and the historical data were collected weekly for three years.

Composition of fish impinged was similar in 2003 and 2004 to the historical data. In the 1974-1977 study, 95% of the total number of fish impinged were clupeids or freshwater drum and no other species contributed more than 1% of the total composition. Clupeids and freshwater drum represented 96% of the fish impinged in the 2003 and 2004 assessment. Other species contributing more than 1% in 2003 and 2004 were channel catfish (1.4%) and yellow bass (1.3%).

CONCLUSIONS

Both historical data and the 2003 and 2004 study demonstrate the variability in the occurrence and spatial-temporal distribution of fish in Wheeler Reservoir near BFN. This variability translates into significant fluctuation in the entrainment and impingement rates associated with plant operation. Factors contributing to these fluctuations include year-class strength of individual species, life history of selected species, and the physical parameters of Wheeler Reservoir in the vicinity of BFN.

Cyclic variation in the year-class strength of the fish species found in Wheeler Reservoir is well documented. In calculating entrainment and impingement estimates, these variations are exacerbated in scenarios where one or two species represent a high percentage of the total composition, as is the case with clupeids and freshwater drum in the vicinity of BFN. Spawning habitat, fecundity, and spatial distribution of these two species are significant in the fluctuations observed in the entrainment rates at BFN. Freshwater drum spawn in open water while shad spawn near shore and each female produces thousands of eggs, creating areas in the reservoir with high densities of fish eggs and early larvae. As these areas of high density eggs or larvae drift downstream, their occurrence within a sampling area (either intake or reservoir) may significantly affect the entrainment estimate. Juvenile and adult clupeids move in large schools throughout the reservoir; consequently, a large school occurring within a sampling area will significantly affect both entrainment and impingement rates.

The location of BFN is probably a contributing factor to the fluctuations in the annual entrainment estimates. Reservoirs are characterized by three zones; the inflow having characteristics more riverine, the forebay is a more lacustrine area immediately upstream from a dam, and the transition zone provides a buffer in the middle of the reservoir. As water flows downstream from the inflow, velocity decreases as the cross-sectional area of the reservoir increases. Areas within the transition zone may exhibit high flow, low flow, or even negative flows depending on the rate water is released through the upstream and downstream dams. The area of Wheeler Reservoir near BFN is characterized as a transition zone where the velocity of water flowing past BFN depends on the rate water released through Guntersville and Wheeler Dams. The rate of water flow past BFN increases and the reservoir surface elevation decreases when the rate of water released through Wheeler Dam exceeds the release through Guntersville Dam. Inversely, the surface elevation increases and rate of flow decreases near BFN when rate of water released through Guntersville Dam exceeds the release in Wheeler Reservoir. CCW

demand for BFN remains fairly constant during normal two unit operation, therefore, hydraulic and fish entrainment estimates will increase as reservoir flow past BFN decreases.

Entrainment at BFN is significantly influenced by the large overbank located immediately upstream from the intake structure. Historical hydrodynamic studies show 53 to 63 percent of the CCW used by BFN is drawn from this overbank and the quantity of flow along the overbank varies with reservoir stage and flow. Based on the spatial distribution of larval fish collected in 2003 and 2004, this overbank is highly productive and may provide a spawning area and nursery for several species of fish. Densities and composition of fish collected in the 2004 intake sampling suggest a higher percentage of the CCW is drawn from the overbank during low flow thus, elevating the entrainment estimate for these fish species.

TVA's valley-wide vital signs monitoring program is an additional tool used to evaluate the condition of the fish community near BFN. The Reservoir Fish Assemblage Index (RFAI), a component of the vital signs program, is used to evaluate reservoir health by rating the system based on community structure and function. A RFAI sampling station was established upstream from BFN at TRM 295.5 in 1992 and a second transition zone station was added downstream at TRM 292.5 in 2000. Based on RFAI scoring criteria from reservoirs throughout the Tennessee Valley, scores of 51-60 were classified as excellent, 41-50 as good, 21-40 as fair, and 22-31 as poor. As observed in the BFN 316(b) studies, annual RFAI scores in Wheeler Reservoir near BFN vary; scores range from 30 to 47 at TRM 292.5 (1993-2004) and 42 to 45 at TRM 292.5 (2000-2004). Based on the average RFAI scores for all years sampled, the fish community near BFN is classified as "Good," averaging 41 at TRM 295.5 and 43 at TRM 292.5.

The 2003 and 2004 316(b) data and recent fish community assessments in Wheeler Reservoir near BFN show no significant impacts from current operation of BFN on the fish community near the plant. Furthermore, current 316(b) data support conclusions presented in the 1977-1979 historical assessments. Results demonstrate annual variations in the relative abundance and spatial-temporal distribution of fish and fluctuations in reservoir flow are common in the vicinity of BFN. Life cycles of the dominant fish species and fluctuation in reservoir flow past BFN are significant factors influencing variations observed in the annual entrainment estimates. These variations in fish density and reservoir flow in the Wheeler transition zone has apparently had little affect on the fish community. Based on the 2003 and 2004 316(b) evaluation and the annual RFAI scores for Wheeler Reservoir, a viable balanced indigenous aquatic community is present in Wheeler Reservoir in the vicinity of BFN.

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Table 1. **Total Volume of Water Filtered by Sample Period during 2003 and 2004 to Estimate Entrainment of Fish Eggs and Larvae.**

	2003				2004		
Sample Date	**Intake m^3**	**Reservoir m^3**	**Total m^3**	**Sample Date**	**Intake m^3**	**Reservoir m^3**	**Total m^3**
Mar 28	598	456	1054	Mar 25	1334	1336	2670
Apr 3	1170	1280	2450	Apr 1	1392	1353	2745
Apr 10	1204	1287	2491	Apr 7	1259	1381	2640
Apr 17	1209	1317	2526	Apr 15	1282	1324	2605
Apr 24				Apr 22	555	540	1095
May 1	1185	1291	2476	Apr 29	1222	1275	2497
May 8	1219	1212	2431	May 6	1106	1404	2510
May 15	1262	1294	2556	May 13	974	1266	2239
May 22	1141	1273	2414	May 20	1112	1436	2548
May 29	1181	1287	2468	May 27	1074	1261	2335
Jun 5	1205	1284	2489	Jun 3	917	1356	2273
Jun 12	1160	1252	3412	Jun 10	995	1351	2347
Jun 19	1259	1231	2490	Jun 17	1108	1329	2436
Jun 26	933	1310	2243	Jun 24	937	1270	2207
Jul 3	1188	1273	2461	Jul 1	1042	1276	2318
				Jul 7	1048	1282	2330
Total	**15915**	**17046**	**32961**		**17356**	**20439**	**37795**
Average	**1137**	**1218**	**2354**		**1087**	**1277**	**2364**

Table 2. **List of Fish Eggs by Family Collected in 2003 and 2004 Entrainment Samples and Lowest Level of Taxonomic Resolution for each Family.**

Scientific Name	Common Name	Lowest Level of Taxonomic Identification
	Unspecified	Identification to family was not possible. Limiting factors were size, stage of development, and season when egg was collected.
Clupeidae	**Shad**	**Family.**
Catostomidae	**Suckers**	**Family.**
Percidae	**Perches**	**Family.**
Sciaenidae	**Drums**	**Species.** freshwater drum

Table 3. **List of Fish by Family Collected in 2003 and 2004 Entrainment Samples and Lowest Level of Taxonomic Resolution for each Family.**

Scientific Name	Common Name	Lowest Level of Taxonomic Identification
Lepisosteidae	**Gars**	**Species** -spotted gar.
Clupeidae	**Shad**	**Family** - all larvae < 20 mm TL.
		Genus or species -larger individuals to Alosa spp.- alewife, skipjack, Dorosoma spp. - gizzard and threadfin shad.
Hiodontidae	**Mooneyes**	**Species** -mooneye.
Cyprinidae	**Minnows and Carps**	**Family** -most minnows, shiners, chubs, dace.
		Genus or species -common carp, golden shiner, and larger individuals to emerald shiner, mimic shiner, Pimephales spp.
Catostomidae	**Suckers**	**Subfamily** - ictiobines (buffalo, carpsuckers, and redhorse).
		Genus - Larger individual to buffalo.
		Species - Spotted sucker
Ictaluridae	**Catfishes**	**Species** - Blue, channel, and flathead catfish.
Poeciliidae	**Livebearers**	**Species** - Western mosquitofish
Moronidae	**Temperate basses**	**Genus** -most larval life phases
		Species - yolk-sac larvae $\geq$ 5 mm TL (striped bass), larger individuals to white, yellow, and striped bass.
Centrarchidae	**Sunfishes**	**Genus** - crappie, lepomids (sunfishes), and black bass.
		Species - larger individuals to largemouth and smallmouth bass.
Percidae	**Perches**	**Family** - darters (Percina or Etheostoma), no yellow perch or sauger were collected.
		Genus or species -larger individuals to logperch and Percina sp.
Sciaenidae	**Drum**	**Species.** freshwater drum
Atherinopsidae	**Silversides**	**Family** -most larvae (either brook or inland silverside).
		Species - larger individuals to inland silverside.

Table 4. **Percent Composition of Fish Eggs and Larvae by Family in Entrainment Samples during 2003 and 2004.**

	Intake Samples			Reservoir Samples			
	2003 %	2004 %	Combined 2003-2004 %	2003 %	2004 %	Combined 2003-2004 %	All Samples %
Eggs							
Unspecified	4.7	T	0.6	0.1	T	T	0.2
Clupeidae	16.5	8.2	9.3	9.5	0.3	3.4	5.5
Catostomidae	T	T	T	T	T	T	T
Percidae	T	T	T	T	T	T	T
Sciaenidae	78.7	91.8	90.1	90.3	99.7	96.5	94.3
Larvae							
Lepisosteidae	T	T	T	T	T	T	T
Clupeidae	91.8	95.0	94.2	88.1	97.3	94.7	94.5
Hiodontidae	T	T	T	T	T	T	T
Cyprinidae	0.2	0.2	0.2	0.3	0.1	0.2	0.2
Catostomidae	1.3	T	0.4	0.8	T	0.2	0.3
Ictaluridae	0.1	0.1	0.1	T	T	T	T
Poeciliidae	T	T	T	T	T	T	T
Moronidae	1.8	1.0	1.2	6.3	0.7	2.3	1.8
Centrarchidae	0.8	1.7	1.5	0.5	0.6	0.6	1.0
Percidae	0.2	T	0.1	0.1	T	0.1	0.1
Sciaenidae	3.2	0.1	0.9	3.8	0.2	1.2	1.1
Atherinopsidae	0.5	1.8	1.5	0.1	1.0	0.7	1.0

T – Taxon was collected in samples but composition was less than 0.1%.

Table 5. **Average Seasonal Density of Fish Eggs and Larvae in Entrainment Samples during 2003 and 2004.**

	Intake Samples			Reservoir Samples			
	2003 $1000m^3$	2004 $1000m^3$	Combined 2003-2004 $1000m^3$	2003 $1000m^3$	2004 $1000m^3$	Combined 2003-2004 $1000m^3$	All Samples $1000m^3$
Eggs							
Unspecified	5	T	1	T	T	T	1
Clupeidae	15	56	17	40	4	11	27
Catostomidae	T	T	T	T	T	T	T
Percidae	T	T	T	T	T	T	T
Sciaenidae	76	577	152	376	693	294	447
Totals	96	633	170	416	697	305	475
Larvae							
Lepisosteidae	T	T	T	T	T	T	T
Clupeidae	2943	8354	2671	3877	9241	3656	6327
Hiodontidae	T	T	T	T	T	T	T
Cyprinidae	8	18	6	11	14	7	13
Catostomidae	43	3	11	34	3	9	19
Ictaluridae	4	6	2	1	1	1	3
Poeciliidae	T	T	T	T	T	T	T
Moronidae	56	90	35	275	72	87	122
Centrarchidae	24	157	42	20	55	21	64
Percidae	8	3	3	6	3	2	5
Sciaenidae	104	8	25	170	19	47	72
Atherinopsidae	16	160	41	6	90	28	69
Totals	3205	8800	2836	4399	9497	3857	6693

T – Taxon was collected in samples but density averaged less than 1 individual per $1000m^3$.

Table 6. Estimated Daily Hydraulic Entrainment at BFN by Sample Period during 2003 and 2004.

Sample Date	Volume Intake m³ day	Volume Reservoir m³ day	Entrained	Sample Date	Volume Intake m³ day	Volume Reservoir m³ day	Entrained
	Q_i	Q_r	%		Q_i	Q_r	%
2003				**2004**			
Mar 28	8.0E+06	5.3E+07	15.1%	Mar 25	4.0E+06	5.3E+07	7.5%
Apr 3	8.0E+06	2.9E+07	27.6%	Apr 1	6.9E+06	6.9E+07	10.0%
Apr 10	8.0E+06	8.4E+07	9.5%	Apr 7	8.0E+06	1.9E+07	42.0%
Apr 17	8.0E+06	1.3E+08	6.3%	Apr 15	8.0E+06	3.0E+07	27.0%
Apr 24	8.0E+06	1.2E+08	6.7%	Apr 22	8.0E+06	4.3E+07	18.6%
May 1	8.0E+06	1.0E+08	7.6%	Apr 29	8.0E+06	4.1E+07	19.5%
May 8	7.9E+06	1.9E+08	4.1%	May 6	8.0E+06	4.4E+07	17.9%
May 15	8.0E+06	2.0E+08	4.0%	May 13	8.0E+06	3.5E+07	22.9%
May 22	8.0E+06	2.0E+08	4.1%	May 20	8.0E+06	3.9E+07	20.6%
May 29	8.0E+06	1.1E+08	7.1%	May 27	8.0E+06	3.0E+07	26.6%
Jun 5	8.0E+06	1.2E+08	6.8%	Jun 3	7.9E+06	7.2E+07	33.0%
Jun 12	8.0E+06	1.1E+08	7.4%	Jun 10	8.0E+06	5.3E+07	15.1%
Jun 19	8.0E+06	1.3E+08	6.1%	Jun 17	8.0E+06	7.0E+07	11.4%
Jun 26	5.4E+06	1.3E+08	4.2%	Jun 24	8.0E+06	1.1E+08	7.2%
Jul 3	8.0E+06	1.8E+08	4.4%	Jul 1	8.0E+06	1.4E+08	5.9%
				Jul 7	8.0E+06	1.2E+08	6.7%
Average	**7.8E+06**	**1.3E+08**	**6.2%**	Average	**7.7E+06**	**6.0E+07**	**12.7%**

Table 7. **Seasonal Entrainment Estimates for Numerically Significant Fish Taxa Collected during 2003 and 2004.**

	2003			2004			2003-2004		
Taxa	Intake Number Entrained Per Day $Q_i X D_i$	Reservoir Total Number Per Day $Q_r X D_r$	Entrainment Estimate %	Intake Number Entrained Per Day $Q_i X D_i$	Reservoir Total Number Per Day $Q_r X D_r$	Entrainment Estimate %	Intake Number Entrained Per Day $Q_i X D_i$	Reservoir Total Number Per Day $Q_r X D_r$	Entrainment Estimate %
Eggs									
Clupeidae	1.2E+08	6.2E+09	2.0%	4.5E+08	2.0E+08	225.7%	3.0E+08	3.0E+09	9.9%
Sciaenidae	5.8E+08	4.9E+10	1.2%	4.6E+09	2.7E+10	17.3%	2.7E+09	3.7E+10	7.3%
Total Eggs	**7.4E+08**	**5.5E+10**	**1.3%**	**5.0E+09**	**2.7E+10**	**18.8%**	**3.0E+09**	**4.0E+10**	**7.6%**
Larvae									
Clupeidae	2.3E+10	5.0E+11	4.6%	6.7E+10	3.6E+11	18.3%	4.6E+10	4.3E+11	10.8%
Hiodontidae	4.5E+05	2.2E+07	2.0%	*	*	*	2.1E+05	1.0E+07	2.0%
Cyprinidae	5.9E+07	1.5E+09	3.9%	1.5E+08	8.5E+08	17.1%	1.1E+08	1.2E+09	9.0%
Catostomidae	3.4E+08	2.7E+09	13.0%	2.3E+07	1.3E+08	17.4%	1.7E+08	1.3E+09	13.2%
Ictaluridae	2.8E+07	1.2E+08	23.4%	4.8E+07	1.3E+08	37.1%	3.9E+07	1.3E+08	31.0%
Moronidae	4.4E+08	1.5E+10	3.0%	7.2E+08	2.9E+09	24.8%	5.9E+08	8.4E+09	7.0%
Centrarchidae	1.9E+08	2.9E+09	6.6%	1.2E+09	2.4E+09	51.8%	7.4E+08	3.3E+08	28.5%
Percidae	6.1E+07	5.5E+08	10.9%	1.6E+07	1.4E+08	11.8%	3.7E+07	3.3E+08	11.1%
Sciaenidae	7.7E+08	2.4E+10	3.2%	6.3E+07	8.5E+08	7.4%	3.9E+08	1.2E+10	3.3%
Atherinopsidae	1.3E+08	8.2E+08	15.4%	1.3E+09	3.7E+09	34.5%	7.4E+08	2.3E+09	31.4%
Total Larvae	**2.5E+10**	**5.4E+11**	**4.5%**	**7.0E+10**	**3.8E+11**	**18.7%**	**4.9E+10**	**4.5E+11**	**10.8%**

* - Not Collected

Table 8. List of Fish Species Collected in Impingement Samples during 2003 and 2004.

Family	Scientific Name		Common Name
	Genus	Species	
Lepisosteidae	Lepisosteus	oculatus	Spotted gar
Clupeidae	Alosa	chrysochloris	Skipjack herring
		pseudoharengus	Alewife
	Dorosoma	cepedianum	Gizzard shad
		petenense	Threadfin shad
Hiodontidae	Hiodon	tergisus	Mooneye
Cyprinidae	Cyprinus	carpio	Common Carp
	Machrybopsis	storeriana	Silver chub
	Notemigonus	crysoleucas	Golden shiner
	Pimephales	vigilax	Bullhead minnow
	Semotilus	atromaculatus	Creek chub
Catostomidae	Hypentelium	nigricans	Northern hog sucker
	Ictiobus	bubalus	Smallmouth buffalo
	Minytrema	melanops	Spotted sucker
	Moxostoma	duquesnei	Black redhorse
		erythrurum	Golden redhorse
Ictaluridae	Amerieuru	melas	Black bullhead
		natalis	Yellow bullhead
	Ictalurus	furcatus	Blue catfish
		punctatus	Channel catfish
	Pylodictis	olivaris	Flathead catfish
Moronidae	Morone	chrysops	White bass
		mississippiensis	Yellow bass
		saxatilis	Striped bass
Centrarchidae	Lepomis	cyanellus	Green sunfish
		gulosus	Warmouth
		humilis	Orangespotted sunfish
		macrochirus	Bluegill
		megalotis	Longear sunfish
		microlophus	Redear sunfish
	Micropterus	salmoides	Largemouth bass
	Pomoxis	annularis	White crappie
		nigromaculatus	Black crappie
Percidae	Percina	caprodes	Logperch
	Sander	canadense	Sauger
Sciaenidae	Aplodinotus	grunniens	Freshwater drum
Atherinidae	Menidia	beryllina	Inland silverside
	Labidesthes	sicculus	Brook silverside

Table 9. **Fish Species Impinged at an Average Rate of One or More Per Day during 2003 and 2004.**

Common Name	2003 Jul 24-Sep 4 Number/Day	2003-2004 Dec 11-Mar 29 Number/Day	All Samples Number/Day
Skipjack herring	5	151	107
Alewife		14	10
Gizzard shad	39	232	173
Threadfin shad	1060	1489	1358
Silver chub	1	3	2
Spotted sucker		1	1
Blue catfish	5	5	5
Channel catfish	10	39	30
White bass	7	1	2
Yellow bass	11	37	29
Striped bass	1	2	2
Green sunfish		1	
Bluegill	12	10	10
Redear sunfish	33	1	11
White crappie	1	2	2
Black crappie		1	
Freshwater drum	199	589	471

Table 10. **Fish Species Impinged at an Average Rate of One or More Kilogram Per Day during 2003 and 2004.**

Common Name	2003 Jul 24-Sep 4 Kilograms/Day	2003-2004 Dec 11-Mar 29 Kilograms/Day	All Samples Kilograms/Day
Skipjack herring	0	2	1
Gizzard shad	0	11	7
Threadfin shad	2	8	6
Blue catfish	1	1	1
Channel catfish	1	3	2
Yellow bass	0	1	1
Freshwater drum	5	15	12

Table 11. **Species Composition Expressed as Percentage of Total Number of Fish Collected in Impingement Samples during 2003 and 2004.**

Common Name	2003 Jul 24-Sep 4 %	2003-2004 Dec 11-Mar 29 %	All Samples %
Spotted gar	T	T	T
Skipjack herring	0.4	5.9	4.8
Alewife	NC	0.6	0.5
Gizzard shad	2.8	9.0	7.8
Threadfin shad	76.4	57.7	61.3
Mooneye	NC	T	T
Common Carp	NC	T	T
Silver chub	0.1	0.1	0.1
Golden shiner	T	T	T
Bullhead minnow	T	T	T
Creek chub	NC	T	T
Northern hog sucker	NC	T	T
Smallmouth buffalo	NC	T	T
Spotted sucker	NC	T	T
Black redhorse	NC	T	T
Golden redhorse	NC	T	T
Black bullhead	NC	T	T
Yellow bullhead	NC	T	T
Blue catfish	0.4	0.2	0.2
Channel catfish	0.7	1.5	1.4
Flathead catfish	T	T	T
White bass	0.5	T	0.1
Yellow bass	0.8	1.4	1.3
Striped bass	0.1	0.1	0.1
Green sunfish	T	T	T
Warmouth	T	T	T
Orangespotted sunfish	NC	T	T
Bluegill	0.9	0.4	0.5
Longear sunfish	T	T	T
Redear sunfish	2.4	0.1	0.5
Largemouth bass	T	T	T
White crappie	0.1	0.9	0.1
Black crappie	T	T	T
Logperch	T	T	T
Sauger	T	T	T
Freshwater drum	14.4	22.8	21.2
Inland silverside	NC	T	T

NC - Species not collected.

T -Percent composition for species is < 0.1 %.

Table 12. Species Composition Expressed as Percentage of Total Biomass of Fish Collected in Impingement Samples during 2003 and 2004.

Common Name	2003 Jul 24-Sep 4 %	2003-2004 Dec 11-Mar 29 %	All Samples %
Spotted gar	2.3	0.6	0.7
Skipjack herring	1.4	3.9	3.7
Alewife	NC	0.5	0.4
Gizzard shad	4.2	25.1	23.1
Threadfin shad	19.3	18.2	18.3
Mooneye	NC	T	T
Common Carp	NC	0.8	0.1
Silver chub	T	0.1	0.1
Golden shiner	0.1	T	0.1
Bullhead minnow	T	T	T
Creek chub	NC	T	T
Northern hog sucker	NC	T	T
Smallmouth buffalo	NC	0.4	0.4
Spotted sucker	NC	0.8	0.7
Black redhorse	NC	0.1	0.1
Golden redhorse	NC	1.0	0.9
Black bullhead	NC	T	T
Yellow bullhead	NC	0.1	0.1
Blue catfish	6.1	1.1	1.6
Channel catfish	5.5	6.5	6.4
Flathead catfish	T	0.4	0.3
White bass	2.4	0.2	0.5
Yellow bass	3.7	2.4	2.6
Striped bass	0.6	0.1	0.1
Green sunfish	T	T	T
Warmouth	T	T	T
Orangespotted sunfish	NC	T	T
Bluegill	0.7	0.7	0.7
Longear sunfish	0.1	T	T
Redear sunfish	1.2	0.2	0.3
Largemouth bass	0.3	T	T
White crappie	0.9	0.1	0.1
Black crappie	T	T	T
Logperch	T	T	T
Sauger	2.0	0.1	0.3
Freshwater drum	49.2	36.4	37.7
Inland silverside	NC	T	T

NC - Species not collected.

T -Percent composition for species is < 0.1 %.

Table 13. Historical and Current Entrainment Estimates at BFN.

		Eggs			Larvae		
		Reservoir	Intake		Reservoir	Intake	
Year	Hydraulic Rate %	Mean Daily Number	Mean Daily Number	Rate %	Mean Daily Number	Mean Daily Number	Rate %
Historical Baseline							
1977	12.0	6.4E+09	1.5E+08	2.3	3.2E+10	3.7E+09	11.7
1978	13.3	1.3E+09	5.0E+07	3.7	5.4E+10	2.9E+09	5.3
1979	9.0	2.3E+09	1.9E+08	8.2	3.0E+10	1.3E+09	4.5
Current Evaluation							
2003	6.2	5.5E+10	7.4E+08	1.3	5.4E+11	2.5E+10	4.5
2004	12.7	2.7E+10	5.0E+09	18.8	3.8E+11	7.0E+10	18.7
2003-2004							
Totals	**8.4**	**4.0E+10**	**3.0E+09**	**7.6**	**4.5E+11**	**4.9E+10**	**10.8**

Table 14. Historical and Current Entrainment Estimates for Numerically Significant Taxa.

	Historical Baseline						Current Evaluation			
	1977		1978		1979		2003		2004	
Taxa	Mean Daily Number	Rate %	Mean Daily Number	Rate %	Mean Daily Number	Rate %	Mean Daily Number	Rate %	Mean Daily Number	Rate %
Clupeidae	3.6E+09	12.1	2.8E+09	5.2	1.2E+09	4.4	2.3E+10	4.6	6.7E+10	18.3
Hiodontidae	2.7E+05	1.2	3.9E+04	2.5	2.6E+05	4.6	4.5E+05	2.0	*	*
Cyprinidae	1.0E+06	4.8	3.1E+06	2.5	2.2E+07	7.9	5.9E+07	3.9	1.5E+08	17.1
Catostomidae	4.4E+07	4.5	1.8E+07	17.0	1.7E+07	3.1	3.4E+08	13.0	2.3E+07	17.4
Ictaluridae	6.1E+05	29.0	6.6E+06	16.2	1.1E+06	6.4	2.8E+07	23.4	4.8E+08	37.4
Moronidae	3.9E+07	15.6	8.4E+07	11.9	5.1E+07	5.3	4.4E+08	3.0	7.2E+08	24.8
Centrarchidae	8.7E+06	4.8	1.6E+07	2.5	7.7E+06	3.7	1.9E+08	6.6	1.2E+09	51.8
Percidae	4.2E+06	14.6	4.0E+06	12.4	5.6E+06	13.9	6.1E+07	10.9	1.6E+07	11.8
Sciaenidae	4.4E+07	6.1	2.5E+07	3.8	5.7E+07	8.6	7.7E+08	3.2	6.3E+07	7.4
Atherinopsidae	*	*	*	*	1.1E+04	T	1.3E+08	15.4	1.3E+09	34.5

* - Not collected.

T - Taxon was entrained at a rate of less than 0.1 %.

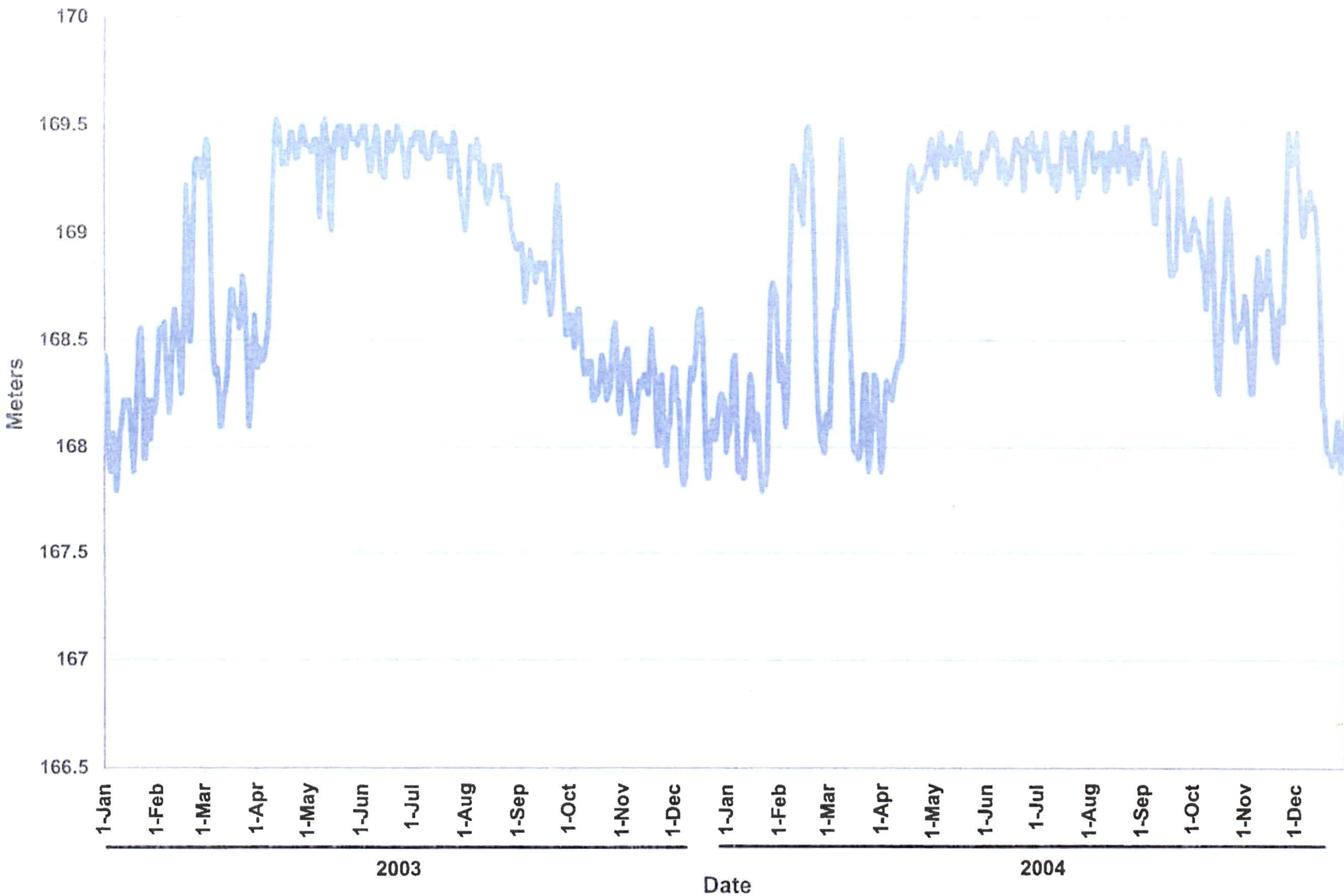

Figure 1. Average daily surface elevation (meters above mean sea level) of Wheeler Reservoir during 2003 and 2004.

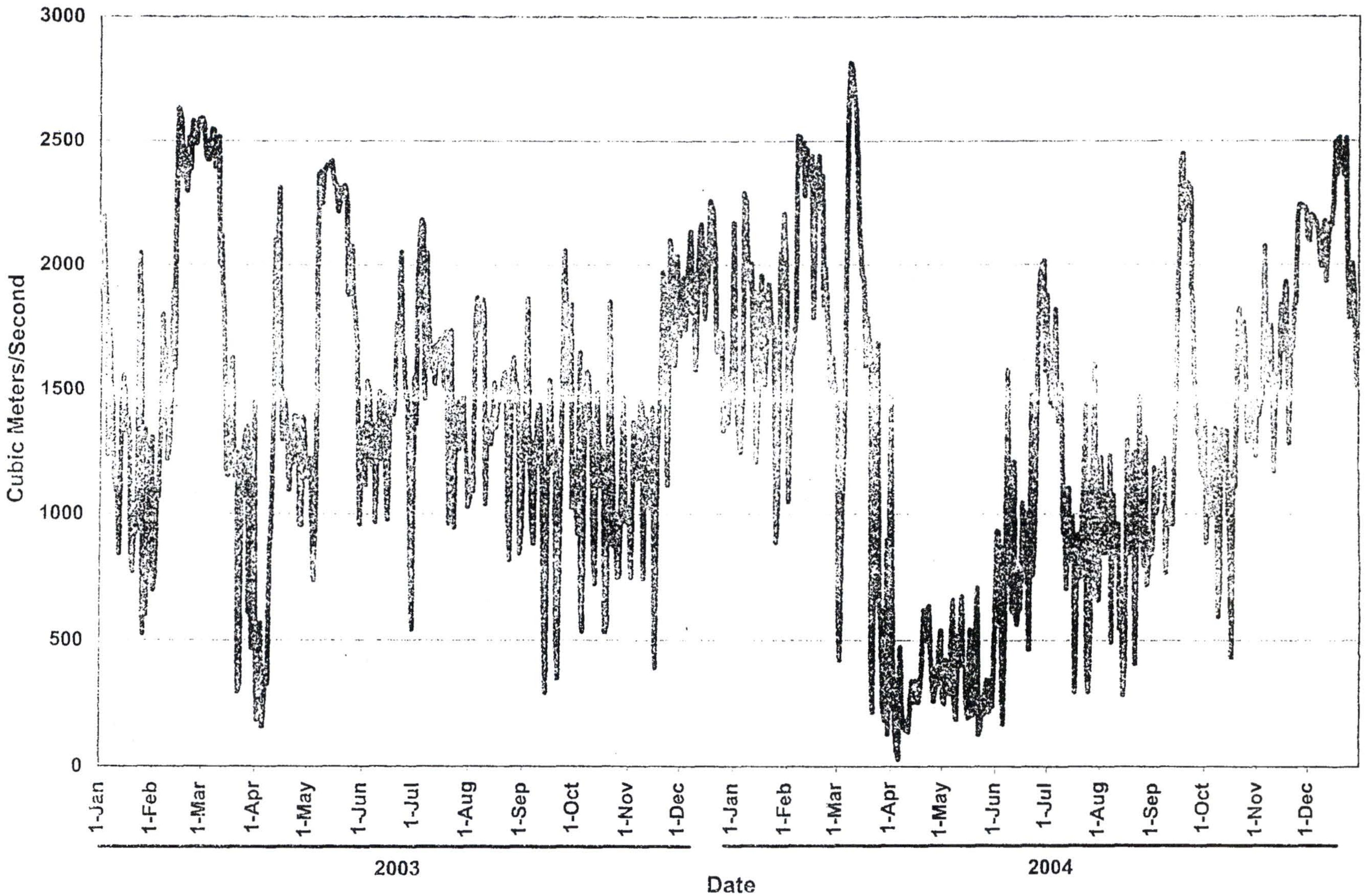

Figure 2. Average daily rate of flow in Wheeler Reservoir near BFN during 2003 and 2004.

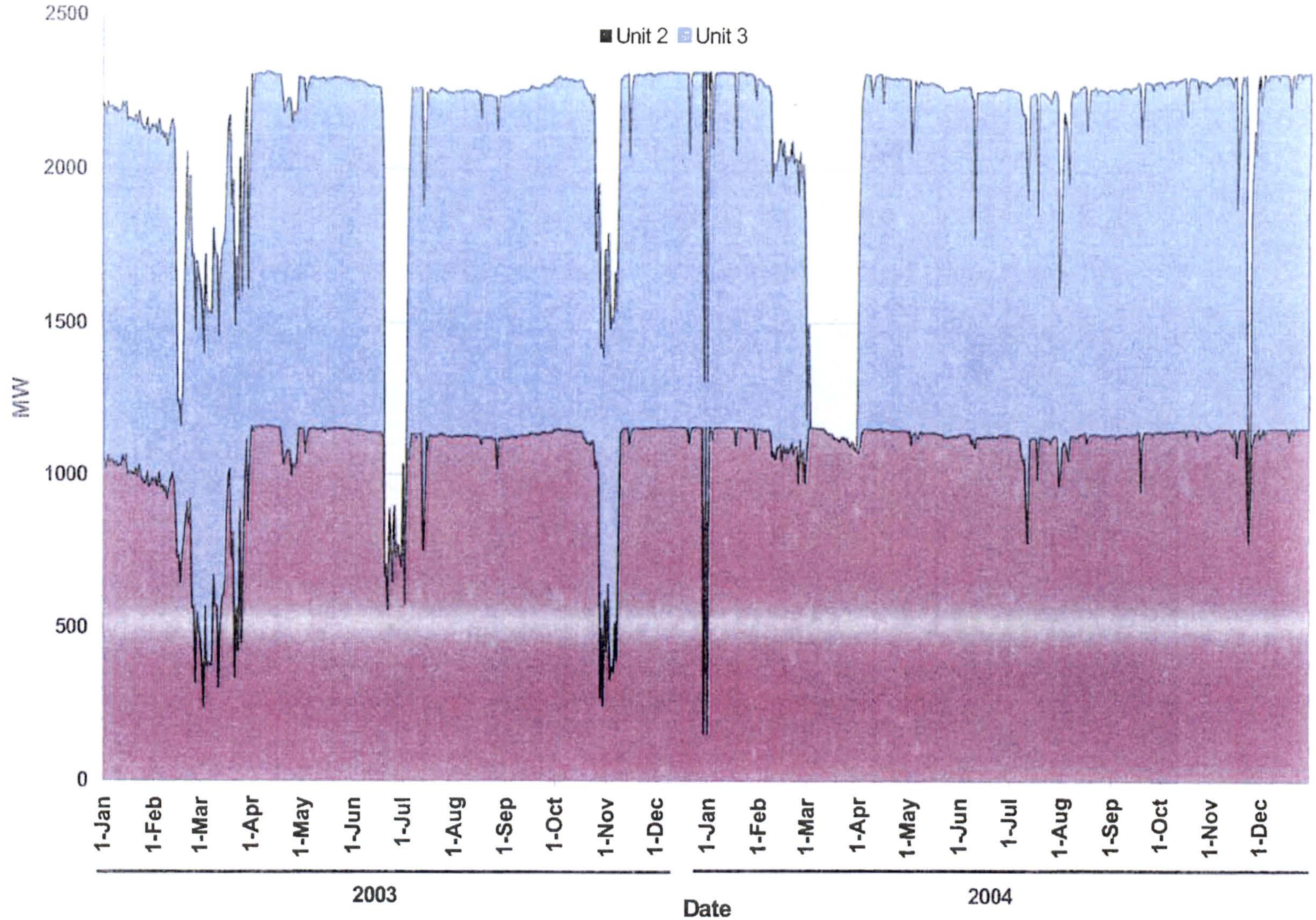

Figure 3. Average daily rate of generation at BFN during 2003 and 2004.

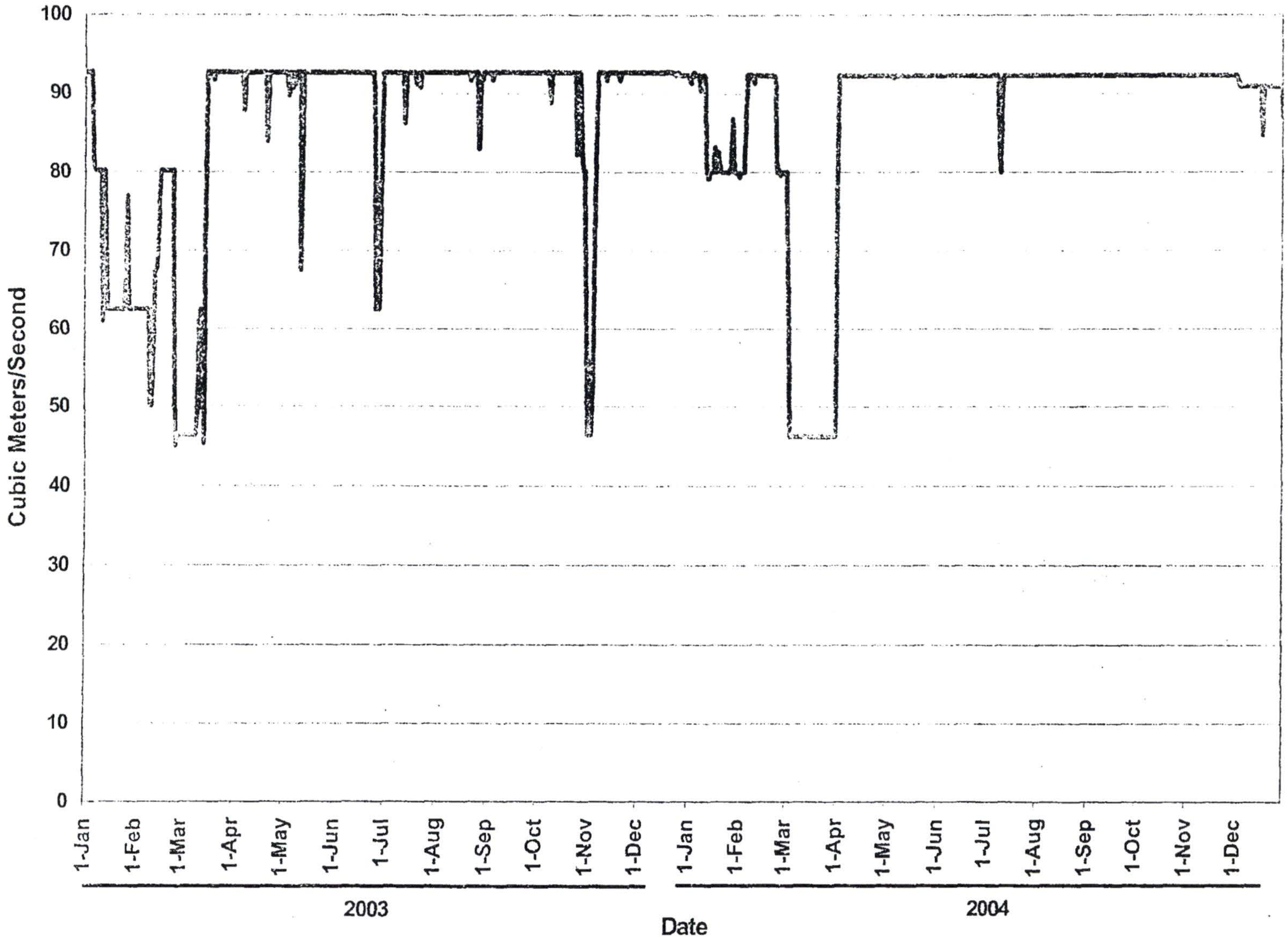

Figure 4. Average daily rate of hydraulic entrainment at BFN during 2003 and 2004.

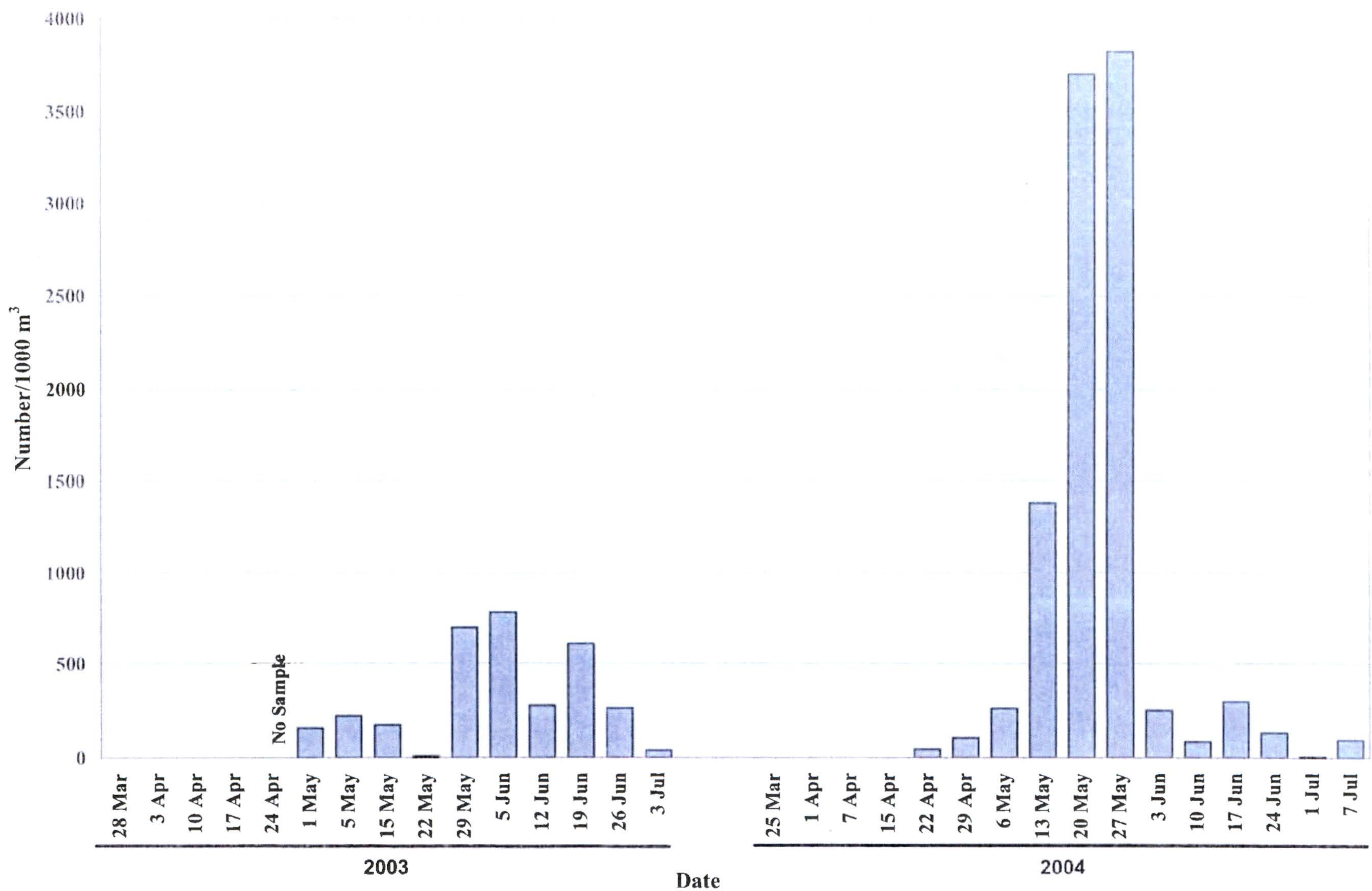

Figure 5. Densities of drum eggs collected in entrainment samples during 2003 and 2004.

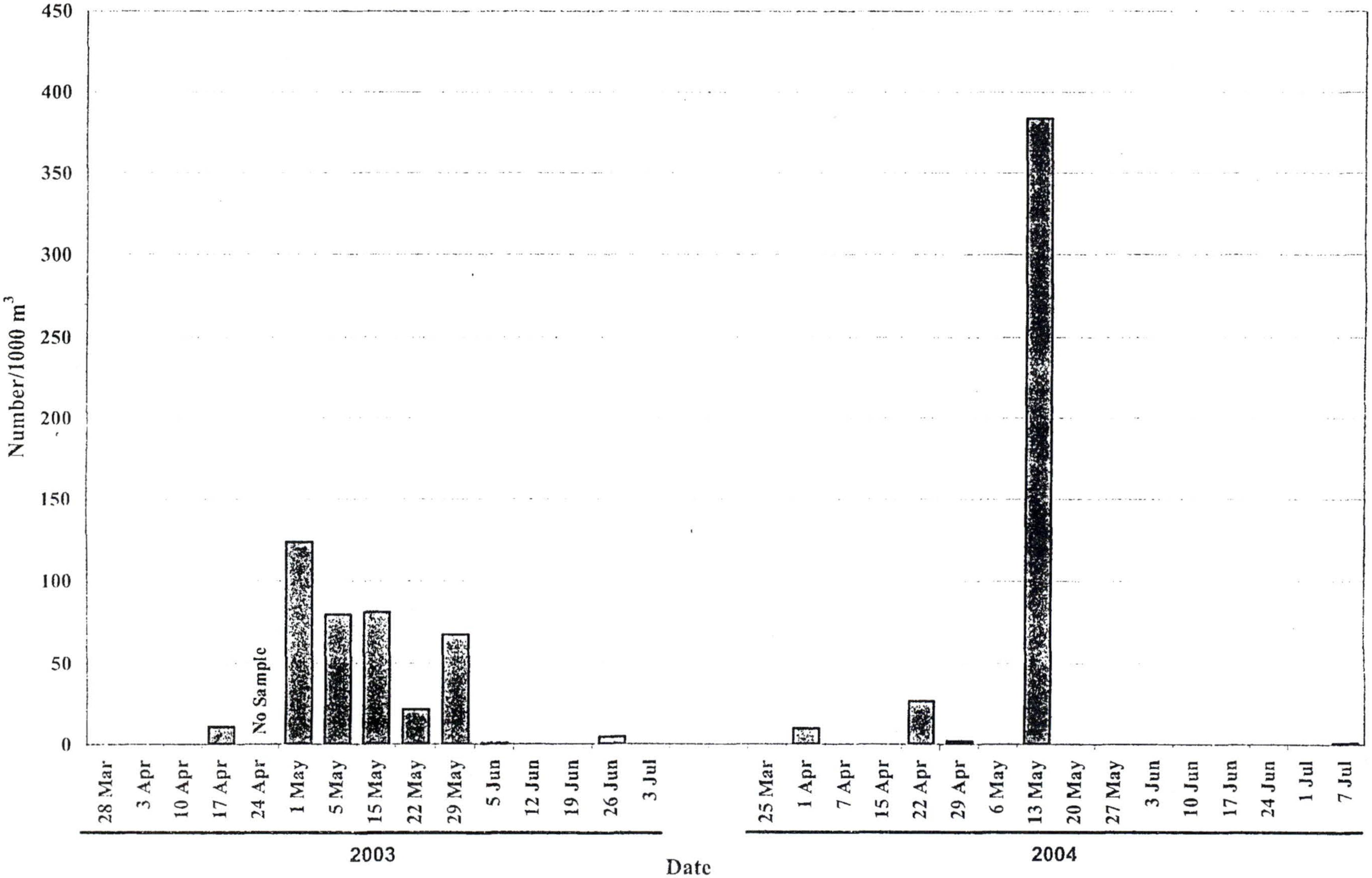

Figure 6. Densities of clupeid eggs collected in entrainment samples during 2003 and 2004.

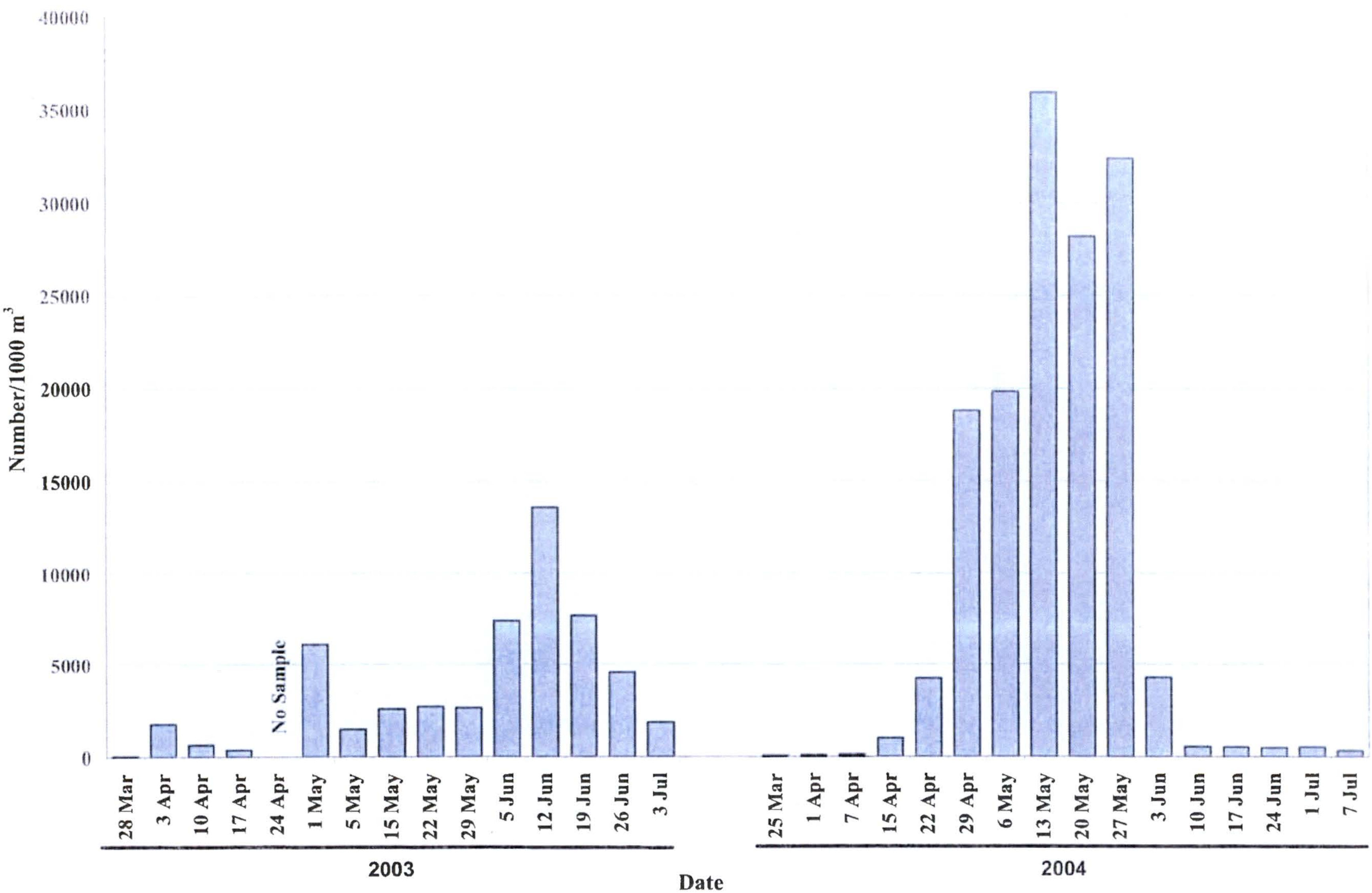

Figure 7. Densities of larval and juvenile fish collected in entrainment samples during 2003 and 2004.

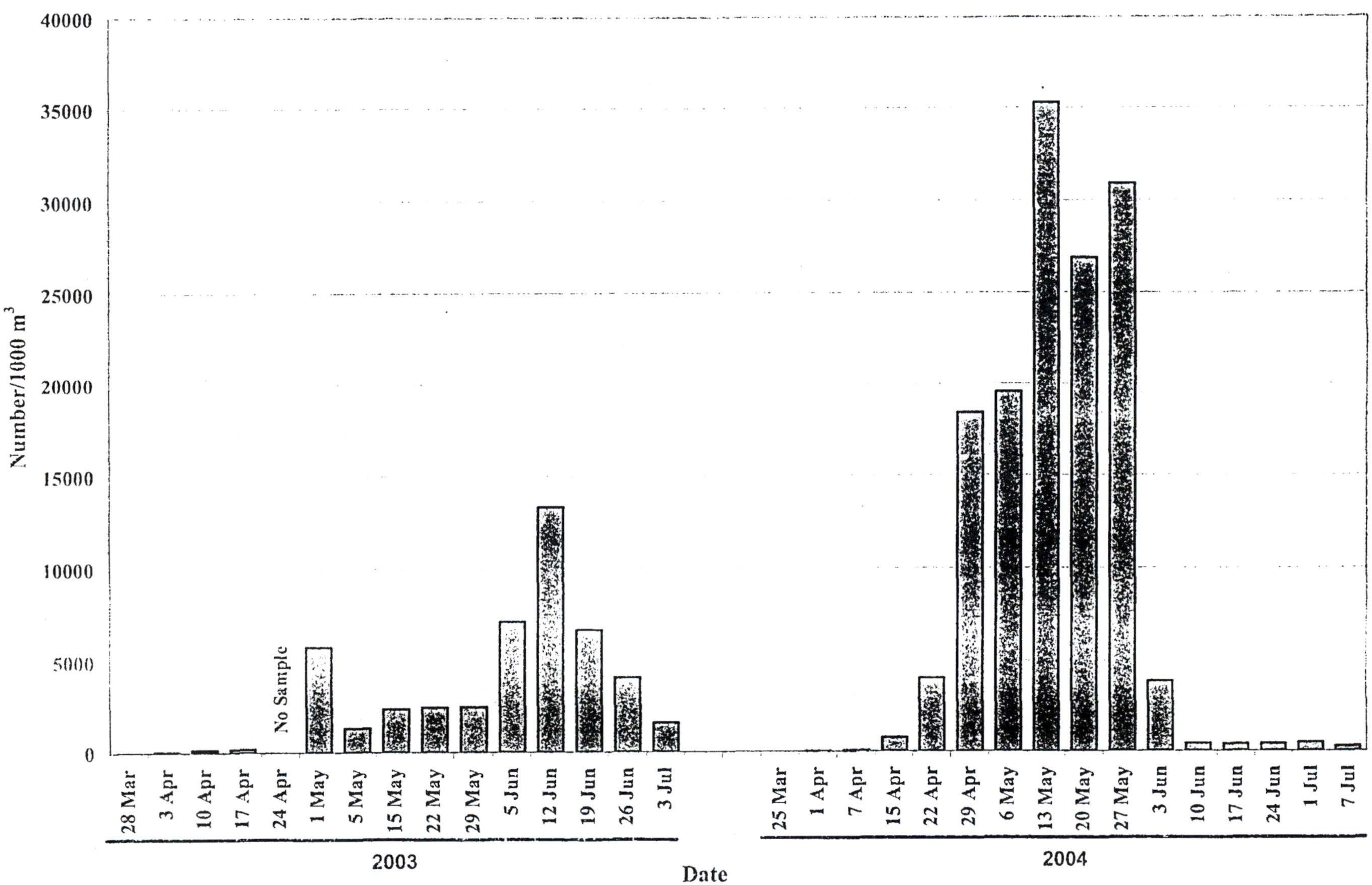

Figure 8. Densities of clupeids collected in entrainment samples during 2003 and 2004.

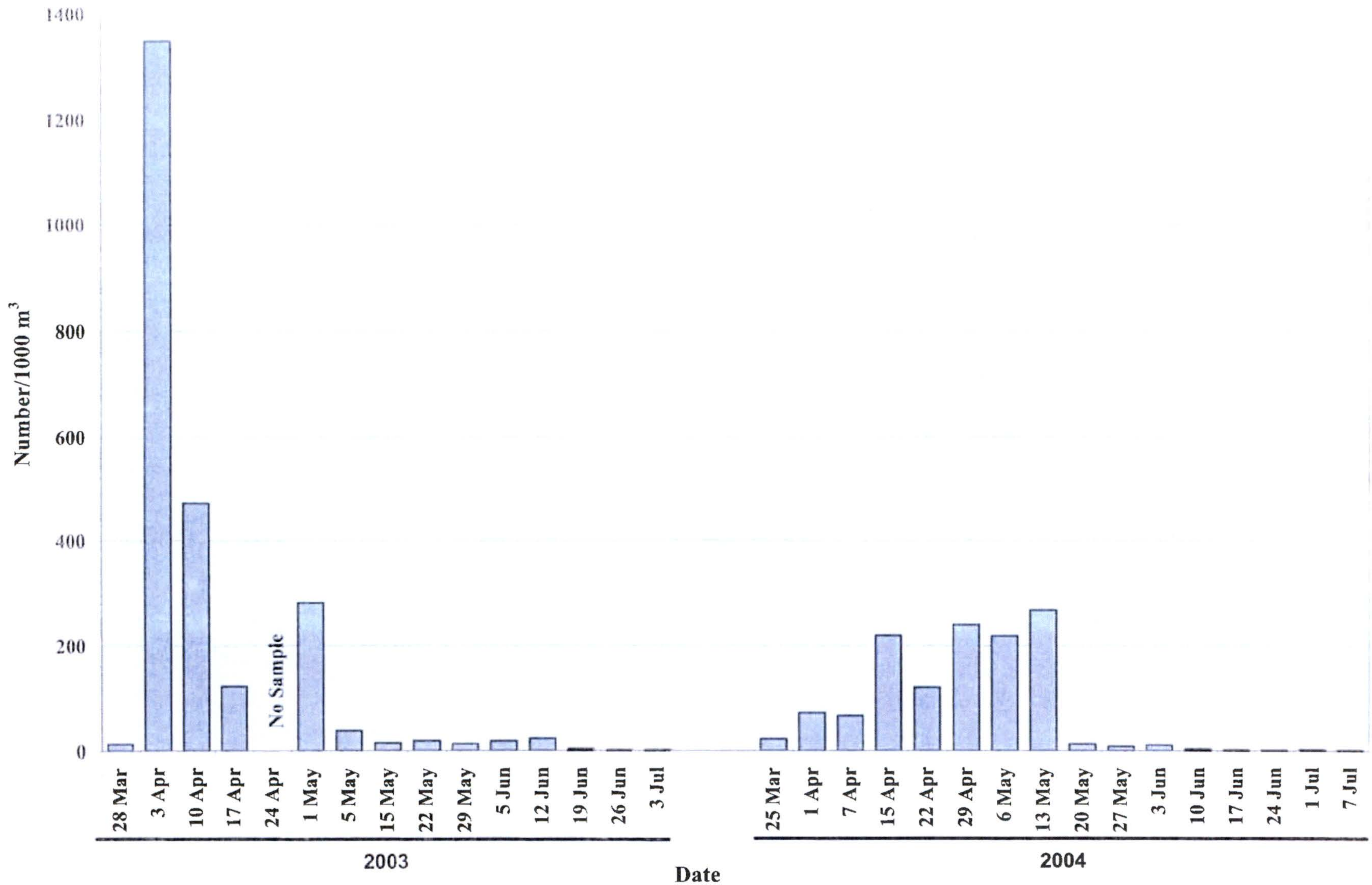

Figure 9. Densities of temperate bass collected in entrainment samples during 2003 and 2004.

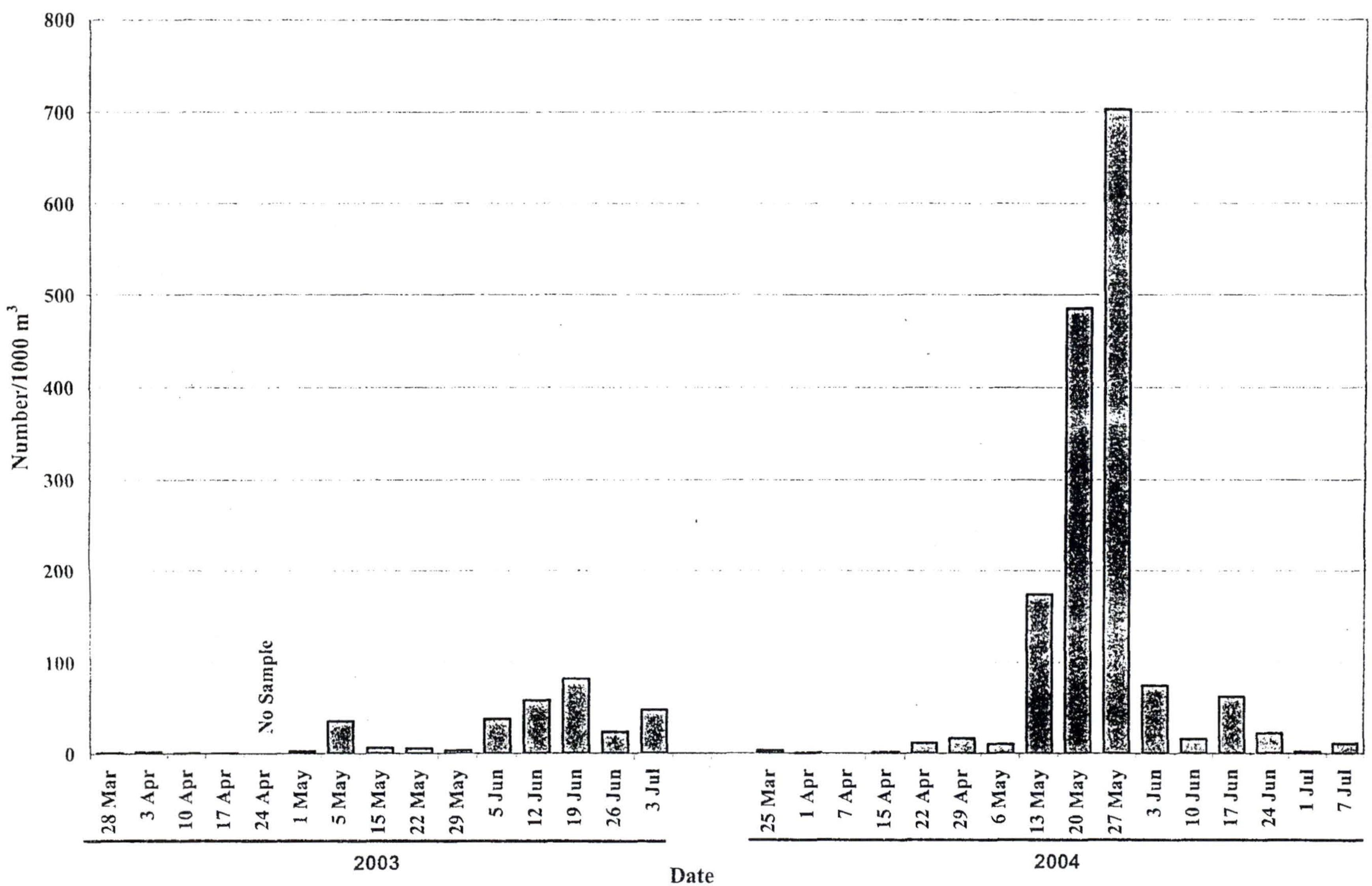

Figure 10. Densities of sunfishes collected in entrainment samples during 2003 and 2004.

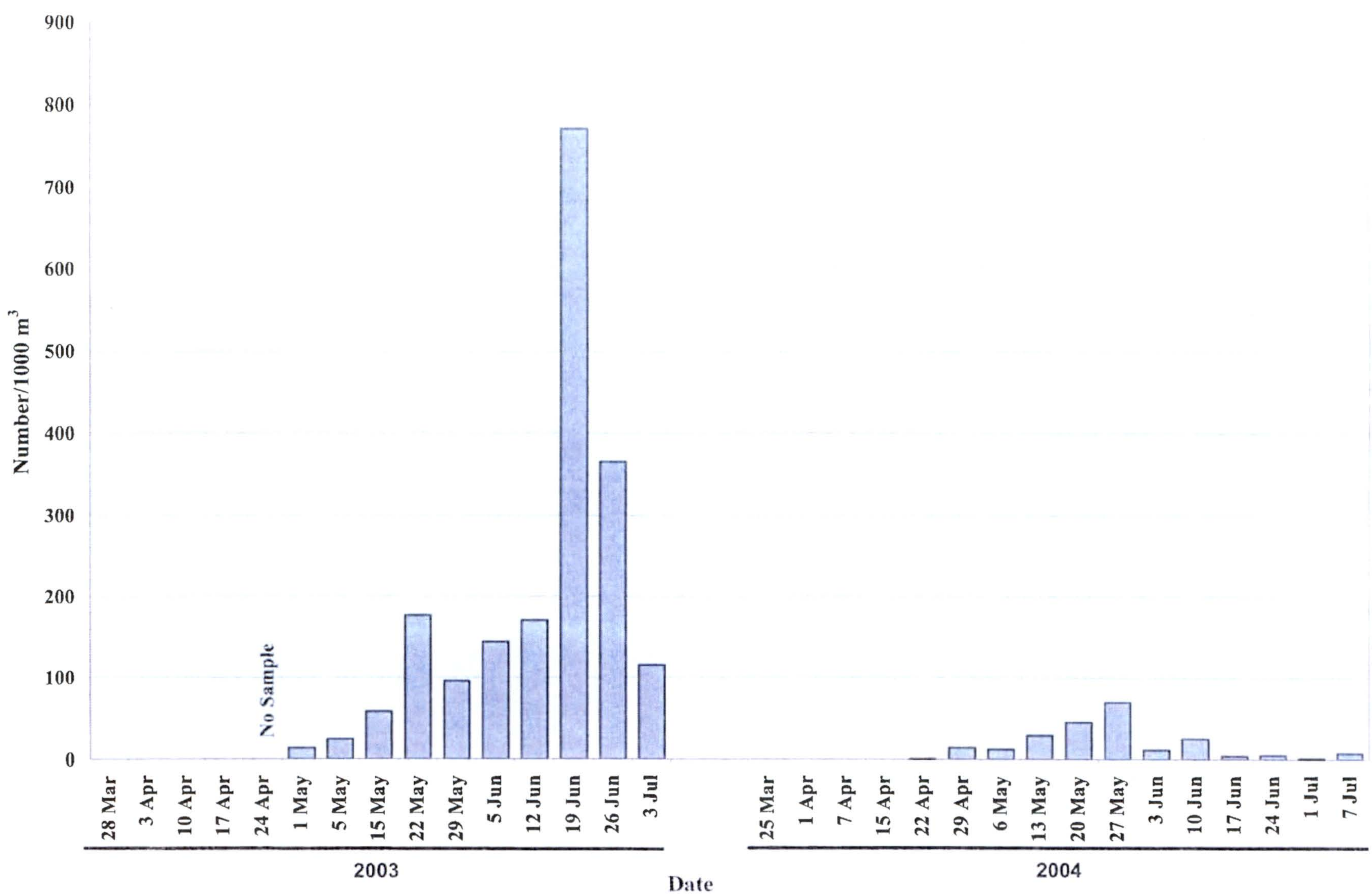

Figure 11. Densities of freshwater drum collected in entrainment samples during 2003 and 2004.

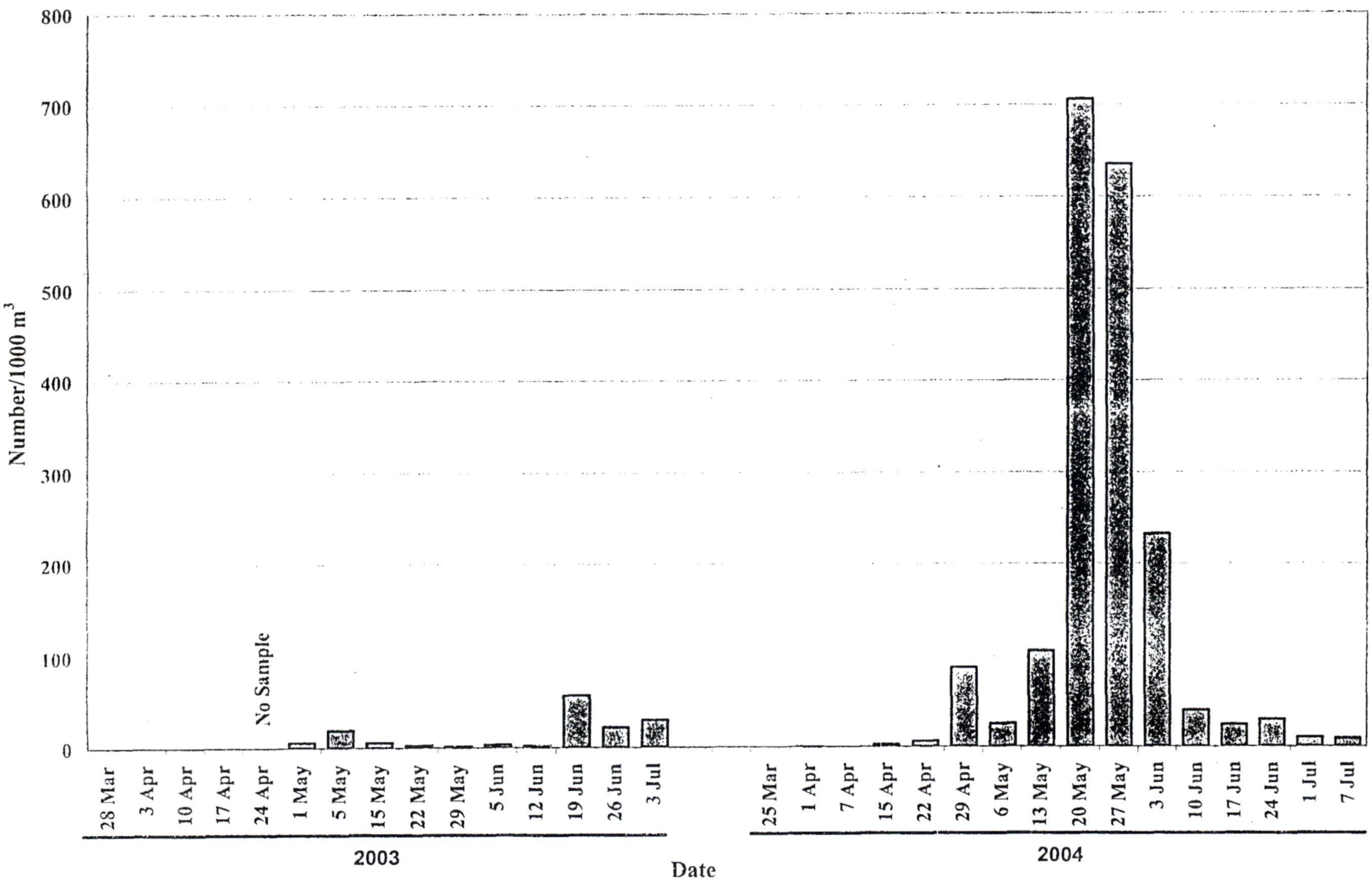

Figure 12. Densities of silversides collected in entrainment samples during 2003 and 2004.

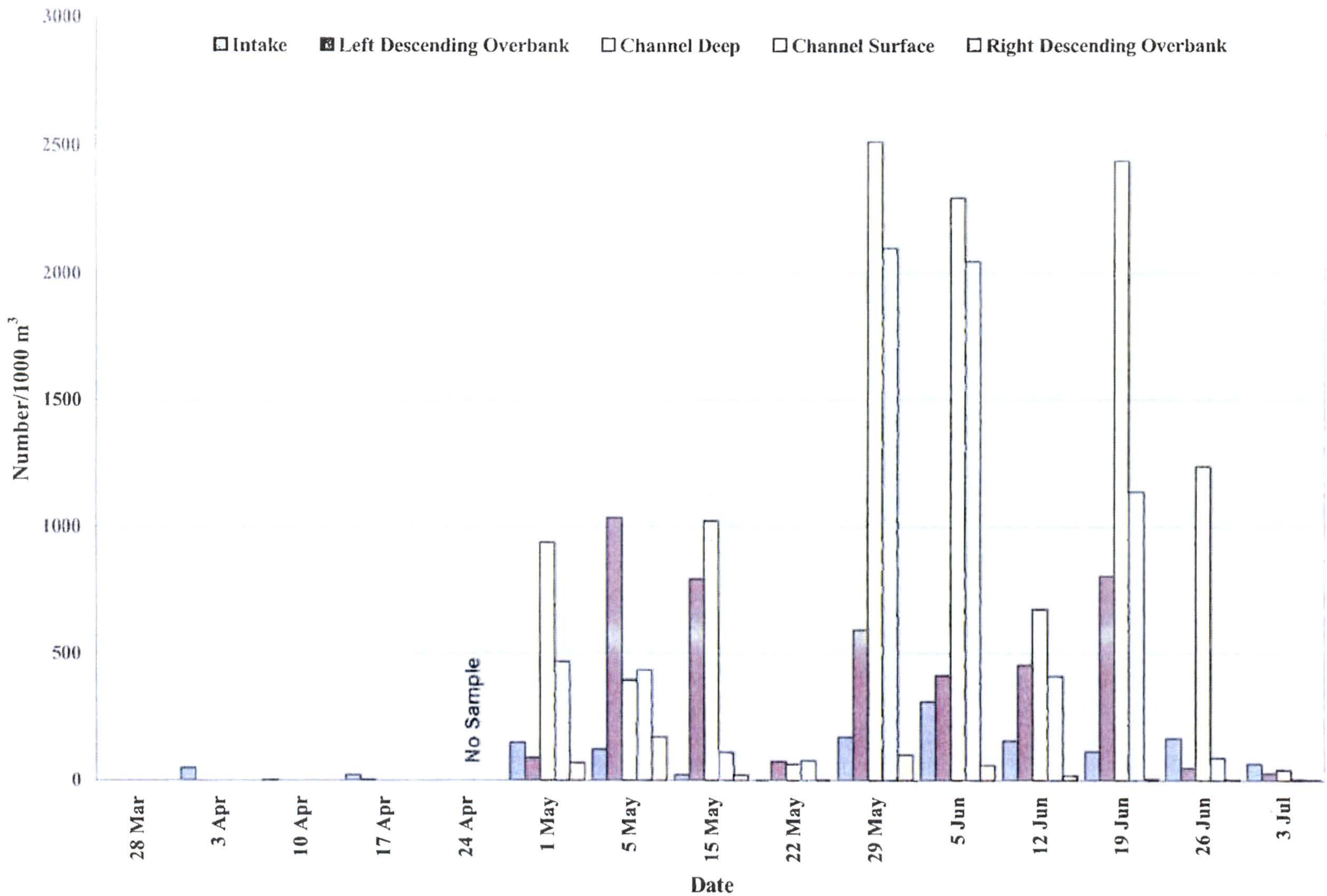

Figure 13. Densities of total fish eggs collected at each station in 2003 entrainment samples.

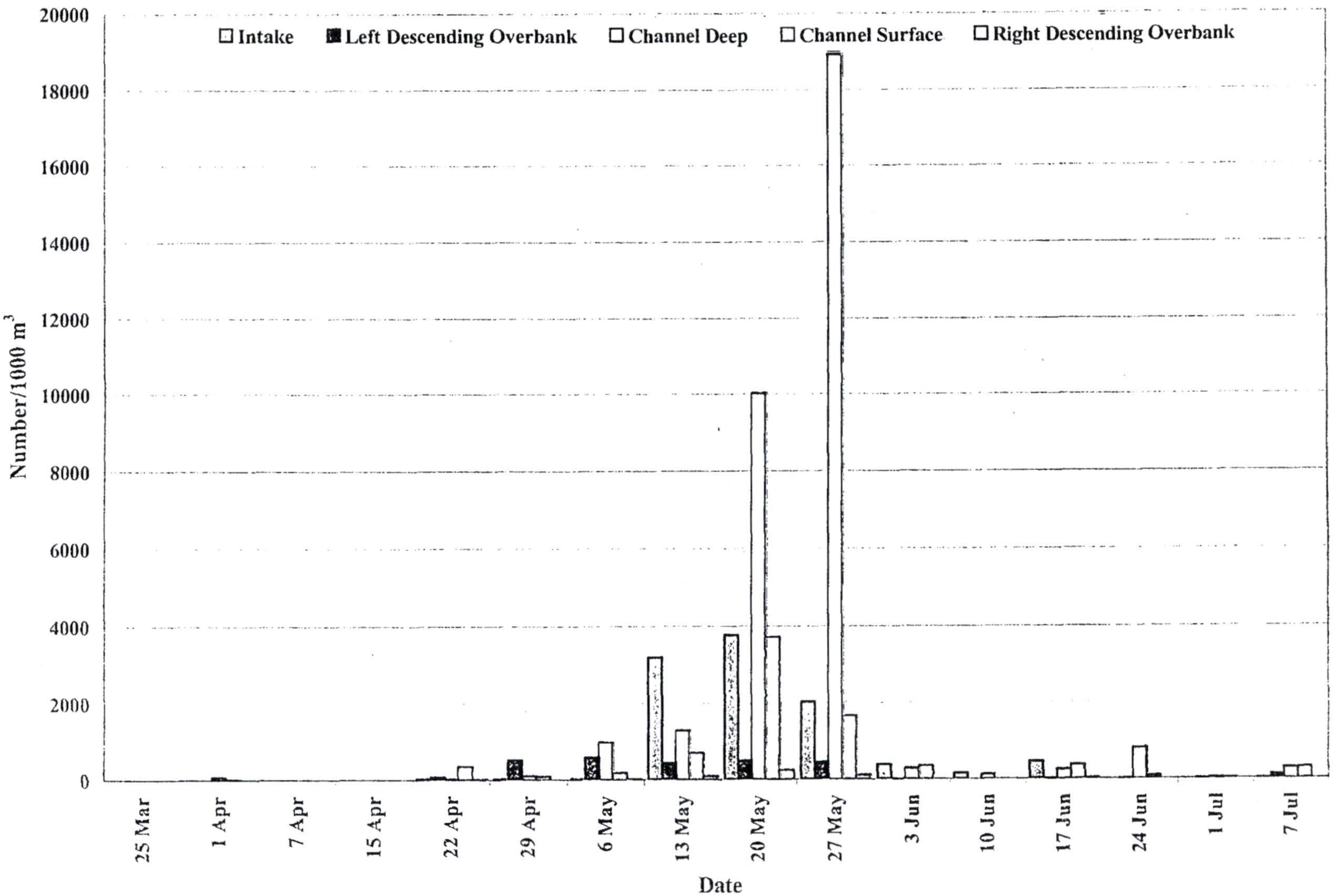

Figure 14. Densities of total fish eggs collected at each station in 2004 entrainment samples.

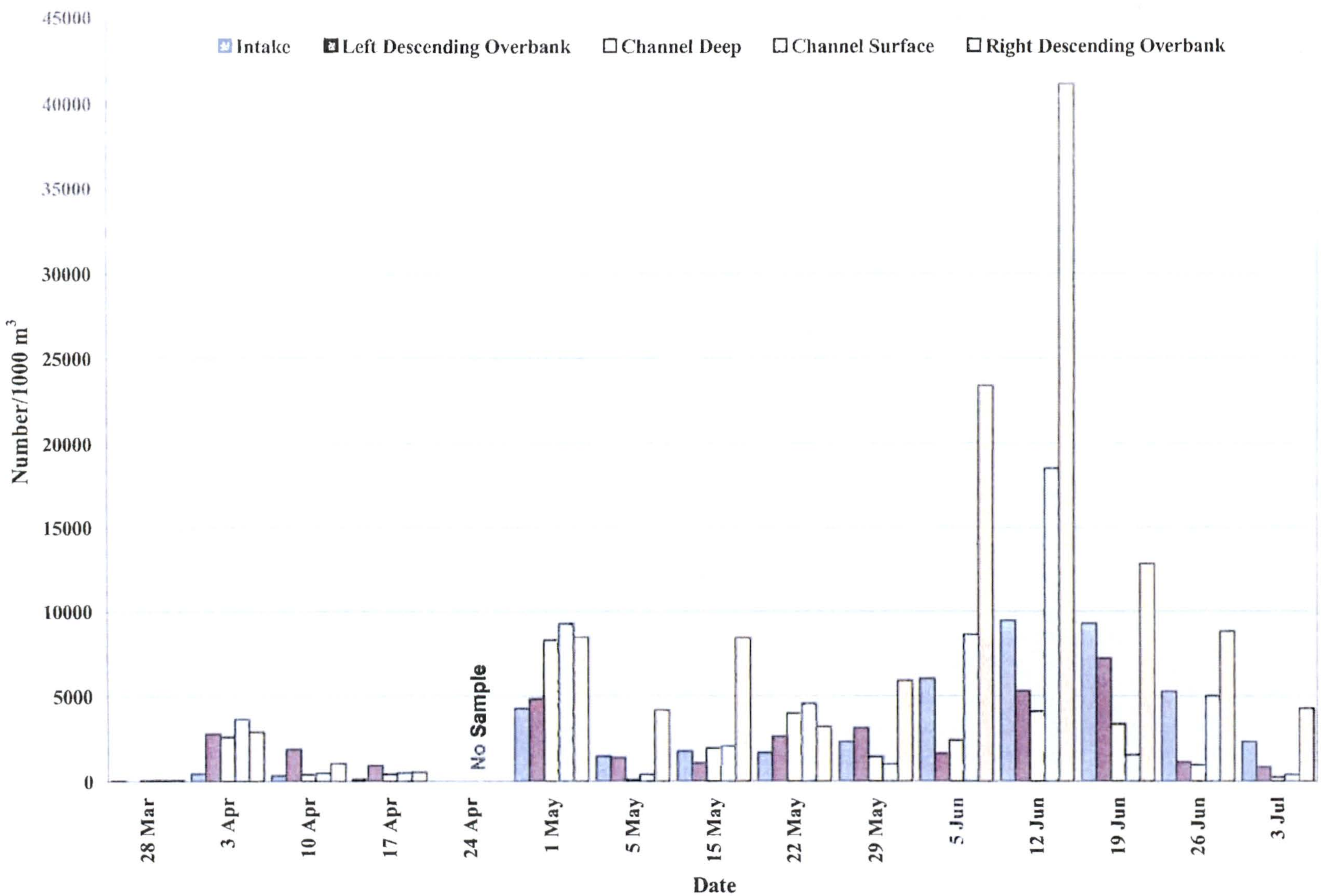

Figure 15. Densities of total fish collected at each station in 2003 entrainment samples.

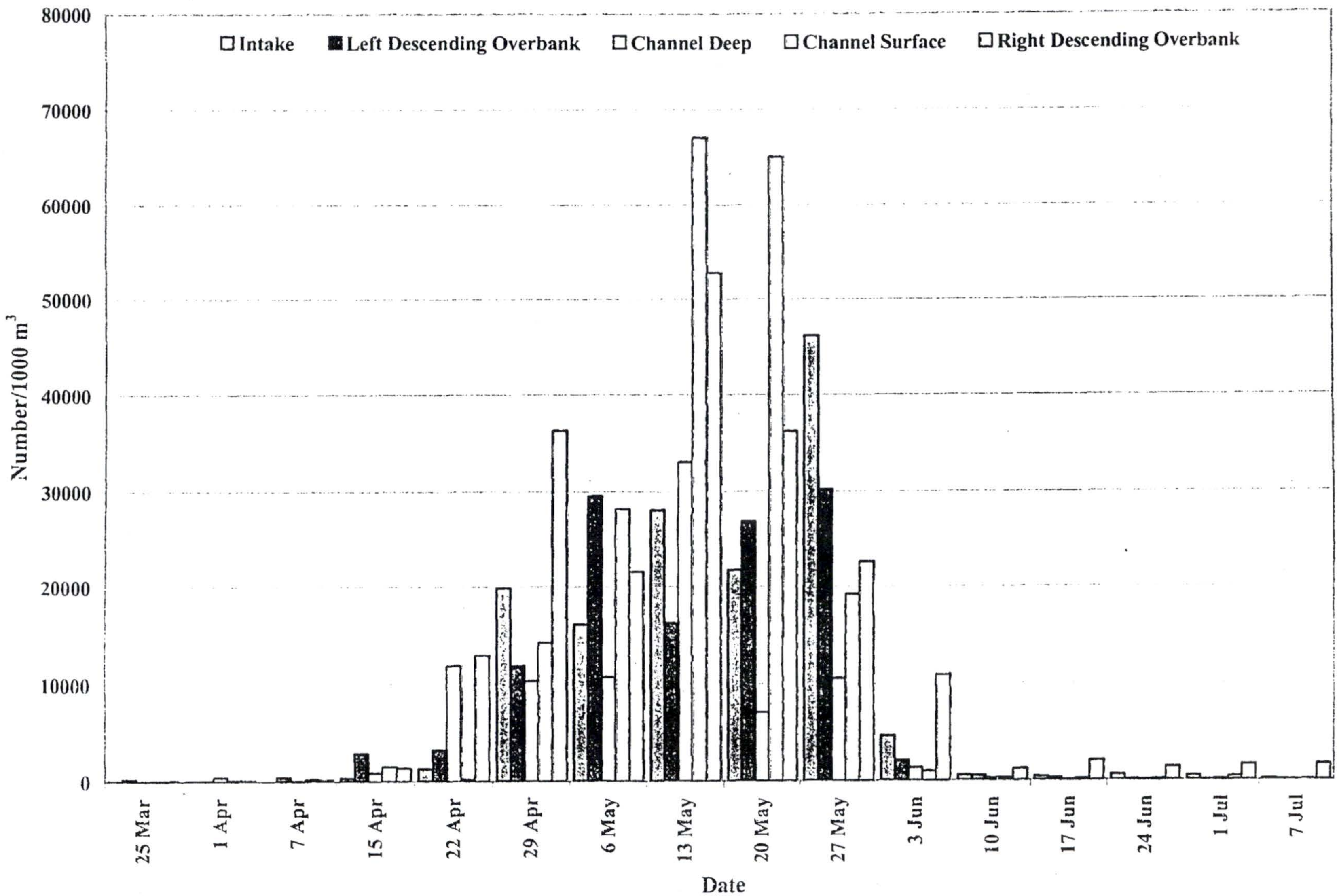

Figure 16. Densities of total fish collected at each station in 2004 entrainment samples.

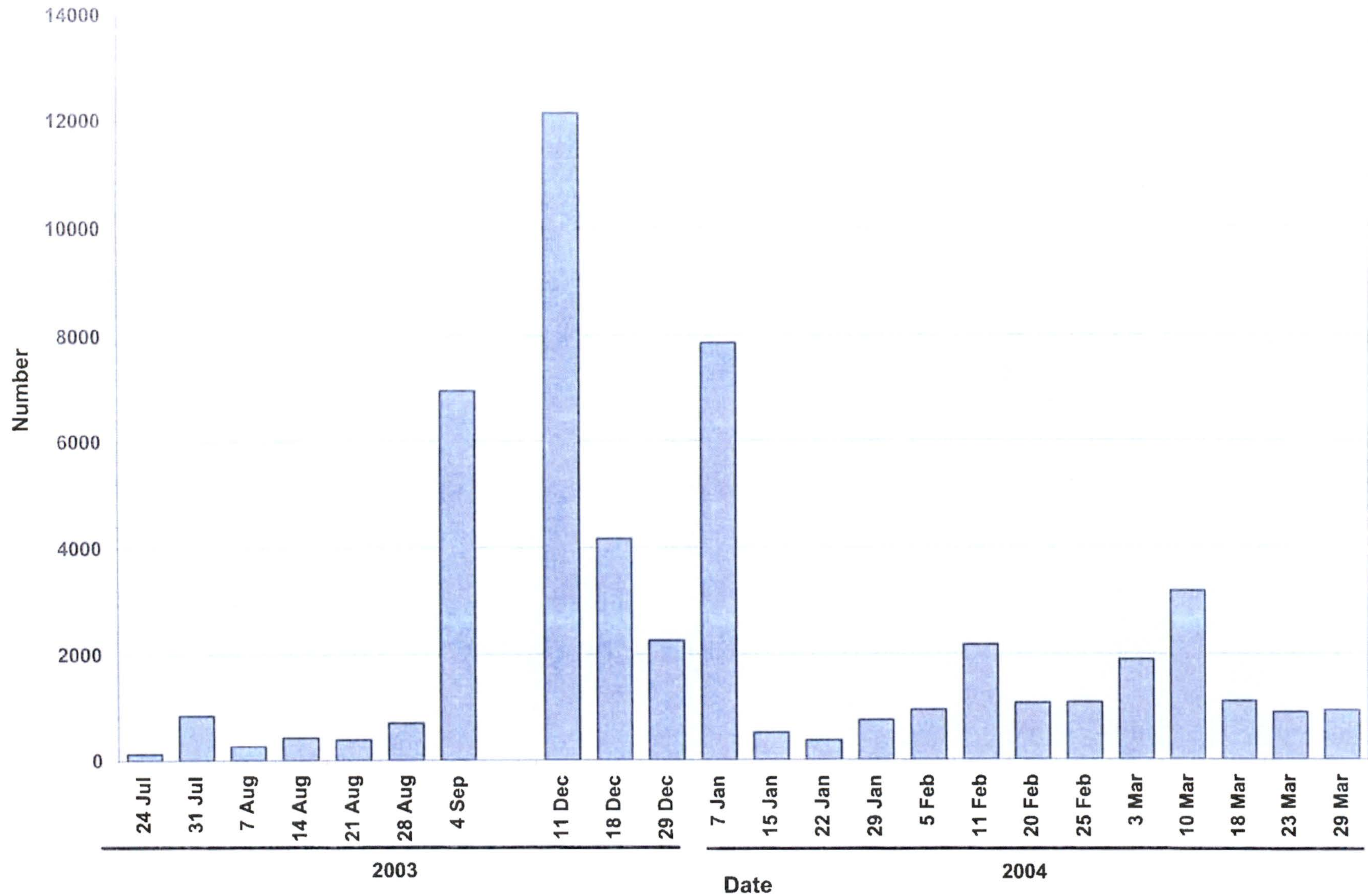

Figure 17. Estimated number of fish impinged daily at BFN during 2003 and 2004.

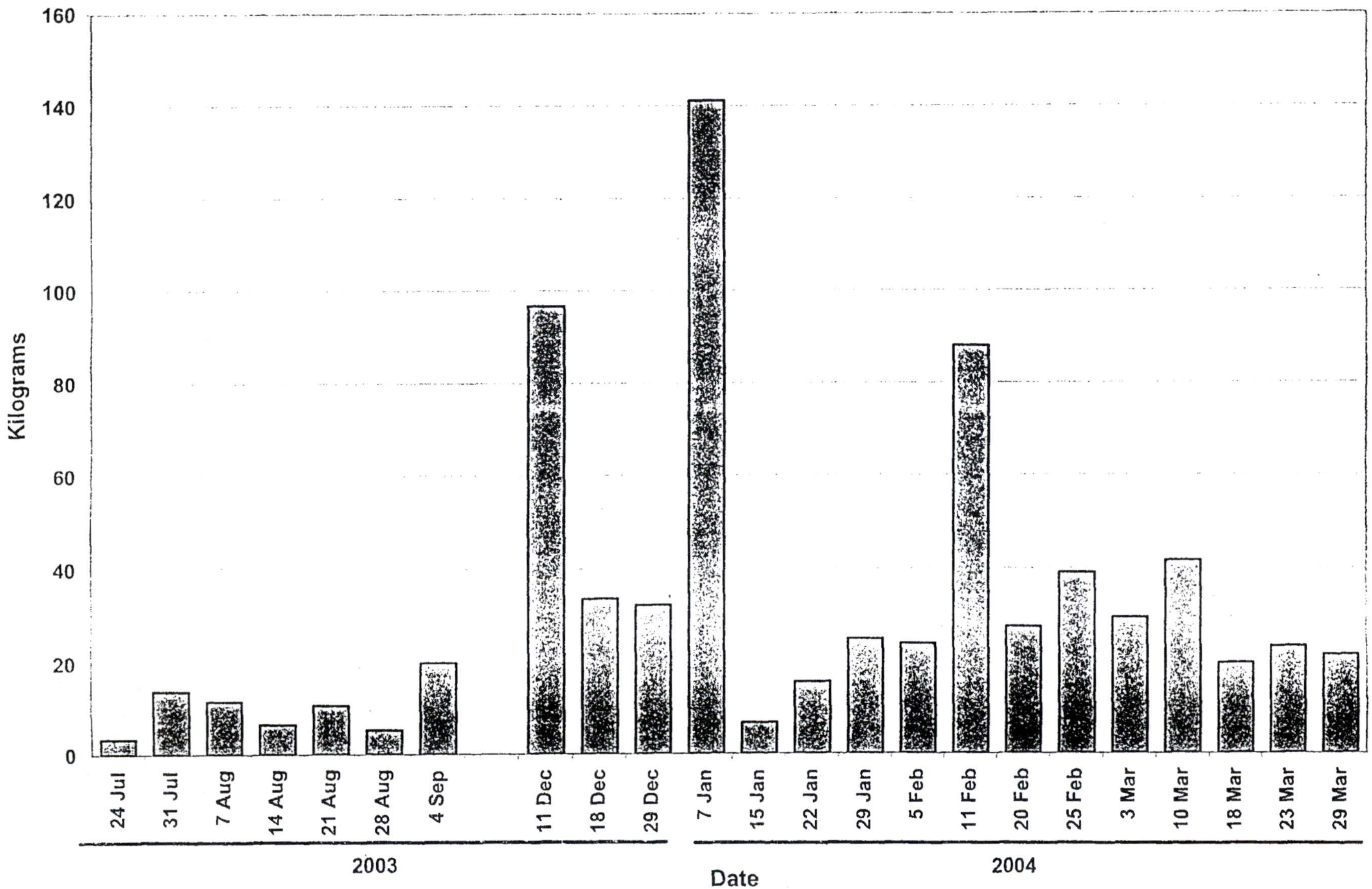

Figure 18. Estimated daily biomass of fish impinged at BFN during 2003 and 2004.

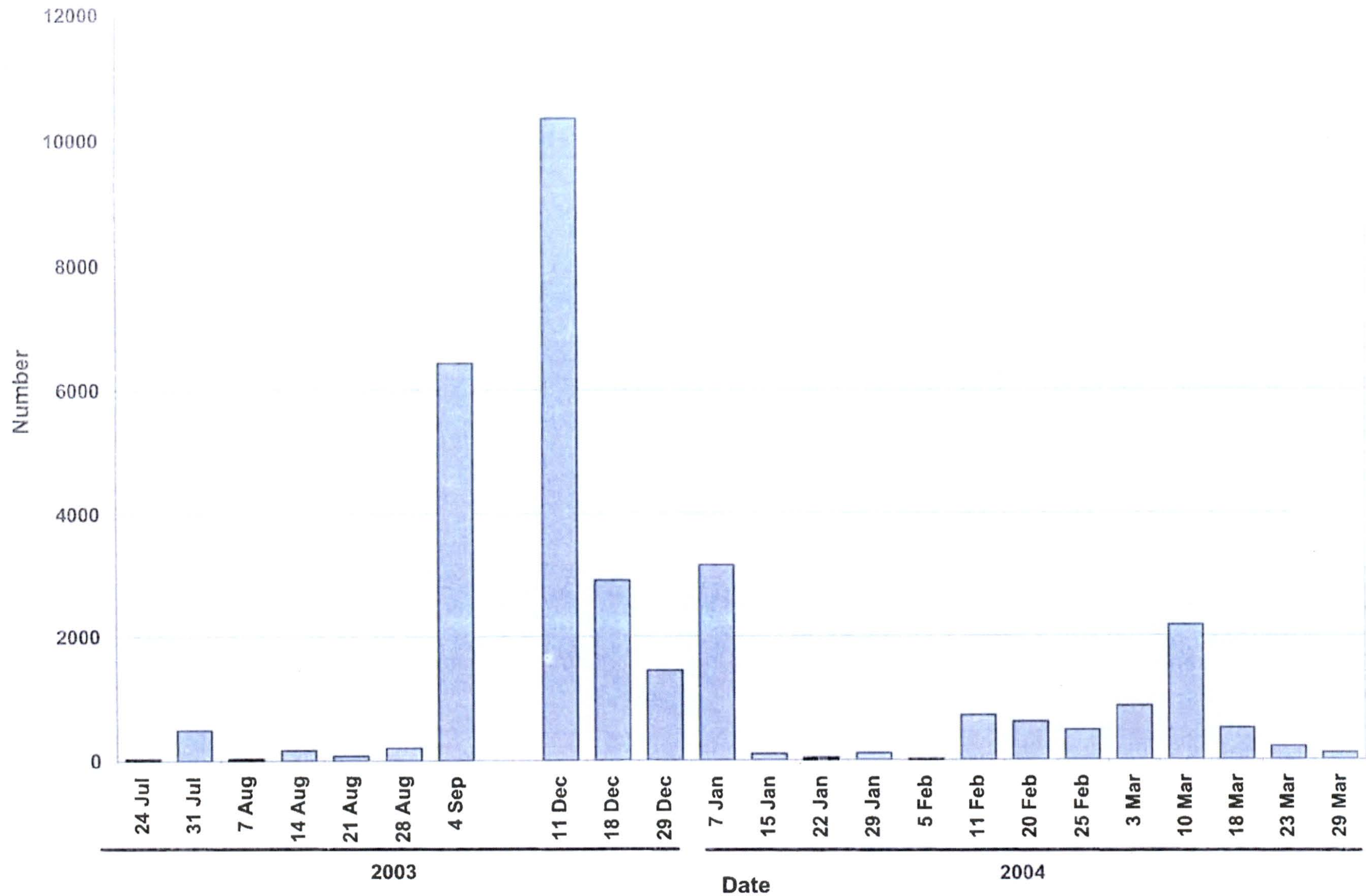

Figure 19. Estimated daily impingement rates of threadfin shad during 2003 and 2004.

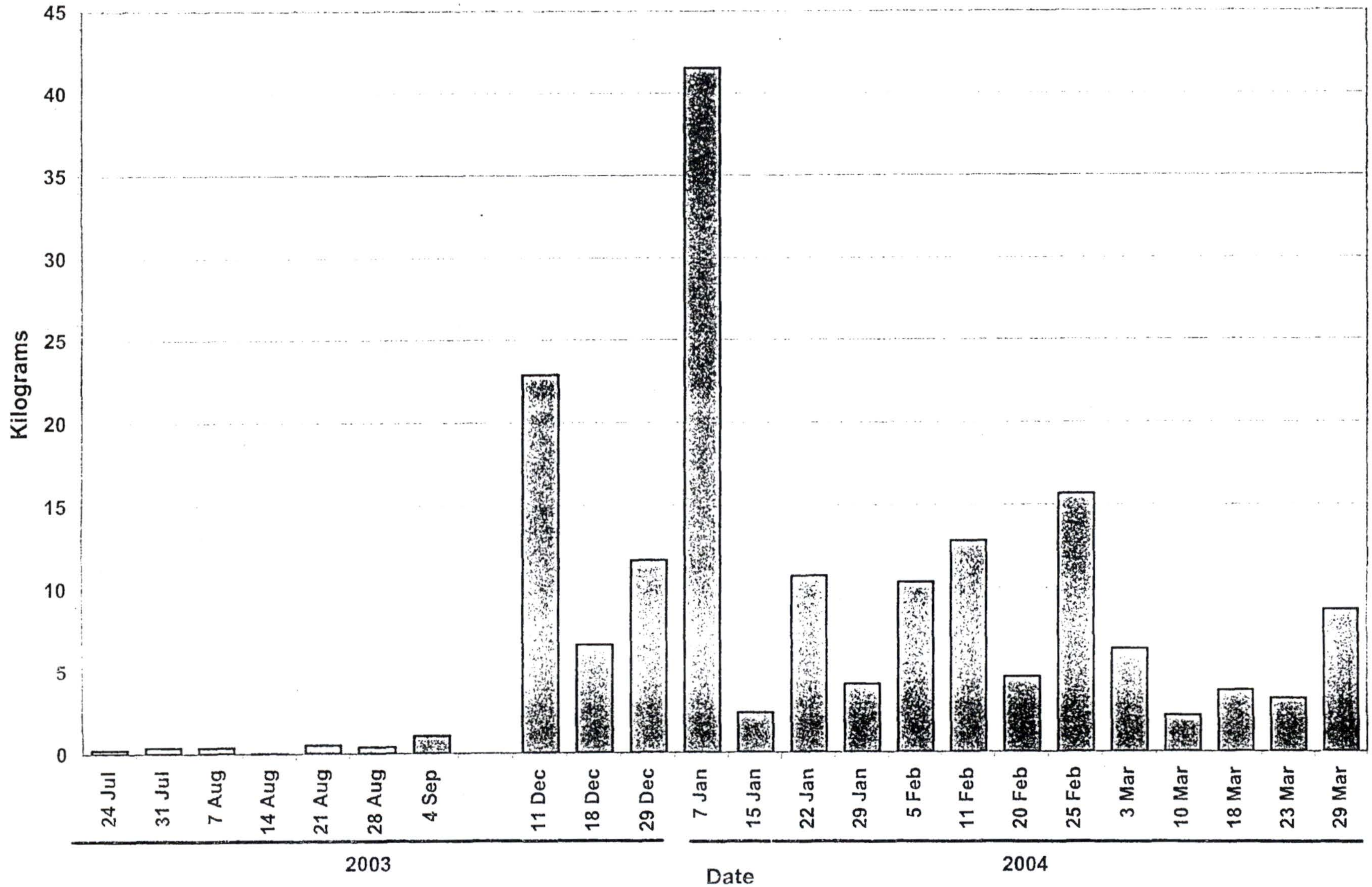

Figure 20. Estimated biomass of gizzard shad impinged during 2003 and 2004.

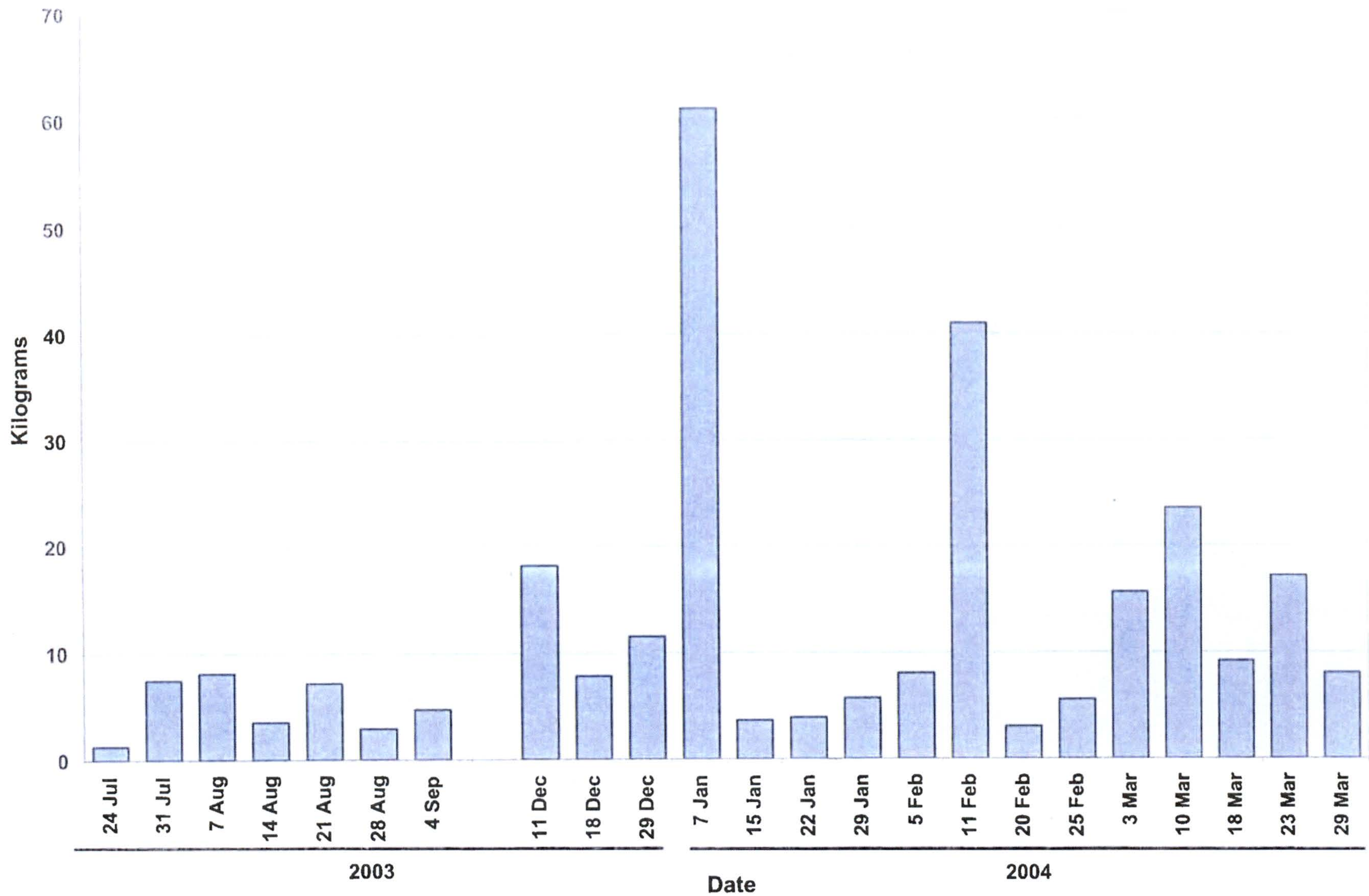

Figure 21. Estimated biomass of freshwater drum impinged during 2003 and 2004.

FISH ENTRAINMENT AT BROWNS FERRY NUCLEAR PLANT, WHEELER RESERVOIR, ALABAMA, FOR THE YEARS 1978 and 1979

March 1980

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INTRODUCTION

Fish eggs and larvae entrained in cooling water may suffer mortality from one or more physical effects of passage through the plant. As a consequence, in conjunction with the construction of Browns Ferry Nuclear Plant (BFNP), TVA investigated the preoperational characteristics and dynamics of the annual ichthyoplankton populations in Wheeler Reservoir (1971-1973) (reported in Chapter 7 in BFNP Preoperational Fisheries Resources Report, TVA 1978a). This investigation was continued through initiation of commercial operation in 1974, and six years of operational monitoring data have been collected. The 1971-1977 data are available in Volume 4: Effects of the Browns Ferry Nuclear Plant Cooling Water Intake on the Fish Populations of Wheeler Reservoir (1978b). This report augments this data base with the results of the 1978 and 1979 investigations and provides a reassessment of the 1977 entrainment estimates.

Specific objectives as presented in the previous description of larval fish entrainment at BFNP (1978b) were:

1. To define the annual patterns and fluctuations in density of the ichthyoplankton community near and/or transported past the plant.
2. To determine the species composition and relative abundance of the various taxa comprising the ichthyoplankton.
3. To define temporal distribution of fish eggs and larvae in order to determine periods of greatest plant entrainment.
4. To describe spatial distribution of ichthyoplankton near the plant in relation to the normal zone of influence of

the cooling water intake and relative vulnerability of the various taxa to entrainment.

5. To estimate numbers and relative abundance of the various taxa entrained during plant operation.

6. To relate periodic densities and relative abundance of ichthyoplankton estimated to be entrained with those occurring in the reservoir in order to determine and assess the impact of this entrainment on the fish community of Wheeler Reservoir.

MATERIALS AND METHODS

Reservoir Sampling

Ichthyoplankton sampling was incorporated in the overall Browns Ferry fisheries monitoring program in 1971. Sampling gear and technique for estimating the abundance of ichthyoplankton were modified in 1978 to better sample deeper strata. Concurrently, the primary transect sampled to measure seasonal transport of ichthyoplankton past BFNP was relocated at TRM 294.5 (Figure 1). The transect at TRM 293.0, referred to as the plant transect, and utilized since 1971, was maintained for comparison with TRM 294.5. Each year samples were collected weekly during both day and night. Sample periods and corresponding dates for each year of full (three-unit) plant operation are listed in Table 1.

Sample gear used in 1978 and 1979 consisted of a square 0.5 m (flow meter equipped) side-towed net (0.505 mm mesh). This net was capable of sampling the water column (except the lowest 0.5 m) in a stair-step, oblique fashion. At a towing speed of 1 m/sec, 10-minute samples filtered approximately 150 m^3 of water. This net replaced the 1 m diameter stern-towed net (0.79 mm mesh) used from 1971-1977 because it increased the effectiveness in sampling more than one or two discrete strata and boat propwash could be avoided.

Transport Estimation Techniques

The method of estimating total numbers of eggs and larvae annually transported past BFNP from 1974-1977 utilized a cross-sectional depth profile of the river at TRM 293. The profile was subdivided into compartments to determine the ratio of overbank ($\leq$ 3 m depth) area to open water (> 3 m depth) area. Compartment weighting factors (0.22-shoreline, 0.78-channel) were multiplied by corresponding larval fish densities

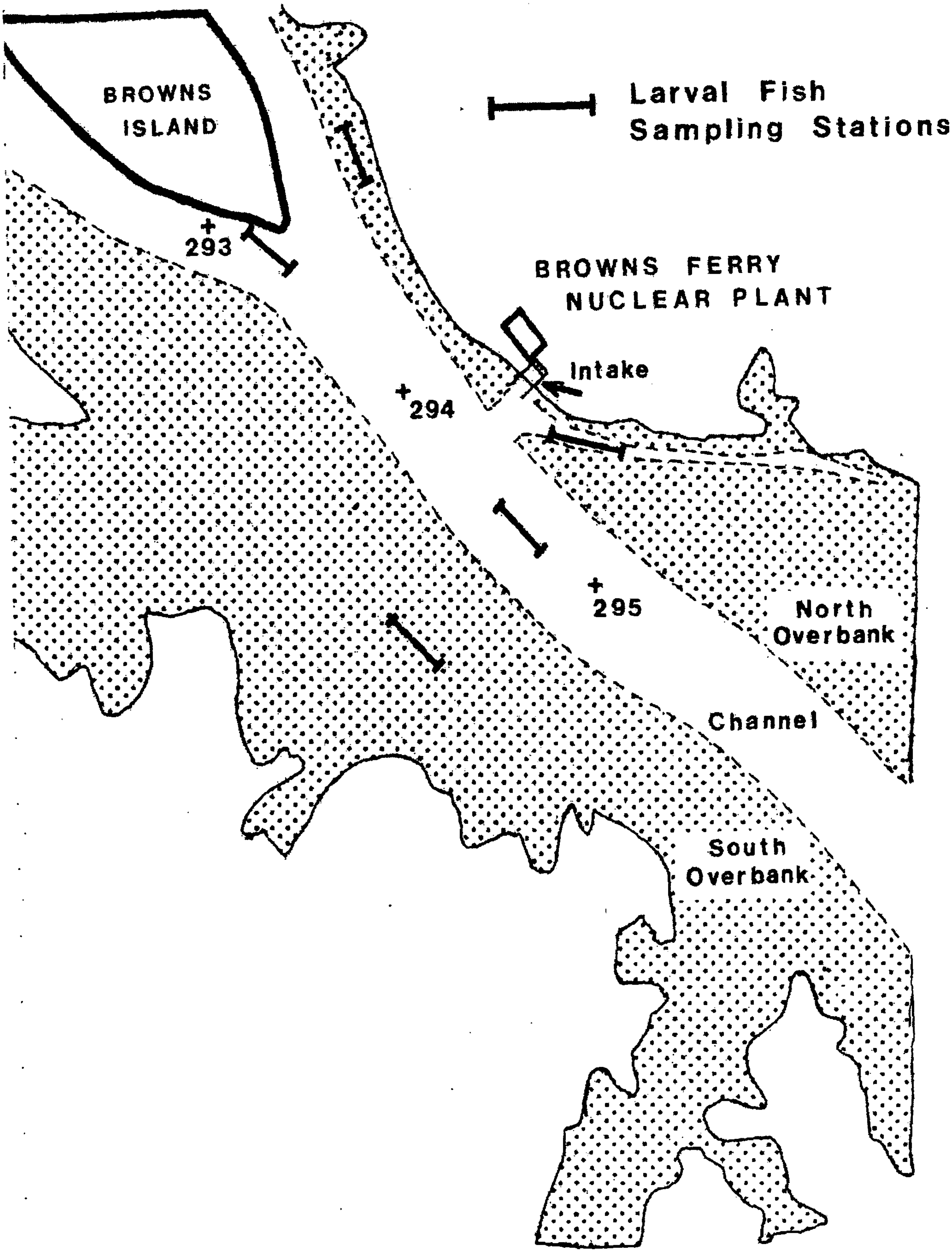

Figure 1: Location of larval fish sample stations (reservoir and intake) at Browns Ferry Nuclear Plant in 1978 and 1979.

Table 1. Larval fish sample dates for reservoir and plant intake stations at Browns Ferry Nuclear Plant during 1977-1979.

Sample Period	Sample Date 1977	1978	1979
1	3-16	3-27	3-13
2	3-23	4-03	3-19
3	3-30	4-10	3-27
4	4-06	4-20	4-02
5	4-13	4-24	4-10
6	4-19	5-01	4-17
7	4-27	5-08	4-26
8	5-04	5-16	4-30
9	5-11	5-22	5-07
10	5-18	5-30	5-14
11	5-26	6-05	5-21
12	6-02	6-12	5-31
13	6-09	6-19	6-04
14	6-15	6-26	6-12
15	6-22	7-03	6-19
16	6-29*	7-10	6-27
17	7-07*	7-17	7-02
18	7-13	7-24	7-10
19	7-20	7-31	7-16
20	7-27	8-07	7-25
21	8-03	8-14	7-30
22	8-10	8-21	8-13
23	8-17	8-28	8-06
24	8-24		8-20
25			8-27

*No intake samples taken

to obtain a weighted mean transect density for each sample period. Data from both channel strata (surface and 5 m) were combined to calculate the weighted density for the channel or open water station.

The initial assumption of uniform water velocities across both main channel and overbank areas was in error according to estimates of flow in the transect compartments at both TRM 293.0 and 294.5 supplied by the TVA Water Systems Development Branch. Velocity measurements on which these estimates are based were taken by the TVA Hydraulic Data Branch on August 1, 1969, at TRM 291.8 and 294.0 when the average river flow was 39,000 cfs. The flows in each transect compartment (TRM 293.0 and 294.5) were calculated by multiplying the average velocity in each sample compartment by its cross-sectional area. Flow volumes were calculated for total overbank area and upper and lower strata of the channel or open water area corresponding to the sections sampled for ichthyoplankton. Figure 2 shows the depth profiles of the two sample transects with the proportionate river flow for each sample compartment. These flow estimates were used as weighting factors to calculate the total number of fish eggs and larvae transported past BFNP during 1978 and 1979. This was an improvement over the previous method which was based on the simple assumption of uniform transect velocity.

Intake Samples

Ichthyoplankton densities in the intake basin at Browns Ferry Nuclear Plant were sampled from 1974-1977 with a 3 x 3 array of 0.5 m diameter (0.79 mm mesh) stationary nets. In accordance with the change to 0.5 m square nets in the reservoir in 1978, intake nets were also changed to 0.5 m square with 0.505 mm mesh; the 3 x 3 array was retained. The three rows of nets were fished at 0.5 m, middepth, and

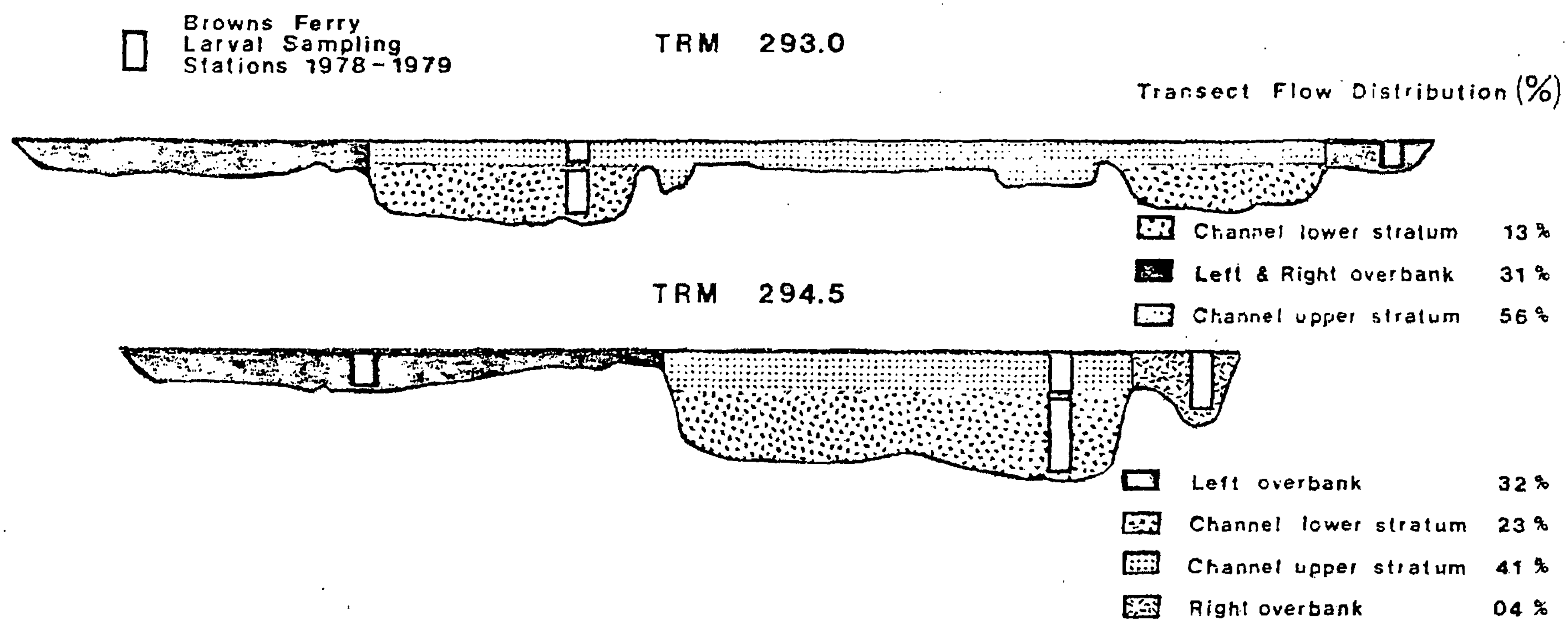

Figure 2: Cross-section profiles of reservoir transects at TRM 293.0 and 294.5 including locations of sample compartments and percentages of river flow calculated for each stratum sampled.

approximately 1 m from the bottom. Nets were fished for two hours except when high intake velocities owing to three-unit operation necessitated reduction in sampling duration to one hour. Flowmeters were mounted in intake nets to estimate the volume of water filtered during each sample.

Analysis of Data

Catch data from both reservoir transects and the intake basin were converted to numbers per 1000 m^3 of water filtered. Weekly densities were thus estimated for each of three strata at the two reservoir transects, as well as in the intake basin.

Calculation of total fish eggs and larvae transported past the plant utilizing the weighting factors for flow in each sample compartment was accomplished as follows:

Observed density x flow weighting factor = weighted density (for each compartment);

Σ weighted densities (all compartments in transect) = transect weighted density (includes day and night samples);

transect weighted density x daily average flow (m^3) past plant = total number transported/24 hours.

Total annual transport can be estimated by determining the area under a graph of numbers transported by sample period.

Transported ichthyoplankton and proportion entrained by the plant by sample period were both estimated in this manner for each family collected, as well as for total eggs and larvae. Individual intake samples were averaged

to provide overall intake densities for each sample period. Plant entrainment rate was estimated by the following equation:

$$\frac{Di}{Dr} \times \frac{Qi}{Qr} \times 100$$

where Di = mean density (No./1,000 m^3) of eggs or larvae in intake samples;
Dr = weighted mean density (No./1,000 m^3) of eggs or larvae in the reservoir (transect);
Qi = intake water demand (m^3/day);
Qr = reservoir flow (m^3/day).

Reservoir flows past the plant for each sample period were estimated based on the upstream and downstream hydroelectric releases and tributary inflow (provided by TVA Hydraulic Data Branch). Intake water demand was calculated from known rating (833 m^3/minute each) of condenser circulating pumps. The number of pumps operating during each sample period was recorded. Table 2 lists 24-hour reservoir (Qr) and intake (Qi) flows ($m^3 \times 10^6$) and proportion hydraulic plant entrainment (Qi/Qr) for 1977-1979 by sample period.

Table 2. Reservoir (Q_r) and intake (Q_i) flows ($m^3 \times 10^6$) at Browns Ferry Nuclear Plant, 1977-1979. Flows are 24-hour totals. (Q_i/Q_r) = proportion hydraulic entrainment.

Sampling Period	1977			1978			1979		
	Q_r	Q_i	Q_i/Q_r	Q_r	Q_i	Q_i/Q_r	Q_r	Q_i	Q_i/Q_r
1	296.06	7.19	0.024	86.12	7.19	0.083	303.37	10.79	0.035
2	95.91	8.39	0.087	64.10	7.19	0.112	139.21	10.79	0.077
3	87.10	10.79	0.123	64.59	7.19	0.111	128.44	10.79	0.084
4	511.88	10.79	0.021	39.15	7.19	0.184	111.56	10.79	0.096
5	189.87	9.59	0.050	45.51	7.19	0.158	100.30	10.79	0.107
6	119.65	8.39	0.070	60.92	7.19	0.118	224.84	10.79	0.047
7	118.76	9.59	0.081	143.37	7.19	0.050	92.48	10.79	0.116
8	98.85	9.59	0.097	103.49	9.59	0.093	98.84	9.59	0.097
9	95.91	10.79	0.112	77.80	7.19	0.092	79.51	9.59	0.120
10	77.56	10.79	0.139	47.95	9.59	0.200	80.73	9.59	0.118
11	82.54	10.79	0.130	57.25	8.99	0.157	75.35	7.19	0.095
12	76.83	10.79	0.140	100.80	9.59	0.095	179.08	9.59	0.053
13	73.65	10.79	0.146	56.52	8.99	0.159	213.09	10.79	0.050
14	92.98	9.59	0.103	76.09	8.39	0.110	106.91	10.79	0.100
15	88.08	7.19	0.081	92.97	8.39	0.090	83.67	10.79	0.128
16	66.06	-[1]	-	70.46	8.39	0.119	83.18	10.79	0.129
17	78.05	-[1]	-	63.37	8.39	0.132	85.87	10.79	0.125
18	60.68	7.19	0.118	96.40	8.39	0.087	87.09	10.79	0.123
19	70.71	9.59	0.135	33.52	8.39	0.250	108.38	10.79	0.099
20	73.40	9.59	0.130	43.67	8.39	0.192	221.65	10.79	0.048
21	48.93	10.79	0.220	59.33	8.39	0.141	185.69	10.79	0.058
22	48.44	9.59	0.197	57.98	8.39	0.145	117.43	10.79	0.091
23	62.39	9.59	0.153	50.89	9.59	0.188	110.82	10.79	0.097
24	39.15	10.79	0.275				94.92	9.59	0.101
25							119.39	7.79	0.065
Mean Seasonal hyd. ent.			0.12			0.133			0.09

1. Data are not available due to plant operational characteristics.

RESULTS

Seasonal occurrence and relative abundance of major taxa of fish eggs and larvae collected in 1978 and 1979 were determined for the reservoir transects (TRM 293.0 and 294.5) and intake basin. Temporal distribution of larval populations in relation to seasonal transport and entrainment was also determined. Because this report serves to update the results of larval entrainment at Browns Ferry from 1974-1977 (TVA 1978b), results were compared with those reported for 1977, the first year of full (three-unit) plant operation. In addition to use for estimating egg and larval entrainment in 1978 and 1979, the modified weighting factors (based on flow) for TRM 293.0 were applied to the 1977 data, and the results compared to the earlier estimate.

Occurrence and Relative Abundance of Eggs and Larvae

Eggs

1978

Planktonic fish eggs were most abundant at TRM 293.0 in 1978 (Appendix B1) and were virtually all sciaenid (drum) eggs (Appendix A1). Highest densities of eggs at all three transects (Appendix B1) occurred on May 22. This was similar to the period of greatest egg density ($3,500/1,000\ m^3$) in 1977, which was May 18 (TVA 1978b).

1979

Egg densities in 1979 were again greater (7 times) at TRM 293.0 than at TRM 294.5. The peak density in 1979 ($5,500/1,000\ m^3$) was similar to the peak in 1978, ($6,500/1,000\ m^3$) but occurred four weeks later on

June 19 (Appendix B2). Greatest densities observed at both TRM 294.5 and in the intake basin were approximately 700/1,000 m^3 on May 21 and June 12, respectively.

Larvae

1978

Larval fish from 14 families were collected in 1978 (Appendix A1); two of these (Lepisostiidae and Poeciliidae) had not been collected in earlier years. Five families were represented by only one specimen each (Appendix A1). As in previous years, the family Clupeidae was the most abundant, composing a high of 95.5 percent of all larvae collected at TRM 294.5 and a low of 93.8 percent at the TRM 293.0 transect (Appendix A1). Intake samples contained 94.7 percent clupeids. Percichthyidae and Centrarchidae were second and third in abundance at the reservoir transects.

Temporal distributions of total larval fish by transect for each sample period during 1978 and 1979 are shown in Appendix B. Larval densities in the reservoir and intake were highest during the month of May (Appendix B3). The greatest density (36,400/1,000 m^3) was observed at TRM 294.5 on May 22. Larval density in the plant intake was highest (16,800/1,000 m^3) a week earlier (May 16). Downstream, at TRM 293.0, a peak larval density of 17,700/1,000 m^3 was recorded on May 30. Appendix C contains densities by sample period and transect for the major families of larval fish collected in 1978 and 1979.

1979

Twelve families of fish larvae were collected in the 1979 samples, including one family (one specimen) Petromyzontidae (lampreys), not

previously observed in BFNP larval samples. Relative abundance of clupeids was lower at all transects than in previous years, ranging from 87.8 percent in the intake to 91.7 percent at TRM 294.5 (Appendix A2). Percichthyids (white and yellow bass) and sciaenids (drum) were second and third in abundance, respectively, and each composed from two to four percent of the catch at all three transects.

As observed in 1978, greatest larval densities occurred during May (Appendix B4). Intake larval densities were highest on May 7 and 14 at 3,100/1,000 m^3. Reservoir densities of 10,100 and 7,700/1,000 m^3 were observed at TRM 294.5 (May 14) and TRM 293.0 (May 7), respectively.

Entrainment

Eggs

1977

The previous (TVA 1978b) estimate for entrainment of fish eggs by BFNP was 2.3 percent. This estimate (as described in methods section) was derived by weighting egg densities by only the cross-sectional area in each compartment sampled. Application of the weighting factors based on volume flow in each compartment (Figure 2) to the 1977 data resulted in an increase in estimated egg entrainment to 2.7 percent. This resulted from a lower estimate (4.76×10^9) of transported eggs than was estimated by the previous method (6.44×10^9). Table 3 shows egg and larval entrainment by year (1977-1979) both by family and for total eggs and larvae. For 1977, the previous entrainment estimates (TVA 1978b) are given in parentheses for comparison with current estimates.

Table 3. Annual entrainment (percent) of fish eggs and larvae by family at Browns Ferry Nuclear Plant from 1977-1979.

Family	Estimated Entrainment (percent)		
	1977*	1978**	1979**
Unidentifiable eggs	0.7 (0.3)	5.9	114.9†
Clupeidae eggs	I	NC	NC
Sciaenidae eggs	2.7 (2.3)	3.6	8.0
Unidentifiable eggs	12.1 (10.3)	5.9	5.5
Petromyzontidae	NC	NC	I
Lepisosteidae	NC	I	NC
Clupeidae	9.1 (12.1)	5.3	4.3
Hiodontidae	1.2 (1.2)	2.1	4.5
Cyprinidae	2.9 (4.8)	2.3	7.8
Catostomidae	4.1 (4.5)	19.2	3.1
Ictaluridae	31.5 (29.0)	16.4	6.4
Cyprinodontidae	NC	I	25.9
Poeciliidae	NC	I	NC
Percichthyidae	11.8 (15.6)	14.7	5.3
Centrarchidae	3.5 (4.8)	2.2	3.6
Percidae	12.7 (14.6)	14.7	13.8
Sciaenidae	6.3 (6.1)	4.4	8.5
Atherinidae	R	R	I
Total eggs	2.7 (2.3)	3.6	8.1
Total fish	9.0 (11.7)	5.4	4.5
Mean hydraulic entrainment (see Table 2)	12.0	13.3	9.0

*Based on densities and weighting factors from TRM 293.0 - values in parentheses are previous entrainment estimates weighted by cross-sectional area only.

**Based on densities and weighting factors from TRM 294.5.

†Seventy-six specimens collected in intake basin, six collected in reservoir sampling; thus high entrainment estimate.

I - Collected in intake samples but not in reservoir (TRM 293.0-1977; TRM 294.5-1978-1979) samples, entrainment estimate not possible.

R - Collected in reservoir samples but not in intake samples, entrainment estimates effectively zero.

NC - None collected in either reservoir or intake samples.

Mean hydraulic entrainment (percent of river flow entrained by the plant) is shown in Table 3 and was calculated by averaging the 24-hour hydraulic entrainment estimates from recorded plant-intake volumes during each sample period. During the period of March 16-August 24, 1977, 12 percent of the flow past BFNP was entrained. This was an increase of 3.6 percent over hydraulic entrainment in 1976 (TVA 1978b) due to initial three-unit plant operation in 1977.

1978

Samples from the transect at TRM 294.5 in 1978 contained lower densities of fish eggs than observed at TRM 293.0 (Appendix B1). Calculated total eggs transported (using densities from TRM 294.5) in 1978 were 1.37×10^9. Estimated entrainment of fish eggs was 5.00×10^7, yielding an entrainment estimate of 3.6 percent (Table 3). Mean hydraulic entrainment in 1978 was 13.3 percent, again higher than the previous year.

1979

Due to increased river flow in 1979 (Table 2), mean hydraulic entrainment was 9.0 percent, a decrease of 4.3 percent from 1978. Total egg transport for 1979 was 2.30×10^9; total egg entrainment by the plant was 1.88×10^8, resulting in an entrainment estimate of 8.1 percent.

Larvae

1977

Total larval entrainment for 1977, based on cross-sectional transect weighting factors was estimated to be 11.7 percent (TVA 1978b). Utilizing the same densities from the plant transect (TRM 293.0), the

weighting factors based on flow were applied, and the refined estimate for larval entrainment in 1977 was 9.0 percent (Table 3). Entrainment of the most abundant family, Clupeidae, decreased from 12.1 to 9.4 percent using this method. Conversely, entrainment of Ictaluridae increased from 29.0 to 32.9 percent. Estimates for Percichthyidae and Percidae decreased from 15.6 and 14.6 to 11.7 and 12.6 percent, respectively (Table 3). Entrainment of drum larvae (Sciaenidae) increased from 6.1 to 6.6 percent based on the refined estimates weighted by compartmental volumes.

1978

In 1978, an estimated 5.35×10^{10} fish larvae were transported past the plant with 2.92×10^{9} of these entrained, yielding an annual estimated entrainment of 5.4 percent (Table 3). Again, total entrainment paralleled that of the dominant clupeids (5.3 percent). The two families with the highest estimated entrainment were Catostomidae and Ictaluridae at 19.2 and 16.5 percent, respectively. Two other families, Percichthyidae and Percidae, were estimated to be entrained at rates of 14.8 and 14.5 percent, respectively.

1979

Total larval transport in 1979 was estimated to be 2.97×10^{10}, lower than for either of the two previous years. Larval entrainment in 1979 was estimated to be 1.34×10^{9}, less than one-half the estimated numbers entrained in 1978. Entrainment for total fish larvae transported in 1979 was estimated to be 4.5 percent. Entrainment of clupeids was 4.4 percent. Cyprinodontidae (topminnow) showed the highest entrainment rate (26.0 percent), but this was based on only two specimens (one each

from TRM 294.5 and the intake). Percidae, at 13.9 percent, was the only other family with estimated entrainment greater than 10 percent. Larval drum (Sciaenidae) at 8.6 percent, ranked highest of the remaining families (Table 3).

DISCUSSION

Hydraulic entrainment at BFNP during ichthyoplankton sample periods for the first three years of three-unit operation, has been 12.0, 13.3, and 9.0 percent for 1977, 1978, and 1979, respectively (Table 3). Entrainment estimates for fish eggs and larvae prior to 1978 were derived from reservoir density measurements immediately downstream of the plant at TRM 293.0 (Figure 1). Beginning in 1978, ichthyoplankton transport was calculated from samples collected at TRM 294.5, immediately upstream of the BFNP intake. This transect should more accurately depict egg and larval populations subjected to entrainment. The addition of the sampling station on the south overbank or left shoreline (Figure 1) at TRM 294.5 should further improve estimates of ichthyoplankton transported past the plant.

The availability of velocity profile data from both transects (Figure 2) has rectified the overly simplistic assumption of uniform velocities in both the channel and overbank areas. The horizontal and vertical compartments of the transect were found to have varying water velocities (Figure 2), which required a new estimate for transported eggs and larvae. The refined weighting factors derived from this data resulted in an estimated increase of 0.4 percent for entrainment of fish eggs in 1977; estimated larval entrainment, however, decreased 2.7 percent (Table 3). These variations are due to nonuniform distribution of eggs and larvae between overbank and channel as well as between the upper and lower strata of the channel.

Entrainment estimates of 3.6 and 8.1 percent for fish eggs in 1978 and 1979 respectively, represent a progressive increase over the estimate for 1977. This increase is attributed to the observed difference in abundance of (drum) eggs between the two reservoir transects (Appendix A1 and A2). Densities more than an order of magnitude lower at TRM 294.5 than at TRM 293.0 (Appendix B1 and B2) resulted in a significantly lower estimate of numbers transported and, thus, a greater proportion entrained. It appears that in 1978 and 1979, intensive spawning by drum occurred adjacent to or immediately below BFNP. Since large numbers of drum eggs appear to be spawned below the plant, it is concluded that estimated entrainment of 8.1 percent of eggs (highest of three years discussed) transported past BFNP in 1979 is not a significant adverse impact to the Wheeler Reservoir fish community. In support of this hypothesis, if 1978 data from the TRM 293.0 transect are employed to estimate egg entrainment, only 0.5 percent of the total transported eggs are estimated to be entrained.

Entrainment of fish larvae, unlike that observed for eggs, showed a decreasing trend for the three years of full (three-unit) operation at BFNP. Even though the highest hydraulic entrainment (13.3 percent) occurred in 1978, larval entrainment (5.4 percent) showed a decrease of 60 percent from the highest observed entrainment of 9.0 percent (in 1977). For comparison, since entrainment was estimated from a different transect (TRM 294.5) beginning in 1978, data from TRM 293.0 analyzed by the same method yielded an estimate of 6.1 percent entrainment for transported fish larvae. In 1979, hydraulic entrainment (9.0 percent) as well as larval entrainment (4.5 percent) decreased from levels observed in 1978.

The four families with estimated entrainment of greater than 10 percent in 1978 all had lower entrainment estimates in 1979 (Table 3). Among the four, only Percidae (logperch and sauger) continued to be

entrained at greater than 10 (13.8) percent. Percids frequently were collected in greater densities in the BFNP intake than at either of the two reservoir transects (Appendix C 13 and 14), which accounts for entrainment estimates ranging from 12.7 to 14.7 percent during 1977-1979. These data suggest that some percid spawning (probably logperch) may be occurring in or near the intake basin. Ictalurids (catfishes) were similarly collected in the intake in densities often greater than those observed in the reservoir and are also suspected to spawn in the basin. Catostomids (buffalo and suckers) were estimated to be entrained at rates (Table 3) lower than those for total larvae in 1977 (4.1 vs 9.0) and 1979 (3.1 vs 4.5). In 1978, estimated entrainment of catostomids was a surprising 19.2 percent. However, on April 20 when catostomids were at peak density (Appendix C5) in both intake and reservoir samples, hydraulic entrainment by BFNP was 18.4 percent. Percichthyid (white and yellow bass) entrainment in 1977 (11.8 percent) and 1978 (14.7 percent) closely paralleled hydraulic entrainment (Table 3), but was considerably lower (5.3 percent) in 1979. Percichthyids are the only family of the four discussed above which consistently compose greater than 1 percent of total larvae collected in BFNP larval samples. In 1978 and 1979, percichthyids ranked second only to clupeids in relative abundance at all transects and comprised a larger percentage of larvae collected in intake samples (1977-1979) than at either reservoir transect (Appendix A).

SUMMARY

In summary, entrainment estimates for total fish larvae in 1978 (5.4 percent) and 1979 (4.5 percent) were considerably lower than those calculated for 1977 (9.0 percent), the initial year of full plant operation. Sampling procedures and weighting factors for estimating numbers of fish eggs and larvae transported past the plant have both improved since the earlier report on entrainment at BFNP (TVA 1978b). Samples from the transect added at TRM 294.5 should more accurately reflect those eggs and larvae most susceptible to plant entrainment.

Since ichthyoplankton in Wheeler Reservoir are produced above and below BFNP, it can be concluded that estimated plant entrainment, as given here, would not add significantly to expected natural mortality of fish eggs and larvae in the reservoir.

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________________________. 1978b. Effects of the Browns Ferry Nuclear Plant Cooling Water Intake, on the Fish Populations of Wheeler Reservoir. Norris, Tennessee: Division of Forestry, Fisheries, and Wildlife Development. 1978. (Biological Effects of Intake Browns Ferry Nuclear Plant; Volume 4.)

APPENDIX A

TOTAL NUMBERS COLLECTED AND RELATIVE ABUNDANCE OF FISH/EGGS AND LARVAE BY FAMILY AND TRANSECT IN 1978 AND 1979

Key to common names of families

Family Name	Common Name*
Petromyzontidae	lampreys
Polyodontidae	paddlefish
Lepisosteidae	gar
Clupeidae	shad and skipjack
Hiodontidae	mooneye
Cyprinidae	minnows and carp
Catostomidae	buffalo and suckers
Ictaluridae	catfishes
Cyprinodontidae	topminnows
Poeciliidae	mosquito fish
Percichthyidae	white and yellow bass
Centrarchidae	crappie and sunfishes
Percidae	sauger and logperch
Sciaenidae	freshwater drum
Atherinidae	brook silversides

*Most common taxa of family occurring in Wheeler Reservoir fish larvae samples.

A1. Total number and relative abundance (percent) of fish eggs and larvae collected at Browns Ferry Nuclear Plant in 1978.

Fish Eggs and Larvae	TRM 294.5		Intake Basin		Plant Transect (TRM 293)	
	Total Collected	Relative Abundance	Total Collected	Relative Abundance	Total Collected	Relative Abundance
Sciaenid eggs (drum)	2,601	92.93	4,087	98.55	18,658	99.97
Unidentifiable fish eggs	198	7.07	60	1.45	5	0.03
Family						
Clupeidae	155,702	95.52	213,043	94.70	83,894	93.76
Percichthyidae	2,404	1.47	6,581	2.93	2,527	2.82
Centrarchidae	2,192	1.34	1,283	0.57	1,070	1.20
Sciaenidae	1,191	0.73	2,147	0.95	865	0.97
Catostomidae	746	0.46	1,152	0.51	662	0.74
Cyprinidae	564	0.35	249	0.11	366	0.41
Percidae	117	0.07	289	0.13	62	0.07
Unidentifiable fish larvae	67	0.04	167	0.07	13	0.01
Ictaluridae	12	0.01	56	0.02	18	0.02
Hiodontidae	3	<0.01	3	<0.01	4	<0.01
Atherinidae	1	<0.01	0	0.00	0	0.00
Lepisosteidae	0	0.00	1	<0.01	0	0.00
Cyprinodontidae	0	0.00	1	<0.01	0	0.00
Poeciliidae	0	0.00	1	<0.01	0	0.00
Polyodontidae	0	0.00	0	0.00	1	<0.01

A2. Total number and relative abundance (percent) of fish eggs and larvae collected at Browns Ferry Nuclear Plant in 1979.

Fish Eggs and Larvae	TRM 294.5		Intake Basin		Plant Transect (TRM 293)	
	Total Collected	Relative Abundance	Total Collected	Relative Abundance	Total Collected	Relative Abundance
Sciaenid Eggs (drum)	2,883	99.93	9,589	99.21	12,128	99.97
Unidentifiable fish eggs	2	0.07	76	0.79	4	0.03
Family						
Clupeidae	46,068	91.70	62,206	87.76	37,828	90.39
Percichthyidae	1,721	3.43	3,022	4.26	1,560	3.73
Sciaenidae	963	1.92	2,823	3.98	981	2.34
Cyprinidae	468	0.93	1,160	1.64	818	1.95
Catostomidae	525	1.04	864	1.22	340	0.81
Centrarchidae	303	0.60	396	0.56	167	0.40
Percidae	104	0.21	255	0.36	63	0.15
Unidentifiable fish larvae	63	0.13	84	0.12	66	0.16
Ictaluridae	16	0.03	54	0.08	19	0.05
Hiodontidae	8	0.02	11	0.02	9	0.02
Petromyzontidae	0	0.00	1	0.00	0	0.00
Cyprinodontidae	1	0.00	1	0.00	0	0.00
Atherinidae	0	0.00	1	0.00	0	0.00

APPENDIX B

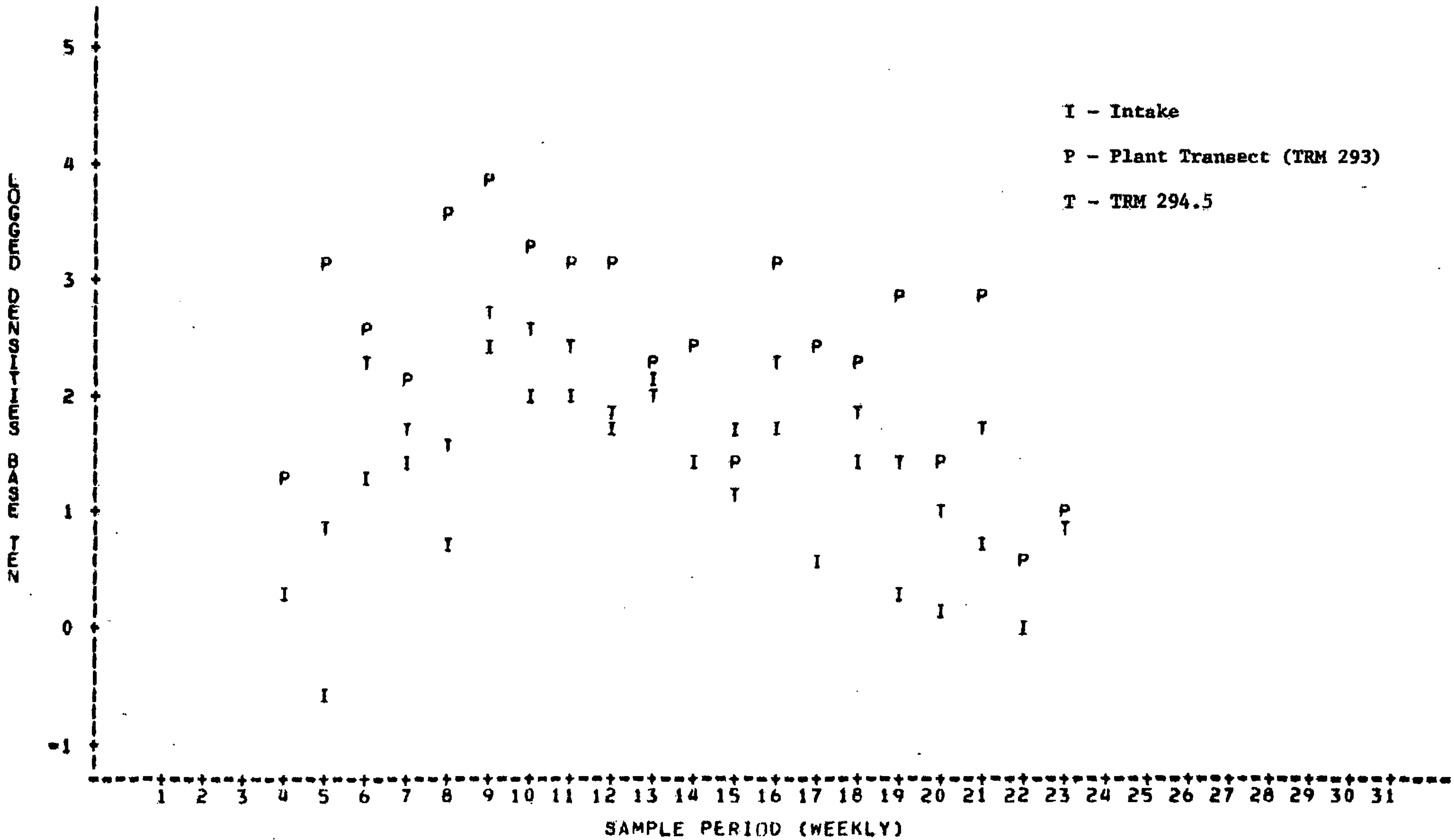
TEMPORAL DISTRIBUTION OF EGGS AND LARVAE
BY TRANSECT IN 1978 AND 1979

Ordinate values are given in logarithms, i.e.,
0 = 1, +1 = 10, etc.

<u>OBS HIDDEN</u> - indicates values plotted on top of another by computer due to approximate densities at two or three transects

B1. DENSITIES OF LARVAL FISHES COLLECTED IN
LARVAL FISH MONITORING AT BROWNS FERRY NUCLEAR PLANT, 1978
TAXATYPE=FISH EGGS YEAR=1978

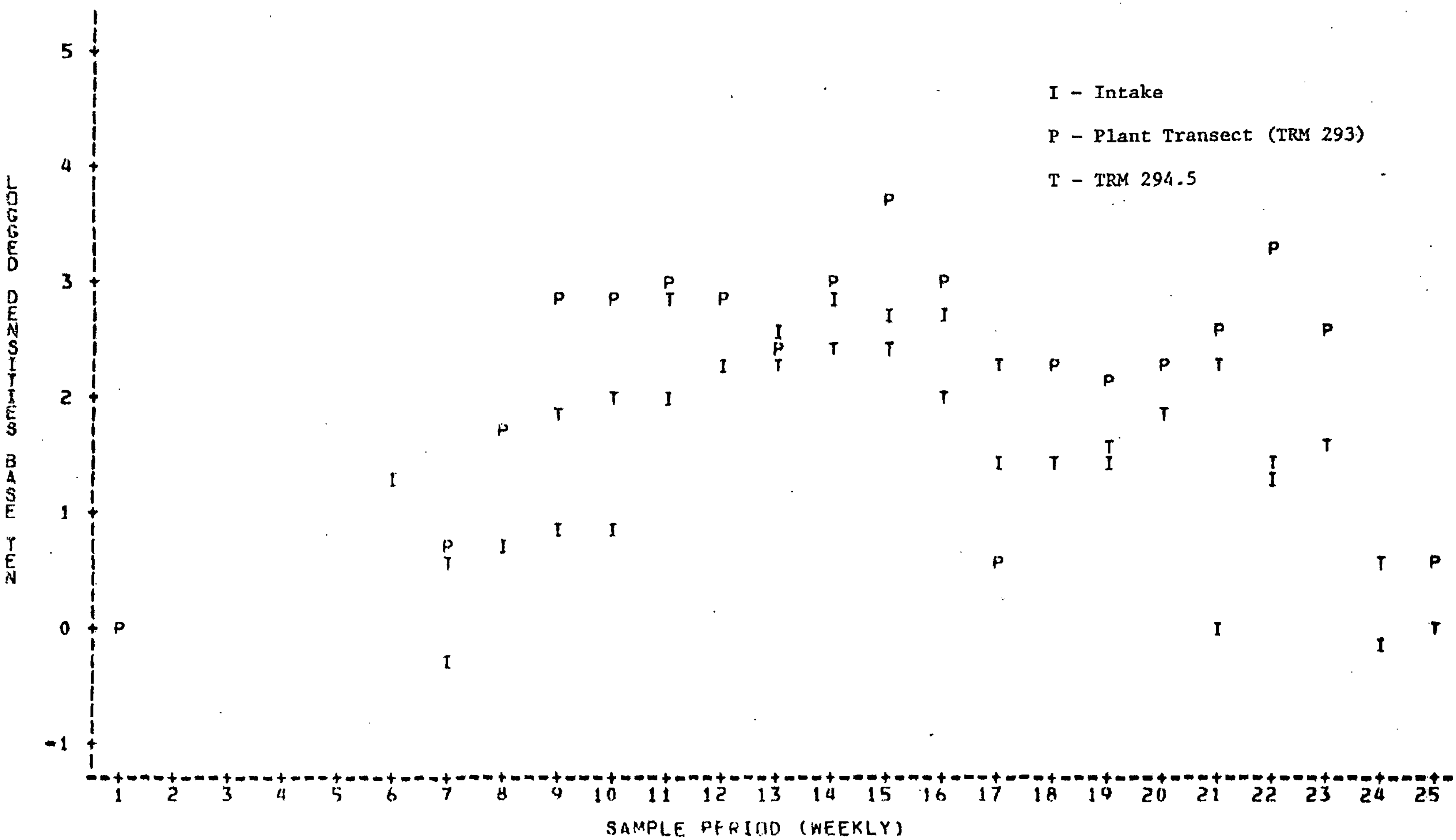
PLOT OF LOGDEN*PERIOD SYMBOL IS VALUE OF TRANSECT



NOTE: 3 OBS HIDDEN

B2. DENSITIES OF LARVAL FISHES COLLECTED IN
LARVAL FISH MONITORING AT BROWNS FERRY NUCLEAR PLANT, 1979
TAXATYPE=FISH EGGS YEAR=1979

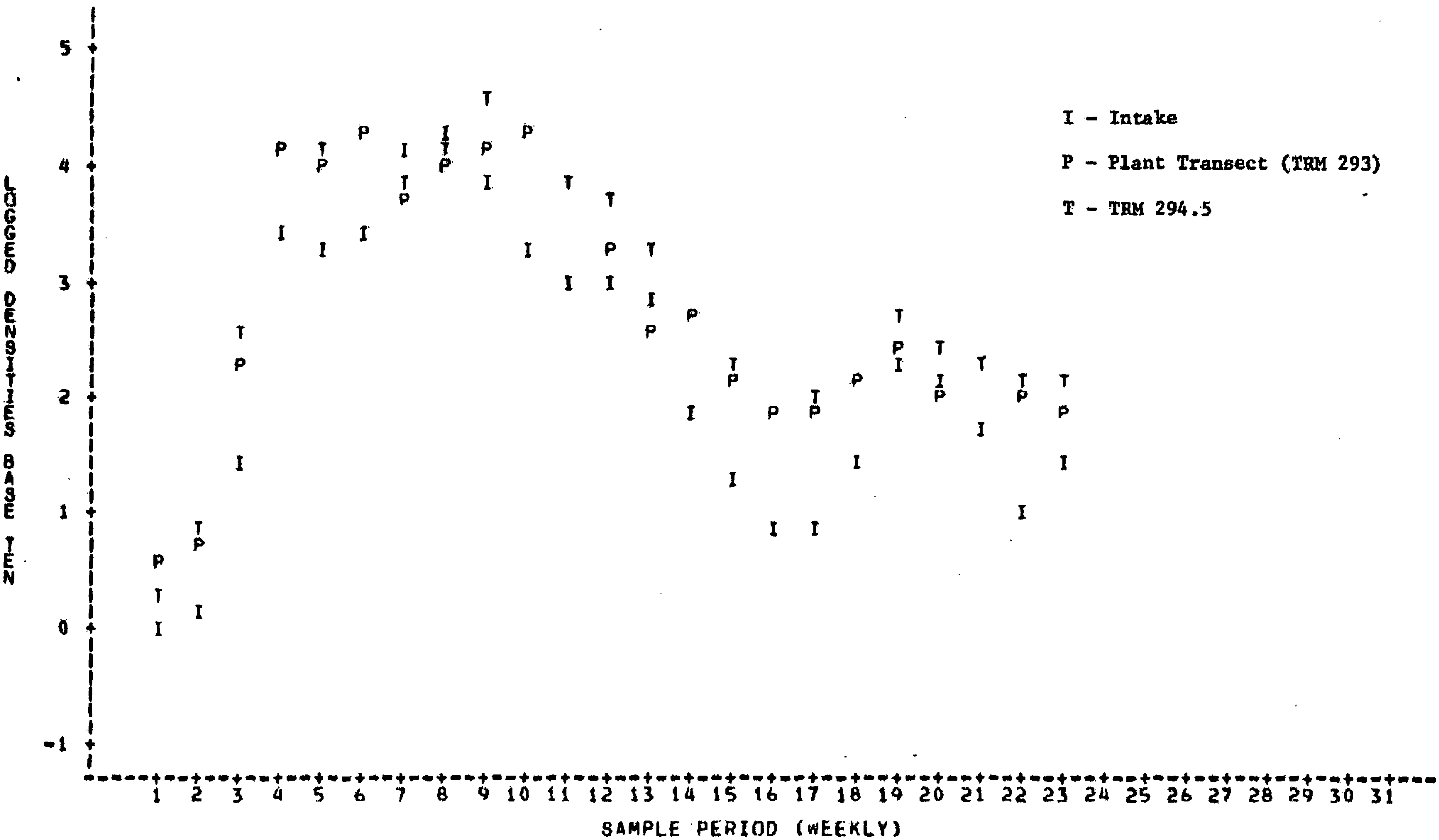
PLOT OF LOGDEN*PERIOD SYMBOL IS VALUE OF TRANSECT



NOTE: 2 OBS HIDDEN

B3. DENSITIES OF LARVAL FISHES COLLECTED IN
LARVAL FISH MONITORING AT BROWNS FERRY NUCLEAR PLANT, 1978
TAXATYPE=FISH LARVAE YEAR=1978

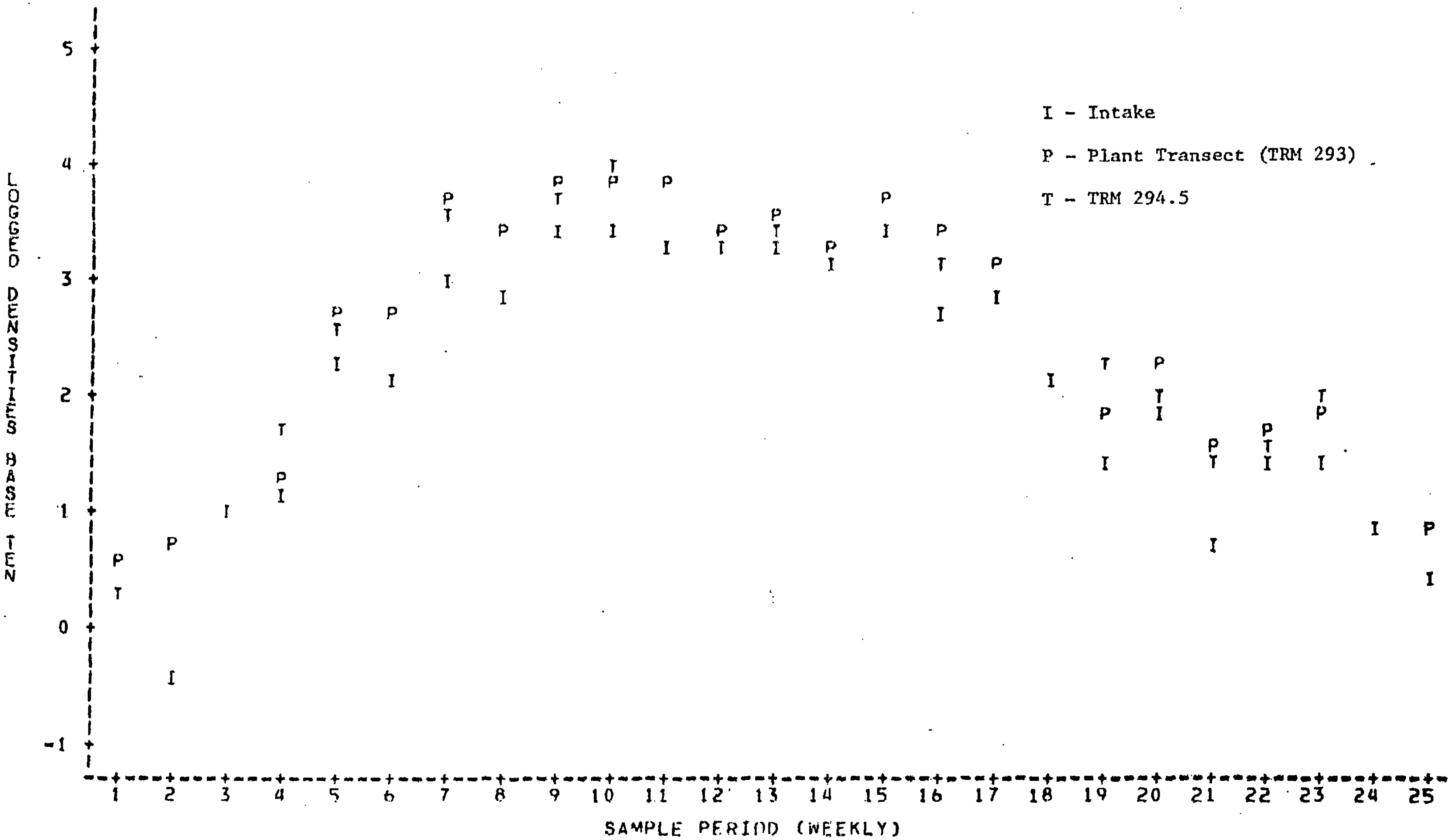
PLOT OF LOGDEN*PERIOD SYMBOL IS VALUE OF TRANSECT



NOTE: 8 OBS HIDDEN

B4. DENSITIES OF LARVAL FISHES COLLECTED IN
LARVAL FISH MONITORING AT BROWNS FERRY NUCLEAR PLANT, 1979
TAXATYPE=FISH LARVAE YEAR=1979

PLOT OF LOGDEN*PERIOD SYMBOL IS VALUE OF TRANSECT



NOTE: 15 OBS HIDDEN

APPENDIX C

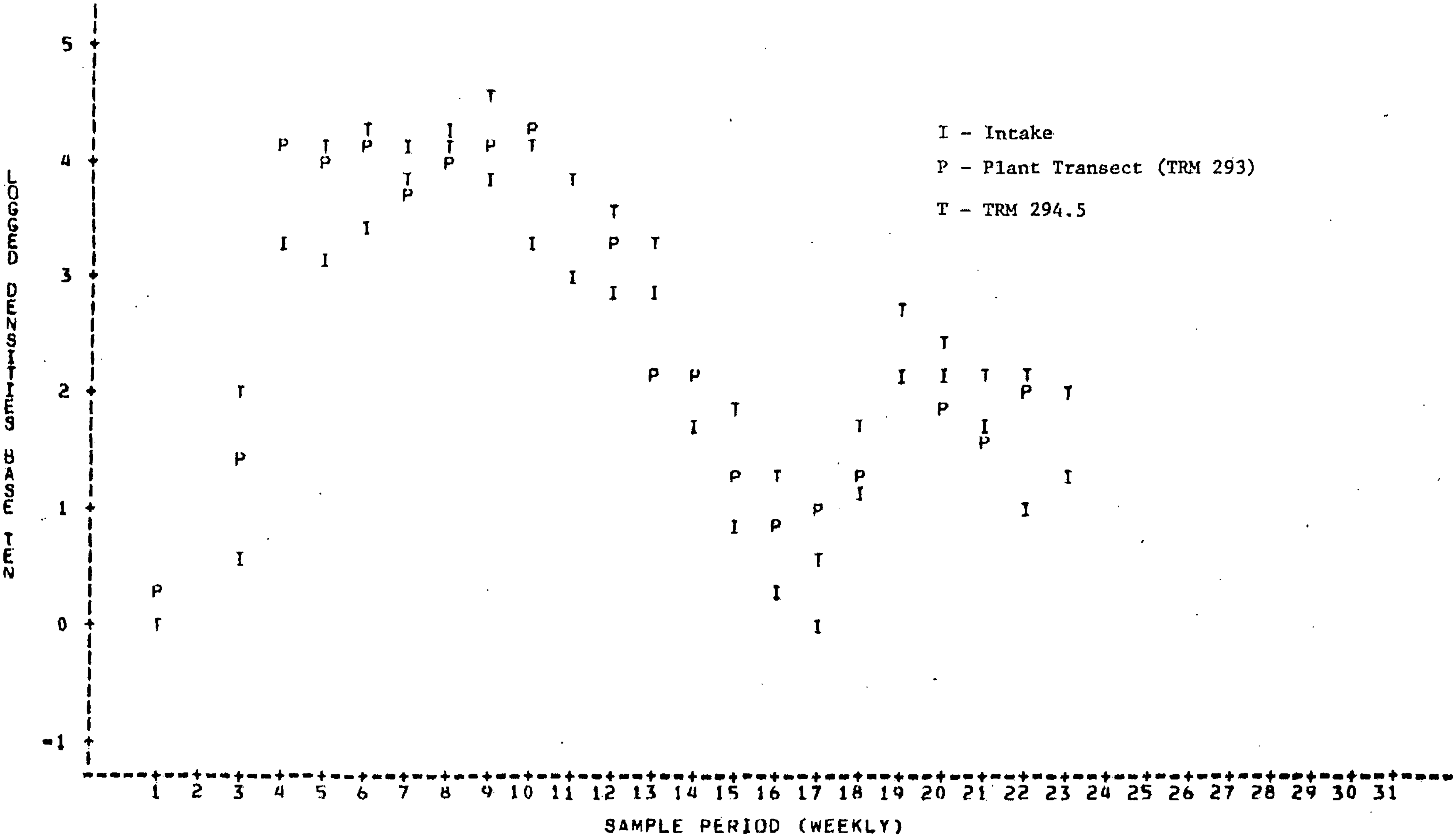
LARVAL FISH DENSITIES FOR MAJOR FAMILIES BY TRANSECT AND SAMPLE PERIOD IN 1978 AND 1979

Ordinate values are given in logarithms, i.e., 0 = 1, +1 = 10, etc.

OBS HIDDEN - indicates values plotted on top of another by computer due to approximate densities at two or three transects

C1. DENSITIES OF LARVAL FISHES COLLECTED IN
LARVAL FISH MONITORING AT BROWNS FERRY NUCLEAR PLANT, 1978
FAMILY=106 FISH_NAM=CLUPEIDAE YEAR=1978

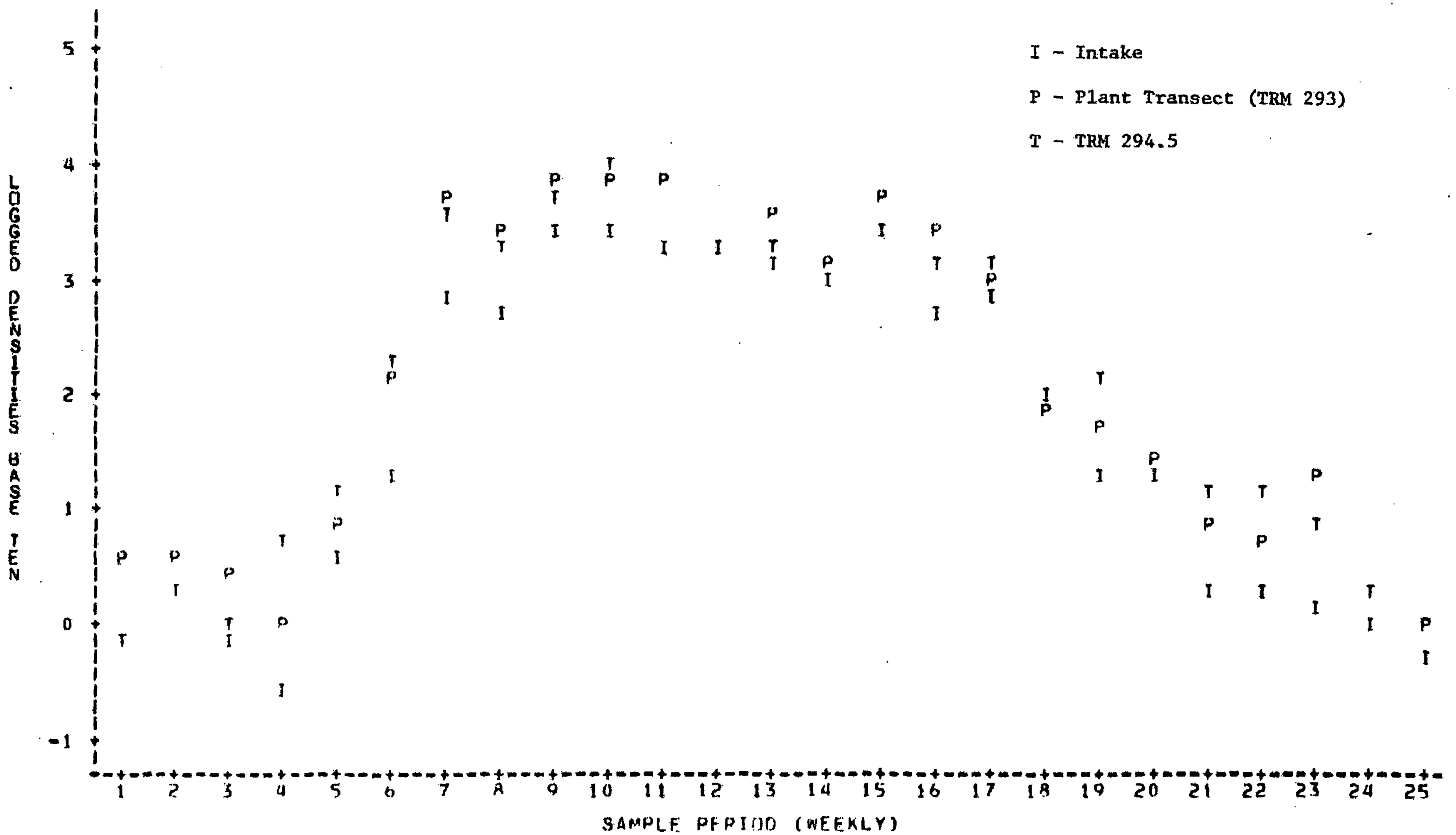
PLOT OF LOGDEN*PERIOD SYMBOL IS VALUE OF TRANSECT



NOTE: 5 OBS HIDDEN

C2. DENSITIES OF LARVAL FISHES COLLECTED AT
BROWNS FERRY NUCLEAR PLANT, 1979
FAMILY=106 FISH_NAM=CLUPEIDAE YEAR=1979

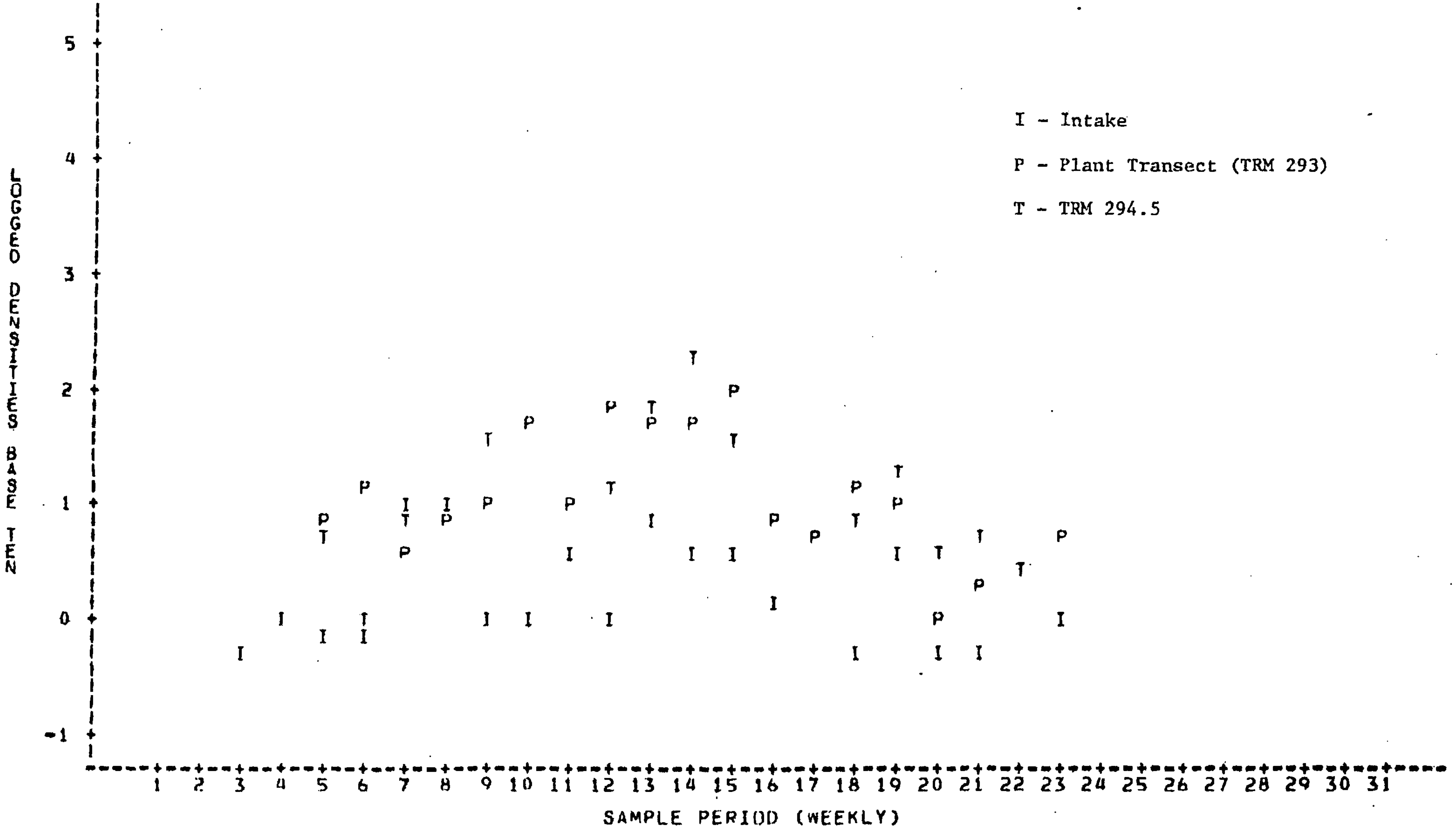
PLOT OF LOGDEN*PERIOD SYMBOL IS VALUE OF TRANSECT



NOTE: 9 OBS HIDDEN

C3. DENSITIES OF LARVAL FISHES COLLECTED IN
LARVAL FISH MONITORING AT BROWNS FERRY NUCLEAR PLANT, 1978
FAMILY=111 FISH_NAM=CYPRINIDAE YEAR=1978

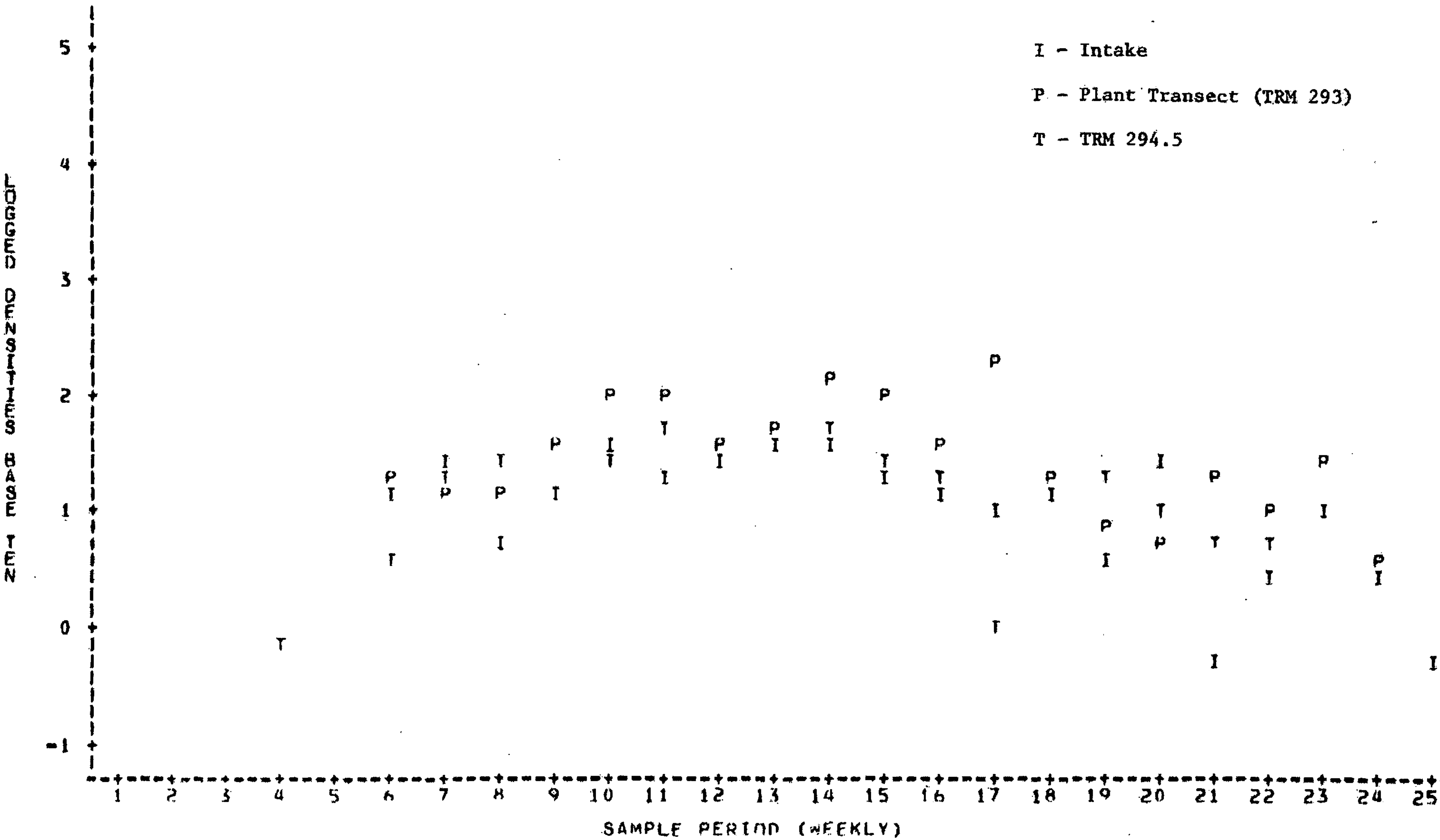
PLOT OF LOGDEN*PERIOD SYMBOL IS VALUE OF TRANSECT



NOTE: 6 OBS HIDDEN

C4. DENSITIES OF LARVAL FISHES COLLECTED AT
BROWNS FERRY NUCLEAR PLANT, 1979
FAMILY=111 FISH_NAM=CYPRINIDAE YEAR=1979

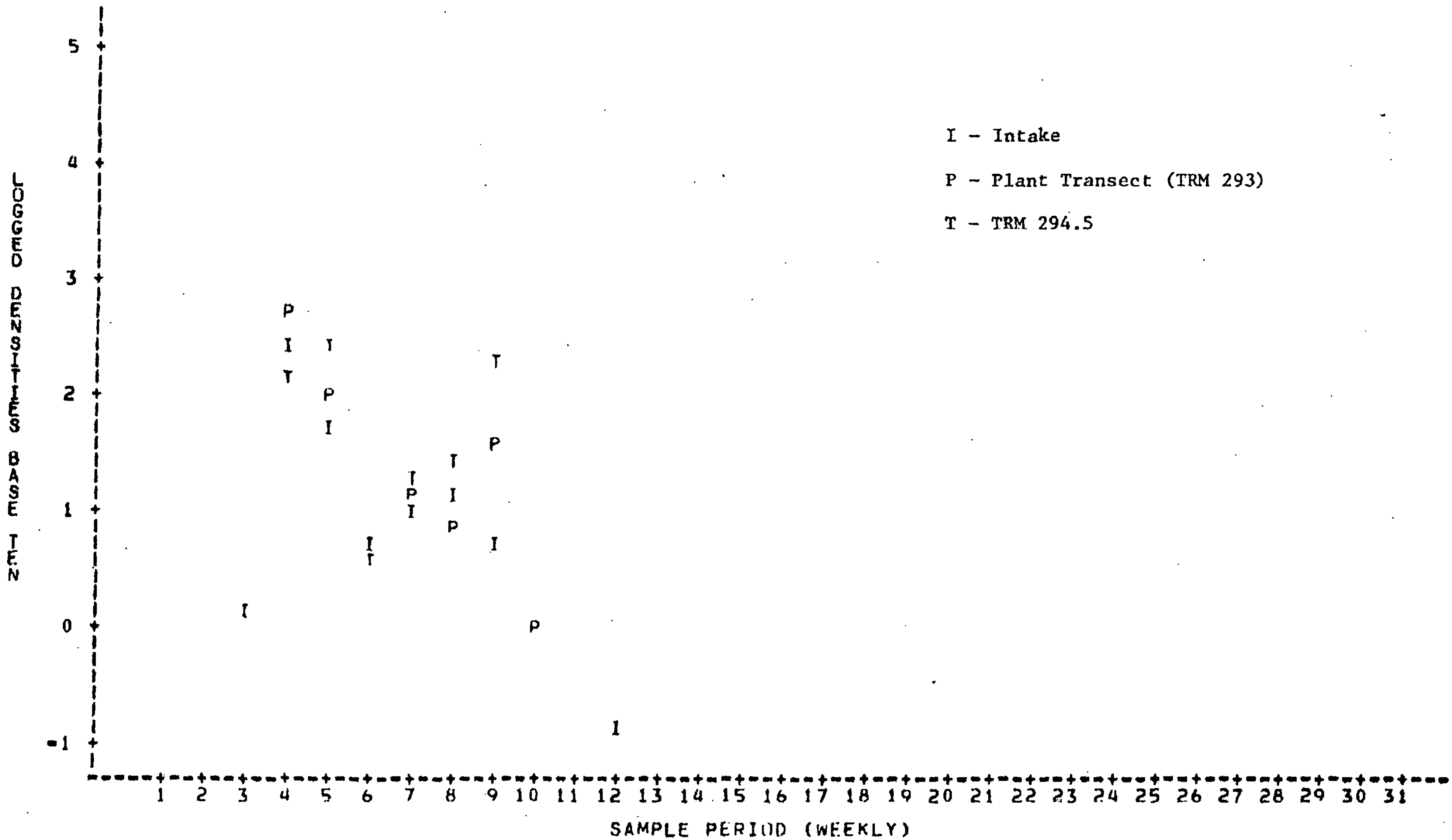
PLOT OF LOGDEN*PERIOD SYMBOL IS VALUE OF TRANSECT



NOTE: 6 OBS HIDDEN

C5. DENSITIES OF LARVAL FISHES COLLECTED IN
LARVAL FISH MONITORING AT BROWNS FERRY NUCLEAR PLANT, 1978
FAMILY=112 FISH_NAM=CATOSTOMIDAE YEAR=1978

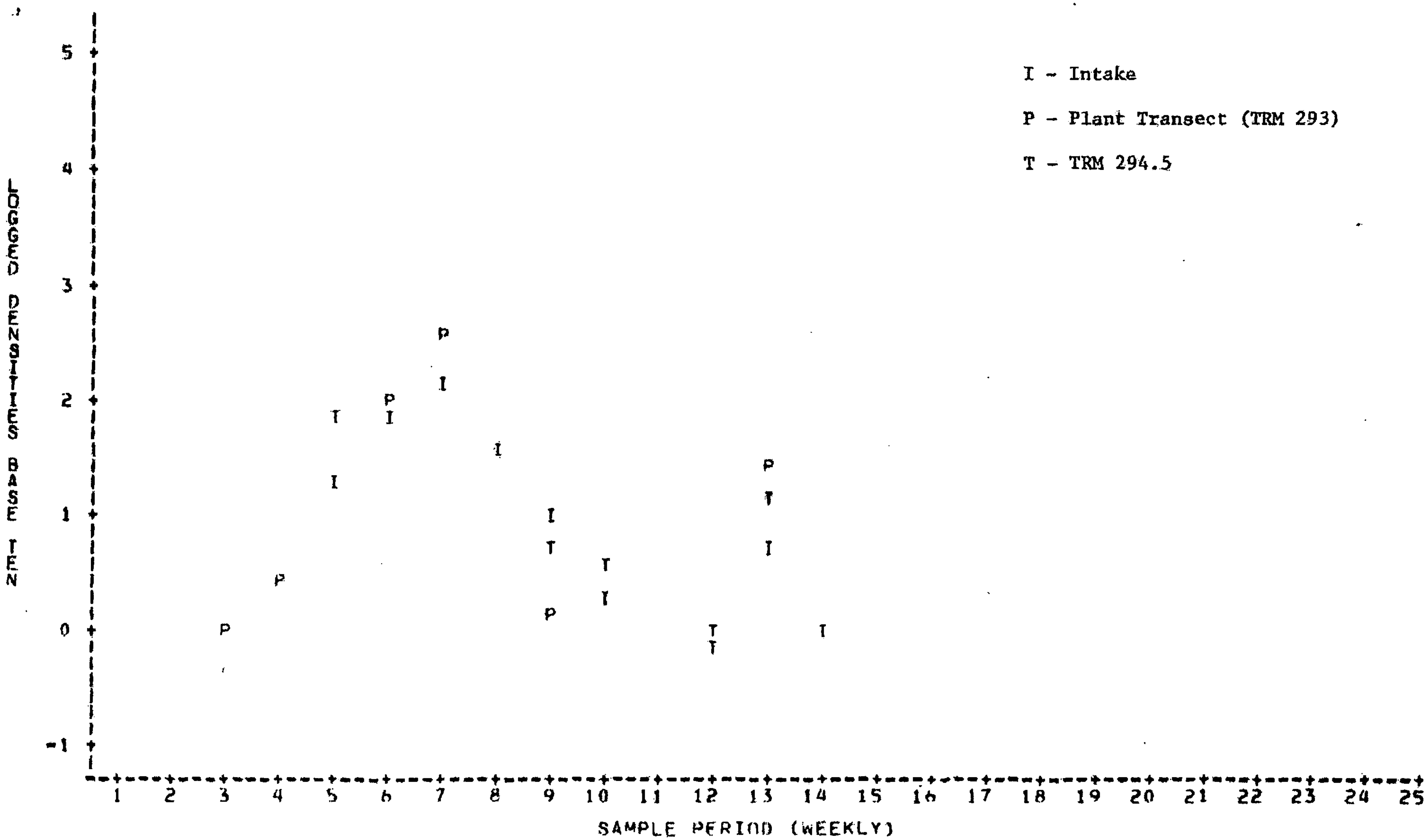
PLOT OF LOGDEN*PERIOD SYMBOL IS VALUE OF TRANSECT



NOTE: 2 OBS HIDDEN

C6. DENSITIES OF LARVAL FISHES COLLECTED AT
BROWNS FERRY NUCLEAR PLANT, 1979
FAMILY=112 FISH_NAM=CATOSTOMIDAE YEAR=1979

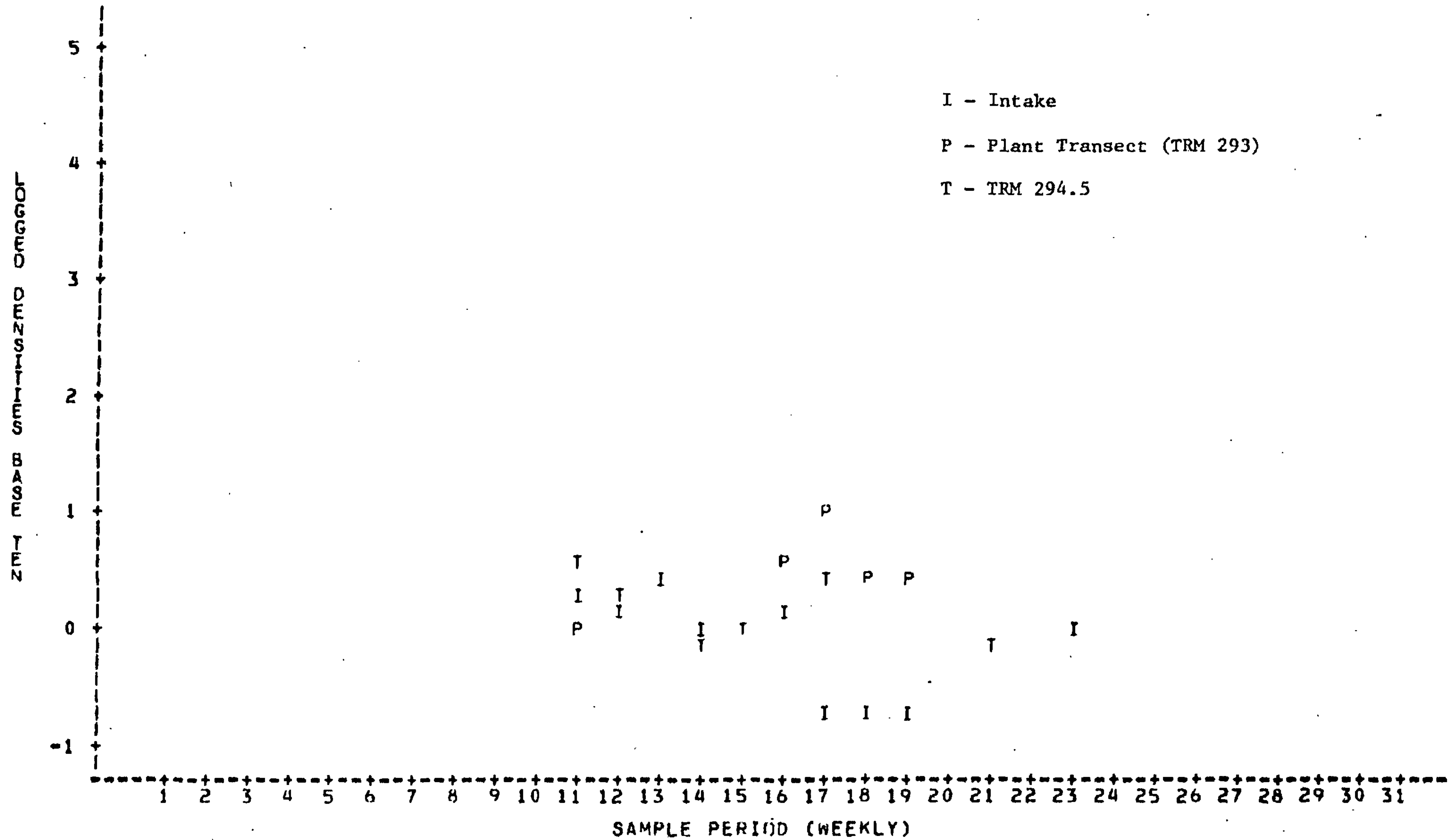
PLOT OF LOGDEN*PERIOD SYMBOL IS VALUE OF TRANSECT



NOTE: 5 OBS HIDDEN

C7. DENSITIES OF LARVAL FISHES COLLECTED IN
LARVAL FISH MONITORING AT BROWNS FERRY NUCLEAR PLANT, 1978
FAMILY=113 FISH_NAM=ICTALURIDAE YEAR=1978

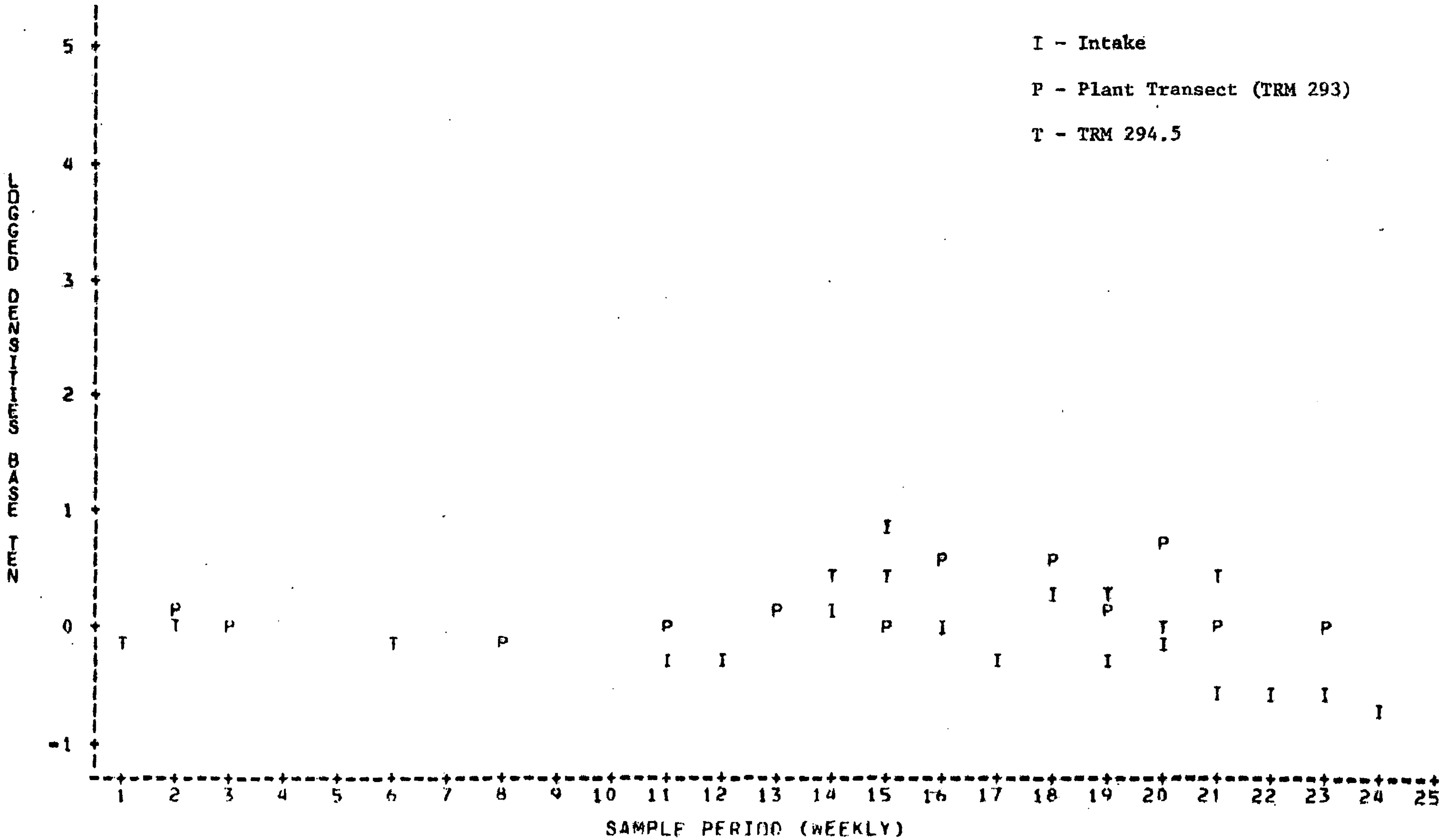
PLOT OF LOGDEN*PERIOD SYMBOL IS VALUE OF TRANSECT



NOTE: 2 OBS HIDDEN

C8. DENSITIES OF LARVAL FISHES COLLECTED AT BROWNS FERRY NUCLEAR PLANT, 1979
FAMILY=113 FISH_NAM=ICTALURIDAE YEAR=1979

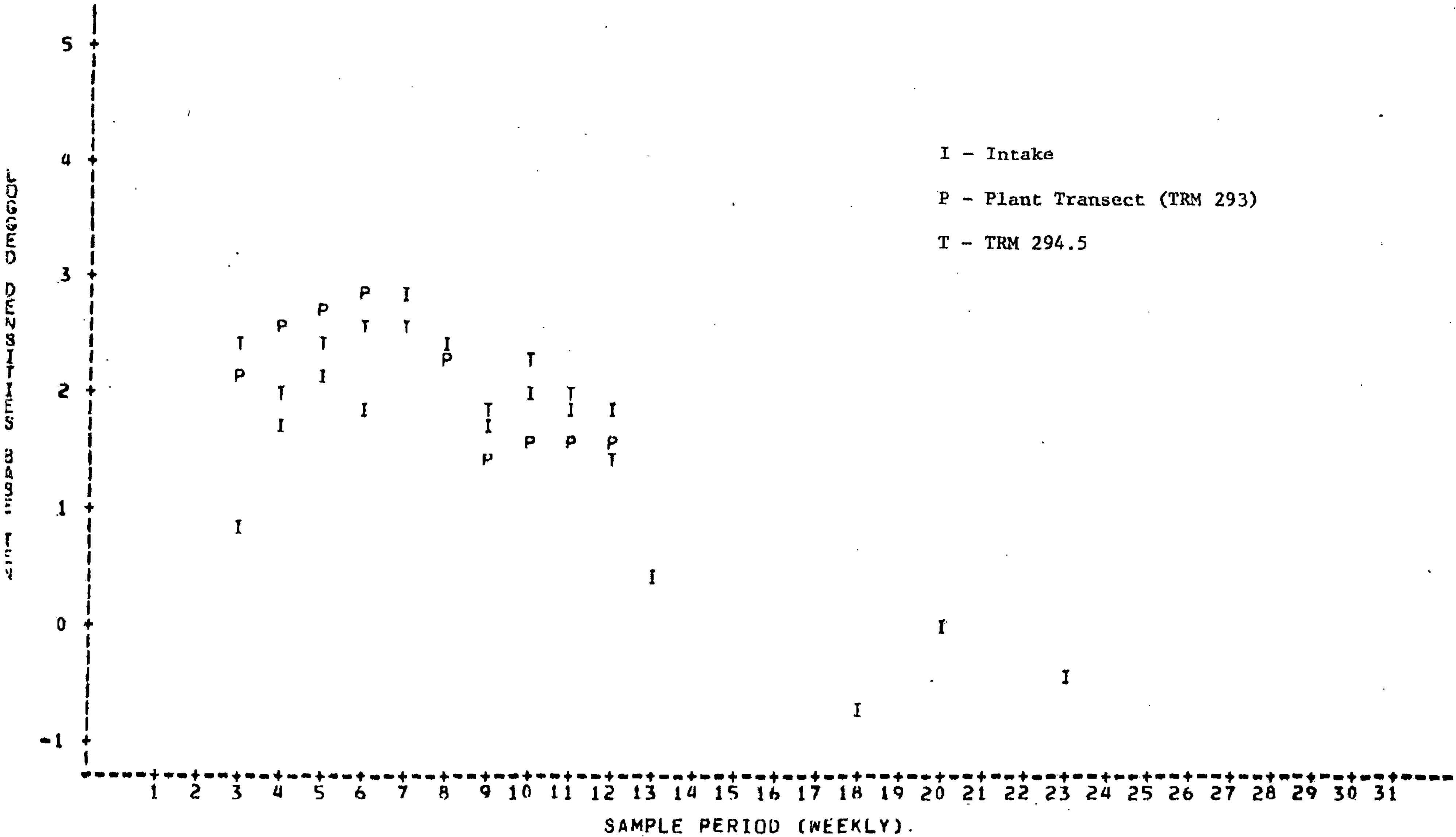
PLOT OF LOGDEN*PERIOD SYMBOL IS VALUE OF TRANSECT



NOTE: 1 OBS HIDDEN

C9. DENSITIES OF LARVAL FISHES COLLECTED IN
LARVAL FISH MONITORING AT BROWNS FERRY NUCLEAR PLANT, 1978
FAMILY=122 FISH_NAM=PERCICHTHYIDAE YEAR=1978

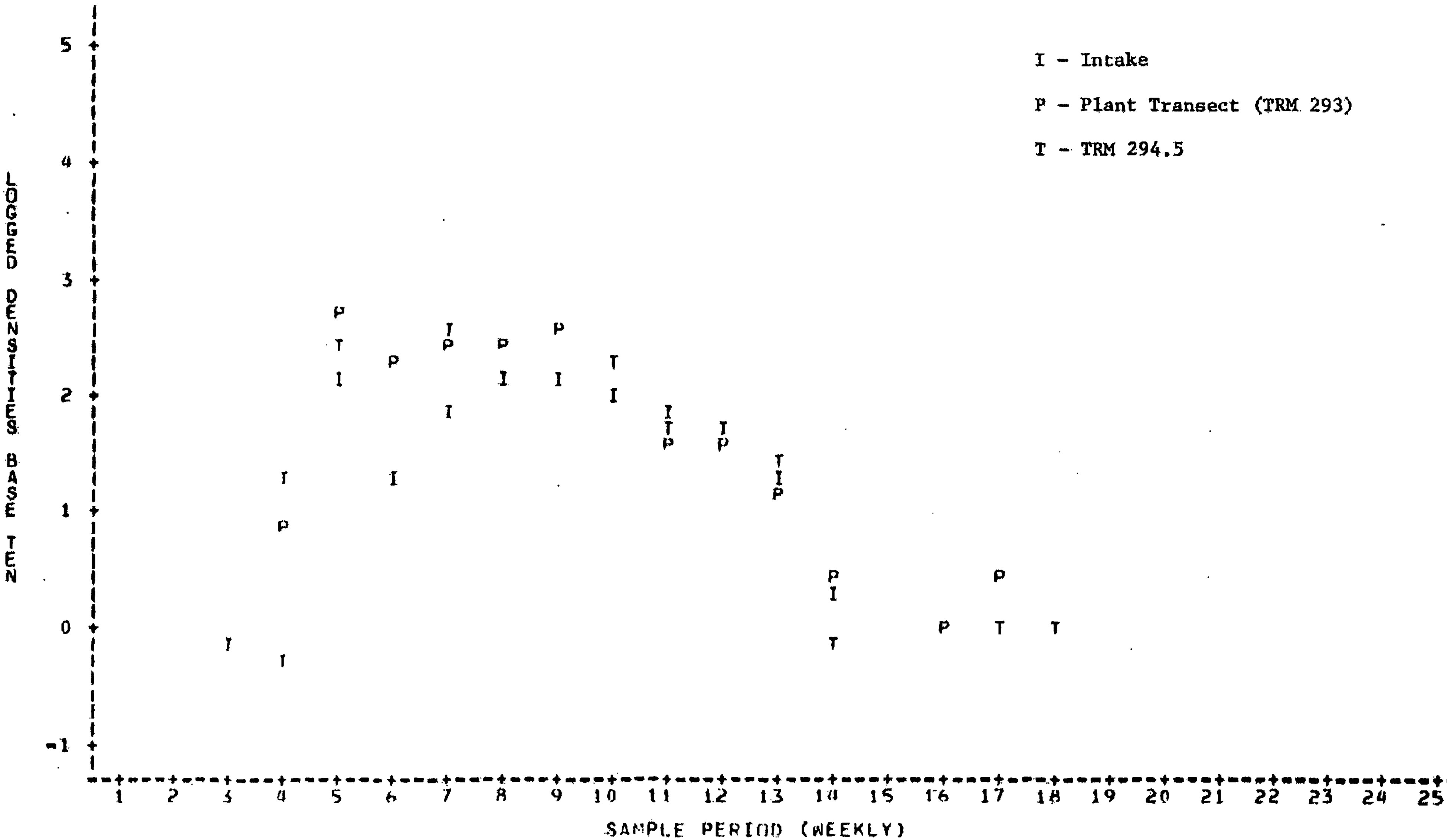
PLOT OF LOGDEN*PERIOD SYMBOL IS VALUE OF TRANSECT



NOTE: 3 OBS HIDDEN

C10. DENSITIES OF LARVAL FISHES COLLECTED AT
BROWNS FERRY NUCLEAR PLANT, 1979
FAMILY=122 FISH_NAM=PERCICHTHYIDAE YEAR=1979

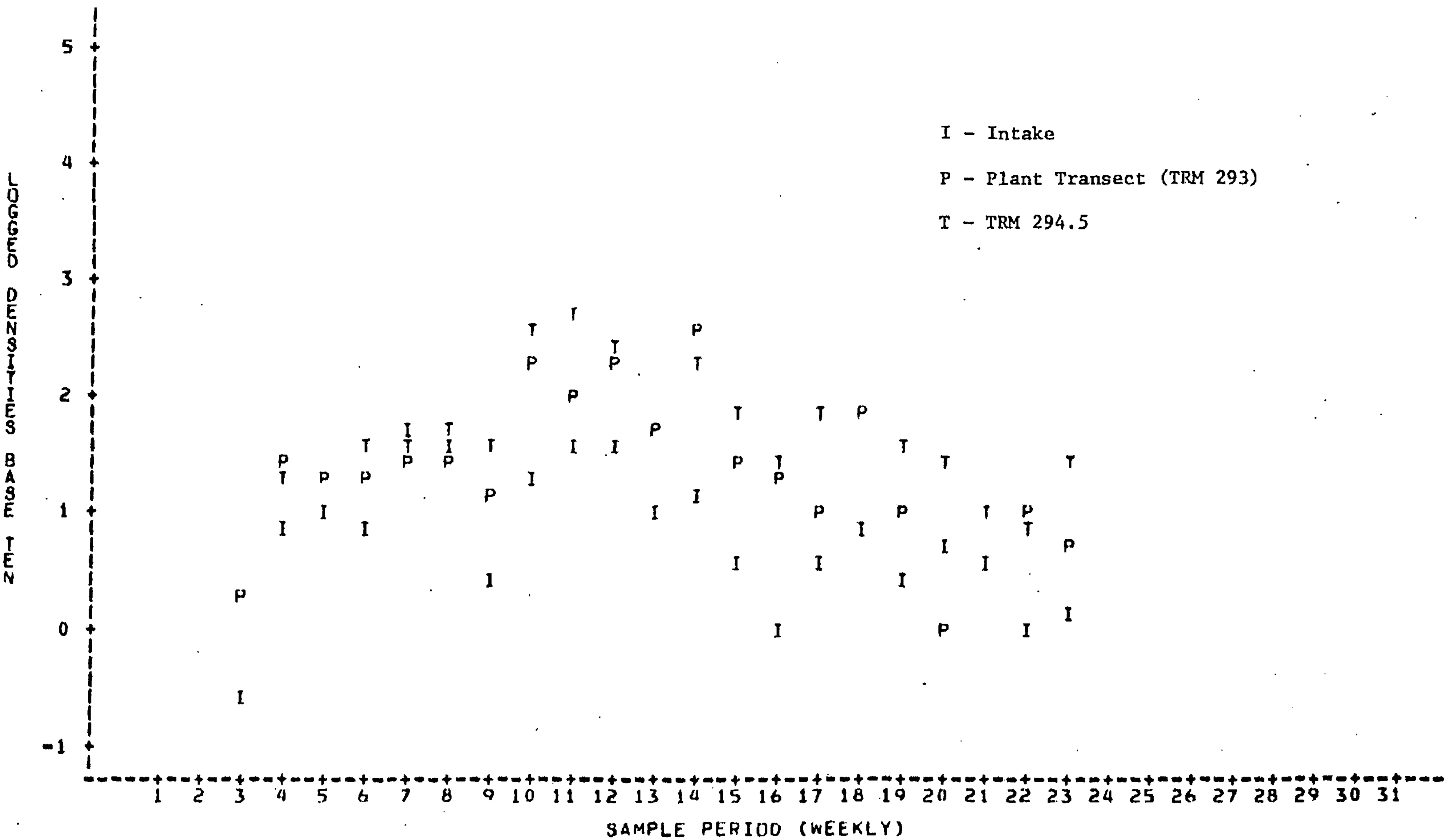
PLOT OF LOGDEN*PERIOD SYMBOL IS VALUE OF TRANSECT



NOTE: 5 OBS HIDDEN

C11. DENSITIES OF LARVAL FISHES COLLECTED IN
LARVAL FISH MONITORING AT BROWNS FERRY NUCLEAR PLANT, 1978
FAMILY=123 FISH_NAM=CENTRARCHIDAE YEAR=1978

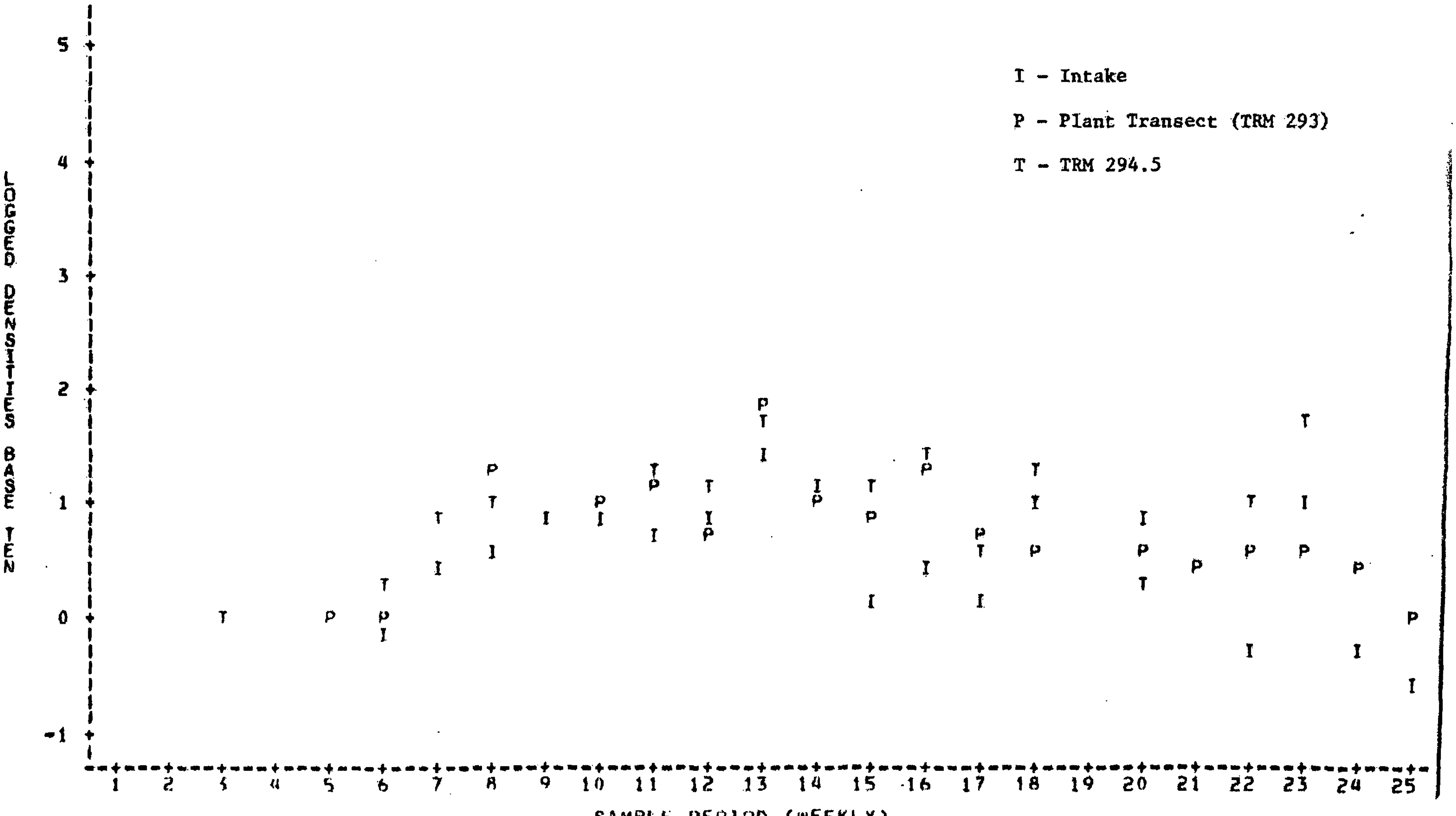
PLOT OF LOGDEN*PERIOD SYMBOL IS VALUE OF TRANSECT



NOTE: 4 OBS HIDDEN

C12. DENSITIES OF LARVAL FISHES COLLECTED AT
BROWNS FERRY NUCLEAR PLANT, 1979
FAMILY=123 FISH_NAM=CENTRARCHIDAE YEAR=1979

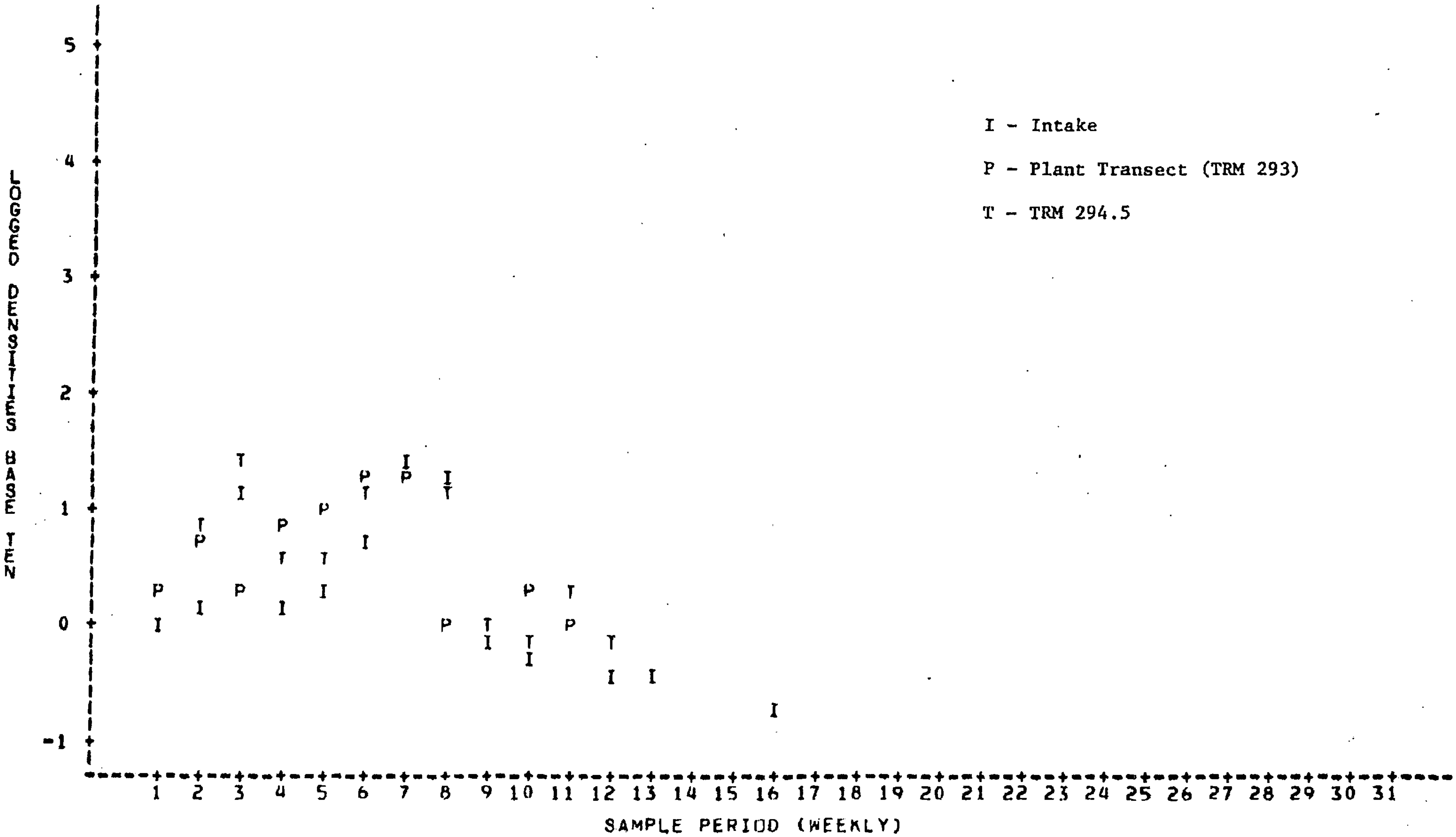
PLOT OF LOGDEN*PERIOD SYMBOL IS VALUE OF TRANSECT



NOTE: 6 OBS HIDDEN

C13. DENSITIES OF LARVAL FISHES COLLECTED IN
LARVAL FISH MONITORING AT BROWNS FERRY NUCLEAR PLANT, 1978
FAMILY=124 FISH_NAM=PERCIDAE YEAR=1978

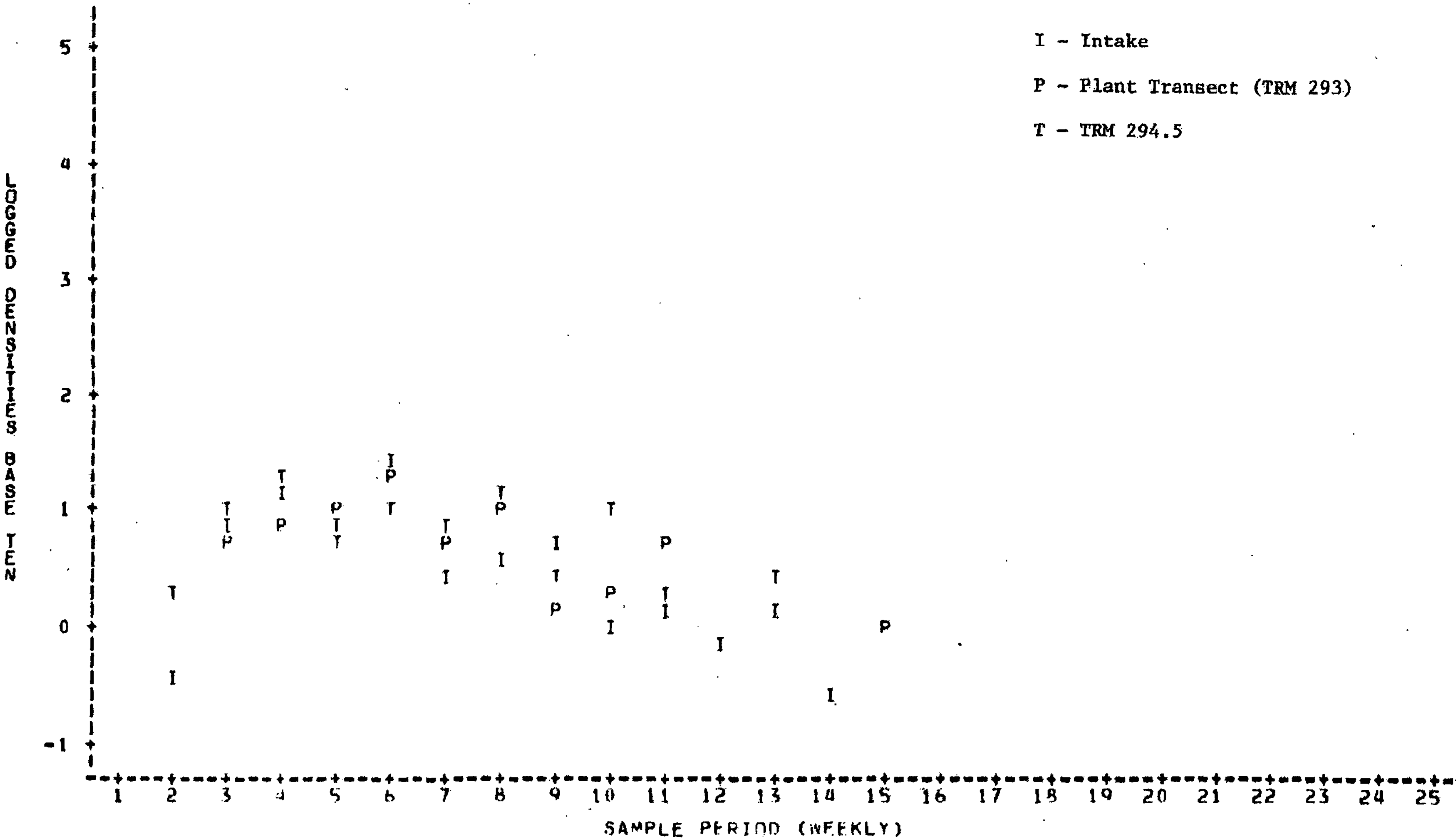
PLOT OF LOGDEN*PERIOD SYMBOL IS VALUE OF TRANSECT



NOTE: 2 OBS HIDDEN

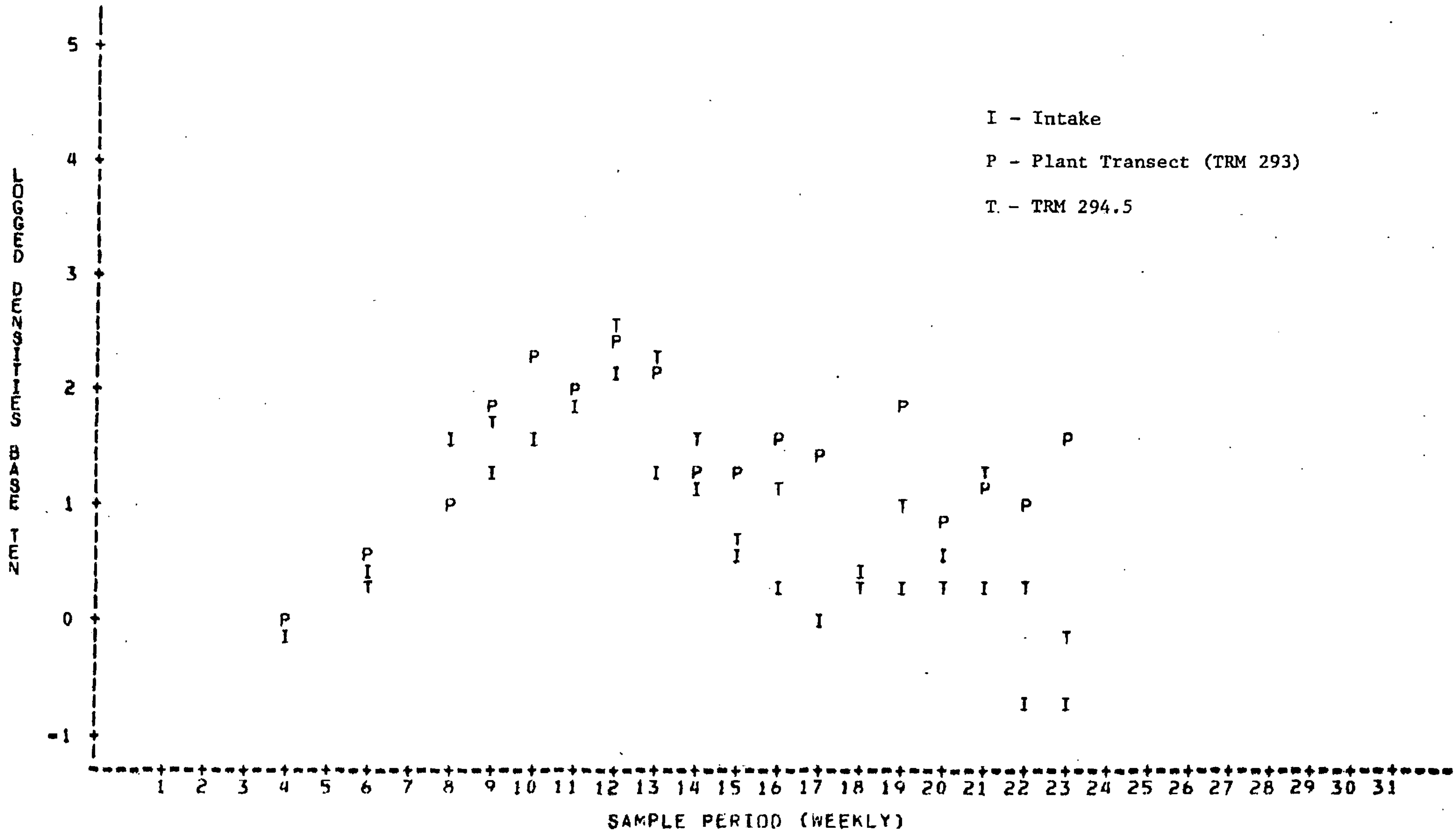
C14. DENSITIES OF LARVAL FISHES COLLECTED AT
BROWNS FERRY NUCLEAR PLANT, 1979
FAMILY=124 FISH_NAM=PERCIDAE YEAR=1979

PLOT OF LOGDEN*PERIOD SYMBOL IS VALUE OF TRANSECT



C15. DENSITIES OF LARVAL FISHES COLLECTED IN
LARVAL FISH MONITORING AT BROWNS FERRY NUCLEAR PLANT, 1978
FAMILY=125 FISH_NAM=SCIAENIDAE YEAR=1978

PLOT OF LOGDEN*PERIOD SYMBOL IS VALUE OF TRANSECT



NOTE: 5 OBS HIDDEN

C16. DENSITIES OF LARVAL FISHES COLLECTED AT
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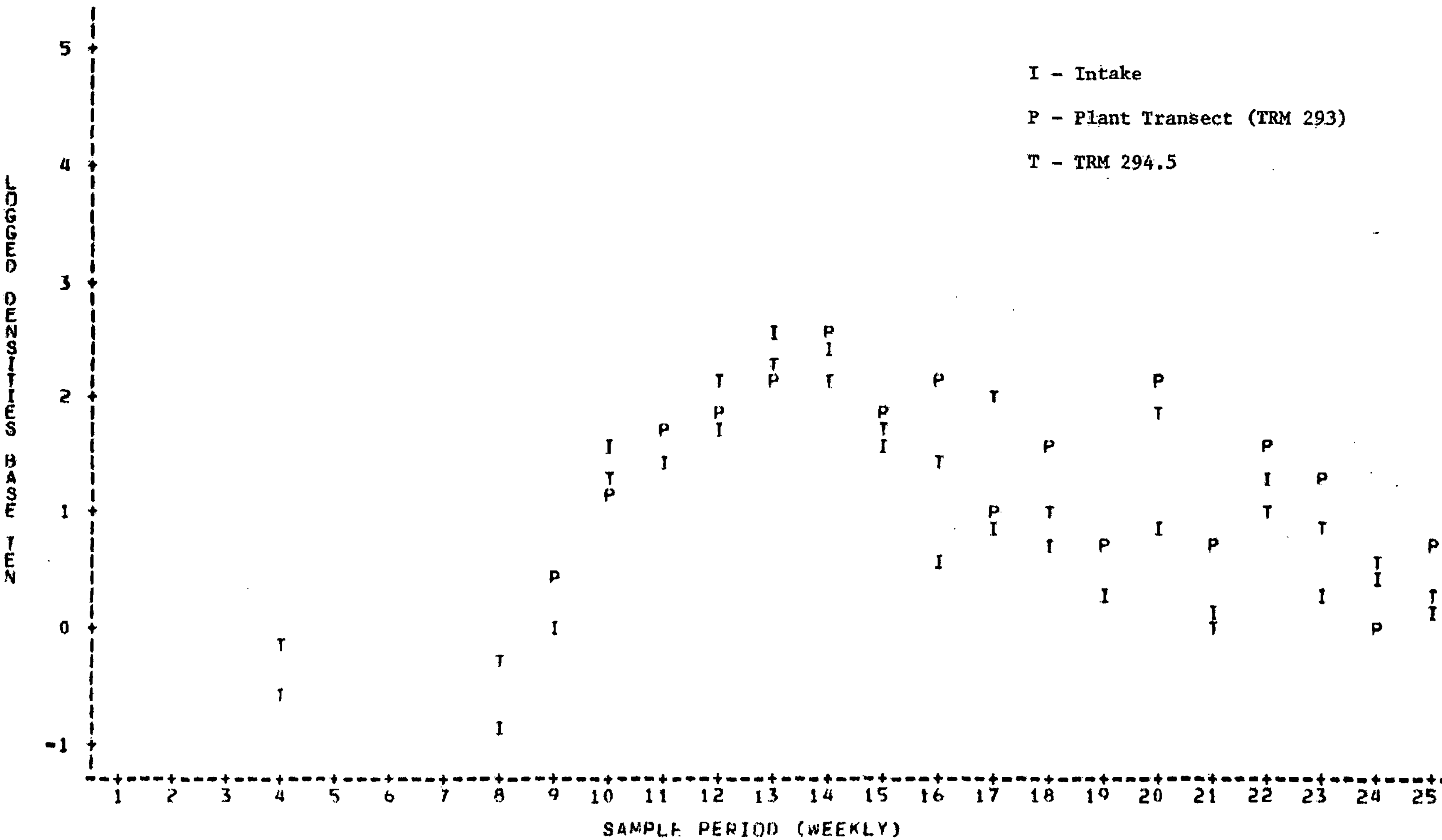
FAMILY=125 FISH_NAM=SCIAENIDAE YEAR=1979

PLOT OF LOGDEN*PERIOD SYMBOL IS VALUE OF TRANSECT



NOTE: 3 OBS HIDDEN

FISH IMPINGEMENT AT BROWNS FERRY NUCLEAR PLANT, WHEELER RESERVOIR: SUPPLEMENT

March 1980

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Division of Water Resources
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INTRODUCTION

The nine BFNP cooling water circulators pump 124.9 m^3 sec^{-1} (1.98 million gpm) of water at full capacity. Fish are impinged as this water passes through 18 vertical traveling screens (9.5 mm mesh) at a velocity of 61.0 cm sec^{-1} (2.0 fps). Using procedures established as part of the requirements for the operating license (NRC) and described in environmental technical specifications for Browns Ferry Nuclear Plant, impingement monitoring studies commenced in February 1974 and have continued uninterrupted. Some observed deficiencies in the sample method required modification of sample design (BFNP Environmental Technical Specifications September 1976) to include a direct count of fish weekly from each screen during one 24-hour period.

Data have been regularly summarized in preoperational and semi-annual and annual operational reports (TVA 1974a, 1974, 1975a, 1975b, 1976, 1978a, 1978b, 1978c, 1979) and have been examined in detail (February 1974-August 1977) in Biological Effects of Intake, Browns Ferry Nuclear Plant, Volume 4, January 1978. These documents indicate fish impingement at BFNP has little, if any, environmental impact on the fish community in Wheeler Reservoir. This report serves to supplement and update this earlier information.

RESULTS AND DISCUSSION

Data collected during operation of BFNP show similarities in species composition, relative abundance, and cycles of impingement susceptibility throughout the 1974-1979 operational period (Figure 1). Consistent increases and decreases in numbers of fish impinged annually,

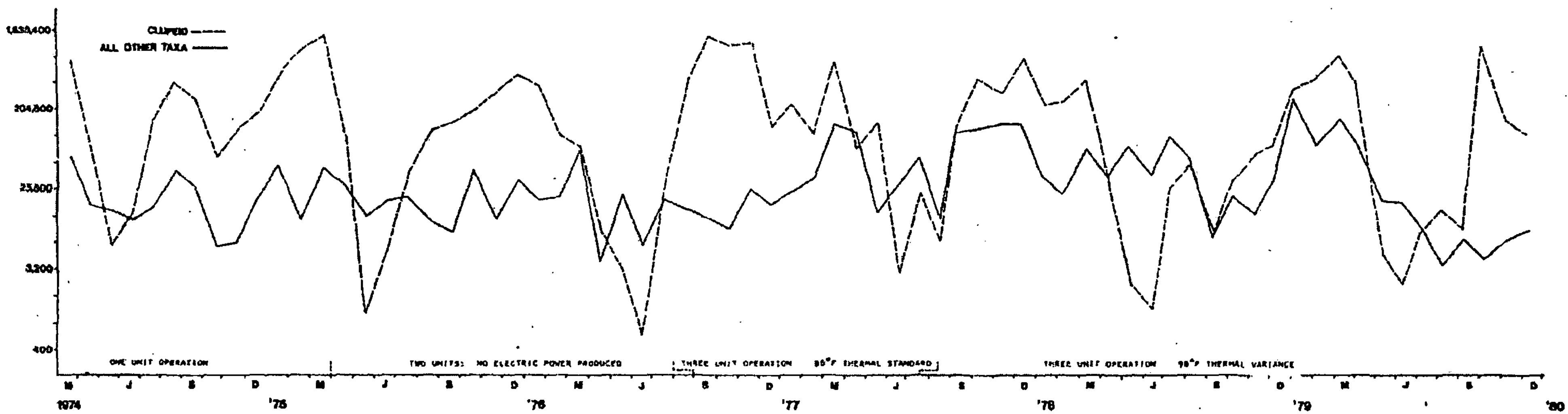

Figure 1. Estimated impingement at Browns Ferry Nuclear Plant by month for clupeids (shad) and all other taxa combined during the period March 1, 1974 through December 31, 1979. A geometric scale was used to show the large range in monthly values.

both clupeids and all other taxa combined show little, if any, effect of either changes in plant operating regime or increases in maximum mixed river temperatures (30°C to 32.2°C) to the fish community.

With the exception of sauger, the three "cool water" species are impinged in low numbers at BFNP. During 1974-1979 only five walleye were identified in the catch (two in 1977 and three in 1978). Sauger are regularly impinged at BFNP and since habitat requirements of walleye and sauger are generally similar (Pflieger 1975), the paucity of impinged walleye further corroborates the rarity of this species in Wheeler Reservoir and the low potential to be affected by operation of BFNP.

Smallmouth bass were impinged at an average rate of less than one fish per day throughout the operational period. This low rate of impingement suggests the BFNP intake area is not an attractive habitat for this species. Table 1 shows standing stock biomass for smallmouth bass well distributed between young-of-year, intermediate, and harvestable size classes. A healthy smallmouth bass population in Wheeler Reservoir indicates BFNP does not adversely affect this species.

The sauger population in Wheeler Reservoir shows fluctuations in estimated reproductive success (Table 2) and numbers (Table 3) that do not seem to be related to operation of the Browns Ferry Nuclear Plant. Comparison of the total number of sauger annually impinged by BFNP with annual estimated standing stock in Wheeler Reservoir (Table 4) shows large fluctuations but an impingement rate of less than one percent. Ichthyoplankton monitoring during plan operation also shows large fluctuations in larval sauger densities (Table 2). Interestingly, larval sauger densities are highly correlated (r^2 = 0.840) with total numbers of young-of-year sauger impinged during the same year (Figure 2).

Table 1. Number and biomass of smallmouth bass per hectare taken in cove-rotene samples, Wheeler Reservoir. YOY = young of year (<125 mm TL); I = intermediate (125-200 mm); H = harvestable (>200 mm). Coves at TRM 275, 286, and ERM (Elk River) 2.7 are preoperational and operational monitoring sites for BFNP.

Location	Year	YOY		I		H	
		N	kg	N	kg	N	kg
TRM 275	1970	95	0.36	19	1.02	12	4.66
	1971	85	0.86	32	1.35	32	18.69
	1972	80	0.64	31	2.56	17	3.39
	1973	36	0.41	7	0.57	8	1.34
	1974	146	0.87	11	0.69	6	0.85
	1975	84	0.68	11	0.67	3	0.87
	1976	108	1.46	19	0.91	24	3.35
	1977	71	0.29	25	1.26	23	4.77
	1978	153	0.72	39	0.97	9	1.24
	1979	48	0.31	40	1.03	14	2.37
TRM 286	1970	86	0.15	13	0.55	2	0.38
	1971	135	1.13	83	2.36	5	0.71
	1972	8	0.05	1	0.09	1	0.18
	1973	1	0.01	0		0	
	1974	1	0.01	0		0	
	1975	3	0.04	0		0	
	1976	7	0.10	1	0.03	7	1.13
	1977	40	0.15	11	0.51	11	0.47
	1978	45	0.23	5	0.11	0	
	1979	26	0.18	6	0.10	1	0.14
ERM 27	1970	20	0.21	2	0.23	0	
(Elk River)	1971	141	1.31	38	1.01	6	0.99
	1972	9	0.10	9	0.75	11	1.61
	1973	0		0		0	
	1974	16	0.13	0		0	
	1975	9	0.10	3	0.18	3	0.35
	1976	0		0		0	
	1977	2	0.01	10	0.23	5	1.18
	1978	9	0.06	5	0.11	5	1.11
	1979	0		0		0	

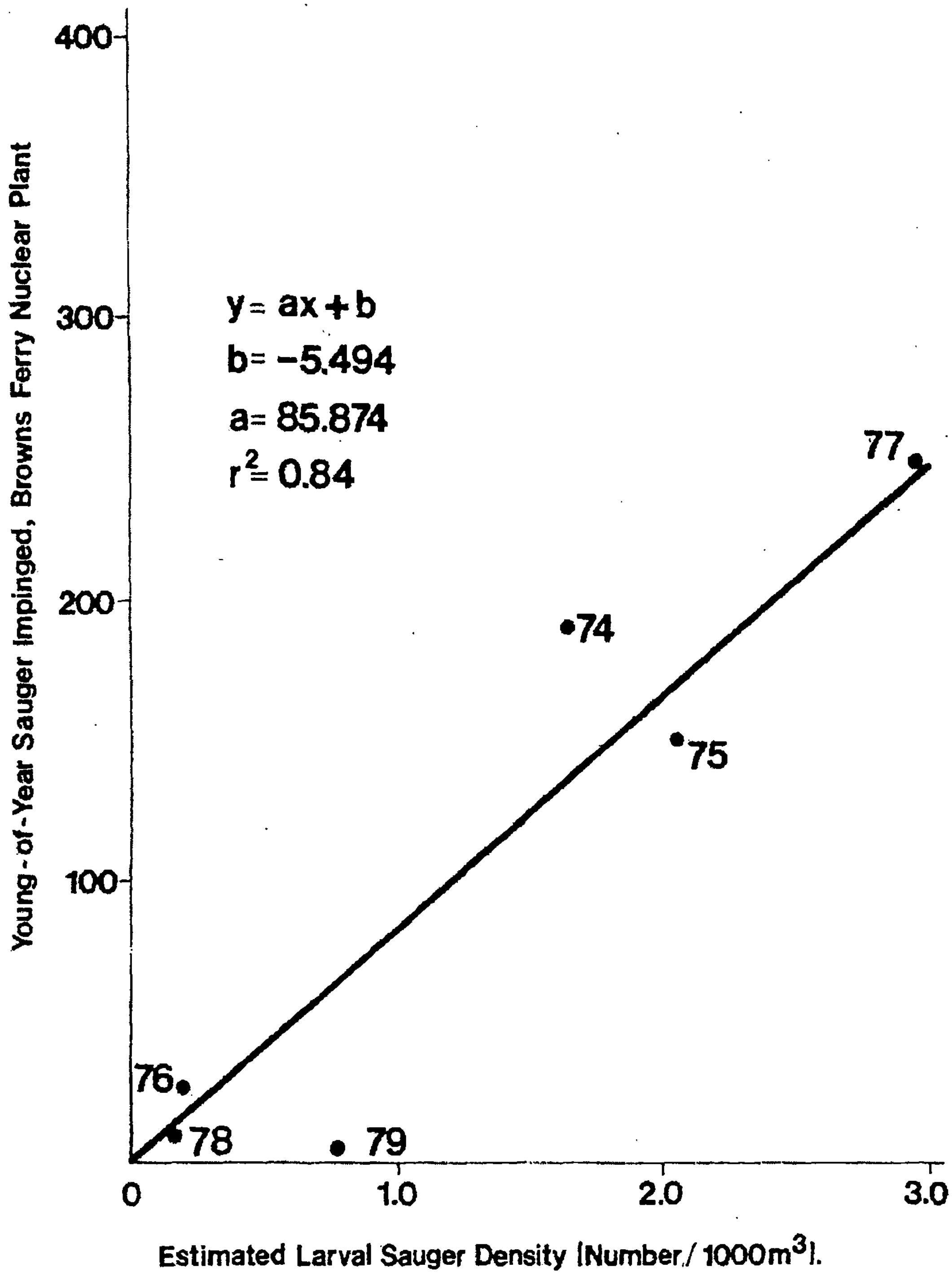

Figure 2. Relationships of young-of-year sauger impinged at Browns Ferry Nuclear Plant to the density of larval sauger (numbers/1000 m^3) in Wheeler Reservoir for the years 1974-1979.

Table 1. Number and biomass of smallmouth bass per hectare taken in cove-rotene samples, Wheeler Reservoir. YOY = young of year (<125 mm TL); I = intermediate (125-200 mm); H = harvestable (>200 mm). Coves at TRM 275, 286, and ERM (Elk River) 2.7 are preoperational and operational monitoring sites for BFNP.

Location	Year	YOY N	YOY kg	I N	I kg	H N	H kg
TRM 275	1970	95	0.36	19	1.02	12	4.66
	1971	85	0.86	32	1.35	32	18.69
	1972	80	0.64	31	2.56	17	3.39
	1973	36	0.41	7	0.57	8	1.34
	1974	146	0.87	11	0.69	6	0.85
	1975	84	0.68	11	0.67	3	0.87
	1976	108	1.46	19	0.91	24	3.35
	1977	71	0.29	25	1.26	23	4.77
	1978	153	0.72	39	0.97	9	1.24
	1979	48	0.31	40	1.03	14	2.37
TRM 286	1970	86	0.15	13	0.55	2	0.38
	1971	135	1.13	83	2.36	5	0.71
	1972	8	0.05	1	0.09	1	0.18
	1973	1	0.01	0		0	
	1974	1	0.01	0		0	
	1975	3	0.04	0		0	
	1976	7	0.10	1	0.03	7	1.13
	1977	40	0.15	11	0.51	11	0.47
	1978	45	0.23	5	0.11	0	
	1979	26	0.18	6	0.10	1	0.14
ERM 27	1970	20	0.21	2	0.23	0	
(Elk River)	1971	141	1.31	38	1.01	6	0.99
	1972	9	0.10	9	0.75	11	1.61
	1973	0		0		0	
	1974	16	0.13	0		0	
	1975	9	0.10	3	0.18	3	0.35
	1976	0		0		0	
	1977	2	0.01	10	0.23	5	1.18
	1978	9	0.06	5	0.11	5	1.11
	1979	0		0		0	

Table 2. Total numbers, density, latest occurrence, and temperature data for Stizostedion spp. (probably sauger) larvae collected from Wheeler Reservoir. 1971-1979.

Year	Total Number	Density (No./1000 m^3)	Latest Occurrence	Mean Temperature (C)
1971***	0	0		
1972***	0	0		
1973	93	2.14	May 15	19.3
1974	107	1.60	May 15	21.0
1975	112	2.09	May 21	22.0
1976	13	0.22	May 6	19.7
1977	225	2.96	May 11	21.9
1978	2	0.07	May 8	19.9
1979	25	0.85	April 30	20.9

* During period of occurrence.

** Mean of day-night water temperature on date of latest occurrence.

*** Sampling not begun until after the period of larval stizostedion spp. occurrence.

Table 3. Numbers and biomass of sauger per hectare taken in cove-rotene samples, Wheeler Reservoir. YOY = young of year (<200 mm TL); I = intermediate (200-300 mm); H = harvestable (>300 mm). Coves at TRM 275, 286, and ERM (Elk River) 2.7 are preoperational and operational monitoring sites for BFNP.

		Sauger - YOY		I		H	
Location	Year	N	kg	N	kg	N	kg
TRM 275	1970	5	0.13	0		0	
	1971	0		1	0.29	0	
	1972	5	0.35	0		0	
	1973	16	0.60	0		0	
	1974	5	0.15	0		1	0.21
	1975	14	0.37	5	0.62	1	0.11
	1976	6	0.31	5	0.88	0	
	1977	86	1.85	1	0.14	4	0.87
	1978	7	0.21	16	1.80	3	0.81
	1979	1	0.03	0		3	0.60
TRM 286	1970	18	0.69	0		0	
	1971	0		0		0	
	1972	1		1	0.05	0	
	1973	9	0.30	0		1	0.17
	1974	8	0.16	1	0.12	1	0.28
	1975	27	0.74	10	1.56	0	
	1976	21	0.99	24	2.48	7	2.45
	1977	124	2.76	0		14	4.38
	1978	4	0.07	8	0.66	1	0.29
	1979	9	0.21	6	0.60	0	
ERM 2.7	1974	5	0.17	0		0	
	1975	3	0.06	5	0.59		
	1976	0		8	0.77	2	0.60
	1977	3	0.09	0		0	
	1978	0	0.00	0		2	0.23
	1979	0	0.00	0		0	

Table 4. Estimated standing stock numbers (based on cove rotenone samples) for sauger in Wheeler Reservoir[1] compared with estimated total impingement of sauger during the period March 1, 1974, through December 31, 1979.

	Estimated Total Number Impinged	Estimated Standing Stock (No/ha) in Wheeler Reservoir	Percent impinged
1979	453	516,000	0.088
1978	2,985	1,113,000	0.268
1977	12,158	6,300,000	0.193
1976	837	2,009,000	0.042
1975	2,099	1,788,000	0.117
1974[2]	4,132	578,000	0.715
1973	None	715,000	-
1972	None	193,000	-

1. Based on a reservoir surface area of 27,154 hectares.
2. Impingement studies began March 1, 1974.

These data suggest the sauger population in Wheeler Reservoir is highly variable, but responds to factors unrelated to either the intake structure or thermal effluent from BFNP. Estimated numbers impinged were low compared to estimated reservoir standing stock and were highly coorelated with numbers of larvae present in the reservoir. Browns Ferry Nuclear Plant seems to be consistently sampling, but not adversely affecting, the sauger in Wheeler Reservoir.

Literature Cited

Pflieger, W. L., 1975. The Fishes of Missouri. Missouri Department of Conservation. 342 pp.

Tennessee Valley Authority. 1974a. Water Quality and Biological Conditions in Wheeler Reservoir During Operation of Browns Ferry Nuclear Plant (Unit 1), August 17, 1973-February 17, 1974. Chattanooga, Tennessee: Division of Environmental Planning, Water Quality Branch.

__________. 1974b. Water Quality and Biological Conditions in Wheeler Reservoir During Operation of Browns Ferry Nuclear Plant (Unit 1), February 18, 1974-June 30, 1974. Chattanooga, Tennessee: Division of Environmental Planning, Water Quality Branch.

__________. 1975a. Water Quality and Biological Conditions in Wheeler Reservoir During Operation of Browns Ferry Nuclear Plant (Unit 1 and 2), July 1, 1974-December 31, 1974. Chattanooga, Tennessee: Division of Environmental Planning, Water Quality Branch.

__________. 1975b. Water Quality and Biological Conditions in Wheeler Reservoir During Operation of Browns Ferry Nuclear Plant (Units 1 and 2), January 1, 1975-June 30, 1975. Chattanooga, Tennessee: Division of Environmental Planning, Water Quality Branch.

__________. 1976. Water Quality and Biological Conditions in Wheeler Reservoir During Operation of Browns Ferry Nuclear Plant (Units 1 and 2), July 1, 1975-December 31, 1975. Chattanooga, Tennessee: Division of Environmental Planning, Water Quality Branch.

__________. 1977. Water Quality and Biological Conditions in Wheeler Reservoir During Operation of Browns Ferry Nuclear Plant, January 1, 1976-December 31, 1976. Chattanooga, Tennessee: Division of Environmental Planning, Water Quality Branch.

__________. 1978a. Water Quality and Biological Conditions in Wheeler Reservoir During Operation of Browns Ferry Nuclear Plant, January 1, 1977-December 31, 1977. Chattanooga, Tennessee: Division of Environmental Planning, Water Quality Branch.

__________. 1978b. Browns Ferry Nuclear Plant Pre-operational Fisheries Resources Report. Norris, Tennessee: Division of Forestry, Fisheries, and Wildlife Development, Fisheries and Waterfowl Resources Branch.

__________. 1978c. Effects of the Browns Ferry Nuclear Plant Cooling Water Intake on the Fish Populations of Wheeler Reservoir. Norris, Tennessee: Division of Forestry, Fisheries, and Wildlife Development. (Biological Effects of Intake, Browns Ferry Nuclear Plant; Volume 4).

________________________. 1979. Water Quality and Biological Conditions in Wheeler Reservoir During Operation of Browns Ferry Nuclear Plant, January 1, 1978-December 31, 1978. Muscle Shoals, Alabama: Division of Water Resources, Water Quality and Ecology Branch.

GE
Water & Process Technologies

Material Safety Data Sheet

Issue Date: 05-FEB-2009
Supercedes: 02-OCT-2008

DEPOSITROL PY5200

1 Identification

Identification of substance or preparation
DEPOSITROL PY5200

Product Application Area
Water-based deposit control agent.

Company/Undertaking Identification
GE Betz, Inc.
4636 Somerton Road
Trevose, PA 19053
T 215 355-3300, F 215 953 5524

Emergency Telephone
(800) 877-1940

Prepared by Product Stewardship Group: T 215-355-3300 Prepared on: 05-FEB-2009

2 Hazard(s) identification

****

EMERGENCY OVERVIEW

CAUTION

May cause slight irritation to the skin. May cause slight irritation to the eyes. Mists/aerosols may cause irritation to upper respiratory tract.

DOT hazard is not applicable
Odor: Slight; Appearance: Yellow, Liquid

Fire fighters should wear positive pressure self-contained breathing apparatus(full face-piece type). Proper fire-extinguishing media: dry chemical, carbon dioxide, foam or water

****

POTENTIAL HEALTH EFFECTS

ACUTE SKIN EFFECTS:
Primary route of exposure; May cause slight irritation to the skin.

ACUTE EYE EFFECTS:
May cause slight irritation to the eyes.

ACUTE RESPIRATORY EFFECTS:
Mists/aerosols may cause irritation to upper respiratory tract.

INGESTION EFFECTS:
May cause slight gastrointestinal irritation.

TARGET ORGANS:
No evidence of potential chronic effects.

MEDICAL CONDITIONS AGGRAVATED:
Not known.

SYMPTOMS OF EXPOSURE:
May cause redness or itching of skin.

3 Composition / information on ingredients

Information for specific product ingredients as required by the U.S. OSHA HAZARD COMMUNICATION STANDARD is listed. Refer to additional sections of this MSDS for our assessment of the potential hazards of this formulation.

HAZARDOUS INGREDIENTS:

This product is not hazardous as defined by OSHA regulations.

No component is considered to be a carcinogen by the National Toxicology Program, the International Agency for Research on Cancer, or the Occupational Safety and Health Administration at OSHA thresholds for carcinogens.

4 First-aid measures

SKIN CONTACT:
Wash thoroughly with soap and water. Remove contaminated clothing. Get medical attention if irritation develops or persists.
EYE CONTACT:
Remove contact lenses. Hold eyelids apart. Immediately flush eyes with plenty of low-pressure water for at least 15 minutes. Get medical attention if irritation persists after flushing.
INHALATION:
If nasal, throat or lung irritation develops - remove to fresh air and get medical attention.
INGESTION:
Do not feed anything by mouth to an unconscious or convulsive victim. Do not induce vomiting. Immediately contact physician. Dilute contents of stomach using 2-8 fluid ounces (60-240 mL) of milk or water.
NOTES TO PHYSICIANS:
No special instructions

5 Fire-fighting measures

FIRE FIGHTING INSTRUCTIONS:
Fire fighters should wear positive pressure self-contained breathing apparatus (full face-piece type).
EXTINGUISHING MEDIA:
dry chemical, carbon dioxide, foam or water
HAZARDOUS DECOMPOSITION PRODUCTS:
oxides of carbon and sulfur
FLASH POINT:
> 210F   > 99C P-M(CC)

6 Accidental release measures

PROTECTION AND SPILL CONTAINMENT:
Ventilate area. Use specified protective equipment. Contain and absorb on absorbent material. Place in waste disposal container. Flush area with water. Wet area may be slippery. Spread sand/grit.
DISPOSAL INSTRUCTIONS:
Water contaminated with this product may be sent to a sanitary sewer treatment facility,in accordance with any local agreement,a permitted waste treatment facility or discharged under a permit. Product as is - Incinerate or land dispose in an approved landfill.

7 Handling and storage

HANDLING:
Normal chemical handling.
STORAGE:
Keep containers closed when not in use. Protect from freezing. If frozen, thaw and mix completely prior to use. Shelf life 360 days.

8 Exposure controls / personal protection

EXPOSURE LIMITS

This product is not hazardous as defined by OSHA regulations.

ENGINEERING CONTROLS:
adequate ventilation
PERSONAL PROTECTIVE EQUIPMENT:
Use protective equipment in accordance with 29CFR 1910 Subpart I
RESPIRATORY PROTECTION:
A RESPIRATORY PROTECTION PROGRAM THAT MEETS OSHA'S 29 CFR 1910.134 AND ANSI Z88.2 REQUIREMENTS MUST BE FOLLOWED WHENEVER WORKPLACE CONDITIONS WARRANT A RESPIRATOR'S USE.
USE AIR PURIFYING RESPIRATORS WITHIN USE LIMITATIONS ASSOCIATED WITH THE EQUIPMENT OR ELSE USE SUPPLIED AIR-RESPIRATORS.
If air-purifying respirator use is appropriate, use any of the following particulate respirators: N95, N99, N100, R95, R99, R100, P95, P99 or P100.
SKIN PROTECTION:
rubber, butyl, viton or neoprene gloves -- Wash off after each use. Replace as necessary.
EYE PROTECTION:
splash proof chemical goggles

9 Physical and chemical properties

Specific Grav.(70F,21C)	1.169	Vapor Pressure (mmHG)	~ 18.0
Freeze Point (F)	25	Vapor Density (air=1)	< 1.00
Freeze Point (C)	-4		
Viscosity(cps 70F,21C)	42	% Solubility (water)	100.0

Odor		Slight	
Appearance		Yellow	
Physical State		Liquid	
Flash Point	P-M(CC)	> 210F	> 98C
pH As Is (approx.)		5.2	
Evaporation Rate (Ether=1)		< 1.00	
Percent VOC:		0.0	

NA = not applicable   ND = not determined

10 Stability and reactivity

CHEMICAL STABILITY:
Stable under normal storage conditions.
POSSIBILITY OF HAZARDOUS REACTIONS:

INCOMPATIBILITIES:
May react with strong oxidizers.
DECOMPOSITION PRODUCTS:
oxides of carbon and sulfur

11 Toxicological information

Oral LD50 RAT:	>5,000 mg/kg
Dermal LD50 RABBIT:	>2,000 mg/kg
Inhalation LC50 RAT:	>5 mg/L/4hr
Skin Irritation Score RABBIT:	1
Eye Irritation Score RABBIT:	1.67

12 Ecological information

AQUATIC TOXICOLOGY

Ceriodaphnia 48 Hour Static Renewal Bioassay
LC50= 1265 mg/L
Ceriodaphnia 7 Day Static Renewal Bioassay
IC25 = 538 mg/L
Daphnia magna 48 Hour Static Renewal Bioassay (pH adjusted)
LC50= 1767; No Effect Level= 1250 mg/L
Fathead Minnow 7 Day Static Renewal Bioassay
LC50 Greater Than= 2000; IC25 = 2000 mg/L
Fathead Minnow 96 Hour Static Renewal Bioassay (pH adjusted)
LC50= 1960; No Effect Level= 313 mg/L
Mysid Shrimp 48 Hour Static Renewal Bioassay (pH adjusted)
10% Mortality= 16000; 0% Mortality= 8000 mg/L
Sheepshead Minnow 96 Hour Static Renewal Bioassay (pH adjusted)
0% Mortality= 16000 mg/L

BIODEGRADATION

BOD-28 (mg/g): 32
BOD-5 (mg/g): 10
COD (mg/g): 368
TOC (mg/g): 144

13 Disposal considerations

If this undiluted product is discarded as a waste, the US RCRA hazardous waste identification number is :
Not applicable.

Please be advised; however, that state and local requirements for waste disposal may be more restrictive or otherwise different from federal regulations. Consult state and local regulations regarding the proper disposal of this material.

14 Transport information

DOT HAZARD: Not Applicable
PROPER SHIPPING NAME:

DOT EMERGENCY RESPONSE GUIDE #: Not applicable
Note: Some containers may be DOT exempt, please check BOL for exact container classification

15 Regulatory information

TSCA:
All components of this product are included on or are in compliance with the U.S. TSCA regulations.
CERCLA AND/OR SARA REPORTABLE QUANTITY (RQ):
No regulated constituent present at OSHA thresholds
FOOD AND DRUG ADMINISTRATION:
FDA APPROVED FOR MILL SUPPLY WATER
NSF Registered and/or meets USDA (according to 1998 Guidelines):
Registration number: Not Registered
This product contains ingredients that have been determined as safe for use in boilers, steamlines and cooling systems where there is no food contact. (G7)
SARA SECTION 312 HAZARD CLASS:
Product is non-hazardous under Section 311/312
SARA SECTION 302 CHEMICALS:
No regulated constituent present at OSHA thresholds
SARA SECTION 313 CHEMICALS:
No regulated constituent present at OSHA thresholds
CALIFORNIA REGULATORY INFORMATION

CALIFORNIA SAFE DRINKING WATER AND TOXIC ENFORCEMENT ACT (PROPOSITION 65):
No regulated constituents present

MICHIGAN REGULATORY INFORMATION

No regulated constituent present at OSHA thresholds

16 Other information

HMIS vII		**CODE TRANSLATION**
Health	1	Slight Hazard
Fire	1	Slight Hazard
Reactivity	0	Minimal Hazard
Special	NONE	No special Hazard
(1) Protective Equipment	B	Goggles,Gloves

(1) refer to section 8 of MSDS for additional protective equipment recommendations.

CHANGE LOG

	EFFECTIVE DATE	REVISIONS TO SECTION:	SUPERCEDES
MSDS status:	29-JAN-1997		** NEW **
	10-SEP-1997	3,8,10,11,16;EDIT:4	29-JAN-1997
	06-FEB-1998	12	10-SEP-1997
	18-JAN-2001	15	06-FEB-1998
	31-AUG-2001	15	18-JAN-2001
	30-OCT-2001	4	31-AUG-2001
	17-APR-2006	7,8	30-OCT-2001
	02-OCT-2008	4,5,8,10	17-APR-2006
	05-FEB-2009	12	02-OCT-2008

DepositTrol™ PY5200

Cooling Water Polymeric Dispersant

- Patented calcium phosphate scale inhibitor
- Advanced polymer technology
- Permits proper phosphate concentration for corrosion inhibition of mild steel
- Provides excellent dispersion of suspended solids

Description and Use

DepositTrol™ PY5200 is a unique deposit control agent for use in cooling water systems. It incorporates a polymeric agent, GE Infrastructure Water & Process Technologies HPS I, a third generation cooling water polymer.

Typical Applications

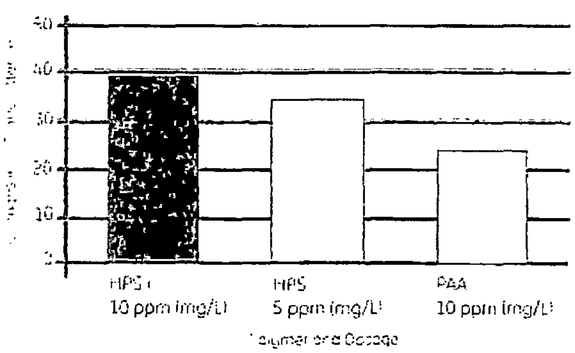

Figure 1: Clay Dispersion

DepositTrol PY5200 controls calcium phosphate formation and general deposition such as silt (see Figure 1), iron, and suspended solids. It is particularly effective in the presence of certain contaminants, such as results from cationic carryover from clarifiers, or in the case where boiler blowdown is added to the cooling system for discharge or water conservation purposes.

DepositTrol PY5200 is designed to be applied as one component of a Dianodic Plus™ program. With DepositTrol PY5200, phosphate concentrations in a Dianodic Plus treatment can be maintained at a high enough level to promote the formation of a passivating film on mild steel, thereby attaining the desired corrosion protection.

Treatment and Feeding Requirement

Dosage - The proper treatment levels of DepositTrol PY5200 depend on the specific needs of your system. The product should be fed in accordance with control procedures that GE establishes for a particular application. For consistent protection, continuous feed is recommended.

Feed point - DepositTrol PY5200 should be fed to a point in the system where it will be rapidly mixed with the bulk cooling water.

Dilution - DepositTrol PY5200 can be diluted with good quality water to convenient feeding strengths.

Feed Equipment - Tanks, pumps, piping, and valves should be made of stainless steel, polyethylene, polypropylene, PVC, Hypalon, or Teflon. Mild steel should not be used.

Physical Properties

Physical properties of DepositTrol PY5200 are shown on the Material Safety Data Sheet, a copy of which is available on request.

Packaging Information

DepositTrol PY5200 is a liquid blend available in a wide variety of customized containers and delivery methods. Contact your GE representative for details.

Safety Precautions

A Material Safety Data Sheet containing detailed information about this product is available upon request.

Global Headquarters
Trevose, PA
215-355-3300

North America
Minnetonka, MN
952-933-2277

Europe/Middle East/Africa
Heverlee, Belgium
32-16-40-20-00

Asia/Pacific
Shanghai, China
86-21-5298-4573

PFC756EN0410

GE
Water & Process Technologies

Material Safety Data Sheet

Issue Date: 24-JUN-2009
Supercedes: 05-FEB-2009

FLOGARD MS6209

1 Identification

Identification of substance or preparation
FLOGARD MS6209

Product Application Area
Water-based corrosion inhibitor.

Company/Undertaking Identification
GE Betz, Inc.
4636 Somerton Road
Trevose, PA 19053
T 215 355-3300, F 215 953 5524

Emergency Telephone
(800) 877-1940

Prepared by Product Stewardship Group: T 215-355-3300 Prepared on: 24-JUN-2009

2 Hazard(s) identification

****

EMERGENCY OVERVIEW

DANGER

Corrosive to skin. Corrosive to the eyes. Mists/aerosols cause irritation to the upper respiratory tract.

DOT hazard: Corrosive to skin/steel
Odor: Slight; Appearance: Colorless To Yellow, Liquid

Fire fighters should wear positive pressure self-contained breathing apparatus(full face-piece type). Proper fire-extinguishing media: dry chemical/CO2/foam or water--slippery condition; use sand/grit.

****

POTENTIAL HEALTH EFFECTS

ACUTE SKIN EFFECTS:
Primary route of exposure; Corrosive to skin.

ACUTE EYE EFFECTS:
Corrosive to the eyes.

ACUTE RESPIRATORY EFFECTS:
Mists/aerosols cause irritation to the upper respiratory tract.

INGESTION EFFECTS:

May cause severe irritation or burning of mouth, throat, and gastrointestinal tract with severe chest and abdominal pain, nausea, vomiting, diarrhea, lethargy and collapse. Possible death when ingested in very large doses.

TARGET ORGANS:
Prolonged or repeated exposures may cause tissue necrosis.

MEDICAL CONDITIONS AGGRAVATED:
Not known.

SYMPTOMS OF EXPOSURE:
Causes severe irritation, burns or tissue ulceration with subsequent scarring.

3 Composition / information on ingredients

Information for specific product ingredients as required by the U.S. OSHA HAZARD COMMUNICATION STANDARD is listed. Refer to additional sections of this MSDS for our assessment of the potential hazards of this formulation.

HAZARDOUS INGREDIENTS:

Cas#	Chemical Name	Range(w/w%)
13598-37-3	PHOSPHORIC ACID, ZINC SALT (2:1) Irritant	40-70
7664-38-2	PHOSPHORIC ACID Corrosive	15-40

4 First-aid measures

SKIN CONTACT:
URGENT! Wash thoroughly with soap and water. Remove contaminated clothing. Get immediate medical attention. Thoroughly wash clothing before reuse.

EYE CONTACT:
URGENT! Immediately flush eyes with plenty of low-pressure water for at least 20 minutes while removing contact lenses. Hold eyelids apart. Get immediate medical attention.

INHALATION:
Remove to fresh air. If breathing is difficult, give oxygen. If breathing has stopped, give artificial respiration. Get immediate medical attention.

INGESTION:
Do not feed anything by mouth to an unconscious or convulsive victim. Do not induce vomiting. Immediately contact physician. Rinse mouth with plenty of water. Dilute contents of stomach using 4-10 fluid ounces (120-300 mL) of milk or water.

NOTES TO PHYSICIANS:
Material is corrosive. It may not be advisable to induce vomiting. Possible mucosal damage may contraindicate the use of gastric lavage.

5 Fire-fighting measures

FIRE FIGHTING INSTRUCTIONS:
Fire fighters should wear positive pressure self-contained breathing apparatus (full face-piece type).
EXTINGUISHING MEDIA:
dry chemical/CO2/foam or water--slippery condition; use sand/grit.
HAZARDOUS DECOMPOSITION PRODUCTS:
oxides of phosphorus
FLASH POINT:
> 200F   > 93C P-M(CC)
MISCELLANEOUS:
Corrosive to skin/steel
UN 1805;Emergency Response Guide #154

6 Accidental release measures

PROTECTION AND SPILL CONTAINMENT:
Ventilate area. Use specified protective equipment. Contain and absorb on absorbent material. Place in waste disposal container. Flush area with water. Wet area may be slippery. Spread sand/grit.
DISPOSAL INSTRUCTIONS:
Water contaminated with this product may be sent to a sanitary sewer treatment facility,in accordance with any local agreement,a permitted waste treatment facility or discharged under a permit. Product as is - Incinerate or land dispose in an approved landfill.

7 Handling and storage

HANDLING:
Acidic. Corrosive(Skin/eyes). Do not mix with alkaline material.
STORAGE:
Keep containers closed when not in use. Preferably stored between 40-100F (5-38C).

8 Exposure controls / personal protection

EXPOSURE LIMITS

CHEMICAL NAME

PHOSPHORIC ACID, ZINC SALT (2:1)
PEL (OSHA): NOT DETERMINED
TLV (ACGIH): NOT DETERMINED

PHOSPHORIC ACID
PEL (OSHA): 1 MG/M3
TLV (ACGIH): 1 MG/M3

ENGINEERING CONTROLS:
Adequate ventilation to maintain air contaminants below exposure limits.
PERSONAL PROTECTIVE EQUIPMENT:
Use protective equipment in accordance with 29CFR 1910 Subpart I
RESPIRATORY PROTECTION:
A RESPIRATORY PROTECTION PROGRAM THAT MEETS OSHA'S 29 CFR

1910.134 AND ANSI Z88.2 REQUIREMENTS MUST BE FOLLOWED WHENEVER WORKPLACE CONDITIONS WARRANT A RESPIRATOR'S USE.
USE AIR PURIFYING RESPIRATORS WITHIN USE LIMITATIONS ASSOCIATED WITH THE EQUIPMENT OR ELSE USE SUPPLIED AIR-RESPIRATORS.
If air-purifying respirator use is appropriate, use any of the following particulate respirators: N95, N99, N100, R95, R99, R100, P95, P99 or P100.

SKIN PROTECTION:
gauntlet-type rubber, butyl or neoprene gloves, chemical resistant apron -- Wash off after each use. Replace as necessary.

EYE PROTECTION:
splash proof chemical goggles, face shield

9 Physical and chemical properties

Spec. Grav.(70F,21C)	1.711	Vapor Pressure (mmHG)	~ 15.0
Freeze Point (F)	< -30	Vapor Density (air=1)	< 1.00
Freeze Point (C)	< -34		
Viscosity(cps 70F,21C)	70	% Solubility (water)	100.0

Odor		Slight
Appearance		Colorless To Yellow
Physical State		Liquid
Flash Point	P-M(CC)	> 200F > 93C
pH As Is (approx.)		< 1.0
Evaporation Rate (Ether=1)		< 1.00
Percent VOC:		0.0

NA = not applicable   ND = not determined

10 Stability and reactivity

CHEMICAL STABILITY:
Stable under normal storage conditions.

POSSIBILITY OF HAZARDOUS REACTIONS:
Contact with strong bases may cause a violent reaction releasing heat.

INCOMPATIBILITIES:
May react with bases or strong oxidizers.

DECOMPOSITION PRODUCTS:
oxides of phosphorus

11 Toxicological information

Oral LD50 RAT:	>2,500 mg/kg
NOTE - Estimated value	
Dermal LD50 RABBIT:	>5,000 mg/kg
NOTE - Estimated value	
Inhalation LC50 RAT:	>20 mg/L/hr
NOTE - Estimated value	
Skin Irritation Score RABBIT:	CORROSIVE
NOTE - EPA Category I	
Eye Irritation Score RABBIT:	CORROSIVE
NOTE - Estimated value	

12 Ecological information

AQUATIC TOXICOLOGY

Ceriodaphnia 48 Hour Static Renewal Bioassay
LC50= 1.5; No Effect Level= .63 mg/L
Ceriodaphnia 7 Day Static Renewal Bioassay
IC25 = 1.9 mg/L
Daphnia magna 48 Hour Static Renewal Bioassay
LC50= 12; No Effect Level= 1.5 mg/L
Fathead Minnow 7 Day Static Renewal Bioassay
IC25 = 5 mg/L
Fathead Minnow 96 Hour Static Renewal Bioassay
LC50= 14; No Effect Level= 2.5 mg/L
Rainbow Trout 96 Hour Static Renewal Bioassay
LC50= 4.9; No Effect Level= 1.6 mg/L

BIODEGRADATION

Product contains only inorganics that are not subject to typical biological degradation. Assimilation by microbes may occur in waste treatment or the environment.

13 Disposal considerations

If this undiluted product is discarded as a waste, the US RCRA hazardous waste identification number is :
D002=Corrosive (pH,steel); D006=Cadmium; D008=Lead.

Please be advised; however, that state and local requirements for waste disposal may be more restrictive or otherwise different from federal regulations. Consult state and local regulations regarding the proper disposal of this material.

14 Transport information

DOT HAZARD:	Corrosive to skin/steel
PROPER SHIPPING NAME:	PHOSPHORIC ACID SOLUTION 8, UN 1805, PG III, RQ
DOT EMERGENCY RESPONSE GUIDE #:	154

Note: Some containers may be DOT exempt, please check BOL for exact container classification

15 Regulatory information

TSCA:

All components of this product are included on or are in compliance with the U.S. TSCA regulations.

CERCLA AND/OR SARA REPORTABLE QUANTITY (RQ):

1,962 gallons due to PHOSPHORIC ACID;

FOOD AND DRUG ADMINISTRATION:

21 CFR 176.170 (components of paper and paperboard in contact with aqueous and fatty foods)

NSF Registered and/or meets USDA (according to 1998 Guidelines):

Registration number: 140901

Category Code(s):

SARA SECTION 312 HAZARD CLASS:

Immediate(acute);Delayed(Chronic)

SARA SECTION 302 CHEMICALS:

No regulated constituent present at OSHA thresholds

SARA SECTION 313 CHEMICALS:

CAS#	CHEMICAL NAME	RANGE
13598-37-3	PHOSPHORIC ACID, ZINC SALT (2:1)	41.0-50.0%

CALIFORNIA REGULATORY INFORMATION

CALIFORNIA SAFE DRINKING WATER AND TOXIC ENFORCEMENT ACT (PROPOSITION 65):

This product contains one or more ingredients at trace levels known to the state of California to cause cancer and reproductive toxicity.

MICHIGAN REGULATORY INFORMATION

No regulated constituent present at OSHA thresholds

16 Other information

HMIS vII		**CODE TRANSLATION**
Health	3	Serious Hazard
Fire	0	Minimal Hazard
Reactivity	0	Minimal Hazard
Special	CORR	DOT corrosive
(1) Protective Equipment	D	Goggles,Face Shield,Gloves,Apron

(1) refer to section 8 of MSDS for additional protective equipment recommendations.

CHANGE LOG

	EFFECTIVE DATE	REVISIONS TO SECTION:	SUPERCEDES
MSDS status:	29-JAN-1997		** NEW **
	05-JAN-1999	10	29-JAN-1997
	25-JUN-1999	11	05-JAN-1999
	23-AUG-1999	12	25-JUN-1999
	13-JUL-2000	15	23-AUG-1999
	03-JAN-2001	15	13-JUL-2000
	01-MAY-2001	12	03-JAN-2001
	01-MAY-2007	4,5,8,10,15	01-MAY-2001
	29-JAN-2008	4,8,13	01-MAY-2007
	29-JAN-2009	3,4,8,10,15	29-JAN-2008
	05-FEB-2009	12	29-JAN-2009
	24-JUN-2009	15	05-FEB-2009

GE BETZ, INC.
MATERIAL SAFETY DATA SHEET

EFFECTIVE DATE:
PRINTED DATE: 02-MAR-2009 SUPERCEDES:

---

1) Identification

Identification of substance or preparation
FLOGARD MS6235

Product Application Area
ONCE-THROUGH SYSTEM TREATMENT

Company/Undertaking Identification
GE Betz, Inc.
4636 Somerton Road, Trevose, Pa. 19053
T 215 355 3300 F 215 953 5524

Emergency Telephone
1 800 877 1940

Prepared by Product Stewardship Group: 215 355-3300

---

2) HAZARD(S) IDENTIFICATION

****

EMERGENCY OVERVIEW

CAUTION

May cause slight irritation to the skin. May cause moderate irritation to the eyes. Mists/aerosols may cause irritation to upper respiratory tract.

DOT hazard: Corrosive to steel
Odor: None; Appearance: Colorless, Liquid

Fire fighters should wear positive pressure self-contained breathing apparatus(full face-piece type). Proper fire-extinguishing media: dry chemical, carbon dioxide, foam or water

****

POTENTIAL HEALTH EFFECTS

ACUTE SKIN EFFECTS:
Primary route of exposure; May cause slight irritation to the skin.

ACUTE EYE EFFECTS:
May cause moderate irritation to the eyes.

ACUTE RESPIRATORY EFFECTS:
Mists/aerosols may cause irritation to upper respiratory tract.

INGESTION EFFECTS:
May cause gastrointestinal irritation.

TARGET ORGANS:
No evidence of potential chronic effects.

MEDICAL CONDITIONS AGGRAVATED:
Not known.

SYMPTOMS OF EXPOSURE:
May cause redness or itching of skin.

3) COMPOSITION / INFORMATION ON INGREDIENTS

Information for specific product ingredients as required by the U.S. OSHA HAZARD COMMUNICATION STANDARD is listed. Refer to additional sections of this MSDS for our assessment of the potential hazards of this formulation.

HAZARDOUS INGREDIENTS:

Cas#	Chemical Name	Range(w/w%)
7758-29-4	SODIUM TRIPOLYPHOSPHATE Potential irritant	10-20

4) FIRST-AID MEASURES

SKIN CONTACT:
Wash thoroughly with soap and water. Remove contaminated clothing. Get medical attention if irritation develops or persists.
EYE CONTACT:
Remove contact lenses. Hold eyelids apart. Immediately flush eyes with plenty of low-pressure water for at least 15 minutes. Get immediate medical attention.
INHALATION:
If nasal, throat or lung irritation develops - remove to fresh air and get medical attention.
INGESTION:
Do not feed anything by mouth to an unconscious or convulsive victim. Do not induce vomiting. Immediately contact physician. Dilute contents of stomach using 2-8 fluid ounces (60-240 mL) of milk or water.
NOTES TO PHYSICIANS:
No special instructions

5) FIRE-FIGHTING MEASURES

FIRE FIGHTING INSTRUCTIONS:
Fire fighters should wear positive pressure self-contained breathing apparatus (full face-piece type).
EXTINGUISHING MEDIA:
dry chemical, carbon dioxide, foam or water
HAZARDOUS DECOMPOSITION PRODUCTS:
oxides of phosphorus
FLASH POINT:
> 213F   > 101C P-M(CC)

---

6) ACCIDENTAL RELEASE MEASURES

PROTECTION AND SPILL CONTAINMENT:
Ventilate area. Use specified protective equipment. Contain and absorb on absorbent material. Place in waste disposal container. Flush area with water. Wet area may be slippery. Spread sand/grit.
DISPOSAL INSTRUCTIONS:
Water contaminated with this product may be sent to a sanitary sewer treatment facility,in accordance with any local agreement,a permitted waste treatment facility or discharged under a permit. Product as is - Incinerate or land dispose in an approved landfill.

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7) HANDLING AND STORAGE

HANDLING:
Normal chemical handling.
STORAGE:
Keep containers closed when not in use. Protect from freezing. If frozen, thaw and mix completely prior to use. Store below 100F (38C). Shelf life 90 days.

---

8) EXPOSURE CONTROLS/PERSONAL PROTECTION

CHEMICAL NAME	EXPOSURE LIMITS
SODIUM TRIPOLYPHOSPHATE	
PEL (OSHA):	NOT DETERMINED
TLV (ACGIH):	NOT DETERMINED

ENGINEERING CONTROLS:
adequate ventilation
PERSONAL PROTECTIVE EQUIPMENT:
Use protective equipment in accordance with 29CFR 1910 Subpart I
RESPIRATORY PROTECTION:
A RESPIRATORY PROTECTION PROGRAM THAT MEETS OSHA'S 29 CFR 1910.134 AND ANSI Z88.2 REQUIREMENTS MUST BE FOLLOWED WHENEVER WORKPLACE CONDITIONS WARRANT A RESPIRATOR'S USE.

CONTINUED

USE AIR PURIFYING RESPIRATORS WITHIN USE LIMITATIONS ASSOCIATED WITH THE EQUIPMENT OR ELSE USE SUPPLIED AIR-RESPIRATORS.

If air-purifying respirator use is appropriate, use any of the following particulate respirators: N95, N99, N100, R95, R99, R100, P95, P99 or P100.

SKIN PROTECTION:

rubber, butyl, viton or neoprene gloves -- Wash off after each use. Replace as necessary.

EYE PROTECTION:

splash proof chemical goggles

---

9) PHYSICAL AND CHEMICAL PROPERTIES

Specific Grav.(70F,21C)	1.336	Vapor Pressure (mmHG)	~ 18.0
Freeze Point (F)	~ 27	Vapor Density (air=1)	< 1.00
Freeze Point (C)	~ -3		
Viscosity(cps 70F,21C)	29	% Solubility (water)	100.0

Odor		None
Appearance		Colorless
Physical State		Liquid
Flash Point	P-M(CC)	> 213F > 100C
pH As Is (approx.)		7.5
Evaporation Rate (Ether=1)		< 1.00
Percent VOC:		0.0

NA = not applicable   ND = not determined

---

10) STABILITY AND REACTIVITY

CHEMICAL STABILITY:

Stable under normal storage conditions.

POSSIBILITY OF HAZARDOUS REACTIONS:

No known hazardous reactions.

INCOMPATIBILITIES:

May react with strong oxidizers.

DECOMPOSITION PRODUCTS:

oxides of phosphorus

---

11) TOXICOLOGICAL INFORMATION

No Data Available.

---

12) ECOLOGICAL INFORMATION

AQUATIC TOXICOLOGY

Ceriodaphnia 48 Hour Static Renewal Bioassay
LC50= 759; No Effect Level= 480 mg/L

Ceriodaphnia 7 Day Chronic Bioassay
IC25 = 623; LC50= 759 mg/L

Fathead Minnow 7 Day Chronic Bioassay
LC50= 1441; IC25 = 605 mg/L

Fathead Minnow 96 Hour Static Renewal Bioassay
LC50= 1654; No Effect Level= 480 mg/L

BIODEGRADATION
No Data Available.

---

13) DISPOSAL CONSIDERATIONS

If this undiluted product is discarded as a waste, the US RCRA hazardous waste identification number is : D002=Corrosive(steel).

Please be advised; however, that state and local requirements for waste disposal may be more restrictive or otherwise different from federal regulations. Consult state and local regulations regarding the proper disposal of this material.

---

14) TRANSPORT INFORMATION

DOT HAZARD:	Corrosive to steel
PROPER SHIPPING NAME:	CORROSIVE LIQUID, N.O.S.(SODIUM TRIPOLYPHOSPHATE) 8, UN1760, PG III, RQ

DOT EMERGENCY RESPONSE GUIDE #: 154
Note: Some containers may be DOT exempt, please check BOL for exact container classification

---

15) REGULATORY INFORMATION

TSCA:
All components of this product are included on or are in compliance with the U.S. TSCA regulations.
CERCLA AND/OR SARA REPORTABLE QUANTITY (RQ):
4,321 gallons due to SODIUM TRIPOLYPHOSPHATE;
NSF Registered and/or meets USDA (according to 1998 Guidelines):
Registration number: Not Registered
SARA SECTION 312 HAZARD CLASS:
Immediate(acute)
SARA SECTION 302 CHEMICALS:
No regulated constituent present at OSHA thresholds
SARA SECTION 313 CHEMICALS:
No regulated constituent present at OSHA thresholds

CALIFORNIA REGULATORY INFORMATION

CALIFORNIA SAFE DRINKING WATER AND TOXIC ENFORCEMENT ACT (PROPOSITION 65):
No regulated constituents present

MICHIGAN REGULATORY INFORMATION

No regulated constituent present at OSHA thresholds

---

16) OTHER INFORMATION

HMIS vII		CODE TRANSLATION
Health	1	Slight Hazard
Fire	0	Minimal Hazard
Reactivity	0	Minimal Hazard
Special	CORR	DOT corrosive
(1) Protective Equipment	B	Goggles,Gloves

(1) refer to section 8 of MSDS for additional protective equipment recommendations.

CHANGE LOG

	EFFECTIVE DATE	REVISIONS TO SECTION:	SUPERCEDES
MSDS status:		** NEW **	

GE
Water & Process Technologies

Material Safety Data Sheet

Issue Date: 29-FEB-2008
Supercedes: 23-JAN-2007

FLOGARD MS6201

1 Identification of Product and Company

Identification of substance or preparation
FLOGARD MS6201

Product Application Area
Water-based corrosion inhibitor.

Company/Undertaking Identification
GE Betz, Inc.
4636 Somerton Road
Trevose, PA 19053
T 215 355-3300, F 215 953 5524

Emergency Telephone
(800) 877-1940

Prepared by Product Stewardship Group: 215 355-3300

2 Composition / Information On Ingredients

Information for specific product ingredients as required by the U.S. OSHA HAZARD COMMUNICATION STANDARD is listed. Refer to additional sections of this MSDS for our assessment of the potential hazards of this formulation.

HAZARDOUS INGREDIENTS:

Cas#	Chemical Name	Range(w/w%)
7320-34-5	TETRAPOTASSIUM PYROPHOSPHATE Corrosive to aluminum; severe eye irritant; skin irritant	40-70

3 Hazards Identification

****
EMERGENCY OVERVIEW

WARNING

May cause moderate irritation to the skin. Severe irritant to the eyes. Mists/aerosols may cause irritation to upper respiratory tract.

DOT hazard: Corrosive to aluminum
Odor: Slight; Appearance: Colorless To Yellow, Liquid

Fire fighters should wear positive pressure self-contained breathing apparatus(full face-piece type). Proper fire-extinguishing media: dry chemical, carbon dioxide, foam or water

****

POTENTIAL HEALTH EFFECTS

ACUTE SKIN EFFECTS:
Primary route of exposure; May cause moderate irritation to the skin.

ACUTE EYE EFFECTS:
Severe irritant to the eyes.

ACUTE RESPIRATORY EFFECTS:
Mists/aerosols may cause irritation to upper respiratory tract.

INGESTION EFFECTS:
May cause slight gastrointestinal irritation.

TARGET ORGANS:
No evidence of potential chronic effects.

MEDICAL CONDITIONS AGGRAVATED:
Not known.

SYMPTOMS OF EXPOSURE:
May cause redness or itching of skin.

4 First Aid Measures

SKIN CONTACT:
Wash thoroughly with soap and water. Remove contaminated clothing. Thoroughly wash clothing before reuse. Get medical attention if irritation develops or persists.

EYE CONTACT:
Remove contact lenses. Hold eyelids apart. Immediately flush eyes with plenty of low-pressure water for at least 15 minutes. Get immediate medical attention.

INHALATION:
If nasal, throat or lung irritation develops - remove to fresh air and get medical attention.

INGESTION:
Do not feed anything by mouth to an unconscious or convulsive victim. Do not induce vomiting. Immediately contact physician. Dilute contents of stomach using 2-8 fluid ounces (60-240 mL) of milk or water.

NOTES TO PHYSICIANS:
No special instructions

5 Fire Fighting Measures

FIRE FIGHTING INSTRUCTIONS:
Fire fighters should wear positive pressure self-contained breathing apparatus (full face-piece type).
EXTINGUISHING MEDIA:
dry chemical, carbon dioxide, foam or water
HAZARDOUS DECOMPOSITION PRODUCTS:
oxides of phosphorus
FLASH POINT:
> 200F > 93C SETA(CC)

6 Accidental Release Measures

PROTECTION AND SPILL CONTAINMENT:
Ventilate area. Use specified protective equipment. Contain and absorb on absorbent material. Place in waste disposal container. Contaminated area may be washed down with water.
DISPOSAL INSTRUCTIONS:
Water contaminated with this product may be sent to a sanitary sewer treatment facility,in accordance with any local agreement,a permitted waste treatment facility or discharged under a permit. Product as is - Incinerate or land dispose in an approved landfill.

7 Handling & Storage

HANDLING:
Alkaline. Do not mix with acidic material.
STORAGE:
Keep containers closed when not in use. Reasonable and safe chemical storage.

8 Exposure Controls / Personal Protection

EXPOSURE LIMITS

CHEMICAL NAME

TETRAPOTASSIUM PYROPHOSPHATE
PEL (OSHA): NOT DETERMINED
TLV (ACGIH): NOT DETERMINED

ENGINEERING CONTROLS:
adequate ventilation
PERSONAL PROTECTIVE EQUIPMENT:
Use protective equipment in accordance with 29CFR 1910 Subpart I
RESPIRATORY PROTECTION:
A RESPIRATORY PROTECTION PROGRAM THAT MEETS OSHA'S 29 CFR 1910.134 AND ANSI Z88.2 REQUIREMENTS MUST BE FOLLOWED WHENEVER WORKPLACE CONDITIONS WARRANT A RESPIRATOR'S USE.
USE AIR PURIFYING RESPIRATORS WITHIN USE LIMITATIONS ASSOCIATED WITH THE EQUIPMENT OR ELSE USE SUPPLIED AIR-RESPIRATORS.
If air-purifying respirator use is appropriate, use any of the following particulate respirators: N95, N99, N100, R95, R99, R100, P95, P99 or P100.
SKIN PROTECTION:
rubber, viton or neoprene gloves -- Wash off after each use. Replace as necessary.
EYE PROTECTION:
splash proof chemical goggles

9 Physical & Chemical Properties

Specific Grav.(70F,21C)	1.729	Vapor Pressure (mmHG)	~ 15.0
Freeze Point (F)	< -30	Vapor Density (air=1)	< 1.00
Freeze Point (C)	< -34		
Viscosity(cps 70F,21C)	78	% Solubility (water)	100.0

Odor		Slight
Appearance		Colorless To Yellow
Physical State		Liquid
Flash Point	SETA(CC)	> 200F > 93C
pH As Is (approx.)		13.0
Evaporation Rate (Ether=1)		< 1.00
Percent VOC:		0.0

NA = not applicable   ND = not determined

10 Stability & Reactivity

STABILITY:
Stable under normal storage conditions.
HAZARDOUS POLYMERIZATION:
Will not occur.
INCOMPATIBILITIES:
May react with strong oxides.
DECOMPOSITION PRODUCTS:
oxides of phosphorus
INTERNAL PUMPOUT/CLEANOUT CATEGORIES:
"A"

11 Toxicological Information

Oral LD50 RAT:	2,980 mg/kg
Dermal LD50 RABBIT:	>7,940 mg/kg
Skin Irritation Score RABBIT:	0.5

12 Ecological Information

AQUATIC TOXICOLOGY

Bluegill Sunfish 48 Hour Static Screen
0% Mortality= 500 mg/L
Daphnia magna 48 Hour Static Renewal Bioassay (pH adjusted)
LC50= 660; No Effect Level= 268 mg/L
Fathead Minnow 96 Hour Static Renewal Bioassay (pH adjusted)
LC50= 785; No Effect Level= 423 mg/L

BIODEGRADATION
Product contains only inorganics that are not subject to typical biological degradation. Assimilation by microbes may occur in waste treatment or the environment.

13 Disposal Considerations

If this undiluted product is discarded as a waste, the US RCRA hazardous waste identification number is : D002=Corrosive(pH).

Please be advised; however, that state and local requirements for waste disposal may be more restrictive or otherwise different from federal regulations. Consult state and local regulations regarding the proper disposal of this material.

14 Transport Information

DOT HAZARD:	Corrosive to aluminum
PROPER SHIPPING NAME:	CORROSIVE LIQUID, BASIC, INORGANIC, N.O.S.(POTASSIUM HYDROXIDE) 8, UN 3266, PG III
DOT EMERGENCY RESPONSE GUIDE #:	154

Note: Some containers may be DOT exempt, please check BOL for exact container classification

15 Regulatory Information

TSCA:
All components of this product are included on or are in compliance with the U.S. TSCA regulations.

CERCLA AND/OR SARA REPORTABLE QUANTITY (RQ):
No regulated constituent present at OSHA thresholds

FOOD AND DRUG ADMINISTRATION:
21 CFR 176.170 (components of paper and paperboard in contact with aqueous and fatty foods)

USDA FOOD PLANT APPROVALS:
SEC.G2,G5,G7

SARA SECTION 312 HAZARD CLASS:
Immediate(acute)

SARA SECTION 302 CHEMICALS:
No regulated constituent present at OSHA thresholds

SARA SECTION 313 CHEMICALS:
No regulated constituent present at OSHA thresholds

CALIFORNIA REGULATORY INFORMATION

CALIFORNIA SAFE DRINKING WATER AND TOXIC ENFORCEMENT ACT (PROPOSITION 65):
No regulated constituents present

MICHIGAN REGULATORY INFORMATION

No regulated constituent present at OSHA thresholds

16 Other Information

NFPA/HMIS		CODE TRANSLATION
Health	2	Moderate Hazard
Fire	0	Minimal Hazard
Reactivity	0	Minimal Hazard
Special	CORR	DOT corrosive
(1) Protective Equipment	B	Goggles,Gloves

(1) refer to section 8 of MSDS for additional protective equipment recommendations.

CHANGE LOG

	EFFECTIVE DATE	REVISIONS TO SECTION:	SUPERCEDES
MSDS status:	28-JAN-1997		** NEW **
	12-MAY-1997	15	28-JAN-1997
	29-MAY-1998	15	12-MAY-1997
	15-JUN-1998	15	29-MAY-1998
	31-MAY-2001	15	15-JUN-1998
	15-JAN-2002	4	31-MAY-2001
	29-NOV-2006	4	15-JAN-2002
	23-JAN-2007	3,5,14	29-NOV-2006
	29-FEB-2008	2,3,4,8,16	23-JAN-2007

Water & Process Technologies

Fact Sheet

FloGard™ MS6201

General Corrosion Inhibitor & Chelant

- Mild steel corrosion inhibitor for once-thorough and recirculating cooling systems
- Effective iron, manganese and calcium chelant for once-through cooling systems
- FDA approved for paper mill supply applications

Description and Use

FloGard™ MS6201 is a liquid polyphosphate product designed to inhibit corrosion and deposition in once-through and recirculating cooling water systems.

Once-through Systems - At typical use levels, the polyphosphate in FloGard MS6201 combines with calcium and/or zinc to form a barrier film as a cathodic inhibitor.

FloGard MS6201 also functions as a deposit control agent. Uncontrolled deposition in a water system can cause numerous problems including reduced heat transfer, restricted water flow and under-deposit corrosion. FloGard MS6201 effectively controls deposition of iron, manganese and calcium to minimize these operating problems.

Recirculating Cooling Systems - FloGard MS6201 is often used in combination with other corrosion inhibitors to minimize corrosion of mild steel surfaces.

Treatment and Feeding Requirements

Proper treatment levels for FloGard MS6201 depend on many factors, such as the cal-cium concentration and pH of the water, and other conditions particular to a given installation. This product should be used in accordance with control procedures GE Infrastructure Water & Process Technologies establishes for a specific application.

FloGard MS6201 may be fed directly from the shipping container or diluted to a convenient strength. For best results, this product should be fed continuously.

A photometric procedure can be used to monitor the total inorganic phosphate level in the treated water.

General Properties

Physical properties of FloGard MS6201 are shown on the Material Safety Data Sheet, a copy of which is available upon request.

Packaging Information

FloGard MS6201 is a liquid blend, supplied in 55-gallon (208-liter), bung-type, nonreturnable steel drums. In addition, it is also available under the GE Semi-Bulk Control™ and Point Of Feed™ Service Programs for contracted quantities in certain geographic areas.

Storage

Protect from freezing. If this product is frozen during shipment or storage, slight mixing may be required to ensure homogeneity.

Safety Precautions

A Material Safety Data Sheet containing detailed information about this product is available upon request.

Visit us online at www.gewater.com

Global Headquarters
Trevose, PA
215-355-3300

North America
Minnetonka, MN
952-933-2277

Europe/Middle East/Africa
Heverlee, Belgium
32-16-40-20-00

Asia/Pacific
Shanghai, China
86-21-5298-4573

GE
Water & Process Technologies

Material Safety Data Sheet

Issue Date: 24-JUN-2009
Supercedes: 05-FEB-2009

SPECTRUS BD1500

1 Identification

Identification of substance or preparation
SPECTRUS BD1500

Product Application Area
Water-based deposit control agent.

Company/Undertaking Identification
GE Betz, Inc.
4636 Somerton Road
Trevose, PA 19053
T 215 355-3300, F 215 953 5524

Emergency Telephone
(800) 877-1940

Prepared by Product Stewardship Group: T 215-355-3300   Prepared on: 24-JUN-2009

2 Hazard(s) identification

****

EMERGENCY OVERVIEW

CAUTION

May cause slight irritation to the skin. May cause moderate irritation to the eyes. Mists/aerosols may cause irritation to upper respiratory tract.

DOT hazard is not applicable
Odor: Slight; Appearance: Colorless, Liquid

Fire fighters should wear positive pressure self-contained breathing apparatus(full face-piece type). Proper fire-extinguishing media: dry chemical, carbon dioxide, foam or water

****

POTENTIAL HEALTH EFFECTS

ACUTE SKIN EFFECTS:
Primary route of exposure; May cause slight irritation to the skin.

ACUTE EYE EFFECTS:
May cause moderate irritation to the eyes.

ACUTE RESPIRATORY EFFECTS:
Mists/aerosols may cause irritation to upper respiratory tract.

INGESTION EFFECTS:
May cause slight gastrointestinal irritation.

TARGET ORGANS:
No evidence of potential chronic effects.

MEDICAL CONDITIONS AGGRAVATED:
Not known.

SYMPTOMS OF EXPOSURE:
May cause redness or itching of skin.

3 Composition / information on ingredients

Information for specific product ingredients as required by the U.S. OSHA HAZARD COMMUNICATION STANDARD is listed. Refer to additional sections of this MSDS for our assessment of the potential hazards of this formulation.

HAZARDOUS INGREDIENTS:

This product is not hazardous as defined by OSHA regulations.

No component is considered to be a carcinogen by the National Toxicology Program, the International Agency for Research on Cancer, or the Occupational Safety and Health Administration at OSHA thresholds for carcinogens.

4 First-aid measures

SKIN CONTACT:
Wash thoroughly with soap and water. Remove contaminated clothing. Get medical attention if irritation develops or persists.
EYE CONTACT:
Remove contact lenses. Hold eyelids apart. Immediately flush eyes with plenty of low-pressure water for at least 15 minutes. Get immediate medical attention.
INHALATION:
If nasal, throat or lung irritation develops - remove to fresh air and get medical attention.
INGESTION:
Do not feed anything by mouth to an unconscious or convulsive victim. Do not induce vomiting. Immediately contact physician. Dilute contents of stomach using 2-8 fluid ounces (60-240 mL) of milk or water.
NOTES TO PHYSICIANS:
No special instructions

5 Fire-fighting measures

FIRE FIGHTING INSTRUCTIONS:
Fire fighters should wear positive pressure self-contained breathing apparatus (full face-piece type).
EXTINGUISHING MEDIA:
dry chemical, carbon dioxide, foam or water
HAZARDOUS DECOMPOSITION PRODUCTS:
oxides of carbon
FLASH POINT:
> 200F   > 93C SETA(CC)

6 Accidental release measures

PROTECTION AND SPILL CONTAINMENT:
Ventilate area. Use specified protective equipment. Contain and absorb on absorbent material. Place in waste disposal container. Flush area with water. Wet area may be slippery. Spread sand/grit.
DISPOSAL INSTRUCTIONS:
Water contaminated with this product may be sent to a sanitary sewer treatment facility,in accordance with any local agreement,a permitted waste treatment facility or discharged under a permit. Product as is - Incinerate or land dispose in an approved landfill.

7 Handling and storage

HANDLING:
Alkaline. Do not mix with acidic material.
STORAGE:
Keep containers closed when not in use. Reasonable and safe chemical storage.

8 Exposure controls / personal protection

EXPOSURE LIMITS

This product is not hazardous as defined by OSHA regulations.

ENGINEERING CONTROLS:
adequate ventilation
PERSONAL PROTECTIVE EQUIPMENT:
Use protective equipment in accordance with 29CFR 1910 Subpart I
RESPIRATORY PROTECTION:
A RESPIRATORY PROTECTION PROGRAM THAT MEETS OSHA'S 29 CFR 1910.134 AND ANSI Z88.2 REQUIREMENTS MUST BE FOLLOWED WHENEVER WORKPLACE CONDITIONS WARRANT A RESPIRATOR'S USE.
USE AIR PURIFYING RESPIRATORS WITHIN USE LIMITATIONS ASSOCIATED WITH THE EQUIPMENT OR ELSE USE SUPPLIED AIR-RESPIRATORS.
If air-purifying respirator use is appropriate, use any of the following particulate respirators: N95, N99, N100, R95, R99, R100, P95, P99 or P100.
SKIN PROTECTION:
rubber, butyl or viton gloves -- Wash off after each use. Replace as necessary.
EYE PROTECTION:
splash proof chemical goggles

9 Physical and chemical properties

Spec. Grav.(70F,21C)	1.020	Vapor Pressure (mmHG)	~ 18.0
Freeze Point (F)	31	Vapor Density (air=1)	< 1.00
Freeze Point (C)	-1		
Viscosity(cps 70F,21C)	30	% Solubility (water)	100.0

Odor		Slight
Appearance		Colorless
Physical State		Liquid
Flash Point	SETA(CC)	> 200F > 93C
pH As Is (approx.)		12.5
Evaporation Rate (Ether=1)		< 1.00
Percent VOC:		0.0

NA = not applicable   ND = not determined

10 Stability and reactivity

CHEMICAL STABILITY:
Stable under normal storage conditions.
POSSIBILITY OF HAZARDOUS REACTIONS:
Contact with strong acids may cause a violent reaction releasing heat.
INCOMPATIBILITIES:
May react with strong oxidizers.
DECOMPOSITION PRODUCTS:
oxides of carbon

11 Toxicological information

Oral LD50 RAT:	>4,600 mg/kg
NOTE - Estimated value	
Dermal LD50 RABBIT:	>2,000 mg/kg
NOTE - Estimated value	

12 Ecological information

AQUATIC TOXICOLOGY

Ceriodaphnia 48 Hour Static Renewal Bioassay
LC50 Greater Than= 3000 mg/L
Ceriodaphnia 7 Day Static Renewal Bioassay
IC25 = 652 mg/L
Daphnia magna 48 Hour Static Acute Bioassay
0% Mortality= 2000 mg/L
Fathead Minnow 7 Day Static Renewal Bioassay
IC25 = 3000; LC50 Greater Than= 3000 mg/L
Fathead Minnow 96 Hour Static Bioassay with 48-Hour Renewal
0% Mortality= 2000 mg/L
Menidia beryllina (Silversides) 96 Hour Static Acute Bioassay
0% Mortality= 5000 mg/L
Mysid Shrimp 96 Hour Static Acute Bioassay
25% Mortality= 5000; No Effect Level= 2500 mg/L
Rainbow Trout 96 Hour Static Renewal Bioassay
No Effect Level= 3000 mg/L

No Data Available.

BIODEGRADATION

BOD-28 (mg/g): 5
BOD-5 (mg/g): 4
COD (mg/g): 341
TOC (mg/g): 80

13 Disposal considerations

If this undiluted product is discarded as a waste, the US RCRA hazardous waste identification number is : D002=Corrosive(pH).

Please be advised; however, that state and local requirements for waste disposal may be more restrictive or otherwise different from federal regulations. Consult state and local regulations regarding the proper disposal of this material.

14 Transport information

DOT HAZARD: Not Applicable
PROPER SHIPPING NAME:

DOT EMERGENCY RESPONSE GUIDE #: Not applicable
Note: Some containers may be DOT exempt, please check BOL for exact container classification

15 Regulatory information

TSCA:
All components of this product are included on or are in compliance with the U.S. TSCA regulations.

CERCLA AND/OR SARA REPORTABLE QUANTITY (RQ):
No regulated constituent present at OSHA thresholds

FOOD AND DRUG ADMINISTRATION:
21 CFR 176.170 (components of paper and paperboard in contact with aqueous and fatty foods)

NSF Registered and/or meets USDA (according to 1998 Guidelines):
Registration number: 141059
Category Code(s):

G5 Cooling and retort water treatment products - all food processing areas

G7 Boiler treatment products - all food processing areas/nonfood contact

SARA SECTION 312 HAZARD CLASS:
Product is non-hazardous under Section 311/312

SARA SECTION 302 CHEMICALS:
No regulated constituent present at OSHA thresholds

SARA SECTION 313 CHEMICALS:
No regulated constituent present at OSHA thresholds

CALIFORNIA REGULATORY INFORMATION

CALIFORNIA SAFE DRINKING WATER AND TOXIC ENFORCEMENT ACT (PROPOSITION 65):
This product contains one or more ingredients at trace levels known

to the state of California to cause cancer and reproductive toxicity.

MICHIGAN REGULATORY INFORMATION

No regulated constituent present at OSHA thresholds

16 Other information

HMIS vII		CODE TRANSLATION
Health	1	Slight Hazard
Fire	0	Minimal Hazard
Reactivity	0	Minimal Hazard
Special	ALK	pH above 12.0
(1) Protective Equipment	B	Goggles,Gloves

(1) refer to section 8 of MSDS for additional protective equipment recommendations.

CHANGE LOG

	EFFECTIVE DATE	REVISIONS TO SECTION:	SUPERCEDES
MSDS status:	14-JUL-1997		** NEW **
	09-SEP-1998	15	14-JUL-1997
	15-SEP-1998	15	09-SEP-1998
	25-JUN-1999	11	15-SEP-1998
	02-APR-2001	12	25-JUN-1999
	25-JUN-2001	15	02-APR-2001
	05-OCT-2001	4,16	25-JUN-2001
	10-JAN-2002	15	05-OCT-2001
	18-JAN-2002	15	10-JAN-2002
	07-FEB-2006	12	18-JAN-2002
	10-JUL-2008	4,8,11,15	07-FEB-2006
	31-OCT-2008	11	10-JUL-2008
	05-FEB-2009	12	31-OCT-2008
	24-JUN-2009	10,15	05-FEB-2009

GE
Water & Process Technologies

Material Safety Data Sheet

Issue Date: 28-JAN-2009
Supercedes: 16-OCT-2006

SPECTRUS OX1201

1 Identification

Identification of substance or preparation
SPECTRUS OX1201

Product Application Area
Water-based microbial control agent.

Company/Undertaking Identification
GE Betz, Inc.
4636 Somerton Road
Trevose, PA 19053
T 215 355-3300, F 215 953 5524

Emergency Telephone
(800) 877-1940

Prepared by Product Stewardship Group: T 215-355-3300 Prepared on: 28-JAN-2009

2 Hazard(s) identification

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*******************************************************************************
                           EMERGENCY OVERVIEW

  CAUTION

        Non-hazardous to skin. May cause moderate irritation to the eyes.
        Mists/aerosols may cause irritation to upper respiratory tract.

        DOT hazard is not applicable
        Odor: Slight; Appearance: Colorless, Liquid

        Fire fighters should wear positive pressure self-contained breathing
        apparatus(full face-piece type). Proper fire-extinguishing media:
        dry chemical, carbon dioxide, foam or water
*******************************************************************************
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POTENTIAL HEALTH EFFECTS

ACUTE SKIN EFFECTS:
Primary route of exposure; Non-hazardous to skin.

ACUTE EYE EFFECTS:
May cause moderate irritation to the eyes.

ACUTE RESPIRATORY EFFECTS:
Mists/aerosols may cause irritation to upper respiratory tract.

INGESTION EFFECTS:

May cause gastrointestinal irritation.

TARGET ORGANS:
No evidence of potential chronic effects.

MEDICAL CONDITIONS AGGRAVATED:
Not known.

SYMPTOMS OF EXPOSURE:
May cause redness or itching of skin.

3 Composition / information on ingredients

Information for specific product ingredients as required by the U.S. OSHA HAZARD COMMUNICATION STANDARD is listed. Refer to additional sections of this MSDS for our assessment of the potential hazards of this formulation.

HAZARDOUS INGREDIENTS:

Cas#	Chemical Name	Range(w/w%)
7647-15-6	SODIUM BROMIDE Irritant	30-60

4 First-aid measures

SKIN CONTACT:
Wash thoroughly with soap and water. Remove contaminated clothing. Get medical attention if irritation develops or persists.

EYE CONTACT:
Remove contact lenses. Hold eyelids apart. Immediately flush eyes with plenty of low-pressure water for at least 15 minutes. Get immediate medical attention.

INHALATION:
If nasal, throat or lung irritation develops - remove to fresh air and get medical attention.

INGESTION:
Do not feed anything by mouth to an unconscious or convulsive victim. Do not induce vomiting. Immediately contact physician. Dilute contents of stomach using 2-8 fluid ounces (60-240 mL) of milk or water.

NOTES TO PHYSICIANS:
Probable mucosal damage may contraindicate the use of gastric lavage.

5 Fire-fighting measures

FIRE FIGHTING INSTRUCTIONS:
Fire fighters should wear positive pressure self-contained breathing apparatus (full face-piece type).
EXTINGUISHING MEDIA:
dry chemical, carbon dioxide, foam or water
HAZARDOUS DECOMPOSITION PRODUCTS:
hydrogen bromide
FLASH POINT:
> 200F > 93C P-M(CC)

6 Accidental release measures

PROTECTION AND SPILL CONTAINMENT:
Ventilate area. Use specified protective equipment. Contain and absorb on absorbent material. Place in waste disposal container. Contaminated area may be washed down with water.
DISPOSAL INSTRUCTIONS:
Water contaminated with this product may be sent to a sanitary sewer treatment facility,in accordance with any local agreement,a permitted waste treatment facility or discharged under a permit. Product as is - Dispose of in approved pesticide facility or according to label instructions.

7 Handling and storage

HANDLING:
Normal chemical handling.
STORAGE:
Keep containers closed when not in use. Protect from freezing. Do not store at elevated temperatures. Shelf life 360 days.

8 Exposure controls / personal protection

EXPOSURE LIMITS

CHEMICAL NAME

SODIUM BROMIDE
PEL (OSHA): NOT DETERMINED
TLV (ACGIH): NOT DETERMINED

ENGINEERING CONTROLS:
adequate ventilation
PERSONAL PROTECTIVE EQUIPMENT:
Use protective equipment in accordance with 29CFR 1910 Subpart I
RESPIRATORY PROTECTION:
A RESPIRATORY PROTECTION PROGRAM THAT MEETS OSHA'S 29 CFR 1910.134 AND ANSI Z88.2 REQUIREMENTS MUST BE FOLLOWED WHENEVER WORKPLACE CONDITIONS WARRANT A RESPIRATOR'S USE.
USE AIR PURIFYING RESPIRATORS WITHIN USE LIMITATIONS ASSOCIATED WITH THE EQUIPMENT OR ELSE USE SUPPLIED AIR-RESPIRATORS.
If air-purifying respirator use is appropriate, use any of the following particulate respirators: N95, N99, N100, R95, R99, R100, P95, P99 or P100.
SKIN PROTECTION:
rubber, butyl, viton or neoprene gloves -- Wash off after

each use. Replace as necessary.

EYE PROTECTION:

splash proof chemical goggles

9 Physical and chemical properties

Specific Grav.(70F,21C)	1.403	Vapor Pressure (mmHG)	~ 18.0
Freeze Point (F)	< -30	Vapor Density (air=1)	< 1.00
Freeze Point (C)	< -34		
Viscosity(cps 70F,21C)	12	% Solubility (water)	100.0

Odor		Slight
Appearance		Colorless
Physical State		Liquid
Flash Point	P-M(CC)	> 200F > 93C
pH As Is (approx.)		7.5
Evaporation Rate (Ether=1)		< 1.00
Percent VOC:		0.0

NA = not applicable   ND = not determined

10 Stability and reactivity

CHEMICAL STABILITY:

Stable under normal storage conditions.

POSSIBILITY OF HAZARDOUS REACTIONS:

No known hazardous reactions.

INCOMPATIBILITIES:

Solid sodium bromide may react with easily oxidizable materials.

DECOMPOSITION PRODUCTS:

hydrogen bromide

11 Toxicological information

Oral LD50 RAT:	>5,000 mg/kg
Reproductive Toxicity RAT:	4,800 mg/kg/day
NOTE - 3-Generation: decreased	fertility
Dermal LD50 RABBIT:	>2,000 mg/kg
Skin Irritation Score RABBIT:	0
Eye Irritation Score RABBIT:	16

12 Ecological information

AQUATIC TOXICOLOGY

Bluegill Sunfish 96 Hour Static Acute Bioassay (As Bromine)
LC50= ..52; No Effect Level= .3 mg/L
Bluegill Sunfish 96 Hour Static Acute Bioassay (Product as is)
LC50 Greater Than= 1000 mg/L
Daphnia magna 48 Hour Static Acute Bioassay (As Bromine)
LC50= .71; No Effect Level= .41 mg/L
Daphnia magna 48 Hour Static Acute Bioassay (Product as is)
LC50= 27500 mg/L

Mysid Shrimp 96 Hour Flow-Thru Bioassay (As Bromine)
LC50= .17 mg/L
Rainbow Trout 96 Hour Static Acute Bioassay (As Bromine)
LC50= .23 mg/L
Rainbow Trout 96 Hour Static Acute Bioassay (Product as is)
LC50 Greater Than= 1000 mg/L
Sheepshead Minnow 96 Hour Flow-Thru Bioassay (As Bromine)
LC50= .19; No Effect Level= .11 mg/L

No Data Available.

BIODEGRADATION

Product contains only inorganics that are not subject to typical biological degradation. Assimilation by microbes may occur in waste treatment or the environment.

13 Disposal considerations

If this undiluted product is discarded as a waste, the US RCRA hazardous waste identification number is :
Not applicable.

Please be advised; however, that state and local requirements for waste disposal may be more restrictive or otherwise different from federal regulations. Consult state and local regulations regarding the proper disposal of this material.

14 Transport information

DOT HAZARD: Not Applicable
PROPER SHIPPING NAME:

DOT EMERGENCY RESPONSE GUIDE #: Not applicable
Note: Some containers may be DOT exempt, please check BOL for exact container classification

15 Regulatory information

TSCA:
This is an EPA registered biocide and is exempt from TSCA inventory requirements.

CERCLA AND/OR SARA REPORTABLE QUANTITY (RQ):
No regulated constituent present at OSHA thresholds

FIFRA REGISTRATION NUMBER:
5185-451-3876

FOOD AND DRUG ADMINISTRATION:
The ingredients in this product are approved by FDA under 21 CFR 176.300.

NSF Registered and/or meets USDA (according to 1998 Guidelines):
Registration number: 141071
Category Code(s):

SARA SECTION 312 HAZARD CLASS:
Immediate(acute)

SARA SECTION 302 CHEMICALS:
No regulated constituent present at OSHA thresholds

SARA SECTION 313 CHEMICALS:
No regulated constituent present at OSHA thresholds

CALIFORNIA REGULATORY INFORMATION

CALIFORNIA SAFE DRINKING WATER AND TOXIC ENFORCEMENT ACT (PROPOSITION 65):
No regulated constituents present

MICHIGAN REGULATORY INFORMATION

No regulated constituent present at OSHA thresholds

16 Other information

HMIS vII		CODE TRANSLATION
Health	1	Slight Hazard
Fire	0	Minimal Hazard
Reactivity	0	Minimal Hazard
Special	NONE	No special Hazard
(1) Protective Equipment	A	Safety Glasses

(1) refer to section 8 of MSDS for additional protective equipment recommendations.

CHANGE LOG

	EFFECTIVE DATE	REVISIONS TO SECTION:	SUPERCEDES
MSDS status:	20-OCT-1997		** NEW **
	02-DEC-1997	15	20-OCT-1997
	09-SEP-1998	15	02-DEC-1997
	05-NOV-2001	3,4,8,10	09-SEP-1998
	27-JAN-2003	7	05-NOV-2001
	02-SEP-2005	16	27-JAN-2003
	16-OCT-2006	16	02-SEP-2005
	28-JAN-2009	4,5,7,8,10	16-OCT-2006

Fact Sheet

Spectrus™ OX1201

Microbiological Control Agent

- Stable, safe, economical source of bromine
- Liquid, easy to feed
- Very effective in NH_3 contaminated and alkaline waters
- Use to reduce chlorine corrosivity
- FDA Approved (176.300)
- USDA Approved (G-5, G-7)
- Approved for sale in California

Description and Use

Spectrus™ OX1201 (40% sodium bromine by weight) is a safe, easy-to-use source of bromine in liquid form. The bromine in this product is present as inactive bromide ion (31% Br^-). It must be oxidized to Br^+ in order to exert a toxic effect on microorganisms. Conversion of Br^- to Br^+ is usually achieved by co-feeding Spectrus OX1201 with chlorine (either gas or liquid bleach). In water, oxidation of Br^- to Br^+ results in the formation of hypobromous acid (HOBr), which is superior to hypochlorous acid (HOCl) for control of microbes in ammonia contaminated, high pH, and/or once-through waters.

Process leaks frequently require high rates of chlorination, from gas or liquid bleach, to maintain microbiological control. These high rates impose a penalty in the form of increased corrosion, however. Experience has shown "topping off" chlorine programs with Spectrus OX1201 can reduce corrosion rates and enhance microbiological control.

Spectrus OX1201 is approved by the EPA for use in once-through and recirculating cooling systems, influent and wastewater systems, as well as water-based scrubbers, brewery pasteurizers, and industrial air washers equipped with mist eliminators.

Control of microbiological populations in industrial water systems is essential to prevent biofouling. In cooling systems, biofouling of heat exchange equipment and tower fill reduces heat transfer efficiency and can force unscheduled shutdowns and extended turnarounds, leading to lost production. Biofouling can also damage equipment through microbiologically influenced corrosion (MIC). As a result of these effects, biofouling must be prevented in order for operating units to achieve profitability goals.

Treatment and Feeding Requirements

Activate bromide and generate HOBr by co-feeding Spectrus OX1201 with a source of chlorine. The ratio of chlorine to Spectrus OX1201 can be adjusted to produce an all HOBr stream or a mix of HOBr and HOCl. For example, to generate 100% HOBr, feed 3.6 pounds (1.6 kg) of Spectrus OX1201 per 1 pound (0.45 kg) of chlorine gas. To generate a 50:50 mix of HOBr and HOCl, feed 1.8 pounds (0.82 kg) of Spectrus OX1201 per 1 pound (0.45 kg) of chlorine gas.

To ensure efficient bromide activation, mix Spectrus OX1201 with bleach or gas chlorinator discharge solution prior to application to the tower basin or recirculating cooling water lines. Use an in-line static mixer to ensure adequate contact. Consult your GE representative for further information on feed system design.

In some systems, conversion from an all chlorine program to a chlorine/bromide program will allow a reduction in daily chlorine usage. A 50% reduction in chlorine consumption is not unusual when Spectrus OX1201 is applied at 1.8 pounds (0.82 kg) per 1 pound (0.45 kg) of chlorine. Further reductions

Global Headquarters
Trevose, PA
215-355-3300

Americas
Minnetonka, MN
952-933-2277

Europe/Middle East/Africa
Heverlee, Belgium
32-16-40-20-00

Asia/Pacific
Shanghai, China
86-21-5298-4573

in chlorine usage may be possible. Your GE representative can assist in optimizing the chlorine/Spectrus OX1201 program.

Correct treatment levels and frequency of Spectrus OX1201 addition depend on many factors. These include, but are not limited to, system cleanliness, types of microbes, nutrient concentrations, temperature, pH, retention time, and other system operating characteristics. Consult the product label for general dosage guidelines. Microbiological monitoring is recommended to evaluate product requirements. Consult your GE representative for technical advice on your specific application.

In all cases, this product must be applied in accordance with use instructions on the Spectrus OX1201 label.

Compatible Materials - Spectrus OX1201 is compatible with the following materials of construction: High Density Cross-linked Polyethylene; Teflon; PVC; PVDF (Kynar); Litharge Viton; Ethylene Propylene Resin; Hypalon; Neoprene; Buna N; and Buna S Rubber. (Teflon is a registered trademark of DuPont, Kynar is a registered trademark of Autofina, Viton is a registered trademark of DuPont Dow Elastomers.)

Avoid: mild steel and stainless steel.

General Properties

Physical properties of Spectrus OX1201 are shown on the Material Safety Data Sheet, a copy of which is available on request.

Packaging Information

Spectrus OX1201 is supplied as a liquid and is available in a variety of containers and delivery methods. Consult your GE representative for details.

Storage

Keep the container closed when product not in use. Do not freeze. If frozen, thaw and mix completely prior to use.

Safety Precautions

A Material Safety Data Sheet containing detailed information about this product is available on request. Use splash-proof chemical goggles and gauntlet-type rubber gloves when handling this product. See Section 7 of the MSDS for additional information on recommended personal protective equipment.

General Information

EPA Registration Number..............5785-81-3876

Material Safety Data Sheet
MSDS Revision Date: 8/20/09

PRODUCT: Sodium Hypochlorite Solution

BRENNTAG

1. Product and Company Identification

Product Identity: **Sodium Hypochlorite Solution**

Chemical Formula: NaOCl
Molecular Weight: 74.45

Synonyms: Sodium Hypochlorite Solution (10-15.6%); Hypochlorite Solution; Bleach Solution, Hypochlorous acid, sodium salt, &/or AB Bleach; sodium hypochlorite/de-ionized water, Sodium Hypochlorite Solution 10%; Sno-glo Bleach; Hypochlorous acid, sodium salt

Brenntag Mid-South Inc.
1405 Hwy 136 W
Henderson, KY 42420

Technical Information: 270-830-1200
Emergency Number: 800-424-9300 (CHEMTREC)
Emergency Number: 703-5273887 (International)

2. Hazards Identification

PRECAUTIONARY STATEMENTS (Hazards to humans and domestic animals): Danger! Corrosive! May cause severe skin and eye irritation or chemical burns to broken skin. Causes eye damage. Exposure to skin may cause sensitization or other allergic responses.

INHALATION: Corrosive! Product may cause severe irritation of the nose, throat and respiratory tract. Repeated and/or prolonged exposures may cause productive cough, runny nose, bronchopneumonia, pulmonary edema (fluid build-up in lungs), and reduction of pulmonary function. Repeated inhalation exposure may cause impairment of lung function and permanent lung damage.

EYE CONTACT: Extremely corrosive! This product causes corneal scarring and clouding. Glaucoma, cataracts and permanent blindness may occur.

SKIN CONTACT: Corrosive! Concentrated solutions may cause pain and deep and severe burns to the skin. Prolonged and repeated exposure to diluted solutions often causes irritation, redness, pain and drying and cracking of the skin. Human evidence has indicated that an ingredient in this product can cause skin sensitization.

INGESTION: Corrosive! Will immediately cause severe corrosion of and damage to the gastrointestinal tract. Exposure characterized by nausea, vomiting, diarrhea, abdominal pain, bleeding, and/or tissue ulceration.

PRIMARY ROUTES OF ENTRY: Inhalation and contact.

3. Composition/Information on Ingredients

CAS NUMBER	CHEMICAL NAME(S)	*WT %
7681-52-9	Sodium hypochlorite**	10 – 15.6
1310-73-2	Sodium hydroxide	0.3 – 1.8
7647-14-5	Sodium Chloride	9 – 14.9
497-19-8	Sodium carbonate	≤ 0.5
7732-18-5	Water	Balance

Material Safety Data Sheet
MSDS Revision Date: 8/20/09

PRODUCT: Sodium Hypochlorite Solution

BRENNTAG

4. First Aid Measures

INHALATION: Remove victim to fresh air. Give artificial respiration if not breathing. Get medical attention.

EYE CONTACT: Wash eyes with plenty of water for at least 15 minutes while holding eyelids open. Consult an eye specialist immediately.

SKIN CONTACT: Flush skin with plenty of water while removing contaminated clothing. Get medical attention for persistent irritation. Clean clothing before reuse.

INGESTION: If swallowed drink large quantities of water. Do NOT induce vomiting. Call a poison control center or doctor immediately for treatment advice. If spontaneous vomiting occurs, have victim lean forward with head down to avoid breathing in of vomitus, rinse mouth and administer more water.

5. Fire Fighting Measures

FLASH POINT (METHOD USED): Non - flammable **FLAMMABLE LIMITS (% BY VOLUME):** n.a.

EXTINGUISHING MEDIA: Use water spray, fog, foam, dry chemicals, or carbon dioxide.

SPECIAL FIRE FIGHTING PROCEDURES: Firefighters should wear protective equipment including self contained breathing apparatus. Avoid fumes. Dilute spill with copius amounts of water, ventilate. Be prepared to use respirator.

UNUSUAL FIRE AND EXPLOSION HAZARDS: Possible vigorous reaction upon contamination with organics or oxidizing agents. Bleach decomposes when heated, decomposition products may cause containers to rupture or explode. Many reactions can cause fire and explosion. This material will react with some metals which may cause liberation of oxygen. Toxic fumes can be liberated by contact with acid or heat. Vigorous reactions can occur with oxidizable materials and organics. Keep material cool using a water spray from a safe distance. Keep all unnecessary people away. Stay up wind and stay out of low-lying areas.

6. Accidental Release Measures

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED: Personnel with proper protective equipment should contain spill. Flush area with large amounts of water. Use reducing agents such as bisulfites or ferrous salt solutions to neutralize.

7. Handling and Storage

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE: Store this product in a cool dry area; away form direct sunlight and heat to avoid deterioration. In case of spill, flood areas with large quantities of water. Product or rinsates that cannot be used should be diluted with water before disposal in a sanitary sewer. Do not reuse container. Do not contaminate food or feed by storage, disposal or cleaning of equipment. Most metals and metal alloys are NOT suitable for use in contact with sodium hypochlorite solutions including aluminum, brass, bronze, copper, cast iron, galvanized steel, mild steel, nickel, or stainless steel, since these metals act as a catalyst which will cause rapid decomposition of the sodium hypochlorite solution through the release of oxygen.

Sodium hypochlorite solutions are basically unstable, and on exposure to heat and/or light, will slowly decompose, becoming less concentrated with time. Sodium hypochlorite solutions should never be allowed to contact or mix with acids or other low pH compounds, due to the release of chlorine gas. Do not allow sodium hypochlorite to mix with ammonia, since chloroamines may be formed.

Decomposition of sodium hypochlorite takes place within a few seconds with following salts: ammonium acetate, ammonium carbonate, ammonium nitrate, ammonium oxalate, and ammonium phosphate.

Hypochlorites react with urea to form nitrogen trichloride, which explodes spontaneously in air.

Solutions of sodium hypochlorite are corrosive to the skin, eyes, and mucous membranes. Proper safety equipment should be used when working with or in close proximity of sodium hypochlorite.

OTHER PRECAUTIONS: Use with adequate ventilation. Wash thoroughly after handling. Do not get in eyes, on skin or clothing. Do NOT breathe fumes or mist. Mixing this product with chemicals (e.g. common household cleaners, ammonia, acids, detergents, etc.) or organic matter will release chlorine gas, which is irritating to eyes, lungs, and mucous membranes.

STRONG OXIDIZING AGENT: Mix only with water according to label directions. Mixing this product with chemicals (e.g. common household cleaners, ammonia, acids, detergents, etc.) or organic matter (e.g. urine, feces, etc.) will release chlorine gas, which is irritating to eyes, lungs and mucous membranes.

8. Exposure Controls/Personal Protection

			THRESHOLD LIMIT VALUES (UNITS)			
			OSHA:		ACGIH:	
CAS NUMBER	CHEMICAL NAME(S)	*WT %	PEL	STEL	TLV	STEL
7681-52-9	Sodium hypochlorite**	10 – 15.6	— NONE ESTABLISHED —			
1310-73-2	Sodium hydroxide	0.3 – 1.8	2 mg/m^3 Ceiling	—	2 mg/m^3 Ceiling	—
7647-14-5	Sodium Chloride	9 – 14.9	— NONE ESTABLISHED —			
497-19-8	Sodium carbonate	≤ 0.5	— NONE ESTABLISHED —			
7732-18-5	Water	Balance	— NONE ESTABLISHED —			

** %(w/w) as Cl_2 9.5 to 14.9% TLV/TWA (ACGIH) 0.5ppm Cl_2; TLV/STEL (ACGIH) 1ppm Cl_2 & PEL (OSHA) 1ppm Cl_2

RESPIRATORY PROTECTION: When fumes present, use NIOSH approved respirator with acid type canister.

VENTILATION: Local exhaust preferable as required to control fumes.

PROTECTIVE GLOVES: Rubber or plastic. **EYE PROTECTION:** Chemical goggles.

OTHER PROTECTIVE EQUIPMENT: Clothing to protect skin. Safety shower and eye wash fountain.

Material Safety Data Sheet
MSDS Revision Date: 8/20/09

PRODUCT: Sodium Hypochlorite Solution

BRENNTAG

9. Physical and Chemical Properties

BOILING POINT °F (°C): 110 °C for 15% NaOCl

VAPOR DENSITY (AIR =1): n.a.

VAPOR PRESSURE (mmHg): Vapor pressure of water plus decomposition products.

SOLUBILITY IN WATER: Complete

SPECIFIC GRAVITY (H_2O=1): 1.08 - 1.27

EVAPORATION RATE: n.a.

PERCENT VOLATILE BY VOLUME (%): Water vapor plus decomposition products.

APPEARANCE AND ODOR: Light, yellow-green liquid

10. Stability and Reactivity

STABILITY: Unstable (Contingent upon temperature, contamination (metals), and pH.)

HAZARDOUS POLYMERIZATION: Will not occur.

CONDITIONS TO AVOID: Heat, light exposure, decrease in pH, and contamination with heavy metals, such as nickel, cobalt, copper and iron.

INCOMPATIBILITY (MATERIALS TO AVOID): Heavy metals, reducing agents, organics, ether, ammonia, ammonium acetate, ammonium carbonate, ammonium nitrate, ammonium oxalate, ammonium phosphate, urea and acids.

HAZARDOUS DECOMPOSITION PRODUCTS: Hypochlorous acid, chlorine, hydrochloric acid, sodium chloride, sodium chlorate, and oxygen. Decomposition of sodium hypochlorite takes place within a few seconds with following salts: ammonium acetate, ammonium carbonate, ammonium nitrate, ammonium oxalate, and ammonium phosphate. Hypochlorites react with urea to form nitrogen trichloride, which explodes spontaneously in air.

11. Toxicological Information

TOXICITY DATA: Oral LD50: 8,910 mg/kg. (Rats)
Dermal LD 50: > 10,000mg/kg. (Rabbits)
Inhalation 0.25-hour LC 50: >10.5 mg/l (Rats)
Acute oral toxicity: IV; LD50, 192 mg/kg
Acute dermal toxicity: III; LD50, > 3,000 mg/kg
Primary eye irritation: I; Corrosive
Primary skin irritation: I; Corrosive

SUMMARY: The concentrated solution is corrosive to skin, and a 5% solution is a severe eye irritant. Solutions containing more than 5% available chlorine are classified by DOT corrosive. Toxicity described in animals from single exposures by ingestion includes muscular weakness, and hyperactivity. Repeated ingestion exposure in animals caused an increase in the relative weight of adrenal glands in one study, but no pathological change were observed in two other studies. Long-term administration of compound in drinking water of rats caused depression of the immune system. No adverse changes were observed in an eight-week dermal study of a 1% solution in guinea pigs. Tests in animals demonstrate no carcinogenic activity by either the oral or dermal routes. Tests in bacterial and mammalian cell cultures demonstrate mutagenic activity.

Material Safety Data Sheet
MSDS Revision Date: 8/20/09

PRODUCT: Sodium Hypochlorite Solution

BRENNTAG

12. Ecological Information

ENVIRONMENTAL HAZARDS: This pesticide is toxic to fish and aquatic organisms. Do not discharge effluents containing this product into lakes, streams, ponds, estuaries, oceans or other waters unless in accordance with the requirements of a National Pollutant Discharge Elimination System (NPDES) permit and the permitting authority has been notified in writing prior to discharge. Do not discharge effluent containing this product to sewer systems without previously notifying the sewage treatment plant authority. For guidance, contact you State Water Board or Regional Office of the EPA.

Acute oral-bobwhite quail: LD50, > 2510 mg/kg
Acute dietary-mallard duck: LC50, > 5220 ppm
Acute dietary-bobwhite quail: LC50, > 5620 ppm
Acute fish-rainbow trout: LC50, 0.18-0.22 mg/l
Acute fish-bluegill sunfish: LC50, 0.44-0.79 mg/l

Acute invertebrate-daphnia: LC50, 0.033-0.048 mg/l
Fathead minnows: 96-hour LC50, 5.9 mg/LO
Rainbow Trout: 96-hour LC50, 0.2mg/liter
Bluegill sunfish: 96-hour LC50, 0.58mg/liter

13. Disposal Considerations

WASTE DISPOSAL METHOD: Disposal is to be in accordance with all Federal, State, and Local regulations.

14. Transport Information

PROPER SHIPPING NAME: Hypochlorite Solutions

HAZARD CLASS: 8 (Corrosive) **UN/NA**: UN 1791 **PACKING GROUP**: III

D.O.T. LABEL REQUIRED: Corrosive **REPORTABLE QUANTITY OF PRODUCT**: 800 to 2,000 lbs.

15. Regulatory Information

TSCA (Toxic Substance Control Act): All components of this product are listed on the TSCA inventory.

CERCLA AND SARA REGULATIONS, 40 CFR §300-373:

Super fund Reportable Discharge = 100 pounds (100% NaOCl) CERCLA Hazardous Material: yes

SARA Extremely Hazardous substance: No SARA Toxic Chemical: No

Title III Hazard Classifications: Acute: yes Chronic: yes Fire: no Reactivity: yes Pressure: No

EPA "CLEAN AIR ACT": This product does not contain nor is it manufactured with ozone depleting substances.

OTHER REGULATIONS/LEGISLATION THAT APPLY TO THIS PRODUCT: Massachusetts, Pennsylvania, and New Jersey Right-to Know Laws.

BRENNTAG

16. Other Information

HMIS HAZARD RATING: Health 3 Flammability 0 Reactivity 2

VOC CONTENT (lbs/gal): n.a.

This MSDS is provided as an information resource only. It should not be taken as a warranty or representation for which Brenntag assumes legal liability. While Brenntag believes the information contained herein is accurate and compiled from sources believed to be reliable, it is the responsibility of the user to investigate and verify its identity. The buyer assumes all responsibility for using and handling the product in accordance with applicable international, federal, state, and local regulations.

Brenntag Mid-South Inc.
1405 Hwy 136 W
Henderson, KY 42420

PREPARED BY: MBMiller APPROVED BY: James Clements/MBM

C:\RD1\WORD\MSDS\SOD HYPOCHLORITE

GE
Water & Process Technologies

Material Safety Data Sheet

Issue Date: 05-FEB-2009
Supercedes: 03-MAY-2000

INHIBITOR AZ8100

1 Identification

Identification of substance or preparation
INHIBITOR AZ8100

Product Application Area
Water-based corrosion inhibitor.

Company/Undertaking Identification
GE Betz, Inc.
4636 Somerton Road
Trevose, PA 19053
T 215 355-3300, F 215 953 5524

Emergency Telephone
(800) 877-1940

Prepared by Product Stewardship Group: T 215-355-3300   Prepared on: 05-FEB-2009

2 Hazard(s) identification

****

EMERGENCY OVERVIEW

DANGER

Corrosive to skin. Corrosive to the eyes. Mists/aerosols cause irritation to the upper respiratory tract.

DOT hazard: Corrosive to skin
Odor: Mild; Appearance: Yellow To Brown, Liquid

Fire fighters should wear positive pressure self-contained breathing apparatus(full face-piece type). Proper fire-extinguishing media: dry chemical, carbon dioxide, foam or water

****

POTENTIAL HEALTH EFFECTS

ACUTE SKIN EFFECTS:
Primary route of exposure; Corrosive to skin.

ACUTE EYE EFFECTS:
Corrosive to the eyes.

ACUTE RESPIRATORY EFFECTS:
Mists/aerosols cause irritation to the upper respiratory tract.

INGESTION EFFECTS:

May cause severe irritation or burning of the gastrointestinal tract.

TARGET ORGANS:
Prolonged or repeated exposures may cause tissue necrosis.

MEDICAL CONDITIONS AGGRAVATED:
Not known.

SYMPTOMS OF EXPOSURE:
Causes redness or itching of skin, possibly leading to burns (dependent on the length of exposure).

3 Composition / information on ingredients

Information for specific product ingredients as required by the U.S. OSHA HAZARD COMMUNICATION STANDARD is listed. Refer to additional sections of this MSDS for our assessment of the potential hazards of this formulation.

HAZARDOUS INGREDIENTS:

Cas#	Chemical Name	Range(w/w%)
64665-57-2	BENZOTRIAZOLE,METHYL,SODIUM SALT (SODIUM TOLYLTRIAZOLE),(TTA) Corrosive (eyes and skin); toxic (by ingestion)	40-70

4 First-aid measures

SKIN CONTACT:
Remove clothing. Wash area with large amounts of soap solution or water for 15 min. Immediately contact physician.
EYE CONTACT:
Remove contact lenses. Hold eyelids apart. Immediately flush eyes with plenty of low-pressure water for at least 15 minutes. Get immediate medical attention.
INHALATION:
Remove to fresh air. Apply necessary first aid treatment. Immediately contact a physician.
INGESTION:
Do not feed anything by mouth to an unconscious or convulsive victim. Do not induce vomiting. Immediately contact physician. Dilute contents of stomach using 2-8 fluid ounces (60-240 mL) of milk or water.
NOTES TO PHYSICIANS:
No special instructions

5 Fire-fighting measures

FIRE FIGHTING INSTRUCTIONS:
Fire fighters should wear positive pressure self-contained breathing apparatus (full face-piece type).
EXTINGUISHING MEDIA:
dry chemical, carbon dioxide, foam or water
HAZARDOUS DECOMPOSITION PRODUCTS:

elemental oxides

FLASH POINT:

> 200F   > 93C SETA(CC)

MISCELLANEOUS:

Corrosive to skin
UN 1719;Emergency Response Guide #154

6 Accidental release measures

PROTECTION AND SPILL CONTAINMENT:

Ventilate area. Use specified protective equipment. Contain and absorb on absorbent material. Place in waste disposal container. Flush area with water. Wet area may be slippery. Spread sand/grit.

DISPOSAL INSTRUCTIONS:

Water contaminated with this product may be sent to a sanitary sewer treatment facility,in accordance with any local agreement,a permitted waste treatment facility or discharged under a permit. Product as is - Incinerate or land dispose in an approved landfill.

7 Handling and storage

HANDLING:

Alkaline. Corrosive(Skin/eyes). Do not mix with acidic material.

STORAGE:

Keep containers closed when not in use. Store in cool ventilated location. Store away from oxidizers.

8 Exposure controls / personal protection

EXPOSURE LIMITS

CHEMICAL NAME

BENZOTRIAZOLE,METHYL,SODIUM SALT (SODIUM TOLYLTRIAZOLE),(TTA)
PEL (OSHA): NOT DETERMINED
TLV (ACGIH): NOT DETERMINED

ENGINEERING CONTROLS:

adequate ventilation

PERSONAL PROTECTIVE EQUIPMENT:

Use protective equipment in accordance with 29CFR 1910 Subpart I

RESPIRATORY PROTECTION:

A RESPIRATORY PROTECTION PROGRAM THAT MEETS OSHA'S 29 CFR 1910.134 AND ANSI Z88.2 REQUIREMENTS MUST BE FOLLOWED WHENEVER WORKPLACE CONDITIONS WARRANT A RESPIRATOR'S USE.
USE AIR PURIFYING RESPIRATORS WITHIN USE LIMITATIONS ASSOCIATED WITH THE EQUIPMENT OR ELSE USE SUPPLIED AIR-RESPIRATORS.
If air-purifying respirator use is appropriate, use any of the following particulate respirators: N95, N99, N100, R95, R99, R100, P95, P99 or P100.

SKIN PROTECTION:

gauntlet-type neoprene gloves, chemical resistant apron--
Wash off after each use. Replace as necessary.

EYE PROTECTION:

splash proof chemical goggles, face shield

9 Physical and chemical properties

Specific Grav.(70F,21C)	1.215	Vapor Pressure (mmHG)	~ 18.0
Freeze Point (F)	-25	Vapor Density (air=1)	< 1.00
Freeze Point (C)	-32		
Viscosity(cps 70F,21C)	190	% Solubility (water)	100.0

Odor	Mild
Appearance	Yellow To Brown
Physical State	Liquid
Flash Point SETA(CC)	> 200F > 93C
pH 10% Sol. (approx.)	~ 11.7
Evaporation Rate (Ether=1)	< 1.00
Percent VOC:	0.0

NA = not applicable ND = not determined

10 Stability and reactivity

CHEMICAL STABILITY:
Stable under normal storage conditions.
POSSIBILITY OF HAZARDOUS REACTIONS:

INCOMPATIBILITIES:
May react with acids.
DECOMPOSITION PRODUCTS:
elemental oxides

11 Toxicological information

Oral LD50 RAT:	1,150 mg/kg
Dermal LD50 RABBIT:	>2,000 mg/kg

NOTE - Estimated value

12 Ecological information

AQUATIC TOXICOLOGY

Bluegill Sunfish 96 Hour Static Acute Bioassay
LC50= 109.3; No Effect Level= 42 mg/L
Ceriodaphnia 48 Hour Static Renewal Bioassay
LC50= 147; No Effect Level= 37 mg/L
Ceriodaphnia 7 Day Static Renewal Bioassay
IC25 = 20 mg/L
Daphnia magna 48 Hour Static Renewal Bioassay (pH adjusted)
LC50= 243; No Effect Level= 75 mg/L
Fathead Minnow 7 Day Static Renewal Bioassay
IC25 = 56 mg/L
Fathead Minnow 96 Hour Static Renewal Bioassay (pH adjusted)
LC50= 105; No Effect Level= 75 mg/L
Mysid Shrimp 48 Hour Static Acute Bioassay
LC50= 166; No Effect Level= 10 mg/L
Rainbow Trout 96 Hour Static Renewal Bioassay
LC50= 34; No Effect Level= 15 mg/L
Sheepshead Minnow 48 Hour Static Acute Bioassay

LC50= 475; No Effect Level= 370 mg/L

BIODEGRADATION

BOD-28 (mg/g): 22
BOD-5 (mg/g): 4
COD (mg/g): 810
TOC (mg/g): 280

13 Disposal considerations

If this undiluted product is discarded as a waste, the US RCRA hazardous waste identification number is :
Not applicable.

Please be advised; however, that state and local requirements for waste disposal may be more restrictive or otherwise different from federal regulations. Consult state and local regulations regarding the proper disposal of this material.

14 Transport information

DOT HAZARD:	Corrosive to skin
PROPER SHIPPING NAME:	CAUSTIC ALKALI LIQUIDS, N.O.S.(SODIUM TOLYLTRIAZOLE) 8, UN 1719, PG II
DOT EMERGENCY RESPONSE GUIDE #:	154

Note: Some containers may be DOT exempt, please check BOL for exact container classification

15 Regulatory information

TSCA:

All components of this product are included on or are in compliance with the U.S. TSCA regulations.

CERCLA AND/OR SARA REPORTABLE QUANTITY (RQ):

No regulated constituent present at OSHA thresholds

NSF Registered and/or meets USDA (according to 1998 Guidelines):

Registration number: Not Registered

SARA SECTION 312 HAZARD CLASS:

Immediate(acute);Delayed(Chronic)

SARA SECTION 302 CHEMICALS:

No regulated constituent present at OSHA thresholds

SARA SECTION 313 CHEMICALS:

No regulated constituent present at OSHA thresholds

CALIFORNIA REGULATORY INFORMATION

CALIFORNIA SAFE DRINKING WATER AND TOXIC ENFORCEMENT ACT (PROPOSITION 65):

No regulated constituents present

MICHIGAN REGULATORY INFORMATION

No regulated constituent present at OSHA thresholds

16 Other information

HMIS vII		**CODE TRANSLATION**
Health	3	Serious Hazard
Fire	1	Slight Hazard
Reactivity	0	Minimal Hazard
Special	CORR	DOT corrosive
(1) Protective Equipment	D	Goggles,Face Shield,Gloves,Apron

(1) refer to section 8 of MSDS for additional protective equipment recommendations.

CHANGE LOG

	EFFECTIVE DATE	REVISIONS TO SECTION:	SUPERCEDES
MSDS status:	28-JAN-1997		** NEW **
	19-FEB-1997	12	28-JAN-1997
	03-OCT-1997	8	19-FEB-1997
	29-MAY-1998	12	03-OCT-1997
	08-FEB-1999	3,5,14	29-MAY-1998
	15-JUN-1999	12	08-FEB-1999
	30-AUG-1999	4;EDIT:9	15-JUN-1999
	03-MAY-2000	12	30-AUG-1999
	05-FEB-2009	12;EDIT:Rebranding	03-MAY-2000

Inhibitor AZ8100

Copper Corrosion Inhibitor

- Inhibits corrosion of copper alloys
- Reduces tube failures
- Extends condenser service life
- Minimizes mild steel corrosion caused by galvanic reaction

Description and Use

Inhibitor AZ8100 is a specially-formulated corrosion inhibitor which establishes a protective film on copper alloy condensers. Inhibitor AZ8100 effectively inhibits the corrosion of copper alloy surfaces. Indirectly, it also reduces the corrosion of steel surfaces when the corrosion is the result of a galvanic reaction between the steel surface and the products of copper corrosion which have been deposited on the steel. Figure 1 shows the reduction in corrosion rate for both admiralty brass and mild steel in a West Coast power plant through use of Inhibitor AZ8100.

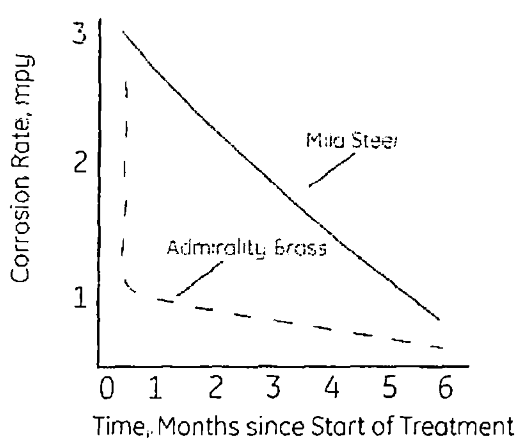


Figure 1: Effect of Inhibitor AZ8100 on the corrosion rates of admiralty brass and of mild steel. (The latter is caused by galvanic reaction between admiralty corrosion products and the mild steel surface.)

Treatment and Feeding Requirement

The normal treatment level for Inhibitor AZ8100 is 4-30 ppm(mg/L). The amount required will depend on many factors, such as operating characteristics of the system and severity of the problem. Therefore, this product should be used in accordance with control parameters GE establishes for a specific application.

Inhibitor AZ8100 should be fed to a point in the cooling system where turbulence and flow patterns will ensure adequate mixing of the product with the cooling water. In recirculating cooling systems the product should be fed continuously to maintain constant residuals in the cooling water. Intermittent product feed is applicable in certain cooling systems.

Inhibitor AZ8100 may be fed directly from the shipping container or diluted with water to any convenient feeding strength.

Mild steel tanks, pumps, and piping are satisfactory for use with Inhibitor AZ8100.

General Properties

Physical properties of Inhibitor AZ8100 are shown on the Material Safety Data Sheet, a copy of which is available on request.

Packaging Information

Inhibitor AZ8100 is available in a variety of containers and delivery methods. Contact your GE sales representative for details.

Safety Precautions

A Material Safety Data Sheet containing detailed information about this product is available upon request.

Global Headquarters
Trevose, PA
215-355-3300

Americas
Minnetonka, MN
952-933-2277

Europe/Middle East/Africa
Heverlee, Belgium
32-16-40-20-00

Asia/Pacific
Shanghai, China
86-21-5298-4573

NALCO

SAFETY DATA SHEET

PRODUCT

EVAC Biocide

EMERGENCY TELEPHONE NUMBER(S)
(800) 424-9300 (24 Hours) CHEMTREC

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

PRODUCT NAME : **EVAC Biocide**

APPLICATION : BIOCIDE

COMPANY IDENTIFICATION : Nalco Company
1601 W. Diehl Road
Naperville, Illinois
60563-1198

EMERGENCY TELEPHONE NUMBER(S) : (800) 424-9300 (24 Hours) CHEMTREC

NFPA 704M/HMIS RATING
HEALTH : 3 / 3 FLAMMABILITY : 1 / 1 INSTABILITY : 0 / 0 OTHER :
0 = Insignificant 1 = Slight 2 = Moderate 3 = High 4 = Extreme * = Chronic Health Hazard

2. COMPOSITION/INFORMATION ON INGREDIENTS

Our hazard evaluation has identified the following chemical substance(s) as hazardous. Consult Section 15 for the nature of the hazard(s).

Hazardous Substance(s)	CAS NO	% (w/w)
Endothall, mono(N,N-dimethylcocoamine) salt	66330-88-9	53.0

3. HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW

DANGER
CORROSIVE. CAUSES IRREVERSIBLE EYE DAMAGE AND SKIN BURNS. MAY BE FATAL IF SWALLOWED OR ABSORBED THROUGH SKIN. HARMFUL IF INHALED.
Do not get in eyes, on skin, on clothing. Do not take internally. Avoid breathing vapor. Use with adequate ventilation. Protect product from freezing. Keep container tightly closed and in a well-ventilated place. In case of contact with eyes, rinse immediately with plenty of water and seek medical advice. After contact with skin, wash immediately with plenty of water. Use a mild soap if available.
Wear a face shield. Wear chemical resistant apron, chemical splash goggles, impervious gloves and boots.
Not flammable or combustible. May evolve oxides of carbon (COx) under fire conditions. May evolve oxides of nitrogen (NOx) under fire conditions.

PRIMARY ROUTES OF EXPOSURE :
Eye, Skin

HUMAN HEALTH HAZARDS - ACUTE :

EYE CONTACT :
Corrosive. Will cause eye burns and permanent tissue damage.

SKIN CONTACT :
Severely irritating; may cause permanent skin damage. Harmful if absorbed through skin.

INGESTION :
Not a likely route of exposure. May cause burns to mouth and gastro-intestinal tract. May be fatal if swallowed.

INHALATION :
Not a likely route of exposure. Elevated temperatures or mechanical action may form vapors, mists or fumes which may be irritating to the eyes, nose, throat and lungs. Harmful if inhaled.

AGGRAVATION OF EXISTING CONDITIONS :
A review of available data does not identify any worsening of existing conditions.

4. FIRST AID MEASURES

IF IN EYES: Hold eyelids open and rinse slowly and gently with water for 15-20 minutes. Remove contact lenses, if present, after the first 5 minutes, then continue rinsing. Call poison control center or doctor for treatment advice.

IF ON SKIN: Take off contaminated clothing. Rinse skin immediately with plenty of water for 15-20 minutes. Call a poison control center or doctor for treatment advice.

IF INHALED: Move person to fresh air. If person is not breathing, call 911 or ambulances, then give artificial respiration, preferably mouth-to-mouth, if possible. Call a poison control center or doctor for treatment advice

IF SWALLOWED: Call a Poison Control Center or doctor immediately for treatment advice. Have person sip a glass of water if able to swallow. Do not induce vomiting unless told to by a poison control center or doctor.

NOTE TO PHYSICIAN :
Probable mucosal damage may contraindicate the use of gastric lavage. Based on the individual reactions of the patient, the physician's judgement should be used to control symptoms and clinical condition.

5. FIRE FIGHTING MEASURES

FLASH POINT : > 230 °F / > 110 °C (TCC)

EXTINGUISHING MEDIA :
Carbon dioxide, Foam, Dry powder, Other extinguishing agent suitable for Class B fires, For large fires, use water spray or fog, thoroughly drenching the burning material.
Water mist may be used to cool closed containers.

FIRE AND EXPLOSION HAZARD :
Not flammable or combustible. May evolve oxides of carbon (COx) under fire conditions. May evolve oxides of nitrogen (NOx) under fire conditions.

SPECIAL PROTECTIVE EQUIPMENT FOR FIRE FIGHTING :
In case of fire, wear a full face positive-pressure self contained breathing apparatus and protective suit.

6. ACCIDENTAL RELEASE MEASURES

PERSONAL PRECAUTIONS :
Restrict access to area as appropriate until clean-up operations are complete. Use personal protective equipment recommended in Section 8 (Exposure Controls/Personal Protection). Stop or reduce any leaks if it is safe to do so. Keep people away from and upwind of spill/leak. Ventilate spill area if possible. Ensure clean-up is conducted by trained personnel only. Do not touch spilled material. Have emergency equipment (for fires, spills, leaks, etc.) readily available. Notify appropriate government, occupational health and safety and environmental authorities.

METHODS FOR CLEANING UP :
SMALL SPILLS: Soak up spill with absorbent material. Place residues in a suitable, covered, properly labeled container. Wash affected area. LARGE SPILLS: Contain liquid using absorbent material, by digging trenches or by diking. Reclaim into recovery or salvage drums or tank truck for proper disposal. Wash site of spillage thoroughly with water. Contact an approved waste hauler for disposal of contaminated recovered material. Dispose of material in compliance with regulations indicated in Section 13 (Disposal Considerations).

ENVIRONMENTAL PRECAUTIONS :
This product is toxic to fish. Do not discharge effluent containing this active ingredient into lakes, streams, ponds, estuaries, oceans or other waters, unless in accordance with the requirements of a National Pollutant Discharge Elimination System (NPDES) permit and the permitting authority has been notified in writing prior to discharge. Do not discharge effluent containing this product to sewer systems without previously notifying the local sewage treatment plant authority. For guidance contact your State Water Board or Regional Office of the EPA.

7. HANDLING AND STORAGE

HANDLING :
Do not get in eyes, on skin, on clothing. Do not take internally. Use with adequate ventilation. Avoid generating aerosols and mists. Keep the containers closed when not in use. Have emergency equipment (for fires, spills, leaks, etc.) readily available.

STORAGE CONDITIONS :
Store the containers tightly closed. Store separately from oxidizers. Store in suitable labeled containers. Protect product from freezing.

SUITABLE CONSTRUCTION MATERIAL :
Shipping and long term storage compatibility with construction materials can vary; we therefore recommend that compatibility is tested prior to use.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

OCCUPATIONAL EXPOSURE LIMITS :
This product does not contain any substance that has an established exposure limit.

ENGINEERING MEASURES :
General ventilation is recommended. Use local exhaust ventilation if necessary to control airborne mist and vapor.

RESPIRATORY PROTECTION :
If significant mists, vapors or aerosols are generated an approved respirator is recommended. A dust, mist, fume cartridge may be used. In event of emergency or planned entry into unknown concentrations a positive pressure, full-facepiece SCBA should be used. If respiratory protection is required, institute a complete respiratory protection program including selection, fit testing, training, maintenance and inspection.

HAND PROTECTION :
NEOPRENE, NITRILE, OR BUTYL GLOVES

SKIN PROTECTION :
When handling this product, the use of overalls, a chemical resistant apron and rubber boots is recommended. A full slicker suit is recommended if gross exposure is possible.

EYE PROTECTION :
Wear a face shield with chemical splash goggles.

HYGIENE RECOMMENDATIONS :
Use good work and personal hygiene practices to avoid exposure. Eye wash station and safety shower are necessary. If clothing is contaminated, remove clothing and thoroughly wash the affected area. Launder contaminated clothing before reuse. Always wash thoroughly after handling chemicals. When handling this product never eat, drink or smoke.

9. PHYSICAL AND CHEMICAL PROPERTIES

PHYSICAL STATE	Liquid
APPEARANCE	Light brown
ODOR	Slight
SPECIFIC GRAVITY	1.044 @ 77 °F / 25 °C
DENSITY	8.7 lb/gal
SOLUBILITY IN WATER	Complete
FREEZING POINT	< 5 °F / < -15 °C
VOC CONTENT	0.00 %

Note: These physical properties are typical values for this product and are subject to change.

10. STABILITY AND REACTIVITY

STABILITY :
Stable under normal conditions.

HAZARDOUS POLYMERIZATION :
Hazardous polymerization will not occur.

CONDITIONS TO AVOID :
Freezing temperatures.

MATERIALS TO AVOID :
Contact with strong oxidizers (e.g. chlorine, peroxides, chromates, nitric acid, perchlorate, concentrated oxygen, permanganate) may generate heat, fires, explosions and/or toxic vapors.

HAZARDOUS DECOMPOSITION PRODUCTS :

Under fire conditions:	Oxides of carbon, Oxides of nitrogen

11. TOXICOLOGICAL INFORMATION

The following results are for the product.

ACUTE ORAL TOXICITY :

Species:	Rat
LD50:	233.4 mg/kg
Test Descriptor:	Product

ACUTE DERMAL TOXICITY :

Species:	Rabbit
LD50:	480.9 mg/kg
Test Descriptor:	

ACUTE INHALATION TOXICITY :

Species:	
LC50:	0.7 mg/l (4 hrs)
Test Descriptor:	Product

PRIMARY SKIN IRRITATION :

Species:	Rabbit
Draize Score:	8 /8.0
Test Descriptor:	Product

PRIMARY EYE IRRITATION :

Species:	Rabbit
Draize Score:	110 /110.0
Test Descriptor:	Product

SENSITIZATION :
This product is not expected to be a sensitizer.

CARCINOGENICITY :
None of the substances in this product are listed as carcinogens by the International Agency for Research on Cancer (IARC), the National Toxicology Program (NTP) or the American Conference of Governmental Industrial Hygienists (ACGIH).

HUMAN HAZARD CHARACTERIZATION :
Based on our hazard characterization, the potential human hazard is: High

12. ECOLOGICAL INFORMATION

ECOTOXICOLOGICAL EFFECTS :

The following results are for the product.

ACUTE FISH RESULTS :

Species	Exposure	LC50	Test Descriptor
Rainbow Trout	96 hrs	0.29 mg/l	Product
Fathead Minnow	96 hrs	0.25 mg/l	Product
Bluegill Sunfish	96 hrs	0.5 mg/l	Product
Channel Catfish	96 hrs	0.58 mg/l	Product

ACUTE INVERTEBRATE RESULTS :

Species	Exposure	LC50	EC50	Test Descriptor
Daphnia magna	48 hrs	0.09 mg/l		Product
Mayfly (Ephemeroptera)	96 hrs	0.15 mg/l		Product
Hyalella	96 hrs	0.22 mg/l		Product
Rotifer	24 hrs	0.47 mg/l		Product
Worm (Oligochaeta)	96 hrs	0.53 mg/l		Product
Crayfish	96 hrs	1.96 mg/l		Product
Midges (Diptera)	96 hrs	0.64 mg/l		Product

ENVIRONMENTAL HAZARD AND EXPOSURE CHARACTERIZATION
Based on our hazard characterization, the potential environmental hazard is: High

If released into the environment, see CERCLA/SUPERFUND in Section 15.

13. DISPOSAL CONSIDERATIONS

If this product becomes a waste, it is not a hazardous waste as defined by the Resource Conservation and Recovery Act (RCRA) 40 CFR 261, since it does not have the characteristics of Subpart C, nor is it listed under Subpart D.

Pesticide wastes are acutely hazardous. Improper disposal of excess pesticide, spray mixture, or rinsate is a violation of Federal law. If these wastes cannot be disposed of by use according to label instructions, contact your State Pesticide or Environmental Control Agency, or the Hazardous Waste Representative at the nearest EPA Regional Office for guidance. As a pesticide waste, consult the FIFRA label for any additional handling, treatment, or disposal requirements. For disposal, contact a properly licensed waste treatment, storage, disposal or recycling facility.

14. TRANSPORT INFORMATION

The information in this section is for reference only and should not take the place of a shipping paper (bill of lading) specific to an order. Please note that the proper Shipping Name / Hazard Class may vary by packaging, properties, and mode of transportation. Typical Proper Shipping Names for this product are as follows.

The presence of an RQ component (Reportable Quantity for U.S. EPA and DOT) in this product causes it to be regulated with an additional description of RQ for road, or as a class 9 for road and air, ONLY when the net weight in the package exceeds the calculated RQ for the product.

LAND TRANSPORT :

Proper Shipping Name :	PESTICIDE, LIQUID, TOXIC, N.O.S.
Technical Name(s) :	Endothall, mono(N,N-dimethylcocoamine) salt
UN/ID No :	UN 2902
Hazard Class - Primary :	6.1
Packing Group :	III
Flash Point :	> 110 °C / > 230 °F
Reportable Quantity (per package) :	4,280 lbs
RQ Component :	ENDOTHALL

AIR TRANSPORT (ICAO/IATA) :

The presence of an RQ component (Reportable Quantity for U.S. EPA and DOT) in this product causes it to be regulated with an additional description of RQ for road, or as a class 9 for road and air, ONLY when the net weight in the package exceeds the calculated RQ for the product.

Proper Shipping Name :	PESTICIDE, LIQUID, TOXIC, N.O.S.
Technical Name(s) :	Endothall, mono(N,N-dimethylcocoamine) salt
UN/ID No :	UN 2902
Hazard Class - Primary :	6.1
Packing Group :	III
Reportable Quantity (per package) :	4,280 lbs
RQ Component :	ENDOTHALL

MARINE TRANSPORT (IMDG/IMO) :

Proper Shipping Name :	PESTICIDE, LIQUID, TOXIC, N.O.S.
Technical Name(s) :	Endothall, mono(N,N-dimethylcocoamine) salt
UN/ID No :	UN 2902
Hazard Class - Primary :	6.1
Packing Group :	III
*Marine Pollutant :	Endothall, mono(N,N-dimethylcocoamine) salt

*Note: This product is regulated as a Marine Pollutant when shipped by Rail, Highway (in bulk quantities), or Air (if no other hazard class applies), and when shipped by water in all quantities.

15. REGULATORY INFORMATION

This section contains additional information that may have relevance to regulatory compliance. The information in this section is for reference only. It is not exhaustive, and should not be relied upon to take the place of an individualized compliance or hazard assessment. Nalco accepts no liability for the use of this information.

NATIONAL REGULATIONS, USA :

OSHA HAZARD COMMUNICATION RULE, 29 CFR 1910.1200 :
Based on our hazard evaluation, the following substance(s) in this product is/are hazardous and the reason(s) is/are shown below.

Endothall, mono(N,N-dimethylcocoamine) salt : Corrosive to eyes, Skin irritant

CERCLA/SUPERFUND, 40 CFR 302 :
This product contains the following Reportable Quantity (RQ) Substance. Also listed is the RQ for the product. If a reportable quantity of product is released, it requires notification to the NATIONAL RESPONSE CENTER, WASHINGTON, D.C. (1-800-424-8802).

RQ Substance	RQ
Endothall, mono(N,N-dimethylcocoamine) salt	4,280 lbs

SARA/SUPERFUND AMENDMENTS AND REAUTHORIZATION ACT OF 1986 (TITLE III) - SECTIONS 302, 311, 312, AND 313 :

SECTION 302 - EXTREMELY HAZARDOUS SUBSTANCES (40 CFR 355) :
This product does not contain substances listed in Appendix A and B as an Extremely Hazardous Substance.

SECTIONS 311 AND 312 - MATERIAL SAFETY DATA SHEET REQUIREMENTS (40 CFR 370) :
Our hazard evaluation has found this product to be hazardous. The product should be reported under the following indicated EPA hazard categories:

X	Immediate (Acute) Health Hazard
-	Delayed (Chronic) Health Hazard
-	Fire Hazard
-	Sudden Release of Pressure Hazard
-	Reactive Hazard

Under SARA 311 and 312, the EPA has established threshold quantities for the reporting of hazardous chemicals. The current thresholds are: 500 pounds or the threshold planning quantity (TPQ), whichever is lower, for extremely hazardous substances and 10,000 pounds for all other hazardous chemicals.

SECTION 313 - LIST OF TOXIC CHEMICALS (40 CFR 372) :
This product does not contain substances on the List of Toxic Chemicals.

TOXIC SUBSTANCES CONTROL ACT (TSCA) :
This product is exempted under TSCA and regulated under FIFRA. The inerts are on the Inventory List.

FEDERAL INSECTICIDE, FUNGICIDE AND RODENTICIDE ACT (FIFRA) :
EPA Reg. No. 70506-189-1706

In all cases follow instructions on the product label.

FEDERAL WATER POLLUTION CONTROL ACT, CLEAN WATER ACT, 40 CFR 401.15 / formerly Sec. 307, 40 CFR 116.4 / formerly Sec. 311 :
Substances listed under this regulation are not intentionally added or expected to be present in this product. Listed components may be present at trace levels.

CLEAN AIR ACT, Sec. 112 (Hazardous Air Pollutants, as amended by 40 CFR 63), Sec. 602 (40 CFR 82, Class I and II Ozone Depleting Substances) :
Substances listed under this regulation are not intentionally added or expected to be present in this product. Listed components may be present at trace levels.

CALIFORNIA PROPOSITION 65 :
Substances listed under California Proposition 65 are not intentionally added or expected to be present in this product.

MICHIGAN CRITICAL MATERIALS :
Substances listed under this regulation are not intentionally added or expected to be present in this product. Listed components may be present at trace levels.

STATE RIGHT TO KNOW LAWS :
This product is a registered biocide and is exempt from State Right to Know Labelling Laws.

INTERNATIONAL CHEMICAL CONTROL LAWS :

AUSTRALIA
This product contains substance(s) which are not in compliance with the National Industrial Chemicals Notification & Assessment Scheme (NICNAS) and may require additional review.

CHINA
This product contains substance(s) which are not in compliance with the Provisions on the Environmental Administration of New Chemical Substances and may require additional review.

EUROPE
This product contains substance(s) which are not in compliance with the European Commission Directive 67/548/EEC and may require additional review.

JAPAN
This product contains substance(s) which are not in compliance with the Law Regulating the Manufacture and Importation Of Chemical Substances and are not listed on the Existing and New Chemical Substances list (ENCS).

KOREA
This product contains substance(s) which are not in compliance with the Toxic Chemical Control Law (TCCL) and may require additional review.

PHILIPPINES
This product contains substance(s) which are not in compliance with the Republic Act 6969 (RA 6969) and may require additional review.

16. OTHER INFORMATION

This product material safety data sheet provides health and safety information. The product is to be used in applications consistent with our product literature. Individuals handling this product should be informed of the recommended safety precautions and should have access to this information. For any other uses, exposures should be evaluated so that appropriate handling practices and training programs can be established to insure safe workplace operations. Please consult your local sales representative for any further information.

REFERENCES

Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices, American Conference of Governmental Industrial Hygienists, OH., (Ariel Insight™ CD-ROM Version), Ariel Research Corp., Bethesda, MD.

Hazardous Substances Data Bank, National Library of Medicine, Bethesda, Maryland (TOMES CPS™ CD-ROM Version), Micromedex, Inc., Englewood, CO.

IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man, Geneva: World Health Organization, International Agency for Research on Cancer.

Integrated Risk Information System, U.S. Environmental Protection Agency, Washington, D.C. (TOMES CPS™ CD-ROM Version),
Micromedex, Inc., Englewood, CO.

Annual Report on Carcinogens, National Toxicology Program, U.S. Department of Health and Human Services, Public Health Service.

Title 29 Code of Federal Regulations, Part 1910, Subpart Z, Toxic and Hazardous Substances, Occupational Safety and Health Administration (OSHA), (Ariel Insight™ CD-ROM Version), Ariel Research Corp., Bethesda, MD.

Registry of Toxic Effects of Chemical Substances, National Institute for Occupational Safety and Health, Cincinnati, OH,
(TOMES CPS™ CD-ROM Version), Micromedex, Inc., Englewood, CO.

Ariel Insight™ (An integrated guide to industrial chemicals covered under major regulatory and advisory programs), North American Module, Western European Module, Chemical Inventories Module and the Generics Module (Ariel Insight™ CD-ROM Version), Ariel Research Corp., Bethesda, MD.

The Teratogen Information System, University of Washington, Seattle, WA (TOMES CPS™ CD-ROM Version), Micromedex, Inc., Englewood, CO.

NALCO

SAFETY DATA SHEET

PRODUCT

EVAC Biocide

EMERGENCY TELEPHONE NUMBER(S)

(800) 424-9300 (24 Hours) CHEMTREC

Prepared By : Product Safety Department
Date issued : 02/09/2011
Version Number : 1.12

GE
Water & Process Technologies

Material Safety Data Sheet

Issue Date: 12-FEB-2009
Supercedes: 10-DEC-2007

SPECTRUS CT1300

1 Identification

Identification of substance or preparation
SPECTRUS CT1300

Product Application Area
Water-based microbial control agent.

Company/Undertaking Identification
GE Betz, Inc.
4636 Somerton Road
Trevose, PA 19053
T 215 355-3300, F 215 953 5524

Emergency Telephone
(800) 877-1940

Prepared by Product Stewardship Group: T 215-355-3300 Prepared on: 12-FEB-2009

2 Hazard(s) identification

****

EMERGENCY OVERVIEW

DANGER

Corrosive to skin. Potential skin sensitizer. Corrosive to the eyes. Vapors, gases, mists and/or aerosols may cause irritation to upper respiratory tract.

DOT hazard: Corrosive to skin, Flammable
Odor: Mild; Appearance: Colorless To Yellow, Liquid

Fire fighters should wear positive pressure self-contained breathing apparatus(full face-piece type). Proper fire-extinguishing media: dry chemical, carbon dioxide or foam--Avoid water if possible.

****

POTENTIAL HEALTH EFFECTS

ACUTE SKIN EFFECTS:
Primary route of exposure; Corrosive to skin. Potential skin sensitizer.

ACUTE EYE EFFECTS:
Corrosive to the eyes.

ACUTE RESPIRATORY EFFECTS:
Vapors, gases, mists and/or aerosols may cause irritation to upper

respiratory tract.

INGESTION EFFECTS:

Toxic;
May cause severe irritation or burning of mouth, throat, and gastrointestinal tract with severe chest and abdominal pain, nausea, vomiting, diarrhea, lethargy and collapse. Possible death when ingested in very large doses.

TARGET ORGANS:

Prolonged or repeated exposures may cause CNS depression, tissue narcoses, skin sensitization, and/or toxicity to the liver and kidney.

MEDICAL CONDITIONS AGGRAVATED:

Not known.

SYMPTOMS OF EXPOSURE:

Inhalation of vapors/mists/aerosols may cause eye, nose, throat and lung irritation. Skin contact may cause severe irritation or burns.

3 Composition / information on ingredients

Information for specific product ingredients as required by the U.S. OSHA HAZARD COMMUNICATION STANDARD is listed. Refer to additional sections of this MSDS for our assessment of the potential hazards of this formulation.

HAZARDOUS INGREDIENTS:

Cas#	Chemical Name	Range(w/w%)
68424-85-1	(C12-16)ALKYL DIMETHYL BENZYL AMMONIUM CHLORIDE Corrosive (eyes and skin);toxic (by ingestion)	40-70
64-17-5	ETHYL ALCOHOL Flammable liquid; irritant (eyes); may cause CNS depression; potential liver, kidney, brain, heart and male reproductive toxin; produced mutagenic effects in germ cells and somatic cells (in vivo)	7-13

4 First-aid measures

SKIN CONTACT:

URGENT! Wash thoroughly with soap and water. Remove contaminated clothing. Get immediate medical attention. Thoroughly wash clothing before reuse.

EYE CONTACT:

URGENT! Immediately flush eyes with plenty of low-pressure water for at least 20 minutes while removing contact lenses. Hold eyelids apart. Get immediate medical attention.

INHALATION:

Remove to fresh air. If breathing is difficult, give oxygen. If breathing has stopped, give artificial respiration. Get immediate medical attention.

INGESTION:

Do not feed anything by mouth to an unconscious or convulsive

victim. Dilute contents of stomach. Induce vomiting by one of the standard methods. Immediately contact a physician.

NOTES TO PHYSICIANS:

Material is corrosive. It may not be advisable to induce vomiting. Possible mucosal damage may contraindicate the use of gastric lavage.

5 Fire-fighting measures

FIRE FIGHTING INSTRUCTIONS:

Fire fighters should wear positive pressure self-contained breathing apparatus (full face-piece type).

EXTINGUISHING MEDIA:

dry chemical, carbon dioxide or foam--Avoid water if possible.

HAZARDOUS DECOMPOSITION PRODUCTS:

oxides of carbon and nitrogen, hydrogen chloride

FLASH POINT:

130F 54C P-M(CC)

MISCELLANEOUS:

Corrosive to skin, Flammable
UN 2920;Emergency Response Guide #132

6 Accidental release measures

PROTECTION AND SPILL CONTAINMENT:

Ventilate area. Use specified protective equipment. Contain and absorb on absorbent material. Place in waste disposal container. Remove ignition sources. Flush area with water. Spread sand/grit.

DISPOSAL INSTRUCTIONS:

Water contaminated with this product may be sent to a sanitary sewer treatment facility,in accordance with any local agreement,a permitted waste treatment facility or discharged under a permit. Product as is - Dispose of in approved pesticide facility or according to label instructions.

7 Handling and storage

HANDLING:

Combustible. Corrosive to skin and/or eyes.

STORAGE:

Keep containers closed when not in use. Keep away from flames or sparks. Bond containers during filling or discharge when performed at temperatures at or above the product flash point. Shelf life 360 days.

8 Exposure controls / personal protection

EXPOSURE LIMITS

CHEMICAL NAME

(C12-16)ALKYL DIMETHYL BENZYL AMMONIUM CHLORIDE
PEL (OSHA): NOT DETERMINED
TLV (ACGIH): NOT DETERMINED

ETHYL ALCOHOL

PEL (OSHA): 1,000 PPM
TLV (ACGIH): 1,000 PPM

ENGINEERING CONTROLS:
Adequate ventilation to maintain air contaminants below exposure limits.

PERSONAL PROTECTIVE EQUIPMENT:
Use protective equipment in accordance with 29CFR 1910 Subpart I

RESPIRATORY PROTECTION:
A RESPIRATORY PROTECTION PROGRAM THAT MEETS OSHA'S 29 CFR 1910.134 AND ANSI Z88.2 REQUIREMENTS MUST BE FOLLOWED WHENEVER WORKPLACE CONDITIONS WARRANT A RESPIRATOR'S USE.
USE AIR PURIFYING RESPIRATORS WITHIN USE LIMITATIONS ASSOCIATED WITH THE EQUIPMENT OR ELSE USE SUPPLIED AIR-RESPIRATORS.
If air-purifying respirator use is appropriate, use organic vapor cartridges and any of the following particulate respirators: N95, N99, N100, R95, R99, R100, P95, P99 or P100.

SKIN PROTECTION:
gauntlet-type rubber, butyl or neoprene gloves, chemical resistant apron -- Wash off after each use. Replace as necessary.

EYE PROTECTION:
splash proof chemical goggles, face shield

9 Physical and chemical properties

Specific Grav.(70F,21C)	0.965	Vapor Pressure (mmHG)	44.0
Freeze Point (F)	-7	Vapor Density (air=1)	< 1.00
Freeze Point (C)	-22		
Viscosity(cps 70F,21C)	73	% Solubility (water)	100.0

Odor		Mild
Appearance		Colorless To Yellow
Physical State		Liquid
Flash Point	P-M(CC)	130F 54C
pH As Is (approx.)		8.9
Evaporation Rate (Ether=1)		< 1.00
Percent VOC:		ND

NA = not applicable ND = not determined

10 Stability and reactivity

CHEMICAL STABILITY:
Stable under normal storage conditions.

POSSIBILITY OF HAZARDOUS REACTIONS:

INCOMPATIBILITIES:
May react with strong oxidizers.

DECOMPOSITION PRODUCTS:
oxides of carbon and nitrogen, hydrogen chloride

11 Toxicological information

Oral LD50 RAT: 445 mg/kg
Dermal LD50 RABBIT: >1,800 mg/kg
Skin Sensitization G.PIG: NEGATIVE

NOTE - Active component was neither a photoallergen nor a skin sensitizer

12 Ecological information

AQUATIC TOXICOLOGY

Annelida(Lumbriculus variegatus) 96 Hour Acute Toxicity
LC50= 1.47; LC10= .37 mg/L
Benthic Crustacean(Gammerus pseutolimnaeus) 96 Hour Acute Toxicity
LC50= .07 mg/L
Ceriodaphnia 48 Hour Static Renewal Bioassay
LC50= .35; No Effect Level= .15 mg/L
Ceriodaphnia 7 Day Chronic Bioassay
IC25 = .098 mg/L
Channel Catfish 96 Hour Acute Toxicity
LC50= .86; No Effect Level= .54 mg/L
Daphnia magna 48 Hour Flow-Thru Bioassay
LC50= .04; No Effect Level= .026 mg/L
Daphnia magna 48 Hour Static Acute Bioassay
LC50= .11; No Effect Level= .06 mg/L
Daphnia pulex 48 Hour Static Renewal Bioassay
LC50= .05; No Effect Level= .031 mg/L
Fathead Minnow 7 Day Chronic Bioassay
IC25 = .259 mg/L
Fathead Minnow 96 Hour Flow-Thru Bioassay
LC50= .72; No Effect Level= .41 mg/L
Freshwater Snail(Physa sp.) 96 Hour Acute Toxicity
LC50= .46; No Effect Level= .36 mg/L
Menidia beryllina (Silversides) 96 Hour Flow-Thru Bioassay
LC50= .62; No Effect Level= .35 mg/L
Midge larvae (Chironomus tentans) 96 Hour Acute Toxicity
LC50= .5; No Effect Level= .13 mg/L
Mysid Shrimp 96 Hour Flow-Thru Bioassay
LC50= .16; No Effect Level= .03 mg/L
Rainbow Trout 96 Hour Flow-Thru Bioassay
LC50= 2; No Effect Level= 1.2 mg/L
Sheepshead Minnow 96 Hour Flow-Thru Bioassay
LC50= 1.76; No Effect Level= 1 mg/L

No Data Available.

BIODEGRADATION

BOD-28 (mg/g): 156
BOD-5 (mg/g): 43
COD (mg/g): 1470
TOC (mg/g): 380

13 Disposal considerations

If this undiluted product is discarded as a waste, the US RCRA hazardous waste identification number is :
Exempt D001 per 40 CFR 261.21(a)(1).

Please be advised; however, that state and local requirements for waste disposal may be more restrictive or otherwise different from federal regulations. Consult state and local regulations regarding the proper disposal of this material.

14 Transport information

DOT HAZARD:	Corrosive to skin, Flammable
PROPER SHIPPING NAME:	CORROSIVE LIQUIDS, FLAMMABLE, N.O.S.(QUATERNARY AMMONIUM COMPOUNDS, ETHYL ALCOHOL) 8(3), UN 2920, PG II
DOT EMERGENCY RESPONSE GUIDE #:	132

Note: Some containers may be DOT exempt, please check BOL for exact container classification

15 Regulatory information

TSCA:
This is an EPA registered biocide and is exempt from TSCA inventory requirements.

CERCLA AND/OR SARA REPORTABLE QUANTITY (RQ):
No regulated constituent present at OSHA thresholds

FIFRA REGISTRATION NUMBER:
3876- 149

FOOD AND DRUG ADMINISTRATION:
21 CFR 176.300 (slimicides for wet end use)
When used in this specified application, all ingredients comprising this product are authorized by FDA for the manufacture of paper and paperboard that may contact aqueous and fatty foods as per 21 CFR 176.170(a)(4).

NSF Registered and/or meets USDA (according to 1998 Guidelines):
Registration number: Not Registered
G5, G7

SARA SECTION 312 HAZARD CLASS:
Immediate(acute);Delayed(Chronic);Fire

SARA SECTION 302 CHEMICALS:
No regulated constituent present at OSHA thresholds

SARA SECTION 313 CHEMICALS:
No regulated constituent present at OSHA thresholds

CALIFORNIA REGULATORY INFORMATION

CALIFORNIA SAFE DRINKING WATER AND TOXIC ENFORCEMENT ACT (PROPOSITION 65):
No regulated constituents present

MICHIGAN REGULATORY INFORMATION

No regulated constituent present at OSHA thresholds

16 Other information

HMIS vII		CODE TRANSLATION
Health	3	Serious Hazard
Fire	2	Moderate Hazard
Reactivity	0	Minimal Hazard
Special	CORR	DOT corrosive
(1) Protective Equipment	D	Goggles,Face Shield,Gloves,Apron

(1) refer to section 8 of MSDS for additional protective equipment recommendations.

CHANGE LOG

	EFFECTIVE DATE	REVISIONS TO SECTION:	SUPERCEDES
MSDS status:	18-NOV-1997		** NEW **
	27-FEB-1998	15	18-NOV-1997
	15-MAY-1998	2	27-FEB-1998
	20-MAY-1998	11	15-MAY-1998
	17-AUG-1998	15	20-MAY-1998
	27-OCT-1998	;EDIT:9	17-AUG-1998
	12-NOV-1998	;EDIT:9	27-OCT-1998
	03-MAY-2000	12	12-NOV-1998
	05-JUL-2001	12	03-MAY-2000
	24-SEP-2001	3,4,5,7,8,14,16	05-JUL-2001
	16-NOV-2001	12	24-SEP-2001
	30-DEC-2005	13;EDIT:15	16-NOV-2001
	19-DEC-2006	13;EDIT:15	30-DEC-2005
	05-APR-2007	2	19-DEC-2006
	10-DEC-2007	5,7,8,10	05-APR-2007
	12-FEB-2009	12	10-DEC-2007

BetzDearborn
A Division of Hercules Incorporated

Lot Number:

Material ID: 6020665

Net Weight: Lbs.

HEALTH	3
FLAMMABILITY	2
REACTIVITY	0
PERSONAL PROTECTION	B

Packaging Date: 07/12/00 Wash: **Made In USA**

SPECTRUS CT1300

FOR CONTROL OF ALGAE AND ALGAL SLIME GROWTH IN WATER COOLING SYSTEMS

PRECAUTIONARY STATEMENTS

HAZARDS TO HUMANS AND DOMESTIC ANIMALS

DANGER

CORROSIVE. CAUSES SEVERE EYE & SKIN DAMAGE. Do not get in eyes, on skin or on clothing. Wear goggles or face shield & rubber gloves when handling. HARMFUL OR FATAL IF SWALLOWED. Avoid contamination of food. Wash thoroughly with soap and water after handling. Remove contaminated clothing and wash before reuse.

ENVIRONMENTAL HAZARDS This product is toxic to fish. Do not discharge effluent containing this product into lakes, streams, ponds, estuaries, oceans or other waters unless in accordance with the requirements of a National Pollutant Discharge Elimination System (NPDES) permit and the permitting authority has been notified in writing prior to discharge. Do not discharge effluent containing this product to sewer systems without previously notifying the local sewage treatment plant authority. For guidance, contact your State Water Board or Regional Office of the EPA.

PHYSICAL AND CHEMICAL HAZARDS Do not use or store near heat or open flame.

STATEMENT OF PRACTICAL TREATMENT In case of contact, immediately flush eyes or skin with plenty of water for at least 15 minutes. For eyes, call a physician. Remove and wash contaminated clothing before reuse. If swallowed, drink promptly a large quantity of milk, egg whites, gelatin solution; or if these are not available, drink large quantities of water. Avoid alcohol. Call a physician immediately.

NOTE TO PHYSICIAN: Probable mucosal damage may contraindicate the use of gastric lavage.

ACTIVE INGREDIENT:	
N-Alkyl (50% C14, 40% C12, 10% C16)	
dimethylbenzyl ammonium chloride	50%
INERT INGREDIENTS	50%
TOTAL	100.0%

CONTENTS: LIQUID
POUNDS PER GALLON: 8.0

EPA REGISTRATION NUMBER: 3876-149

EPA ESTABLISHMENT NUMBER:

KEEP OUT OF REACH OF CHILDREN

DANGER

For Industrial Use. Technical advice regarding specific site problems is available from BetzDearborn, a Division of Hercules Incorporated.

A Material Safety Data Sheet containing more detailed information relative to this product is available upon request.

For product use see Panel 2.

DIRECTIONS FOR USE: It is a violation of Federal law to use this product in a manner inconsistent with its labeling.

STORAGE AND DISPOSAL

PROHIBITIONS: Do not contaminate water, food or feed by storage or disposal. Open dumping is prohibited. Do not reuse empty container.
STORAGE INSTRUCTIONS: Store in original container. Keep from freezing.
SPILL OR LEAK PROCEDURE: Small spills may be mopped up or flushed away with water or absorbed on some absorbent material and incinerated.
PESTICIDE DISPOSAL
Pesticide wastes are acutely hazardous. Improper disposal of excess pesticide, spray mixture or rinsate is a violation of Federal Law. If these wastes cannot be disposed of by use according to label instructions, contact your State Pesticide or Environmental Control Agency, or the Hazardous Waste Representative at the nearest EPA Regional Office for guidance.
CONTAINER DISPOSAL
Triple rinse (or equivalent). Then offer for recycling or reconditioning, or puncture and dispose of in a sanitary landfill, or by other procedures approved by state and local authorities.

BetzDearborn Inc., Water Management Group, 4636 Somerton Road, Trevose, PA, 19053
Business Phone: 215-355-3300 • Emergency Phone: 800-877-1940

BetzDearborn

Made in USA

GEN 9905- 7/12/00

HEALTH	[illegible]
FLAMMABILITY	2
REACTIVITY	0
PERSONAL PROTECTION	B

SPECTRUS CT1300

FOR CONTROL OF ALGAE AND ALGAL SLIME GROWTH IN WATER COOLING SYSTEMS

DIRECTIONS FOR USE: It is a violation of Federal law to use this product in a manner inconsistent with its labeling.

INDUSTRIAL AND/OR COMMERCIAL RECIRCULATING COOLING WATER SYSTEMS This product aids in the control of mollusca, barnacles, hydrozoa, bryozoa and of bacterial, fungal and algal slimes in evaporative condensers, heat exchange water systems, commercial and industrial cooling towers, influent systems such as flow-through filters and lagoons, industrial water scrubbing systems and brewery pasteurizers. Do not use water containing residues from use of this product to irrigate crops used for food or feed. Use of this product in either public/municipal or single or multiple family private/residential potable/drinking water systems is strictly prohibited. Use of this product in any cooling water system that discharges effluent within 1/4 mile of either a public/municipal or single or multiple family private/residential potable/drinking water intake is strictly prohibited. This product may be added to the systems as needed. The frequency of feeding and duration of the treatment will depend upon the severity of the problem. BADLY FOULED SYSTEMS must be cleaned before treatment is begun.

FOR THE CONTROL OF ALGAE
INITIAL DOSE: When the system is noticeably fouled, add this product at the rate of 0.15 to 0.65 pound (18 to 78 ppm) per 1000 gallons of water in the system. Repeat until control is achieved
SUBSEQUENT DOSE: When control is evident, add this product at the rate of 0.1 to 0.45 pound (12 to 36 ppm) per 1000 gallons of water in the system.

FOR CONTROL OF BACTERIA AND FUNGI
INITIAL DOSE: When the system is noticeably fouled, add this product at the rate of 0.1 to 0.45 pound (12 to 36 ppm) per 1000 gallons of water in the system. Repeat until control is achieved.
SUBSEQUENT DOSE: When control is evident, add this product at the rate of 0.05 to 0.15 pound (6 to 18 ppm) per 1000 gallons of water in the system.

FOR CONTROL OF MOLLUSCA, BARNACLES, HYDROZOA AND BRYOZOA
Add this product at the rate of 0.016 to 0.166 pound (2 to 20 ppm) per 1000 gallons of water in the system. Maintain this concentration for 3 to 48 hours.

ONCE-THROUGH INDUSTRIAL COOLING WATER SYSTEMS
This product aids in the control of mollusca, barnacles, hydrozoa, bryozoa and of algal, bacterial and fungal slimes in once-through fresh and sea water cooling systems, cooling ponds, canals and lagoons. This product may be added to the system inlet water or before any contaminated area in the system. **BADLY FOULED SYSTEMS** must be cleaned before treatment is begun.

FOR THE CONTROL OF ALGAE, BACTERIA AND FUNGI
INITIAL DOSE: When the system is noticeably fouled, add this product at the rate of 0.15 to 0.65 pound (18 to 78 ppm) per 1000 gallons of water based on the flow rate through the system. Minimum treatment intervals should be 15 minutes. Repeat until control is achieved. SUBSEQUENT DOSE: When control is evident, add this product at the rate of 0.1 to 0.45 pound (12 to 36 ppm) per 1000 gallons of water based on the flow rate through the system.

FOR THE CONTROL OF MOLLUSCA, BARNACLES, HYDROZOA AND BRYOZOA
Add this product at the rate of 0.016 to 0.166 pound (2 to 20 ppm) per 1000 gallons of water based on the flow rate through the system. Maintain this concentration for 3 to 48 hours.

AUXILIARY WATER/SERVICE WATER AND WASTE WATER SYSTEMS
This product is effective for the control of mollusca, barnacles, hydrozoa, bryozoa and of odor-forming and slime-forming bacteria, fungi and algae in auxiliary water systems such as fire protection systems and pump or screen bays, waste water and waste material disposal, holding or recovery systems such as storage tanks, storage piles, associated piping, settling ponds or lagoons, transport spillways or canals and disposal wells. This product may be added to the system water or by spraying onto a waste pile as needed. The frequency of feed or spray and the duration of treatment will depend upon the severity of the contamination. Additions to water systems should be made during the pumping operation and as close to the pump as possible to ensure adequate mixing.
INTERMITTENT OR SLUG METHOD - When treatment is required, add this product at the rate of 0.3 to 1.3 pounds (36 to 156 ppm) per 1000 gallons of water already in the system, or being added to the system, for 4 to 8 hours, 1 to 4 times per week or as needed to achieve the desired level of control. When control is obtained, add this product at the rate of 0.15 to 0.65 pound (18 to 78 ppm) per 1000 gallons of water in the system.

Lot Number: Material ID: 6020665 Packaging Date: 07/12/00 Net Weight: Lbs.

BetzDearborn Inc., Water Management Group, 4636 Somerton Road, Trevose, PA, 19053
Business Phone: 215-355-3300 - Emergency Phone: 800-877-1940

Water & Process Technologies

Fact Sheet

Spectrus* CT1300

Mollusk Control Agent

- Controls common fouling mollusks at all life stages using brief (6 to 24 hr) seasonal applications
- Effective on all types of fresh and salt water clams, mussels, and oysters
- Can be rapidly detoxified and is readily biodegradable
- Field test methods available for determining product concentrations

Description and Use

Spectrus* CT1300 is an environmentally friendly, bio-control agent that can be used to control mollusks in a variety of industrial, water-based systems. Spectrus CT1300 can also be used for control of algae, bacteria, and fungal slimes in these same water systems. Spectrus CT1300 is concentrated. It contains 50% of quaternary ammonium hydrochloride (Quat) as active ingredient.

Spectrus CT1300, applied in brief (6 to 24 hr) seasonal applications, is effective against all mollusks at all life stages. Spectrus CT1300 is effective against adult organisms and will prevent immature forms from growing to a fouling size.

Spectrus CT1300 is EPA-approved for use in recirculating cooling systems, heat exchange systems, and evaporative condensers. This product is also approved for use in once-through cooling systems, service water, auxiliary water, and fire protection systems, as well as influent and wastewater systems. See the Spectrus CT1300 product label for a complete listing of approved end-uses.

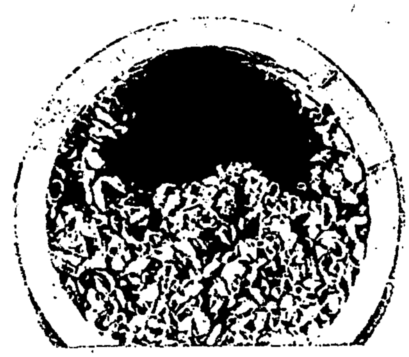


Figure 1: Zebra Mussel Accumulation after 3 Months in a 6-in. (15.2 cm) Diameter Discharge Line.

Control of macrofouling organisms such as mollusks is needed to prevent blocked water lines and damaged equipment. Uncontrolled growth of macrofouling organisms can lead to higher maintenance and production costs, reduced plant safety, and even plant outages. Therefore, an effective macrofouling control is necessary for operating units to achieve profitability goals. More importantly, effective macrofouling control is essential to ensure availability of fire protection systems and other safety-related equipment.

Environmental Benefits

The active ingredient in Spectrus CT1300 (Quat) is short-lived in the environment. Quats are cationic and rapidly adsorbed by natural, anionic substrates and sediments. Adsorption effectively detoxifies Quats and renders them harmless to aquatic and benthic organisms as well as microbes.

Find a contact near you by visiting www.ge.com/water or e-mailing custhelp@ge.com.

Global Headquarters
Trevose, PA
+1-215-355-3300

Americas
Watertown, MA
+1-617-926-2500

Europe/Middle East/Africa
Heverlee, Belgium
+32-16-40-20-00

Asia/Pacific
Shanghai, China
+86 (0) 411-8366-6489

Spectrus CT1300 can be deliberately detoxified by use of highly adsorbent, anionic materials such as those found in Spectrus DT1400 or DT1401. These products may be used where natural adsorption is not adequate to comply with water quality criteria. Once adsorbed, Quats are readily biodegraded to carbon dioxide and water.

Because Spectrus CT1300 provides macrofouling control in just a few hours, it reduces chemical consumption, environmental impact and treatment costs compared to halogen-based macrofouling treatments. When halogens are used for mollusk control, they must be applied continuously for several weeks if they are to be effective, and they must be dehalogenated. In addition, continuous feed of halogens promotes formation of undesirable byproducts such as trihalomethanes (THMs), total organic halides (TOX), and adsorbable halogenated organics (AOX). Since Spectrus CT1300 is not an oxidizer, it does not produce these compounds.

Treatment and Feeding Requirements

Correct treatment levels and frequency of Spectrus CT1300 addition depend on many factors. These include, but are not limited to, degree of infestation, type of mollusk, temperature, system retention time, and discharge environment. Heavy infestations of mollusks should be physically removed by vacuuming, dredging, or scraping prior to treatment. Consult your GE representative for technical advice on your specific application.

Feed point - Apply Spectrus CT1300 to a point in the system where turbulence and flow patterns assure good mixing with the water being treated.

Dilution - This product is best fed neat (undiluted) from the storage container.

Feed Equipment - Spectrus CT1300 is compatible with the following materials of construction: Hastalloy 825; High Density Cross-linked Polyethylene; Teflon; PVC; Neoprene; Buna N; Buna S; Litharge Viton; Ethylene Propylene Resin; Hypalon. (Teflon and Viton are registered trademarks of DuPont.)

Avoid use of: 304 and 316 Stainless Steels (especially in thin walled feed lines); High Density Polypropylene; Linear High Density Polyethylene; Nylon.

This product may be fed using the PaceSetter* control system.

General Properties

Physical properties of Spectrus CT1300 are shown on the Material Safety Data Sheet, a copy of which is available on request.

Packaging Information

Spectrus CT1300 is a liquid and is available in a wide variety of containers and delivery methods, including GE's ChemSure* Drumless Delivery Services

Storage

Protect from extreme temperatures. Protect from freezing. Keep containers closed when not in use. Keep away from flames or sparks.

Safety Precautions

Use of eye protection (goggles and face shield) and gauntlet-type neoprene gloves is required when handling this product. See section 7 of the MSDS for additional information on recommended personal protective equipment.

General Information

EPA Registration Number..............3876-149

Purchase of Spectrus CT1300 from GE includes a license to practice the process covered by U.S. Patent 4,857,209.

BENTONITE PERFORMANCE MINERALS

MATERIAL SAFETY DATA SHEET

NATIONAL® Bentonite

Revision Date: February 25, 2002

1. PRODUCT COMPANY AND IDENTIFICATION

Product Trade Name:	NATIONAL® Bentonite	
Generic Description:	Wyoming Bentonite, Sodium montmorillonite	CAS# 1302-78-9
Supplier:	Bentonite Performance Minerals 410 17th Street, Suite 405 Denver, Colorado 80202-4447	
Telephone:	(303) 571-8240	
Fax Number:	(303) 571-8280	
Chemtrec Emergency Number:	(800) 424-9300	

2. COMPOSITION/INFORMATION ON THE COMPONENTS

MATERIAL OR COMPONENT			**ACGIH-TLV-TWA**	**OSHA PEL-TWA**
Wyoming Bentonite, Sodium Montmorillonite	(60-100%)	CAS # 1302-78-9	not applicable	not applicable
Crystalline Silica				
Quartz	(1-5%)	CAS#14808-60-7	0.05 mg/m^3	$(10mg/m^3)/(\%SiO_2+2)$
Cristobalite	(0-1%)	CAS#14464-46-1	0.05 mg/m^3	$1/2x(10mg/m^3)/(\%SiO_2+2)$
Tridymite	(0-1%)	CAS#15468-32-3	0.05 mg/m^3	$1/2x(10mg/m^3)/(\%SiO_2+2)$

More restrictive exposure limits may be enforced by some states, agencies, or other authorities.

3. HAZARD IDENTIFICATION

Hazard Overview:

CAUTION! - ACUTE HEALTH HAZARD
May cause eye and respiratory irritation

DANGER! - CHRONIC HEALTH HAZARD
Breathing crystalline silica can cause lung disease, including silicosis and lung cancer. Crystalline silica has also been associated with scleroderma and kidney disease.

This product contains quartz, cristobalite and tridymite which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposures below recommended exposure limits. Wear a NIOSH specified, European Standard EN 149, or equivalent respirator when using this product. Review the Material Safety Data Sheet (MSDS) for this product, which has been provided to your employer.

4. FIRST AID MEASURES

Inhalation If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.

Skin	Wash with soap and water. Get medical attention if irritation persists.
Eyes	In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.
Ingestion	Under normal conditions, first aid procedures are not required.
Notes to Physicians	Treat symptomatically.

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	Not determined
Flash Point/Range (C):	Not determined
Flash Point Method:	Not determined
Autoignition Temperature (F):	Not determined
Autoignition Temperature (C):	Not determined
Flammability Limits in Air-Lower (%):	Not determined
Flammability Limits in Air-Upper (%):	Not determined
Fire Extinguishing Media	All standard firefighting media.
Special Exposure Hazards	Not applicable.
Special Protective Equipment for Fire-Fighters	Not applicable
NFPA Ratings:	Health 0, Flammability 0, Reactivity 0
HMIS Ratings:	Flammability 0, Reactivity 0, Health 0*

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures:	Use appropriate protective equipment. Avoid creating and breathing dust.
Environmental Precautionary Measures:	None known.
Procedure for Cleaning/Absorption	Collect using dustless method and hold for appropriate disposal. Consider possible toxic or fire hazards associated with contaminating substances and use appropriate methods for collection, storage and disposal.

7. HANDLING AND STORAGE

Handling Precautions This product contains quartz, cristobalite and tridymite, which may become airborne without a visible dust cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposure below recommended exposure limits. Wear a NIOSH specified, European Standard EN 149, or equivalent respirator when using this product. Material is slippery when wet.

Storage Information	Use good housekeeping in storage and work areas to prevent accumulation of dust. Close container when not in use. Do not reuse empty container.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls	Use approved industrial ventilation and local exhaust as required to maintain exposures below applicable exposure limits listed in Section 2.
Respiratory Protection	Wear a NIOSH specified, European Standard EN 149, or equivalent respirator when using this product.
Hand Protection	Normal work gloves.
Skin Protection	Wear clothing appropriate for the work environment. Dusty clothing should be laundered before reuse. Use precautionary measures to avoid creating dust when removing or laundering clothes.
Eye Protection	Wear safety glasses or goggles to protect against exposure.
Other Precautions	None known

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State	Solid
Color	various
Odor	Odorless
pH	8 to 10 in 6% slurry
Specific Gravity (H_2O = 1)	2.65
Density at 20C (lb/gallon)	Not determined
Bulk Density at 20 C (lb/gal)(uncompacted)	50-70 lb/ft^3
Boiling Point/Range (F):	Not determined
Boiling Point/Range (C):	Not determined
Freezing Point/Range (F):	Not determined
Freezing Point/Range (C):	Not determined
Vapor Pressure at 20C (mm Hg)	Not determined
Vapor Density (Air = 1)	Not determined
Percent Volatiles:	Not determined
Evaporation Rate (Butyl Acetate=1)	Not determined
Solubility in Water (g/100ml)	Insoluble
Solubility in Solvents (g/ml)	Not determined
Solubility is Sea Water (g/ml)	Insoluble
VOCs (lb/gallon)	Not determined
Viscosity, Dynamic at 20C (centipoise)	Not determined
Viscosity, Kinematic at 20C (centistoke)	Not determined
Partition Coefficient/n-Octanol/water	Not determined
Molecular weight (g/mole)	Not determined

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization	Will not occur.
Conditions to Avoid	None anticipated
Incompatibility (Materials to Avoid)	Hydrofluoric acid
Hazardous Decomposition Products	Amorphous silica may transform at elevated temperatures to crystallize to tridymite (870C) or cristobalite (1470C).
Additional Guidelines	Not applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye or skin contact, inhalation.
Inhalation	Inhaled crystalline silica in the form of quartz or cristobalite from occupational sources is carcinogenic to humans (IARC Group 1). There is sufficient evidence in experimental animals for the carcinogenicity of tridymite (IARC, Group 2A). Breathing silica dust may cause irritation of the nose, throat, and respiratory passages. Breathing silica dust may not cause noticeable injury or illness even though permanent lung damage may be occurring. Inhalation of dust may also have serious chronic health effects (See "Chronic Effects/Carcinogenicity subsection below).
Skin Contact	May cause mechanical skin irritation.
Eye Contact	May cause eye irritation.
Ingestion	None known.
Aggravated medical Conditions	Individuals with respiratory disease, including but not limited to asthma and bronchitis, or subject to eye irritation, should not be exposed to quartz dust.

Chronic Effects/Carcinogenicity
Silicosis: Excessive inhalation of respirable crystalline silica dust may cause a progressive, disabling and sometimes-fatal lung disease called silicosis. Symptoms include cough, shortness of breath, wheezing, non-specific chest illness and reduced pulmonary function. This disease is exacerbated by smoking. Individuals with silicosis are predisposed to develop tuberculosis.

Cancer Status: The International Agency for Research on Cancer (IARC) has determined that crystalline silica inhaled in the form of quartz or cristobalite from occupational sources can cause lung cancer in humans (Group 1 – carcinogenic to humans) and has determined that there is sufficient evidence in experimental animals for the carcinogenicity of tridymite (Group 2A – possible carcinogen to humans).

Refer to IARC Monograph 68, Silica, Some Silicates and Organic Fibres (June 1997) in conjunction with the use of these minerals. The National Toxicology Program classifies respirable crystalline silica as "Known to be a human carcinogen". Refer to the 9th Report on Carcinogens (2000). The American Conference of Governmental Industrial Hygienists (ACGIH) classifies crystalline silica, quartz, as a suspected human carcinogen (A2).

There is some evidence that breathing respirable crystalline silica or the disease silicosis is associated with an increased incidence of significant disease endpoints such as scleroderma (an immune system disorder manifested by scarring of the lungs, skin and other internal organs) and kidney disease.

Other Information: For further information consult "Adverse Effects of Crystalline Silica Exposure" published by the American Thoracic Society Medical Section of the American Lung Association, American Journal of Respiratory and Critical Care Medicine, Volume 155, pp 761-768 (1997).

Toxicity Tests

Oral Toxicity:	Not determined
Dermal Toxicity:	Not determined
Inhalation Toxicity:	Not determined
Primary Irritation Effect:	Not determined
Carcinogenicity	International Agency for Research on Cancer (IARC) Group 1 Carcinogen (Carcinogenic to Humans)
Genotoxicity:	Not determined
Reproductive/Developmental Toxicity	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Air/Soil)	Not determined
Persistence/Degradability	Not determined
Bio-accumulation	Not determined

Ecotoxicological Information

Acute Fish Toxicity:	TLM96: 10000 ppm (Oncorhynchus mykiss)
Acute Crustaceans Toxicity:	Not determined
Acute Algae Toxicity:	Not determined

Chemical Fate Information Not determined

Other Information Not applicable

13. DISPOSAL

Disposal Method Bury in a licensed landfill according to federal, state and local regulations.

Contaminated Packaging Follow all applicable national or local regulations.

14. TRANSPORTATION INFORMATION

Land Transportation

DOT	Not restricted
Canadian TDG	Not restricted
ADR	Not restricted

Air Transportation

ICAO/IATA Not restricted

Sea Transportation

IMDG Not restricted

Other Shipping Information

Labels: None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components are listed on inventory.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311/312) Hazard Class	Acute Health Hazard Chronic Health Hazard
EPA SARA(313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity For This Product	Not applicable
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.

California Proposition 65	The California Proposition 65 regulations apply to this product.
MA Right-To-Know Law	One or more components listed.
NJ Right-To-Know Law	One or more components listed.
PA Right-To-Know Law	One or more components listed.
Canadian Regulations	
Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	D2A Very Toxic Materials (crystalline silica)

16. OTHER INFORMATION

Abbreviations

®: Registered Trademark of Halliburton Energy Services Inc.
™: Trademark of Halliburton Energy Services Inc.
N/A: Denotes no applicable information found or available
CAS#: Chemical Abstracts Service Number
ACGIH: American Conference of Governmental Industrial Hygienists
OSHA: Occupational Safety and Health Administration
TLV: Threshold Limit Value
PEL: Permissible Exposure Limit
STEL: Short Term Exposure Limit
NTP: National Toxicology Program
IARC: International Agency for Research on Cancer
R: Risk
S: Safety
LC50: Lethal Concentration 50%
LD50: Lethal Dose 50%
BOD: Biological Oxygen Demand
KoC: Soil Organic Carbon Partition Coefficient

This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and third party sources. This information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

MSDS Data Revised: February 25, 2002

BENTONITE PERFORMANCE MINERALS
410 17th Street, Suite 405
Denver, CO 80202-4447
Telephone (303) 571-8240
Facsimile (303) 571-8280

TECHNICAL INFORMATION SHEET

WYO-BEN, INC.
550 South 24th Street West, Suite 201
P. O. Box 1979
Billings, Montana 59103
USA
Tel: 406~652-6351 / Fax: 406~656-0748

SUBJECT: **BIG HORN® FS 200 BENTONITE**

Specially sized pure sodium bentonite for animal feed and other industry applications.

COLOR: Light Gray

TYPICAL CHEMICAL ANALYSIS:

	%
SiO_2	60.34
Al_2O_3	19.28
Fe_2O_3	3.48
Na_2O	2.34
TiO_2	.22
CaO	.38
MgO	1.67
K_2O	.10
Other	.07
H_2O	7.75
L.O.I.	4.37

E.P. TOXICITY ANALYSIS:

	E.P.A. Standard ppm	Typical Analysis ppm
Arsenic	5.0	< 0.1
Barium	100.0	0.5
Cadmium	1.0	< 0.05
Chromium	5.0	< 0.1
Lead	5.0	< 0.1
Mercury	0.2	< 0.02
Selenium	1.0	< 0.05
Silver	5.0	< 0.1

SPECIFIC GRAVITY: 2.55 ± 0.1

SURFACE AREA (m^2/gm):

External Surface	82
All Surfaces	800

BULK DENSITY (lbs/ft^3): 52 ± 3

TYPICAL PARTICLE SIZE:

U.S. Std. Sieve Size	% Passing
100 mesh (15m)	96
200 mesh (75m)	80
325 mesh (45m)	52

TYPICAL CHARACTERISTICS:

Wet Screen Analysis Residue on U.S. Sieve No. 200	3.0 ± 0.5
Ph	9.1 ± 0.4
Moisture Content - %	6-10
Cation Exchange Capacity (CEC meq(100 gm)	70-90
Swell (cc/2 gm)	20 ± 3

USES:

Binder for animal feed pelletizing.
Free choice feed additive for direct feeding.
Industrial binding, sealing and gelling.

...haded areas only
...or elite type, i.e., 12 characters/inch).

Form Approved. OMB No. 2040-0086. Approval expires 5-31-92.

GENERAL

EPA

U.S. ENVIRONMENTAL PROTECTION AGENCY

GENERAL INFORMATION

Consolidated Permits Program

(Read the "General Instructions" before starting.)

I. EPA I.D. NUMBER

S/F		T/A	C
F	A L 8 6 4 0 0 1 5 4 1 0		D
1	2 ... 13	14	15

LABEL ITEMS

I. EPA I.D. NUMBER

III. FACILITY NAME

V. FACILITY MAILING ADDRESS

VI. FACILITY LOCATION

PLEASE PLACE LABEL IN THIS SPACE

GENERAL INSTRUCTIONS

If a preprinted label has been provided, affix in the designated space. Review the information carefully; if any of it is incorrect, cross through it and enter the correct data in the appropriate fill-in area below. Also, if any of the preprinted data is absent *(the area to the left of the label space lists the information that should appear)*, please provide it in the proper fill-in area(s) below. If the label is complete and correct, you need not complete *Items I, III, V, and VI (except VI-B which must be completed regardless)*. Complete all items if no label has been provided. Refer to the instructions for detailed item descriptions and for the legal authorizations under which this data is collected.

II. POLLUTANT CHARACTERISTICS

INSTRUCTIONS: Complete A through J to determine whether you need to submit any permit application forms to the EPA. If you answer "yes" to any questions, you must submit this form and the supplemental form listed in the parenthesis following the question. Mark "X" in the box in the third column if the supplemental form is attached. If you answer "no" to each question, you need not submit any of these forms. You may answer "no" if your activity is excluded from permit requirements; see Section C of the instructions. See also, Section D of the instructions for definitions of **bold-faced terms**.

SPECIFIC QUESTIONS	MARK 'X' YES	NO	FORM ATTACHED	SPECIFIC QUESTIONS	MARK 'X' YES	NO	FORM ATTACHED
A. Is this facility a **publicly owned treatment works** which results in a discharge to **waters of the U.S.**? (FORM 2A)		X		B. Does or will this facility *(either existing or proposed)* include a **concentrated animal feeding operation** or **aquatic animal production facility** which results in a discharge to **waters of the U.S.**? (FORM 2B)		X	
	16	17	18		19	20	21
C. Is this a facility which currently results in discharges to **waters of the U.S.** other than those described in A or B above? (FORM 2C)	X		X	D. Is this a proposed facility *(other than those described in A or B above)* which will result in a discharge to **waters of the U.S.**? (FORM 2D)		X	
	22	23	24		25	26	27
E. Does or will this facility treat, store, or dispose of **hazardous wastes**? (FORM 3)		X		F. Do you or will you inject at this facility industrial or municipal effluent below the lowermost stratum containing, within one quarter mile of the well bore, **underground sources of drinking water**? (FORM 4)		X	
	28	29	30		31	32	33
G. Do you or will you inject at this facility any produced water or other fluids which are brought to the surface in connection with conventional oil or natural gas production, inject fluids used for enhanced recovery of oil or natural gas, or inject fluids for storage of liquid hydrocarbons? (FORM 4)		X		H. Do you or will you inject at this facility fluids for special processes such as mining of sulfur by the Frasch process, solution mining of minerals, in situ combustion of fossil fuel, or recovery of geothermal energy? (FORM 4)		X	
	34	35	36		37	38	39
I. Is this facility a proposed **stationary source** which is one of the 28 industrial categories listed in the instructions and which will potentially emit 100 tons per year of any air pollutant regulated under the Clean Air Act and may affect or be located in an **attainment area**? (FORM 5)		X		J. Is this facility a proposed **stationary source** which is NOT one of the 28 industrial categories listed in the instructions and which will potentially emit 250 tons per year of any air pollutant regulated under the Clean Air Act and may affect or be located in an **attainment area**? (FORM 5)		X	
	40	41	42		43	44	45

III. NAME OF FACILITY

1	SKIP	T V A B R O W N S F E R R Y N U C L E A R P L A N T
15	16-29	30 ... 69

IV. FACILITY CONTACT

A. NAME & TITLE *(last, first, & title)*	B. PHONE *(area code & no.)*		
2 C O O P E R , C . R U S T Y ; E N V M A N A G E R	2 5 6	7 2 9	2 6 8 1
15 16 ... 45	46 - 48	49 - 51	52 - 55

V. FACILITY MAILING ADDRESS

A. STREET OR P.O. BOX
3 P . O . B O X 2 0 0 0 , N A B 1 G
15 16 A ... 45

B. CITY OR TOWN	C. STATE	D. ZIP CODE
4 D E C A T U R	A L	3 5 6 0 9
15 16 ... 40	41 42	47 - 51

VI. FACILITY LOCATION

A. STREET, ROUTE NO. OR OTHER SPECIFIC IDENTIFIER
5 1 0 8 3 5 S H A W R O A D
15 16 ... 45

B. COUNTY NAME
L I M E S T O N E
46 ... 70

C. CITY OR TOWN	D. STATE	E. ZIP CODE	F. COUNTY CODE *(if known)*
6 A T H E N S	A L	3 5 6 0 9	
15 16 ... 40	41 42	47 - 51	52 - 54

CONTINUE ON PAGE 2

CONTINUED FROM PAGE 1

VII. SIC CODES (4-digit, in order of priority)

	Code	Specify
A. FIRST	4911	Electric Services
B. SECOND		
C. THIRD		
D. FOURTH		

VIII. OPERATOR INFORMATION

A. NAME: TENNESSEE VALLEY AUTHORITY

B. Is the name listed as Item VIII-A also the owner? [X] YES [ ] NO

C. STATUS OF OPERATOR (Enter the appropriate letter into the answer box; if "Other", specify.)
F = FEDERAL M = PUBLIC (other than federal or state)
S = STATE O = OTHER (specify)
P = PRIVATE

Answer: F

D. PHONE (area code & no.): 256 729 2681

E. STREET OR P.O. BOX: P.O. BOX 2000, NAB 1G

F. CITY OR TOWN: DECATUR

G. STATE: AL

H. ZIP CODE: 35609

IX. INDIAN LAND

Is the facility located on Indian lands? [ ] YES [X] NO

X. EXISTING ENVIRONMENTAL PERMITS

Permit	Number	Specify
A. NPDES (Discharges to Surface Water)	N AL0022080	
B. UIC (Underground Injection of Fluids)	U	
C. RCRA (Hazardous Wastes)	R AL8640015410	
D. PSD (Air Emissions from Proposed Sources)	P 708-0003-Z001	
E. OTHER (specify)	708-0003-Z003	PSD for fueling facility
E. OTHER (specify)	42-02	Inert Landfill

XI. MAP

Attach to this application a topographic map of the area extending to at least one mile beyond property boundaries. The map must show the outline of the facility, the location of each of its existing and proposed intake and discharge structures, each of its hazardous waste treatment, storage, or disposal facilities, and each well where it injects fluids underground. Include all springs, rivers and other surface water bodies in the map area. See instructions for precise requirements.

XII. NATURE OF BUSINESS (provide a brief description)

Browns Ferry Nuclear Plant (BFN) operates three boiling water reactors for the purpose of generating electric power.

XIII. CERTIFICATION (see instructions)

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this application and all attachments and that, based on my inquiry of those persons immediately responsible for obtaining the information contained in the application, I believe that the information is true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

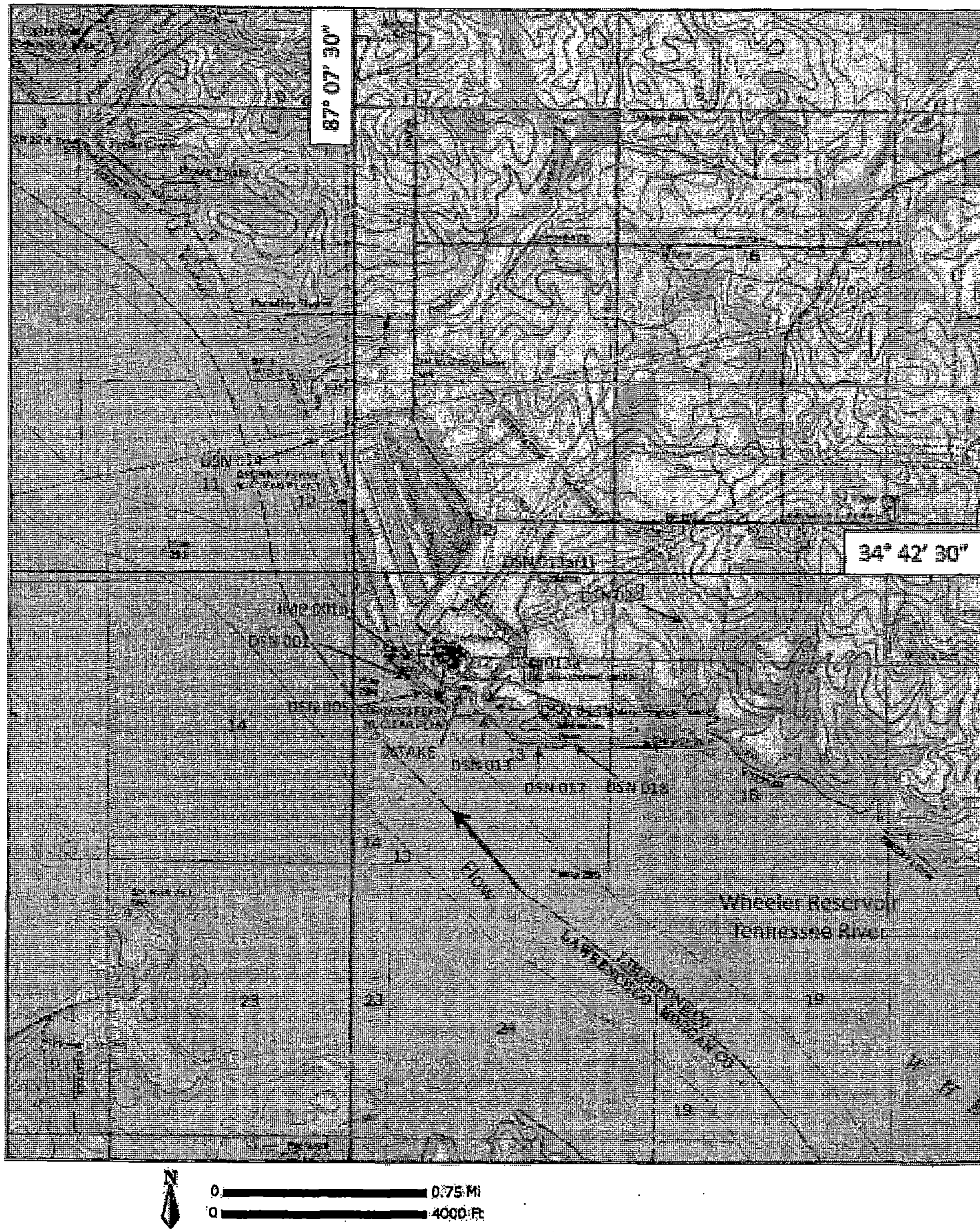
A. NAME & OFFICIAL TITLE (type or print): K. J. Polson, Site Vice President

B. SIGNATURE: [signature]

C. DATE SIGNED: 2-26-11

COMMENTS FOR OFFICIAL USE ONLY

EPA Form 3510-1 (8-90)



TVA BROWNS FERRY NUCLEAR PLANT
NPDES PERMIT NO. AL0022080

Athens, Limestone Co., Alabama
Jones Crossroads & Hillsboro, Alabama 7.5-minute Quadrangles

December 2010

Please print or type in the unshaded areas only

EPA I.D. NUMBER (*copy from Item 1 of Form 1*)
AL8640015410

Form Approved
OMB No. 2040-0086
Approval expires 5/31/92

FORM 2C NPDES

EPA

U. S. ENVIRONMENTAL PROTECTION AGENCY

APPLICATION FOR PERMIT TO DISCHARGE WASTEWATER

EXISTING MANUFACTURING, COMMERCIAL, MINING AND SILVICULTURAL OPERATIONS

Consolidated Permits Program

I. OUTFALL LOCATION

For each outfall, list the latitude and longitude of its location to the nearest 15 seconds and the name of the receiving water.

A. OUTFALL NUMBER (*list*)	B. LATITUDE 1. DEG.	2. MIN	3. SEC.	C. LONGITUDE 1. DEG.	2. MIN.	3. SEC.	D. RECEIVING WATER (*name*)
001	34	42	15	87	07	15	Tennessee River
001b	34	42	15	87	07	15	Tennessee River via DSN001 (internal monitoring point)
005	34	42	15	87	07	15	Tennessee River
013a(1)	34	42	30	87	07	00	Tennessee River via DSN013a and DSN013
013b	34	43	00	87	07	00	Tennessee River via DSN013

II. FLOWS, SOURCES OF POLLUTION, AND TREATMENT TECHNOLOGIES

A. Attach a line drawing showing the water flow through the facility. Indicate sources of intake water, operations contributing wastewater to the effluent, and treatment units labeled to correspond to the more detailed descriptions in Item B. Construct a water balance on the line drawing by showing average flows between intakes, operations, treatment units, and outfalls. If a water balance cannot be determined (*e.g., for certain mining activities*), provide a pictorial description of the nature and amount of any sources of water and any collection or treatment measures.

B. For each outfall, provide a description of: (1) All operations contributing wastewater to the effluent, including process wastewater, sanitary wastewater, cooling water, and storm water runoff; (2) The average flow contributed by each operation; and (3) The treatment received by the wastewater. Continue on additional sheets if necessary.

1. OUT-FALL NO (*list*)	2. OPERATION(S) CONTRIBUTING FLOW a. OPERATION (*list*)	b. AVERAGE FLOW (*include units*)	3. TREATMENT a. DESCRIPTION	b. LIST CODES FROM TABLE 2C-1	
001	Diffuser Discharge which includes:	2895.0 MGD	Discharge to surface water	4	A
	(1) Treated Raw Cooling Water (RCW)	(33.2490 MGD)	Mixing	1	O
	(2) Turbine Building station sumps	(0.1330 MGD)			
	(3) Reactor Building cooling water	(19.8720 MGD)			
	(4) Liquid Radwaste System (DSN001b)	(0.03 MGD)			
	(5) Condenser Cooling Water System	(2841.7 MGD)			
005	Residual Heat Removal Service Water	0.5924 MGD	Discharge to surface water	4	A
	(RHRSW) System				
013a(1)	Wastewater Lagoon discharges which	0.0268 MGD	Grinding	1	L
	include sanitary waste; waste from a medical		Stabilization Ponds	3	G
	and metals lab photo developers; Standby		Aerated Lagoons	3	B
	Liquid Control discharges (i.e., boron)		Discharge to surface water	4	A
	flushes (i.e., trisodium phosphate) from the				
	cooler air compressor cleaning activities;				
	blowdown from the Training Center				
	chiller system (includes corrosion, scale, and				
	biofouling inhibitors); waste from insulator				
	showers used by personnel involved with				
	asbestos abatement activities; & rainwater.				

Continue on Page 2

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EXISTING MANUFACTURING, COMMERCIAL, MINING AND SILVICULTURAL OPERATIONS

Consolidated Permits Program

I. OUTFALL LOCATION

For each outfall, list the latitude and longitude of its location to the nearest 15 seconds and the name of the receiving water.

A. OUTFALL NUMBER (*list*)	B. LATITUDE 1. DEG.	2. MIN	3. SEC.	C. LONGITUDE 1. DEG.	2. MIN.	3. SEC.	D. RECEIVING WATER (*name*)
See page 1a							

II. FLOWS, SOURCES OF POLLUTION, AND TREATMENT TECHNOLOGIES

A. Attach a line drawing showing the water flow through the facility. Indicate sources of intake water, operations contributing wastewater to the effluent, and treatment units labeled to correspond to the more detailed descriptions in Item B. Construct a water balance on the line drawing by showing average flows between intakes, operations, treatment units, and outfalls. If a water balance cannot be determined (*e.g., for certain mining activities*), provide a pictorial description of the nature and amount of any sources of water and any collection or treatment measures.

B. For each outfall, provide a description of: (1) All operations contributing wastewater to the effluent, including process wastewater, sanitary wastewater, cooling water, and storm water runoff; (2) The average flow contributed by each operation; and (3) The treatment received by the wastewater. Continue on additional sheets if necessary.

1. OUT-FALL NO (*list*)	2. OPERATION(S) CONTRIBUTING FLOW a. OPERATION (*list*)	b. AVERAGE FLOW (*include units*)	3. TREATMENT a. DESCRIPTION	b. LIST CODES FROM TABLE 2C-1	
013b	Sedimentation Pond discharges which	0.0666 MGD	Flocculation	1	G
	include:		Sedimentation	1	U
	(1) Water Filtration System Backwash;	(0.0554 MGD)	Discharge to surface water	4	A
	(2) Intake Building sump (alternate	(0.007 MGD)			
	discharge); diesel generator sump; and				
	(3) Rainwater minus evaporation	(0.0042 MGD)			

OFFICIAL USE ONLY (*effluent guidelines sub-categories*)

Continue on Page 2

...off, leaks, or spills, are any of the discharges described in Items II-A or B intermittent or seasonal?

[ ] YES *(complete the following table)* [X] NO *(go to Section III)*

1. OUTFALL NUMBER *(list)*	2. OPERATION(s) CONTRIBUTING FLOW *(list)*	3. FREQUENCY		4. FLOW				
		a. DAYS PER WEEK *(specify average)*	b. MONTHS PER YEAR *(specify average)*	a. FLOW RATE *(in mgd)*		b. TOTAL VOLUME *(specify with units)*		c. DURATION *(in days)*
				1. LONG TERM AVERAGE	2. MAXIMUM DAILY	1. LONG TERM AVERAGE	2. MAXIMUM DAILY	
005	Residual Heat Removal Service Water System (includes operational discharges and periodic flushes)	3 days/wk; 3-4 wks/mo (on avg.)	12 mos./yr (on avg.)	3.93	19.60	3.93 MG	19.6 MG	126
013a(1)	Wastewater Lagoons	4 days/wk; 3.2 wks/mo (on avg.)	10 mos./yr (on avg.)	0.22	0.28	0.22 MG	0.28 MG	128
013b	Sedimentation Ponds	5 dyas/wk.; 1 wk./mo (on avg.)	12 mos./yr (on avg.)	0.23	0.49	0.23 MG	0.49 MG	60

III. PRODUCTION

A. Does an effluent guideline limitation promulgated by EPA under Section 304 of the Clean Water Act apply to your facility?

[X] YES *(complete Item III-B)* [ ] NO *(go to Section IV)*

B. Are the limitations in the applicable effluent guideline expressed in terms of production *(or other measure of operation)*?

[ ] YES *(complete Item III-C)* [X] NO *(go to Section IV)*

C. If you answered "yes" to Item III-B, list the quantity which represents an actual measurement of your level of production, expressed in the terms and units used in the applicable effluent guideline, and indicate the affected outfalls.

1. AVERAGE DAILY PRODUCTION			2. AFFECTED OUTFALLS *(list outfall numbers)*
a. QUANTITY PER DAY	b. UNITS OF MEASURE	c. OPERATION, PRODUCT, MATERIAL, ETC. *(specify)*	

IV. IMPROVEMENTS

A. Are you now required by any Federal, State or local authority to meet any implementation schedule for the construction, upgrading or operation of wastewater treatment equipment or practices or any other environmental programs which may affect the discharges described in this application? This includes, but is not limited to, permit conditions, administrative or enforcement orders, enforcement compliance schedule letters, stipulations, court orders, and grant or loan conditions.

[ ] YES *(complete the following table)* [X] NO *(go to Item IV-B)*

1. IDENTIFICATION OF CONDITION, AGREEMENT, ETC.	2. AFFECTED OUTFALLS		3. BRIEF DESCRIPTION OF PROJECT	4. FINAL COMPLIANCE DATE	
	a. NO.	b. SOURCE OF DISCHARGE		a. REQUIRED	b. PROJECTED

B. OPTIONAL: You may attach additional sheets describing any additional water pollution control programs *(or other environmental projects which may affect your discharges)* you now have underway or which you plan. Indicate whether each program is now underway or planned, and indicate your actual or planned schedules for construction.

[ ] MARK "X" IF DESCRIPTION OF ADDITIONAL CONTROL PROGRAMS IS ATTACHED

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V. INTAKE AND EFFLUENT CHARACTERISTICS

A, B, & C: See instructions before proceeding - Complete one set of tables for each outfall - Annotate the outfall number in the space provided.
NOTE: Tables V-A, V-B, and V-C are included on separate sheets numbered V-1 through V-9.

D. Use the space below to list any of the pollutants listed in Table 2C-3 of the instructions, which you know or have reason to believe is discharged or may be discharged from any outfall. For every pollutant you list, briefly describe the reasons you believe it to be present and report any analytical data in your possession.

1. POLLUTANT	2. SOURCE	1. POLLUTANT	2. SOURCE
(1) Asbestos	(1) The discharge from the Wastewater Lagoons, DSN 013a(1), has the potential to contain asbestos. Water from showers provided for workers involved in asbestos stripping and handling operations are filtered through 0.03 micron filters prior to being discharged to the Wastewater Lagoons.		
(2) Xylene	(2) The discharge from DSN 018 (storm water outfall listed in Form 2F) has the potential to contain xylene due to the presence of a gasoline fuel pump for vehicles within the 018 drainage area.		

VI. POTENTIAL DISCHARGES NOT COVERED BY ANALYSIS

Is any pollutant listed in Item V-C a substance or a component of a substance which you currently use or manufacture as an intermediate or final product or byproduct?

☐ YES *(list all such pollutants below)* ☒ NO *(go to Item VI-B)*

Continue on Page 4

...ICITY TESTING DATA

...ny knowledge or reason to believe that any biological test for acute or chronic toxicity has been made on any of your discharges or ...ceiving water in relation to your discharge within the last 3 years?

[X] YES *(identify the test(s) and describe their purposes below)* [ ] NO *(go to Section VIII)*

WET Biomonitoring data has been collected on process water (DSN 001) over the past five years in accordance with Part IV. Effluent Toxicity Limitations and Biomonitoring Requirements, of the current NPDES Permit AL00222080 (see attached Resonable Potential Evaluation).

VIII. CONTRACT ANALYSIS INFORMATION

Were any of the analyses reported in Item V performed by a contract laboratory or consulting firm?

[X] YES *(list the name, address, and telephone number of, and pollutants analyzed by, each such laboratory or firm below)* [ ] NO *(go to Section IX)*

A. NAME	B. ADDRESS	C. TELEPHONE *(area code & no.)*	D. POLLUTANTS ANALYZED *(list)*
Environmental Science Corporation	12065 Lebanon Road Mt. Juliet, TN 37122	800-707-5859	All pollutants except field parameters (pH, temp, TRC, and LLHg) were analyzed by ESC with the exception of DSN001b.
Mercury One LTD	2241 Pinnacle Parkway Suite B Twinsburg, OH 44087	330-963-0843	Low level mercury
GEL Laboratories, LLC	2040 Savage Road Charleston, SC 29407	843-556-8171	All DSN 001b pollutants except field parameters (pH, temp, TRC)

IX. CERTIFICATION

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

A. NAME & OFFICIAL TITLE *(type or print)*	B. PHONE NO. *(area code & no.)*
K.J. Polson, Site Vice President	(256) 729-3675
C. SIGNATURE	**D. DATE SIGNED**
[signature]	2-26-11

PLEASE PRINT OR TYPE IN THE UNSHADED AREAS ONLY. You may report some or all of this information on separate sheets *(use the same format)* instead of completing these pages.
SEE INSTRUCTIONS.

EPA I.D. NUMBER *(copy from Item 1 of Form 1)*
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V. INTAKE AND EFFLUENT CHARACTERISTICS *(continued from page 3 of Form 2-C)* [redacted]

OUTFALL NO. 001

PART A - You must provide the results of at least one analysis for every pollutant in this table. Complete one table for each outfall. See instructions for additional details.

1. POLLUTANT	2. EFFLUENT: a. MAXIMUM DAILY VALUE (1) CONCENTRATION	a. MAXIMUM DAILY VALUE (2) MASS	b. MAXIMUM 30 DAY VALUE *(if available)* (1) CONCENTRATION	b. (2) MASS	c. LONG TERM AVRG. VALUE *(if available)* (1) CONCENTRATION	c. (2) MASS	d. NO. OF ANALYSES	3. UNITS *(specify if blank)* a. CONCEN-TRATION	3. b. MASS	4. INTAKE *(optional)* a. LONG TERM AVERAGE VALUE (1) CONCENTRATION	a. (2) MASS	b. NO. OF ANALYSES
a. Biochemical Oxygen Demand *(BOD)*	<5.0						2	mg/L		<5.0		1
b. Chemical Oxygen Demand *(COD)*	<24.						2	mg/L		<10.		1
c. Total Organic Carbon *(TOC)*	2.4						2	mg/L		1.7		1
d. Total Suspended Solids *(TSS)*	10.						2	mg/L		4.9		1
e. Ammonia *(as N)*	0.16						2	mg/L		<0.10		1
f. Flow	VALUE 2985.5		VALUE		VALUE 2843		365	MGD				
g. Temperature *(winter)*	VALUE 95.8		VALUE		VALUE 74.2		182	°F				
h. Temperature *(summer)*	VALUE 106.7		VALUE		VALUE 93.8		183	°F				
i. pH	MINIMUM 7.00	MAXIMUM 8.38	MINIMUM	MAXIMUM			67	STANDARD UNITS				

PART B - Mark "X" in column 2-a for each pollutant you know or have reason to believe is present. Mark "X" in column 2-b for each pollutant you believe to be absent. If you mark column 2a for any pollutant which is limited either directly, or indirectly but expressly, in an effluent limitations guideline, you must provide the results of at least one analysis for that pollutant. For other pollutants for which you mark column 2a, you must provide quantitative data or an explanation of their presence in your discharge. Complete one table for each outfall. See the instructions for additional details and requirements.

1. POLLUTANT AND CAS NO. *(if available)*	2. MARK "X" a. BELIEVED PRESENT	2. b. BELIEVED ABSENT	3. EFFLUENT: a. MAXIMUM DAILY VALUE (1) CONCENTRATION	a. (2) MASS	b. MAXIMUM 30 DAY VALUE *(if available)* (1) CONCENTRATION	b. (2) MASS	c. LONG TERM AVRG. VALUE *(if available)* (1) CONCENTRATION	c. (2) MASS	d. NO. OF ANALYSES	4. UNITS a. CONCEN-TRATION	4. b. MASS	5. INTAKE *(optional)* a. LONG TERM AVERAGE VALUE (1) CONCENTRATION	a. (2) MASS	b. NO. OF ANALYSES
a. Bromide (24959-67-9)	X		<1.0						2	mg/L		<1.0		1
b. Chlorine, Total Residual	X		<0.05						6	mg/L		<0.05		1
c. Color	X		10.						2	PC Units		5.0		1
d. Fecal Coliform		X												
e. Fluoride (16984-48-8)	X		<0.10						2	mg/L		<0.10		1
f. Nitrate-Nitrite *(as N)*	X		<0.10						2	mg/L		<0.10		1

CONTINUE ON PAGE V-2

V-B CONTINUED FROM PAGE V-1

1. POLLUTANT AND CAS NO. (if available)	2. MARK 'X'		3. EFFLUENT							4. UNITS		5. INTAKE (optional)		
	a. BELIEVED PRESENT	b. BELIEVED ABSENT	a. MAXIMUM DAILY VALUE		b. MAXIMUM 30 DAY VALUE (if available)		c. LONG TERM AVRG. VALUE (if available)		d. NO. OF ANALYSES	a. CONCENTRATION	b. MASS	a. LONG TERM AVERAGE VALUE		b. NO. OF ANALYSES
			(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS				(1) CONCENTRATION	(2) MASS	
g. Nitrogen, Total Organic (as N)	X		0.48						2	mg/L		0.46		1
h. Oil and Grease	X		<5.6						2	mg/L		<5.2		1
i. Phosphorus (as P), Total (7723-14-0)	X		<0.10						2	mg/L		<0.10		1
j. Radioactivity														
(1) Alpha, Total		X												
(2) Beta, Total		X												
(3) Radium, Total		X												
(4) Radium 226, Total		X												
k. Sulfate (as SO_4) (14808-79-8)	X		11.						2	mg/L		11.		1
l. Sulfide (as S)		X												
m. Sulfite (as SO_3) (14265-45-3)		X												
n. Surfactants		X												
o. Aluminum, Total (7429-90-5)	X		0.35						2	mg/L		0.20		1
p. Barium, Total (7440-39-3)	X		0.031						2	mg/L		0.026		1
q. Boron, Total (7440-42-8)	X		<0.20						2	mg/L		<0.20		1
r. Cobalt, Total (7440-48-4)	X		<0.0010						2	mg/L		<0.0010		1
s. Iron, Total (7439-89-6)	X		0.28						2	mg/L		0.14		1
t. Magnesium, Total (7439-95-4)	X		5.0						2	mg/L		4.6		1
u. Molybdenum, Total (7439-98-7)	X		<0.0050						2	mg/L		<0.0050		1
v. Manganese, Total (7439-96-5)	X		0.065						2	mg/L		0.045		1
w. Tin, Total (7440-31-5)	X		<0.0010						2	mg/L		<0.0010		1
x. Titanium, Total (7440-32-6)	X		<0.010						2	mg/L		<0.010		1

 CONTINUE ON PAGE V-3

EPA I.D. NUMBER (copy from Item 1 of Form 1)	OUTFALL NUMBER
AL8640015410	001

CONTINUED FROM PAGE 3 OF FORM 2-C

PART C - If you are a primary industry and this outfall contains process wastewater, refer to Table 2c-2 in the instructions to determine which of the GC/MS fractions you must test for. Mark "X" in column 2-a for all such GC/MS fractions that apply to your industry and for ALL toxic metals, cyanides, and total phenols. If you are not required to mark column 2-a (*secondary industries, nonprocess wastewater outfalls, and nonrequired GC/MS fractions*), mark "X" in column 2-b for each pollutant you know or have reason to believe is present. Mark "X" in column 2-c for each pollutant you believe is absent. If you mark column 2a for any pollutant, you must provide the results of at least one analysis for that pollutant. If you mark column 2b for any pollutant, you must provide the results of at least one analysis for that pollutant if you know or have reason to believe it will be discharged in concentrations of 10 ppb or greater. If you mark column 2b for acrolein, acrylonitrile, 2,4 dinitrophenol, or 2-methyl-4, 6 dinitrophenol, you must provide the results of at least one analysis for each of these pollutants which you know or have reason to believe that you discharge in concentrations of 100 ppb or greater. Otherwise for pollutants for which you mark column 2b, you must either submit at least one analysis or briefly describe the reasons the pollutant is expected to be discharged. Note that there are 7 pages to this part; please review each carefully. Complete one table (*all 7 pages*) for each outfall. See instructions for additional details and requirements.

1. POLLUTANT AND CAS NUMBER (if available)	2. MARK 'X'			3. EFFLUENT							4. UNITS		5. INTAKE (optional)		
	a. TESTING REQUIRED	b. BELIEVED PRESENT	c. BELIEVED ABSENT	a. MAXIMUM DAILY VALUE		b. MAXIMUM 30 DAY VALUE (if available)		c. LONG TERM AVRG. VALUE (if available)		d. NO. OF ANALYSES	a. CONCENTRATION	b. MASS	a. LONG TERM AVERAGE VALUE		b. NO. OF ANALYSES
				(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS				(1) CONCENTRATION	(2) MASS	
METALS, CYANIDE, AND TOTAL PHENOLS															
1M. Antimony, Total (7440-36-0)	X			<0.0010						2	mg/L		<0.0010		1
2M. Arsenic, Total (7440-38-2)	X			<0.0010						2	mg/L		<0.0010		1
3M. Beryllium, Total (7440-41-7)	X			<0.0010						2	mg/L		<0.0010		1
4M. Cadmium, Total (7440-43-9)	X			<0.00050						2	mg/L		<0.00050		1
5M. Chromium, Total (7440-47-3)	X			<0.0010						2	mg/L		<0.0010		1
6M. Copper, Total (7440-50-8)	X			0.0013						2	mg/L		0.0020		1
7M. Lead, Total (7439-92-1)	X			<0.0010						2	mg/L		<0.0010		1
8M. Mercury, Total (7439-97-6)	X			2.21						2	ng/L		1.82		1
9M. Nickel, Total (7440-02-0)	X			0.0013						2	mg/L		0.0020		1
10M. Selenium, Total (7782-49-2)	X			<0.0010						2	mg/L		<0.0010		1
11M. Silver, Total (7440-22-4)	X			<0.00050						2	mg/L		<0.00050		1
12M. Thallium, Total (7440-28-0)	X			<0.0010						2	mg/L		<0.0010		1
13M. Zinc, Total (7440-66-6)	X			<0.010						2	mg/L		<0.010		1
14M. Cyanide, Total (57-12-5)	X			<0.0050						2	mg/L		<0.0050		1
15M. Phenols, Total (108-95-2)	X			<0.040						2	mg/L		<0.040		1
DIOXIN															
2,3,7,8-Tetra-chlorodibenzo-P-Dioxin (1764-01-6)			X	DESCRIBE RESULTS											

 CONTINUE ON PAGE V-4

CONTINUED FROM PAGE V-3

1. POLLUTANT AND CAS NUMBER (if available)	2. MARK 'X' a. TESTING REQUIRED	b. BELIEVED PRESENT	c. BELIEVED ABSENT	3. EFFLUENT a. MAXIMUM DAILY VALUE (1) CONCENTRATION	(2) MASS	b. MAXIMUM 30 DAY VALUE (if available) (1) CONCENTRATION	(2) MASS	c. LONG TERM AVRG. VALUE (if available) (1) CONCENTRATION	(2) MASS	d. NO. OF ANALYSES	4. UNITS a. CONCENTRATION	b. MASS	5. INTAKE (optional) a. LONG TERM AVERAGE VALUE (1) CONCENTRATION	(2) MASS	b. NO. OF ANALYSES
GC/MS FRACTION - VOLATILE COMPOUNDS															
1V. Acrolein (107-02-8)	X			< 0.050						2	mg/L		< 0.050		1
2V. Acrylonitrile (107-13-1)	X			< 0.010						2	mg/L		< 0.010		1
3V. Benzene (71-43-2)	X			< 0.0010						2	mg/L		< 0.0010		1
4V. Bis (Chloromethyl) Ether (542-88-1)			X												
5V. Bromoform (75-25-2)	X			< 0.0010						2	mg/L		< 0.0010		1
6V. Carbon Tetrachloride (56-23-5)	X			< 0.0010						2	mg/L		< 0.0010		1
7V. Chlorobenzene (108-90-7)	X			< 0.0010						2	mg/L		< 0.0010		1
8V. Chlorodibromomethane (124-48-1)	X			< 0.0010						2	mg/L		< 0.0010		1
9V. Chloroethane (75-00-3)	X			< 0.0050						2	mg/L		< 0.0050		1
10V. 2-Chloroethylvinyl Ether (110-75-8)	X			< 0.050						2	mg/L		< 0.050		1
11V. Chloroform (67-66-3)	X			< 0.0050						2	mg/L		< 0.0050		1
12V. Dichlorobromomethane (75-27-4)	X			< 0.0010						2	mg/L		< 0.0010		1
13V. Dichlorodifluoromethane (75-71-8)	X			< 0.0050						2	mg/L		< 0.0050		1
14V. 1,1-Dichloroethane (75-34-3)	X			< 0.0010						2	mg/L		< 0.0010		1
15V. 1,2-Dichloroethane (107-06-2)	X			< 0.0010						2	mg/L		< 0.0010		1
16V. 1,1-Dichloroethylene (75-35-4)	X			< 0.0010						2	mg/L		< 0.0010		1
17V. 1,2-Dichloropropane (78-87-5)	X			< 0.0010						2	mg/L		< 0.0010		1
18V. 1,3-Dichloropropylene (542-75-6)	X			< 0.0020						2	mg/L		< 0.0020		1
19V. Ethylbenzene (100-41-4)	X			< 0.0010						2	mg/L		< 0.0010		1
20V. Methyl Bromide (74-83-9)	X			< 0.0050						2	mg/L		< 0.0050		1
21V. Methyl Chloride (74-87-3)	X			< 0.0025						2	mg/L		< 0.0025		1

CONTINUE ON PAGE V-5

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EPA I.D. NUMBER (copy from Item 1 of Form 1)	OUTFALL NUMBER
AL8640015410	001

1. POLLUTANT AND CAS NUMBER (if available)	2. MARK "X" a. TESTING REQUIRED	b. BELIEVED PRESENT	c. BELIEVED ABSENT	3. EFFLUENT a. MAXIMUM DAILY VALUE (1) CONCENTRATION	(2) MASS	b. MAXIMUM 30 DAY VALUE (if available) (1) CONCENTRATION	(2) MASS	c. LONG TERM AVRG. VALUE (if available) (1) CONCENTRATION	(2) MASS	d. NO. OF ANALYSES	4. UNITS a. CONCENTRATION	b. MASS	5. INTAKE (optional) a. LONG TERM AVERAGE VALUE (1) CONCENTRATION	(2) MASS	b. NO. OF ANALYSES
GC/MS FRACTION - VOLATILE COMPOUNDS (continued)															
22V. Methylene Chloride (75-09-2)	X			< 0.0050						2	mg/L		< 0.0050		1
23V. 1,1,2,2-Tetrachloroethane (79-34-5)	X			< 0.0010						2	mg/L		< 0.0010		1
24V. Tetrachloroethylene (127-18-4)	X			< 0.0010						2	mg/L		< 0.0010		1
25V. Toluene (108-88-3)	X			< 0.0050						2	mg/L		< 0.0050		1
26V. 1,2-Trans-Dichloroethylene (156-60-5)	X			< 0.0010						2	mg/L		< 0.0010		1
27V. 1,1,1-Trichloroethane (71-55-6)	X			< 0.0010						2	mg/L		< 0.0010		1
28V. 1,1,2-Trichloroethane (79-00-5)	X			< 0.0010						2	mg/L		< 0.0010		1
29V. Trichloroethylene (79-01-6)	X			< 0.0010						2	mg/L		< 0.0010		1
30V. Trichlorofluoromethane (75-69-4)	X			< 0.0050						2	mg/L		< 0.0050		1
31V. Vinyl Chloride (75-01-4)	X			< 0.0010						2	mg/L		< 0.0010		1
GC/MS FRACTION - ACID COMPOUNDS															
1A. 2-Chlorophenol (95-57-8)	X			< 0.20						2	mg/L		< 0.20		1
2A. 2,4-Dichlorophenol (120-83-2)	X			< 0.20						2	mg/L		< 0.20		1
3A. 2,4-Dimethylphenol (105-67-9)	X			< 0.20						2	mg/L		< 0.20		1
4A. 4,6-Dinitro-O-Cresol (534-52-1)	X			< 0.20						2	mg/L		< 0.20		1
5A. 2,4-Dinitrophenol (51-28-5)	X			< 0.20						2	mg/L		< 0.20		1
6A. 2-Nitrophenol (88-75-5)	X			< 0.20						2	mg/L		< 0.20		1
7A. 4-Nitrophenol (100-02-7)	X			< 0.20						2	mg/L		< 0.20		1
8A. P-Chloro-M-Cresol (59-50-7)	X			< 0.20						2	mg/L		< 0.20		1
9A. Pentachlorophenol (87-86-5)	X			< 0.20						2	mg/L		< 0.20		1
10A. Phenol (108-95-2)	X			< 0.20						2	mg/L		< 0.20		1
11A. 2,4,6-Trichlorophenol (88-06-2)	X			< 0.20						2	mg/L		< 0.20		1

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CONTINUED FROM PAGE V-5

1. POLLUTANT AND CAS NUMBER (if available)	2. MARK 'X'			3. EFFLUENT							4. UNITS		5. INTAKE (optional)		
	a. TESTING REQUIRED	b. BELIEVED PRESENT	c. BELIEVED ABSENT	a. MAXIMUM DAILY VALUE		b. MAXIMUM 30 DAY VALUE (if available)		c. LONG TERM AVRG. VALUE (if available)		d. NO. OF ANALYSES	a. CONCENTRATION	b. MASS	a. LONG TERM AVERAGE VALUE		b. NO. OF ANALYSES
				(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS				(1) CONCENTRATION	(2) MASS	
GC/MS FRACTION - BASE/NEUTRAL COMPOUNDS															
1B. Acenaphthene (83-32-9)			X												
2B. Acenaphtylene (208-96-8)			X												
3B. Anthracene (120-12-7)			X												
4B. Benzidine (92-87-5)			X												
5B. Benzo (a) Anthracene (56-55-3)			X												
6B. Benzo (a) Pyrene (50-32-8)			X												
7B. 3,4-Benzo-fluoranthene (205-99-2)			X												
8B. Benzo (ghi) Perylene (191-24-2)			X												
9B. Benzo (k) Fluoranthene (207-08-9)			X												
10B. Bis (2-Chloro-ethoxy) Methane (111-91-1)			X												
11B. Bis (2-Chloro-ethyl) Ether (111-44-4)			X												
12B. Bis (2-Chloro-isopropyl) Ether (108-60-1)			X												
13B. Bis (2-Ethyl-hexyl) Phthalate (117-81-7)			X												
14B. 4-Bromo-phenyl Phenyl Ether (101-55-3)			X												
15B. Butyl Benzyl Phthalate (85-68-7)			X												
16B. 2-Chloro-naphthalene (91-58-7)			X												
17B. 4-Chloro-phenyl Phenyl Ether (7005-72-3)			X												
18B. Chrysene (218-01-9)			X												
19B. Dibenzo (a,h) Anthracene (53-70-3)			X												
20B. 1,2-Dichloro-benzene (95-50-1)			X	< 0.0010						2	mg/L		< 0.0010		1
21B. 1,3-Dichloro-benzene (541-73-1)			X	< 0.0010						2	mg/L		< 0.0010		1

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EPA I.D. NUMBER (copy from Item 1 of Form 1)	OUTFALL NUMBER
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1. POLLUTANT AND CAS NUMBER (if available)	2. MARK 'X'			3. EFFLUENT							4. UNITS		5. INTAKE (optional)		
	a. TESTING REQUIRED	b. BELIEVED PRESENT	c. BELIEVED ABSENT	a. MAXIMUM DAILY VALUE		b. MAXIMUM 30 DAY VALUE (if available)		c. LONG TERM AVRG. VALUE (if available)		d. NO. OF ANALYSES	a. CONCENTRATION	b. MASS	a. LONG TERM AVERAGE VALUE		b. NO. OF ANALYSES
				(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS				(1) CONCENTRATION	(2) MASS	
GC/MS FRACTION - BASE/NEUTRAL COMPOUNDS (continued)															
22B. 1,4-Dichlorobenzene (106-46-7)			X	< 0.0010						2	mg/L		< 0.0010		1
23B. 3,3'-Dichlorobenzidine (91-94-1)			X												
24B. Diethyl Phthalate (84-66-2)			X												
25B. Dimethyl Phthalate (131-11-3)			X												
26B. Di-N-Butyl Phthalate (84-74-2)			X												
27B. 2,4-Dinitrotoluene (121-14-2)			X												
28B. 2,6-Dinitrotoluene (606-20-2)			X												
29B. Di-N-Octyl Phthalate (117-84-0)			X												
30B. 1,2-Diphenylhydrazine (as Azobenzene) (122-66-7)			X												
31B. Fluoranthene (206-44-0)			X												
32B. Fluorene (86-73-7)			X												
33B. Hexachlorobenzene (118-74-1)			X												
34B. Hexachlorobutadiene (87-68-3)			X												
35B. Hexachlorocyclopentadiene (77-47-4)			X												
36B. Hexachloroethane (67-72-1)			X												
37B. Indeno (1,2,3-cd) Pyrene (193-39-5)			X												
38B. Isophorone (78-59-1)			X												
39B. Naphthalene (91-20-3)			X												
40B. Nitrobenzene (98-95-3)			X												
41B. N-Nitrosodimethylamine (62-75-9)			X												
42B. N-Nitrosodi-Propylamine (621-64-7)			X												

CONTINUE ON PAGE V-8

CONTINUED FROM PAGE V-7

1. POLLUTANT AND CAS NUMBER *(if available)*	2. MARK 'X'			3. EFFLUENT							4. UNITS		5. INTAKE *(optional)*		
	a. TESTING REQUIRED	b. BELIEVED PRESENT	c. BELIEVED ABSENT	a. MAXIMUM DAILY VALUE		b. MAXIMUM 30 DAY VALUE *(if available)*		c. LONG TERM AVRG. VALUE *(if available)*		d. NO. OF ANALYSES	a. CONCENTRATION	b. MASS	a. LONG TERM AVERAGE VALUE		b. NO. OF ANALYSES
				(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS				(1) CONCENTRATION	(2) MASS	
GC/MS FRACTION - BASE/NEUTRAL COMPOUNDS *(continued)*															
43B. N-Nitrosodiphenylamine (86-30-6)			X												
44B. Phenanthrene (85-01-8)			X												
45B. Pyrene (129-00-0)			X												
46B. 1,2,4 - Trichlorobenzene (120-82-1)			X												
GC/MS FRACTION - PESTICIDES															
1P. Aldrin (309-00-2)			X												
2P. α-BHC (319-84-6)			X												
3P. β-BHC (319-85-7)			X												
4P. γ-BHC (58-89-9)			X												
5P. δ-BHC (319-86-8)			X												
6P. Chlordane (57-74-9)			X												
7P. 4,4'-DDT (50-29-3)			X												
8P. 4,4'-DDE (72-55-9)			X												
9P. 4,4'-DDD (72-54-8)			X												
10P. Dieldrin (60-57-1)			X												
11P. α-Endosulfan (115-29-7)			X												
12P. β-Endosulfan (115-29-7)			X												
13P. Endosulfan Sulfate (1031-07-8)			X												
14P. Endrin (72-20-8)			X												
15P. Endrin Aldehyde (7421-93-4)			X												
16P. Heptachlor (76-44-8)			X												

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1. POLLUTANT AND CAS NUMBER *(if available)*	2. MARK 'X'			3. EFFLUENT							4. UNITS		5. INTAKE *(optional)*		
	a. TESTING REQUIRED	b. BELIEVED PRESENT	c. BELIEVED ABSENT	a. MAXIMUM DAILY VALUE		b. MAXIMUM 30 DAY VALUE *(if available)*		c. LONG TERM AVRG. VALUE *(if available)*		d. NO. OF ANALYSES	a. LONG TERM AVERAGE VALUE		a. LONG TERM AVERAGE VALUE		b. NO. OF ANALYSES
				(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS		a. CONCENTRATION	b. MASS	(1) CONCENTRATION	(2) MASS	
GC/MS FRACTION - PESTICIDES *(continued)*															
17B. Heptachlor Epoxide (1024-57-3)			X												
18P. PCB-1242 (53469-21-9)			X												
19P. PCB-1254 (11097-69-1)			X												
20P. PCB-1221 (11104-28-2)			X												
21P. PCB-1232 (11141-16-5)			X												
22P. PCB-1248 (12672-29-6)			X												
23P. PCB-1260 (11096-82-5)			X												
24P. PCB-1016 (12674-11-2)			X												
25P. Toxaphene (8001-35-2)			X												

PLEASE PRINT OR TYPE IN THE UNSHADED AREAS ONLY. You may report some or all of this information on separate sheets (*use the same format*) instead of completing these pages.
SEE INSTRUCTIONS.

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V. INTAKE AND EFFLUENT CHARACTERISTICS (*continued from page 3 of Form 2-C*)

OUTFALL NO.
005

PART A - You must provide the results of at least one analysis for every pollutant in this table. Complete one table for each outfall. See instructions for additional details.

1. POLLUTANT	2. EFFLUENT: a. MAXIMUM DAILY VALUE (1) CONCENTRATION	a. (2) MASS	b. MAXIMUM 30 DAY VALUE (*if available*) (1) CONCENTRATION	b. (2) MASS	c. LONG TERM AVRG. VALUE (*if available*) (1) CONCENTRATION	c. (2) MASS	d. NO. OF ANALYSES	3. UNITS (*specify if blank*) a. CONCENTRATION	b. MASS	4. INTAKE (*optional*) a. LONG TERM AVERAGE VALUE (1) CONCENTRATION	a. (2) MASS	b. NO. OF ANALYSES
a. Biochemical Oxygen Demand (*BOD*)	<5.0						1	mg/L				
b. Chemical Oxygen Demand (*COD*)	54.						1	mg/L				
c. Total Organic Carbon (*TOC*)	1.7						1	mg/L				
d. Total Suspended Solids (*TSS*)	13.						1	mg/L				
e. Ammonia (*as N*)	0.38						1	mg/L				
f. Flow	VALUE 19.6		VALUE		VALUE 3.93		27	MGD				
g. Temperature (*winter*)	VALUE 103.8		VALUE		VALUE 69.5		13	°F				
h. Temperature (*summer*)	VALUE 83.3		VALUE		VALUE 76.6		18	°F				
i. pH	MINIMUM 6.67	MAXIMUM 8.31	MINIMUM	MAXIMUM			32	STANDARD UNITS				

PART B - Mark "X" in column 2-a for each pollutant you know or have reason to believe is present. Mark "X" in column 2-b for each pollutant you believe to be absent. If you mark column 2a for any pollutant which is limited either directly, or indirectly but expressly, in an effluent limitations guideline, you must provide the results of at least one analysis for that pollutant. For other pollutants for which you mark column 2a, you must provide quantitative data or an explanation of their presence in your discharge. Complete one table for each outfall. See the instructions for additional details and requirements.

1. POLLUTANT AND CAS NO. (*if available*)	2. MARK "X" a. BELIEVED PRESENT	b. BELIEVED ABSENT	3. EFFLUENT: a. MAXIMUM DAILY VALUE (1) CONCENTRATION	a. (2) MASS	b. MAXIMUM 30 DAY VALUE (*if available*) (1) CONCENTRATION	b. (2) MASS	c. LONG TERM AVRG. VALUE (*if available*) (1) CONCENTRATION	c. (2) MASS	d. NO. OF ANALYSES	4. UNITS a. CONCENTRATION	b. MASS	5. INTAKE (*optional*) a. LONG TERM AVERAGE VALUE (1) CONCENTRATION	a. (2) MASS	b. NO. OF ANALYSES
a. Bromide (24959-67-9)		X												
b. Chlorine, Total Residual		X												
c. Color	X		5.0						1	mg/L				
d. Fecal Coliform		X												
e. Fluoride (16984-48-8)		X												
f. Nitrate-Nitrite (*as N*)		X												

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1. POLLUTANT AND CAS NO. *(if available)*	2. MARK "X"		3. EFFLUENT							4. UNITS		5. INTAKE *(optional)*		
	a. BELIEVED PRESENT	b. BELIEVED ABSENT	a. MAXIMUM DAILY VALUE		b. MAXIMUM 30 DAY VALUE *(if available)*		c. LONG TERM AVRG. VALUE *(if available)*		d. NO. OF ANALYSES	a. CONCENTRATION	b. MASS	a. LONG TERM AVERAGE VALUE		b. NO. OF ANALYSES
			(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS				(1) CONCENTRATION	(2) MASS	
g. Nitrogen, Total Organic *(as N)*		X												
h. Oil and Grease	X		< 5.0						1	mg/L				
i. Phosphorus *(as P)*, Total (7723-14-0)	X		0.17						1	mg/L				
j. Radioactivity														
(1) Alpha, Total		X												
(2) Beta, Total		X												
(3) Radium, Total		X												
(4) Radium 226, Total		X												
k. Sulfate *(as SO_4)* (14808-79-8)	X		11.						1	mg/L				
l. Sulfide *(as S)*		X												
m. Sulfite *(as SO_3)* (14265-45-3)		X												
n. Surfactants		X												
o. Aluminum, Total (7429-90-5)	X		0.46						1	mg/L				
p. Barium, Total (7440-39-3)	X		0.029						1	mg/L				
q. Boron, Total (7440-42-8)	X		<0.20						1	mg/L				
r. Cobalt, Total (7440-48-4)	X		<0.0010						1	mg/L				
s. Iron, Total (7439-89-6)	X		0.49						1	mg/L				
t. Magnesium, Total (7439-95-4)	X		4.6						1	mg/L				
u. Molybdenum, Total (7439-98-7)	X		<0.0050						1	mg/L				
v. Manganese, Total (7439-96-5)	X		0.10						1	mg/L				
w. Tin, Total (7440-31-5)	X		<0.0010						1	mg/L				
x. Titanium, Total (7440-32-6)	X		<0.010						1	mg/L				

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PART C - If you are a primary industry and this outfall contains process wastewater, refer to Table 2c-2 in the instructions to determine which of the GC/MS fractions you must test for. Mark "X" in column 2-a for all such GC/MS fractions that apply to your industry and for ALL toxic metals, cyanides, and total phenols. If you are not required to mark column 2-a *(secondary industries, nonprocess wastewater outfalls, and nonrequired GC/MS fractions)*, mark "X" in column 2-b for each pollutant you know or have reason to believe is present. Mark "X" in column 2-c for each pollutant you believe is absent. If you mark column 2a for any pollutant, you must provide the results of at least one analysis for that pollutant. If you mark column 2b for any pollutant, you must provide the results of at least one analysis for that pollutant if you know or have reason to believe it will be discharged in concentrations of 10 ppb or greater. If you mark column 2b for acrolein, acrylonitrile, 2,4 dinitrophenol, or 2-methyl-4, 6 dinitrophenol, you must provide the results of at least one analysis for each of these pollutants which you know or have reason to believe that you discharge in concentrations of 100 ppb or greater. Otherwise for pollutants for which you mark column 2b, you must either submit at least one analysis or briefly describe the reasons the pollutant is expected to be discharged. Note that there are 7 pages to this part; please review each carefully. Complete one table *(all 7 pages)* for each outfall. See instructions for additional details and requirements.

1. POLLUTANT AND CAS NUMBER *(if available)*	2. MARK "X"			3. EFFLUENT							4. UNITS		5. INTAKE *(optional)*		
	a. TESTING REQUIRED	b. BELIEVED PRESENT	c. BELIEVED ABSENT	a. MAXIMUM DAILY VALUE (1) CONCENTRATION	a. MAXIMUM DAILY VALUE (2) MASS	b. MAXIMUM 30 DAY VALUE *(if available)* (1) CONCENTRATION	b. MAXIMUM 30 DAY VALUE *(if available)* (2) MASS	c. LONG TERM AVRG. VALUE *(if available)* (1) CONCENTRATION	c. LONG TERM AVRG. VALUE *(if available)* (2) MASS	d. NO. OF ANALYSES	a. CONCENTRATION	b. MASS	a. LONG TERM AVERAGE VALUE (1) CONCENTRATION	a. LONG TERM AVERAGE VALUE (2) MASS	b. NO. OF ANALYSES
METALS, CYANIDE, AND TOTAL PHENOLS															
1M. Antimony, Total (7440-36-0)	X			<0.0010						1	mg/L				
2M. Arsenic, Total (7440-38-2)	X			<0.0010						1	mg/L				
3M. Beryllium, Total, (7440-41-7)	X			<0.0010						1	mg/L				
4M. Cadmium, Total (7440-43-9)	X			<0.00050						1	mg/L				
5M. Chromium, Total (7440-47-3)	X			<0.0010						1	mg/L				
6M. Copper, Total (7440-50-8)	X			<0.0010						1	mg/L				
7M. Lead, Total (7439-92-1)	X			<0.0010						1	mg/L				
8M. Mercury, Total (7439-97-6)			X												
9M. Nickel, Total (7440-02-0)	X			0.001						1	mg/L				
10M. Selenium, Total (7782-49-2)	X			<0.0010						1	mg/L				
11M. Silver, Total (7440-22-4)	X			<0.00050						1	mg/L				
12M. Thallium, Total (7440-28-0)	X			<0.0010						1	mg/L				
13M. Zinc, Total (7440-66-6)	X			<0.010						1	mg/L				
14M. Cyanide, Total (57-12-5)	X			<0.0050						1	mg/L				
15M. Phenols, Total (108-95-2)	X			<0.040						1	mg/L				
DIOXIN															
2,3,7,8-Tetrachlorodibenzo-P-Dioxin (1764-01-6)				DESCRIBE RESULTS											

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1. POLLUTANT AND CAS NUMBER (if available)	2. MARK "X"			3. EFFLUENT							4. UNITS		5. INTAKE (optional)		
	a. TESTING REQUIRED	b. BELIEVED PRESENT	c. BELIEVED ABSENT	a. MAXIMUM DAILY VALUE (1) CONCENTRATION	a. MAXIMUM DAILY VALUE (2) MASS	b. MAXIMUM 30 DAY VALUE (if available) (1) CONCENTRATION	b. MAXIMUM 30 DAY VALUE (if available) (2) MASS	c. LONG TERM AVRG. VALUE (if available) (1) CONCENTRATION	c. LONG TERM AVRG. VALUE (if available) (2) MASS	d. NO. OF ANALYSES	a. CONCENTRATION	b. MASS	a. LONG TERM AVERAGE VALUE (1) CONCENTRATION	a. LONG TERM AVERAGE VALUE (2) MASS	b. NO. OF ANALYSES
GC/MS FRACTION - VOLATILE COMPOUNDS															
1V. Acrolein (107-02-8)	X			< 0.050						1	mg/L				
2V. Acrylonitrile (107-13-1)	X			< 0.010						1	mg/L				
3V. Benzene (71-43-2)	X			< 0.0010						1	mg/L				
4V. Bis (Chloromethyl) Ether (542-88-1)			X												
5V. Bromoform (75-25-2)	X			< 0.0010						1	mg/L				
6V. Carbon Tetrachloride (56-23-5)	X			< 0.0010						1	mg/L				
7V. Chlorobenzene (108-90-7)	X			< 0.0010						1	mg/L				
8V. Chlorodibromomethane (124-48-1)	X			< 0.0010						1	mg/L				
9V. Chloroethane (75-00-3)	X			< 0.0050						1	mg/L				
10V. 2-Chloroethylvinyl Ether (110-75-8)	X			< 0.050						1	mg/L				
11V. Chloroform (67-66-3)	X			0.012						1	mg/L				
12V. Dichlorobromomethane (75-27-4)	X			0.0023						1	mg/L				
13V. Dichlorodifluoromethane (75-71-8)	X			< 0.0050						1	mg/L				
14V. 1,1-Dichloroethane (75-34-3)	X			< 0.0010						1	mg/L				
15V. 1,2-Dichloroethane (107-06-2)	X			< 0.0010						1	mg/L				
16V. 1,1-Dichloroethylene (75-35-4)	X			< 0.0010						1	mg/L				
17V. 1,2-Dichloropropane (78-87-5)	X			< 0.0010						1	mg/L				
18V. 1,3-Dichloropropylene (542-75-6)	X			< 0.0020						1	mg/L				
19V. Ethylbenzene (100-41-4)	X			< 0.0010						1	mg/L				
20V. Methyl Bromide (74-83-9)	X			< 0.0050						1	mg/L				
21V. Methyl Chloride (74-87-3)	X			< 0.0025						1	mg/L				

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EPA I.D. NUMBER (copy from Item 1 of Form 1)	OUTFALL NUMBER
AL8640015410	005

1. POLLUTANT AND CAS NUMBER (if available)	2. MARK 'X'			3. EFFLUENT							4. UNITS		5. INTAKE (optional)		
	a. TESTING REQUIRED	b. BELIEVED PRESENT	c. BELIEVED ABSENT	a. MAXIMUM DAILY VALUE		b. MAXIMUM 30 DAY VALUE (if available)		c. LONG TERM AVRG. VALUE (if available)		d. NO. OF ANALYSES	a. CONCENTRATION	b. MASS	a. LONG TERM AVERAGE VALUE		b. NO. OF ANALYSES
				(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS				(1) CONCENTRATION	(2) MASS	
GC/MS FRACTION - VOLATILE COMPOUNDS (continued)															
22V. Methylene Chloride (75-09-2)	X			< 0.0050						1	mg/L				
23V. 1,1,2,2-Tetrachloroethane (79-34-5)	X			< 0.0010						1	mg/L				
24V. Tetrachloroethylene (127-18-4)	X			< 0.0010						1	mg/L				
25V. Toluene (108-88-3)	X			< 0.0050						1	mg/L				
26V. 1,2-Trans-Dichloroethylene (156-60-5)	X			< 0.0010						1	mg/L				
27V. 1,1,1-Trichloroethane (71-55-6)	X			< 0.0010						1	mg/L				
28V. 1,1,2-Trichloroethane (79-00-5)	X			< 0.0010						1	mg/L				
29V. Trichloroethylene (79-01-6)	X			< 0.0010						1	mg/L				
30V. Trichlorofluoromethane (75-69-4)	X			< 0.0050						1	mg/L				
31V. Vinyl Chloride (75-01-4)	X			< 0.0010						1	mg/L				
GC/MS FRACTION - ACID COMPOUNDS															
1A. 2-Chlorophenol (95-57-8)	X			< 0.040						1	mg/L				
2A. 2,4-Dichlorophenol (120-83-2)	X			< 0.040						1	mg/L				
3A. 2,4-Dimethylphenol (105-67-9)	X			< 0.040						1	mg/L				
4A. 4,6-Dinitro-O-Cresol (534-52-1)	X			< 0.040						1	mg/L				
5A. 2,4-Dinitrophenol (51-28-5)	X			< 0.040						1	mg/L				
6A. 2-Nitrophenol (88-75-5)	X			< 0.040						1	mg/L				
7A. 4-Nitrophenol (100-02-7)	X			< 0.040						1	mg/L				
8A. P-Chloro-M Cresol (59-50-7)	X			< 0.040						1	mg/L				
9A. Pentachlorophenol (87-86-5)	X			< 0.040						1	mg/L				
10A. Phenol (108-95-2)	X			< 0.040						1	mg/L				
11A. 2,4,6-Trichlorophenol (88-06-2)	X			< 0.040						1	mg/L				

CONTINUE ON PAGE V-6

CONTINUED FROM PAGE V-5

1. POLLUTANT AND CAS NUMBER (if available)	2. MARK 'X' a. TESTING REQUIRED	b. BELIEVED PRESENT	c. BELIEVED ABSENT	3. EFFLUENT a. MAXIMUM DAILY VALUE (1) CONCENTRATION	(2) MASS	b. MAXIMUM 30 DAY VALUE (if available) (1) CONCENTRATION	(2) MASS	c. LONG TERM AVRG. VALUE (if available) (1) CONCENTRATION	(2) MASS	d. NO. OF ANALYSES	4. UNITS a. CONCENTRATION	b. MASS	5. INTAKE (optional) a. LONG TERM AVERAGE VALUE (1) CONCENTRATION	(2) MASS	b. NO. OF ANALYSES
GC/MS FRACTION - BASE/NEUTRAL COMPOUNDS															
1B. Acenaphthene (83-32-9)			X												
2B. Acenaphtylene (208-96-8)			X												
3B. Anthracene (120-12-7)			X												
4B. Benzidine (92-87-5)			X												
5B. Benzo (a) Anthracene (56-55-3)			X												
6B. Benzo (a) Pyrene (50-32-8)			X												
7B. 3,4-Benzofluoranthene (205-99-2)			X												
8B. Benzo (ghi) Perylene (191-24-2)			X												
9B. Benzo (k) Fluoranthene (207-08-9)			X												
10B. Bis (2-Chloroethoxy) Methane (111-91-1)			X												
11B. Bis (2-Chloroethyl) Ether (111-44-4)			X												
12B. Bis (2-Chloroisopropyl) Ether (108-60-1)			X												
13B. Bis (2-Ethylhexyl) Phthalate (117-81-7)			X												
14B. 4-Bromophenyl Phenyl Ether (101-55-3)			X												
15B. Butyl Benzyl Phthalate (85-68-7)			X												
16B. 2-Chloronaphthalene (91-58-7)			X												
17B. 4-Chlorophenyl Phenyl Ether (7005-72-3)			X												
18B. Chrysene (218-01-9)			X												
19B. Dibenzo (a,h) Anthracene (53-70-3)			X												
20B. 1,2-Dichlorobenzene (95-50-1)			X	< 0.0010						1	mg/L				
21B. 1,3-Dichlorobenzene (541-73-1)			X	< 0.0010						1	mg/L				

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EPA I.D. NUMBER (copy from Item 1 of Form 1): AL8640015410

OUTFALL NUMBER: 005

CONTINUED FROM PAGE V-6

1. POLLUTANT AND CAS NUMBER (if available)	2. MARK 'X'			3. EFFLUENT							4. UNITS		5. INTAKE (optional)		
	a. TESTING REQUIRED	b. BELIEVED PRESENT	c. BELIEVED ABSENT	a. MAXIMUM DAILY VALUE (1) CONCENTRATION	a. MAXIMUM DAILY VALUE (2) MASS	b. MAXIMUM 30 DAY VALUE (if available) (1) CONCENTRATION	b. MAXIMUM 30 DAY VALUE (if available) (2) MASS	c. LONG TERM AVRG. VALUE (if available) (1) CONCENTRATION	c. LONG TERM AVRG. VALUE (if available) (2) MASS	d. NO. OF ANALYSES	a. CONCENTRATION	b. MASS	a. LONG TERM AVERAGE VALUE (1) CONCENTRATION	a. LONG TERM AVERAGE VALUE (2) MASS	b. NO. OF ANALYSES
GC/MS FRACTION - BASE/NEUTRAL COMPOUNDS (continued)															
22B. 1,4-Dichlorobenzene (106-46-7)			X	< 0.0010						1	mg/L				
23B. 3,3'-Dichlorobenzidine (91-94-1)			X												
24B. Diethyl Phthalate (84-66-2)			X												
25B. Dimethyl Phthalate (131-11-3)			X												
26B. Di-N-Butyl Phthalate (84-74-2)			X												
27B. 2,4-Dinitrotoluene (121-14-2)			X												
28B. 2,6-Dinitrotoluene (606-20-2)			X												
29B. Di-N-Octyl Phthalate (117-84-0)			X												
30B. 1,2-Diphenylhydrazine (as Azobenzene) (122-66-7)			X												
31B. Fluoranthene (206-44-0)			X												
32B. Fluorene (86-73-7)			X												
33B. Hexachlorobenzene (118-74-1)			X												
34B. Hexachlorobutadiene (87-68-3)			X												
35B. Hexachlorocyclopentadiene (77-47-4)			X												
36B. Hexachloroethane (67-72-1)			X												
37B. Indeno (1,2,3-cd) Pyrene (193-39-5)			X												
38B. Isophorone (78-59-1)			X												
39B. Naphthalene (91-20-3)			X												
40B. Nitrobenzene (98-95-3)			X												
41B. N-Nitrosodimethylamine (62-75-9)			X												
42B. N-Nitrosodi-Propylamine (621-64-7)			X												

 CONTINUE ON PAGE V-8

CONTINUED FROM PAGE V-7

1. POLLUTANT AND CAS NUMBER (if available)	2. MARK 'X'			3. EFFLUENT							4. UNITS		5. INTAKE (optional)		
	a. TESTING REQUIRED	b. BELIEVED PRESENT	c. BELIEVED ABSENT	a. MAXIMUM DAILY VALUE		b. MAXIMUM 30 DAY VALUE (if available)		c. LONG TERM AVRG. VALUE (if available)		d. NO. OF ANALYSES	a. CONCENTRATION	b. MASS	a. LONG TERM AVERAGE VALUE		b. NO. OF ANALYSES
				(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS				(1) CONCENTRATION	(2) MASS	
GC/MS FRACTION - BASE/NEUTRAL COMPOUNDS (continued)															
43B. N-Nitrosodiphenylamine (86-30-6)			X												
44B. Phenanthrene (85-01-8)			X												
46B. Pyrene (129-00-0)			X												
46B. 1,2,4 - Trichlorobenzene (120-82-1)			X												
GC/MS FRACTION - PESTICIDES															
1P. Aldrin (309-00-2)			X												
2P. α-BHC (319-84-6)			X												
3P. β-BHC (319-85-7)			X												
4P. γ-BHC (58-89-9)			X												
5P. δ-BHC (319-86-8)			X												
6P. Chlordane (57-74-9)			X												
7P. 4,4'-DDT (50-29-3)			X												
8P. 4,4'-DDE (72-55-9)			X												
9P. 4,4'-DDD (72-54-8)			X												
10P. Dieldrin (60-57-1)			X												
11P. α-Endosulfan (115-29-7)			X												
12P. β-Endosulfan (115-29-7)			X												
13P. Endosulfan Sulfate (1031-07-8)			X												
14P. Endrin (72-20-8)			X												
15P. Endrin Aldehyde (7421-93-4)			X												
16P. Heptachlor (76-44-8)			X												

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EPA I.D. NUMBER (copy from Item 1 of Form 1)	OUTFALL NUMBER
AL8640015410	005

CONTINUED FROM PAGE V-8

1. POLLUTANT AND CAS NUMBER (if available)	2. MARK 'X'			3. EFFLUENT							4. UNITS		5. INTAKE (optional)		
	a. TESTING REQUIRED	b. BELIEVED PRESENT	c. BELIEVED ABSENT	a. MAXIMUM DAILY VALUE		b. MAXIMUM 30 DAY VALUE (if available)		c. LONG TERM AVRG. VALUE (if available)		d. NO. OF ANALYSES	a. LONG TERM AVERAGE VALUE		a. LONG TERM AVERAGE VALUE		b. NO. OF ANALYSES
				(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS		a. CONCENTRATION	b. MASS	(1) CONCENTRATION	(2) MASS	
GC/MS FRACTION - PESTICIDES (continued)															
17B. Heptachlor Epoxide (1024-57-3)			X												
18P. PCB-1242 (53469-21-9)			X												
19P. PCB-1254 (11097-69-1)			X												
20P. PCB-1221 (11104-28-2)			X												
21P. PCB-1232 (11141-16-5)			X												
22P. PCB-1248 (12672-29-6)			X												
23P. PCB-1260 (11096-82-5)			X												
24P. PCB-1016 (12674-11-2)			X												
25P. Toxaphene (8001-35-2)			X												

PLEASE PRINT OR TYPE IN THE UNSHADED AREAS ONLY. You may report some or all of this information on separate sheets *(use the same format)* instead of completing these pages.
SEE INSTRUCTIONS.

EPA I.D. NUMBER *(copy from Item 1 of Form 1)*: AL8640015410

V. INTAKE AND EFFLUENT CHARACTERISTICS *(continued from page 3 of Form 2-C)*

OUTFALL NO. 013a(1)

PART A - You must provide the results of at least one analysis for every pollutant in this table. Complete one table for each outfall. See instructions for additional details.

1. POLLUTANT	2. EFFLUENT a. MAXIMUM DAILY VALUE (1) CONCENTRATION	a. (2) MASS	b. MAXIMUM 30 DAY VALUE *(if available)* (1) CONCENTRATION	b. (2) MASS	c. LONG TERM AVRG. VALUE *(if available)* (1) CONCENTRATION	c. (2) MASS	d. NO. OF ANALYSES	3. UNITS *(specify if blank)* a. CONCENTRATION	b. MASS	4. INTAKE *(optional)* a. LONG TERM AVERAGE VALUE (1) CONCENTRATION	a. (2) MASS	b. NO. OF ANALYSES
a. Biochemical Oxygen Demand *(BOD)*	9.1				4.0		9	mg/L				
b. Chemical Oxygen Demand *(COD)*	350						1	mg/L				
c. Total Organic Carbon *(TOC)*	4.9						1	mg/L				
d. Total Suspended Solids *(TSS)*	67.5				40.6		9	mg/L				
e. Ammonia *(as N)*	<0.10						1	mg/L				
f. Flow	VALUE 0.27792		VALUE 0.21487		VALUE		12	MGD				
g. Temperature *(winter)*	VALUE		VALUE		VALUE			°C				
h. Temperature *(summer)*	VALUE		VALUE		VALUE			°C				
i. pH	MINIMUM 7.01	MAXIMUM 7.88	MINIMUM	MAXIMUM			12	STANDARD UNITS				

PART B - Mark "X" in column 2-a for each pollutant you know or have reason to believe is present. Mark "X" in column 2-b for each pollutant you believe to be absent. If you mark column 2a for any pollutant which is limited either directly, or indirectly but expressly, in an effluent limitations guideline, you must provide the results of at least one analysis for that pollutant. For other pollutants for which you mark column 2a, you must provide quantitative data or an explanation of their presence in your discharge. Complete one table for each outfall. See the instructions for additional details and requirements.

1. POLLUTANT AND CAS NO. *(if available)*	2. MARK "X" a. BELIEVED PRESENT	b. BELIEVED ABSENT	3. EFFLUENT a. MAXIMUM DAILY VALUE (1) CONCENTRATION	a. (2) MASS	b. MAXIMUM 30 DAY VALUE *(if available)* (1) CONCENTRATION	b. (2) MASS	c. LONG TERM AVRG. VALUE *(if available)* (1) CONCENTRATION	c. (2) MASS	d. NO. OF ANALYSES	4. UNITS a. CONCENTRATION	b. MASS	5. INTAKE *(optional)* a. LONG TERM AVERAGE VALUE (1) CONCENTRATION	a. (2) MASS	b. NO. OF ANALYSES
a. Bromide (24959-67-9)		X												
b. Chlorine, Total Residual														
c. Color			20.						1	mg/L				
d. Fecal Coliform	X		117				79		4	col/100mL				
e. Fluoride (16984-48-8)	X		0.53						1	mg/L				
f. Nitrate-Nitrite *(as N)*	X		<0.10						1	mg/L				

CONTINUE ON PAGE V-2

…B CONTINUED FROM PAGE V-1

1. POLLUTANT AND CAS NO. (if available)	2. MARK 'X' a. BELIEVED PRESENT	b. BELIEVED ABSENT	3. EFFLUENT a. MAXIMUM DAILY VALUE (1) CONCENTRATION	(2) MASS	b. MAXIMUM 30 DAY VALUE (if available) (1) CONCENTRATION	(2) MASS	c. LONG TERM AVRG. VALUE (if available) (1) CONCENTRATION	(2) MASS	d. NO. OF ANALYSES	4. UNITS a. CONCENTRATION	b. MASS	5. INTAKE (optional) a. LONG TERM AVERAGE VALUE (1) CONCENTRATION	(2) MASS	b. NO. OF ANALYSES
g. Nitrogen, Total Organic (as N)	X		0.69						1	mg/L				
h. Oil and Grease	X		< 5.6						1	mg/L				
i. Phosphorus (as P), Total (7723-14-0)	X		0.42						1	mg/L				
j. Radioactivity														
(1) Alpha, Total		X												
(2) Beta, Total		X												
(3) Radium, Total		X												
(4) Radium 226, Total		X												
k. Sulfate (as SO_4) (14808-79-8)	X		10.						1	mg/L				
l. Sulfide (as S)		X												
m. Sulfite (as SO_3) (14265-45-3)		X												
n. Surfactants		X												
o. Aluminum, Total (7429-90-5)	X		0.49						1	mg/L				
p. Barium, Total (7440-39-3)	X		0.022						1	mg/L				
q. Boron, Total (7440-42-8)	X		<0.20						1	mg/L				
r. Cobalt, Total (7440-48-4)	X		<0.0010						1	mg/L				
s. Iron, Total (7439-89-6)	X		0.51						1	mg/L				
t. Magnesium, Total (7439-95-4)	X		4.9						1	mg/L				
u. Molybdenum, Total (7439-98-7)	X		0.0081						1	mg/L				
v. Manganese, Total (7439-96-5)	X		0.05						1	mg/L				
w. Tin, Total (7440-31-5)	X		<0.0010						1	mg/L				
x. Titanium, Total (7440-32-6)	X		0.012						1	mg/L				

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CONTINUED FROM PAGE 3 OF FORM 2-C

EPA I.D. NUMBER *(copy from Item 1 of Form 1)*	OUTFALL NUMBER
AL8640015410	013a(1)

PART C - If you are a primary industry and this outfall contains process wastewater, refer to Table 2c-2 in the instructions to determine which of the GC/MS fractions you must test for. Mark "X" in column 2-a for all such GC/MS fractions that apply to your industry and for ALL toxic metals, cyanides, and total phenols. If you are not required to mark column 2-a *(secondary industries, nonprocess wastewater outfalls, and nonrequired GC/MS fractions)*, mark "X" in column 2-b for each pollutant you know or have reason to believe is present. Mark "X" in column 2-c for each pollutant you believe is absent. If you mark column 2a for any pollutant, you must provide the results of at least one analysis for that pollutant. If you mark column 2b for any pollutant, you must provide the results of at least one analysis for that pollutant if you know or have reason to believe it will be discharged in concentrations of 10 ppb or greater. If you mark column 2b for acrolein, acrylonitrile, 2,4 dinitrophenol, or 2-methyl-4, 6 dinitrophenol, you must provide the results of at least one analysis for each of these pollutants which you know or have reason to believe that you discharge in concentrations of 100 ppb or greater. Otherwise for pollutants for which you mark column 2b, you must either submit at least one analysis or briefly describe the reasons the pollutant is expected to be discharged. Note that there are 7 pages to this part; please review each carefully. Complete one table *(all 7 pages)* for each outfall. See instructions for additional details and requirements.

1. POLLUTANT AND CAS NUMBER *(if available)*	2. MARK "X"			3. EFFLUENT							4. UNITS		5. INTAKE *(optional)*		
	a. TESTING REQUIRED	b. BELIEVED PRESENT	c. BELIEVED ABSENT	a. MAXIMUM DAILY VALUE		b. MAXIMUM 30 DAY VALUE *(if available)*		c. LONG TERM AVRG. VALUE *(if available)*		d. NO. OF ANALYSES	a. CONCENTRATION	b. MASS	a. LONG TERM AVERAGE VALUE		b. NO. OF ANALYSES
				(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS				(1) CONCENTRATION	(2) MASS	
METALS, CYANIDE, AND TOTAL PHENOLS															
1M. Antimony, Total (7440-36-0)	X			<0.0010						1	mg/L				
2M. Arsenic, Total (7440-38-2)	X			0.0024						1	mg/L				
3M. Beryllium, Total, (7440-41-7)	X			<0.0010						1	mg/L				
4M. Cadmium, Total (7440-43-9)	X			<0.00050						1	mg/L				
5M. Chromium, Total (7440-47-3)	X			<0.0010						1	mg/L				
6M. Copper, Total (7440-50-8)	X			<0.0010						1	mg/L				
7M. Lead, Total (7439-92-1)	X			<0.0010						1	mg/L				
8M. Mercury, Total (7439-97-6)	X			<0.00020						1	mg/L				
9M. Nickel, Total (7440-02-0)	X			0.0013						1	mg/L				
10M. Selenium, Total (7782-49-2)	X			<0.0010						1	mg/L				
11M. Silver, Total (7440-22-4)	X			<0.00050						1	mg/L				
12M. Thallium, Total (7440-28-0)	X			<0.0010						1	mg/L				
13M. Zinc, Total (7440-66-6)	X			<0.010						1	mg/L				
14M. Cyanide, Total (57-12-5)	X			<0.0050						1	mg/L				
15M. Phenols, Total (108-95-2)	X			<0.040						1	mg/L				
DIOXIN															
2,3,7,8-Tetrachlorodibenzo-P-Dioxin (1764-01-6)				DESCRIBE RESULTS											

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...INUED FROM PAGE V-3

1. POLLUTANT AND CAS NUMBER (if available)	2. MARK 'X' a. TESTING REQUIRED	b. BELIEVED PRESENT	c. BELIEVED ABSENT	3. EFFLUENT a. MAXIMUM DAILY VALUE (1) CONCENTRATION	(2) MASS	b. MAXIMUM 30 DAY VALUE (if available) (1) CONCENTRATION	(2) MASS	c. LONG TERM AVRG. VALUE (if available) (1) CONCENTRATION	(2) MASS	d. NO. OF ANALYSES	4. UNITS a. CONCENTRATION	b. MASS	5. INTAKE (optional) a. LONG TERM AVERAGE VALUE (1) CONCENTRATION	(2) MASS	b. NO. OF ANALYSES
GC/MS FRACTION - VOLATILE COMPOUNDS															
1V. Acrolein (107-02-8)	X			< 0.050						1	mg/L				
2V. Acrylonitrile (107-13-1)	X			< 0.010						1	mg/L				
3V. Benzene (71-43-2)	X			< 0.0010						1	mg/L				
4V. Bis (Chloromethyl) Ether (542-88-1)			X												
5V. Bromoform (75-25-2)	X			< 0.0010						1	mg/L				
6V. Carbon Tetrachloride (56-23-5)	X			< 0.0010						1	mg/L				
7V. Chlorobenzene (108-90-7)	X			< 0.0010						1	mg/L				
8V. Chlorodibromomethane (124-48-1)	X			< 0.0010						1	mg/L				
9V. Chloroethane (75-00-3)	X			< 0.0050						1	mg/L				
10V. 2-Chloroethylvinyl Ether (110-75-8)	X			< 0.050						1	mg/L				
11V. Chloroform (67-66-3)	X			< 0.0050						1	mg/L				
12V. Dichlorobromomethane (75-27-4)	X			< 0.0010						1	mg/L				
13V. Dichlorodifluoromethane (75-71-8)	X			< 0.0050						1	mg/L				
14V. 1,1-Dichloroethane (75-34-3)	X			< 0.0010						1	mg/L				
15V. 1,2-Dichloroethane (107-06-2)	X			< 0.0010						1	mg/L				
16V. 1,1-Dichloroethylene (75-35-4)	X			< 0.0010						1	mg/L				
17V. 1,2-Dichloropropane (78-87-5)	X			< 0.0010						1	mg/L				
18V. 1,3-Dichloropropylene (542-75-6)	X			< 0.0020						1	mg/L				
19V. Ethylbenzene (100-41-4)	X			< 0.0010						1	mg/L				
20V. Methyl Bromide (74-83-9)	X			< 0.0050						1	mg/L				
21V. Methyl Chloride (74-87-3)	X			< 0.0025						1	mg/L				

 CONTINUE ON PAGE V-5

				EPA I.D. NUMBER (copy from Item 1 of Form 1) AL8640015410					OUTFALL NUMBER 013a(1)						

CONTINUED FROM PAGE V-4

1. POLLUTANT AND CAS NUMBER (if available)	2. MARK 'X'			3. EFFLUENT							4. UNITS		5. INTAKE (optional)		
	a. TESTING REQUIRED	b. BELIEVED PRESENT	c. BELIEVED ABSENT	a. MAXIMUM DAILY VALUE		b. MAXIMUM 30 DAY VALUE (if available)		c. LONG TERM AVRG. VALUE (if available)		d. NO. OF ANALYSES	a. CONCENTRATION	b. MASS	a. LONG TERM AVERAGE VALUE		b. NO. OF ANALYSES
				(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS				(1) CONCENTRATION	(2) MASS	
GC/MS FRACTION - VOLATILE COMPOUNDS (continued)															
22V. Methylene Chloride (75-09-2)	X			< 0.0050						1	mg/L				
23V. 1,1,2,2-Tetrachloroethane (79-34-5)	X			< 0.0010						1	mg/L				
24V. Tetrachloroethylene (127-18-4)	X			< 0.0010						1	mg/L				
25V. Toluene (108-88-3)	X			< 0.0050						1	mg/L				
26V. 1,2-Trans-Dichloroethylene (156-60-5)	X			< 0.0010						1	mg/L				
27V. 1,1,1-Trichloroethane (71-55-6)	X			< 0.0010						1	mg/L				
28V. 1,1,2-Trichloroethane (79-00-5)	X			< 0.0010						1	mg/L				
29V. Trichloroethylene (79-01-6)	X			< 0.0010						1	mg/L				
30V. Trichlorofluoromethane (75-69-4)	X			< 0.0050						1	mg/L				
31V. Vinyl Chloride (75-01-4)	X			< 0.0010						1	mg/L				
GC/MS FRACTION - ACID COMPOUNDS															
1A. 2-Chlorophenol (95-57-8)	X			< 0.040						1	mg/L				
2A. 2,4-Dichlorophenol (120-83-2)	X			< 0.040						1	mg/L				
3A. 2,4-Dimethylphenol (105-67-9)	X			< 0.040						1	mg/L				
4A. 4,6-Dinitro-O-Cresol (534-52-1)	X			< 0.040						1	mg/L				
5A. 2,4-Dinitrophenol (51-28-5)	X			< 0.040						1	mg/L				
6A. 2-Nitrophenol (88-75-5)	X			< 0.040						1	mg/L				
7A. 4-Nitrophenol (100-02-7)	X			< 0.040						1	mg/L				
8A. P-Chloro-M-Cresol (59-50-7)	X			< 0.040						1	mg/L				
9A. Pentachlorophenol (87-86-5)	X			< 0.040						1	mg/L				
10A. Phenol (108-95-2)	X			< 0.040						1	mg/L				
11A. 2,4,6-Trichlorophenol (88-06-2)	X			< 0.040						1	mg/L				

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CONTINUED FROM PAGE V-5

1. POLLUTANT AND CAS NUMBER (if available)	2. MARK 'X'			3. EFFLUENT							4. UNITS		5. INTAKE (optional)		
	a. TESTING REQUIRED	b. BELIEVED PRESENT	c. BELIEVED ABSENT	a. MAXIMUM DAILY VALUE (1) CONCENTRATION	a. MAXIMUM DAILY VALUE (2) MASS	b. MAXIMUM 30 DAY VALUE (if available) (1) CONCENTRATION	b. MAXIMUM 30 DAY VALUE (if available) (2) MASS	c. LONG TERM AVRG. VALUE (if available) (1) CONCENTRATION	c. LONG TERM AVRG. VALUE (if available) (2) MASS	d. NO. OF ANALYSES	a. CONCENTRATION	b. MASS	a. LONG TERM AVERAGE VALUE (1) CONCENTRATION	a. LONG TERM AVERAGE VALUE (2) MASS	b. NO. OF ANALYSES
GC/MS FRACTION - BASE/NEUTRAL COMPOUNDS															
1B. Acenaphthene (83-32-9)			X												
2B. Acenaphtylene (208-96-8)			X												
3B. Anthracene (120-12-7)			X												
4B. Benzidine (92-87-5)			X												
5B. Benzo (a) Anthracene (56-55-3)			X												
6B. Benzo (a) Pyrene (50-32-8)			X												
7B. 3,4-Benzofluoranthene (205-99-2)			X												
8B. Benzo (ghi) Perylene (191-24-2)			X												
9B. Benzo (k) Fluoranthene (207-08-9)			X												
10B. Bis (2-Chloroethoxy) Methane (111-91-1)			X												
11B. Bis (2-Chloroethyl) Ether (111-44-4)			X												
12B. Bis (2-Chloroisopropyl) Ether (108-60-1)			X												
13B. Bis (2-Ethylhexyl) Phthalate (117-81-7)			X												
14B. 4-Bromophenyl Phenyl Ether (101-55-3)			X												
15B. Butyl Benzyl Phthalate (85-68-7)			X												
16B. 2-Chloronaphthalene (91-58-7)			X												
17B. 4-Chlorophenyl Phenyl Ether (7005-72-3)			X												
18B. Chrysene (218-01-9)			X												
19B. Dibenzo (a,h) Anthracene (53-70-3)			X												
20B. 1,2-Dichlorobenzene (95-50-1)			X	< 0.0010						1	mg/L				
21B. 1,3-Dichlorobenzene (541-73-1)			X	< 0.0010						1	mg/L				

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CONTINUED FROM PAGE V-6

1. POLLUTANT AND CAS NUMBER (if available)	2. MARK 'X' a. TESTING REQUIRED	b. BELIEVED PRESENT	c. BELIEVED ABSENT	3. EFFLUENT a. MAXIMUM DAILY VALUE (1) CONCENTRATION	(2) MASS	b. MAXIMUM 30 DAY VALUE (if available) (1) CONCENTRATION	(2) MASS	c. LONG TERM AVRG. VALUE (if available) (1) CONCENTRATION	(2) MASS	d. NO. OF ANALYSES	4. UNITS a. CONCENTRATION	b. MASS	5. INTAKE (optional) a. LONG TERM AVERAGE VALUE (1) CONCENTRATION	(2) MASS	b. NO. OF ANALYSES
GC/MS FRACTION - BASE/NEUTRAL COMPOUNDS (continued)															
22B. 1,4-Dichlorobenzene (106-46-7)			X	< 0.0010						1	mg/L				
23B. 3,3'-Dichlorobenzidine (91-94-1)			X												
24B. Diethyl Phthalate (84-66-2)			X												
25B. Dimethyl Phthalate (131-11-3)			X												
26B. Di-N-Butyl Phthalate (84-74-2)			X												
27B. 2,4-Dinitrotoluene (121-14-2)			X												
28B. 2,6-Dinitrotoluene (606-20-2)			X												
29B. Di-N-Octyl Phthalate (117-84-0)			X												
30B. 1,2-Diphenylhydrazine (as Azobenzene) (122-66-7)			X												
31B. Fluoranthene (206-44-0)			X												
32B. Fluorene (86-73-7)			X												
33B. Hexachlorobenzene (118-74-1)			X												
34B. Hexachlorobutadiene (87-68-3)			X												
35B. Hexachlorocyclopentadiene (77-47-4)			X												
36B. Hexachloroethane (67-72-1)			X												
37B. Indeno (1,2,3-cd) Pyrene (193-39-5)			X												
38B. Isophorone (78-59-1)			X												
39B. Naphthalene (91-20-3)			X												
40B. Nitrobenzene (98-95-3)			X												
41B. N-Nitrosodimethylamine (62-75-9)			X												
42B. N-Nitrosodi-Propylamine (621-64-7)			X												

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CONTINUED FROM PAGE V-7

1. POLLUTANT AND CAS NUMBER (if available)	2. MARK 'X'			3. EFFLUENT							4. UNITS		5. INTAKE (optional)		
	a. TESTING REQUIRED	b. BELIEVED PRESENT	c. BELIEVED ABSENT	a. MAXIMUM DAILY VALUE		b. MAXIMUM 30 DAY VALUE (if available)		c. LONG TERM AVRG. VALUE (if available)		d. NO. OF ANALYSES	a. CONCENTRATION	b. MASS	a. LONG TERM AVERAGE VALUE		b. NO. OF ANALYSES
				(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS				(1) CONCENTRATION	(2) MASS	
GC/MS FRACTION - BASE/NEUTRAL COMPOUNDS (continued)															
43B. N-Nitrosodiphenylamine (86-30-6)			X												
44B. Phenanthrene (85-01-8)			X												
45B. Pyrene (129-00-0)			X												
46B. 1,2,4 - Trichlorobenzene (120-82-1)			X												
GC/MS FRACTION - PESTICIDES															
1P. Aldrin (309-00-2)			X												
2P. α-BHC (319-84-6)			X												
3P. β-BHC (319-85-7)			X												
4P. γ-BHC (58-89-9)			X												
5P. δ-BHC (319-86-8)			X												
6P. Chlordane (57-74-9)			X												
7P. 4,4'-DDT (50-29-3)			X												
8P. 4,4'-DDE (72-55-9)			X												
9P. 4,4'-DDD (72-54-8)			X												
10P. Dieldrin (60-57-1)			X												
11P. α-Endosulfan (115-29-7)			X												
12P. β-Endosulfan (115-29-7)			X												
13P. Endosulfan Sulfate (1031-07-8)			X												
14P. Endrin (72-20-8)			X												
15P. Endrin Aldehyde (7421-93-4)			X												
16P. Heptachlor (76-44-8)			X												

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EPA I.D. NUMBER *(copy from Item 1 of Form 1)*	OUTFALL NUMBER
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1. POLLUTANT AND CAS NUMBER *(if available)*	2. MARK 'X'			3. EFFLUENT							4. UNITS		5. INTAKE *(optional)*		
	a. TESTING REQUIRED	b. BELIEVED PRESENT	c. BELIEVED ABSENT	a. MAXIMUM DAILY VALUE		b. MAXIMUM 30 DAY VALUE *(if available)*		c. LONG TERM AVRG. VALUE *(if available)*		d. NO. OF ANALYSES	a. CONCENTRATION	b. MASS	a. LONG TERM AVERAGE VALUE		b. NO. OF ANALYSES
				(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS				(1) CONCENTRATION	(2) MASS	
GC/MS FRACTION - PESTICIDES *(continued)*															
17B. Heptachlor Epoxide (1024-57-3)			X												
18P. PCB-1242 (53469-21-9)			X												
19P. PCB-1254 (11097-69-1)			X												
20P. PCB-1221 (11104-28-2)			X												
21P. PCB-1232 (11141-16-5)			X												
22P. PCB-1248 (12672-29-6)			X												
23P. PCB-1260 (11096-82-5)			X												
24P. PCB-1016 (12674-11-2)			X												
25P. Toxaphene (8001-35-2)			X												

PLEASE PRINT OR TYPE IN THE UNSHADED AREAS ONLY. You may report some or all of this information on separate sheets *(use the same format)* instead of completing these pages. SEE INSTRUCTIONS.

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V. INTAKE AND EFFLUENT CHARACTERISTICS *(continued from page 3 of Form 2-C)*

OUTFALL NO. 013b

PART A - You must provide the results of at least one analysis for every pollutant in this table. Complete one table for each outfall. See instructions for additional details.

1. POLLUTANT	2. EFFLUENT: a. MAXIMUM DAILY VALUE (1) CONCENTRATION	a. (2) MASS	b. MAXIMUM 30 DAY VALUE *(if available)* (1) CONCENTRATION	b. (2) MASS	c. LONG TERM AVRG. VALUE *(if available)* (1) CONCENTRATION	c. (2) MASS	d. NO. OF ANALYSES	3. UNITS *(specify if blank)* a. CONCENTRATION	b. MASS	4. INTAKE *(optional)* a. LONG TERM AVERAGE VALUE (1) CONCENTRATION	a. (2) MASS	b. NO. OF ANALYSES
a. Biochemical Oxygen Demand *(BOD)*	<5.0						1	mg/L				
b. Chemical Oxygen Demand *(COD)*	180						1	mg/L				
c. Total Organic Carbon *(TOC)*	4.7						1	mg/L				
d. Total Suspended Solids *(TSS)*	11.30				5.26		23	mg/L				
e. Ammonia *(as N)*	<0.10						1	mg/L				
f. Flow	VALUE 0.49		VALUE 0.23		VALUE		96	MGD				
g. Temperature *(winter)*	VALUE		VALUE		VALUE			°C				
h. Temperature *(summer)*	VALUE		VALUE		VALUE			°C				
i. pH	MINIMUM 6.73	MAXIMUM 8.95	MINIMUM	MAXIMUM			25	STANDARD UNITS				

PART B - Mark "X" in column 2-a for each pollutant you know or have reason to believe is present. Mark "X" in column 2-b for each pollutant you believe to be absent. If you mark column 2a for any pollutant which is limited either directly, or indirectly but expressly, in an effluent limitations guideline, you must provide the results of at least one analysis for that pollutant. For other pollutants for which you mark column 2a, you must provide quantitative data or an explanation of their presence in your discharge. Complete one table for each outfall. See the instructions for additional details and requirements.

1. POLLUTANT AND CAS NO. *(if available)*	2. MARK "X" a. BELIEVED PRESENT	b. BELIEVED ABSENT	3. EFFLUENT: a. MAXIMUM DAILY VALUE (1) CONCENTRATION	a. (2) MASS	b. MAXIMUM 30 DAY VALUE *(if available)* (1) CONCENTRATION	b. (2) MASS	c. LONG TERM AVRG. VALUE *(if available)* (1) CONCENTRATION	c. (2) MASS	d. NO. OF ANALYSES	4. UNITS a. CONCENTRATION	b. MASS	5. INTAKE *(optional)* a. LONG TERM AVERAGE VALUE (1) CONCENTRATION	a. (2) MASS	b. NO. OF ANALYSES
a. Bromide (24959-67-9)		X												
b. Chlorine, Total Residual		X												
c. Color			5.0						1	mg/L				
d. Fecal Coliform		X												
e. Fluoride (16984-48-8)		X												
f. Nitrate-Nitrite *(as N)*		X												

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1. POLLUTANT AND CAS NO. (if available)	2. MARK 'X' a. BELIEVED PRESENT	2. MARK 'X' b. BELIEVED ABSENT	3. EFFLUENT a. MAXIMUM DAILY VALUE (1) CONCENTRATION	a. MAXIMUM DAILY VALUE (2) MASS	b. MAXIMUM 30 DAY VALUE (if available) (1) CONCENTRATION	b. (2) MASS	c. LONG TERM AVRG. VALUE (if available) (1) CONCENTRATION	c. (2) MASS	d. NO. OF ANALYSES	4. UNITS a. CONCENTRATION	4. UNITS b. MASS	5. INTAKE (optional) a. LONG TERM AVERAGE VALUE (1) CONCENTRATION	a. (2) MASS	b. NO. OF ANALYSES
g. Nitrogen, Total Organic (as N)		X												
h. Oil and Grease		X	<5.3				< 5.3		24	mg/L				
i. Phosphorus (as P), Total (7723-14-0)		X												
j. Radioactivity														
(1) Alpha, Total		X												
(2) Beta, Total		X												
(3) Radium, Total		X												
(4) Radium 226, Total		X												
k. Sulfate (as SO_4) (14808-79-8)		X												
l. Sulfide (as S)		X												
m. Sulfite (as SO_3) (14265-45-3)		X												
n. Surfactants		X												
o. Aluminum, Total (7429-90-5)	X		0.94						1	mg/L				
p. Barium, Total (7440-39-3)	X		0.062						1	mg/L				
q. Boron, Total (7440-42-8)	X		<0.20						1	mg/L				
r. Cobalt, Total (7440-48-4)	X		<0.0010						1	mg/L				
s. Iron, Total (7439-89-6)		X												
t. Magnesium, Total (7439-95-4)	X		6.6						1	mg/L				
u. Molybdenum, Total (7439-98-7)	X		0.011						1	mg/L				
v. Manganese, Total (7439-96-5)	X		0.068						1	mg/L				
w. Tin, Total (7440-31-5)	X		<0.0010						1	mg/L				
x. Titanium, Total (7440-32-6)	X		<0.010						1	mg/L				

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EPA I.D. NUMBER *(copy from Item 1 of Form 1)*	OUTFALL NUMBER
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PART C - If you are a primary industry and this outfall contains process wastewater, refer to Table 2c-2 in the instructions to determine which of the GC/MS fractions you must test for. Mark "X" in column 2-a for *all* such GC/MS fractions that apply to your industry and for ALL toxic metals, cyanides, and total phenols. If you are not required to mark column 2-a *(secondary industries, nonprocess wastewater outfalls, and nonrequired GC/MS fractions)*, mark "X" in column 2-b for each pollutant you know or have reason to believe is present. Mark "X" in column 2-c for each pollutant you believe is absent. If you mark column 2a for any pollutant, you must provide the results of at least one analysis for that pollutant. If you mark column 2b for any pollutant, you must provide the results of at least one analysis for that pollutant if you know or have reason to believe it will be discharged in concentrations of 10 ppb or greater. If you mark column 2b for acrolein, acrylonitrile, 2,4 dinitrophenol, or 2-methyl-4, 6 dinitrophenol, you must provide the results of at least one analysis for each of these pollutants which you know or have reason to believe that you discharge in concentrations of 100 ppb or greater. Otherwise for pollutants for which you mark column 2b, you must either submit at least one analysis or briefly describe the reasons the pollutant is expected to be discharged. Note that there are 7 pages to this part; please review each carefully. Complete one table *(all 7 pages)* for each outfall. See instructions for additional details and requirements.

1. POLLUTANT AND CAS NUMBER *(if available)*	2. MARK 'X'			3. EFFLUENT							4. UNITS		5. INTAKE *(optional)*		
	a. TESTING REQUIRED	b. BELIEVED PRESENT	c. BELIEVED ABSENT	a. MAXIMUM DAILY VALUE		b. MAXIMUM 30 DAY VALUE *(if available)*		c. LONG TERM AVRG. VALUE *(if available)*		d. NO. OF ANALYSES	a. CONCENTRATION	b. MASS	a. LONG TERM AVERAGE VALUE		b. NO. OF ANALYSES
				(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS				(1) CONCENTRATION	(2) MASS	
METALS, CYANIDE, AND TOTAL PHENOLS															
1M. Antimony, Total (7440-36-0)	X			<0.0010						1	mg/L				
2M. Arsenic, Total (7440-38-2)	X			0.0011						1	mg/L				
3M. Beryllium, Total, (7440-41-7)	X			<0.0010						1	mg/L				
4M. Cadmium, Total (7440-43-9)	X			<0.00050						1	mg/L				
5M. Chromium, Total (7440-47-3)	X			<0.0010						1	mg/L				
6M. Copper, Total (7440-50-8)	X			<0.0010						1	mg/L				
7M. Lead, Total (7439-92-1)	X			<0.0010						1	mg/L				
8M. Mercury, Total (7439-97-6)			X												
9M. Nickel, Total (7440-02-0)	X			<0.0010						1	mg/L				
10M. Selenium, Total (7782-49-2)	X			0.0016						1	mg/L				
11M. Silver, Total (7440-22-4)	X			<0.00050						1	mg/L				
12M. Thallium, Total (7440-28-0)	X			<0.0010						1	mg/L				
13M. Zinc, Total (7440-66-6)	X			<0.010						1	mg/L				
14M. Cyanide, Total (57-12-5)	X			<0.0050						1	mg/L				
15M. Phenols, Total (108-95-2)	X			<0.040						1	mg/L				
DIOXIN															
2,3,7,8-Tetra-chlorodibenzo-P-Dioxin (1764-01-6)			X	DESCRIBE RESULTS											

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1. POLLUTANT AND CAS NUMBER (if available)	2. MARK 'X'			3. EFFLUENT							4. UNITS		5. INTAKE (optional)		
	a. TESTING REQUIRED	b. BELIEVED PRESENT	c. BELIEVED ABSENT	a. MAXIMUM DAILY VALUE		b. MAXIMUM 30 DAY VALUE (if available)		c. LONG TERM AVRG. VALUE (if available)		d. NO. OF ANALYSES	a. CONCENTRATION	b. MASS	a. LONG TERM AVERAGE VALUE		b. NO. OF ANALYSES
				(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS				(1) CONCENTRATION	(2) MASS	
GC/MS FRACTION - VOLATILE COMPOUNDS															
1V. Acrolein (107-02-8)	X			< 0.050						1	mg/L				
2V. Acrylonitrile (107-13-1)	X			< 0.010						1	mg/L				
3V. Benzene (71-43-2)	X			< 0.0010						1	mg/L				
4V. Bis (Chloromethyl) Ether (542-88-1)			X												
5V. Bromoform (75-25-2)	X			< 0.0010						1	mg/L				
6V. Carbon Tetrachloride (56-23-5)	X			< 0.0010						1	mg/L				
7V. Chlorobenzene (108-90-7)	X			< 0.0010						1	mg/L				
8V. Chlorodibromomethane (124-48-1)	X			< 0.0010						1	mg/L				
9V. Chloroethane (75-00-3)	X			< 0.0050						1	mg/L				
10V. 2-Chloroethylvinyl Ether (110-75-8)	X			< 0.050						1	mg/L				
11V. Chloroform (67-66-3)	X			< 0.0050						1	mg/L				
12V. Dichlorobromomethane (75-27-4)	X			< 0.0010						1	mg/L				
13V. Dichlorodifluoromethane (75-71-8)	X			< 0.0050						1	mg/L				
14V. 1,1-Dichloroethane (75-34-3)	X			< 0.0010						1	mg/L				
15V. 1,2-Dichloroethane (107-06-2)	X			< 0.0010						1	mg/L				
16V. 1,1-Dichloroethylene (75-35-4)	X			< 0.0010						1	mg/L				
17V. 1,2-Dichloropropane (78-87-5)	X			< 0.0010						1	mg/L				
18V. 1,3-Dichloropropylene (542-75-6)	X			< 0.0020						1	mg/L				
19V. Ethylbenzene (100-41-4)	X			< 0.0010						1	mg/L				
20V. Methyl Bromide (74-83-9)	X			< 0.0050						1	mg/L				
21V. Methyl Chloride (74-87-3)	X			< 0.0025						1	mg/L				

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EPA I.D. NUMBER (copy from Item 1 of Form 1)	OUTFALL NUMBER
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1. POLLUTANT AND CAS NUMBER (if available)	2. MARK 'X' a. TESTING REQUIRED	b. BELIEVED PRESENT	c. BELIEVED ABSENT	3. EFFLUENT a. MAXIMUM DAILY VALUE (1) CONCENTRATION	(2) MASS	b. MAXIMUM 30 DAY VALUE (if available) (1) CONCENTRATION	(2) MASS	c. LONG TERM AVRG. VALUE (if available) (1) CONCENTRATION	(2) MASS	d. NO. OF ANALYSES	4. UNITS a. CONCENTRATION	b. MASS	5. INTAKE (optional) a. LONG TERM AVERAGE VALUE (1) CONCENTRATION	(2) MASS	b. NO. OF ANALYSES
GC/MS FRACTION - VOLATILE COMPOUNDS (continued)															
22V. Methylene Chloride (75-09-2)	X			< 0.0050						1	mg/L				
23V. 1,1,2,2-Tetrachloroethane (79-34-5)	X			< 0.0010						1	mg/L				
24V. Tetrachloroethylene (127-18-4)	X			< 0.0010						1	mg/L				
25V. Toluene (108-88-3)	X			< 0.0050						1	mg/L				
26V. 1,2-Trans-Dichloroethylene (156-60-5)	X			< 0.0010						1	mg/L				
27V. 1,1,1-Trichloroethane (71-55-6)	X			< 0.0010						1	mg/L				
28V. 1,1,2-Trichloroethane (79-00-5)	X			< 0.0010						1	mg/L				
29V. Trichloroethylene (79-01-6)	X			< 0.0010						1	mg/L				
30V. Trichlorofluoromethane (75-69-4)	X			< 0.0050						1	mg/L				
31V. Vinyl Chloride (75-01-4)	X			< 0.0010						1	mg/L				
GC/MS FRACTION - ACID COMPOUNDS															
1A. 2-Chlorophenol (95-57-8)	X			< 0.040						1	mg/L				
2A. 2,4-Dichlorophenol (120-83-2)	X			< 0.040						1	mg/L				
3A. 2,4-Dimethylphenol (105-67-9)	X			< 0.040						1	mg/L				
4A. 4,6-Dinitro-O-Cresol (534-52-1)	X			< 0.040						1	mg/L				
5A. 2,4-Dinitrophenol (51-28-5)	X			< 0.040						1	mg/L				
6A. 2-Nitrophenol (88-75-5)	X			< 0.040						1	mg/L				
7A. 4-Nitrophenol (100-02-7)	X			< 0.040						1	mg/L				
8A. P-Chloro-M Cresol (59-50-7)	X			< 0.040						1	mg/L				
9A. Pentachlorophenol (87-86-5)	X			< 0.040						1	mg/L				
10A. Phenol (108-95-2)	X			< 0.040						1	mg/L				
11A. 2,4,6-Trichlorophenol (88-06-2)	X			< 0.040						1	mg/L				

 CONTINUE ON PAGE V-6

CONTINUED FROM PAGE V-5

1. POLLUTANT AND CAS NUMBER (if available)	2. MARK 'X' a. TESTING REQUIRED	b. BELIEVED PRESENT	c. BELIEVED ABSENT	3. EFFLUENT a. MAXIMUM DAILY VALUE (1) CONCENTRATION	(2) MASS	b. MAXIMUM 30 DAY VALUE (if available) (1) CONCENTRATION	(2) MASS	c. LONG TERM AVRG. VALUE (if available) (1) CONCENTRATION	(2) MASS	d. NO. OF ANALYSES	4. UNITS a. CONCENTRATION	b. MASS	5. INTAKE (optional) a. LONG TERM AVERAGE VALUE (1) CONCENTRATION	(2) MASS	b. NO. OF ANALYSES
GC/MS FRACTION - BASE/NEUTRAL COMPOUNDS															
1B. Acenaphthene (83-32-9)			X												
2B. Acenaphtylene (208-96-8)			X												
3B. Anthracene (120-12-7)			X												
4B. Benzidine (92-87-5)			X												
5B. Benzo (a) Anthracene (56-55-3)			X												
6B. Benzo (a) Pyrene (50-32-8)			X												
7B. 3,4-Benzo-fluoranthene (205-99-2)			X												
8B. Benzo (ghi) Perylene (191-24-2)			X												
9B. Benzo (k) Fluoranthene (207-08-9)			X												
10B. Bis (2-Chloroethoxy) Methane (111-91-1)			X												
11B. Bis (2-Chloroethyl) Ether (111-44-4)			X												
12B. Bis (2-Chloroisopropyl) Ether (108-60-1)			X												
13B. Bis (2-Ethylhexyl) Phthalate (117-81-7)			X												
14B. 4-Bromophenyl Phenyl Ether (101-55-3)			X												
15B. Butyl Benzyl Phthalate (85-68-7)			X												
16B. 2-Chloronaphthalene (91-58-7)			X												
17B. 4-Chlorophenyl Phenyl Ether (7005-72-3)			X												
18B. Chrysene (218-01-9)			X												
19B. Dibenzo (a,h) Anthracene (53-70-3)			X												
20B. 1,2-Dichlorobenzene (95-50-1)			X	< 0.0010						1	mg/L				
21B. 1,3-Dichlorobenzene (541-73-1)			X	< 0.0010						1	mg/L				

 CONTINUE ON PAGE V-7

				EPA I.D. NUMBER *(copy from Item 1 of Form 1)* AL8640015410						OUTFALL NUMBER 013b						

CONTINUED FROM PAGE V-6

1. POLLUTANT AND CAS NUMBER *(if available)*	2. MARK "X"			3. EFFLUENT							4. UNITS		5. INTAKE *(optional)*		
	a. TESTING REQUIRED	b. BELIEVED PRESENT	c. BELIEVED ABSENT	a. MAXIMUM DAILY VALUE (1) CONCENTRATION	a. MAXIMUM DAILY VALUE (2) MASS	b. MAXIMUM 30 DAY VALUE *(if available)* (1) CONCENTRATION	b. MAXIMUM 30 DAY VALUE *(if available)* (2) MASS	c. LONG TERM AVRG. VALUE *(if available)* (1) CONCENTRATION	c. LONG TERM AVRG. VALUE *(if available)* (2) MASS	d. NO. OF ANALYSES	a. CONCENTRATION	b. MASS	a. LONG TERM AVERAGE VALUE (1) CONCENTRATION	a. LONG TERM AVERAGE VALUE (2) MASS	b. NO. OF ANALYSES
GC/MS FRACTION - BASE/NEUTRAL COMPOUNDS *(continued)*															
22B. 1,4-Dichlorobenzene (106-46-7)			X	< 0.0010						1	mg/L				
23B. 3,3'-Dichlorobenzidine (91-94-1)			X												
24B. Diethyl Phthalate (84-66-2)			X												
25B. Dimethyl Phthalate (131-11-3)			X												
26B. Di-N-Butyl Phthalate (84-74-2)			X												
27B. 2,4-Dinitrotoluene (121-14-2)			X												
28B. 2,6-Dinitrotoluene (606-20-2)			X												
29B. Di-N-Octyl Phthalate (117-84-0)			X												
30B. 1,2-Diphenylhydrazine *(as Azobenzene)* (122-66-7)			X												
31B. Fluoranthene (206-44-0)			X												
32B. Fluorene (86-73-7)			X												
33B. Hexachlorobenzene (118-74-1)			X												
34B. Hexachlorobutadiene (87-68-3)			X												
35B. Hexachlorocyclopentadiene (77-47-4)			X												
36B. Hexachloroethane (67-72-1)			X												
37B. Indeno *(1,2,3-cd)* Pyrene (193-39-5)			X												
38B. Isophorone (78-59-1)			X												
39B. Naphthalene (91-20-3)			X												
40B. Nitrobenzene (98-95-3)			X												
41B. N-Nitrosodimethylamine (62-75-9)			X												
42B. N-Nitrosodi-Propylamine (621-64-7)			X												

 CONTINUE ON PAGE V-8

CONTINUED FROM PAGE V-7

1. POLLUTANT AND CAS NUMBER (if available)	2. MARK 'X'			3. EFFLUENT							4. UNITS		5. INTAKE (optional)		
	a. TESTING REQUIRED	b. BELIEVED PRESENT	c. BELIEVED ABSENT	a. MAXIMUM DAILY VALUE		b. MAXIMUM 30 DAY VALUE (if available)		c. LONG TERM AVRG. VALUE (if available)		d. NO. OF ANALYSES	a. CONCENTRATION	b. MASS	a. LONG TERM AVERAGE VALUE		b. NO. OF ANALYSES
				(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS				(1) CONCENTRATION	(2) MASS	
GC/MS FRACTION - BASE/NEUTRAL COMPOUNDS (continued)															
43B. N-Nitrosodiphenylamine (86-30-6)			X												
44B. Phenanthrene (85-01-8)			X												
45B. Pyrene (129-00-0)			X												
46B. 1,2,4 - Trichlorobenzene (120-82-1)			X												
GC/MS FRACTION - PESTICIDES															
1P. Aldrin (309-00-2)			X												
2P. α-BHC (319-84-6)			X												
3P. β-BHC (319-85-7)			X												
4P. γ-BHC (58-89-9)			X												
5P. δ-BHC (319-86-8)			X												
6P. Chlordane (57-74-9)			X												
7P. 4,4'-DDT (50-29-3)			X												
8P. 4,4'-DDE (72-55-9)			X												
9P. 4,4'-DDD (72-54-8)			X												
10P. Dieldrin (60-57-1)			X												
11P. α-Endosulfan (115-29-7)			X												
12P. β-Endosulfan (115-29-7)			X												
13P. Endosulfan Sulfate (1031-07-8)			X												
14P. Endrin (72-20-8)			X												
15P. Endrin Aldehyde (7421-93-4)			X												
16P. Heptachlor (76-44-8)			X												

 CONTINUE ON PAGE V-9

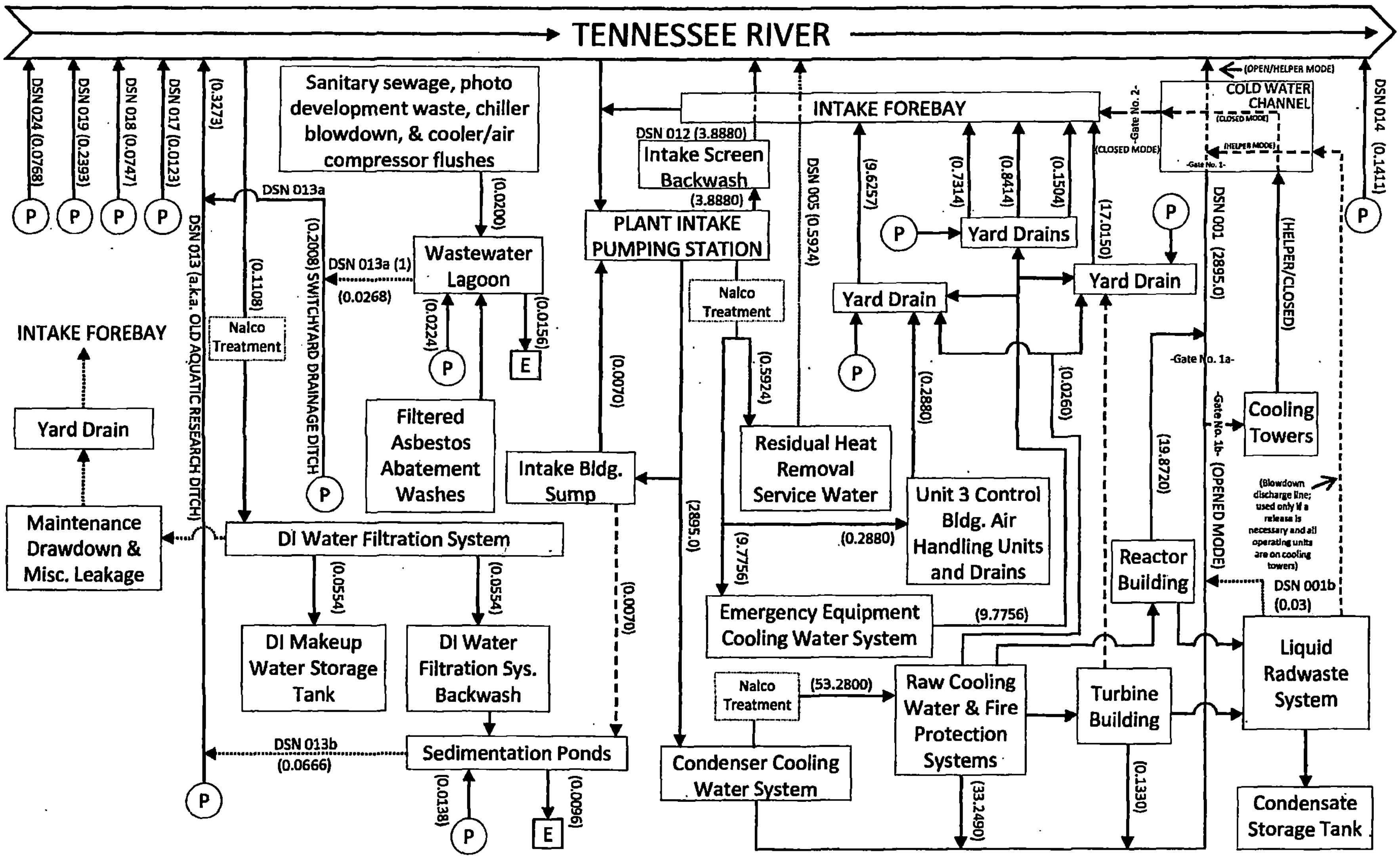
													EPA I.D. NUMBER *(copy from Item 1 of Form 1)* AL8640015410		OUTFALL NUMBER 013b

CONTINUED FROM PAGE V-8

1. POLLUTANT AND CAS NUMBER *(if available)*	2. MARK 'X'			3. EFFLUENT							4. UNITS		5. INTAKE *(optional)*		
	a. TESTING REQUIRED	b. BELIEVED PRESENT	c. BELIEVED ABSENT	a. MAXIMUM DAILY VALUE		b. MAXIMUM 30 DAY VALUE *(if available)*		c. LONG TERM AVRG. VALUE *(if available)*		d. NO. OF ANALYSES	a. CONCENTRATION	b. MASS	a. LONG TERM AVERAGE VALUE		b. NO. OF ANALYSES
				(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS				(1) CONCENTRATION	(2) MASS	
GC/MS FRACTION - PESTICIDES *(continued)*															
17P. Heptachlor Epoxide (1024-57-3)			X												
18P. PCB-1242 (53469-21-9)			X												
19P. PCB-1254 (11097-69-1)			X												
20P. PCB-1221 (11104-28-2)			X												
21P. PCB-1232 (11141-16-5)			X												
22P. PCB-1248 (12672-29-6)			X												
23P. PCB-1260 (11096-82-5)			X												
24P. PCB-1016 (12674-11-2)			X												
25P. Toxaphene (8001-35-2)			X												

BROWNS FERRY NUCLEAR PLANT – DISCHARGE FLOW SCHEMATIC

NPDES PERMIT AL0022080
Schematic Revised Feb 2011



DSN 0XX Permitted Outfall
Primary Pathway
Alternate Pathway
Intermittent Flow

P Precipitation
E Evaporation

EECW
+Standby diesel engine coolers
+Core spray pump room coolers
+RHR pump room coolers
+Electric board on ACU condensers
+RHR pump seal coolers
+Shutdown board on ACU condensers
+Shutdown board on Chillers
+Control Bay chillers
+H2O2 analyzers
+Backup for several RCW components

RCW/FP
+Turbine lube oil coolers
+Gen. stator water & hydrogen coolers
+Reactor feed pump turbine oil coolers
+Svs. & control air compressors
+Steam jet air ejector precoolers
+Gen. alternator coolers
+Air conditioning condensers
+Recirc. Pump M-G sel coolers
+RBCCW heat exchangers
+Gen. breakers to main 500kV
+Misc. coolers

Please type or print in the unshaded areas only.

EPA ID Number (copy from Item 1 of Form 1)	Form Approved
AL8640015410	OMB No. 2040-0086 Approval expires 7-31-88

Form 2E NPDES

EPA Facilities Which Do Not Discharge Process Wastewater

I. Receiving Waters

For this outfall, list the latitude and longitude, and name of the receiving water(s).

Outfall Number (list)	Latitude Deg	Latitude Min	Latitude Sec	Longitude Deg	Longitude Min	Longitude Sec	Receiving Water (name)
012**	34	43	15	87	07	15	Tennessee River

II. Discharge Date (If a new discharger, the date you expect to begin discharging)

III. Type of Waste

A. Check the box(es) indicating the general type of wastes discharged.

☐ Sanitary Wastes ☐ Restaurant or Cafeteria Wastes ☐ Noncontact Cooling Water ☒ Other Nonprocess Wastewater (identify)

B. If any cooling water additives are used, list them here. Briefly describe their composition if this information is available.

DSN 012 receives backwash from the intake screens and discharges directly to the Tennessee River. Ricer water from the intake is used to backwash the intake screens, with no chemical treatment provided. While DSN 012 does receive a small quantity of Nalco-treated Emergency Equipment Cooling Water (EECW) influent water, it represents less than ten percent of the discharge volume. This small quantity of treated water will have little, if any, impact on the quality of the outfall's total discharge.

IV. Effluent Characteristics

A. Existing Sources - Provide measurements for the parameters listed in the left-hand column below, unless waived by the permitting authority (see instructions).

B. New Discharges - Provide estimates for the parameters listed in the left-hand column below, unless waived by the permitting authority. Instead of the number of measurements taken, provide the source of estimated values (see instructions).

Pollutant or Parameter	(1) Maximum Daily Value (include units)		(2) Average Daily Value (last year) (include units)		(3) Number of Measurements Taken (last year)	(or) (4) Source of Estimate (if new discharger)
	Mass	Concentration	Mass	Concentration		
Biochemical Oxygen Demand (BOD)						
Total Suspended Solids (TSS)						
Fecal Coliform (if believed present or if sanitary waste is discharged)						
Total Residual Chlorine (if chlorine is used)						
Oil and Grease						
*Chemical oxygen demand (COD)						
*Total organic carbon (TOC)						
Ammonia (as N)						
Discharge Flow	Value					
pH (give range)	Value					
Temperature (Winter)	°C		°C			
Temperature (Summer)	°C		°C			

*If noncontact cooling water is discharged ** The current permit requires no monitoring of this outfall, this, no sample was collected for the permit renewal process.

...ks or spills, will the discharge described in this form be intermittent or seasonal?
...briefly describe the frequency of flow and duration.

[ ] Yes [X] No

VI. Treatment System *(Describe briefly any treatment system(s) used or to be used)*

NONE

VII. Other Information *(Optional)*

Use the space below to expand upon any of the above questions or to bring to the attention of the reviewer any other information you feel should be considered in establishing permit limitation. Attach additional sheets, if necessary.

N/A

VIII. Certification

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

A. Name & Official Title	B. Phone No. *(area code & no.)*
K.J. Polson, Site Vice President	(256) 729-3675
C. Signature	D. Date Signed
	2-26-11

.t or type in the unshaded areas only

EPA ID Number (copy from Item 1 of Form 1): AL8640015410

Form Approved. OMB No. 2040-0085 Approval Expires 5-31-92

Form 2F NPDES

EPA

United States Environmental Protection Agency
Washington, DC 20460

Application for Permit to Discharge Storm Water

Paperwork Reduction Act Notice

Public reporting burden for this application is estimated to average 28.6 hours per application, including times for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding the burden estimate, any other aspect of this collection of information, or suggestions for improving this form, including suggestions which may increase or reduce this burden to: Chief, Information Policy Branch, PM-223, U.S. Environmental Protection Agency, 401 M St., SW, Washington, DC 20460, or Director, Office of Information and Regulatory Affairs, Office of Management and Budget, Washington, DC 20503

I. Outfall Location

For each outfall, list the latitude and longitude of its location to the nearest 15 seconds and the name of the receiving water.

A. Outfall Number (list)	B. Latitude			C. Longitude			D. Receiving Water (name)
013	34	43	00	87	07	00	Tennessee River
013a	34	42	00	87	07	00	Tennessee River via outfall 013
014*	34	43	00	87	07	30	Tennessee River
017*	34	42	00	87	07	00	Tennessee River
018	34	42	00	87	06	45	Tennessee River
019	34	42	00	87	06	15	Tennessee River
024	34	42	30	87	06	30	Tennessee River via offsite ditch and farmland

*Because no monitoring is required of 014 and 017 and because these outfalls receive only storm water runoff from areas with no industrial activity, no sample was collected for this permit renewal application.

II. Improvements

A. Are you now required by any Federal, State, or local authority to meet any implementation schedule for the construction, upgrading or operation of wastewater treatment equipment or practices of any other environmental programs which may affect the discharges described in this application? This includes, but is not limited to, permit conditions, administrative or enforcement orders, enforcement compliance schedule letters, stipulations, court orders, and grant or loan conditions. NO

1. Identification of Conditions, Agreements, Etc.	2. Affected Outfalls number	2. Affected Outfalls source of discharge	3. Brief Description of Project	4. Final Compliance Date a. req.	4. Final Compliance Date b. proj.
N/A					

B. You may attach additional sheets describing any additional water pollution (or other environmental projects which may affect your discharges) you now have under way or which you plan. Indicate whether each program is now under way or planned, and indicate your actual or planned schedules for construction.

III. Site Drainage Map

Attach a site map showing topography (for indicating the outline of drainage areas served by the outfall(s) covered in the application if a topographic map is unavailable) depicting the facility including: each of its intake and discharge structures; the drainage area of each storm water outfall; paved areas and buildings within the drainage area of each storm water outfall, each known past or present areas used for outdoor storage or disposal of significant materials, each existing structural control measure to reduce pollutants in storm water runoff, materials loading and access areas, areas where pesticides, herbicides, soil conditioners and fertilizers are applied; each of its hazardous waste treatment, storage or disposal units (including each area not required to have a RCRA permit which is used for accumulating hazardous waste under 40 CFR 262.34); each well where fluids from the facility are injected underground; springs, and other surface water bodies which receive storm water discharges from the facility.

Continue on Page 2

... Description of Pollutant Sources

...ach outfall, provide an estimate of the area (include units) of impervious surfaces (including paved areas and building roofs) drained to ...is outfall, and an estimate of the total surface area drained by the outfall.

Outfall Number	Area of Impervious Surface (provide units)	Total Area Drained (provide units)	Outfall Number	Area of Impervious Surface (provide units)	Total Area Drained (provide units)
013	5.0 acres	6.8 acres	018	18.8 acres	34.2 acres
013a	40.5 acres	94.5 acres	019	48.0 acres	156.7 acres
014	5.0 acres	202 acres	024	8.4 acres	84.3 acres
017	3.0 acres	6.0 acres			

B. Provide a narrative description of significant materials that are currently or in the past three years have been treated, stored or disposed in a manner to allow exposure to storm water; method of treatment, storage, or disposal; past and present materials management practices employed to minimize contact by these materials with storm water runoff; materials loading and access areas; and the location, manner and frequency in which pesticides, herbicides, soil conditioners, and fertilizers are applied.

See EPA Form 2F Attachment 1

C. For each outfall, provide the location and a description of existing structural and nonstructural control measures to reduce pollutants in storm water runoff; and a description of the treatment the storm water receives, including the schedule and type of maintenance for control and treatment measures and the ultimate disposal of any solid or fluid wastes other than by discharge.

Outfall Number	Treatment	List Codes from Table 2F-1
	See EPA Form 2F Attachment 1	

V. Nonstormwater Discharges

A. I certify under penalty of law that the outfall(s) covered by this application have been tested or evaluated for the presence of nonstormwater discharges, and that all nonstormwater discharges from these outfall(s) are identified in either an accompanying Form 2C or Form 2E application for the outfall.

Name and Official Title *(type or print)*	Signature	Date Signed
K. J. Polson, Site Vice President	Keith J Polson	2-26-11

B. Provide a description of the method used, the date of any testing, and the onsite drainage points that were directly observed during a test.

These outfalls were evaluated through field evaluations and through interviews with plant personnel.

VI. Significant Leaks or Spills

Provide existing information regarding the history of significant leaks or spills of toxic or hazardous pollutants at the facility in the last three years, including the approximate date and location of the spill or leak, and the type and amount of material released.

There have been no significant leaks or spills of toxic or hazardous pollutants at the facility during the last three years.

 Continue on Page 3

. rom Page 2

EPA ID Number *(copy from Item 1 of Form 1)*
AL8640015410

Discharge Information

A, B, C, & D: See instructions before proceeding. Complete one set of tables for each outfall. Annotate the outfall number in the space provided. Tables VII-A, VII-B, and VII-C are included on separate sheets numbered VII-1 and VII-2.

E. Potential discharges not covered by analysis - is any toxic pollutant listed in table 2F-2, 2F-3 or 2F-4, a substance or a component of a substance which you currently use or manufacture as an intermediate or final product or byproduct?

[ ] Yes *(list all such pollutants below)* [X] No *(go to Section IX)*

VIII. Biological Toxicity Testing Data

Do you have any knowledge or reason to believe that any biological test for acute or chronic toxicity has been made on any of your discharges or on a receiving water in relation to your discharge within the last 3 years?

[X] Yes *(list all such pollutants below)* [ ] No *(go to Section IX)*

No biological test for chronic toxicity has been performed on any storm water discharge; however, WET Biomonitoring data has been collected on process water (DSN 001) over the past five years in accordance with Part IV. Effluent Toxicity Limitations and Biomonitoring Requirements, of the current NPDES Permit AL0022080 (see Resonable Potential evaluation).

IX. Contract Analysis Information

Were any of the analysis reported in item VII performed by a contract laboratory or consulting firm?

[ ] Yes (list the name, address, and telephone number of, and pollutants analyzed by, each such laboratory or firm below. [X] No *(go to Section X)*

A. Name	B. Address	C. Area Code & Phone No.	D. Pollutants Analyzed

X. Certification

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

A. Name & Official Title *(type or print)*	B. Area Code and Phone No.
K. J. Polson, Site Vice President	(256) 729-3675
C. Signature	D. Date Signed
[signature]	2-26-11

EPA ID Number (copy from Item 1 of Form 1)
AL8640015410

Form Approved. OMB No. 2040-0085
Approval Expires 5-31-92

...charge Information *(Continued from page 3 of Form 2F)*

...art A - You must provide the results of at least one analysis for every pollutant in this table. Complete one table for each outfall. See instructions for additional details.

DSN 013 Pollutant and CAS Number (if available)	Maximum Values *(include units)*		Average Values *(include units)*		Number of Storm Events Sampled	Sources of Pollutants
	Grab Sample Taken During First 20 Minutes	Flow-weighted Composite	Grab Sample Taken During First 20 Minutes	Flow-weighted Composite		
Oil and Grease	<5.6 mg/L	N/A			1	
Biological Oxygen Demand (BOD)	<5.0 mg/L	<5.0 mg/L			1	
Chemical Oxygen Demand (COD)	12. mg/L	16. mg/L			1	
Total Suspended Solids (TSS)	14. mg/L	18. mg/L			1	
Total Nitrogen	1.30 mg/L	0.62 mg/L			1	
Total Phosphorus	<0.10 mg/L	<0.10 mg/L			1	
pH	Minimum 7.38 s.u.	Maximum 7.38 s.u.	Minimum	Maximum	1	

Part B - List each pollutant that is limited in an effluent guideline which the facility is subject to or any pollutant listed in the facility's NPDES permit for its process wastewater (if the facility is operating under an existing NPDES permit). Complete one table for each outfall. See the instructions for additional details and requirements.

Pollutant and CAS Number (if available)	Maximum Values *(include units)*		Average Values *(include units)*		Number of Storm Events Sampled	Sources of Pollutants
	Grab Sample Taken During First 20 Minutes	Flow-weighted Composite	Grab Sample Taken During First 20 Minutes	Flow-weighted Composite		
Fecal Coliforms	721 (colonies/100 ml)	N/A			1	
Temperature	10.7°C	N/A			1	
TRC	<0.05 mg/L Cl	N/A			1	
Ammonia Nitrogen	N/A	0.20 mg/L			1	
Color	10. pcu	10. pcu			1	
Nitrate-Nitrite	0.74 mg/L	0.62 mg/L			1	
TKN	0.58 mg/L	<0.10 mg/L			1	
Antimony	<0.0010 mg/L	<0.0010 mg/L			1	
Arsenic	<0.0010 mg/L	<0.0010 mg/L			1	
Barium	0.0180 mg/L	0.0150 mg/L			1	
Beryllium	<0.0010 mg/L	<0.0010 mg/L			1	
Cadmium	<0.00050 mg/L	<0.00050 mg/L			1	
Chromium	0.0013 mg/L	0.0026 mg/L			1	
Cobalt	<0.0010 mg/L	<0.0010 mg/L			1	
Copper	0.0025 mg/L	0.0039 mg/L			1	
Lead	0.0011 mg/L	0.0016 mg/L			1	
Nickel	0.0016 mg/L	0.0026 mg/L			1	
Selenium	<0.0010 mg/L	<0.0010 mg/L			1	
Silver	<0.00050 mg/L	<0.00050 mg/L			1	
Thallium	<0.0010 mg/L	<0.0010 mg/L			1	
Tin	<0.0010 mg/L	<0.0010 mg/L			1	
Zinc	0.016 mg/L	0.018 mg/L			1	
Mercury	<0.00020 mg/L	<0.00020 mg/L			1	
Naphthalene	<0.0010 mg/L	<0.0010 mg/L			1	

Continue on Reverse

..ch pollutant shown in Tables 2F-2, 2F-3, and 2F-4, that you know or have reason to believe is present. See the instructions for ..ditional details and requirements. Complete one table for each outfall.

DSN 013 Pollutant and CAS Number (if available)	Maximum Values (*include units*)		Average Values (*include units*)		Number of Storm Events Sampled	Sources of Pollutants
	Grab Sample Taken During First 20 Minutes	Flow-weighted Composite	Grab Sample Taken During First 20 Minutes	Flow-weighted Composite		
Acrolein	<0.050 mg/L	<0.050 mg/L			1	
Acrylonitrile	<0.010 mg/L	<0.010 mg/L			1	
Benzene	<0.0010 mg/L	<0.0010 mg/L			1	
Bromodichloromethane	0.0020 mg/L	<0.0010 mg/L			1	
Bromoform	<0.0010 mg/L	<0.0010 mg/L			1	
Bromomethane	<0.0050 mg/L	<0.0050 mg/L			1	
Carbon tetrachloride	<0.0010 mg/L	<0.0010 mg/L			1	
Chlorobenzene	<0.0010 mg/L	<0.0010 mg/L			1	
Chlorodibromomethane	<0.0010 mg/L	<0.0010 mg/L			1	
Chloroethane	<0.0050 mg/L	<0.0050 mg/L			1	
2-Chloroethyl vinyl ether	<0.050 mg/L	<0.050 mg/L			1	
Chloroform	0.0150 mg/L	0.0075 mg/L			1	
Chloromethane	<0.0025 mg/L	<0.0025 mg/L			1	
1,2-Dichlorobenzene	<0.0010 mg/L	<0.0010 mg/L			1	
1,3-Dichlorobenzene	<0.0010 mg/L	<0.0010 mg/L			1	
1,4-Dichlorobenzene	<0.0010 mg/L	<0.0010 mg/L			1	
Dichlorodifluoromethane	<0.0050 mg/L	<0.0050 mg/L			1	
1,1-Dichloroethane	<0.0010 mg/L	<0.0010 mg/L			1	
1,2-Dichloroethane	<0.0010 mg/L	<0.0010 mg/L			1	
1,1-Dichloroethane	<0.0010 mg/L	<0.0010 mg/L			1	
trans-1,2-Dichloroethene	<0.0010 mg/L	<0.0010 mg/L			1	
1,2-Dichloropropane	<0.0010 mg/L	<0.0010 mg/L			1	
cis-1,3-Dichloropropene	<0.0010 mg/L	<0.0010 mg/L			1	
trans-1,3-Dichloropropene	<0.0010 mg/L	<0.0010 mg/L			1	
Ethylbenzene	<0.0010 mg/L	<0.0010 mg/L			1	
Methylene Chloride	<0.0050 mg/L	<0.0050 mg/L			1	
1,1,2,2-Tetrachloroethane	<0.0010 mg/L	<0.0010 mg/L			1	
Tetrachloroethene	<0.0010 mg/L	<0.0010 mg/L			1	
Toluene	<0.0050 mg/L	<0.0050 mg/L			1	
1,1,1-Trichloroethane	<0.0010 mg/L	<0.0010 mg/L			1	
1,1,2-Trichloroethane	<0.0010 mg/L	<0.0010 mg/L			1	
Trichloroethene	<0.0010 mg/L	<0.0010 mg/L			1	
Trichlorofluoromethane	<0.0050 mg/L	<0.0050 mg/L			1	
Vinyl chloride	<0.0010 mg/L	<0.0010 mg/L			1	
Total Xylenes	<0.0030 mg/L	<0.0030 mg/L			1	
Toluene-d8	92.4 % Rec	103.% Rec			1	
Dibromofluoromethane	90.7% Rec	104.% Rec			1	
4-Bromofluorobenzene	90.4% Rec	112.% Rec			1	

Part D - Provide data for the storm event(s) which resulted in the maximum values for the flow weighted composite sample.

1 Date of Storm Event	2 Duration of Storm Event (*in minutes*)	3 Total rainfall during storm event (*in inches*)	4 Number of hours between beginning of storm measured and end of previous measurable rain event	5 Maximum flow rate during rain event (*gallons/minute or specify units*)	6 Total flow from rain event (*gallons or specify units*)
03/21/2010	780	0.82	213	0.931 MGD	73,765 gallons

7. Provide a description of the method of flow measurement or estimate.

The flow was estimated using Manning's Equation and depth of the flow in the pipe.

...scharge Information *(Continued from page 3 of Form 2F)*

...art A - You must provide the results of at least one analysis for every pollutant in this table. Complete one table for each outfall. See instructions for additional details.

DSN 013a Pollutant and CAS Number (if available)	Maximum Values *(include units)* Grab Sample Taken During First 20 Minutes	Maximum Values Flow-weighted Composite	Average Values *(include units)* Grab Sample Taken During First 20 Minutes	Average Values Flow-weighted Composite	Number of Storm Events Sampled	Sources of Pollutants
Oil and Grease	<5.3 mg/L	N/A			1	
Biological Oxygen Demand (BOD)	< 5.0 mg/L	< 5.0 mg/L			1	
Chemical Oxygen Demand (COD)	10. mg/L	11. mg/L			1	
Total Suspended Solids (TSS)	32. mg/L	32. mg/L			1	
Total Nitrogen	1.4 mg/L	1.1 mg/L			1	
Total Phosphorus	0.18 mg/L	0.14 mg/L			1	
pH	Minimum 7.63 s.u.	Maximum 7.63 s.u.	Minimum	Maximum	1	

Part B - List each pollutant that is limited in an effluent guideline which the facility is subject to or any pollutant listed in the facility's NPDES permit for its process wastewater (if the facility is operating under an existing NPDES permit). Complete one table for each outfall. See the instructions for additional details and requirements.

Pollutant and CAS Number (if available)	Maximum Values *(include units)* Grab Sample Taken During First 20 Minutes	Maximum Values Flow-weighted Composite	Average Values *(include units)* Grab Sample Taken During First 20 Minutes	Average Values Flow-weighted Composite	Number of Storm Events Sampled	Sources of Pollutants
Fecal Coliforms	181 (colonies/100 ml)	N/A			1	
Temperature	14.2°C	N/A			1	
TRC	<0.05 mg/L Cl	N/A			1	
Ammonia Nitrogen	0.14mg/L	0.20 mg/L			1	
Color	5.0 pcu	5.0 pcu			1	
Nitrate-Nitrite	0.77 mg/L	0.58 mg/L			1	
TKN	0.66 mg/L	0.53 mg/L			1	
Antimony	<0.0010 mg/L	<0.0010 mg/L			1	
Arsenic	0.0012 mg/L	0.0012 mg/L			1	
Barium	0.021mg/L	0.021mg/L			1	
Beryllium	<0.0010 mg/L	<0.0010 mg/L			1	
Cadmium	<0.00050 mg/L	<0.00050 mg/L			1	
Chromium	0.0027 mg/L	0.0028 mg/L			1	
Cobalt	<0.0010 mg/L	<0.0010 mg/L			1	
Copper	0.0013 mg/L	0.0013 mg/L			1	
Lead	0.0023 mg/L	0.0024 mg/L			1	
Nickel	0.0016 mg/L	0.0026 mg/L			1	
Selenium	0.0010 mg/L	<0.0010 mg/L			1	
Silver	<0.00050 mg/L	<0.00050 mg/L			1	
Thallium	<0.0010 mg/L	<0.0010 mg/L			1	
Tin	<0.0010 mg/L	<0.0010 mg/L			1	
Zinc	0.014 mg/L	0.015 mg/L			1	
Mercury	<0.00020 mg/L	<0.00020 mg/L			1	
Naphthalene	<0.0010 mg/L	<0.0010 mg/L			1	
Aluminum	2.2 mg/L	2.0 mg/L			1	
Boron	<0.20 mg/L	<0.20 mg/L			1	
Iron	1.4 mg/L	1.5 mg/L			1	
Magnesium	4.0 mg/L	3.9 mg/L			1	
Manganese	0.070 mg/L	0.072 mg/L			1	
Molybdenum	<0.0050 mg/L	0.0052 mg/L			1	
Titanium	0.046 mg/L	0.039 mg/L			1	

Continue on Reverse

..n pollutant shown in Tables 2F-2, 2F-3, and 2F-4, that you know or have reason to believe is present. See the instructions for ..ditional details and requirements. Complete one table for each outfall.

DSN 013a Pollutant and CAS Number (if available)	Maximum Values *(include units)*		Average Values *(include units)*		Number of Storm Events Sampled	Sources of Pollutants
	Grab Sample Taken During First 20 Minutes	Flow-weighted Composite	Grab Sample Taken During First 20 Minutes	Flow-weighted Composite		
Acrolein	<0.050 mg/L	<0.050 mg/L			1	
Acrylonitrile	<0.010 mg/L	<0.010 mg/L			1	
Benzene	<0.0010 mg/L	<0.0010 mg/L			1	
Bromodichloromethane	<0.0010 mg/L	<0.0010 mg/L			1	
Bromoform	<0.0010 mg/L	<0.0010 mg/L			1	
Bromomethane	<0.0050 mg/L	<0.0050 mg/L			1	
Carbon tetrachloride	<0.0010 mg/L	<0.0010 mg/L			1	
Chlorobenzene	<0.0010 mg/L	<0.0010 mg/L			1	
Chlorodibromomethane	<0.0010 mg/L	<0.0010 mg/L			1	
Chloroethane	<0.0050 mg/L	<0.0050 mg/L			1	
2-Chloroethyl vinyl ether	<0.050 mg/L	<0.050 mg/L			1	
Chloroform	<0.0050 mg/L	<0.0050 mg/L			1	
Chloromethane	<0.0025 mg/L	<0.0025 mg/L			1	
1,2-Dichlorobenzene	<0.0010 mg/L	<0.0010 mg/L			1	
1,3-Dichlorobenzene	<0.0010 mg/L	<0.0010 mg/L			1	
1,4-Dichlorobenzene	<0.0010 mg/L	<0.0010 mg/L			1	
Dichlorodifluoromethane	<0.0050 mg/L	<0.0050 mg/L			1	
1,1-Dichloroethane	<0.0010 mg/L	<0.0010 mg/L			1	
1,2-Dichloroethane	<0.0010 mg/L	<0.0010 mg/L			1	
1,1-Dichloroethane	<0.0010 mg/L	<0.0010 mg/L			1	
trans-1,2-Dichloroethene	<0.0010 mg/L	<0.0010 mg/L			1	
1,2-Dichloropropane	<0.0010 mg/L	<0.0010 mg/L			1	
cis-1,3-Dichloropropene	<0.0010 mg/L	<0.0010 mg/L			1	
trans-1,3-Dichloropropene	<0.0010 mg/L	<0.0010 mg/L			1	
Ethylbenzene	<0.0010 mg/L	<0.0010 mg/L			1	
Methylene Chloride	<0.0050 mg/L	<0.0050 mg/L			1	
1,1,2,2-Tetrachloroethane	<0.0010 mg/L	<0.0010 mg/L			1	
Tetrachloroethene	<0.0010 mg/L	<0.0010 mg/L			1	
Toluene	<0.0050 mg/L	<0.0050 mg/L			1	
1,1,1-Trichloroethane	<0.0010 mg/L	<0.0010 mg/L			1	
1,1,2-Trichloroethane	<0.0010 mg/L	<0.0010 mg/L			1	
Trichloroethene	<0.0010 mg/L	<0.0010 mg/L			1	
Trichlorofluoromethane	<0.0050 mg/L	<0.0050 mg/L			1	
Vinyl chloride	<0.0010 mg/L	<0.0010 mg/L			1	
Total Xylenes	<0.0030 mg/L	<0.0030 mg/L			1	
Toluene-d8	92.6 % Rec	103.% Rec			1	
Dibromofluoromethane	89.1% Rec	103.% Rec			1	
4-Bromofluorobenzene	94.2% Rec	113.% Rec			1	

Part D - Provide data for the storm event(s) which resulted in the maximum values for the flow weighted composite sample.

1 Date of Storm Event	2 Duration of Storm Event *(in minutes)*	3 Total rainfall during storm event *(in inches)*	4 Number of hours between beginning of storm measured and end of previous measurable rain event	5 Maximum flow rate during rain event *(gallons/minute or specify units)*	6 Total flow from rain event *(gallons or specify units)*
03/21/2010	780	0.82	213	0.156 MGD	813,418 gallons

7. Provide a description of the method of flow measurement or estimate.

The flow was measured using the existing weir.

...charge Information *(Continued from page 3 of Form 2F)*

...art A - You must provide the results of at least one analysis for every pollutant in this table. Complete one table for each outfall. See instructions for additional details.

DSN 018 Pollutant and CAS Number (if available)	Maximum Values *(include units)* Grab Sample Taken During First 20 Minutes	Maximum Values Flow-weighted Composite	Average Values *(include units)* Grab Sample Taken During First 20 Minutes	Average Values Flow-weighted Composite	Number of Storm Events Sampled	Sources of Pollutants
Oil and Grease	<5.3 mg/L	N/A			1	
Biological Oxygen Demand (BOD)	<5.0 mg/L	<5.0 mg/L			1	
Chemical Oxygen Demand (COD)	<10. mg/L	<10. mg/L			1	
Total Suspended Solids (TSS)	4.6 mg/L	5.2 mg/L			1	
Total Nitrogen	0.40 mg/L	1.3 mg/L			1	
Total Phosphorus	<0.10 mg/L	<0.10 mg/L			1	
pH	Minimum 8.30 s.u.	Maximum 8.30 s.u.	Minimum	Maximum	1	

Part B - List each pollutant that is limited in an effluent guideline which the facility is subject to or any pollutant listed in the facility's NPDES permit for its process wastewater (if the facility is operating under an existing NPDES permit). Complete one table for each outfall. See the instructions for additional details and requirements.

Pollutant and CAS Number (if available)	Maximum Values *(include units)* Grab Sample Taken During First 20 Minutes	Maximum Values Flow-weighted Composite	Average Values *(include units)* Grab Sample Taken During First 20 Minutes	Average Values Flow-weighted Composite	Number of Storm Events Sampled	Sources of Pollutants
Fecal Coliforms	181 (colonies/100 ml)	N/A			1	
Temperature	11.5°C	N/A			1	
TRC	<0.05 mg/L Cl	N/A			1	
Ammonia Nitrogen	0.26 mg/L	0.34 mg/L			1	
Color	10. pcu	15. pcu			1	
Nitrate-Nitrite	0.40 mg/L	0.72 mg/L			1	
TKN	<0.10 mg/L	0.58 mg/L			1	
Antimony	<0.0010 mg/L	<0.0010 mg/L			1	
Arsenic	0.0011 mg/L	0.0012 mg/L			1	
Barium	0.0070 mg/L	0.0089 mg/L			1	
Beryllium	<0.0010 mg/L	<0.0010 mg/L			1	
Cadmium	<0.00050 mg/L	<0.00050 mg/L			1	
Chromium	0.0011 mg/L	0.0015 mg/L			1	
Cobalt	<0.0010 mg/L	<0.0010 mg/L			1	
Copper	0.0036 mg/L	0.0044 mg/L			1	
Lead	0.0020 mg/L	0.0019 mg/L			1	
Nickel	<0.0010 mg/L	0.0066 mg/L			1	
Selenium	0.0032 mg/L	<0.0010 mg/L			1	
Silver	<0.00050 mg/L	<0.00050 mg/L			1	
Thallium	<0.0010 mg/L	<0.0010 mg/L			1	
Tin	<0.0010 mg/L	<0.0010 mg/L			1	
Zinc	0.041 mg/L	0.084 mg/L			1	
Mercury	<0.00020 mg/L	<0.00020 mg/L			1	
Naphthalene	<0.0010 mg/L	<0.0010 mg/L			1	

Continue on Reverse

...n pollutant shown in Tables 2F-2, 2F-3, and 2F-4, that you know or have reason to believe is present. See the instructions for ...ditional details and requirements. Complete one table for each outfall.

DSN 018 Pollutant and CAS Number (if available)	Maximum Values (include units)		Average Values (include units)		Number of Storm Events Sampled	Sources of Pollutants
	Grab Sample Taken During First 20 Minutes	Flow-weighted Composite	Grab Sample Taken During First 20 Minutes	Flow-weighted Composite		
Acrolein	<0.050 mg/L	<0.050 mg/L			1	
Acrylonitrile	<0.010 mg/L	<0.010 mg/L			1	
Benzene	<0.0010 mg/L	<0.0010 mg/L			1	
Bromodichloromethane	<0.0010 mg/L	<0.0010 mg/L			1	
Bromoform	<0.0010 mg/L	<0.0010 mg/L			1	
Bromomethane	<0.0050 mg/L	<0.0050 mg/L			1	
Carbon tetrachloride	<0.0010 mg/L	<0.0010 mg/L			1	
Chlorobenzene	<0.0010 mg/L	<0.0010 mg/L			1	
Chlorodibromomethane	<0.0010 mg/L	<0.0010 mg/L			1	
Chloroethane	<0.0050 mg/L	<0.0050 mg/L			1	
2-Chloroethyl vinyl ether	<0.050 mg/L	<0.050 mg/L			1	
Chloroform	<0.0050 mg/L	<0.0050 mg/L			1	
Chloromethane	<0.0025 mg/L	<0.0025 mg/L			1	
1,2-Dichlorobenzene	<0.0010 mg/L	<0.0010 mg/L			1	
1,3-Dichlorobenzene	<0.0010 mg/L	<0.0010 mg/L			1	
1,4-Dichlorobenzene	<0.0010 mg/L	<0.0010 mg/L			1	
Dichlorodifluoromethane	<0.0050 mg/L	<0.0050 mg/L			1	
1,1-Dichloroethane	<0.0010 mg/L	<0.0010 mg/L			1	
1,2-Dichloroethane	<0.0010 mg/L	<0.0010 mg/L			1	
1,1-Dichloroethane	<0.0010 mg/L	<0.0010 mg/L			1	
trans-1,2-Dichloroethene	<0.0010 mg/L	<0.0010 mg/L			1	
1,2-Dichloropropane	<0.0010 mg/L	<0.0010 mg/L			1	
cis-1,3-Dichloropropene	<0.0010 mg/L	<0.0010 mg/L			1	
trans-1,3-Dichloropropene	<0.0010 mg/L	<0.0010 mg/L			1	
Ethylbenzene	<0.0010 mg/L	<0.0010 mg/L			1	
Methylene Chloride	<0.0050 mg/L	<0.0050 mg/L			1	
1,1,2,2-Tetrachloroethane	<0.0010 mg/L	<0.0010 mg/L			1	
Tetrachloroethene	<0.0010 mg/L	<0.0010 mg/L			1	
Toluene	<0.0050 mg/L	<0.0050 mg/L			1	
1,1,1-Trichloroethane	<0.0010 mg/L	<0.0010 mg/L			1	
1,1,2-Trichloroethane	<0.0010 mg/L	<0.0010 mg/L			1	
Trichloroethene	<0.0010 mg/L	<0.0010 mg/L			1	
Trichlorofluoromethane	<0.0050 mg/L	<0.0050 mg/L			1	
Vinyl chloride	<0.0010 mg/L	<0.0010 mg/L			1	
Total Xylenes	<0.0030 mg/L	<0.0030 mg/L			1	
Toluene-d8	92.7 % Rec	104.% Rec			1	
Dibromofluoromethane	93.3% Rec	105.% Rec			1	
4-Bromofluorobenzene	93.2% Rec	112.% Rec			1	

Part D - Provide data for the storm event(s) which resulted in the maximum values for the flow weighted composite sample.

1 Date of Storm Event	2 Duration of Storm Event *(in minutes)*	3 Total rainfall during storm event *(in inches)*	4 Number of hours between beginning of storm measured and end of previous measurable rain event	5 Maximum flow rate during rain event *(gallons/minute or specify units)*	6 Total flow from rain event *(gallons or specify units)*
03/21/2010	780	0.82	213	0.8897	324,637 gallons

7. Provide a description of the method of flow measurement or estimate.

The flow rate was estimated using the rational method.

EPA ID Number *(copy from Item 1 of Form 1)*
AL8640015410

Form Approved. OMB No. 2040-0085
Approval Expires 5-31-92

...scharge Information *(Continued from page 3 of Form 2F)*

Part A - You must provide the results of at least one analysis for every pollutant in this table. Complete one table for each outfall. See instructions for additional details.

DSN 019 Pollutant and CAS Number (if available)	Maximum Values *(include units)*		Average Values *(include units)*		Number of Storm Events Sampled	Sources of Pollutants
	Grab Sample Taken During First 20 Minutes	Flow-weighted Composite	Grab Sample Taken During First 20 Minutes	Flow-weighted Composite		
Oil and Grease	<5.0 mg/L	N/A			1	
Biological Oxygen Demand (BOD)	<5.0 mg/L	<5.0 mg/L			1	
Chemical Oxygen Demand (COD)	<10. mg/L	<10. mg/L			1	
Total Suspended Solids (TSS)	8.1 mg/L	10. mg/L			1	
Total Nitrogen	0.88 mg/L	0.95 mg/L			1	
Total Phosphorus	<0.10 mg/L	<0.10 mg/L			1	
pH	Minimum 6.52 s.u.	Maximum 6.52 s.u.	Minimum	Maximum	1	

Part B - List each pollutant that is limited in an effluent guideline which the facility is subject to or any pollutant listed in the facility's NPDES permit for its process wastewater (if the facility is operating under an existing NPDES permit). Complete one table for each outfall. See the instructions for additional details and requirements.

Pollutant and CAS Number (if available)	Maximum Values *(include units)*		Average Values *(include units)*		Number of Storm Events Sampled	Sources of Pollutants
	Grab Sample Taken During First 20 Minutes	Flow-weighted Composite	Grab Sample Taken During First 20 Minutes	Flow-weighted Composite		
Fecal Coliforms	<100 (colonies/100 ml)	N/A			1	
Temperature	11.6°C	N/A			1	
TRC	<0.05 mg/L Cl	N/A			1	
Ammonia Nitrogen	0.17 mg/L	0.14 mg/L			1	
Color	5.0 pcu	10. pcu			1	
Nitrate-Nitrite	0.40 mg/L	0.72 mg/L			1	
TKN	0.33 mg/L	0.38 mg/L			1	
Antimony	0.0014 mg/L	<0.0010 mg/L			1	
Arsenic	<0.0010 mg/L	<0.0010 mg/L			1	
Barium	0.030 mg/L	0.029 mg/L			1	
Beryllium	<0.0010 mg/L	<0.0010 mg/L			1	
Cadmium	<0.00050 mg/L	<0.00050 mg/L			1	
Chromium	0.0012 mg/L	0.0016 mg/L			1	
Cobalt	0.0013 mg/L	0.0012 mg/L			1	
Copper	0.0020 mg/L	0.0048 mg/L			1	
Lead	<0.0010 mg/L	0.0012 mg/L			1	
Nickel	0.0013 mg/L	0.0066 mg/L			1	
Selenium	<0.0010 mg/L	<0.0010 mg/L			1	
Silver	<0.00050 mg/L	0.00900 mg/L			1	
Thallium	<0.0010 mg/L	<0.0010 mg/L			1	
Tin	<0.0010 mg/L	<0.0010 mg/L			1	
Zinc	<0.010 mg/L	0.019 mg/L			1	
Mercury	<0.00020 mg/L	<0.00020 mg/L			1	
Naphthalene	<0.0010 mg/L	<0.0010 mg/L			1	
Aluminum	0.91 mg/L	1.3 mg/L			1	
Boron	<0.20 mg/L	<0.20 mg/L			1	
Iron	0.77 mg/L	0.91 mg/L			1	
Magnesium	2.8 mg/L	2.6 mg/L			1	
Manganese	0.33 mg/L	0.30 mg/L			1	
Molybdenum	<0.0050 mg/L	<0.0050 mg/L			1	
Titanium	0.025 mg/L	0.036 mg/L			1	

Continue on Reverse

...ach pollutant shown in Tables 2F-2, 2F-3, and 2F-4, that you know or have reason to believe is present. See the instructions for additional details and requirements. Complete one table for each outfall.

DSN 019 Pollutant and CAS Number (if available)	Maximum Values (include units)		Average Values (include units)		Number of Storm Events Sampled	Sources of Pollutants
	Grab Sample Taken During First 20 Minutes	Flow-weighted Composite	Grab Sample Taken During First 20 Minutes	Flow-weighted Composite		
Acrolein	<0.050 mg/L	<0.050 mg/L			1	
Acrylonitrile	<0.010 mg/L	<0.010 mg/L			1	
Benzene	<0.0010 mg/L	<0.0010 mg/L			1	
Bromodichloromethane	<0.0010 mg/L	<0.0010 mg/L			1	
Bromoform	<0.0010 mg/L	<0.0010 mg/L			1	
Bromomethane	<0.0050 mg/L	<0.0050 mg/L			1	
Carbon tetrachloride	<0.0010 mg/L	<0.0010 mg/L			1	
Chlorobenzene	<0.0010 mg/L	<0.0010 mg/L			1	
Chlorodibromomethane	<0.0010 mg/L	<0.0010 mg/L			1	
Chloroethane	<0.0050 mg/L	<0.0050 mg/L			1	
2-Chloroethyl vinyl ether	<0.050 mg/L	<0.050 mg/L			1	
Chloroform	<0.0050 mg/L	<0.0050 mg/L			1	
Chloromethane	<0.0025 mg/L	<0.0025 mg/L			1	
1,2-Dichlorobenzene	<0.0010 mg/L	<0.0010 mg/L			1	
1,3-Dichlorobenzene	<0.0010 mg/L	<0.0010 mg/L			1	
1,4-Dichlorobenzene	<0.0010 mg/L	<0.0010 mg/L			1	
Dichlorodifluoromethane	<0.0050 mg/L	<0.0050 mg/L			1	
1,1-Dichloroethane	<0.0010 mg/L	<0.0010 mg/L			1	
1,2-Dichloroethane	<0.0010 mg/L	<0.0010 mg/L			1	
1,1-Dichloroethane	<0.0010 mg/L	<0.0010 mg/L			1	
trans-1,2-Dichloroethene	<0.0010 mg/L	<0.0010 mg/L			1	
1,2-Dichloropropane	<0.0010 mg/L	<0.0010 mg/L			1	
cis-1,3-Dichloropropene	<0.0010 mg/L	<0.0010 mg/L			1	
trans-1,3-Dichloropropene	<0.0010 mg/L	<0.0010 mg/L			1	
Ethylbenzene	<0.0010 mg/L	<0.0010 mg/L			1	
Methylene Chloride	<0.0050 mg/L	<0.0050 mg/L			1	
1,1,2,2-Tetrachloroethane	<0.0010 mg/L	<0.0010 mg/L			1	
Tetrachloroethene	<0.0010 mg/L	<0.0010 mg/L			1	
Toluene	<0.0050 mg/L	<0.0050 mg/L			1	
1,1,1-Trichloroethane	<0.0010 mg/L	<0.0010 mg/L			1	
1,1,2-Trichloroethane	<0.0010 mg/L	<0.0010 mg/L			1	
Trichloroethene	0.023 mg/L	0.023 mg/L			1	
Trichlorofluoromethane	<0.0050 mg/L	<0.0050 mg/L			1	
Vinyl chloride	<0.0010 mg/L	<0.0010 mg/L			1	
Total Xylenes	<0.0030 mg/L	<0.0030 mg/L			1	
Toluene-d8	103.% Rec	103.% Rec			1	
Dibromofluoromethane	108.% Rec	108.% Rec			1	
4-Bromofluorobenzene	106.% Rec	111.% Rec			1	

Part D - Provide data for the storm event(s) which resulted in the maximum values for the flow weighted composite sample.

1 Date of Storm Event	2 Duration of Storm Event *(in minutes)*	3 Total rainfall during storm event *(in inches)*	4 Number of hours between beginning of storm measured and end of previous measurable rain event	5 Maximum flow rate during rain event *(gallons/minute or specify units)*	6 Total flow from rain event *(gallons or specify units)*
03/21/2010	780	0.82	213	0.094 MGD	1,208,898 gallons

7. Provide a description of the method of flow measurement or estimate.

The flow rate was measured using the existing weir.

EPA ID Number *(copy from Item 1 of Form 1)*
AL8640015410

Form Approved. OMB No. 2040-0085
Approval Expires 5-31-92

...scharge Information *(Continued from page 3 of Form 2F)*

...art A - You must provide the results of at least one analysis for every pollutant in this table. Complete one table for each outfall. See instructions for additional details.

DSN 024 Pollutant and CAS Number (if available)	Maximum Values *(include units)*		Average Values *(include units)*		Number of Storm Events Sampled	Sources of Pollutants
	Grab Sample Taken During First 20 Minutes	Flow-weighted Composite	Grab Sample Taken During First 20 Minutes	Flow-weighted Composite		
Oil and Grease	<5.6 mg/L	N/A			1	
Biological Oxygen Demand (BOD)	<5.0 mg/L	<5.0 mg/L			1	
Chemical Oxygen Demand (COD)	23. mg/L	23. mg/L			1	
Total Suspended Solids (TSS)	190 mg/L	32. mg/L			1	
Total Nitrogen	1.6 mg/L	1.2 mg/L			1	
Total Phosphorus	0.29 mg/L	0.13 mg/L			1	
pH	Minimum 8.58 s.u.	Maximum 8.58 s.u.	Minimum	Maximum	1	

Part B - List each pollutant that is limited in an effluent guideline which the facility is subject to or any pollutant listed in the facility's NPDES permit for its process wastewater (if the facility is operating under an existing NPDES permit). Complete one table for each outfall. See the instructions for additional details and requirements.

Pollutant and CAS Number (if available)	Maximum Values *(include units)*		Average Values *(include units)*		Number of Storm Events Sampled	Sources of Pollutants
	Grab Sample Taken During First 20 Minutes	Flow-weighted Composite	Grab Sample Taken During First 20 Minutes	Flow-weighted Composite		
Fecal Coliforms	<100 (colonies/100 ml)	N/A			1	
Temperature	11.5°C	N/A			1	
TRC	<0.05 mg/L Cl	N/A			1	
Ammonia Nitrogen	0.26 mg/L	0.19 mg/L			1	
Color	100 pcu	75. pcu			1	
Nitrate-Nitrite	0.60 mg/L	0.39 mg/L			1	
TKN	1.0 mg/L	0.81 mg/L			1	
Antimony	<0.0010 mg/L	<0.0010 mg/L			1	
Arsenic	0.0025 mg/L	0.0012 mg/L			1	
Barium	0.0033 mg/L	0.0019 mg/L			1	
Beryllium	<0.0010 mg/L	<0.0010 mg/L			1	
Cadmium	<0.00050 mg/L	<0.00050 mg/L			1	
Chromium	0.010 mg/L	0.003 mg/L			1	
Cobalt	0.0015 mg/L	<0.0010 mg/L			1	
Copper	0.0061 mg/L	0.0027 mg/L			1	
Lead	0.0062 mg/L	0.0019 mg/L			1	
Nickel	0.0064 mg/L	0.0024 mg/L			1	
Selenium	0.0014 mg/L	<0.0010 mg/L			1	
Silver	<0.00050 mg/L	<0.00050 mg/L			1	
Thallium	<0.0010 mg/L	<0.0010 mg/L			1	
Tin	<0.0010 mg/L	<0.0010 mg/L			1	
Zinc	0.056 mg/L	0.019 mg/L			1	
Mercury	<0.00020 mg/L	<0.00020 mg/L			1	
Naphthalene	<0.0010 mg/L	<0.0010 mg/L			1	
Aluminum	8.4 mg/L	3.7 mg/L			1	
Boron	<0.20 mg/L	<0.20 mg/L			1	
Iron	5.6 mg/L	2.0 mg/L			1	
Magnesium	1.8 mg/L	0.89 mg/L			1	
Manganese	0.20 mg/L	0.057 mg/L			1	
Molybdenum	<0.0050 mg/L	<0.0050 mg/L			1	
Titanium	0.13 mg/L	0.089 mg/L			1	

 Continue on Reverse

…ach pollutant shown in Tables 2F-2, 2F-3, and 2F-4, that you know or have reason to believe is present. See the instructions for …dditional details and requirements. Complete one table for each outfall.

DSN 024 Pollutant and CAS Number (if available)	Maximum Values (include units) Grab Sample Taken During First 20 Minutes	Maximum Values Flow-weighted Composite	Average Values (include units) Grab Sample Taken During First 20 Minutes	Average Values Flow-weighted Composite	Number of Storm Events Sampled	Sources of Pollutants
Acrolein	<0.050 mg/L	<0.050 mg/L			1	
Acrylonitrile	<0.010 mg/L	<0.010 mg/L			1	
Benzene	<0.0010 mg/L	<0.0010 mg/L			1	
Bromodichloromethane	<0.0010 mg/L	<0.0010 mg/L			1	
Bromoform	<0.0010 mg/L	<0.0010 mg/L			1	
Bromomethane	<0.0050 mg/L	<0.0050 mg/L			1	
Carbon tetrachloride	<0.0010 mg/L	<0.0010 mg/L			1	
Chlorobenzene	<0.0010 mg/L	<0.0010 mg/L			1	
Chlorodibromomethane	<0.0010 mg/L	<0.0010 mg/L			1	
Chloroethane	<0.0050 mg/L	<0.0050 mg/L			1	
2-Chloroethyl vinyl ether	<0.050 mg/L	<0.050 mg/L			1	
Chloroform	<0.0050 mg/L	<0.0050 mg/L			1	
Chloromethane	<0.0025 mg/L	<0.0025 mg/L			1	
1,2-Dichlorobenzene	<0.0010 mg/L	<0.0010 mg/L			1	
1,3-Dichlorobenzene	<0.0010 mg/L	<0.0010 mg/L			1	
1,4-Dichlorobenzene	<0.0010 mg/L	<0.0010 mg/L			1	
Dichlorodifluoromethane	<0.0050 mg/L	<0.0050 mg/L			1	
1,1-Dichloroethane	<0.0010 mg/L	<0.0010 mg/L			1	
1,2-Dichloroethane	<0.0010 mg/L	<0.0010 mg/L			1	
1,1-Dichloroethane	<0.0010 mg/L	<0.0010 mg/L			1	
trans-1,2-Dichloroethene	<0.0010 mg/L	<0.0010 mg/L			1	
1,2-Dichloropropane	<0.0010 mg/L	<0.0010 mg/L			1	
cis-1,3-Dichloropropene	<0.0010 mg/L	<0.0010 mg/L			1	
trans-1,3-Dichloropropene	<0.0010 mg/L	<0.0010 mg/L			1	
Ethylbenzene	<0.0010 mg/L	<0.0010 mg/L			1	
Methylene Chloride	<0.0050 mg/L	<0.0050 mg/L			1	
1,1,2,2-Tetrachloroethane	<0.0010 mg/L	<0.0010 mg/L			1	
Tetrachloroethene	<0.0010 mg/L	<0.0010 mg/L			1	
Toluene	<0.0050 mg/L	<0.0050 mg/L			1	
1,1,1-Trichloroethane	<0.0010 mg/L	<0.0010 mg/L			1	
1,1,2-Trichloroethane	<0.0010 mg/L	<0.0010 mg/L			1	
Trichloroethene	<0.0010 mg/L	<0.0010 mg/L			1	
Trichlorofluoromethane	<0.0050 mg/L	<0.0050 mg/L			1	
Vinyl chloride	<0.0010 mg/L	<0.0010 mg/L			1	
Total Xylenes	<0.0030 mg/L	<0.0030 mg/L			1	
Toluene-d8	93.0 % Rec	103.% Rec			1	
Dibromofluoromethane	91.4% Rec	105.% Rec			1	
4-Bromofluorobenzene	92.1% Rec	110.% Rec			1	

Part D - Provide data for the storm event(s) which resulted in the maximum values for the flow weighted composite sample.

1 Date of Storm Event	2 Duration of Storm Event *(in minutes)*	3 Total rainfall during storm event *(in inches)*	4 Number of hours between beginning of storm measured and end of previous measurable rain event	5 Maximum flow rate during rain event *(gallons/minute or specify units)*	6 Total flow from rain event *(gallons or specify units)*
03/21/2010	780	0.82	213	4.479 MGD	523,107 gallons

7. Provide a description of the method of flow measurement or estimate.

The flow rate was estimated using Manning's Equation and the measured depth of flow in the pipe.

IV. Narrative Description of Pollutant Sources, B-C

BFN's Spill Prevention Control and Countermeasures (SPCC) Plan is the basic non-structural control for reducing pollutants in storm water runoff. It incorporates best management practices into daily activities conducted on site and is available for review at all times. BFN has instituted a Chemical Traffic Control Plan for the purpose of ensuring that all chemicals brought on site are reviewed are reviewed to prevent the usage of hazardous materials when a non-hazardous material substitute is available. The plan also ensures the proper use, storage, and disposal of all chemicals used at the facility.

DSN 013

DSN 013 receives storm water from the Environmental and Meteorology offices parking lot, the northeast corner of the Training Center parking lot, a storm drain located between the two sedimentation ponds, and from a gravel parking lot and grassy area located south of the Environmental and Meteorology offices (i.e., approximately 1.8 acres of grassed area and 5.0 acres of impervious surfaces). DSN 013 also receives storm water drainage from DSN 013a and process water discharges from DSN 013b prior to discharging to the Tennessee River. DSNs 013a and 013b were sampled at their respective discharge points in accordance with the requirements of the renewal application.

DSN 013a

DSN 013a receives storm water from the 4kV Capacitor Yard, the main plant transformer yard, the switchyard, the parking lot east of and part of the parking lot west of the Wastewater Lagoons, and the grassland north of the east parking lot (i.e., approximately 40.5 acres of impervious area and 54 acres of grassed area). The capacitor yard, the transformer yard, and the switchyard contain only non-PCB, oil-filled equipment. The transformer yard contains two 37,000-gallon mineral oil tanks (abandoned in place) and one 1,500-gallon above-ground diesel storage tank. DSN 013a is provided with secondary containment to prevent oil spills from reaching the river by the presence of a concrete oil skimmer and weir.

DSN 013a also receives wastewater discharged from DSN 013a(1), the Wastewater Lagoons which includes treated sanitary waste, waste from a photo-processing lab, a metal-processing lab, a medical lab, blowdown from the Training Center's chiller system, flush water from the standby liquid control system and from various cooler and air compressor cleanings, waste from insulator showers used by personnel involved with periodic asbestos stripping and handling operations, and rain water. DSN 013a discharges to DSN 013 which in turn discharges to the Tennessee River.

DSN 014

DSN 014 is located northwest of the cooling towers, and receives drainage from two roads (approximately 5 acres), grassland (approximately 197 acres), and offsite farmland located on the north and northwest sides of the facility. DSN 014 discharges directly to the Tennessee River. Because monitoring is not required for this outfall in the current NPDES permit and because it receives drainage from areas with no industrial activity as defined in 40 CFR122.26(b)(14), it was not monitored for the permit renewal application.

DSN 017

DSN 017 receives storm water runoff from an approximately 6-acre area (approximately 3 acres of which is impervious area) which includes the Training Center and the Live Well Center parking lots, the Training Center roof, and grassed/wooded land. DSN 017 discharges directly into the Tennessee River. Because monitoring is not required for this outfall in the current NPDES permit and because it receives drainage from areas with no industrial activity as defined in 40 CFR122.26(b)(14), it was not monitored for the permit renewal application.

DSN 018

DSN 018 receives storm water from the Materials and Procurement Complex (MPC) parking lot, the firing range parking lot, the Facilities Maintenance area, the vehicle fuel dispensing area, part of the parking lot southwest of the MPC, and from adjacent grassed area (approximately 18.8 acres of impervious drainage and 15.4 acres of grassed land). The MPC includes several enclosed chemical staging areas (e.g., for paints, solvents, oil, and lubricants). DSN 018 discharges directly to the Tennessee River.

DSN 019

FDN 019 receives storm water drainage from the east site drainage area (i.e., 101.1 acres of grassed land, 48 acres of impervious area including a small borrow pit, the Fire Training Area, the Low Level Radwaste Storage Facility, the inert landfill, and the 180-day Hazardous Waste Storage Area. These areas contain kerosene, gasoline, and diesel tanks; a flammable storage area; Facilities Satellite Storage area; a diesel fire pump and fuel tank; oil and used drum storage areas; and hazardous and mixed waste storage area. DSN 019 discharges to the Tennessee River.

DSN 024

DSN 024 is located along the facility's east property boundary and discharges to an adjacent farmland. This outfall receives storm water drainage from offsite grassland, offsite farmland located north of the facility, and from a vehicle servicing and mechanic shop located just south of the northeast corner of the site (approximately 75.9 acres of grassland and 8.4 acres of impervious surfaces). The shop includes a covered storage area for solvents, oils, and lubricants.

Review/Concurrence Sheet

Subject: NPDES Renewal Application			
Originating Organization	Environmental / Chemistry		
Document Prepared By	Mike Stiefel		
EDMS No.(Optional)		Date:	2/23/11
Correspond No.	DUE DATE: 2/25/11		

CONCURRENCES		
Name	Signature - Comment	Date
Carroll R. Cooper/Environmental Mgr.	Carroll R. Cooper	2/23/11
Robert Pitcock/Chemistry Mgr.	Robert Pitcock	2/23/11
James Emens/ Licensing Mgr.	James E. Emens	2/23/11
John Cornelius Gannon, General Mgr.	[illegible]	2/23/11

concur.doc

E&T Review & Concurrence

Environment & Technology SharePoint Site > E&T Review & Concurrence > NPG > Workflow Status

Workflow Status: Approval

Workflow Information

Initiator: Gould, Vicki M

Started: 2/25/2011 3:57 PM

Last run: 2/28/2011 4:44 PM

Document: BFN NPDES Renewal 2011 Cover Letter final for approval

Status: Rejected

Tasks

The following tasks have been assigned to the participants in this workflow. Click a task to edit it. You can also view these tasks in the list Tasks.

Assigned To	Title	Due Date	Status	Outcome
Johnson, Linden Printz	Please approve BFN NPDES Renewal 2011 Cover Letter final for approval	2/28/2011	Completed	Approved by Johnson, Linden Printz
Brickhouse, Brenda Etheridge	Please approve BFN NPDES Renewal 2011 Cover Letter final for approval ! NEW		Completed	Approved by Brickhouse, Brenda Etheridge

Workflow History

View workflow reports

The following events have occurred in this workflow.

Date Occurred	Event Type	User ID	Description	Outcome
2/25/2011 3:57 PM	Workflow Initiated	Gould, Vicki M	Approval was started. Participants: Johnson, Linden Printz, Cooper, Carroll R, Anderson, Cynthia M, Brickhouse, Brenda Etheridge	
2/25/2011 3:57 PM	Task Created	Gould, Vicki M	Task created for Johnson, Linden Printz. Due by: None	
2/28/2011 8:44 AM	Comment	Stiefel, Michael B	Tasks for Approval on BFN NPDES Renewal 2011 Cover Letter final for approval were updated by Stiefel, Michael B. Due by: 2/28/2011 12:00:00 AM Task instructions: Vicki, please review\revise as necessary. Please workflow to Lindy Johnson, Carroll Cooper, C	
2/28/2011 9:58 AM	Task Completed	Johnson, Linden Printz	Task assigned to Johnson, Linden Printz was approved by Johnson, Linden Printz. Comments: ok	Approved by Johnson, Linden Printz
2/28/2011 9:58 AM	Task Created	Gould, Vicki M	Task created for Cooper, Carroll R. Due by: None	
2/28/2011 12:39 PM	Task Rolled Back	Gould, Vicki M	Task update by Stiefel, Michael B was rejected.	Reason: The user who attempted to complete the task is not the user to whom the task is assigned.
2/28/2011 12:44 PM	Task Deleted	Stiefel, Michael B	Task assigned to Cooper, Carroll R was deleted by Stiefel, Michael B.	
2/28/2011 12:44 PM	Task Completed	Stiefel, Michael B	Task assigned to Cooper, Carroll R was automatically rejected because it was deleted by Stiefel, Michael B	Rejected by Stiefel, Michael B
2/28/2011 12:44 PM	Task Created	Gould, Vicki M	Task created for Anderson, Cynthia M. Due by: None	
2/28/2011 12:44 PM	Task Deleted	Stiefel, Michael B	Task assigned to Anderson, Cynthia M was deleted by Stiefel, Michael B.	
2/28/2011 12:44 PM	Task Completed	Stiefel, Michael B	Task assigned to Anderson, Cynthia M was automatically rejected because it was deleted by Stiefel, Michael B	Rejected by Stiefel, Michael B
2/28/2011 12:44 PM	Task Created	Gould, Vicki M	Task created for Brickhouse, Brenda Etheridge. Due by: None	

2/28/2011 4:44 PM	Task Completed	Brickhouse, Brenda Etheridge	Task assigned to Brickhouse, Brenda Etheridge was approved by Brickhouse, Brenda Etheridge. Comments: I concur. Thanks, B	Approved by Brickhouse, Brenda Etheridge
2/28/2011 4:44 PM	Workflow Completed	Gould, Vicki M	Approval was completed.	Approval on BFN NPDES Renewal 2011 Cover Letter final for approval has successfully completed. All participants have completed their tasks.

ATTACHMENT 4

Browns Ferry Nuclear Plant
Annual Water Use Reports 2011 - 2015

Annual Water Use Report for 2015

Alabama Water Use Reporting Program

Certificate Number: 1058

Owner: TVA-Browns Ferry Nuclear Plant

Withdrawal Name: Browns Ferry Nuclear   Status: Active

Calendar Year 2015	Average Withdrawal (mgd)	Peak Withdrawal (mgd)
January	2902.088	2902.088
February	2894.675	2894.675
March	2428.095	2894.895
April	2626.149	2903.149
May	3097.468	2894.798
June	2895.076	2895.076
July	2895.154	2895.154
August	2894.502	2894.502
September	2896.862	2896.862
October	2844.745	2894.445
November	2989.333	3044.026
December	3043.930	3043.930

Comments:

CERTIFICATION: To the best of my knowledge and belief, the information contained in this report is true, accurate and complete.

Certified by:

Date: 2/12/2016

Please return completed forms to ADECA - Office of Water Resources

ADECA - Office of Water Resources - P.O. Box 5690 - 401 Adams Avenue - Montgomery, AL 36103-5690 - Fax (334) 242-0776

Annual Water Use Report for 2014

Alabama Water Use Reporting Program

Certificate Number: 1058

Owner: TVA-Browns Ferry Nuclear Plant

Withdrawal Name: Browns Ferry Nuclear

Status: Active

Calendar Year 2014	Average Withdrawal (mgd)	Peak Withdrawal (mgd)
January	2509.840	2509.840
February	2035.457	2510.357
March	2178.260	2702.560
April	2509.923	2509.923
May	2758.134	2895.034
June	2894.993	2894.993
July	2895.090	2895.090
August	2870.083	2894.883
September	2844.623	2895.923
October	2174.239	2902.139
November	2895.323	2895.323
December	2895.831	2895.831

Comments:

CERTIFICATION: To the best of my knowledge and belief, the information contained in this report is true, accurate and complete.

Certified by: ______________________

Date: ______________________

Annual Water Use Report for 2013

Alabama Water Use Reporting Program

Certificate Number: 1058

Owner: TVA-Browns Ferry Nuclear Plant

Withdrawal Name: Browns Ferry Nuclear

Status: Active

Calendar Year 2013	Average Withdrawal (mgd)	Peak Withdrawal (mgd)
January	2701.800	2894.300
February	2576.900	2894.300
March	2390.200	2894.300
April	1941.900	2298.500
May	2776.100	2894.300
June	2894.300	2894.300
July	2894.300	2894.300
August	2894.300	284.300
September	2894.300	284.300
October	2801.200	2894.300
November	2390.400	2701.800
December	2515.800	2701.800

Comments: (Insert any appropiate comments.)

CERTIFICATION: To the best of my knowledge and belief, the information contained in this report is true, accurate and complete.

Certified by:

Date: 2-25-14

Please return completed forms to ADECA - Office of Water Resources

ADECA - Office of Water Resources - P.O. Box 5690 - 401 Adams Avenue - Montgomery, AL 36103-5690 - Fax (334) 242-0776

Annual Water Use Report for 2012

Alabama Water Use Reporting Program

Certificate Number: 1058

Owner: TVA-Browns Ferry Nuclear Plant

Withdrawal Name: Browns Ferry Nuclear

Status: Active

Calendar Year 2012	Average Withdrawal (mgd)	Peak Withdrawal (mgd)
January	2534.100	2701.800
February	2559.800	2894.300
March	2521.600	2701.800
April	2077.100	2509.200
May	2392.800	2894.300
June	2887.900	2894.300
July	2894.300	2894.300
August	2894.300	2894.300
September	2894.300	2894.300
October	2464.500	2894.300
November	2315.700	2701.800
December	2857.000	2894.300

Comments: (Insert any appropiate comments.)

CERTIFICATION: To the best of my knowledge and belief, the information contained in this report is true, accurate and complete.

Certified by: [signature]

Date: 2/25/14

Please return completed forms to ADECA - Office of Water Resources

ADECA - Office of Water Resources - P.O. Box 5690 - 401 Adams Avenue - Montgomery, AL 36103-5690 - Fax (334) 242-0776

Annual Water Use Report for 2011

Alabama Water Use Reporting Program

Certificate Number: 1058

Owner: TVA - Browns Ferry Nuclear Plant

Withdrawal Name: Browns Ferry Nuclear Plant

Status: Active

Calendar Year 2011	Average Withdrawal (mgd)	Peak Withdrawal (mgd)
January	2698.1000	2722.5000
February	2770.4000	2894.3000
March	2014.0000	2701.8000
April	2751.8000	2894.3000
May	967.9000	2894.3000
June	2894.3000	2894.3000
July	2894.3000	2894.3000
August	2875.7000	2894.3000
September	2894.3000	2894.3000
October	2720.4000	2894.3000
November	2733.9000	2894.3000
December	2595.6000	2701.8000

Comments:

CERTIFICATION: To the best of my knowledge and belief, the information contained in this report is true, accurate and complete.

Certified by: Carroll R. Cooper

Date: 3-20-12

Please return completed forms to ADECA - Office of Water Resources

ADECA - Office of Water Resources - P.O. Box 5690 - 401 Adams Avenue - Montgomery, AL 36103-5690 - Fax (334) 242-0776

ATTACHMENT 5

Browns Ferry Nuclear Plant
Certificate Of Use (COU) from the Alabama Department of Economic and Community Affairs (ADECA)/Office of Water Resources (OWR), dated December 1, 2005

OFFICE OF THE GOVERNOR

BOB RILEY
GOVERNOR

ALABAMA DEPARTMENT OF ECONOMIC AND COMMUNITY AFFAIRS

BILL JOHNSON
DIRECTOR

STATE OF ALABAMA

December 1, 2005

Mr. Carroll Cooper
Environmental Supervisor
TVA - Browns Ferry Nuclear Plant
P.O. Box 2000 WSP 1A
Decatur, AL 35609-2000

Re: Renewal Certificate of Use No. 1058.0

Dear Mr. Cooper:

Enclosed is the Certificate of Use, which has been renewed, based on data provided in the updated Declaration of Beneficial Use you filed with the Office of Water Resources (OWR). The information you provide is vital to maintaining a database that will enable the long term planning and coordination of water resources in Alabama.

Each entity filing a Declaration of Beneficial Use is required to provide this office with annual water use reports. Each year, you will continue to receive the forms to complete and submit to OWR.

Each entity is also responsible for notifying the OWR of any changes in the data contained in the Declaration of Beneficial Use. If you need to amend your Declaration of Beneficial Use, please contact us to secure the appropriate forms.

We look forward to working with you. If we can answer any questions or be of further assistance, please call Tom Littlepage at (334) 242-5697.

Sincerely,

Edward E. Davis

Edward E. Davis, Acting Division Director
Office of Water Resources

Enclosures

STATE OF ALABAMA
CERTIFICATE OF USE
Alabama Water Use Reporting Program

OWR

Certificate Number: 1058.0

TVA - Browns Ferry Nuclear Plant		
Owner		
400 West Summit Hill Drive		
Address		
Knoxville	**TN**	**37902-1499**
City	State	Zip Code

Classification: **NonPublic**

Estimated System Withdrawal Capacity:	**2074.300**	Million Gallons /Day (MGD)
Estimated System Annual Withdrawal:	**746748.000**	Million Gallons /Year (MGY)

Water Use Reporting Requirements:

As a condition of this Certificate of Use, water use reports shall be submitted to the Office of Water Resources no later than March 31st of each year. The annual water use reporting form(s) shall contain water withdrawn, diverted, or consumed, in gallons, and tabulated for average daily use per month and peak day for the previous calendar year, and other data as deemed appropriate by the Office of Water Resources. The reporting forms shall be provided by the Office of Water Resources to the holder (or representative) of this Certificate of Use. Alternate reporting options must be reviewed and approved by the Office of Water Resources for appropriateness prior to submittal.

Issued by the Office of Water Resources in accordance with the Alabama Water Resources Act, Code of Alabama 1975, Section 9-10B-19 and the Administrative Rules implementing the Alabama Water Use Reporting Program.

By: Edward E. Davis

Edward E. Davis, Acting Division Director
Office of Water Resources
Alabama Department of Economic and Community Affairs

Issued on: December 01, 2005
Last Revised on:
Certificate of Use EXPIRATION DATE: January 01, 2011

THE ISSUANCE OF THIS CERTIFICATE OF USE SHALL NOT CONFER OR MODIFY ANY PERMANENT INTERESTS OR RIGHTS IN THE HOLDER THEREOF TO THE CONTINUED USE OF THE WATERS OF THE STATE OF ALABAMA.

Water Withdrawal Information

Owner: TVA - Browns Ferry Nuclear Plant

Certificate No.
1058.0

Withdrawal	Facility Name Description Location	Source (Stream, Aquifer, etc)	Maximum Capacity (MGD)	Average Use (MGY)
Ground Water				
		Ground Water Summary	0	0
Surface Water				
	Browns Ferry Nuclear 34° 42' 15" / -87° 7' 15"	Wheeler Lake	2074.300	746748.000
		Surface Water Summary	2074.300	746748.000
Totals for: TVA - Browns Ferry Nuclear Plant			2074.300	746748.000

ATTACHMENT 6

Browns Ferry Nuclear Plant
Most Recent Application for Renewal and
Declaration of Beneficial Use, dated September 23, 2015

 Certificate No. 1058

Declaration of Beneficial Use

Alabama Water Use Reporting Program

(AN APPLICATION IS REQUIRED FOR EACH WITHDRAWAL OR DIVERSION)

OWR

Company Name TVA - Browns Ferry Nuclear Plant

Mailing Address P.O. Box 2000, WSP 1A

City Decatur State AL Zip 35609

Phone ~~(256) 729-2681~~ 729-3850 Fax (256) 729-3101

Email ~~crcooper@tva.gov~~ swkeenum@tva.gov

Operator/Contact Person Mr. ~~Marty Gaston~~ Mr. George J Wynn

Title Environmental Scientist

Mailing Address P.O. Box 2000, WSP 1A

City Decatur State AL Zip 35609-2000

Phone (256) ~~729-3234~~ 729-7352 Fax (256) 729-3101

Email ~~crcooper@tva.gov~~ gjwynn@tva.gov

APPLICATION FOR:

Primary Purpose of Water Use (check one): ☐ Public ☒ Non-Public ☐ Irrigation

PUBLIC WATER USE ONLY

Purpose(s) of water use (check): ☐ Domestic/Residential ☐ Commercial ☐ Governmental/Institutional ☐ Industrial ☐ Other

Counties in Service Area

Municipalities in Service Area

No. of Residential Connections No. of Non-Residential Connections

Water Treatment Facilities (if applicable)

NON-PUBLIC WATER USE ONLY

Purpose(s) of water use (check): ☐ Industrial/Processing ☒ Cooling ☐ Commercial ☐ Other

IRRIGATION WATER USE ONLY

Purpose(s) of water use (check): ☐ Agriculture ☐ Turf ☐ Nurseries ☐ Fish Production ☐ Golf Courses ☐ Other

Attachments included as part of this submittal ALL WATER USERS (Public, Non-Public, and Irrigation)

☐ Water Conservation Plan ☐ Drought Plan/Ordinance ☐ Withdrawal Calculation Worksheets ☐ Other

BASIS FOR LEGAL USE OF WATER

This Declaration of Beneficial Use shall, at a minimum, also include the necessary attachments to establish that the proposed water use constitutes a lawful, reasonable and beneficial use of such water, is consistent with the public interest, and does not interfere with any legal usage of water existing at the time of the submittal and complies with the Alabama Water Resources Act and the Rules of the ADECA Office of Water Resources and the Alabama Water Resources Commission (§§ 305-7-9 through 305-7-12). This form should be accompanied by a map showing the location of the water source and its proximity to the actual use, in case of a stream, river, or lake indicate whether the source is navigable or non-navigable, and briefly explain how the withdrawal/diversion/consumption does not interfere with any presently known existing legal use of water.

Certification

To the best of my knowledge and belief, the information provided by this Declaration of Beneficial Use is true, accurate and complete.

Signature of Owner or Representative Date 09/23/2015

Name (Typed or printed) George J Wynn Title Chemistry/Environmental Manager

 Certificate No. 1058

If the Application includes DISCHARGES TO SURFACE WATER, complete this section:

Discharge ID ~~DSN 005~~ DSN 005 I — Status Active
Receiving Stream Tennessee River — Average Discharge 1810 million gallons per year
Latitude and Longitude 34° 42' 15" / -87° 7' 15" — Maximum Discharge Capacity 141 million gallons per day
River Basin 06030002400 - Round Island Creek

If the Application includes DISCHARGES TO SURFACE WATER, complete this section:

Discharge ID ~~DSN 001~~ DSN 001 I , DSN 001 Q , DSN 001 Y — Status Active
Receiving Stream Tennessee River — Average Discharge 1029592 million gallons per year
Latitude and Longitude 34° 42' 15" / -87° 7' 15" — Maximum Discharge Capacity 2709 million gallons per day
River Basin 06030002400 - Round Island Creek

If the Application includes DISCHARGES TO SURFACE WATER, complete this section:

Discharge ID ~~DSN 013a~~ DSN 13C1 — Status Active
Receiving Stream Tennessee River — Average Discharge 72.6 million gallons per year
Latitude and Longitude 34° 42' 30" / -87° 7' 0" — Maximum Discharge Capacity 0.383 million gallons per day
River Basin 06030002400 - Round Island Creek

If the Application includes DISCHARGES TO SURFACE WATER, complete this section:

Discharge ID ~~DSN 013b~~ DSN 13B1 — Status Active
Receiving Stream Tennessee River — Average Discharge 94.54 million gallons per year
Latitude and Longitude 34° 43' 0" / -87° 7' 0" — Maximum Discharge Capacity 0.778 million gallons per day
River Basin 06030002400 - Round Island Creek

If the Application includes DISCHARGES TO SURFACE WATER, complete this section:

Discharge ID Inactive (Old DSN 001A) — Status Inactive
Receiving Stream — Average Discharge 0 million gallons per year
Latitude and Longitude 0° 0' 0" /0° 0' 0" — Maximum Discharge Capacity 0 million gallons per day
River Basin

If the Application is for SURFACE WATER, complete this section:

Withdrawal ID Browns Ferry Nuclear Status Active

Date of Pump Installation 06-26-1973 Latitude and Longitude 34° 42' 15" / -87° 7' 15"

Critical Intake Elevation 13 feet Average Withdrawal 1031563 million gallons per year

Water Source Wheeler Lake Maximum Withdrawal Capacity 2851.2 million gallons per day

County LIMESTONE Pumping Capacity 1980000 gallons per minute

Estimation Method ☐ Metered ☐ Worksheet ☒ Other Calculation based on pump calibration

River Basin 06030002400 - Round Island Creek

IRRIGATION WATER USE ONLY

Acres irrigated from this source ___ Estimated average number of inches of water applied per year ___

Type of Use ☐ Seasonal ☐ Continuous ☐ Varies Monthly ☐ Other

If seasonable, approximate number of months you irrigate ___ If variable by month, approximate number of days per month ___

BASIS FOR LEGAL USE GUIDELINES

All Water Users (Public, Non-Public, and Irrigation)

Legal Attachments/Documents Attached (Must include at least one)

☐ Property Deed ☐ Lease Agreement

☐ Permits/Licenses ☐ Opinion of Counsel

☒ Other Legal Discription (on file)

Geographic Location of the Facility/Property and Proximity to Water Source

Please provide a location map and as many details as possible.

See map on file.

Statement of Legal Right to Use Water

Briefly describe the basis of your legal right to use water to be diverted, including how the withdrawal/diversion/consumption does not interfere with any presently known existing legal use of water.

TVA operates the Browns Ferry Nuclear Plant pursuant to the authority granted by Congress under the TVA Act of 1933, as amended. The plant is operated in accordance with the terms and conditions of the operating lcense issued by the Nuclear Regulatory Commission. Further, discharges of water to the Tennessee River incident to the withdrawal are made in accordance with the terms and conditions of the National Pollutant Discharge Elemination System (NPDES) permit issued by the State of Alabama for the Browns Ferry Nuclear Plant. The water used by the plant constitutes a lawful, reasonable and beneficial use of water, and does not interfere with any other known uses of this water.

Statement of Navigability

Water Source Wheeler Lake

Is this source navigable? True

If so, what information was used to make this determination? It is evidendeced by the barge traffic use of the reservoir.

 Certificate No. 1058

If the Application is for SURFACE WATER, complete this section:

Withdrawal ID Inactive Facility 4 Status Inactive

Date of Pump Installation 01-01-1900 Latitude and Longitude 34° 42' 15" / -87° 7' 15"

Critical Intake Elevation 0 feet Average Withdrawal 0 million gallons per year

Water Source Maximum Withdrawal Capacity 0 million gallons per day

County LIMESTONE Pumping Capacity 0 gallons per minute

Estimation Method ☐ Metered ☐ Worksheet ☐ Other

River Basin 06030002400 - Round Island Creek

IRRIGATION WATER USE ONLY

Acres irrigated from this source Estimated average number of inches of water applied per year

Type of Use ☐ Seasonal ☐ Continuous ☐ Varies Monthly ☐ Other

If seasonable, approximate number of months you irrigate If variable by month, approximate number of days per month

BASIS FOR LEGAL USE GUIDELINES

All Water Users (Public, Non-Public, and Irrigation)

Legal Attachments/Documents Attached (Must include at least one)

☐ Property Deed ☐ Lease Agreement

☐ Permits/Licenses ☐ Opinion of Counsel

☐ Other

Geographic Location of the Facility/Property and Proximity to Water Source

Please provide a location map and as many details as possible.

Statement of Legal Right to Use Water

Briefly describe the basis of your legal right to use water to be diverted, including how the withdrawal/diversion/consumption does not interfere with any presently known existing legal use of water.

Statement of Navigability

Water Source

Is this source navigable? False

If so, what information was used to make this determination? 0

ATTACHMENT 7

Reference TVA. 2010.
Fish Impingement at Browns Ferry Nuclear Plant,
September 2007 through September 2009.
TVA Environmental Stewardship and Policy.

TENNESSEE VALLEY AUTHORITY

BROWNS FERRY NUCLEAR PLANT
NPDES PERMIT NO. AL0022080
316(b) MONITORING PROGRAM

FISH IMPINGEMENT AT BROWNS FERRY NUCLEAR PLANT SEPTEMBER 2007 THROUGH SEPTEMBER 2009

ENVIRONMENTAL STEWARDSHIP AND POLICY

APRIL 2010

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List of Acronyms and Abbreviations

AM&M	**Aquatic Monitoring and Management**
BFN	**Browns Ferry Nuclear Plant**
CCW	**Condenser Cooling Water**
CWA	**Clean Water Act**
EA	**Equivalent Adult**
EPA	**Environmental Protection Agency**
EPRI	**Formerly the Electric Power Research Institute**
GPM	**Gallons Per Minute**
MSL	**Mean Sea Level**
MW	**Megawatt**
PF	**Production Foregone**

Introduction

Browns Ferry Nuclear Plant (BFN) is a three unit nuclear-fueled facility located on Wheeler Reservoir in Limestone County, Alabama. Currently, all three units are in operation. Unit 1 was shutdown in 1985 and was returned to service in June 2007. Three condenser cooling water (CCW) pumps associated with Unit 1 are now in operation in addition to the CCW pumps used for Units 2 and 3. BFN's current operation utilizes a once-through CCW system, withdrawing water from the Tennessee River through an intake structure and discharging the water through diffuser pipes located downstream from the plant. This process is regulated by BFN's National Pollutant Discharge Elimination System permit, AL0022080, and is subject to compliance with the federal Clean Water Act (CWA). Section 316(b) of the CWA requires the location, design, construction, and capacity of cooling water intake structures to reflect the best technology available for minimizing adverse environmental impacts. A potential impact associated with cooling water intake structures is impingement of aquatic organisms. Impingement occurs when fish and shellfish are trapped against intake screens by the force of cooling water withdrawal. Impingement data related to the operation of Units 2 and 3 were collected during 2003 and 2004 to update baseline data so that potential impingement impacts from increased CCW demand after the restart of Unit 1 could be more accurately assessed (Baxter et al., 2006). Additional impingement data was collected to assess impingement rates associated with the CCW withdrawal for the operation of three units. Impingement monitoring began in September 2007 and continued weekly for two years. This report presents impingement data collected from the CCW intake screens during September 2007 through September 2009.

Plant Description

BFN is located at Tennessee River Kilometer 473 (Tennessee River Mile 294) on the north shore (right descending bank) of Wheeler Reservoir (Figure 1). The three units (boiling water reactors) each have a nameplate rating of 1,100 megawatts (MW). Units Two and Three were uprated in 1997 and 1998 and Unit One in 2007, resulting in an increase of 1280MW for each unit. The uprate was accomplished without additional increase in CCW demand. Six mechanical draft cooling towers enable BFN to operate in either open or helper mode.

The CCW intake channel extends approximately 152 m (500 ft) from the intake structure to the skimmer wall. The skimmer wall is a 66 m (218 ft) long concrete and steel structure positioned across the entrance of the intake channel. Water is drawn into the intake channel through the lower portion of the wall through three 12 m (40 ft) wide sections, enabling BFN to withdraw cooler water from the lower stratum. The three open sections have movable gates with bottom elevations that can vary between 161 m (527 ft) mean sea level (msl) and 167 m (547 ft) msl. Actual water depth in the channel varies based on reservoir elevations: the normal minimum pool elevation is 168 m (550 ft) msl and normal maximum pool elevation is 169 m (556 ft) msl.

The CCW pumping station is comprised of a concrete pumping structure 71 m (232 ft) long by 36 m (117 ft) wide and 14 m (47 ft) high. The bottom elevation of the pumping station is 158 m (517 ft) msl. Each unit has three CCW pumps. Each pump has a design flow rate of 220,000 gallons per minute (gpm), giving a design intake flow of 660,000 gpm per unit. The pumps are installed in separate pump bays that are each covered by two trashracks and two traveling screens. The screens are each 2.3 m (7.5 ft) wide with mesh openings of 9.5 mm (3/8 in). The

design through screen velocity is 2.0 feet per second at normal minimum pool and 1.64 feet per second at normal high pool. The CCW pumps can operate in parallel for each unit. However, if one pump is out of service, the two remaining pumps will deliver sufficient flow for full-load operation but with a higher turbine backpressure.

The traveling screens and screen wash system can be operated automatically or manually. Differential pressure across each pair of traveling screens for a given CCW pump is monitored. When operating the system in the automatic mode, the screen wash pump is started when a preset differential pressure of water is reached across any of the three pairs of screens. When a preset pressure is established at the screen wash nozzles, the screen motors are automatically started and the screens are washed. In either manual or automatic mode, the pump and screens run until manually stopped.

Methods

Impingement data presented in this report is from weekly samples collected from September 12, 2007 through September 9, 2009.

At BFN, a continuous backwash is utilized to remove fish and debris from the traveling screens. This backwash sends fish and debris back to Wheeler Reservoir through a sluice pipe. A catch basket constructed of 9.5 mm (3/8-in) mesh is located at the end of the sluice pipe and is moved into place to catch fish during sampling periods. Weekly, impingement sampling is conducted in six hour intervals during a twenty-four hour period to ensure that any diel variations in fish impingement could be detected. After the Aquatic Monitoring and Management (AM&M) crew removes the sample from the basket during each sampling period, fish are sorted from debris, identified, separated into 25 mm (1 in) length classes, enumerated, and weighed. Any fish collected alive are returned to the reservoir after processing. Incidental numbers of fish which appeared to have been dead for more than 24 hours (i.e., exhibiting pale gills, cloudy eyes, fungus, or partial decomposition) are not included in the sample. Data recorded by one member of the AM&M crew is checked and verified (signed) by the other for quality control. Quality Assurance/Quality Control procedures for impingement sampling (TVA 2004) are followed to ensure samples compare with historical impingement mortality data.

Data Analysis
Estimated annual impingement was calculated by extrapolating impingement rates from weekly samples (24-hr sample x 7 x 52).

To facilitate the implementation of and compliance with the Environmental Protection Agency (EPA) regulations for Section 316(b) of the CWA (Federal Register Vol. 69, No. 131; July 9, 2004), prior to its suspension by EPA, fish lost to impingement were evaluated by extrapolating the losses to equivalent reductions of adult fish, or of biomass production available to predators in the case of forage species. EPRI (formerly the Electric Power Research Institute) has identified two models for extrapolating losses of juvenile fish at intake structures to numbers or production of older fish (Barnthouse 2004). The Equivalent Adult (EA) model quantifies impingement losses in terms of the number of fish that would have survived to a given future age. The Production Foregone (PF) model was applied to forage fish species to quantify the loss

from impingement in terms of potential forage available for consumption by predators. These models were used to determine the "biological liability" of the CCW intake structure based on the EPA guidance developed under the suspended rule.

Fish Community Assessment

Prior to 2000, the Tennessee Valley Authority's (TVA) Browns Ferry Nuclear Plant (BFN) was operating under a 316(a) Alternative Thermal Limit (ATL) that had been continued with each permit renewal based on studies conducted in the mid-1970s. In 1999, EPA Region IV began requesting additional data in conjunction with NPDES permit renewal applications to verify that BIP was being maintained at TVA's thermal plants with ATLs. TVA proposed that its existing Vital Signs (VS) monitoring program, supplemented with additional fish and benthic macroinvertebrate community monitoring upstream and downstream of thermal plants with ATLs, was appropriate for that purpose. The VS monitoring program began in 1990 in the Tennessee River System. This program was implemented to evaluate ecological health conditions in major reservoirs as part of TVA's stewardship role. One of the 5 indicators used in the VS program to evaluate reservoir health is the Reservoir Fish Assemblage Index (RFAI) methodology. RFAI has been thoroughly tested on TVA and other reservoirs and published in peer-reviewed literature (Jennings, et al., 1995; Hickman and McDonough, 1996; McDonough and Hickman, 1999).

TVA initiated a study to evaluate fish communities in areas immediately upstream and downstream of BFN during 2000-2009 using RFAI and RBI multi-metric evaluation techniques. This report presents the results and comparisons of autumn RFAI data collected upstream and downstream of BFN during autumn 2000-2009 (Shaffer et al. 2010).

Results and Discussion

Weekly impingement sampling at BFN from September 12, 2007 through September 9, 2009, resulted in collection of 3,983,438 fish, comprising 46 species (Table 1). During Year One of the study (September 2007 through September 2008), 2,810,778 fish representing 46 species were collected. Of these, 2,731,184 threadfin shad were impinged representing 97% of the total fish collected. During Year Two (September 2008 through September 2009), samples included 1,172,660 fish (43 species) were collected and included 92% (1,074,676) threadfin shad. Threadfin shad were predominant in the samples (96%) for both years combined, followed by gizzard shad (2%), yellow bass, freshwater drum and bluegill (0.1% each). All other species contributed less than 1% of the total number of fish impinged. The rate of impingement was highest during November through January (87%) both years (Table 2, Figure 2). The sample collected on January 2 and 3, 2008 contained 1,684,003 fish (99.1% threadfin shad) and comprised 60% of the total fish collected during Year One. Low ambient water temperatures caused by a cold front during this period caused the high numbers of threadfin shad upstream of BFN to become lethargic from thermal shock to be drawn into the intake and impinged on the traveling screens. This extensive impingement resulted in damage to several traveling screens and a power reduction event which was documented in TVA's Performance Evaluation Report (PER) #135963. The second highest number impinged during Year One was 391,375 on week four of November 2007 (Table 3, Figure 2). Peak impingement during Year Two was recorded

during week three of November (208,051) and week two of December (206,874), 2007.

Annual extrapolated estimates of numbers impinged and corresponding biomass including the average for both years are compared by species and year in Table 4. Estimated impingement (numbers and biomass) during Year One (19,675,446 fish) was over twice that recorded for Year Two (8,208,620). The impingement of thermally shocked threadfin shad observed on January 2 and 3, 2008 was the primary reason for this difference between years. Relatively similar numbers of gizzard shad and freshwater drum were impinged both years.

Application of the EA and PF models to the estimated number impinged annually resulted in reduced numbers of fish (520,309 during Year One and 318,226 during Year Two) which would have been expected to survive to either harvestable size/age or to provide forage (Table 5). This reduced number is considered the "biological liability" resulting from plant CCW impingement mortality based on the guidance developed for the now suspended 316(b) regulations.

Historical impingement monitoring at BFN conducted during 2003 and 2004 with two units operating estimated an annual impingement of 8.1 million fish.

Fish Community Assessment - RFAI
In 2008, fish community RFAI scores of 45 ("Good") and 42 ("Good") were observed at the stations downstream and upstream of BFN respectively (Table 6). Both sites met BIP screening criteria, were within the 6 point range of acceptable variation and were therefore, considered similar. In 2009, fish community RFAI scores of 36 ("Fair") and 39 ("Fair") were observed at the downstream and upstream stations, respectively (Table 7). However, both sites were within the 6-point range of acceptable variation and were considered similar. Average scores for 2000-2009 were 41 for both the upstream and downstream sites (Table 8).

Summary and Conclusions

Impingement monitoring conducted at BFN during September 2007 through September 2009 collected 3,983,438 fish representing 46 species. Threadfin shad dominated the samples comprising 96% during the two years, combined. Gizzard shad (two percent) were next in abundance followed by yellow bass, freshwater drum and bluegill. Seasonal impingement was highest (87%) during November through January both years. Higher impingement during this period is attributed to large numbers of threadfin shad drawn into the plant CCW intake as a result of cold or thermal shock. Extrapolated estimates of numbers impinged were over twice as high (19,675,446) during the first year than estimated for Year Two (8,208,620). This difference was primarily the result of one sample in January, 2008 containing 1,684,003 fish (99.1% threadfin shad). Equivalent Adult and Production Foregone models were applied to the numbers impinged and resulted in reduced numbers of fish or "biological liability" of 520,309 during Year One and 318,226 during Year Two. When the models were applied a second time using an average number of threadfin shad impinged for the anomalous January 2008 sample, the resulting losses to impingement were reduced to 254,509 for Year One. The numbers of fish impinged at BFN are not considered detrimental to the fish community in Wheeler Reservoir.

Fish community or RFAI monitoring during autumn 2008 and 2009 upstream and downstream of BFN resulted in scores rated "Good" in 2008 and "Fair" during 2009. Scores between sites both years were within the acceptable range of variation and were therefore considered similar which suggests no effect from the operation of BFN to the downstream fish community.

References

Barnthouse, L. W. 2004. Extrapolating Impingement and Entrainment Losses to Equivalent Adults and Production Foregone. EPRI Report 1008471, July 2004.

Baxter, D.S., J.P. Buchanan, and L.K. Kay. 2006. Effects of condenser cooling water withdrawal on the fish community near the Browns Ferry Nuclear Plant intake. Tennessee Valley Authority, Aquatic Monitoring and Management, Knoxville, Tennessee. 46 pp.

EPA. 2004. NPDES – Final Regulations to Establish Requirements for Cooling Water Intake Structures at Phase II Existing Facilities; Final Rule. 69 FR No. 131, July 9, 2004.

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McDonough, T.A. and G.D. Hickman. 1999. Reservoir Fish Assemblage Index development: A tool for assessing ecological health in Tennessee Valley Authority impoundments. *In*: Assessing the sustainability and biological integrity of water resources using fish communities. Simon, T. (Ed.) CRC Press, Boca Raton, pp 523-540.

Shaffer, G.P., J.W. Simmons, and D.S. Baxter. 2010. Biological Monitoring of the Tennessee River Near Browns Ferry Nuclear Plant Discharge Autumn and Spring 2009. Tennessee Valley Authority, Aquatic Monitoring and Management, Knoxville, Tennessee. 78 pp.

Tennessee Valley Authority. 1978. Biological Effects of Intake Browns Ferry Nuclear Plant. Volume 4: Effects of the Browns Ferry Nuclear Plant Cooling Water Intake on the Fish Populations of Wheeler Reservoir. Division of Forestry, Fisheries, and Wildlife Development, Fisheries and Waterfowl Resources Branch. January, 1978

Tennessee Valley Authority. 2004. Impingement Counts. Quality Assurance Procedure No. RSO&E-BR-23.11, Rev 1. TVA River Systems Operation and Environment, Aquatic Monitoring and Management Knoxville TN. 11 pp.

Tennessee Valley Authority. 2009. Biological Monitoring of the Tennessee River Near Browns Ferry Nuclear Plant Discharge.

Table 1. List of Fish Species by Family, Scientific, and Common Name Including Numbers Collected in Impingement Samples During September 12, 2007 through September 3, 2008 and September 10, 2008 and September 9, 2009 at Browns Ferry Nuclear Plant.

Family	Scientific Name	Common Name	Total Number Impinged	
			Year One	Year Two
Petromyzontidae	*Ichthyomyzon castaneus*	Chestnut lamprey	4	2
Lepisosteidae	*Lepisosteus osseus*	Longnose gar	0	3
	Lepisosteus oculatus	Spotted gar	16	36
Hiodontidae	*Hiodon tergisus*	Mooneye	4	0
Clupeidae	*Dorosoma cepedianum*	Gizzard shad	34,015	54,678
	Alosa chrysochloris	Skipjack herring	54	21
	Dorosoma petenense	Threadfin shad	2,731,184	1,074,676
	Alosa pseudoharengus	Alewife	122	1,622
Cyprinidae	*Pimephales vigilax*	Bullhead minnow	1,622	197
	Pimephales notatus	Bluntnose minnow	10	0
	Notropis atherinoides	Emerald shiner	21	2
	Notemigonus crysoleucas	Golden Shiner	25	65
	Cyprinella spiloptera	Spotfin shiner	5	0
	Luxilus chrysocephalus	Striped shiner	5	2
	Cyprinus carpio	Common carp	23	74
Catostomidae	*Ictiobus bubalus*	Smallmouth buffalo	2	2
	Ictiobus niger	Black buffalo	4	0
	Moxostoma erythrurum	Golden redhorse	1	0
	Hypentelium nigricans	Northern hogsucker	6	23
	Carpiodes cyprinus	Quillback	0	3
	Minytrema melanops	Spotted sucker	516	735
Ictaluridae	*Ictalurus furcatus*	Blue catfish	516	735
	Ictalurus punctatus	Channel catfish	2,907	2,565
	Pylodictis olivaris	Flathead catfish	46	23
	Ameiurus nebulosus	Brown bullhead	0	13
	Ameiurus melas	Black bullhead	3	0
Atherinopsidae	*Labidesthes sicculus*	Brook silverside	13	0
	Menidia beryllina	Inland Silverside	40	1,798
Belonidae	*Strongylura marina*	Atlantic needlefish	38	11
Moronidae	*Morone chrysops*	White bass	535	255
	Morone mississippiensis	Yellow bass	9,280	15,657
	Morone saxatilis	Striped bass	7	8
	Morone saxatilis x M. chrysops	Hybrid striped bass	13	5
Centrarchidae	*Lepomis macrochirus*	Bluegill	15,132	5,565

Table 1. (continued)

Family	Scientific Name	Common Name	Total Number Impinged	
			Year One	Year Two
Centrarchidae	*Lepomis auritus*	Redbreast sunfish	0	58
	Lepomis microlophus	Redear sunfish	4,160	534
	Lepomis gulosus	Warmouth	14	106
	Lepomis humilis	Orangespotted sunfish	370	959
	Lepomis cyanellus	Green sunfish	35	270
	Lepomis megalotis	Longear sunfish	132	174
		Hybrid sunfish	1	0
	Micropterus dolomieu	Smallmouth bass	2	4
	Micropterus salmoides	Largemouth bass	78	73
	Micropterus punctulatus	Spotted bass	79	72
	Pomoxis annularis	White crappie	197	693
	Pomoxis nigromaculatus	Black crappie	20	2
Percidae	*Sander canadense*	Sauger	14	5
	Perca flavescens	Yellow perch	512	212
	Percina caprodes	Logperch	523	211
	Percina shumardi	River darter	0	3
Sciaenidae	*Aplodinotus grunniens*	Freshwater drum	9,483	11,426
		Total Number of Fish	**2,810,778**	**1,172,660**
		Total Number of Fish Species	**46**	**43**
		Number of Sample Days	**52**	**53**

Table 2. Number of fish impinged by month and percent of annual total during September, 2007 through September, 2009.

Month	Total Number of Fish Impinged 2007-2008 (Year 1)	Percent of Annual Total	Number of Fish Impinged 2008-2009 (Year 2)	Percent of Annual Total	Years 1 and 2 Combined	Percent of Two-Year Total
Jan	12,051,564	61	1,166,907	14	13,218,471	47
Feb	556,703	3	142,702	2	699,405	3
Mar	220,136	1	211,918	3	432,054	2
Apr	274,302	1	91,021	1	365,323	1
May	183,197	1	4,438	0	187,635	1
Jun	23,912	0	7,399	0	31,311	0
Jul	24,570	0	25,186	0	49,756	0
Aug	279,706	1	4,256	0	283,962	1
Sep	127,169	1	58,695	1	185,864	1
Oct	664,783	3	556,395	7	1,221,178	4
Nov	3,025,932	15	2,040,311	25	5,066,243	18
Dec	2,243,472	11	3,899,392	48	6,142,864	22
Total	**19,675,446**		**8,208,620**		**27,884,066**	

Table 3. Comparison of estimated weekly fish impingement at TVA's Browns Ferry Nuclear Plant during 2007 and 2008.

	Sept		Oct		Nov		Dec	
	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2
Week 1	-	-	9120	3881	4648	4304	72693	175411
Week 2	1050	2494	7900	34764	13330	6119	116023	206874
Week 3	2218	4012	23215	5892	22923	208051	84264	77367
Week 4	6144	1805	23334	3834	391375	72999	47516	97404
Week 5	-	-	31400	31114	-	-	-	-

	Jan		Feb		March		April	
	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2
Week 1	1684003	45658	4162	7478	5820	4121	7865	9810
Week 2	11410	89512	25196	5439	6506	5274	14337	1309
Week 3	12693	16101	26393	5216	7904	15571	5136	1718
Week 4	3995	5716	23778	2253	11218	5308	2905	166
Week 5	9551	9714	-	-	-	-	8943	0

	May		June		July		Aug	
	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2
Week 1	19708	141	1019	92	861	616	1824	23
Week 2	4006	345	807	280	612	0	1937	10
Week 3	1469	128	747	206	400	1322	1468	148
Week 4	988	20	843	479	519	475	34729	427
Week 5	-	-	-	-	1118	1185	-	-

Table 4. Annual extrapolated estimates of numbers and biomass of fish impinged by species and year at Watts Bar Nuclear Plant during September 2007 through September 2009.

	Estimated Number			Estimated Biomass (g)			
Species	9/12/2007 - 9/03/2008	9/10/2008 - 9/09/2009	Average	9/12/2007 - 9/03/2008	9/10/2008 - 9/09/2009	Average	Percent Composition by Number
Threadfin Shad	19,118,288	7,522,732	**13,320,510**	52,372,460	25,157,615	**38,765,038**	**96**
Gizzard Shad	238,105	382,746	**310,426**	8,348,508	7,366,639	**7,857,574**	**2**
Yellow Bass	64,960	109,599	**87,280**	1,528,870	2,181,942	**1,855,406**	**1**
Freshwater Drum	66,381	79,982	**73,182**	4,842,915	5,830,720	**5,336,818**	**1**
Bluegill	105,924	38,955	**72,440**	580,223	435,358	**507,791**	**1**
Channel Catfish	20,349	17,955	**19,152**	948,367	1,082,508	**1,015,438**	**T**
Redear Sunfish	29,120	3,738	**16,429**	183,232	140,707	**161,970**	**T**
Inland Silverside	280	12,586	**6,433**	1,218	66,010	**33,614**	**T**
Bullhead Minnow	11,354	1,379	**6,367**	67,130	5,369	**36,250**	**T**
Alewife	854	11,354	**6,104**	6,748	116,095	**61,422**	**T**
Orangespotted Sunfish	2,590	6,713	**4,652**	12,509	16,506	**14,508**	**T**
Blue Catfish	3,612	5,145	**4,379**	321,951	267,337	**294,644**	**T**
White Crappie	1,379	4,851	**3,115**	75,775	149,205	**112,490**	**T**
White Bass	3,745	1,785	**2,765**	713,489	462,112	**587,801**	**T**
Logperch	3,661	1,477	**2,569**	21,280	14,203	**17,742**	**T**
Longear Sunfish	924	1,218	**1,071**	8,834	11,004	**9,919**	**T**
Green Sunfish	245	1,890	**1,068**	3,570	7,630	**5,600**	**T**
Largemouth Bass	546	511	**529**	68,054	92,491	**80,273**	**T**
Spotted Bass	553	504	**529**	50,918	43,491	**47,205**	**T**
Warmouth	98	742	**420**	1,799	9,184	**5,492**	**T**
Common Carp	161	518	**340**	770	5,068	**2,919**	**T**
Golden Shiner	175	455	**315**	1,960	6,503	**4,232**	**T**
Skipjack Herring	378	147	**263**	183,015	30,254	**106,635**	**T**
Flathead Catfish	322	161	**242**	80,227	22,876	**51,552**	**T**
Redbreast Sunfish	0	406	**203**	0	2,513	**1,257**	**T**
Spotted Gar	112	252	**182**	215,719	354,508	**285,114**	**T**
Atlantic Needlefish	266	77	**172**	23,737	4,501	**14,119**	**T**
Northern Hog Sucker	42	161	**102**	441	4,879	**2,660**	**T**

Table 4. (continued)

Species	Estimated Number 9/12/2007 - 9/03/2008	Estimated Number 9/10/2008 - 9/09/2009	Estimated Number Average	Estimated Biomass (g) 9/12/2007 - 9/03/2008	Estimated Biomass (g) 9/10/2008 - 9/09/2009	Estimated Biomass (g) Average	Percent Composition by Number
Yellow Perch	84	84	**84**	728	1,323	**1,026**	**T**
Emerald Shiner	147	14	**81**	1,211	168	**690**	**T**
Black Crappie	140	14	**77**	8,834	252	**4,543**	**T**
Sauger	98	35	**67**	46,858	16,114	**31,486**	**T**
Hybrid Striped Bass	91	35	**63**	58,023	371	**29,197**	**T**
Spotted Sucker	0	126	**63**	0	41,503	**20,752**	**T**
Striped Bass	49	56	**53**	26,523	399	**13,461**	**T**
Brook Silverside	91	0	**46**	308	0	**154**	**T**
Brown Bullhead	0	91	**46**	0	525	**263**	**T**
Bluntnose Minnow	70	0	**35**	252	0	**126**	**T**
River Darter	35	14	**25**	35	56	**46**	**T**
Striped Shiner	35	14	**25**	294	56	**175**	**T**
Chestnut Lamprey	28	14	**21**	1,365	532	**949**	**T**
Smallmouth Bass	14	28	**21**	6,986	119	**3,553**	**T**
Spotfin Shiner	35	0	**18**	259	0	**130**	**T**
Black Buffalo	28	0	**14**	11,550	0	**5,775**	**T**
Mooneye	28	0	**14**	9,702	0	**4,851**	**T**
Smallmouth Buffalo	14	14	**14**	4,774	7,588	**6,181**	**T**
Black Bullhead	21	0	**11**	203	0	**102**	**T**
Longnose Gar	0	21	**11**	0	60,214	**30,107**	**T**
Quillback	0	21	**11**	0	27,727	**13,864**	**T**
Golden Redhorse	7	0	**4**	4,900	0	**2,450**	**T**
Hybrid Sunfish	7	0	**4**	7	0	**4**	**T**

Table 5. Extrapolated annual numbers of fish impinged at Browns Ferry Nuclear Plant September 2007 through August 2008 and September 2008 through August 2009. Also included are numbers of fish for which TVA is liable after EA and PF reduction.

	Year 1	Year 2
	2007-2008	2008-2009
Extrapolated Annual Number of fish Impinged	19,675,446	8,208,620
Number Liable for after EA & PF Reduction	520,309	318,226

Table 6. Individual Metric Scores and the Overall RFAI Scores Downstream (TRM 292.5) and Upstream (TRM 295.9) of Browns Ferry Nuclear Plant Discharge, Autumn 2008.

Autumn 2008	TRM 292.5		TRM 295.9	
Metric	Obs	Score	Obs	Score
A. Species richness and composition				
1. Number of indigenous species	28 species	3	28 species	3
2. Number of centrarchid species (less Micropterus)	6 species Green sunfish Bluegill Longear sunfish Warmouth Black crappie Redear sunfish	5	7 species Green sunfish Bluegill Longear sunfish Warmouth Redear sunfish White crappie Black crappie	5
3. Number of benthic invertivore species	5 species Spotted sucker Black redhorse Golden redhorse Freshwater drum Logperch	3	4 species Spotted sucker Northern hog sucker Freshwater drum Logperch	3
4. Number of intolerant species	5 species Spotted sucker Skipjack herring Black redhorse Longear sunfish Smallmouth bass	5	5 species Spotted sucker Northern hog sucker Skipjack herring Longear sunfish Smallmouth bass	5

Table 6. (Continued)

Autumn 2008		TRM 292.5		TRM 295.9	
Metric		Obs	Score	Obs	Score
5. Percent tolerant individuals	Electrofishing	37.4% Bluegill 10.3% Gizzard shad 19.3% Largemouth bass 7.2% Spotfin shiner 0.2% Green sunfish 0.3%	1.5	50.6% Bluegill 8.2% Gizzard shad 31.7% Common carp 0.3% Largemouth bass 9.4% Spotfin shiner 0.2% Golden shiner 0.2% Green sunfish 0.4%	1.5
	Gill Netting	23.6% Gizzard shad 14.1% Common carp 0.5% Bluegill 1.0% Largemouth bass 8.0%	1.5	32.1% Gizzard shad 12.3% Common carp 0.5% Bluegill 3.2% Largemouth bass 7.0% Longnose gar 4.8% Golden shiner 2.7% White crappie 1.6%	0.5
6. Percent dominance by one species	Electrofishing	52.7% Inland silverside	1.5	31.7% Gizzard shad	1.5
	Gill Netting	28.6% White bass	1.5	19.8% Channel catfish	1.5
7. Percent non-indigenous species	Electrofishing	52.7% Inland silverside 52.7%	0.5	29.5% Inland silverside 29.0% Atlantic needlefish 0.1% Common carp 0.3%	0.5
	Gill Netting	0.5% Common carp 0.5%	2.5	1.6% Common carp 0.5% Striped bass 1.1%	1.5

Table 6. (Continued)

Autumn 2008		TRM 292.5		TRM 295.9	
Metric		Obs	Score	Obs	Score
8. Number of top carnivore species		10 species Spotted gar Largemouth bass Spotted bass Smallmouth bass Skipjack herring Flathead catfish White bass Yellow bass Black crappie Sauger	5	11 species Longnose gar Spotted gar Largemouth bass Spotted bass Smallmouth bass Skipjack herring Flathead catfish White bass Yellow bass Black crappie White crappie	5
B. Trophic composition					
9. Percent top carnivores	Electrofishing	8.5% Largemouth bass 7.2% Spotted bass 0.2% Smallmouth bass 1.0% Flathead catfish 0.06%	1.5	12.6% Largemouth bass 9.4% Spotted bass 0.7% Smallmouth bass 0.7% Flathead catfish 0.3% White bass 0.2% Yellow bass 1.0% Spotted gar 0.2%	2.5
	Gill Netting	61.3% Spotted gar 0.5% Largemouth bass 8.0% Spotted bass 1.0% Skipjack herring 15.6% Flathead catfish 4.5% White bass 28.6% Yellow bass 1.5% Black crappie 0.5% Sauger 1.0%	2.5	39.6% Longnose gar 4.8% Largemouth bass 7.0% Spotted bass 1.6% Skipjack herring 1.6% Flathead catfish 2.1% White bass 14.0% Yellow bass 5.3% White crappie 1.6% Black crappie 0.5%	2.5

Table 6. (Continued)

Autumn 2008		TRM 292.5		TRM 295.9	
Metric		Obs	Score	Obs	Score
10. Percent omnivores	Electrofishing	20.7% Gizzard shad 19.3% Channel catfish 1.2% Blue catfish 0.2%	2.5	38.5% Gizzard shad 31.7% Channel catfish 5.8% Smallmouth buffalo 0.4% Common carp 0.3% Golden shiner 0.2%	1.5
	Gill Netting	26.6% Gizzard shad 14.1% Blue catfish 6.0% Channel catfish 3.5% Smallmouth buffalo 2.0% Black buffalo 0.5% Common carp 0.5%	1.5	44.4% Gizzard shad 12.3% Blue catfish 5.3% Channel catfish 19.8% Golden shiner 2.7% Smallmouth buffalo 3.7% Common carp 0.5%	0.5
C. Fish abundance and health					
11. Average number per run	Electrofishing	112.2	0.5	59.9	0.5
	Gill Netting	19.9	1.5	18.7	1.5
12. Percent anomalies	Electrofishing	0.4%	2.5	1%	2.5
	Gill Netting	0.5%	2.5	0.5%	2.5
Overall RFAI Score			**45**		**42**
			Good		**Good**

Table 7. Individual Metric Scores and the Overall RFAI Scores Downstream (TRM 292.5) and Upstream (TRM 295.9) of Browns Ferry Nuclear Plant Discharge, Autumn 2009.

Autumn 2009	TRM 292.5		TRM 295.9	
Metric	Obs	Score	Obs	Score
A. Species richness and composition				
1. Number of indigenous species (Tables 7 and 8)	27	3	26	3
2. Number of centrarchid species (less Micropterus)	7 Black crappie Bluegill Green sunfish Longear sunfish Redbreast sunfish Redear sunfish Warmouth	5	6 Black crappie Bluegill Green sunfish Longear sunfish Redear sunfish Warmouth	5
3. Number of benthic invertivore species	3 Freshwater drum Golden redhorse Logperch	1	4 Black redhorse Freshwater drum Golden redhorse Spotted sucker	3
4. Number of intolerant species	3 Longear sunfish Skipjack herring Smallmouth bass	3	5 Black redhorse Longear sunfish Skipjack herring Smallmouth bass Spotted sucker	5

Table 7. (Continued)

Autumn 2009		TRM 292.5		TRM 295.9	
Metric		Obs	Score	Obs	Score
5. Percent tolerant individuals	Electrofishing	40.9% Bluegill 5.67% Bluntnose minnow 0.07% Common carp 0.07% Gizzard shad 24.93% Golden shiner 0.07% Green sunfish 1.00% Largemouth bass 7.07% Redbreast sunfish 0.07% Spotfin shiner 1.93%	1.5	43.1% Bluegill 5.30% Common carp 0.18% Gizzard shad 26.97% Golden shiner 0.46% Green sunfish 0.73% Largemouth bass 9.05% Spotfin shiner 0.46%	1.5
	Gill Netting	45.7% Bluegill 4.35% Gizzard shad 39.13% Largemouth bass 2.17%	0.5	30.5% Common carp 3.39% Gizzard shad 23.73% White sucker 3.39%	0.5
6. Percent dominance by one species	Electrofishing	42.6% Inland silverside	1.5	35.6% Inland silverside	1.5
	Gill Netting	39.1% Gizzard shad	0.5	23.7% Gizzard shad	1.5

Table 7. (Continued)

Autumn 2009		TRM 292.5		TRM 295.9	
Metric		Obs	Score	Obs	Score
7. Percent non-indigenous species	Electrofishing	42.7% Common carp 0.07% Inland silverside 42.60%	0.5	35.8% Common carp 0.18% Inland silverside 35.56% Striped bass 0.09%	0.5
	Gill Netting	0.0%	2.5	3.4% Common carp 3.39%	0.5
8. Number of top carnivore species		9 Black crappie Flathead catfish Largemouth bass Skipjack herring Smallmouth bass Spotted bass Spotted gar White bass Yellow bass	5	9 Black crappie Flathead catfish Largemouth bass Skipjack herring Smallmouth bass Spotted bass Spotted gar White bass Yellow bass	5
B. Trophic composition					
9. Percent top carnivores	Electrofishing	11.5% Black crappie 0.07% Flathead catfish 0.27% Largemouth bass 7.07% Smallmouth bass 3.73% White bass 0.07% Yellow bass 0.27%	2.5	14.4% Black crappie 0.09% Flathead catfish 1.28% Largemouth bass 9.05% Smallmouth bass 0.18% Spotted bass 0.46% Spotted gar 0.46% Striped bass 0.09% Yellow bass 2.83%	2.5

Table 7. (Continued)

Autumn 2009		TRM 292.5		TRM 295.9	
Metric		Obs	Score	Obs	Score
	Gill Netting	32.6% Flathead catfish 6.52% Largemouth bass 2.17% Skipjack herring 2.17% Spotted bass 6.52% Spotted gar 8.70% White bass 4.35% Yellow bass 2.17%	1.5	30.5% Black crappie 1.69% Flathead catfish 1.69% Skipjack herring 8.47% Spotted bass 1.69% Spotted gar 1.69% White bass 6.78% Yellow bass 8.47%	1.5
10. Percent omnivores	Electrofishing	29.5% Bluntnose minnow 0.07% Channel catfish 4.20% Common carp 0.07% Gizzard shad 24.93% Golden shiner 0.07% Smallmouth buffalo 0.20%	1.5	36.8% Blue catfish 0.18% Channel catfish 8.96% Common carp 0.18% Gizzard shad 26.97% Golden shiner 0.46% Smallmouth buffalo 0.09%	1.5
	Gill Netting	56.5% Blue catfish 4.35% Channel catfish 6.52% Gizzard shad 39.13% Smallmouth buffalo 6.52%	0.5	54.2% Blue catfish 3.39% Channel catfish 20.34% Common carp 3.39% Gizzard shad 23.73% White sucker 3.39%	0.5

Table 7. (Continued)

Autumn 2009		TRM 292.5		TRM 295.9	
Metric		Obs	Score	Obs	Score
C. Fish abundance and health					
11. Average number per run	Electrofishing	100.0	0.5	72.9	0.5
	Gill Netting	4.6	0.5	5.9	0.5
12. Percent anomalies	Electrofishing	0.5%	2.5	0.6%	2.5
	Gill Netting	0.0%	2.5	0.0%	2.5
Overall RFAI Score			**36**		**39**
			Fair		**Fair**

Table 8. Summary of RFAI Scores from Sites Located Directly Upstream and Downstream of Browns Ferry Nuclear Plant as Well as Scores from Sampling Conducted During 1993-2009 as Part of the Vital Signs Monitoring Program in Wheeler Reservoir.

Station	Location	1993	1994	1995	1997	1999	1993-1999 Average	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2000-2009 Average
Inflow	TRM 348.0	46	48	42	48	36	44	-	38	42	38	44	44	42	38	38	40	40
Transition BFN Upstream	TRM 295.9	43	43	35	40	30	38	41	37	43	39	43	46	41	39	42	39	41
Transition BFN Downstream	TRM 292.5	-	-	-	-	-	N/A	43	40	41	43	43	36	42	42	45	36	41
Forebay	TRM 277.0	52	44	49	45	42	46	-	41	45	44	43	45	46	49	46	47	45
Elk River Embayment	ERM 6.0	43	46	36	49	36	42	-	49	-	44	49	47	-	39	-	42	45

Note: No data were collected for 1996 and 1998.
RFAI Scores: 12-21 ("Very Poor"), 22-31 ("Poor"), 32-40 ("Fair"), 41-50 ("Good"), or 51-60 ("Excellent").

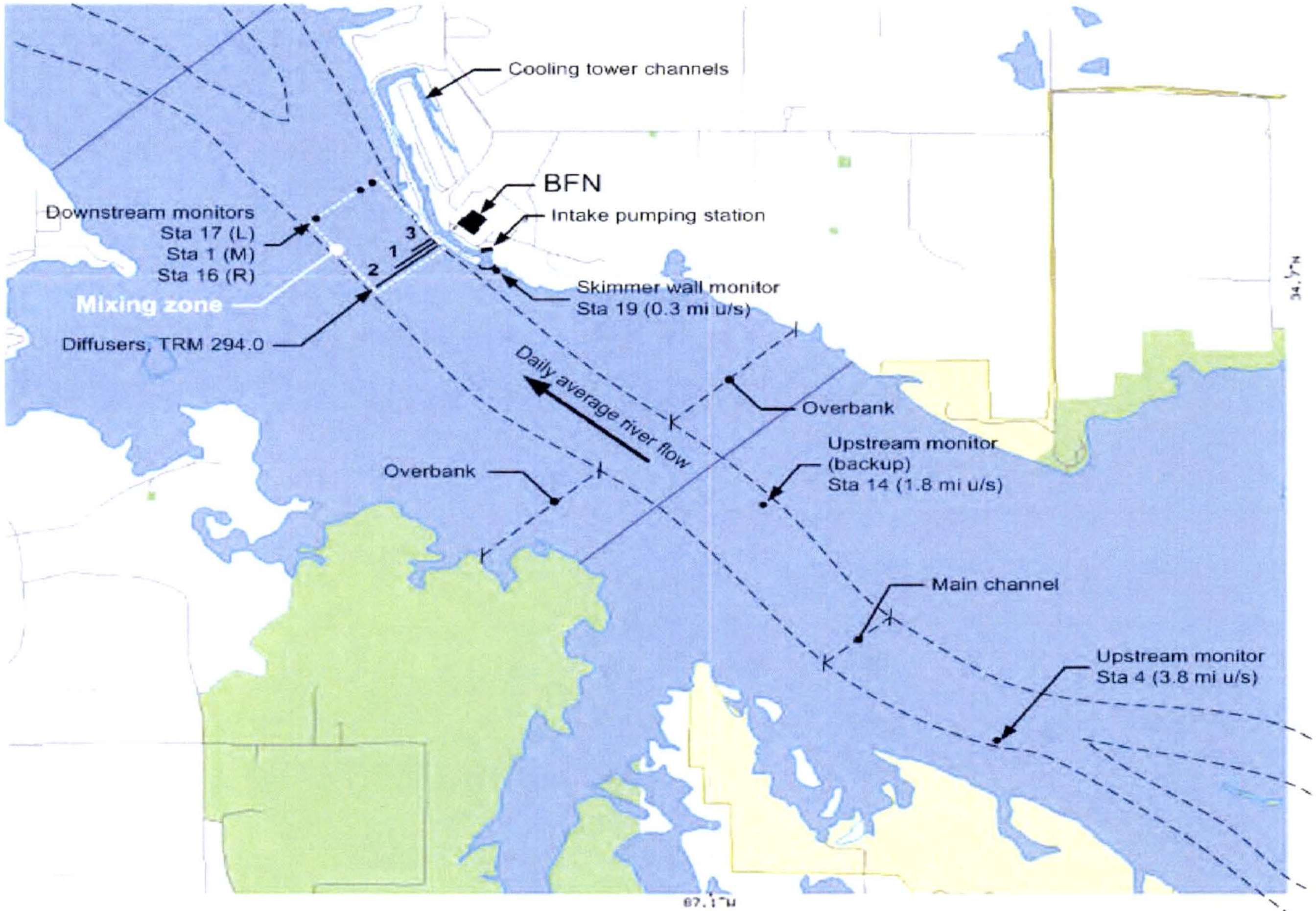

Figure 1. Location of Browns Ferry Nuclear Plant and Condenser Cooling Water (CCW) intake and discharge. Browns Ferry Nuclear Power Plant is located on the north shore of Wheeler Reservoir at Tennessee River Mile 294.

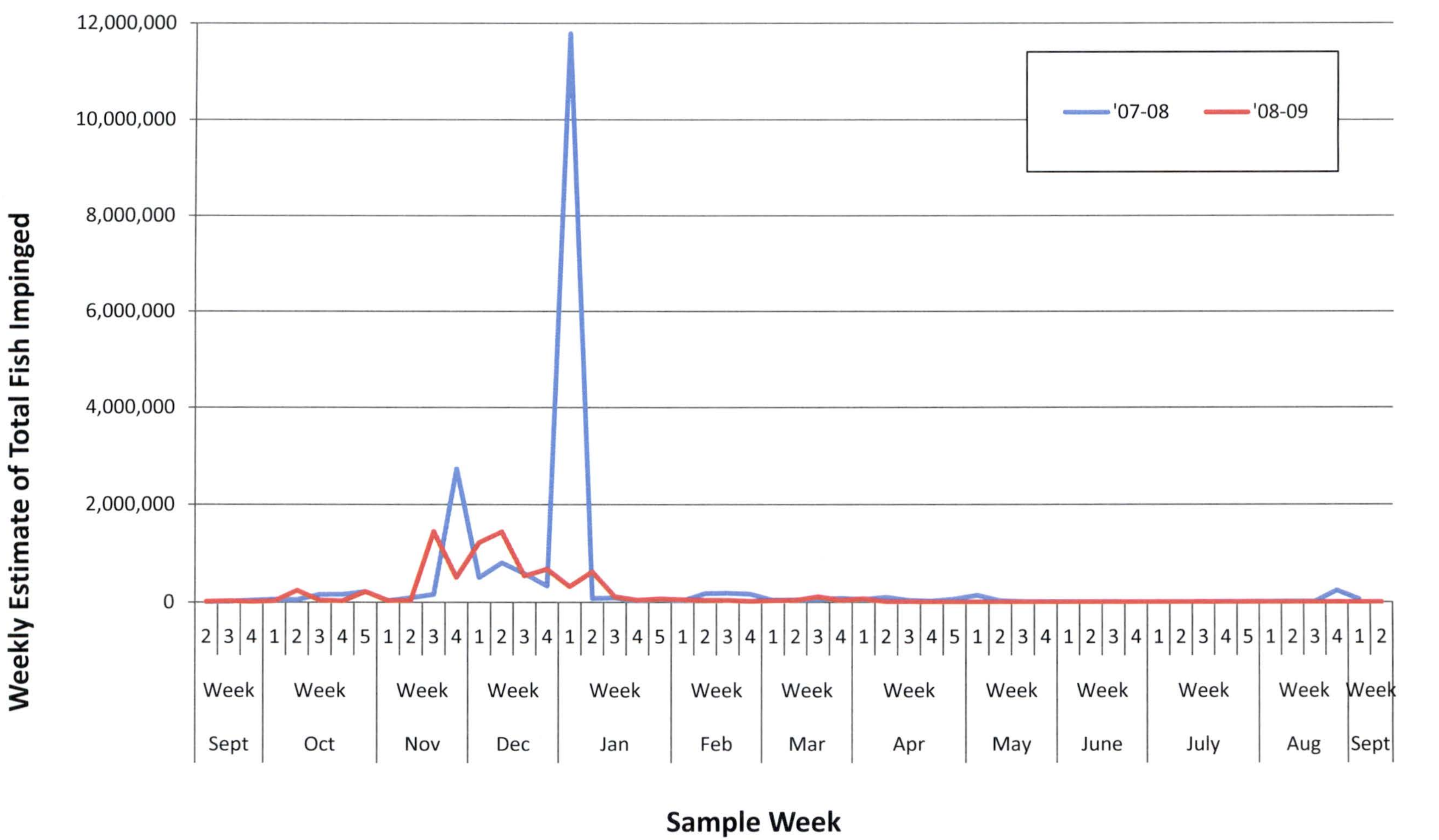

Figure 2. Weekly estimate of total fish impinged at Browns Ferry Nuclear Plant, September 2007 through August 2008 (Year 1) and September 2008 through August 2009 (Year 2).

ATTACHMENT 8

Reference TVA. 2012a.
Biological Monitoring of the Tennessee River Near Browns Ferry Nuclear Plant Discharge, Autumn 2011. TVA Biological and Water Resources, Chattanooga, Tennessee.

Biological Monitoring of the Tennessee River Near Browns Ferry Nuclear Plant Discharge Autumn 2011

July 2012

Tennessee Valley Authority
Biological and Water Resources
Chattanooga, Tennessee

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Acronyms and Abbreviations

ATL	Alternate Thermal Limit
BIP	Balanced Indigenous Population
BFN	Browns Ferry Nuclear Power Plant
CCW	Condenser Cooling Water
CWA	Clean Water Act
EPA	Environmental Protection Agency
LD	Left Descending (Bank)
NPDES	National Pollutant Discharge Elimination System
QA	Quality Assurance
RBI	Reservoir Benthic Macroinvertebrate Index
RD	Right Descending (Bank)
RFAI	Reservoir Fish Assemblage Index
SAHI	Shoreline Assessment Habitat Index
TRM	Tennessee River Mile
TVA	Tennessee Valley Authority
VS	Vital Signs

Executive Summary

As required by the National Pollutant Discharge Elimination System (NPDES) Permit Number AL0022080 for operation of Browns Ferry Nuclear Plant (BFN), this report is an evaluation of operational aquatic monitoring at BFN conducted during autumn 2011. The primary objective of the aquatic monitoring in the vicinity of BFN was to determine if thermal variances established for control of the thermal component of the discharges assured protection of a Balanced Indigenous Populations (BIP) of aquatic life. Biological and chemical components monitored to detect and evaluate significant effects, if any, of BFN's thermal discharge included: fish, benthic macroinvertebrate and wildlife communities; thermal plume characterization; and various water quality parameters.

Both the upstream and downstream fish communities were found to be similar and met EPA's criteria for a Balanced Indigenous Population (BIP), therefore it was concluded that the BIP was not adversely affected by thermal effluent from BFN.

Sampling locations of the benthic macroinvertebrate community were modified in 2011 compared to previous years. Samples were collected upstream at the same site, but were collected at two new sites downstream of BFN: within the thermal plume and downstream and outside of thermal plume's influence. The three sites were different in diversity and abundance of taxa, and the most downstream site was deemed "Fair", compared to a rating of "Good" at the upstream site. It was determined that these differences were due to differences in substrate composition and not the BFN thermal effluent.

A visual wildlife survey was conducted for the first time in 2011 to assess bird, reptile, and mammal populations upstream and downstream of BFN. Turtles and a variety of birds were encountered. Based on observations, shoreline wildlife communities appeared to be similar upstream and downstream of BFN.

During the autumn 2011 monitoring period, the thermal plume extended from the discharge (TRM 294) downstream to TRM 291.2. The entire biomonitoring zone downstream of the BFN discharge was not contained within the 3.6°F (2°C) isopleth of the thermal plume on the sample date.

Depth profiles of water temperature, conductivity, dissolved oxygen concentration, and acidity (pH) indicated that values of all these parameters were within acceptable levels both upstream and downstream of BFN.

It appears that relatively healthy fish, benthic, and wildlife communities existed downstream of the BFN thermal discharge and that the heated BFN effluent has not adversely impacted these communities.

Introduction

Section 316(a) of the Clean Water Act (CWA) authorizes thermal variances for the control of the thermal component of a point source discharge so long as the limits will assure the protection of Balanced Indigenous Populations (BIP) of aquatic life. The term "balanced indigenous population," as defined by EPA, describes a biotic community that is typically characterized by:

(1) diversity appropriate to the ecoregion;

(2) the capacity to sustain itself through cyclic seasonal changes;

(3) the presence of necessary food chain species; and

(4) lack of domination by pollution-tolerant species

Prior to 2000, the Tennessee Valley Authority's (TVA) Browns Ferry Nuclear Plant (BFN) was operating under a 316(a) ATL that had been continued with each permit renewal based on studies conducted in the mid-1970s. In 1999, EPA Region IV requested additional data in conjunction with National Pollutant Discharge Elimination System (NPDES) permit renewal applications to verify that BIP was being maintained at TVA's thermal plants with thermal variances. TVA proposed that its existing Vital Signs (VS) monitoring program, supplemented with additional fish and benthic macroinvertebrate community monitoring upstream and downstream of thermal plants with thermal variances, was appropriate for that purpose. The VS monitoring program began in 1990 in the Tennessee River System. This program was implemented to evaluate ecological health conditions in major reservoirs as part of TVA's stewardship role. One of the 5 indicators used in the VS program to evaluate reservoir health is the Reservoir Fish Assemblage Index (RFAI) methodology which incorporates fish species richness and composition, trophic composition, and fish abundance and health. RFAI has been thoroughly tested on TVA and other reservoirs and published in peer-reviewed literature (Jennings et al., 1995; Hickman and McDonough, 1996; McDonough and Hickman, 1999). Fish communities are used to evaluate ecological conditions because of their importance in the aquatic food web and because fish life cycles are long enough to integrate conditions over time. Benthic macroinvertebrate populations are assessed using the Reservoir Macroinvertebrate Benthic Index (RBI) methodology. Because benthic macroinvertebrates are relatively immobile, negative impacts to aquatic ecosystems can be detected earlier in benthic macroinvertebrate communities than in fish communities. These data are used to supplement RFAI results to provide a more thorough examination of differences in aquatic communities upstream and downstream of thermal discharges.

During 2000-2010, TVA conducted monitoring to evaluate fish and benthic macroinvertebrate communities in areas immediately upstream and downstream of BFN using RFAI and RBI multi-metric evaluation techniques. Monitoring was continued in 2011 and broadened to include additional data for analyses requested by the EPA. Reported here are the results of RFAI, RBI, visual wildlife observations, shoreline and river bottom habitat/substrate characterization, and water quality data collected upstream and downstream of BFN during 2011, with comparisons to RFAI and RBI data collected at these sites during autumn 2000 through 2010.

Plant Description

BFN is located on Wheeler Reservoir, approximately 18 miles upstream of Wheeler Dam at Tennessee River Mile (TRM) 294 in Limestone County, Alabama (Figure 1). BFN is a three-unit nuclear-fueled facility. Unit One, which remained idle for several years, returned to service June 2007. Current operation utilizes a once-through condenser cooling water (CCW) system, withdrawing water from the Tennessee River through an intake structure at TRM 294.3 and discharging the water through a multi-port diffuser located downstream from the plant at TRM 293.6 (Figure 2). Maximum flow rate of the CCW is approximately 3,468 million gallons per day.

Methods

Fish and Benthic Macroinvertebrate Sample Locations Upstream and Downstream of BFN

Thermal discharge from BFN enters the Tennessee River at TRM 293.6 in Wheeler Reservoir (Figure 2). The fish community was sampled at a station centered at TRM 292.5, downstream of the cooling water discharge (Figure 3) and at a station centered at TRM 295.9, upstream of the plant's intake (Figure 4).

In previous years, benthic macroinvertebrate community data were collected along transects at two sites: TRM 291.7, downstream of the BFN discharge and TRM 295.9, upstream of the BFN intake. In 2011, samples were collected along transects at three sites. Two sites were selected downstream: one below the thermal plume at TRM 290.4, and a second at TRM 293.2, within the thermal plume from the BFN discharge (Figure 3). The third site, upstream of the plant intake, was maintained at TRM 295.9 (Figure 4).

Aquatic Habitat in the Vicinity of Browns Ferry Nuclear Plant

Shoreline and river bottom habitat data presented in this report were collected during autumn 2009; habitat will be sampled again during autumn 2012. TVA assumes habitat data to be valid for three years, barring any major changes to the river/reservoir (e.g., flood). In the event of a major change to the river/ reservoir, habitat would be re-sampled the following autumn.

Shoreline Aquatic Habitat Assessment

The Shoreline Aquatic Habitat Index (SAHI), which incorporates several habitat parameters important to resident fish species, was used to measure existing fish habitat quality in the vicinity of Browns Ferry Nuclear Plant during autumn 2009. Using the general format developed by Plafkin et al. (1989), seven metrics were established to characterize selected physical habitat attributes important to resident fish populations, which rely heavily on the littoral (shoreline) zone for reproduction, recruitment, and prey availability (Table 1). Habitat Suitability Indices (US Fish and Wildlife Service), along with other sources of information on biology and habitat requirements (e.g. Etnier and Starnes 1993), were consulted to develop "reference" criteria or "expected" conditions from a high quality environment for each parameter. Some generalizations were necessary in setting up scoring criteria to cover the various requirements of all species into one index. Individual metrics were scored through comparison of observed conditions with these "reference" conditions and assigned a corresponding value: good-5; fair-3;

or poor-1 (Table 1). The scores for each metric were summed to obtain the SAHI value. The range of potential SAHI values (7-35) was trisected to provide some descriptor of habitat quality (poor 7-16, fair 17-26, and good 27-35).

The quality of shoreline aquatic habitat was assessed while traveling parallel to the shoreline in a boat. Eight line-of-sight transects were established across the width of Wheeler reservoir within the BFN downstream (TRMs 290.3 to 293.7) and upstream (TRMs 294.4 to 296.8) fish community sampling stations (Figure 4). Near-shore aquatic habitat was assessed along sections of shoreline corresponding to the left descending (LDB) and right descending bank (RDB) locations for each of the eight line-of-sight transects. These individual sections (8 on the LDB and 8 on the RDB for a total of 16 shoreline assessments) were then scored using SAHI criteria. Percentages of aquatic macrophytes in the littoral areas of the 8 LDB and 8 RDB shoreline sections were also estimated.

River Bottom Habitat

Along each of the 8 line-of-sight transects described above (8 transects below BFN thermal discharge, 8 transects at upstream reference site; Figure 5), 10 benthic grab samples were collected with a Ponar sampler at equally spaced points from the LDB to the RDB. Substrate material collected with the Ponar was emptied into a screen and substrate percentages were estimated to determine existing benthic habitat across the width of the river. Water depths (feet) at each sample location were recorded. If no substrate was collected after multiple Ponar drops, it was assumed that the substrate was bedrock. For example, when the Ponar sampler was pulled shut, collectors could feel substrate consistency. If it shut easily and was not embedded in the substrate on numerous drops within the same location, collectors recorded the substrate as bedrock.

Fish Community Sampling Methods and Data Analysis for Sites Upstream and Downstream of BFN

Fish sampling methods included boat electrofishing and gill netting (Hubert 1996; Reynolds 1996). Electrofishing methodology consisted of fifteen electrofishing boat runs near the shoreline, each 300 meters long and of approximately 15 minutes duration (Figures 2 and 3). The total near-shore area sampled was approximately 4,500 meters (15,000 feet).

Experimental gill nets (so called because of their use for research as opposed to commercial fishing) were used as an additional gear type to collect fish from deeper habitats not effectively sampled by electrofishing. Each experimental gill net consists of five panels, each 6.1 meters in length, for a total length of 30.5 meters (100.1 feet). The distinguishing characteristic of experimental gill nets is mesh size that varies between panels. For this application, each net has panels with mesh sizes of 2.5, 5.1, 7.6, 10.2, and 12.7 cm. Experimental gill nets are typically set perpendicular to river flow, extending from near-shore toward the main channel of the reservoir. Ten overnight experimental gill net sets were used at each sampling station (Figures 2 and 3).

Fish collected were identified by species, counted, and examined for anomalies (such as disease, deformations, parasites, or hybridization). The resulting data were analyzed using RFAI methodology.

The RFAI uses 12 fish community metrics from four general categories: Species Richness and Composition; Trophic Composition; Abundance; and Fish Health. Individual species can be utilized for more than one metric. Together, these 12 metrics provide a balanced evaluation of fish community integrity. The individual metrics are described below, grouped by category:

Species Richness and Composition

(1) Total number of species -- Greater numbers of species are considered to be representative of healthier aquatic ecosystems. As conditions degrade, numbers of species at an area decline.

(2) Number of centrarchid species -- Sunfish species (excluding black basses) are invertivores and a high diversity of this group is indicative of reduced siltation and suitable sediment quality in littoral areas.

(3) Number of benthic invertivore species -- Due to the special dietary requirements of this species group and the limitations of their food source in degraded environments, numbers of benthic invertivore species increase with better environmental quality.

(4) Number of intolerant species -- A group comprised of species that are particularly intolerant of physical, chemical, and thermal habitat degradation. Higher numbers of intolerant species suggest the presence of fewer environmental stressors.

(5) Percentage of tolerant individuals (excluding young-of-year) -- A metric that signifies poorer water quality with increasing proportions of individuals tolerant of degraded conditions.

(6) Percent dominance by one species -- Ecological quality is considered reduced if one species inordinately dominates the resident fish community.

(7) Percentage of non-indigenous species -- Based on the assumption that non-indigenous species reduce the quality of resident fish communities.

(8) Number of top carnivore species -- Higher diversity of piscivores is indicative of the availability of diverse and plentiful forage species and the presence of suitable habitat.

Trophic Composition

(9) Percentage of individuals as top carnivores -- A measure of the functional aspect of top carnivores which feed on major planktivore populations.

(10) Percentage of individuals as omnivores -- Omnivores are less sensitive to environmental stresses due to their ability to vary their diets. As trophic links are disrupted due to degraded conditions, specialist species such as insectivores decline while opportunistic omnivorous species increase in relative abundance.

Abundance

(11) Average number per run -- (number of individuals) -- A metric based on the assumption that high quality fish assemblages support large numbers of individuals.

Fish Health

(12) Percentage of individuals with anomalies -- Occurrence of diseases, lesions, tumors, external parasites, deformities, blindness, and natural hybridization is noted. A higher proportion of individuals exhibiting such conditions is representative of poor environmental conditions.

RFAI methodology addresses all four attributes or characteristics of a "balanced indigenous population" (BIP) defined by the CWA, as described below:

(1) **A biotic community characterized by diversity appropriate to the ecoregion**: Diversity is addressed by the metrics in the Species Richness and Composition category, especially metric 1 – "Number of indigenous species." Determination of reference conditions based on the transition zones of lower mainstem Tennessee River reservoirs (as described below) ensures appropriate species expectations for the ecoregion.

(2) **The capacity for the community to sustain itself through cyclic seasonal change**: TVA uses an autumn data collection period for biological indicators, both VS and upstream/downstream monitoring. Autumn monitoring is used to document community condition or health after being subjected to the wide variety of stressors throughout the year. One of the main benefits of using biological indicators is their ability to integrate stressors through time. Examining the condition or health of a community at the end of the "biological year" (i.e., autumn) provides insight into how well the community has dealt with the stresses through an annual seasonal cycle. Likewise, evaluation of the condition of individuals in the community (in this case, individual fish as reflected in Metric 12) provides insight into how well the community can be expected to withstand stressors through winter. Further, multiple sampling years during the permit renewal cycle add to the evidence of whether or not the autumn monitoring approach has correctly demonstrated the ability of the community to sustain itself through repeated seasonal changes.

(3) **The presence of necessary food chain species**: Three dominant fish trophic levels exist within Tennessee River reservoirs: insectivores, omnivores, and top carnivores. To determine the presence of necessary food chain species, these three groups should be well represented within the overall fish community. Other fish trophic levels include benthic invertivores, planktivores, herbivores, and parasitic species. Insectivores include most sunfish, minnows, and silversides. Omnivores include gizzard shad, common carp, carpsuckers, buffalo, and channel and blue catfish. Top carnivores include black and temperate bass, gar, skipjack herring, crappie, flathead catfish, sauger, and walleye. Benthic invertivores include drum, suckers, and darters. Planktivores include alewife, threadfin shad, and paddlefish. Herbivores include largescale stonerollers. Lampreys in the genus *Ichthyomyzon* are the only parasitic species occurring in Tennessee River reservoirs.

To establish expected proportions of each trophic guild and the expected number of species included in each guild occurring in lower mainstem Tennessee River reservoirs (Kentucky, Pickwick, Wilson, Wheeler, and Guntersville reservoirs), data collected from 1993 through 2010 were analyzed for each reservoir zone (forebay, transition, inflow). Samples collected in the downstream vicinity of thermal discharges were not included in this analysis so that accurate expectations could be calculated with the assumption that these data represent what should occur in lower mainstem Tennessee River reservoirs absent from point source effects (i.e. power plant discharges). Data from 900 electrofishing runs (a total of 405,000 meters of shoreline sampled) and from 600 overnight experimental gill net sets were included in this analysis for transition areas in lower mainstem Tennessee River reservoirs. From these data, the range of proportional values for each trophic level and the range of the number of species included in each trophic level were trisected. This trisection is intended to show less than expected, expected or average, and above expected or average values for trophic level proportions and species occurring within each reservoir zone in lower mainstem Tennessee River reservoirs (Table 2). These data were also averaged and bound by confidence intervals (95 %) to further evaluate expected values for proportions of each trophic level and the number of species expected for each trophic level by reservoir zone (Table 3).

(4) A lack of domination by pollution-tolerant species: Domination by pollution-tolerant species is determined by metrics 3 ("Number of benthic invertivore species"), 4 ("Number of intolerant species"), 5 ("Percentage of tolerant individuals"), 6 ("Percent dominance by one species"), and 10 ("Percentage of individuals as omnivores").

Scoring categories are based on "expected" fish community characteristics in the absence of human-induced impacts other than impoundment of the reservoir. These categories were developed from historical fish assemblage data representative of transition zones from lower mainstem Tennessee River reservoirs (Hickman and McDonough, 1996). Attained values for each of the 12 metrics were compared to the scoring criteria and assigned scores to represent relative degrees of degradation: least degraded (5); intermediate degraded (3); and greatest degraded (1). For both the upstream (TRM 295.9) and the downstream (TRM 292.5) stations, RFAI metrics were scored using evaluation criteria for the "transition" reservoir zone (Table 4).

If a metric was calculated as a percentage (e.g., "Percentage of tolerant individuals"), the data from electrofishing and gill netting were scored separately and allotted half the total score for that individual metric. Individual metric scores for a sampling area (i.e., upstream or downstream) are summed to obtain the RFAI score for the area.

TVA uses RFAI results to determine maintenance of BIP using two approaches. One is "absolute" in that it compares the RFAI scores and individual metrics to predetermined values. The other is "relative" in that it compares RFAI scores attained downstream to the upstream control site. The "absolute" approach is based on Jennings et al. (1995) who suggested that favorable comparisons of the attained RFAI score from the potential impact zone to a predetermined criterion can be used to identify the presence of normal community structure and function and hence existence of BIP. For multi-metric indices, TVA uses two criteria to ensure a conservative screening of BIP. First, if an RFAI score reaches 70% of the highest attainable score of 60 (adjusted upward to include sample variability as described below), and second, if

fewer than half of RFAI metrics receive a low (1) or moderate (3) score, then normal community structure and function would be present indicating that BIP had been maintained, thus no further evaluation would be needed.

RFAI scores range from 12 to 60. Ecological health ratings (12-21 ["Very Poor"], 22-31 ["Poor"], 32-40 ["Fair"], 41-50 ["Good"], or 51-60 ["Excellent"]) are then applied to scores. As discussed in detail below, the average variation for RFAI scores in TVA reservoirs is 6 ($\pm$ 3). Therefore, any location that attains an RFAI score of 45 (42 plus the upward sample variation of 3) or higher would be considered to have BIP. It must be stressed that scores below this threshold do not necessarily reflect an adversely impacted fish community. The threshold is used to serve as a conservative screening level; i.e., any fish community that meets these criteria is obviously not adversely impacted. RFAI scores below this level would require a more in-depth look to determine if BIP exists. An inspection of individual RFAI metric results and species of fish used in each metric would be an initial step to help identify if operation of BFN is a contributing factor. This approach is appropriate because a validated multi-metric index is being used and scoring criteria applicable to the zone of study are available.

A difference in RFAI scores attained at the downstream area compared to the upstream (control) area is used as one basis for determining presence or absence of impacts on the resident fish community from BFN's operations. The definition of "similar" is integral to accepting the validity of these interpretations. The Quality Assurance (QA) component of the Vital Signs monitoring program deals with how well the RFAI scores can be repeated and is accomplished by collecting a second set of samples at 15%-20% of the areas each year. Comparison of paired-sample QA data collected over seven years shows that the difference in RFAI index scores ranges from 0 to 18 points. The mean difference between these 54 paired scores is 4.6 points with 95% confidence limits of 3.4 and 5.8. The 75th percentile of the sample differences is 6, and the 90th percentile is 12. Based on these results, a difference of 6 points or less in the overall RFAI scores is the value selected for defining "similar" scores between upstream and downstream fish communities. That is, if the downstream RFAI score is within 6 points of the upstream score and if there are no major differences in overall fish community composition, then the two locations are considered similar. It is important to bear in mind that differences greater than 6 points can be expected simply due to method variation (i.e., 25% of the QA paired sample sets exceeded a difference of 6). An examination of the 12 metrics (with emphases on fish species used for each metric) is conducted to determine any difference in scores and the potential for the difference to be thermally related.

Traditional Analyses
In addition to RFAI analyses, data were analyzed using traditional statistical methods. Data from the survey were used to calculate catch per unit effort (CPUE), which was expressed as number of fish per electrofishing run. CPUE values were calculated by pollution tolerance, trophic guilds (e.g., benthic invertivores, top carnivores, etc.), thermal sensitivity (Yoder et al. 2006), and indigenousness. CPUE, species richness, and diversity values were computed for each electrofishing effort (to maximize sample size; n = 30) and compared upstream and downstream to assess potential effects of power plant discharges.

Diversity was quantified using two commonly used diversity indices: Shannon diversity index (Shannon 1948) and Simpson diversity index (Simpson 1949). Both indices account for the number of species present, as well as the relative abundance of each species.

Shannon diversity index values were computed using the formula:

$$H' = -\sum_{i=1}^{S}\left(\frac{n_i}{N}\right)\ln\left(\frac{n_i}{N}\right)$$

where:
S = total number of species
N = total number of individuals
n_i = total number of individuals in the i^{th} species

The Simpson diversity index was calculated as follows:

$$D_S = \left(\sum_{i=1}^{S}\left(\frac{n_i}{N}\right)^2\right) - 1$$

where:
S = total number of species
N = total number of individuals
n_i = total number of individuals in the i^{th} species

An independent two-sample *t*-test was used to test for differences in CPUE, species richness, and diversity values upstream and downstream of BFN ($\alpha = 0.05$). Before statistical tests were performed using this method, data were analyzed for normality using the Shapiro-Wilk test (Shapiro and Wilk, 1965) and homogeneity of variance using Levene's test (Levene, 1960). Non-normal data or data with unequal variances were transformed using square root conversion or the ln(x+1) transformation. Transformed data were reanalyzed for normal distribution and equal variances. If transformation normalized the data and/ or resulted in homogeneous variances, transformed data were tested using an independent two-sample *t*-test. If transformed data were not normally distributed or had unequal variances, statistical analysis was conducted using the Wilcoxon-Mann-Whitney test (Mann and Whitney, 1947; Wilcoxon, 1945).

Benthic Macroinvertebrate Community Sampling Methods and Data Analysis for Sites Upstream and Downstream of BFN

Along each of the three transects described above, a benthic grab sample was collected at each of ten points, equally-spaced from the LDB to the RDB. A Ponar sampler (area per sample 0.06 m^2) was used for most samples. When heavier substrate was encountered, a Peterson sampler (area per sample 0.11 m^2) was used. Each sample was washed on a 533µ screen, and organisms were picked from the screen and from any remaining substrate. For each sample, organisms and substrate were placed in a sample jar and fixed in formalin. In most previous sample years, samples were processed in the field, which limited the accuracy of taxa identification and

abundance. In 2011, samples were lab-processed by an independent consultant who identified each organism to the lowest possible taxonomic level.

The samples were evaluated using seven community characteristics, or "metrics". Results for each metric were compared to reference conditions developed for VS reservoir inflow sample sites, and based on this comparison, were then assigned a score of 1, 3, or 5. The increased accuracy of lab-processed samples requires that they be scored using different criteria than those for field-processed samples. Scoring criteria for both processing methods of samples collected from lower mainstem Tennessee River reservoirs are shown in Table 5.

To produce an overall benthic score for each sample site, the scores for the seven metrics were summed: potential scores ranged from 7 to 35. Ecological health ratings (7-12 "Very Poor", 13-18 "Poor", 19-23 "Fair", 24-29 "Good", or 30-35 "Excellent") were then applied to scores. The individual metrics are shown below:

(1) **Average number of taxa**—calculated by averaging the total number of taxa present in each sample at a site. Greater taxa richness indicates better conditions than lower taxa richness.

(2) **Proportion of samples with long-lived organisms**—a presence/absence metric which is evaluated based on the proportion of samples with at least one long-lived organism (*Corbicula, Hexagenia,* mussels, or snails) present. The presence of long-lived taxa is indicative of conditions which allow long-term survival.

(3) **Average number of EPT taxa**—calculated by averaging the number of *Ephemeroptera* (mayfly), *Plecoptera* (stonefly), and *Trichoptera* (caddis fly) taxa present in each sample at a site. Higher diversity of these taxa indicates good water quality and better habitat conditions.

(4) **Average proportion of Oligochaete individuals**—calculated by averaging the percentage of oligochaetes in each sample at a site. Oligochaetes are considered tolerant organisms so a higher proportion indicates poorer water quality.

(5) **Average proportion of total abundance comprised by the two most abundant taxa**—calculated by selecting the two most abundant taxa in a sample, summing the number of individuals in those two taxa, dividing that sum by the total number of animals in the sample, and converting to a percentage for that sample. The percentage is then averaged for the 10 samples at each site. Often, the most abundant taxa differed among the 10 samples at a site. This allows more discretion to identify imbalances at a site than developing an average for a single dominant taxon for all samples at a site. This metric is used as an evenness indicator. Dominance of one or two taxa indicates poor conditions.

(6) **Average density excluding Chironomids and Oligochaetes**—calculated by first summing the number of organisms, excluding chironomids and oligochaetes, present in each sample and then averaging these densities for the 10 samples at a site. This metric examines the community, excluding taxa which often dominate under adverse conditions. A higher abundance of non-chironomids and non-oligochaetes indicates good water quality conditions.

(7) **Zero-samples: Proportion of samples containing no organisms**—the proportion of samples at a site which have no organisms present. "Zero-samples" indicate living conditions unsuitable to support aquatic life (i.e. toxicity, unsuitable substrate, etc.). Any site having one empty sample was assigned a score of three, and any site with two or more empty samples received a score of one. Sites with no empty samples were assigned a score of five.

A similar or higher benthic index score at the downstream site compared to the upstream site is used as basis for determining absence of impact on the benthic macroinvertebrate community related to BFN's thermal discharge. The QA component of VS monitoring shows that the comparison of benthic index scores from 49 paired sample sets collected over the past seven years range from 0 to 14 points, the 75th percentile is 4, the 90th percentile is 6. The mean difference between these 49 paired scores is 3.1 points with 95% confidence limits of 2.2 and 4.1. Based on these results, a difference of 4 points or less is the value selected for defining "similar" scores between upstream and downstream benthic communities. That is, if the downstream benthic score is within 4 points of the upstream score, the communities will be considered similar and it will be concluded that BFN has had no effect. Once again, it is important to bear in mind that differences greater than 4 points can be expected simply due to method variation (25% of the QA paired sample sets exceeded that value). When such occurs, a metric-by-metric examination will be conducted to determine what caused the difference in scores and the potential for the difference to be thermally related.

Prior to 2000, a sampling site in the forebay zone of Wheeler Reservoir (TRM 277) was used as the downstream comparison site. Other factors unrelated to influence from BFN have kept benthic communities depressed, both at the forebay site and in the Elk River embayment (Wheeler Reservoir, Elk River Mile [ERM] 6 – between BFN and the forebay site). In order to more accurately assess the effects from BFN, a second transition zone site two miles downstream from the BFN diffuser at TRM 291.7 was created in 2000. Benthic scores and community composition from this site have been used since 2000 for downstream comparisons.

Visual Encounter Survey (Wildlife Observations)

Two permanent transects were established both upstream and downstream of the BFN effluent. The midpoint of the upstream transect was positioned at the RFAI upstream study area and spanned a distance of 2,100 m within this transect (Figure 4). The downstream transect was directly below the power plant and likewise spanned a distance 2,100 m (Figure 3). The beginning and ending point of each transect was marked with GPS for relocation. Transects were positioned approximately 30 m offshore and parallel to the shoreline occurring on both right and left descending banks. Basic inventories were conducted to provide a representative sampling of wildlife present in autumn.

Each transect was surveyed by steadily traversing the length by boat and simultaneously recording observations of wildlife. Sampling frame of each transect generally followed the strip or belt transect concept with all individuals enumerated that crossed the center-line of each transect landward to an area that included the shoreline and riparian zone (i.e., belt width generally averages 60 m where vision is not obscured). Information recorded included wildlife identification (to the lowest taxonomic trophic level) that was observed visually and/or detected audibly and a direct count of individuals observed per trophic level. If flocks of a species or

mixed flock of a group of species were observed, an estimate of the number of individuals present was generated. Time was recorded at the start and end points of each transect to provide a general measure of effort expended. However, times may vary among transects primarily due to the difficulty in approaching some wildlife species without inadvertently flushing them from basking or perching sites. To compensate for the variation of effort expended per transect, observations were standardized to numbers per minute or numbers per hectare in preparation for analysis.

The principal objective and purpose behind the surveys were to provide a preliminary set of observations to verify trophic levels of birds, mammals, amphibians and reptiles have not been affected by thermal effects from the BFN discharge. If trophic levels were not represented, further investigations will be used to target specific species and/or species groups (guilds) in an attempt to determine the cause.

Thermal Plume Characterization

Physical measurements were taken to characterize and map the BFN thermal plume concurrent with biological field sampling. Measurements were collected during periods of low to no power production from BFN. This effort allowed general delineation of the "Primary Study Area" per the EPA (1977) draft guidance defined as the "*entire geographic area bounded annually by the locus of the 2°C above ambient surface isotherms as these isotherms are distributed throughout an annual period*", ensuring placement of the biological sampling locations within thermally influenced areas.

However, it is important to emphasize that the ≥2°C isopleth boundary is not a bright line; it is dynamic, changing geometrically in response to changes in ambient river flows and temperatures and BFN operations. As such, samples collected outside of, but generally proximate to the Primary Study Area boundary should not be discounted as non-thermally influenced. Every effort was made to collect biological samples in thermally affected areas as guided by the Primary Study Area definition.

Field activities included measurement of surface to bottom temperature profiles along transects across the plume. One transect was located proximate to the thermal discharge point; subsequent downstream transects were concentrated in the near field area of the plume where the change in plume temperature was expected to be most rapid. The distance between transects in the remainder of the Primary Study Area increased with distance downstream or away from the discharge point. The farthest downstream transect was just outside of the Primary Study Area. A transect upstream of the discharge that is not affected by the thermal plume was included for determining ambient temperature conditions. The total number of transects needed to fully characterize and delineate the plume were determined in the field.

Temperature profile measurement (surface to bottom) points along a given transect were spaced equally across the river channel. Points began at or near the shoreline from which the discharge originates and continued across the plume [based on surface (0.1 m or 0.3 ft) depth measurements] until the far shore was reached. Measurements along transects were conducted at points 10%, 30%, 50%, 70%, and 90% from the originating shoreline. The distances between transects and measurement points depended on the size of the discharge plume.

The temperature measurement instrument (Hydrolab®) was calibrated to a thermometer whose calibration is traceable to the National Institute of Standards and Technology. Temperature data were compiled and analyzed to present the horizontal and vertical dimensions of the BFN thermal plume, which was used to demonstrate the existence of a zone of passage under and/or around the plume.

Wheeler Reservoir Flow and BFN Temperature

Total daily average discharge from Guntersville Dam was used to describe the volume of water flowing past BFN and was obtained from TVA's River Operations database.

Water temperature data were obtained from TVA's River Operations database. Locations of water temperature monitoring stations used to measure water temperatures upstream of BFN intake and downstream of BFN discharge are depicted in Figure 6. Ambient temperatures upstream of the BFN intake were measured at Station 4, located at TRM 297.8. Upstream daily mean temperatures were calculated by averaging temperatures collected at depths of 3-, 5-, and 7-feet. Temperatures downstream of BFN discharge were measured at Stations 1, 16, and 17, all located at TRM 293.5. Downstream temperatures were calculated by first averaging temperatures at each station across depths of 3, 5, and 7 feet. The resultant values from each station were then averaged together to obtain overall mean daily water temperatures downstream of BFN.

Water Quality Parameters at Fish Sampling Stations during RFAI Samples

Water quality conditions were measured each season at both the upstream (TRM 295.9) and downstream (TRM 292.5) stations using a hydrolab® that provided readings for water temperature (°C), conductivity (µS/cm), dissolved oxygen (ppm), and pH. Three samples—one at the left descending bank, one at mid-channel, and one at the right descending bank—were collected at three locations within each sample station—the most downstream boundary, the mid-point, and the most upstream boundary—for a total of nine samples per station. For each sample, readings were recorded at 1 to 2 meter intervals along a vertical gradient from just above the bottom of the river to approximately 0.3 meters from the surface.

Results and Discussion

Aquatic Habitat in the Vicinity of Browns Ferry Nuclear Plant

Shoreline Aquatic Habitat Assessment

Of the sixteen shoreline transects sampled upstream of BFN, 19% (3 transects) rated "Good," 8% (12 transects) "Fair," and 6% (1 transect) "Poor." The average score for transects on the left descending bank was 24 ("Fair"), while scores for transects on the right descending bank averaged 23 ("Fair"). The average SAHI score for both shorelines was 23.5 ("Fair"). The average percentage of macrophytes was 0% on each shoreline (Table 6).

Of the sixteen shoreline transects sampled downstream of BFN, 0% scored as good, 88% (14 transects) scored as fair, and 12% (2 transects) scored as poor. The average scores for transects on the LDB were equal to those on the RDB (20 "Fair"). The average percentage of macrophytes was 0% on each shoreline (Table 7).

River Bottom Habitat
Figures 7-10 compare substrate proportions at each sample point along each of the 8 transects downstream of BFN during autumn 2009. Figures 11-14 compare substrate proportions at each sample point along each of the 8 transects upstream of BFN (Figure 5).

The three most dominant substrate types encountered along the 8 transects downstream of BFN were silt (65.1%), mollusk shell (19.4%), and sand (5.4%). Silt (51.1%), mollusk shell (32.0%), and sand (5.1%) were also the dominant substrate types observed along the 8 transects upstream of BFN (Table 8).

Aquatic Habitat Summary
In summary, shoreline habitat was similar between the BFN downstream and upstream sites, as average scores were 23.5 and 20, respectively, both ratings of "Fair." Silt, mollusk shell, and sand were the three dominant substrate types at both upstream and downstream sites; therefore, river bottom habitat was similar between sites.

Fish Community

In autumn 2011, fish community RFAI scores of 38 ("Fair") and 40 ("Fair") were observed at the downstream and upstream stations, respectively. A comparison of each RFAI metric score between sites is shown in Table 9. Fish species collected upstream and downstream of BFN and corresponding catch rates are shown in Tables 10 and 11. RFAI scores from previous years at these and other monitoring stations in Wheeler Reservoir are shown in Table 12.

Results for each metric, as they apply to the characteristics of BIP, are discussed below.

(1) A biotic community characterized by diversity appropriate to the ecoregion

Number of indigenous species (> 30 required for highest score)
Twenty-eight indigenous species were collected downstream and 29 upstream, resulting in mid-range (3) metric scores for both stations. Four species, black redhorse, chestnut lamprey, redbreast sunfish, and silver redhorse, were collected in small numbers (four individuals or less) downstream of BFN but were not collected upstream. Five species (largescale stoneroller, logperch, longnose gar, northern hogsucker, and yellow bass) were collected at the upstream site only. Largescale stoneroller, logperch, and northern hogsucker were represented by only one individual each.

Number of centrarchid species (> 2 required for highest score)
Eight centrarchid species were collected downstream and 7 upstream, resulting in the highest metric score (5) for both stations. Redbreast sunfish (2 individuals collected downstream) was the only species not collected at both sites.

Number of benthic invertivore species (> 7 required for highest score)
Four benthic invertivore species were collected at each station, resulting in mid-range scores at both sites. Freshwater drum and spotted sucker were collected at both stations, black redhorse and silver redhorse were collected at the downstream site only, and logperch and northern hogsucker were collected at the upstream site only.

Number of intolerant species (> 4 required for highest score)
Five intolerant species were collected at both upstream and downstream sites, resulting in the highest metric score at both sites. Longear sunfish, skipjack herring, smallmouth bass, and spotted sucker were collected at both stations. Black redhorse was collected at the downstream site only and northern hogsucker was collected only at the upstream site.

Number of top carnivore species (> 7 required for highest score)
Nine top carnivore species were collected at the downstream site and eleven at the upstream site, which resulted in scores of 5 for both sites. In addition to the top carnivore species encountered at the downstream station (black crappie, flathead catfish, largemouth bass, skipjack herring, smallmouth bass, spotted bass, spotted gar, white bass, and white crappie), longnose gar and yellow bass were collected upstream of BFN.

Both sites received the same scores for each of the metrics discussed above. These results demonstrate the presence of diverse fish communities upstream and downstream of BFN.

(2) The capacity for the community to sustain itself through cyclic seasonal change

Number of indigenous species (> 30 required for highest score)
The species composition of the autumn sample should be indicative of the ability of the fish community to withstand the stressors of an annual seasonal cycle. During autumn 2011, 28 indigenous species were collected downstream of BFN and 29 upstream; total numbers of species at both sites were within the range of variability observed at each site from autumn 2000 through 2011. Numbers of indigenous species collected from autumn 2000 through 2011 ranged from 23 to 28 at the downstream site and 24 to 32 at the upstream site (Figure 15).

Percentage of anomalies (< 2% required for highest score)
The percentage of anomalies (i.e. visible lesions, bacterial and fungal infections, parasites, muscular and skeletal deformities, and hybridization) observed in samples is an indicator of the ability of the fish community to withstand the stressors of an annual seasonal cycle. Percentages of anomalies at both sampling sites were low, resulting in the highest score (5) for this metric at both sites.

During autumn 2011, species diversity was similar and percentages of anomalies were low at both sites, indicating that fish communities were able to sustain themselves through cyclic seasonal change.

(3) The presence of necessary food chain species

The trophic composition of the fish community upstream and downstream of BFN was similar during autumn 2011. At both sites, insectivores and omnivores were dominant trophic guilds (Table 2; Figure 16). Mississippi silversides and bluegill were abundant in samples and accounted for the majority of insectivores at each site. Gizzard shad constituted approximately 90% of omnivores collected at each site. Twice the total number of top carnivores were collected upstream of BFN than downstream, but proportions of top carnivores were lower than expected at both sites (Tables 2 and 3). Percentages of planktivores (threadfin shad was only planktivore species collected) were similar between sites, but the percentages of benthic invertivores were low at both sites. One parasitic species (one chestnut lamprey) was collected downstream and none were collected upstream. One herbivore (one largescale stoneroller) was collected upstream and none downstream.

Proportions of insectivores and planktivores were within the expected range for lower mainstem Tennessee River reservoir transition zones for both sampling sites (Tables 2 and 3; Figure 16). Proportions of benthic invertivores and top carnivores were below expected values at both sites. Omnivores were above expected values at both stations which could be an indicator of water quality impairment at both stations. Parasitic and herbivore species are infrequently collected, and when collected, are typically present in low numbers as was the case at both stations.

Overall, the number of species collected met or exceeded expectations at both downstream and upstream sites during autumn 2011 (Tables 2 and 3). At the downstream site six trophic levels were represented, which included four benthic invertivore, eight insectivore, seven omnivore, one planktivore, one parasitic, and nine top carnivore species. At the upstream site, six trophic levels were represented and included four benthic invertivore, seven invertivore, seven omnivore, one planktivore, 11 top carnivore, and one herbivore species.

Proportions and numbers of species of each trophic guild were similar between sites; therefore, it was determined that the downstream site was similar to the upstream site during autumn 2011 with respect to the presence of necessary food chain species.

(4) A lack of domination by pollution-tolerant species

Number of intolerant species (> 4 required for highest score)
In autumn 2011, five pollution intolerant species were collected at both upstream and downstream sites. Both sites received the highest score of 5 for this metric. Longear sunfish, skipjack herring, smallmouth bass, and spotted sucker were collected at both stations. Black redhorse was collected at the downstream site only and northern hogsucker at the upstream site only (Table 9).

Percentage of tolerant individuals (for highest score, < 27% required in electrofishing sample and < 15% required in gill netting sample)
At the downstream site, nine pollution tolerant species were collected which consisted of 59.6% of the electrofishing sample and 40.0% of the gill netting sample. Similarly, nine pollution tolerant species were collected upstream composing 54.6% of the electrofishing sample and

36.0% of the gill netting sample. Both sites received the lowest score (1) for this metric (Tables 9, 10, and 11).

Eight tolerant species, bluegill, common carp, gizzard shad, golden shiner, green sunfish, largemouth bass, spotfin shiner, and white crappie, were collected at both sites. Redbreast sunfish was collected at the downstream site only and longnose gar at the upstream site only. Gizzard shad was the most abundant species collected by both electrofishing and gill netting methods at both sites (34.6% - electrofishing downstream, 32.2% - gill netting downstream; 36.8% - electrofishing upstream, 15.1% - gill netting upstream).

Percentage of omnivores (for highest score, < 24% required in electrofishing sample; < 16% required in gill netting sample)
During autumn of 2011, seven omnivore species (channel catfish, common carp, gizzard shad, golden shiner, smallmouth buffalo, black buffalo, and blue catfish) were collected at both sites. At the downstream site, omnivores constituted 37.8% of the electrofishing sample and 52.9% of the gill netting sample. At the upstream site, omnivores made up 41.0% of the electrofishing sample and 33.7% of the gill netting sample. Both sites received scores of 2 for this metric.

Percent dominance by one species (for highest score, < 29% required in electrofishing sample; < 17% required in gill netting sample)
Gizzard shad were dominant in both electrofishing and gill net samples at the downstream site. Gizzard shad dominated the electrofishing sample and white bass dominated the gill net sample at the upstream site. Both sites received a mid-range score for this metric.

The downstream and upstream sites scored equally in the 4 pollution tolerance metrics. Fish communities at both sites showed relatively low abundance and consisted of relatively high percentages of non-indigenous and pollution-tolerant individuals. It was, therefore, determined that the downstream site was similar to the upstream site during autumn 2011 with respect to the lack of domination by pollution-tolerant species.

Traditional Analyses
Two species richness parameters (benthic invertivore and intolerant species) were statistically ($P<0.05$) higher at the downstream site than upstream site. Although the differences were not significant, 3 species richness parameters (total number of species and insectivore and planktivore species) were higher at the downstream site and 3 (omnivore, top carnivore, and tolerant species) were higher at the upstream site (Table 13).

Of the parameters comparing CPUE, one (CPUE of top carnivore individuals) was statistically significant, being higher at the upstream site than downstream. Two CPUE parameters (CPUEs of omnivores and planktivores) were higher upstream of BFN than downstream, but the differences were not significant. Total CPUE and CPUEs of benthic invertivores, insectivores, tolerant, and intolerant individuals were higher at the downstream site, but differences were not significant.

Both diversity values were similar between sites (Table 13).

Fish Community Summary

Overall RFAI scores were similar between the downstream (38 -"Fair") and upstream (40 - "Fair") sampling sites. The score at the downstream site was within the 6-point range of acceptable variation when compared the upstream site. Therefore, the downstream site met BIP screening criteria and was considered similar to the upstream site.

As previously discussed, RFAI scores have an intrinsic variability of ± 3 points. This variability comes from various sources, including annual variations in air temperature and stream flow; variations in pollutant loadings from nonpoint sources; changes in habitat, such as extent and density of aquatic vegetation; natural population cycles and movements of the species being measured. Another source of variability arises from the fact that nearly any practical measurement, lethal or non-lethal, of a biological community is a sample rather than a measurement of the entire population. As long as the score is within the 6-point range, there is no certainty that any real difference exists beyond method variability. This variability due to methods must be considered when comparing scores between sampling sites.

In summary, diversity was similar between downstream and upstream sites. Numbers of both omnivore and top carnivore species exceeded expected values at both sites, while numbers of species collected were lower than expected for only one trophic guild at each site (herbivores downstream and parasitic species upstream). Numbers of all other trophic guilds were within expected ranges (Tables 2, 10 and 11). Proportions observed were within or above the expected ranges for four trophic guilds downstream and for three trophic guilds upstream (Table 2; Figure 16). It was therefore concluded that necessary food chain species were present in at both sites.

Both sites received identical combined scores for 11 of the twelve RFAI metrics in 2011. The downstream station earned scores of 3 or 5 for eight RFAI metrics, but earned the lowest score (1) for the metrics "Percent tolerant individuals," "Average number per run," the electrofishing portion of "Percent top carnivores," and the gill netting portion of "Percent omnivores." The upstream site earned scores of 3 or 5 for nine of the twelve RFAI metrics, but earned the lowest score (1; 0.5 for metrics portioned by gear) for metrics "Percent tolerant individuals," "Average number per run," and the gill netting portion of "Percent omnivores."

Two thermally sensitive species were collected at the upstream site and one downstream (Tables 10 and 11). Thermally sensitive species are defined as those having an upper lethal limit for water temperatures less than 90°F, as determined by Yoder et al. (2006). Nine commercially valuable species were collected at the downstream site and seven at the upstream site (Table 10 and 11). Commercially valuable species include freshwater drum, buffalo, and all members of the catfish and sucker families (ALDCNR, 2012). Twenty-one recreationally valuable species were collected both sites (Tables 10 and 11). Recreationally valuable species are those species that are commonly sought by anglers, bowfishers, or used for bait. All fish species collected were considered Representative Important Species because all species were used to obtain overall RFAI scores. Representative important species are defined in EPA guidance as those species which are representative, in terms of their biological requirements, of a balanced, indigenous community of fish, shellfish, and wildlife in the body of water into which a discharge is released (EPA and NRC 1977).

Autumn RFAI sampling was conducted upstream and downstream of BFN from 2000 through 2011. RFAI scores during this period averaged 41 for both upstream and downstream sites (Table 12), resulting in an ecological health rating of "Good" for both sites. Both sites were within the 6-point range of accepted variability each year—with the exception of 2005 when the upstream station scored 10 points higher—indicating the stations were similar annually and that the BFN heated effluent has not adversely affected the fish community in the vicinity of BFN (Table 12).

RFAI scores are presented for the Wheeler Reservoir inflow site (TRM 348.0), the forebay site (TRM 277.0), and the Elk River embayment site (ERM 6.0) to provide additional information about the health of the fish community throughout the reservoir. However, aquatic communities at these sites are not subjected to the effects of thermal effluent from Brown's Ferry Nuclear Plant and are not used to determine the status of a BIP in relation to BFN. Average RFAI scores at these three sites among all sampling years have remained in the "Good" range (Table 12).

Given the comparison of RFAI scores and analysis of the four characteristics of BIP and their respective metrics discussed above, it can be concluded that during autumn 2011 the fish community at the site downstream of BFN was similar to that at the control site upstream.

Benthic Macroinvertebrate Community

Data used to evaluate the benthic macroinvertebrate community near BFN were collected from three sites during autumn 2011. RBI metrics for all three sites were scored using evaluation criteria for laboratory-processed samples collected in the "transition" reservoir zone (Table 5). Data collected at TRM 290.4 downstream of the thermal plume earned an overall RBI score of 21 ("Fair"), and from TRM 293.2, within the thermal plume, a score of 23 ("Fair"). Data from the upstream site, TRM 295.9, earned an overall RBI score of 27 ("Good") (Table 13).

Conditions among sites are considered "similar" if RBI scores for the sites differ by four points or less. The two sites downstream differed by two points and were considered similar based on the definition above. The upstream site, TRM 295.9, and the site within the thermal plume, TRM 293.2, differed by four points and were also considered similar. The score at TRM 295.9 (upstream) was six points higher than that at TRM 290.4 (farthest downstream), and these two sites were not deemed similar. Based on these comparisons, it was concluded that conditions for the benthic macroinvertebrate community were somewhat degraded between the upstream and the most downstream sampling sites.

In order to help determine the causes of the differences in scores from upstream to downstream, the discussion below compares each individual metric among the three sites sampled. To aid in this discussion, historic data from sites upstream and downstream of BFN were referenced. However, it is important to note that comparisons of these data to those collected in 2011 are limited for several reasons. Firstly, in previous years a single downstream site was established at TRM 291.7, while in 2011 data were collected at two sites downstream of BFN: one within the thermal plume at TRM 293.2 and one downstream of the plume at TRM 290.4. Secondly, data collected in 2011 were processed in a laboratory. Most samples collected for RBI analysis during the years 2000 through 2010 were field-processed and scored using different criteria than those used for laboratory-processed samples. Metric values and the resultant scores based on

field-processed criteria for the years 2000 through 2010 are presented in Table 15. However, some samples collected during this period were processed in a laboratory. The metric values and the resultant scores based on lab-processed criteria are included for comparison in Table 16.

Average number of taxa (> 6.6 required for highest score)
The former downstream site (TRM 291.7) earned a field-based score of 3 for the year 2000, but earned the highest score (5) for each year from 2001 through 2010. The mean value over the period from 2000 through 2010 is 5.7 taxa per sample. The site upstream (TRM 295.9) earned a field-based score of 5 for each year from 2000 through 2009, and earned a score of 3 for 2010. The mean value over the period from 2000 through 2010 is 5.5 taxa per sample (Table 15).

Lab-based scoring at the downstream site generated the highest score (5) for four of the five years sampled, and a score of 3 for 2002. The mean value over the five years of lab-processed data is 7.6 taxa per sample. The upstream site earned lab-based scores of 3 for two (2003, 2004) of the six years sampled and 5 for the other four years. The mean value over six years of lab-processed data is 7.4 taxa per sample (Table 16).

In 2011, an average of 6.2 taxa per sample was collected at the newly established site further downstream at TRM 290.4, resulting in a score of 3. At the upstream site, an average of 8.4 taxa per sample was collected, resulting in a score of 5. The average value at the site within the plume (TRM 293.2) was 11.7 taxa per sample, which earned the site a score of 5 (Table 14). This value was appreciably higher than any lab- or field-based scores previously observed either downstream or upstream of this site over the history of sampling at BFN.

Proportion of samples with long-lived organisms (> 0.9 required for highest score)
The downstream site (TRM 291.7) earned field-based scores of 5 for each year from 2000 to 2008 and midrange scores of 3 for 2009 and 2010. The proportion of samples with long-lived organisms was 1.0 from 2000 through 2007, but decreased to 0.9 in 2008 and again to 0.7 in 2009 and 2010. The upstream site earned the highest score of 5 for all years sampled except 2008, when the score was 3 (Table 15).

For all years in which samples were lab-processed, the downstream site earned the highest score of 5. The upstream site earned lab-based scores of 5 from 2001 through 2004, but earned scores of 3 for 2006 and 2011 (Table 16).

In 2011, at the most downstream site (TRM 290.4) the proportion was 0.6. Within the plume (TRM 293.2), 0.8 of samples contained long-lived organisms, compared with 0.7 of the samples upstream. All three sites earned midrange scores (3) (Table 14).

Average number of EPT taxa (> 1.4 required for highest score)
The site at TRM 291.7 earned field-based scores of 5 for each year from 2000 through 2008, but scores dropped to 3 in 2009 and 2010. The upstream site (TRM 295.9) earned field-processed mid-range scores or higher (3 or 5) for all years during this period with no discernible trend (Table 15).

The downstream site earned lab-based scores of 3 from 2001 through 2004, but the highest score of 5 for 2006. The mean value over this period was 1.12 EPT taxa per sample. The upstream site earned lab-based scores of 3 for all years sampled, with a mean value over these years of 1.0 EPT taxa per sample (Table 16).

In 2011, an average of 0.7 EPT taxa per sample was recorded at the most downstream site. Within the plume, an average of 1.2 EPT taxa per sample was recorded, compared to 1.0 EPT taxa per sample upstream. All three sites earned mid-range scores (3) (Table 14).

Average proportion of oligochaete individuals (< 11% required for highest score)
Both downstream and the upstream sites earned field-based scores of 5 for all years from 2000 through 2010 (Table 15).

The downstream site earned scores of 5 for each year of lab-processed samples. The mean percentage of oligochaetes for the five years sampled was 4.6%. The upstream site also earned lab-based scores of 5 for each year of sampling. The mean percentage of oligochaetes for the six years sampled was 4.2% (Table 16).

In 2011, 5% of the average sample downstream at TRM 290.4 was oligochaete organisms, compared with 6.3% upstream at TRM 295.9. Both these sites earned the highest score of 5, based on lab processing. Within the plume however, at TRM 293.2, the average percentage of oligochaete organisms per sample was 35.4%, resulting in the lowest score (1) (Table 14).

Proportion of total abundance comprised by two dominant taxa (< 77.8% required for highest score)
The site downstream earned field-based midrange scores or higher (3 or 5) for eight of the eleven years sampled and scores of 1 for three years (2002, 2009 and 2010). The mean proportion downstream over the years 2000 through 2010 was 78.7%, the criteria limit for a mean score of 5 (Table 5). The site upstream earned mid-range scores or higher for ten of the eleven years sampled, and it earned the lowest score for only one year (2010). The mean proportion upstream for the years 2000 through 2010 was 79.8% (Table 15).

For years with lab-scored samples, the downstream site earned the lowest score for only one year (2002). The mean value downstream over the five years sampled was 76.9% for an average score of 5.

In 2011, the same two taxa – the chironomid species *Coelotanypus tricolor* and the fingernail clam *Musculium transversum* – were the most abundant at all three sites. At the most downstream site, these two taxa made up 89.2% of the average sample, resulting in the lowest score (1). Within the thermal plume, these two taxa constituted 80.6% of the average sample, resulting in a mid-range score (3). Upstream, these two taxa composed 81.1% of the average sample, also resulting in a score of 3 (Tables 14 and 16).

Average density excluding chironomids and oligochaetes (> 609.9/m^2 required for highest score)
Based on field-processing criteria, the downstream site at TRM 291.7 earned the lowest score (1) for eight of the eleven years from 2000 through 2010, mid-range scores (3) for 2004 and 2005

and the highest score (5) for 2003. The upstream site also showed poor results for this metric, earning mid-range scores for five years (2003 through 2007) and the lowest scores for the other six years during this period (Table 15).

Lab-based scores were generally the same as field-based scores. The downstream site earned higher lab-based scores of 3 in 2001 and 2006. For all other years sampled, the lab-based scores were the same as the field-based scores: 1 (2002), 5 (2003), 3 (2004). Upstream, lab-based scores were the same as field-based for all years except 2006, when the lab score was higher (5) (Table 16).

In 2011, the site further downstream at TRM 290.4 earned the lowest score (1), with an average density of taxa other than chironomids and oligochaetes of 193.3 organisms per m^2. The densities of these organisms increased progressively from downstream to upstream: for the site within the plume, the density was 321.7 organisms per m^2, which earned a midrange score (3); for the site farthest upstream, the density was 430 organisms per $meter^2$, also earning a midrange score (3) (Table 14).

<u>*Proportion of samples containing no organisms*</u> (all samples must contain organisms for highest score)
No "zero" samples have been collected at any of the sites since 2000. All sites sampled earned the highest rating (5) for each year from 2000 through 2011 (Tables 14, 15, and 16).

Benthic Macroinvertebrate Community Summary
During autumn 2011, the overall score of 21 ("Fair") for the most downstream site (TRM 290.4) was due primarily to low scores for the metrics "Proportion of total abundance comprised by two dominant taxa " and "Average density excluding chironomids and oligochaetes." Additionally, the site received a lower score than the other sites for the metric "Average number of taxa" (Table 14). The total mean density at this site was 578 organisms per m^2, compared to 1,077 organisms per m^2 within the plume and 1,197 organisms per m^2 upstream (Table 17). These values indicate that the benthic macroinvertebrate community at the most downstream site was less diverse and was more heavily dominated (89.2%) by the two most abundant taxa than either of the other two sites upstream (Table 14).

At the site within the thermal plume (TRM 293.2), 50 different taxa were collected in 2011, compared with 42 upstream and 31 downstream (Table 17). Both the average number of taxa per sample (11.7 organisms/m^2) and the percentage of oligochaetes per sample (35.4%) were greater than any values previously recorded at any of the sites around BFN (Table 14). Excluding chironomids and oligochaetes, the average density of the remaining taxa was still fairly high (321.7 organisms/m^2), which suggests that the high percentage of oligochaetes at this site was made up of relatively few species collected in high numbers (Table 14).

Silt was the primary component in substrate dredge samples collected upstream; seven samples contained 75% or more silt, while two samples contained mollusk shell in proportions of 85% or more. The second most abundant component was mollusk shell, ranging from 5% to 45% in five samples. Clay constituted 50% of one sample and gravel 15% of another. At the most downstream site, silt was even more abundant in dredge samples as nine of ten samples

contained 80% or more silt, five of which contained 98% silt. The second most abundant component was mollusk shell, ranging from 1% to 20% in six of ten samples. No clay, sand, or gravel was observed in significant amounts in any sample (Table 18).

At the site within the plume, mollusk shell was the most abundant component, ranging from 50 to 100% in five samples; these samples contained sand or gravel as the secondary component. Silt was the primary component in only three samples ranging from 50 to 95%, with detritus as the secondary component (Table 18).

Based on these observations, it was concluded that differences in diversity and abundance of benthic macroinvertebrates, and thus the difference in the overall RBI scores between the upstream and the most downstream sites, were due primarily to the differences in substrate composition. Silt, compared to larger particle substrates such as sand, gravel, and cobble, leaves little space for macroinvertebrate colonization and can quickly become anoxic. The large proportion of silt and the particular lack of sand or gravel at the downstream sites indicate that less suitable habitat was available for benthic macroinvertebrates compared to upstream.

Similarly, the greater comparative abundance of sand, gravel, mollusk shell, and detritus at the site within the thermal plume helps to explain the "spikes" in the number and density of taxa that were observed at this point between the upstream and downstream sites.

To provide additional data on the overall health of the benthic macroinvertebrate community in Wheeler Reservoir, RBI scores for the inflow, forebay, and Elk River embayment sites are presented in Table 19. Comparison of these scores to current RBI scores at the sites near BFN is limited for two reasons. First, as discussed previously the data from these sites were scored from field-based criteria and cannot be directly compared to lab-based scores. Second, these sites are many river miles away from BFN. The inflow site is 53 river miles upstream, and the forebay site located 17 river miles downstream. The Elk River embayment site is located 10 river miles downstream of BFN. Because of these distances from the plant, poor scores at these sites cannot be considered indicative of thermal effects from BFN.

The inflow site (TRM 347) earned RBI ratings of "Good" or "Excellent" for 10 of the 13 years sampled, while the Wheeler Reservoir forebay site (TRM 277) and the Elk River embayment site (ERM 6.0) both consistently earned "Poor" scores for all years sampled (Table 19). Based on the correlation of RBI scores to benthic substrate discussed above, it is hypothesized that these scores fit the same pattern: relatively high flow within the inflow reservoir zone keeps silt suspended in the water column and results in higher quality habitat for benthic macroinvertebrates, while as flow slows through the transition zone and into the forebay and embayment areas, silt settles to the bottom, resulting in lower quality habitat within these areas.

Overall, it was concluded that the health of the benthic macroinvertebrate community around BFN was relative to the composition of the substrate on the river bottom, and that the health of the community was better in areas with higher proportions of large particle substrates, such as sand, gravel, and mollusk shell. In addition, it was further concluded that the benthic macroinvertebrate community downstream of BFN was not affected by thermal effluent from the plant in 2011.

Visual Encounter Survey (Wildlife Observations)

Numbers and categories of wildlife observed during autumn of 2011 survey are presented in Table 20. Observations recorded were almost entirely birds commonly associated with riparian or shoreline habitat: kingfishers, sandpipers, blackbirds, herons, and ducks. Other bird species observed included American crow and unidentifiable species of songbirds. The only reptiles recorded were turtles, observed on the left descending bank of the upstream station. No amphibians or mammals were observed.

The observations recorded indicate fair diversity of common waterfowl and shoreline birds and both sites were similar. However, the lack of observations of other groups targeted by this survey limits what we can conclude about the health of the wildlife community upstream and downstream of BFN. Limited observations of reptiles and mammals in this survey were due primarily to the fact that wildlife species are not easily observed by passing visual observation, being cryptically patterned and secretive in behavior. The Visual Encounter Survey provides a preliminary near shore wildlife assessment to determine if the thermally affected area downstream of a power plant has adversely affected the bird, reptile, amphibian and mammal communities. If such adverse environmental impact is suspected, more semi-quantitative sampling strategies, such as trapping or netting, active search, investigation of mammal tracks along shoreline areas, long-term observation from blinds, or the use of cameras will be proposed to accurately estimate the presence and diversity of these groups.

Thermal Plume Characterization

On the date of the autumn sample, the BFN thermal plume extended downstream approximately 2.8 miles to TRM 291.2. The average ambient surface water temperature (0.3 m and 1 m depths) measured upstream at TRM 296.5 on the date of the survey was 76.3°F. The thermal plume (water 3.6°F or 2.0°C above ambient) was detected at all sampling locations (10, 30, 50, and 70% of RDB) across the river channel at TRM 294, except the one nearest the left descending bank (90% from RDB). The thermal plume was detected only to the mid-channel sampling location (50% from RDB) at TRM 292.4 and only at the sampling location nearest the RDB (10% from RDB) at TRM 291.2 (Table 21; Figure 3). TRM 291.2 was considered the downstream limit of the thermal plume.

In summary, the entire biomonitoring zone downstream of BFN was not contained within the thermal plume when measured in autumn 2011.

Wheeler Reservoir Flow and BFN Water Temperature

Daily mean flows from Guntersville Dam over the fiscal year 2011 (October 2010 through November 2011) are compared in Figure 17 to historic daily mean flows over the same fiscal year period, averaged from 1976 through 2010.

Figure 18 compares daily average water temperatures recorded upstream of BFN intake (TRM 294.4) and downstream of BFN discharge (TRM 293.6) during October 2010 through November 2011. Water temperatures were similar at both stations through this period.

Water Quality Parameters at Fish Sampling Stations during RFAI Samples

Values of water quality parameters (water temperature, dissolved oxygen, conductivity, and pH) collected along vertical depth profiles at nine locations within each RFAI sample station are presented in Table 22.

Depth profiles of water temperature at the sites downstream (TRM 292.5) and upstream (TRM 295.9) of BFN are presented for comparison in Figures 19 and 20, respectively. Water temperatures collected downstream ranged from 71° to 78°F and 68° to 75°F upstream. With one exception, all profiles generally indicate a decrease in temperature as depth increased. At the upstream station, temperatures were collected at only the surface and at 1.5 m depth for the profile at the left descending bank of the upstream boundary, and within this limited range temperature increased slightly (Table 22).

Depth profiles of conductivity at the downstream and upstream sites are presented for comparison in Figures 21 and 22, respectively. Conductivity at the downstream site ranged from 176.5 to 181.5 µS/cm and 178 to 190 µS/cm upstream, with the exception of the profile for the left descending bank of the upper boundary that ranged from 198 to 202 µS/cm. Conductivity measurements presented in this profile were collected only at the surface and at 1.5 m depth (Table 22).

Depth profiles of dissolved oxygen (DO) concentration at the downstream and upstream sites are presented for comparison in Figures 23 and 24, respectively. Downstream, DO concentrations ranged from 7.7 to 11.8 ppm, and upstream from 6.9 to 10.6 ppm. Profiles collected at the downstream site generally indicated that DO concentrations decreased with increasing depth, while the profiles collected upstream indicated no relationship between DO concentration and water depth (Table 22).

Depth profiles of acidity (pH level) for the downstream and upstream stations are presented for comparison in Figures 25 and 26, respectively. Downstream, pH level ranged from 7.39 to 8.58, and profiles generally showed pH level decreased as depth increased. Upstream, pH level ranged from 7.15 to 8.41, but the profiles collected generally showed little change in pH level as depth increased (Table 22).

Water Quality Summary

Water temperatures at both RFAI stations were in the range expected for lower mainstem Tennessee River reservoirs in autumn, and the profiles indicated little to no thermal stratification, which is typical during autumn. Conductivity values observed at both RFAI stations were within a range of 14 units and indicated stable concentrations of dissolved ions. Concentrations of dissolved oxygen at both RFAI sites were within the range expected for lower mainstem Tennessee River reservoirs in autumn, and profiles indicated little difference in concentrations as depth increased from surface to bottom. Values of pH at both RFAI stations were slightly alkaline, but within the range of expected values.

Based on these results, it was concluded that water temperatures, conductivity, dissolved oxygen concentrations and pH levels were similar at all stations sampled around BFN during October

2011. We further conclude that the values of these parameters indicate that the water around BFN during autumn 2011 was of a quality capable of supporting, in fair ecological health, a balanced indigenous population of the type expected for this reservoir, and that water quality was not affected by thermal effluent from BFN.

<u>Literature Cited</u>

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Table 1. Shoreline Aquatic Habitat Index (SAHI) metrics and scoring criteria.

Metric	Scoring Criteria	Score
Cover	Stable cover (boulders, rootwads, brush, logs, aquatic vegetation, artificial structures) in 25 to 75% of the drawdown zone	5
	Stable cover in 10 to 25% or > 75% of the drawdown zone	3
	Stable Cover in < 10% of the drawdown zone	1
Substrate	Percent of drawdown zone with gravel substrate > 40	5
	Percent of drawdown zone with gravel substrate between 10 and 40	3
	Percent substrate gravel < 10	1
Erosion	Little or no evidence of erosion or bank failure. Most bank surfaces stabilized by woody vegetation.	5
	Areas of erosion small and infrequent. Potential for increased erosion due to less desirable vegetation cover (grasses) on > 25% of bank surfaces.	3
	Areas of erosion extensive, exposed or collapsing banks occur along > 30% of shoreline.	1
Canopy Cover	Tree or shrub canopy > 60% along adjacent bank	5
	Tree or shrub canopy 30 to 60% along adjacent bank	3
	Tree or shrub canopy < 30% along adjacent bank	1
Riparian Zone	Width buffered > 18 meters	5
	Width buffered between 6 and 18 meters	3
	Width buffered < 6 meters	1
Habitat	Habitat diversity optimum. All major habitats (logs, brush, native vegetation, boulders, gravel) present in proportions characteristic of high quality, sufficient to support all life history aspects of target species. Ready access to deeper sanctuary areas present.	5
	Habitat diversity less than optimum. Most major habitats present, but proportion of one is less than desirable, reducing species diversity. No ready access to deeper sanctuary areas.	3
	Habitat diversity is nearly lacking. One habitat dominates, leading to lower species diversity. No ready access to deeper sanctuary areas.	1
Gradient	Drawdown zone gradient abrupt (> 1 meter per 10 meters). Less than 10% of shoreline with abrupt gradient due to dredging.	5
	Drawdown zone gradient abrupt. (> 1 meter per 10 meters) in 10 to 40% of the shoreline resulting from dredging. Rip-rap used to stabilize bank along > 10% of the shoreline.	3
	Drawdown zone gradient abrupt in > 40 % of the shoreline resulting from dredging. Seawalls used to stabilize bank along > 10 % of the shoreline.	1

Table 2. Expected values for lower mainstem Tennessee River reservoir transition zone calculated from data collected from 900 electrofishing runs and 600 overnight experimental gill net sets in transition areas of lower mainstem Tennessee River reservoirs. This trisection is intended to show below expected (-), expected (Avg), and above expected (+) values for trophic level proportions and species occurring within the transition zone in lower mainstem Tennessee River reservoirs.

	Lower Mainstem Tennessee River Transition						Observed Downstream of BFN (TRM 292.5)		Observed Upstream of BFN (TRM 295.9)	
	Proportion (%)			Number of species						
Trophic Guild	-	Avg	+	-	Avg	+	Proportion (%)	Number of Species	Proportion (%)	Number of Species
Benthic Invertivore	< 6.7	6.4 to 13.4	> 13.4	< 3	3 to 5	> 5	2.5	4	1.5	4
Insectivore	< 24.6	24.6 to 49.1	> 49.1	< 4	4 to 8	> 8	40.9	8	31.2	7
Top Carnivore	< 15.1	15.1 to 30.2	> 30.2	< 4	4 to 8	> 8	5.2	9	10.6	11
Omnivore	> 38.5	19.3 to 38.5	< 19.3	> 6	3 to 6	< 3	38.5	7	40.7	7
Planktivore	> 18.7	9.4 to 18.7	< 9.4	0	1	> 1	12.8	1	16.0	1
Parasitic	< 0.1	0.1 to 0.2	> 0.2	0	1	> 1	0.1	1	---	---
Herbivore	<1.8	1.8 to 3.6	>3.6	0	1	> 1	---	---	0.1	1

Table 3. Average trophic guild proportions and average number of species, bound by confidence intervals (95 %), expected in lower mainstem Tennessee River reservoir transition zones. These values were calculated from data collected from 900 electrofishing runs and 600 overnight experimental gill net sets in transition areas of lower mainstem Tennessee River reservoirs.

Trophic Guild	Lower Mainstem TN River Reservoir Transition Zones	
	Average Proportion (%)	Average Number of Species
Benthic Invertivore	5.5 ± 1.2	5 ± 1
Insectivore	40.0 ± 4.5	8 ± 1
Top Carnivore	18.3 ± 2.2	10 ± 1
Omnivore	28.7 ± 3.3	6 ± 1
Planktivore	6.4 ± 2.6	1 ± 1
Parasitic	0.1 ± 0.04	1 ± 0
Herbivore	0.6 ± 0.4	1 ± 0

Table 4. RFAI scoring criteria (2002) for fish community samples in forebay, transition, and inflow sections of lower mainstem Tennessee River reservoirs, which include Guntersville, Wheeler, Wilson, Pickwick, and Kentucky. Transition criteria were used to score the sites upstream and downstream of Browns Ferry Nuclear Plant.

		Scoring Criteria								
		Forebay			Transition			Inflow		
Metric	**Gear**	**1**	**3**	**5**	**1**	**3**	**5**	**1**	**3**	**5**
1. Total species	Combined	<14	14-27	>27	<16	16-30	>30	<14	14-27	>27
2. Total Centrarchid species	Combined	<2	2-3	>3	<2	2-2	>2	<2	2-4	>4
3. Total benthic invertivores	Combined	<4	4-6	>6	<4	4-7	>7	<4	4-7	>7
4. Total intolerant species	Combined	<2	2-4	>4	<3	3-4	>4	<3	3-6	>6
5. Percent tolerant individuals	Electrofishing	>61%	30-61%	<30%	>54%	27-54%	<27%	>51%	26-51%	<26%
	Gill netting	>46%	22-46%	<22%	>30%	15-30%	<15%			
6. Percent dominance by 1 species	Electrofishing	>59%	30-59%	<30%	>58%	29-58%	<29%	>47%	24-47%	<24%
	Gill netting	>43%	21-43%	<21%	>34%	17-34%	<17%			
7. Percent non-indigenous species	Electrofishing	>2%	2-2%	<2%	>2%	1-2%	<1%	>4%	2-4%	<2%
	Gill netting	>2%	1-2%	<1%	>2%	1-2%	<1%			
8. Total top carnivore species	Combined	<4	4-7	>7	<4	4-7	>7	<4	4-7	>7
9. Percent top carnivores	Electrofishing	<6%	6-12%	>12%	<5%	5-10%	>10%	<15%	15-29%	>29%
	Gill netting	<25%	25-49%	>49%	<20%	20-39%	>39%			
10. Percent omnivores	Electrofishing	>59%	30-59%	<30%	>48%	24-48%	<24%	>48%	24-48%	<24%
	Gill netting	>49%	24-49%	<24%	>33%	16-33%	<16%			
11. Average number per run	Electrofishing	<170	170-341	>341	<243	243-487	>487	<68	68-136	>136
	Gill netting	<20	20-40	>40	<11	11-22	>22			
12. Percent anomalies	Electrofishing	>5%	2-5%	<2%	>5%	2-5%	<2%	>5%	2-5%	<2%
	Gill netting	>5%	2-5%	<2%	>5%	2-5%	<2%			

Table 5. Scoring criteria for RBI analysis of benthic macroinvertebrate samples, compared for the different zones of mainstem Tennessee River reservoirs and for two different sample processing strategies (lab-processing and field-processing).

Benthic Community Metrics	Field-processing Criteria								
	Forebay			Transition			Inflow		
	1	3	5	1	3	5	1	3	5
Average number of taxa	≤2.4	2.5-4.7	≥4.8	≤2.1	2.2-4.3	≥4.4	≤2.8	2.9-5.7	≥5.8
Proportion of samples with long-lived organisms	≤0.3	0.4-0.7	≥0.8	≤0.3	0.4-0.7	≥0.8	≤0.3	0.4-0.7	≥0.8
Average number of EPT (Ephemeroptera, Plecoptera, Trichoptera)	≤0.4	0.5-0.7	≥0.8	≤0.3	0.4-0.7	≥0.8	≤0.3	0.4-0.7	≥0.8
Average proportion of oligochaete individuals	≥29.7	14.9-29.6	≤14.8	≥28.0	14.0-27.9	≤13.9	≥40.0	20.1-39.9	≤20.0
Average proportion of total abundance comprised by the two most abundant taxa	≥90.7	81.4-90.6	≤81.3	≥87.8	78.8-87.7	≤78.7	≥85.0	78.8-84.9	≤78.7
Average density excluding chironomids and oligochaetes	≤118	119-235	≥236	≤291	292-580	≥581	≤568	569-1152	≥1153
Zero-samples - proportion of samples containing no organisms	≥0.2	0.1	0	≥0.2	0.1	0	≥0.2	0.1	0

Benthic Community Metrics	Lab-processing Criteria								
	Forebay			Transition			Inflow		
	1	3	5	1	3	5	1	3	5
Average number of taxa	< 2.8	2.8-5.5	> 5.5	< 3.3	3.3-6.6	> 6.6	< 4.2	4.2-8.3	> 8.3
Proportion of samples with long-lived organisms	< 0.6	0.6-0.8	> 0.8	< 0.6	0.6-0.9	> 0.9	< 0.6	0.6-0.8	> 0.8
Average number of EPT (Ephemeroptera, Plecoptera, Trichoptera)	< 0.6	0.6-0.9	> 0.9	< 0.6	0.6-1.4	> 1.4	< 0.9	0.9-1.9	> 1.9
Average proportion of oligochaete individuals	> 41.9	41.9-21.0	< 21.0	> 21.9	21.9-11.0	< 11.0	> 23.9	23.9-12.0	< 12.0
Average proportion of total abundance comprised by the two most abundant taxa	> 90.3	90.3-81.7	< 81.7	> 87.9	87.9-77.8	< 77.8	> 86.2	86.2-73.1	< 73.1
Average density excluding chironomids and oligochaetes	< 125.0	125.0-249.9	> 249.9	< 305.0	305.0-609.9	> 609.9	< 400.0	400.0-799.9	> 799.9
Zero-samples - proportion of samples containing no organisms	> 0	---	0	> 0	---	0	> 0	---	0

Table 6. SAHI scores for 16 sections of shoreline assessed within the RFAI fish community sample area upstream of BFN, autumn 2009.

Left Descending Bank	1	2	3	4	5	6	7	8	Avg.
Latitude	34.68917	34.6832	34.6806	34.67959	34.67709	34.66978	34.67027	34.66841	
Longitude	-87.13621	-87.13172	-87.12188	-87.1183	-87.10876	-87.10915	-87.10009	-87.09753	
Aquatic Macrophytes	0%	0%	0%	0%	0%	0%	0%	0%	0%
SAHI Variables									
Cover	3	1	3	5	1	3	3	3	3
Substrate	1	5	3	3	5	1	1	1	3
Erosion	3	5	5	3	3	3	3	3	4
Canopy Cover	5	5	5	5	5	5	5	5	5
Riparian Zone	1	5	5	5	3	5	5	5	4
Habitat	3	3	1	3	1	3	1	1	2
Slope	1	5	5	1	3	5	1	1	3
Total	**17**	**29**	**27**	**25**	**21**	**25**	**19**	**19**	**24**
Rating	**Fair**	**Good**	**Good**	**Fair**	**Fair**	**Fair**	**Fair**	**Fair**	**Fair**
Right Descending Bank	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Avg.**
Latitude	34.70109	34.69937	34.69862	34.6986	34.69566	34.69302	34.69062	34.68843	
Longitude	-87.11896	-87.11535	-87.10973	-87.10061	-87.09157	-87.08836	-87.08452	-87.08094	
Aquatic Macrophytes	0%	0%	0%	0%	0%	0%	0%	0%	0%
SAHI Variables									
Cover	3	3	5	5	1	1	5	5	4
Substrate	1	5	1	5	5	5	5	5	4
Erosion	5	5	5	5	5	1	5	5	5
Canopy Cover	1	5	5	1	1	5	1	1	3
Riparian Zone	1	5	5	1	1	5	1	1	3
Habitat	3	1	3	1	1	1	1	1	2
Slope	1	3	1	1	3	1	1	1	2
Total	**15**	**27**	**25**	**19**	**17**	**19**	**19**	**19**	**23**
Rating	**Poor**	**Good**	**Fair**	**Fair**	**Fair**	**Fair**	**Fair**	**Fair**	**Fair**

Scoring criteria: poor (7-16); fair (17-26); and good (27-35).

Table 7. SAHI scores for 16 sections of shoreline assessed within the RFAI fish community sample area downstream of BFN, autumn 2009.

Left Descending Bank	1	2	3	4	5	6	7	8	Avg.
Latitude	34.72824	34.72603	34.72398	34.72068	34.71496	34.7128	34.71082	34.70351	
Longitude	-87.1759	-87.1728	-87.1704	-87.1678	-87.4621	-87.1577	-87.1543	-87.1488	
Aquatic Macrophytes	0%	0%	0%	0%	0%	0%	0%	0%	0%
SAHI Variables									
Cover	1	3	1	1	1	1	1	3	2
Substrate	5	1	1	5	5	5	5	5	4
Erosion	1	5	5	1	1	1	5	5	3
Canopy Cover	5	5	5	5	5	5	3	1	4
Riparian Zone	5	5	5	5	5	5	3	1	4
Habitat	3	3	1	1	1	1	1	1	2
Slope	1	1	1	1	1	1	1	3	1
Total	**21**	**23**	**19**	**19**	**19**	**19**	**19**	**19**	**20**
Rating	**Fair**	**Fair**	**Fair**	**Fair**	**Fair**	**Fair**	**Fair**	**Fair**	**Fair**

Right Descending Bank	1	2	3	4	5	6	7	8	Avg.
Latitude	34.74369	34.74081	34.73891	34.73519	34.73081	34.7266	34.72058	34.71239	
Longitude	-87.1565	-87.1522	-87.1507	-87.1475	-87.1428	-87.1376	-87.1325	-87.1275	
Aquatic Macrophytes	0%	0%	0%	0%	0%	0%	0%	0%	0%
SAHI Variables									
Cover	3	3	3	1	5	5	5	1	3
Substrate	1	1	5	5	1	5	1	5	3
Erosion	5	1	1	1	5	5	5	5	4
Canopy Cover	5	5	5	5	3	3	1	1	4
Riparian Zone	3	5	3	5	1	1	1	1	3
Habitat	3	1	1	1	3	1	1	1	2
Slope	1	1	1	1	1	1	1	1	1
Total	**21**	**17**	**19**	**19**	**19**	**21**	**15**	**15**	**20**
Rating	**Fair**	**Fair**	**Fair**	**Fair**	**Fair**	**Fair**	**Poor**	**Poor**	**Fair**

Scoring criteria: poor (7-16); fair (17-26); and good (27-35).

Table 8. Substrate percentages and average water depth (ft) per transect upstream and downstream of BFN, autumn 2009.

Upstream of BFN	% Substrate per transect								
Substrate Type	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**AVG**
Silt	68.5	45.0	25.5	49.0	27.1	79.5	56.0	58.0	51.1
Mollusk Shell	3.5	30.5	45.5	38.5	56.8	13.5	38.0	30.0	32.0
Sand	12.5	0	19.0	0	9.0	0	0	0	5.1
Detritus	4.0	2.0	0.5	2.5	7.5	2.5	5.5	10.0	4.3
Boulder	9.0	9.5	0	10.0	0	0	0	0	3.6
Gravel	0.5	0.5	9.0	0	1.5	0.5	0.5	0	1.6
Cobble	1.0	10.0	0.5	0	0.5	0	0	0	1.5
Clay	0	0	0	0	0	0	4.0	0	0.5
Average Depth (ft)	19.2	17.4	13.3	17.5	16.2	15.0	15.5	15.5	16.2
Actual Depth Range: 6.5 to 36.9 ft									

Downstream of BFN	% Substrate per transect								
Substrate Type	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**AVG**
Silt	75.4	80.5	77.0	56.3	69.5	55.5	44.0	62.5	65.1
Mollusk Shell	22.6	12.5	14.5	32.0	7.0	11.5	26.0	29.0	19.4
Sand	0	0	0.0	9.1	9.0	9.0	17.0	0.0	5.5
Detritus	2.0	6.5	8.0	2.5	0.5	1.0	2.5	4.5	3.4
Bedrock	0	0	0.0	0.0	9.0	0.0	10.0	0.0	2.4
Boulder	0	0	0.0	0.0	0.0	10.0	0.0	0.0	1.3
Cobble	0	0	0.0	0.0	1.0	0.0	0.0	4.0	0.6
Gravel	0	0	1.0	0.0	0.0	0.0	0.5	0.0	0.2
Clay	0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Average Depth (ft)	21.0	20.0	20.2	18.7	18.3	18.9	20.6	20.2	19.7
Actual Depth Range: 9.1 to 31.7 ft									

Table 9. Individual metric scores and the overall RFAI scores downstream (TRM 292.5) and upstream (TRM 295.9) of Browns Ferry Nuclear Plant, Autumn 2011.

Autumn 2011 Metric	Gear	TRM 292.5 Obs	Score	TRM 295.9 Obs	Score
Species richness and composition					
1. Number of indigenous species		**28**	**3**	**29**	**3**
2. Number of Centrarchid species (less *Micropterus*)		**8** Black crappie Bluegill Green sunfish Longear sunfish Redbreast sunfish Redear sunfish Warmouth White crappie	**5**	**7** Black crappie Bluegill Green sunfish Longear sunfish Redear sunfish Warmouth White crappie	**5**
3. Number of benthic invertivore species		**4** Black redhorse Freshwater drum Silver redhorse Spotted sucker	**3**	**4** Freshwater drum Logperch Northern hog sucker Spotted sucker	**3**
4. Number of intolerant species		**5** Black redhorse Longear sunfish Skipjack herring Smallmouth bass Spotted sucker	**5**	**5** Longear sunfish Northern hog sucker Skipjack herring Smallmouth bass Spotted sucker	**5**
5. Percent tolerant individuals	EF	**59.6 %** Gizzard shad 34.6 % Bluegill 13.3 % Spotfin shiner 6.1 % Green sunfish 3.7 % Largemouth bass 1.6 % Common carp 0.1 % Golden shiner 0.1 % Redbreast sunfish 0.1 %	**0.5**	**54.6 %** Gizzard shad 36.8 % Bluegill 6.7 % Largemouth bass 5.9 % Green sunfish 2.6 % Golden shiner 1.4 % Spotfin shiner 0.8 % Common carp 0.3 % White crappie 0.1 %	**0.5**
	GN	**40.2 %** Gizzard shad 32.2 % White crappie 4.6 % Largemouth bass 3.4 %	**0.5**	**36.0 %** Gizzard shad 15.1 % Longnose gar 14.0 % Largemouth bass 3.5 % Bluegill 1.2 % Golden shiner 1.2 % White crappie 1.2 %	**0.5**

Table 9. (Continued)

Autumn 2011 Metric	Gear	TRM 292.5 Obs	TRM 292.5 Score	TRM 295.9 Obs	TRM 295.9 Score
6. Percent dominance by one species	EF	**34.6 %** Gizzard shad	**1.5**	**36.8 %** Gizzard shad	**1.5**
	GN	**32.2 %** Gizzard shad	**1.5**	**20.9 %** White bass	**1.5**
7. Percent non-indigenous species	EF	**15.7 %** Mississippi silverside 15.6 % Common carp 0.1 %	**0.5**	**19.8 %** Mississippi silverside 19.4 % Common carp 0.3 %	**0.5**
	GN	**0 %**	**2.5**	**0 %**	**2.5**
8. Number of top carnivore species		**9** Black crappie Flathead catfish Largemouth bass Skipjack herring Smallmouth bass Spotted bass Spotted gar White bass White crappie	**5**	**11** Black crappie Flathead catfish Largemouth bass Longnose gar Skipjack herring Smallmouth bass Spotted bass Spotted gar White bass White crappie Yellow bass	**5**
Trophic composition					
9. Percent top carnivores	EF	**3.8 %** Largemouth bass 1.6 % Smallmouth bass 1.6 % Flathead catfish 0.2 % Spotted gar 0.2 % Black crappie 0.1 % Spotted bass 0.1 %	**0.5**	**8.4%** Largemouth bass 5.9 % Smallmouth bass 1.0 % Flathead catfish 0.5 % Spotted gar 0.5 % Spotted bass 0.2 % Black crappie 0.1 % White crappie 0.1 % Yellow bass 0.1 %	**1.5**
	GN	**35.6 %** Flathead catfish 11.5 % White bass 9.2 % Skipjack herring 4.6 % White crappie 4.6 % Largemouth bass 3.4 % Spotted gar 2.3 %	**1.5**	**57.0 %** White bass 20.9 % Longnose gar 14.0 % Yellow bass 11.6 % Largemouth bass 3.5 % Flathead catfish 2.3 % Skipjack herring 2.3 % Smallmouth bass 1.2 % White crappie 1.2 %	**2.5**

Table 9. (Continued)

Autumn 2011 Metric	Gear	TRM 292.5 Obs	Score	TRM 295.9 Obs	Score
10. Percent omnivores	EF	**37.8 %** Gizzard shad 34.6 % Channel catfish 2.6 % Smallmouth buffalo 0.5 % Common carp 0.1 % Golden shiner 0.1 %	**1.5**	**41.0 %** Gizzard shad 36.8 % Channel catfish 2.2 % Golden shiner 1.4 % Common carp 0.3 % Smallmouth buffalo 0.3 %	**1.5**
	GN	**52.9 %** Gizzard shad 32.2 % Channel catfish 10.3 % Black buffalo 4.6 % Blue catfish 4.6 % Smallmouth buffalo 1.1 %	**0.5**	**33.7 %** Gizzard shad 15.1 % Channel catfish 11.6 % Black buffalo 2.3 % Blue catfish 2.3 % Golden shiner 1.2 % Smallmouth buffalo 1.2 %	**0.5**
Fish abundance and health					
11. Average number per run	EF	**118.9**	**0.5**	**120.7**	**0.5**
	GN	**8.7**	**0.5**	**8.6**	**0.5**
12. Percent anomalies	EF	**0.3 %**	**2.5**	**0.4 %**	**2.5**
	GN	**0 %**	**2.5**	**0 %**	**2.5**
Overall RFAI Score			**38** **Fair**		**40** **Fair**

RFAI Scores: 12-21 ("Very Poor"), 22-31 ("Poor"), 32-40 ("Fair"), 41-50 ("Good"), or 51-60 ("Excellent").

Table 10. Species collected, ecological and recreational designations, and corresponding electrofishing (EF) and gill net (GN) catch per unit effort downstream (TRM 292.5) of the BFN discharge – Autumn 2011.

Common Name	Scientific name	Trophic level	Indigenous species	Tolerance	Thermally Sensitive Species	Comm. Valuable Species	Rec. Valuable Species	EF Catch Per Run	EF Catch Per Hour	Total Fish EF	GN Catch Per Net	Total Fish GN	Total Fish Combined	Percent Composition
Gizzard shad	*Dorosoma cepedianum*	OM	X	TOL	.	.	X	41.13	188.69	617	2.80	28	645	34.5%
Common carp*	*Cyprinus carpio*	OM	.	TOL	.	.	X	0.07	0.31	1	.	.	1	0.1%
Golden shiner	*Notemigonus crysoleucas*	OM	X	TOL	.	.	X	0.07	0.31	1	.	.	1	0.1%
Spotfin shiner	*Cyprinella spiloptera*	IN	X	TOL	.	.	.	7.27	33.33	109	.	.	109	5.8%
Redbreast sunfish	*Lepomis auritus*	IN	X	TOL	.	.	X	0.13	0.61	2	.	.	2	0.1%
Green sunfish	*Lepomis cyanellus*	IN	X	TOL	.	.	X	4.40	20.18	66	.	.	66	3.5%
Bluegill	*Lepomis macrochirus*	IN	X	TOL	.	.	X	15.87	72.78	238	.	.	238	12.7%
Largemouth bass	*Micropterus salmoides*	TC	X	TOL	.	.	X	1.93	8.87	29	0.30	3	32	1.7%
White crappie	*Pomoxis annularis*	TC	X	TOL	.	.	X	.	.	.	0.40	4	4	0.2%
Skipjack herring	*Alosa chrysochloris*	TC	X	INT	.	.	X	.	.	.	0.40	4	4	0.2%
Spotted sucker	*Minytrema melanops*	BI	X	INT	X	X	.	0.47	2.14	7	.	.	7	0.4%
Black redhorse	*Moxostoma duquesnei*	BI	X	INT	.	X	.	0.53	2.45	8	.	.	8	0.4%
Longear sunfish	*Lepomis megalotis*	IN	X	INT	.	.	X	3.67	16.82	55	0.10	1	56	3.0%
Smallmouth bass	*Micropterus dolomieu*	TC	X	INT	.	.	X	1.93	8.87	29	.	.	29	1.5%
Spotted gar	*Lepisosteus oculatus*	TC	X	.	.	.	.	0.20	0.92	3	0.20	2	5	0.3%
Threadfin shad	*Dorosoma petenense*	PK	X	.	.	.	X	16.00	73.39	240	.	.	240	12.8%
Smallmouth buffalo	*Ictiobus bubalus*	OM	X	.	.	X	.	0.60	2.75	9	0.10	1	10	0.5%
Black buffalo	*Ictiobus niger*	OM	X	.	.	X	.	.	.	.	0.40	4	4	0.2%
Silver redhorse	*Moxostoma anisurum*	BI	X	.	.	X	.	0.07	0.31	1	.	.	1	0.1%
Blue catfish	*Ictalurus furcatus*	OM	X	.	.	X	X	.	.	.	0.40	4	4	0.2%
Channel catfish	*Ictalurus punctatus*	OM	X	.	.	X	X	3.07	14.07	46	0.90	9	55	2.9%
Flathead catfish	*Pylodictis olivaris*	TC	X	.	.	X	X	0.27	1.22	4	1.00	10	14	0.7%
White bass	*Morone chrysops*	TC	X	.	.	.	X	.	.	.	0.80	8	8	0.4%
Warmouth	*Lepomis gulosus*	IN	X	.	.	.	X	0.13	0.61	2	.	.	2	0.1%
Redear sunfish	*Lepomis microlophus*	IN	X	.	.	.	X	0.93	4.28	14	.	.	14	0.7%
Spotted bass	*Micropterus punctulatus*	TC	X	.	.	.	X	0.07	0.31	1	.	.	1	0.1%
Black crappie	*Pomoxis nigromaculatus*	TC	X	.	.	.	X	0.07	0.31	1	.	.	1	0.1%
Freshwater drum	*Aplodinotus grunniens*	BI	X	.	.	X	X	1.40	6.42	21	0.90	9	30	1.6%
Mississippi silverside*	*Menidia audens*	IN	.	.	.	.	.	18.60	85.32	279	.	.	279	14.9%
Chestnut lamprey	*Ichthyomyzon castaneus*	PS	X	.	.	.	.	0.07	0.31	1	.	.	1	0.1%
Total								**118.95**	**545.58**	**1,784**	**8.70**	**87**	**1,871**	**100.0%**
Number Samples								**15**			**10**			
Species Collected	**30**		**28**		**1**	**9**	**21**	**25**			**13**			

Trophic level: benthic invertivore (BI), insectivore (IN), omnivore (OM), top carnivore (TC); planktivore (PK), parasitic (PS). Tolerance: tolerant species (TOL), intolerant species (INT); Comm.-Commercially, Rec.-Recreationally. *Denotes aquatic nuisance species next to common name. All species are considered representative important species. No species collected have a Federal Threatened or Endangered status.

Table 11. Species collected, ecological and recreational designations, and corresponding electrofishing (EF) and gill net (GN) catch per unit effort upstream (TRM 295.9) of the BFN Plant discharge – Autumn 2011.

Common Name	Scientific name	Trophic level	Indigenous species	Tolerance	Thermally Sensitive Species	Comm. Valuable Species	Rec. Valuable Species	EF Catch Per Run	EF Catch Per Hour	Total Fish EF	GN Catch Per Net	Total Fish GN	Total Fish Combined	Percent Composition
Longnose gar	*Lepisosteus osseus*	TC	X	TOL	.	.	.	.	.	.	1.20	12	12	0.6%
Gizzard shad	*Dorosoma cepedianum*	OM	X	TOL	.	.	X	44.40	197.63	666	1.30	13	679	35.8%
Common carp*	*Cyprinus carpio*	OM	.	TOL	.	.	X	0.40	1.78	6	.	.	6	0.3%
Golden shiner	*Notemigonus crysoleucas*	OM	X	TOL	.	.	X	1.67	7.42	25	0.10	1	26	1.4%
Spotfin shiner	*Cyprinella spiloptera*	IN	X	TOL	.	.	.	0.93	4.15	14	.	.	14	0.7%
Green sunfish	*Lepomis cyanellus*	IN	X	TOL	.	.	X	3.13	13.95	47	.	.	47	2.5%
Bluegill	*Lepomis macrochirus*	IN	X	TOL	.	.	X	8.13	36.20	122	0.10	1	123	6.5%
Largemouth bass	*Micropterus salmoides*	TC	X	TOL	.	.	X	7.13	31.75	107	0.30	3	110	5.8%
White crappie	*Pomoxis annularis*	TC	X	TOL	.	.	X	0.13	0.59	2	0.10	1	3	0.2%
Skipjack herring	*Alosa chrysochloris*	TC	X	INT	.	.	X	.	.	.	0.20	2	2	0.1%
Northern hog sucker	*Hypentelium nigricans*	BI	X	INT	.	.	.	0.07	0.30	1	.	.	1	0.1%
Spotted sucker	*Minytrema melanops*	BI	X	INT	X	X	.	0.93	4.15	14	.	.	14	0.7%
Longear sunfish	*Lepomis megalotis*	IN	X	INT	.	.	X	1.80	8.01	27	.	.	27	1.4%
Smallmouth bass	*Micropterus dolomieu*	TC	X	INT	.	.	X	1.27	5.64	19	0.10	1	20	1.1%
Spotted gar	*Lepisosteus oculatus*	TC	X	.	.	.	.	0.60	2.67	9	.	.	9	0.5%
Threadfin shad	*Dorosoma petenense*	PK	X	.	.	.	X	20.20	89.91	303	.	.	303	16.0%
Largescale stoneroller	*Campostoma oligolepis*	HB	X	.	.	.	.	0.07	0.30	1	.	.	1	0.1%
Smallmouth buffalo	*Ictiobus bubalus*	OM	X	.	.	X	.	0.33	1.48	5	0.10	1	6	0.3%
Black buffalo	*Ictiobus niger*	OM	X	.	.	X	.	.	.	.	0.20	2	2	0.1%
Blue catfish	*Ictalurus furcatus*	OM	X	.	.	X	X	.	.	.	0.20	2	2	0.1%
Channel catfish	*Ictalurus punctatus*	OM	X	.	.	X	X	2.67	11.87	40	1.00	10	50	2.6%
Flathead catfish	*Pylodictis olivaris*	TC	X	.	.	X	X	0.60	2.67	9	0.20	2	11	0.6%
White bass	*Morone chrysops*	TC	X	.	.	.	X	.	.	.	1.80	18	18	0.9%
Yellow bass	*Morone mississippiensis*	TC	X	.	.	.	X	0.07	0.30	1	1.00	10	11	0.6%
Warmouth	*Lepomis gulosus*	IN	X	.	.	.	X	0.07	0.30	1	.	.	1	0.1%
Redear sunfish	*Lepomis microlophus*	IN	X	.	.	.	X	1.73	7.72	26	0.20	2	28	1.5%
Spotted bass	*Micropterus punctulatus*	TC	X	.	.	.	X	0.20	0.89	3	.	.	3	0.2%
Black crappie	*Pomoxis nigromaculatus*	TC	X	.	.	.	X	0.13	0.59	2	.	.	2	0.1%
Logperch	*Percina caprodes*	BI	X	.	X	.	.	0.07	0.30	1	.	.	1	0.1%
Freshwater drum	*Aplodinotus grunniens*	BI	X	.	.	X	X	0.47	2.08	7	0.50	5	12	0.6%
Mississippi silverside*	*Menidia audens*	IN	.	.	.	.	.	23.47	104.45	352	.	.	352	18.6%
Total								**120.67**	**537.10**	**1,810**	**8.60**	**86**	**1,896**	**100.0%**
Number Samples								**15**			**10**			
Species Collected	**31**		**29**		**2**	**7**	**21**	**26**			**17**			

Trophic level: benthic invertivore (BI), herbivore (HB), insectivore (IN), omnivore (OM), top carnivore (TC); planktivore (PK). Tolerance: tolerant species (TOL), intolerant species (INT); Comm.-Commercially, Rec.-Recreationally. *Denotes aquatic nuisance species next to common name. All species are considered representative important species. No species collected have a Federal Threatened or Endangered status.

Table 12. Summary of RFAI scores from sites located directly upstream and downstream of BFN and scores from sampling conducted during 1993 through 2011 as part of the Vital Signs monitoring program in Wheeler Reservoir.

Station	Location	1993	1994	1995	1997	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Avg.
Inflow	TRM 348.0	46	48	42	48	36	-	38	42	38	44	44	42	38	38	40	40	46	**42**
Transition BFN Upstream	TRM 295.9	45	45	34	40	30	41	37	43	39	43	46	41	39	42	39	44	40	**41**
Transition BFN Downstream	TRM 292.5	-	-	-	-	-	43	40	41	43	43	36	42	42	45	36	38	38	**41**
Forebay	TRM 277.0	52	44	48	45	42	-	41	45	44	43	45	46	49	46	47	40	46	**45**
Elk River Embayment	ERM 6.0	43	47	36	49	36	-	49	-	44	49	47	-	39	-	42	-	43	**44**

Note: No data were collected for 1996 and 1998.
RFAI Scores: 12-21 ("Very Poor"), 22-31 ("Poor"), 32-40 ("Fair"), 41-50 ("Good"), or 51-60 ("Excellent")

Table 13. Spatial statistical comparisons of numbers of fish species, mean electrofishing catch per unit effort values (number/run), tolerance designations, trophic levels, and non-indigenous individuals, along with species richness and Simpson and Shannon diversity values, collected downstream and upstream of Browns Ferry Nuclear Plant, autumn 2011.

Parameter	Mean (Standard Deviation) Downstream	Upstream	Significant Difference	Test Statistic(a)	P Value
Number of species (per run)					
Total (species richness)	16.5 (4.5)	14.7 (5.3)	No	t = 1.0	0.31
Benthic Invertivores	1.5 (0.7)	0.8 (0.9)	Yes	Z = -2.2	0.01
Insectivores	4.5 (1.7)	3.6 (1.6)	No	t = 1.5	0.12
Omnivores	2.1 (1.0)	2.7 (1.1)	No	t = 1.4	0.15
Planktivores	0.3 (0.5)	0.2 (0.4)	No	t = 0.4	0.67
Top Carnivores	1.9 (1.1)	2.1 (1.3)	No	t = 0.5	0.64
Tolerant	4.0 (1.3)	4.1 (1.6)	No	t = 0.3	0.80
Intolerant	2.1 (0.8)	1.1 (1.1)	Yes	Z = 2.2	0.01
CPUE (per run)					
Total	13.0 (6.9)	12.7 (9.1)	No	t = 0.1	0.92
Benthic Invertivores	0.2 (0.1)	0.1 (0.2)	No	t = 1.0	0.30
Insectivores	3.4 (2.1)	2.6 (2.5)	No	t = 0.9	0.35
Omnivores	2.9 (2.3)	3.3 (2.1)	No	t = 0.5	0.65
Planktivores	1.1 (3.1)	1.4 (4.3)	No	t = 0.2	0.84
Top Carnivores	0.3 (0.3)	0.7 (0.6)	Yes	Z = 2.1	0.02
Tolerant	4.7 (2.3)	4.4 (3.2)	No	t = 0.3	0.74
Intolerant	0.4 (0.3)	0.3 (0.4)	No	t = 1.1	0.27
Diversity Indices (per run)					
Simpson	0.7 (0.1)	0.7 (0.1)	No	t = 0.7	0.51
Shannon	1.6 (0.3)	1.5 (0.39)	No	t = 0.6	0.55

a) *t*-Value indicates results of independent two-sample *t*-test (α=0.05). *Z*-Value indicates results of Wilcoxon Rank-Sum *Z*-test (α=0.05) used when raw data could not be normalized using transformation.

Table 14. Individual metric ratings and the overall RBI scores (laboratory-processed) for downstream and upstream sampling sites near Browns Ferry Nuclear Plant, Wheeler Reservoir, Autumn 2011.

	Downstream				Upstream	
	TRM 290.4		TRM 293.2		TRM 295.9	
Metric	**Obs**	**Rating**	**Obs**	**Rating**	**Obs**	**Rating**
1. Average number of taxa	6.2	3	11.7	5	8.4	5
2. Proportion of samples with long-lived organisms	0.6	3	0.8	3	0.7	3
3. Average number of EPT taxa	0.7	3	1.2	3	1.0	3
4. Average proportion of oligochaete individuals	5.0	5	35.4	1	6.3	5
5. Average proportion of total abundance comprised by the two most abundant taxa	89.2	1	80.6	3	81.1	3
6. Average density excluding chironomids and oligochaetes	193.3	1	321.7	3	430	3
7. Zero-samples – proportion of samples containing no organisms	0	5	0	5	0	5
Benthic Index Score		**21**		**23**		**27**
Ecological Health Rating		**Fair**		**Fair**		**Good**

Reservoir Benthic Index Scores: 7-12 ("Very Poor"), 13-18 ("Poor"), 19-23 ("Fair"), 24-29 ("Good"), 30-35 ("Excellent")

Table 15. Metric scores and the overall RBI scores determined from field-processed criteria, for sites upstream and downstream of Browns Ferry Nuclear Plant, Wheeler Reservoir, Autumn 2000-2010.

Downstream – TRM 291.7															
	Avg No. Taxa		% Long-Lived		Avg. No. EPT taxa		% Oligochaetes		% Dominant Taxa		Density excl chiro and oligo		Zero Samples		Overall
Sample Year	Obs	Score	Obs	Score	Obs	Score	Obs	Score	Obs	Score	Obs	Score	Obs	Score	Score
2000	4	3	1	5	0.8	5	6.4	5	79.6	3	125	1	0	5	**27**
2001	5.6	5	1	5	1.1	5	5.7	5	43	5	230	1	0	5	**31**
2002	5.7	5	1	5	0.8	5	7.4	5	88.1	1	120	1	0	5	**27**
2003	6.5	5	1	5	1	5	0.3	5	76.1	5	1270	5	0	5	**35**
2004	6.7	5	1	5	1	5	1.4	5	74.4	5	523.3	3	0	5	**33**
2005	5.5	5	1	5	0.8	5	3.6	5	80.3	3	508.3	3	0	5	**31**
2006	6.2	5	1	5	0.1	5	2.3	5	77.3	5	272.3	1	0	5	**31**
2007	6.4	5	1	5	0.8	5	12.4	5	80.2	3	166.7	1	0	5	**29**
2008	6.3	5	0.9	5	1.1	5	7.2	5	81.5	3	181.7	1	0	5	**29**
2009	5	5	0.7	3	0.6	3	4.6	5	90.3	1	83.3	1	0	5	**23**
2010	4.6	5	0.7	3	0.6	3	0.3	5	94.8	1	126.7	1	0	5	**23**
Mean:	**5.7**		**0.9**		**0.8**		**4.7**		**78.7**		**327.9**		**0.0**		**29**
Maximum:	**6.7**		**1**		**1.1**		**12.4**		**94.8**		**1270**		**0**		
Minimum:	**4**		**0.7**		**0.1**		**0.3**		**43**		**83.3**		**0**		

Table 15. (Continued)

Upstream – TRM 295.9															
	Avg No. Taxa		% Long-Lived		Avg. No. EPT taxa		% Oligochaetes		% Dominant Taxa		Density excl chiro and oligo		Zero Samples		Overall
Sample Year	Obs	Score	Obs	Score	Obs	Score	Obs	Score	Obs	Score	Obs	Score	Obs	Score	Score
2000	4.6	5	1	5	0.8	5	6.6	5	77.6	5	190	1	0	5	**31**
2001	5.3	5	1	5	1	5	2.7	5	79.8	3	188.3	1	0	5	**29**
2002	6.5	5	1	5	0.8	5	7.2	5	75.6	5	266.7	1	0	5	**31**
2003	5.1	5	0.8	5	1	5	0.8	5	84.1	3	456.7	3	0	5	**31**
2004	6.2	5	1	5	0.9	5	1.1	5	73.7	5	353.6	3	0	5	**33**
2005	5.6	5	1	5	1.2	5	2.3	5	85.4	3	490	3	0	5	**31**
2006	5.9	5	0.8	5	0.7	3	7	5	75	5	348.3	3	0	5	**31**
2007	6.5	5	0.9	5	0.9	5	1.9	5	74.2	5	353.3	3	0	5	**33**
2008	5.8	5	0.7	3	0.5	3	7.8	5	85.4	3	220	1	0	5	**25**
2009	5.1	5	1	5	0.4	3	12.2	5	75.2	5	133.3	1	0	5	**29**
2010	4.2	3	1	5	0.8	5	2.1	5	92	1	108.3	1	0	5	**25**
Mean:	**5.5**		**0.9**		**0.8**		**4.7**		**79.8**		**282.6**		**0**		**30**
Maximum:	**6.5**		**1**		**1.2**		**12.2**		**92**		**490**		**0**		
Minimum:	**4.2**		**0.7**		**0.4**		**0.8**		**73.7**		**108.3**		**0**		

Table 16. Metric scores and the overall RBI scores determined from lab-processed criteria, for sites upstream and downstream of Browns Ferry Nuclear Plant, Wheeler Reservoir, 2001-2006.

Downstream – TRM 291.7															
	Avg No. Taxa		% Long-Lived		Avg. No. EPT taxa		% Oligochaetes		% Dominant Taxa		Density excl chiro and oligo		Zero Samples		Overall Score
Sample Year	Obs	Score	Obs	Score	Obs	Score	Obs	Score	Obs	Score	Obs	Score	Obs	Score	
2001	7.8	5	1	5	1.1	3	7.6	5	71.7	5	315	3	0	5	**31**
2002	5.4	3	1	5	0.9	3	10.9	5	88.2	1	106.7	1	0	5	**23**
2003	7.3	5	1	5	1	3	0.4	5	73.2	5	1,270.0	5	0	5	**33**
2004	7.9	5	1	5	1	3	1.6	5	73.5	5	551.7	3	0	5	**31**
2006	9.4	5	1	5	1.6	5	2.3	5	78.1	3	448.2	3	0	5	**31**
Mean:	**7.56**		**1**		**1.12**		**4.56**		**76.94**		**538.32**		**0**		**30**
Maximum:	**9.4**		**1**		**1.6**		**10.9**		**88.2**		**1,270.0**		**0**		
Minimum:	**5.4**		**1**		**0.9**		**0.4**		**71.7**		**106.7**		**0**		

Upstream – TRM 295.9															
	Avg No. Taxa		% Long-Lived		Avg. No. EPT taxa		% Oligochaetes		% Dominant Taxa		Density excl chiro and oligo		Zero Samples		Overall Score
Sample Year	Obs	Score	Obs	Score	Obs	Score	Obs	Score	Obs	Score	Obs	Score	Obs	Score	
2001	7.4	5	1	5	1	3	6.9	5	75.6	5	281.7	1	0	5	**29**
2002	6.8	5	1	5	1.1	3	5	5	74.1	5	281.7	1	0	5	**29**
2003	6.3	3	1	5	0.9	3	0.6	5	82.2	3	583.3	3	0	5	**27**
2004	6.2	3	1	5	0.8	3	1.1	5	72.2	5	336.2	3	0	5	**29**
2006	9.2	5	0.8	3	1.2	3	5.1	5	78.6	3	1,273.3	5	0	5	**29**
2011	8.4	5	0.7	3	1	3	6.3	5	81.1	3	430	3	0	5	**27**
Mean:	**7.4**		**0.9**		**1.0**		**4.2**		**77.3**		**531.0**		**0**		**28**
Maximum:	**9.2**		**1**		**1.2**		**6.9**		**82.2**		**1,273.3**		**0**		
Minimum:	**6.2**		**0.7**		**0.8**		**0.6**		**72.2**		**281.7**		**0**		

Table 17. Mean densities (organisms/m^2) of benthic taxa collected by dredge sample along transects upstream and downstream of Browns Ferry Nuclear Plant, 2011. Estimates of total mean density per sample are included.

Taxon	Downstream		Upstream
	TRM 290.4	TRM 293.2	TRM 295.9
Cnidaria			
Hydrozoa			
Hydroida			
Hydridae			
Hydra sp.	---	---	5
Nematoda	---	3	2
Platyhelminthes			
Turbellaria			
Tricladida			
Planariidae			
Dugesia tigrina	---	---	13
Annelida			
Oligochaeta			
Haplotaxida			
Naididae	---	45	15
Bratis unidentata	2	10	---
Dero trifida	---	2	---
Dero sp.	---	60	32
Nais pardalis	---	23	13
Pristina aequiseta	---	2	---
Pristina sp.	---	2	2
Pristinella jenkinae	---	5	---
Slavina appendiculata	---	5	---
Tubificidae	15	83	25
Aulodrilus piqueti	---	20	---
Branchiura sowerbyi	5	13	2
Limnodrilus hoffmeisteri	8	40	17
Quistadrilus multisetosus	---	5	---
Hirudinea			
Rhynchobdellida			
Glossiphoniidae			
Actinobdella inequiannulata	2	3	2
Helobdella stagnalis	7	---	---
Helobdella sp.	---	2	---
Placobdella montifera	2	---	---
Arthropoda			
Arachnomorpha			
Arachnida			
Trombidiformes			
Unionicolidae			
Unionicola sp.	2	---	2

Table 17. (Continued)

Taxon	Downstream 290.4	293.2	Upstream 295.9
Crustacea			
Brachiopoda			
Cladocera			
Sididae			
Sida crystallina	---	122	3
Malacostraca			
Amphipoda			
Corophiidae			
Apocorophium lacustre	---	---	3
Isopoda			
Gammaridae			
Gammarus sp.	2	---	---
Maxillopoda			
Copepoda			
Cyclopoida	---	7	---
Ostracoda	---	2	---
Podocopa			
Candoniidae			
Candona sp.	13	8	5
Insecta			
Diptera			
Chaoboridae			
Chaoborus punctipennis	2	5	3
Chironomidae			
Ablabesmyia annulata	5	25	18
Ablabesmyia mallochi	---	---	3
Ablabesmyia rhamphe gp.	---	2	---
Axarus sp.	---	---	2
Chironomus crassicaudatus	8	15	18
Chironomus decorus gp.	5	2	---
Chironomus major	40	10	---
Chironomus sp.	7	27	---
Cladotanytarsus sp.	---	5	8
Coelotanypus tricolor	250	122	228
Coelotanypus sp.	8	30	38
Cryptochironomus sp.	2	5	5
Dicrotendipes lucifer	---	8	28
Dicrotendipes modestus	3	18	98
Dicrotendipes neomodestus	---	2	2
Dicrotendipes simpsoni	---	2	53
Glyptotendipes sp.	3	25	103
Microchironomus sp.	---	---	7
Nanocladius alternantherae	---	2	7
Nanocladius distinctus	---	3	18
Parachironomus sp.	---	2	---
Polypedilum halterale gp	---	5	3
Procladius sp.	3	5	3
Tanypodinae			
Tanytarsus sp.	---	2	---
Thienemanniella lobapodema	---	2	---

Table 17. (Continued)

Taxon	Downstream 290.4	Downstream 293.2	Upstream 295.9
Ephemeroptera			
Caenidae			
Caenis sp.	---	3	---
Ephemeridae			
Hexagenia limbata <10mm	3	20	10
Hexagenia limbata >10mm	12	17	17
Trichoptera			
Hydroptilidae			
Orthotrichia sp	---	---	2
Polycentropodidae			
Cyrnellus fraternus	2	23	107
Leptoceridae			
Oecetis sp.	2	---	5
Mollusca			
Gastropoda			
Mesogastropoda			
Hydrobiidae			
Amnicola limosa	2	3	17
Somatogyrus sp.	---	3	---
Pleuroceridae			
Pleurocera canaliculata	---	3	---
Viviparidae			
Campeloma decisum	---	2	---
Lioplax sulculosa	3	---	---
Viviparus sp.	2	2	---
Bivalvia			
Veneroida			
Corbiculidae			
Corbicula fluminea <10mm	7	18	18
Corbicula fluminea >10mm	2	15	77
Sphaeriidae			
Eupera cubensis	---	5	2
Musculium transversum	147	177	153
Unionoida			
Unionidae			
Megalonaias nervosa	2	---	---
Obliquaria reflexa	---	---	3
Truncilla donaciformis <10mm	---	2	---
Number of samples	**10**	**10**	**10**
Total Mean Density per meter^2	**578**	**1,077**	**1,197**
Taxa Richness	**31**	**50**	**42**
Sum of area sampled (meter^2)	**0.6**	**0.6**	**0.6**

Table 18. Field estimates of substrate composition in benthic dredge samples collected around Brown's Ferry Nuclear Plant, October 2011.

River Mile	Sample #	% Distance from LDB	Depth (ft)	Primary Component		Secondary Component	
TRM 290.4	1	5	12.4	Silt	85%	Mollusk shell	15%
	2	15	17.4	Silt	95%	Detritus	5%
	3	25	21.2	Silt	98%	Mollusk shell	1%
	4	35	25.5	Silt	90%	Mollusk shell	10%
	5	45	23.4	Silt	98%	Detritus	2%
	6	55	10.8	Silt	80%	Mollusk shell	20%
	7	65	11.8	Mollusk shell	80%	Silt	20%
	8	75	23.5	Silt	98%	Mollusk shell	2%
	9	85	12.7	Silt	98%	Mollusk shell	2%
	10	95	11.5	Silt	98%	Boulder	1%
TRM 293.2	1	5	6.5	Mollusk shell	80%	Gravel	15%
	2	15	7.8	Mollusk shell	50%	Sand	50%
	3	25	11.8	Mollusk shell	50%	Gravel	50%
	4	35	12.7	Mollusk shell	100%	--	--
	5	45	14.2	Clay	60%	Mollusk shell	30%
	6	55	12	Clay	60%	Mollusk shell	30%
	7	65	24	Silt	90%	Detritus	8%
	8	75	22	Silt	50%	Detritus	30%
	9	85	20	Silt	95%	Detritus	4%
	10	95	8.3	Mollusk shell	60%	Gravel	38%
TRM 295.9	1	5	8.9	Silt	88%	Detritus	10%
	2	15	9.4	Mollusk shell	90%	Silt	10%
	3	25	9.6	Silt	90%	Mollusk shell	8%
	4	35	6.1	Mollusk shell	88%	Silt	8%
	5	45	22.0	Silt	75%	Detritus	15%
	6	55	26.0	Silt	75%	Gravel	15%
	7	65	8.0	Clay	50%	Mollusk shell	45%
	8	75	13.9	Silt	90%	Mollusk shell	5%
	9	85	11.8	Silt	90%	Mollusk shell	8%
	10	95	9.1	Silt	75%	Mollusk shell	15%

Table 19. RBI scores from data collected from 1994 through 2011 at Wheeler Reservoir inflow, transition, embayment, and forebay sampling sites.

Sample Year	Inflow TRM 347	BFN Upstream, Transition TRM 295.9	BFN Downstream 1994-2010 Transition TRM 291.7	BFN Thermal Plume Transition TRM 293.2	BFN Downstream 2011 Transition TRM 290.4	Forebay, TRM 277	Elk River Embayment, ERM 6
1994	31	33	-	-	-	19	15
1995	21	25	-	-	-	15	13
1997	25	31	-	-	-	23	15
1999	23	31	-	-	-	17	15
Average: 1994-1999	**25**	**30**	**N/A**	**N/A**	**N/A**	**19**	**15**
2000	-	31	27	-	-	-	-
2001	21	29	31	-	-	17	15
2002	25	31	27	-	-	15	-
2003	31	31	35	-	-	15	15
2004	31	33	33	-	-	19	-
2005	31	31	31	-	-	15	17
2006	33	31	31	-	-	13	-
2007	33	33	29	-	-	13	13
2008	-	25	29	-	-	15	-
2009	31	29	23	-	-	13	13
2010	-	25	23	-	-	-	-
2011	27	27	-	23	21	13	13
Average: 2000-2011	**29**	**30**	**29**	**23**	**21**	**15**	**14**
Average: 1994-2011	**28**	**30**	**29**	**23**	**21**	**16**	**14**

Note: No data were collected for 1996 and 1998.

Reservoir Benthic Index Scores: 7-12 ("Very Poor"), 13-18 ("Poor"), 19-23 ("Fair"), 24-29 ("Good"), 30-35 ("Excellent")

Table 20. Wildlife observed along 2100 m transects parallel to the shoreline, upstream and downstream of BFN, autumn 2011.

RDB = Right descending bank   LDB = Left descending bank

Transect		Birds	Obs.	Reptiles	Obs.
Upstream	RDB	American Crow	6		
		Belted Kingfisher	1		
		Songbird sp.	1		
		Great Blue Heron	4		
		Double-crested Cormorant	1		
		Mallard	5		
	LDB	Sandpiper sp.	2	Turtle sp.	20
		Belted Kingfisher	2		
		Great Blue Heron	4		
Downstream	RDB	Blackbird	20		
		Songbird sp.	2		
		Belted Kingfisher	1		
		Great Blue Heron	6		
		American Coot	6		
		Wood Duck	8		
		Mallard	7		
	LDB	Songbird sp.	5		
		Great Blue Heron	5		
		Mallard	8		
		Wood Duck	4		

Table 21. Water temperature (°F) profiles measured at five locations (10%, 30%, 50%, 70%, 90%) from right descending bank along transects located at TRM 296.5, TRM 294, TRM 292.4, TRM 291.2, and TRM 289.1 during autumn 2011 to characterize the BFN thermal plume.

	Ambient (TRM 296.5)					TRM 294 (at Discharge)					TRM 292.4 (Middle of plume)					TRM 291.2 (Downstream limit of plume)					TRM 289.1 (Outside of plume)				
Depth (m)	10%	30%	50%	70%	90%	10%	30%	50%	70%	90%	10%	30%	50%	70%	90%	10%	30%	50%	70%	90%	10%	30%	50%	70%	90%
0.3	77.3	76.2	76.2	76.2	75.3	82.7	82.5	81.2	81.9	76.6	81.0	81.1	81.4	79.7	76.4	80.1	79.7	78.1	77.4	76.9	79.6	78.9	78.4	78.1	76.8
1	77.3	76.2	76.2	76.2	75.3	82.6	82.5	81.1	81.9	76.7	81.0	81.1	81.3	79.1	76.4	80.1	79.6	78.1	77.4	76.9	79.6	78.9	78.4	78.1	76.8
2	77.2	76.2	76.2	76.2	75.3	82.4	82.5	78.9	81.8	76.6	81.0	80.9	80.1	76.9	76.4	80.1	79.3	78.1	77.4	76.9	79.6	78.9	78.4	78.1	76.8
3	77.2	76.2		76.2	75.3	82.2	82.4	78.8	77.7	76.4	80.1	79.9	79.5	76.7	76.4	80.0	79.1	78.1	77.4	76.9	79.6	78.8	78.4	78.1	76.8
4				76.3		82.0					79.9		77.9		76.4	80.0		78.1	77.4	76.9	79.6	78.7	78.4	78.1	76.8
5				76.2		81.4					79.8		77.7						77.4	76.9					76.8
6				76.3		81.2					79.8		77.6						77.4						76.7
7				76.2		80.9					79.8		77.6												
8				76.2		80.8																			
9						80.0																			

*Shaded numbers represent temperatures 3.6°F (2°C) or greater above ambient temperature

Table 22. Water quality parameters collected along vertical depth profiles at the downstream, midpoint, and upstream end of the RFAI sample reach downstream (TRM 292.5) and upstream (TRM 295.9) of BFN, autumn 2011.

TRM 292.5	LDB						Mid-channel						RDB					
	Depth	°C	°F	Cond	DO	pH	Depth	°C	°F	Cond	DO	pH	Depth	°C	°F	Cond	DO	pH
Downstream Boundary	0.3	22.86	73.15	177.6	9.78	8.16	0.3	23.14	73.65	176.9	11.78	8.02	0.3	23.24	73.83	177.3	9.09	8.37
	1.0	22.29	72.12	178.6	8.11	7.52	1.5	22.43	72.37	178.8	9.98	8.03	1.5	22.76	72.97	177.5	9.29	8.11
	3	22.26	72.07	178.5	7.93	7.43	3	22.41	72.34	177.9	8.68	7.73	3	22.66	72.79	177.9	9.12	7.87
	4	22.22	72.00	179	7.90	7.39	4	22.41	72.34	178.0	8.64	7.70						
							6	22.25	72.05	178.0	8.40	7.63						
							8	22.24	72.03	178.2	8.24	7.59						
Midpoint	0.3	23.10	73.58	177.3	10.9	8.40	0.3	24.18	75.52	178.4	9.62	8.18	0.3	24.01	75.22	178.3	9.44	7.97
	1.5	22.79	73.02	177.1	9.21	7.85	1.5	23.58	74.44	178.1	8.64	7.82	1.5	23.44	74.19	178.1	8.39	7.73
	3	22.58	72.64	177.0	9.49	7.67	3	23.02	73.44	177.9	8.47	7.61	3	22.98	73.36	178.1	8.33	7.61
							4	22.68	72.82	177.5	8.36	7.63						
							6	22.46	72.43	178.5	8.18	7.58						
Upstream Boundary	0.3	24.91	76.84	180.8	8.62	7.70	0.3	25.23	77.41	180.0	8.84	7.77	0.3	23.15	73.67	181.2	11.58	8.58
	1.5	24.48	76.06	180.7	8.43	7.67	1.5	24.37	75.86	180.1	8.67	7.70	1.5	22.38	72.28	179.7	10.51	8.45
	3	23.00	73.40	180.4	8.31	7.60	3	23.51	74.32	180.7	8.44	7.62	3	21.69	71.04	179.7	9.80	8.09
	4	22.84	73.11	179.5	8.20	7.57	4	23.06	73.51	180.8	8.36	7.58						
	6	22.21	71.98	179.1	7.87	7.48	6	22.48	72.46	181.1	8.18	7.52						
	8	21.95	71.51	180.0	7.99	7.43	8	22.17	71.91	180.5	8.11	7.46						
TRM 295.9	**LDB**						**Mid-channel**						**RDB**					
	Depth	°C	°F	Cond	DO	pH	Depth	°C	°F	Cond	DO	pH	Depth	°C	°F	Cond	DO	pH
Downstream Boundary	0.3	22.42	72.36	185.0	9.81	7.86	0.3	23.81	74.86	184.4	8.82	7.80	0.3	23.87	74.97	185.0	8.83	7.86
	1.0	21.75	71.15	184.2	9.24	7.82	1.5	22.94	73.29	184.6	8.63	7.78	1.5	23.48	74.26	184.5	8.79	7.81
	3	21.55	70.79	185.5	9.35	7.8	3	22.67	72.81	184.3	8.68	7.66	3	22.85	73.13	184.2	8.55	7.73
							4	22.26	72.07	184.1	8.53	7.63	4	22.39	72.30	184.3	8.45	7.85
							6	21.76	71.17	183.8	8.66	7.62	6	21.92	71.46	183.2	8.58	7.75
							8	21.64	70.95	184.4	8.80	7.62	8	21.36	70.45	185.6	9.01	7.83
Midpoint	0.3	21.88	71.38	188.3	7.74	7.28	0.3	21.96	71.53	186.8	7.29	7.32	0.3	20.59	69.06	183.9	8.6	8.07
	1.5	22.20	71.96	187.4	7.75	7.19	1.5	21.48	70.66	185.6	7.46	7.35	1.5	20.08	68.14	179.4	10.30	8.33
	3	21.64	70.95	190.0	7.80	7.15	3	21.27	70.29	181.5	7.84	7.40	2	20.04	68.07	179.7	9.98	8.27
							5	21.23	70.21	180.8	8.11	7.41						
							7	21.05	69.89	180.3	8.18	7.37						
Upstream Boundary	0.3	21.18	70.12	199.6	8.38	7.60	0.3	21.77	71.19	187.8	6.95	7.33	0.3	21.46	70.63	182.9	9.36	7.89
	1.5	21.50	70.70	202.2	8.62	7.57	1.5	21.75	71.15	183.5	6.97	7.33	1.5	20.91	69.64	179.9	10.51	8.30
							3	21.65	70.97	182.5	7.18	7.35	2	20.59	69.06	178.8	10.58	8.41
							5	21.52	70.74	181.5	7.69	7.42						
							7	21.36	70.45	180.7	7.85	7.42						

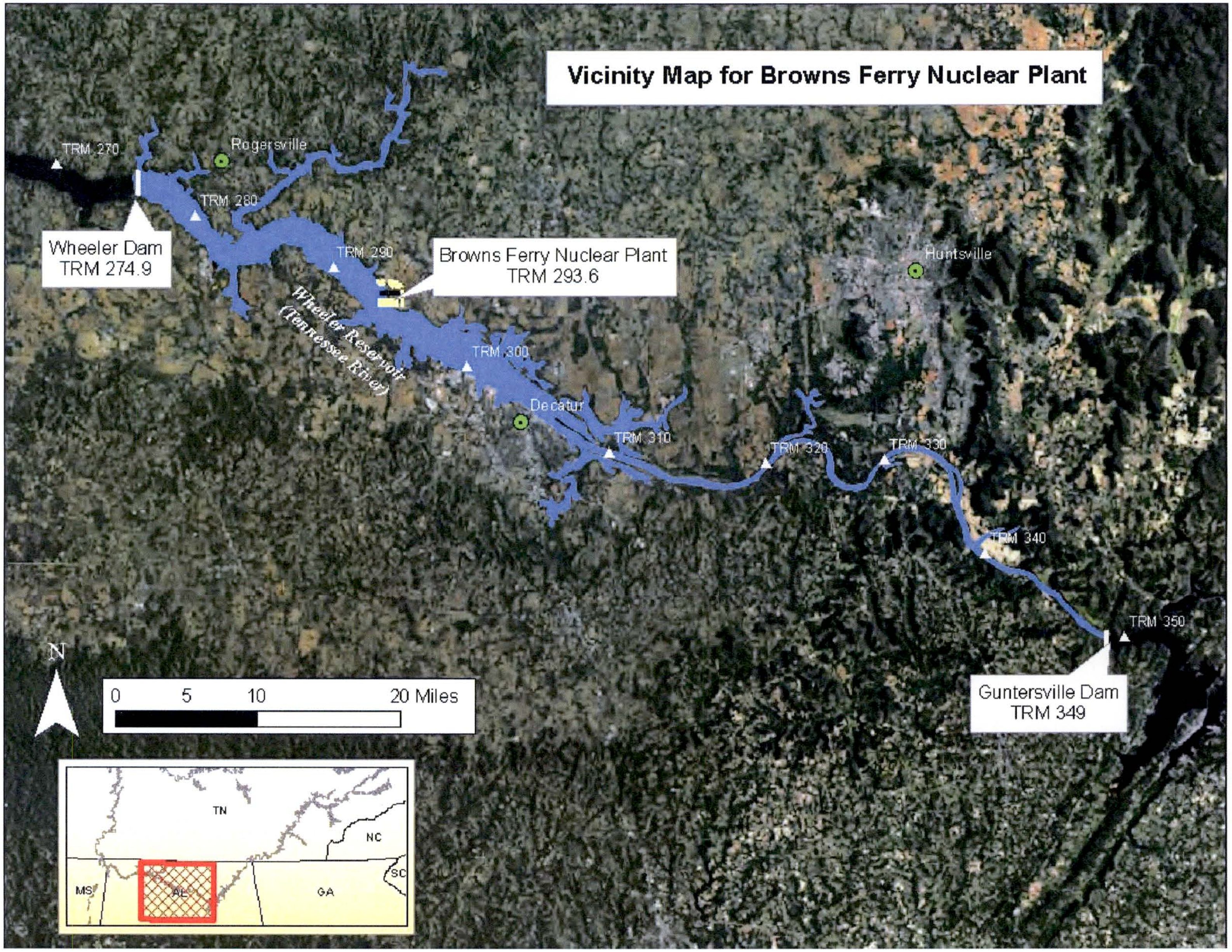


Figure 1. Location of Browns Ferry Nuclear Plant on Wheeler Reservoir.

Figure 2. Location of Condenser Cooling Water (CCW) intake and discharge at Browns Ferry Nuclear Plant.

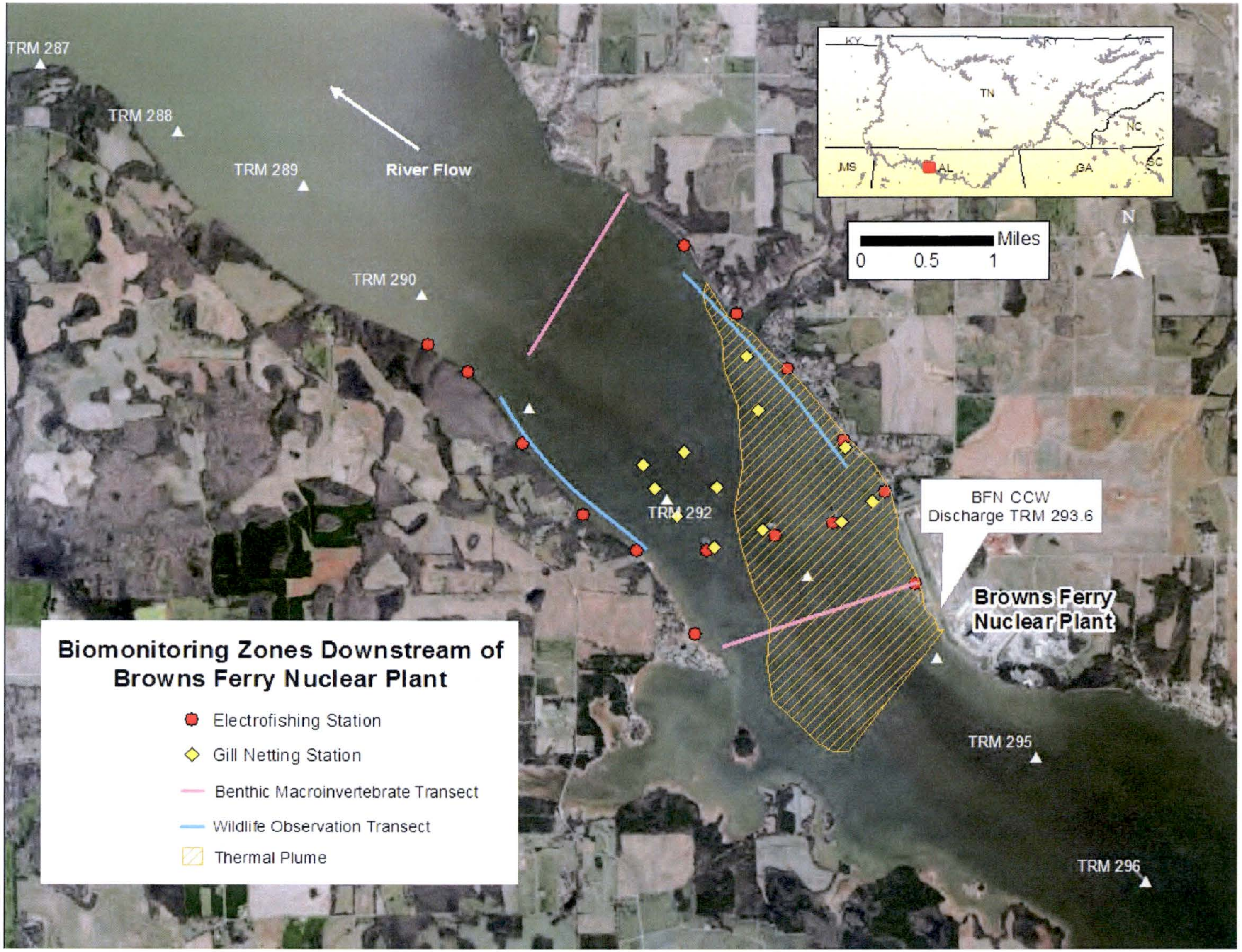


Figure 3. Locations of biomonitoring sites downstream of Browns Ferry Nuclear Plant, including thermal plume resulting from BFN discharge.

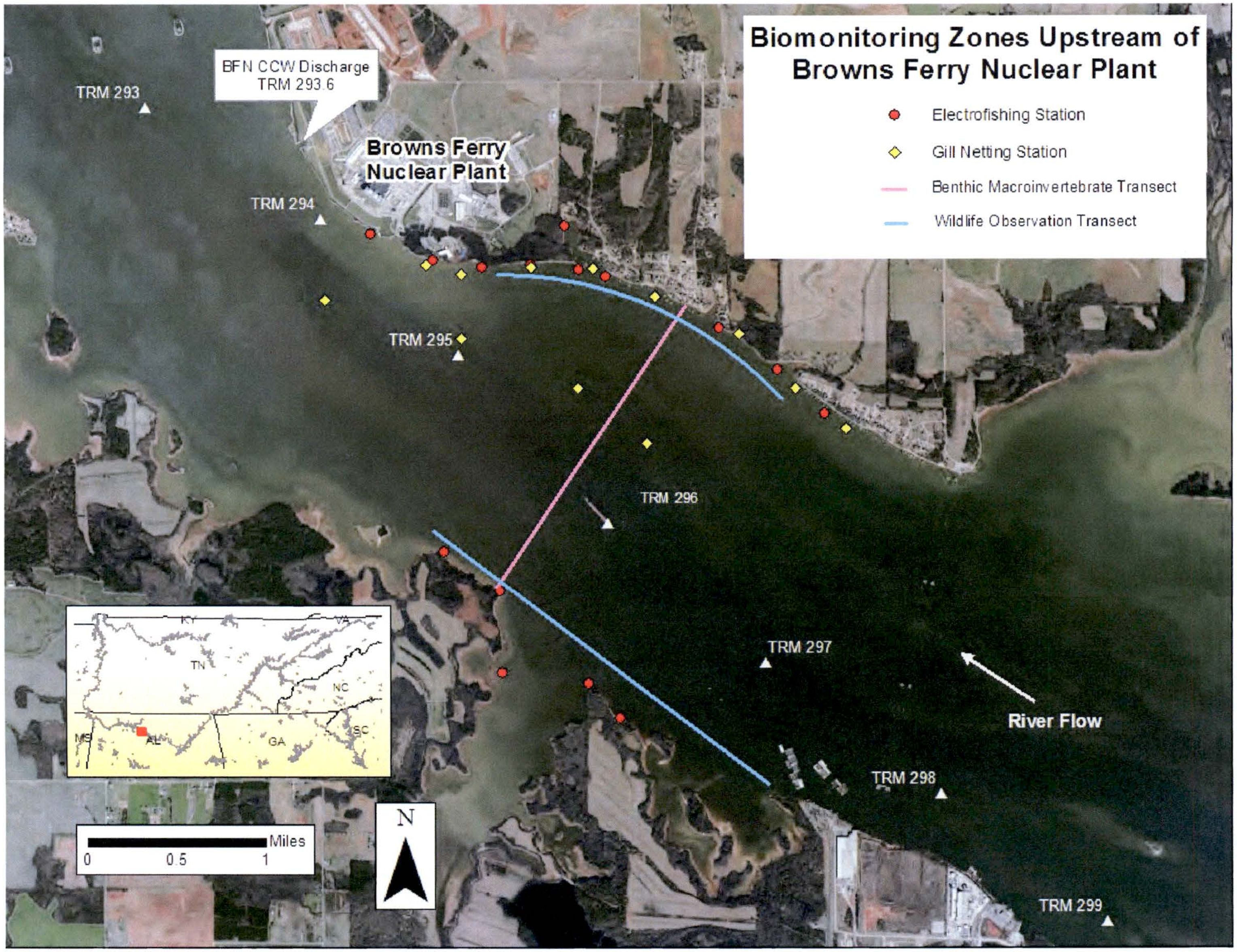


Figure 4. Locations of biomonitoring sites upstream of Browns Ferry Nuclear Plant.

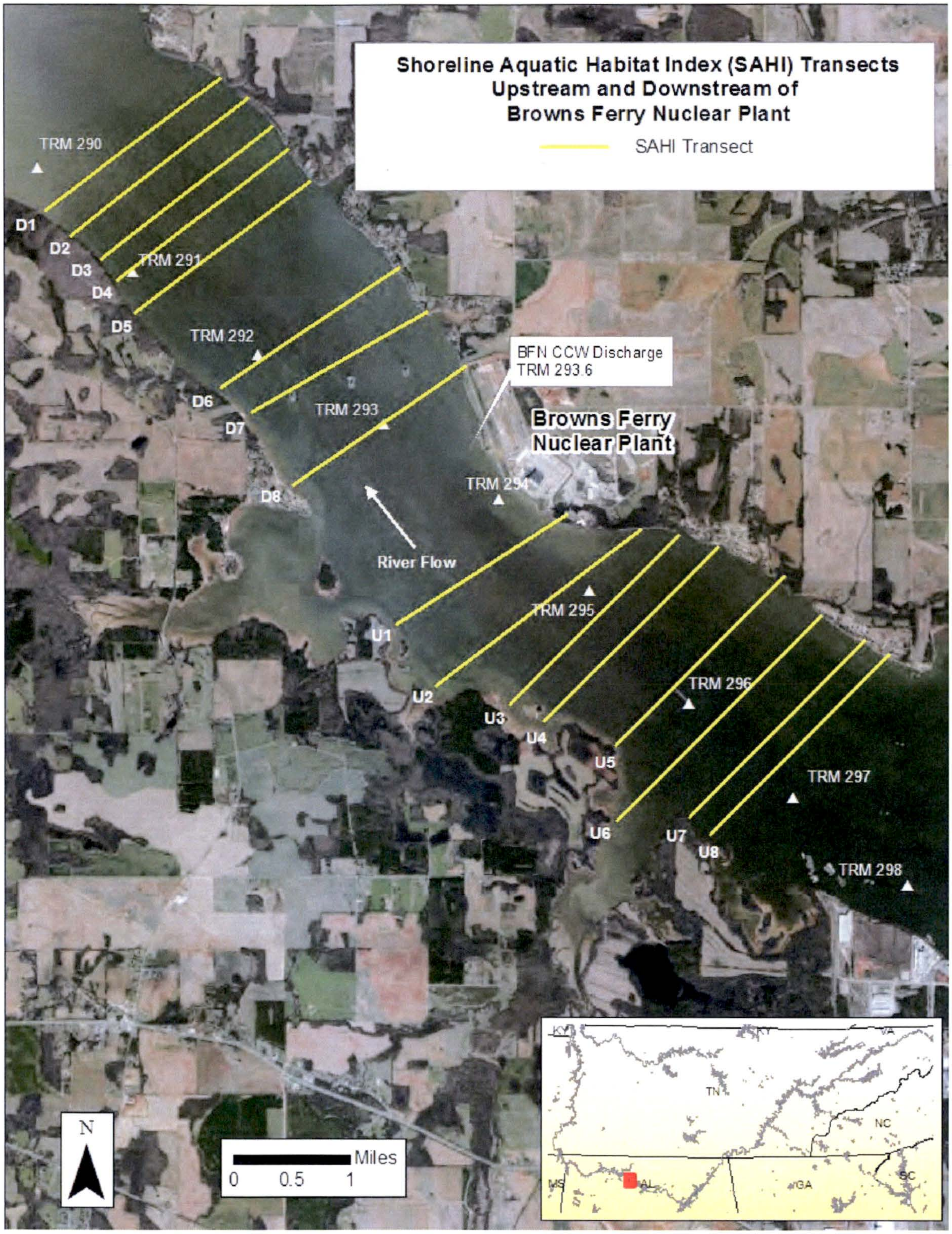


Figure 5. Locations of transects used to characterize shoreline and river bottom habitat upstream and downstream of Browns Ferry Nuclear Plant.

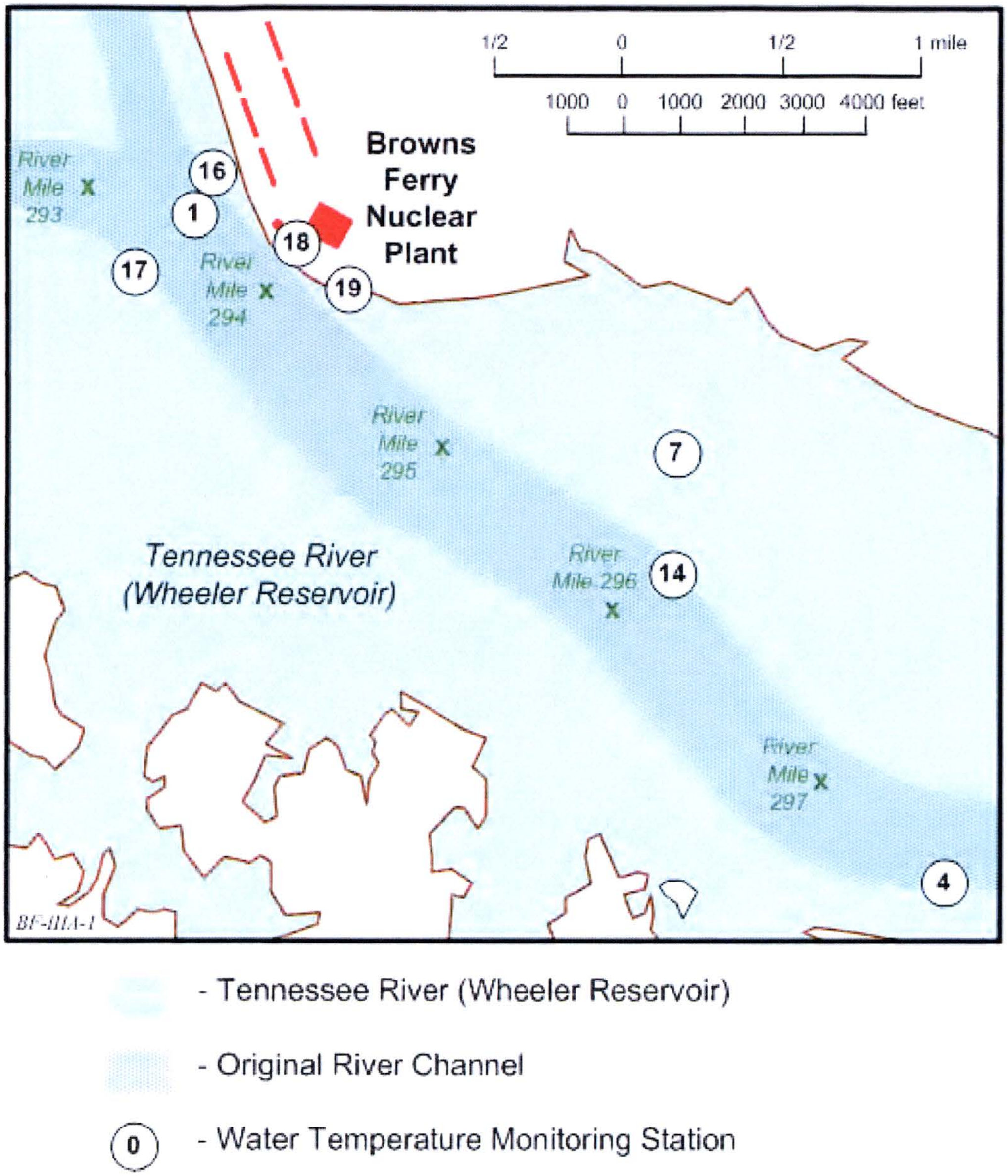


Figure 6. Locations of water temperature monitoring stations used to compare water temperatures upstream of Browns Ferry Nuclear Plant (BFN) intake and downstream of BFN discharge during October 2009 through November 2010.

*Station 4 was used for upstream ambient temperatures of the BFN intake and was located at TRM 297.8. Stations 1, 16, and 17 were used for temperatures downstream of BFN discharge and were each located at TRM 293.5. This figure originated in the technical report: Browns Ferry Nuclear Plant Module III, Water Temperature Monitoring.

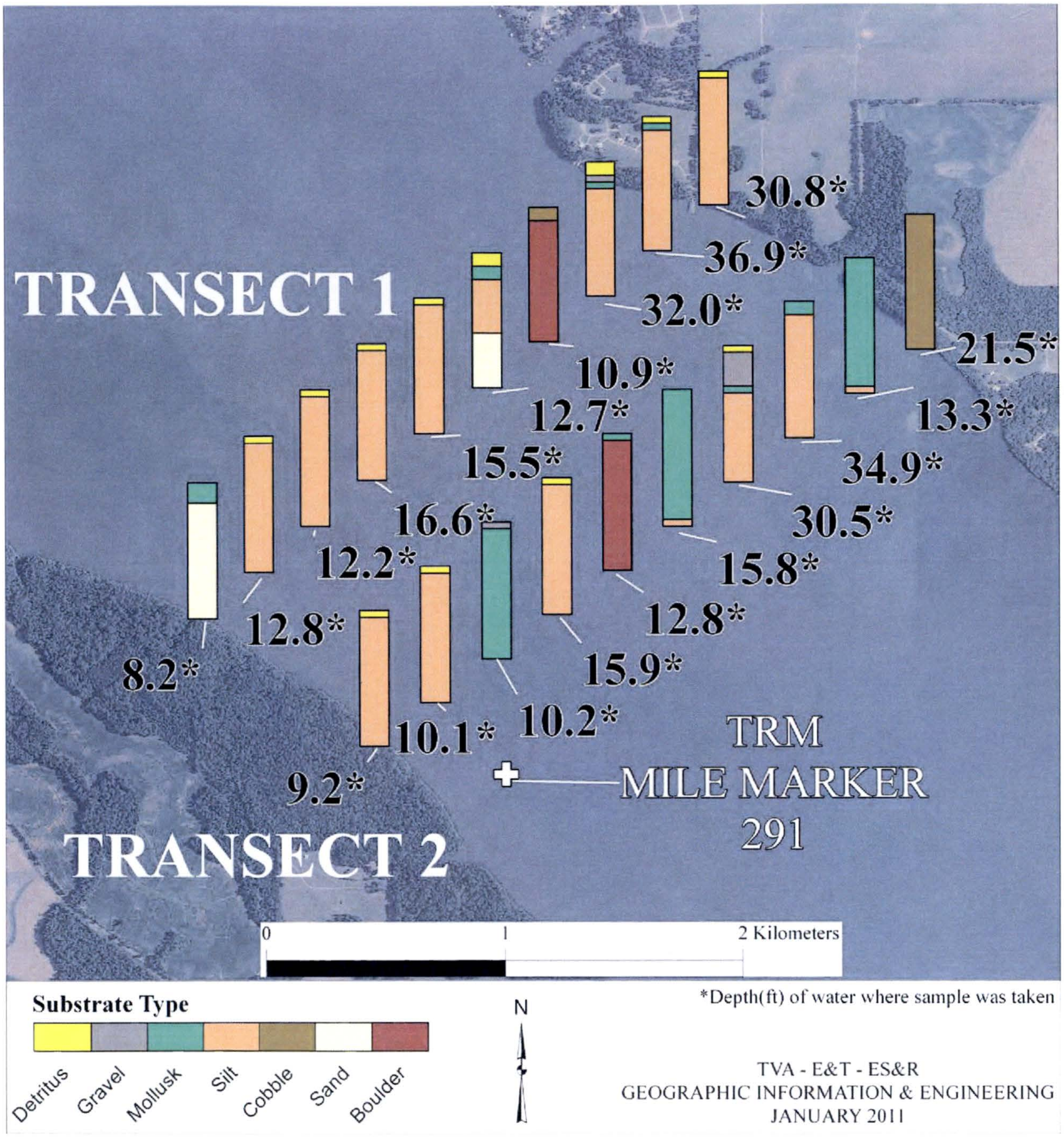


Figure 7. Substrate composition at ten equally spaced points per transect across the Tennessee River downstream of Browns Ferry Nuclear Plant. ***Water depth (ft) at each point is denoted. Transects 1 and 2 are the farthest downstream of the eight transects established downstream of Browns Ferry Nuclear Plant.**

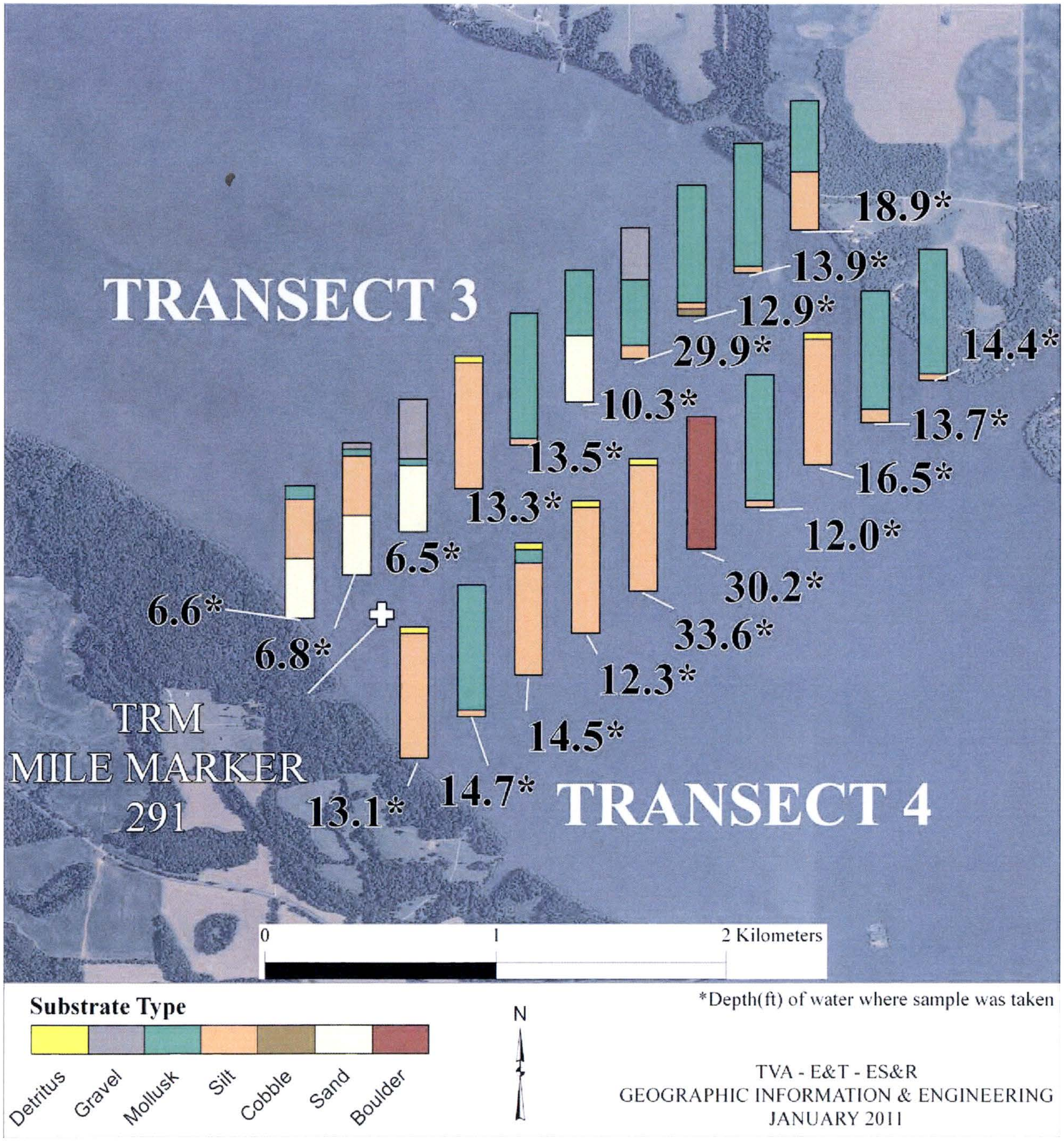


Figure 8. Substrate composition at ten equally spaced points per transect across the Tennessee River downstream of Browns Ferry Nuclear Plant. ***Water depth (ft) at each point is denoted.**

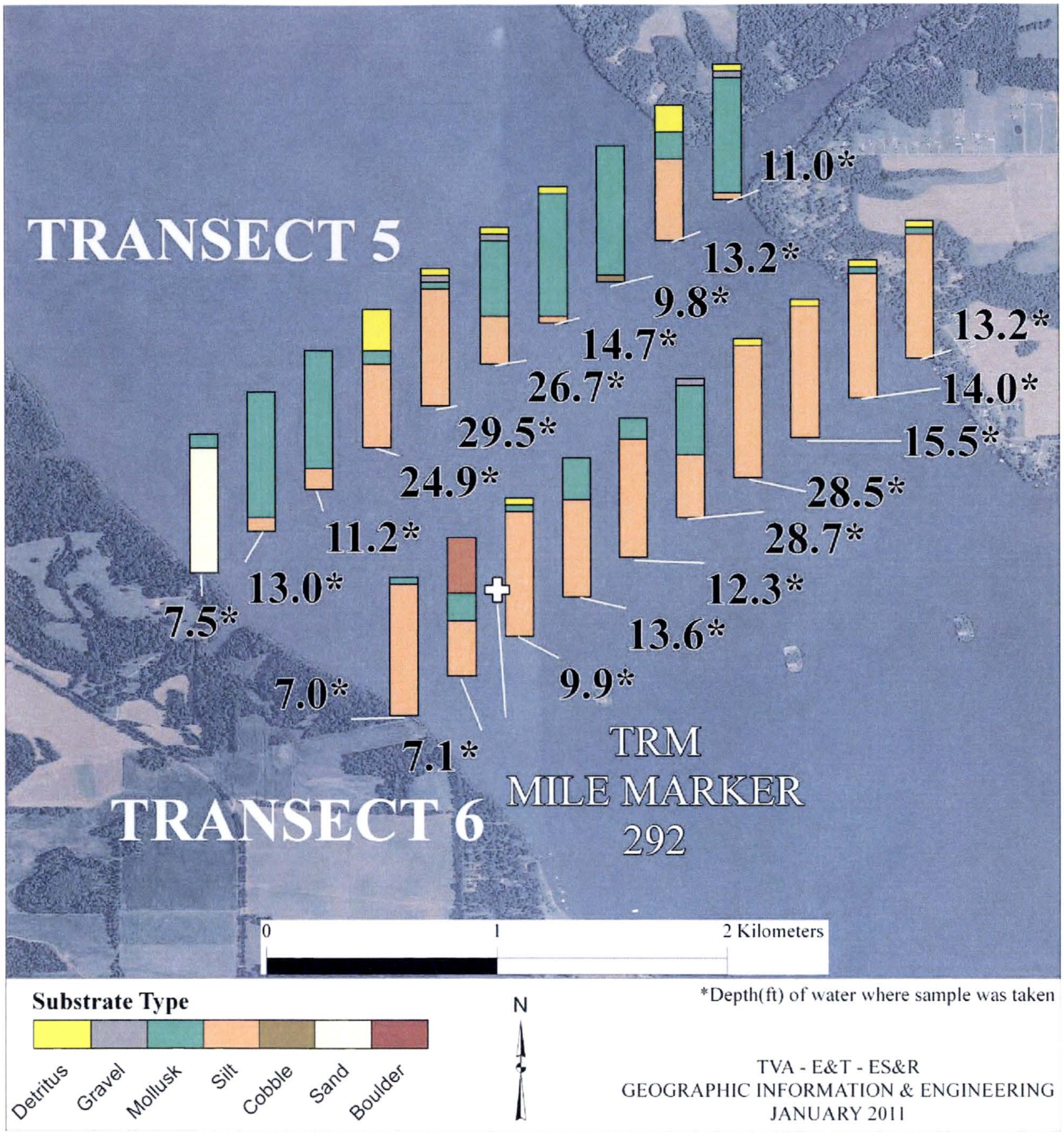


Figure 9. Substrate composition at ten equally spaced points per transect across the Tennessee River downstream of Browns Ferry Nuclear Plant. ***Water depth (ft) at each point is denoted.**

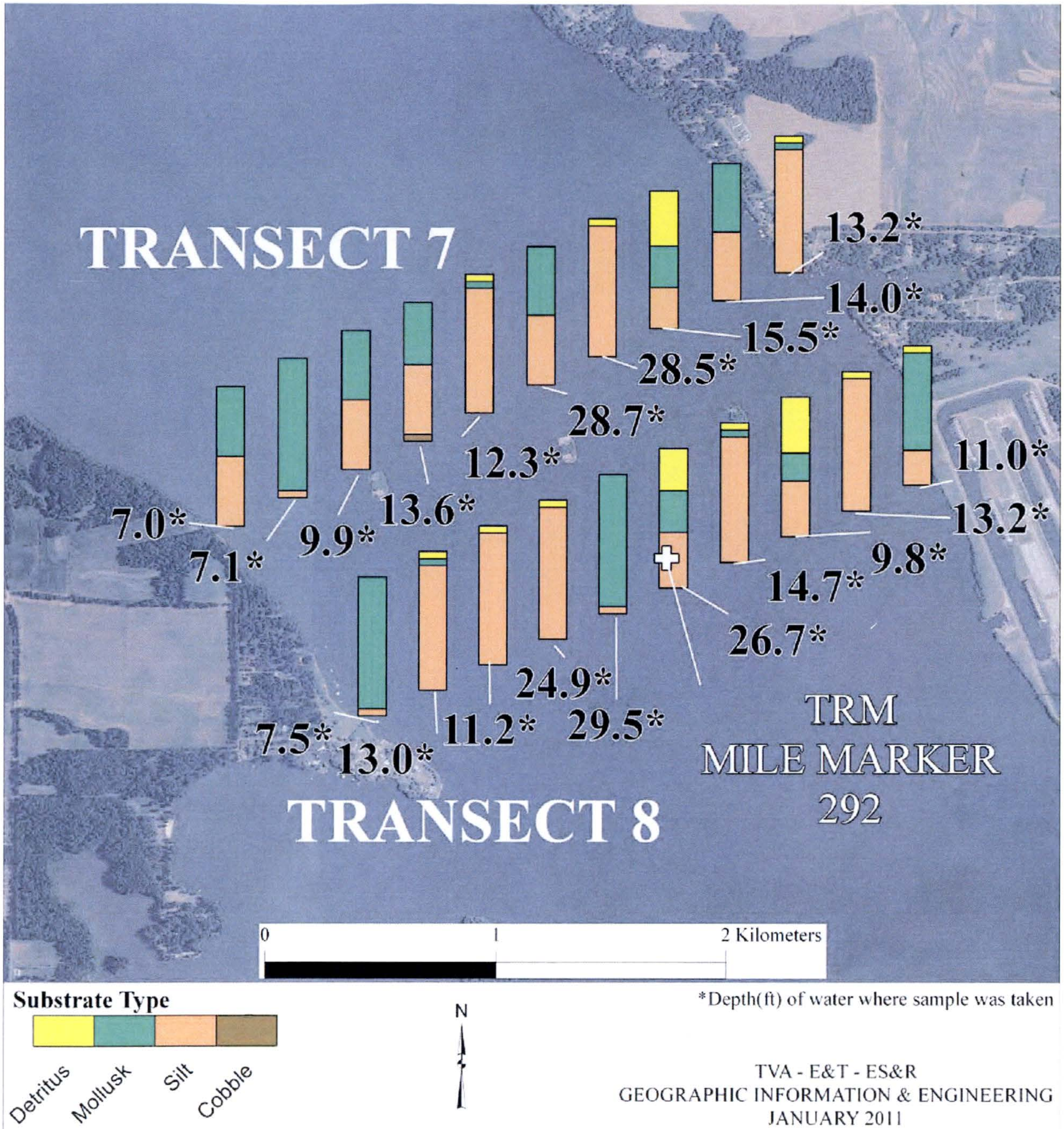


Figure 10. Substrate composition at ten equally spaced points per transect across the Tennessee River downstream of Browns Ferry Nuclear Plant. ***Water depth (ft) at each point is denoted.**

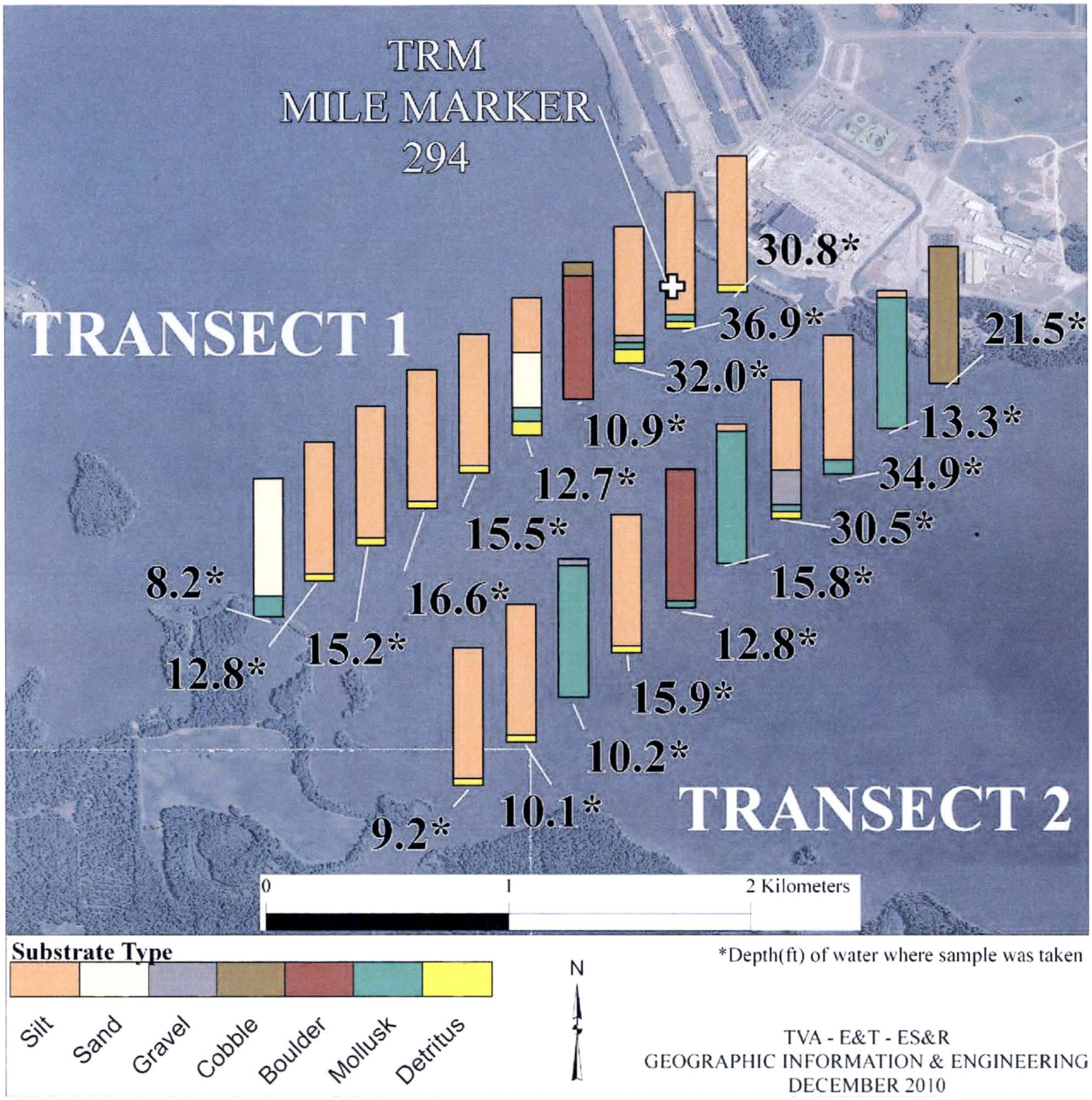


Figure 11. Substrate composition at ten equally spaced points per transect across the Tennessee River upstream of Browns Ferry Nuclear Plant. ***Water depth (ft) at each point is denoted. Of the eight transects established upstream of Browns Ferry Nuclear Plant, transects 1 and 2 are the closest to the plant.**

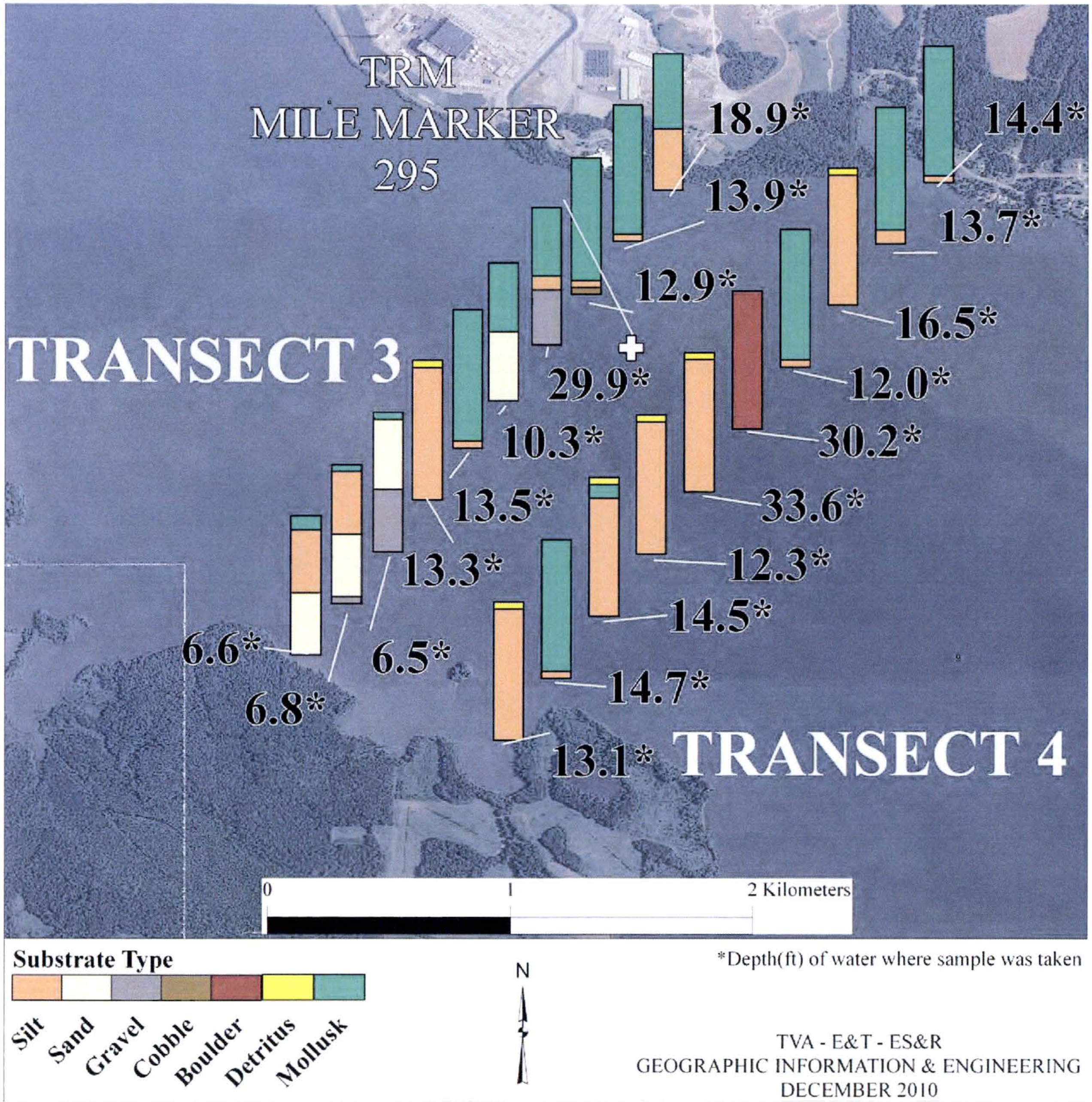


Figure 12. Substrate composition at ten equally spaced points per transect across the Tennessee River upstream of Browns Ferry Nuclear Plant. *Water depth (ft) at each point is denoted.

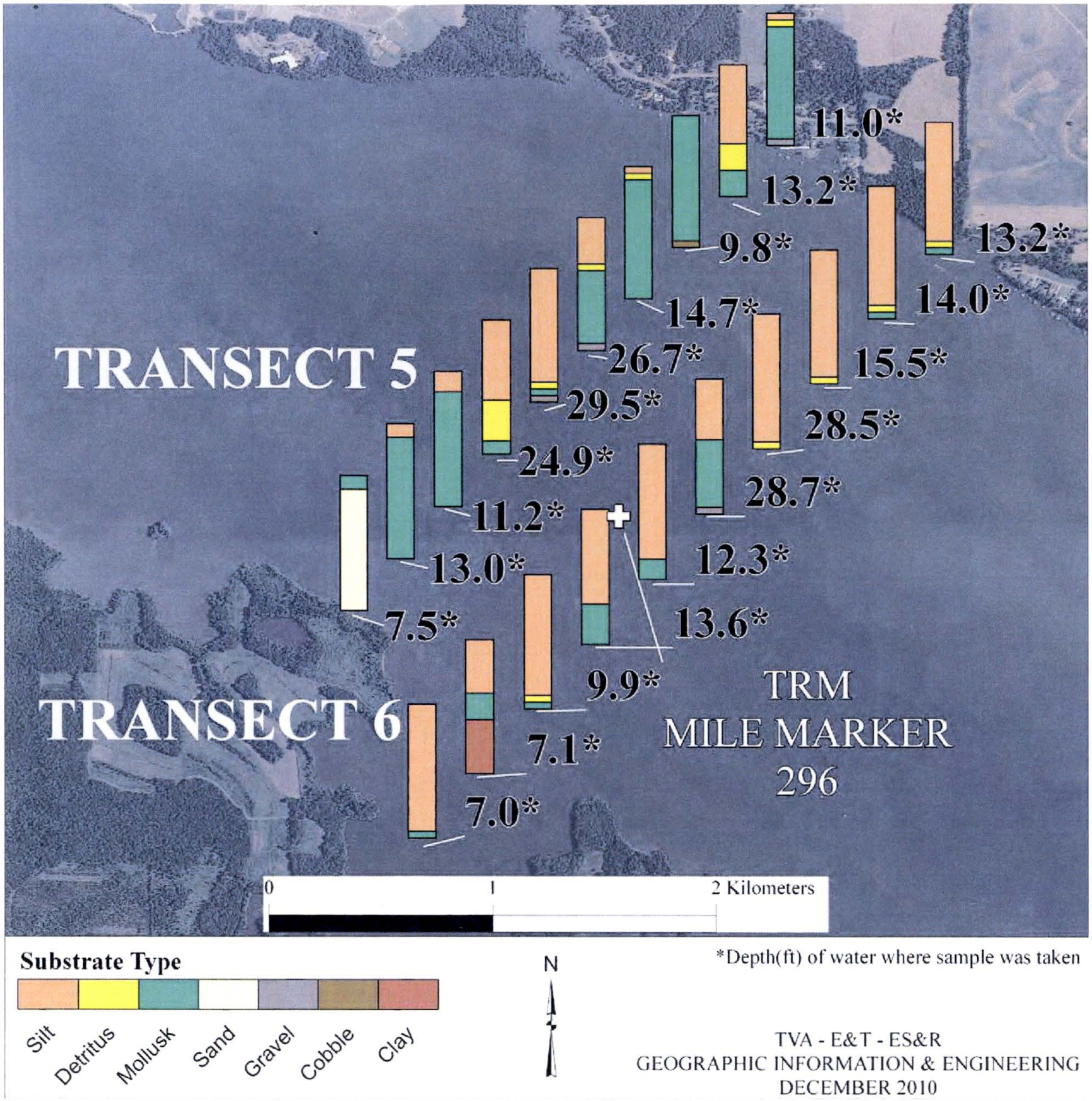
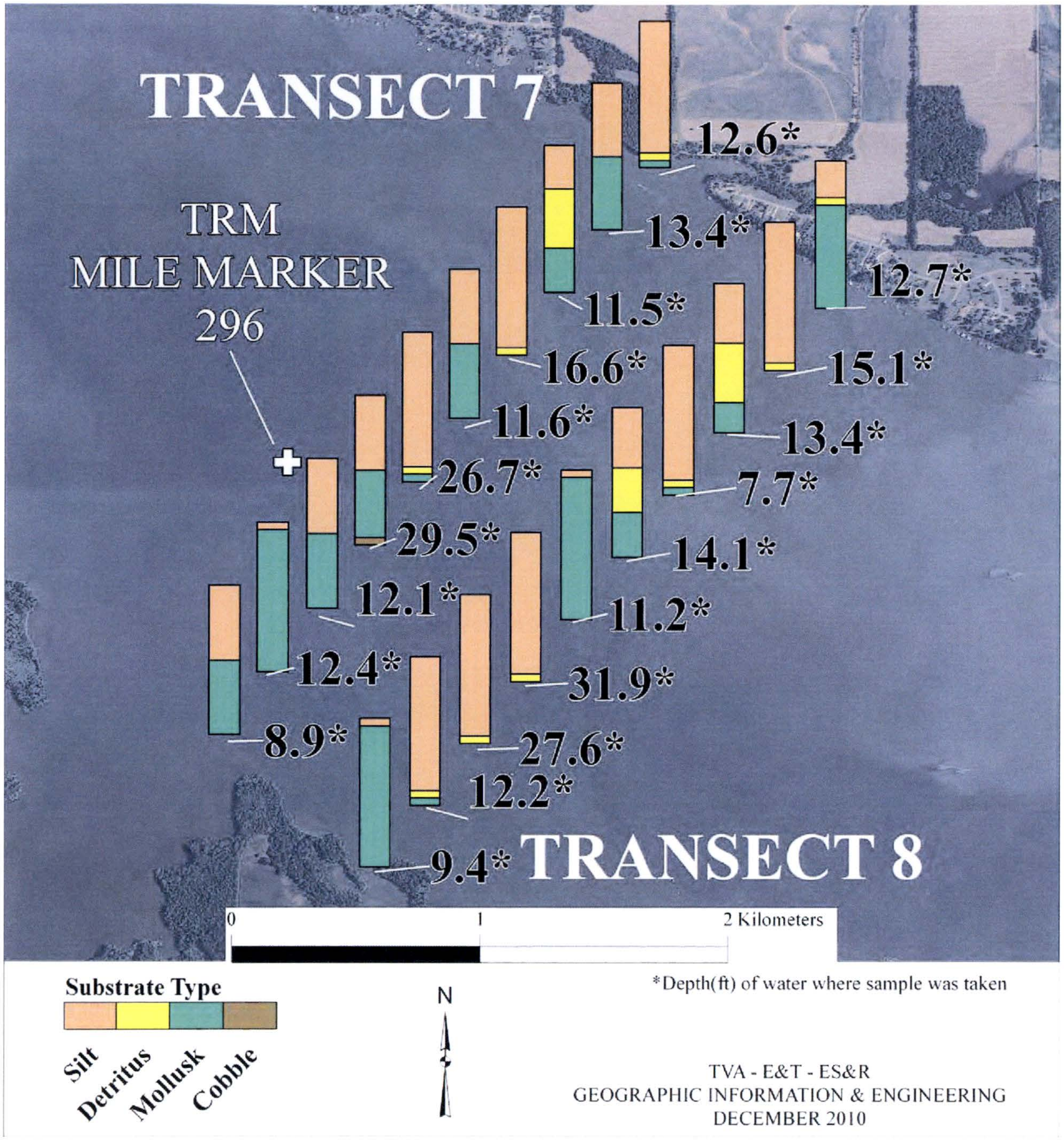


Figure 13. Substrate composition at ten equally spaced points per transect across the Tennessee River upstream of Browns Ferry Nuclear Plant. ***Water depth (ft) at each point is denoted.**



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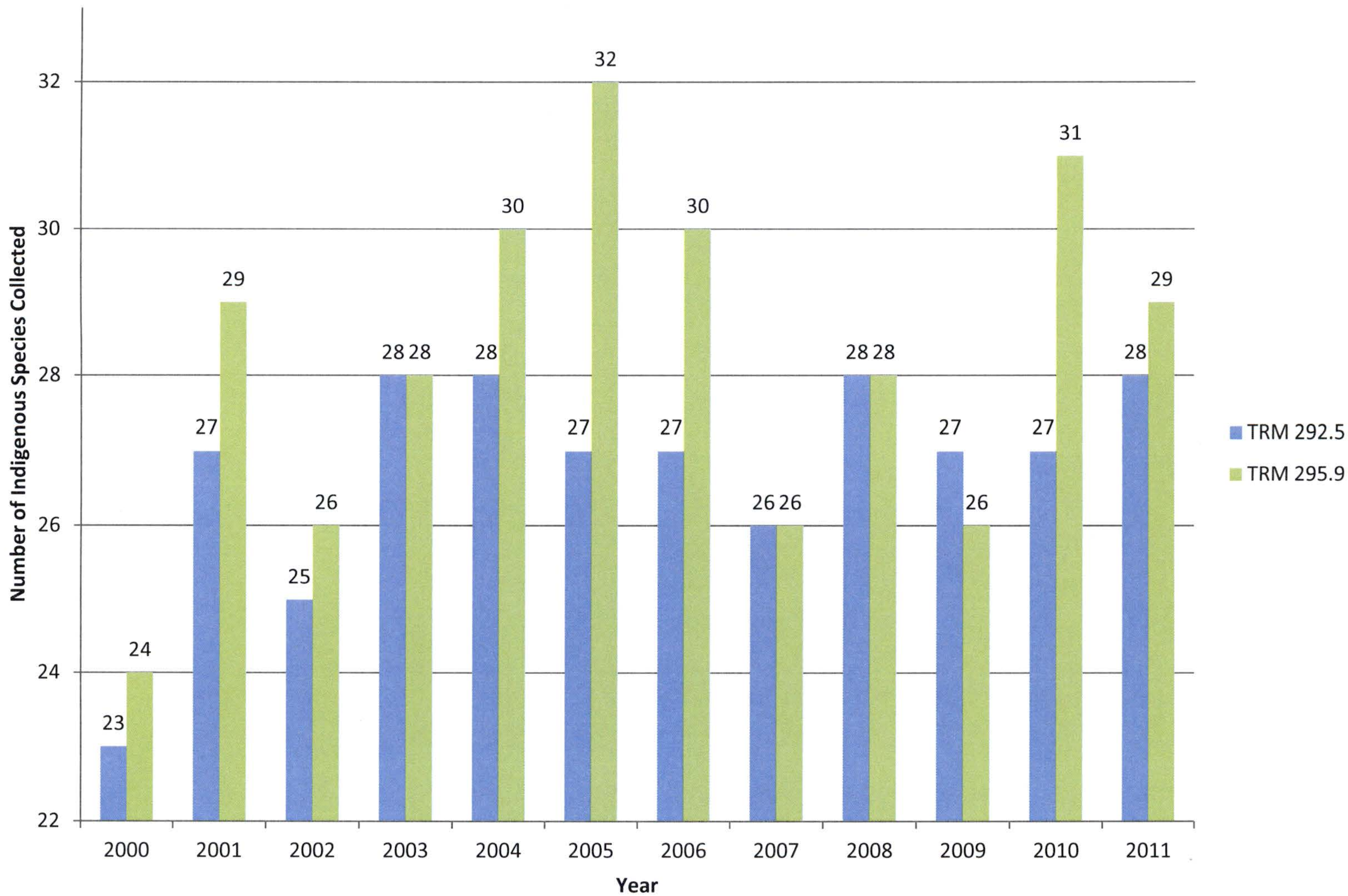

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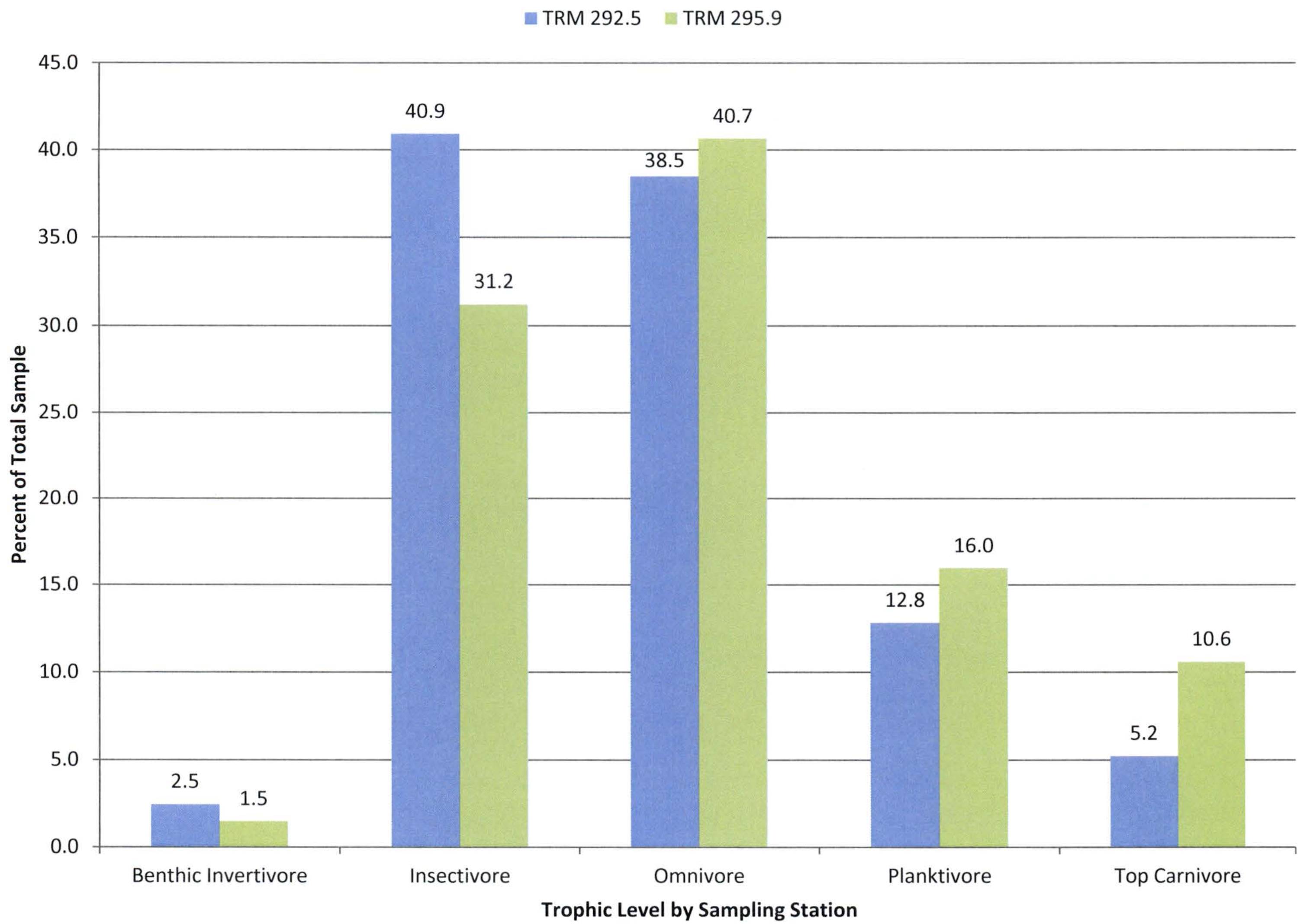

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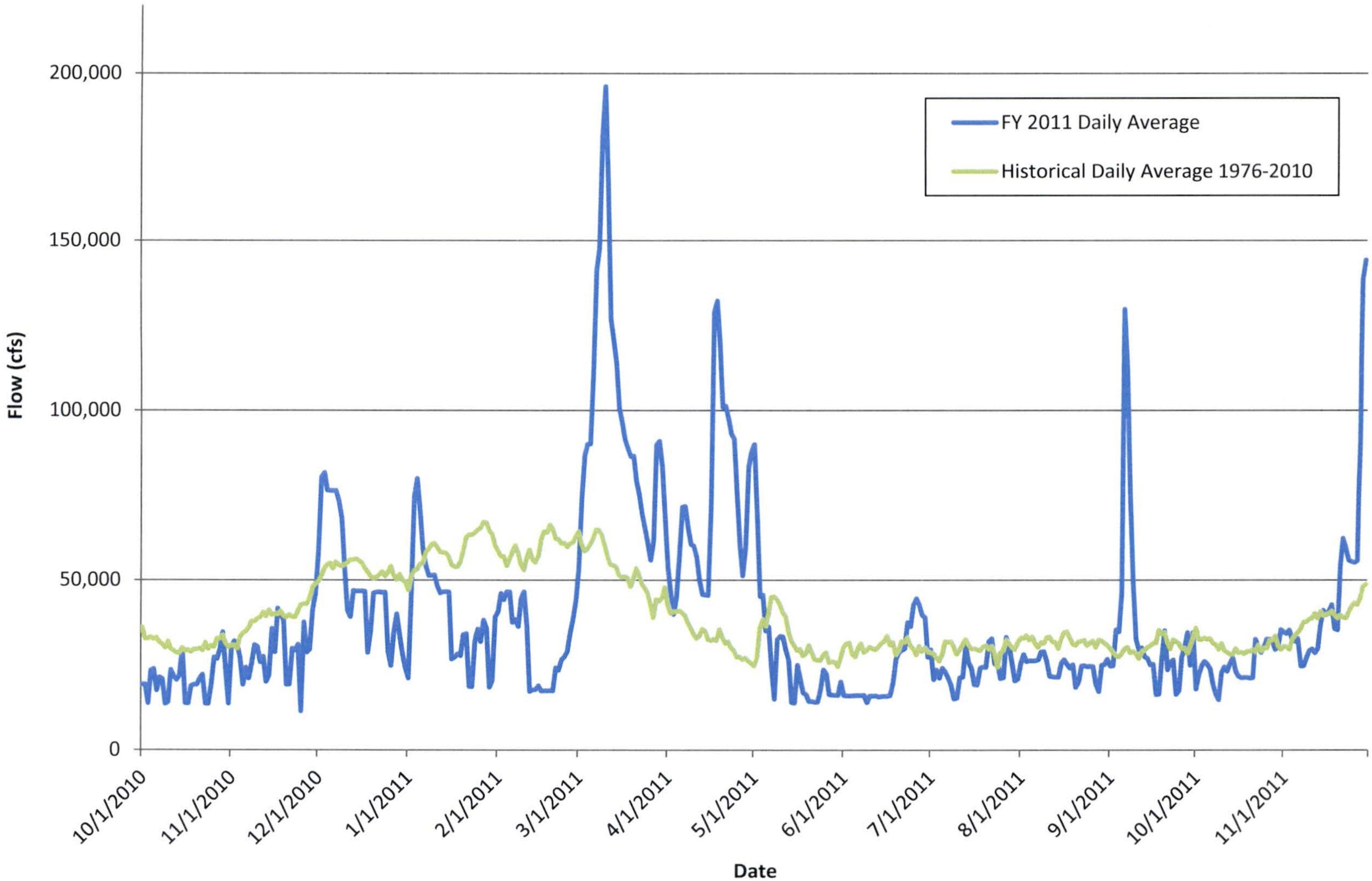

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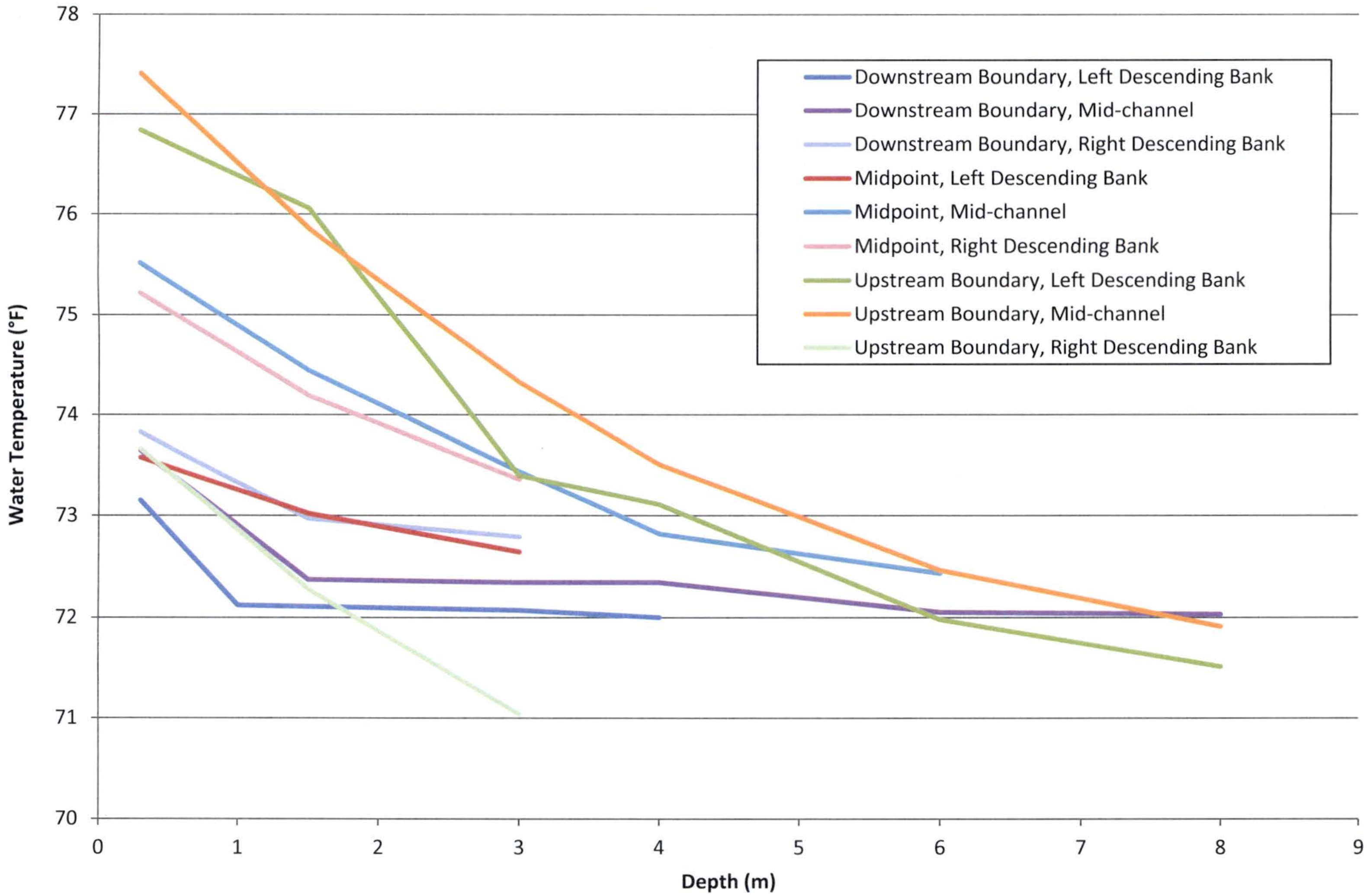

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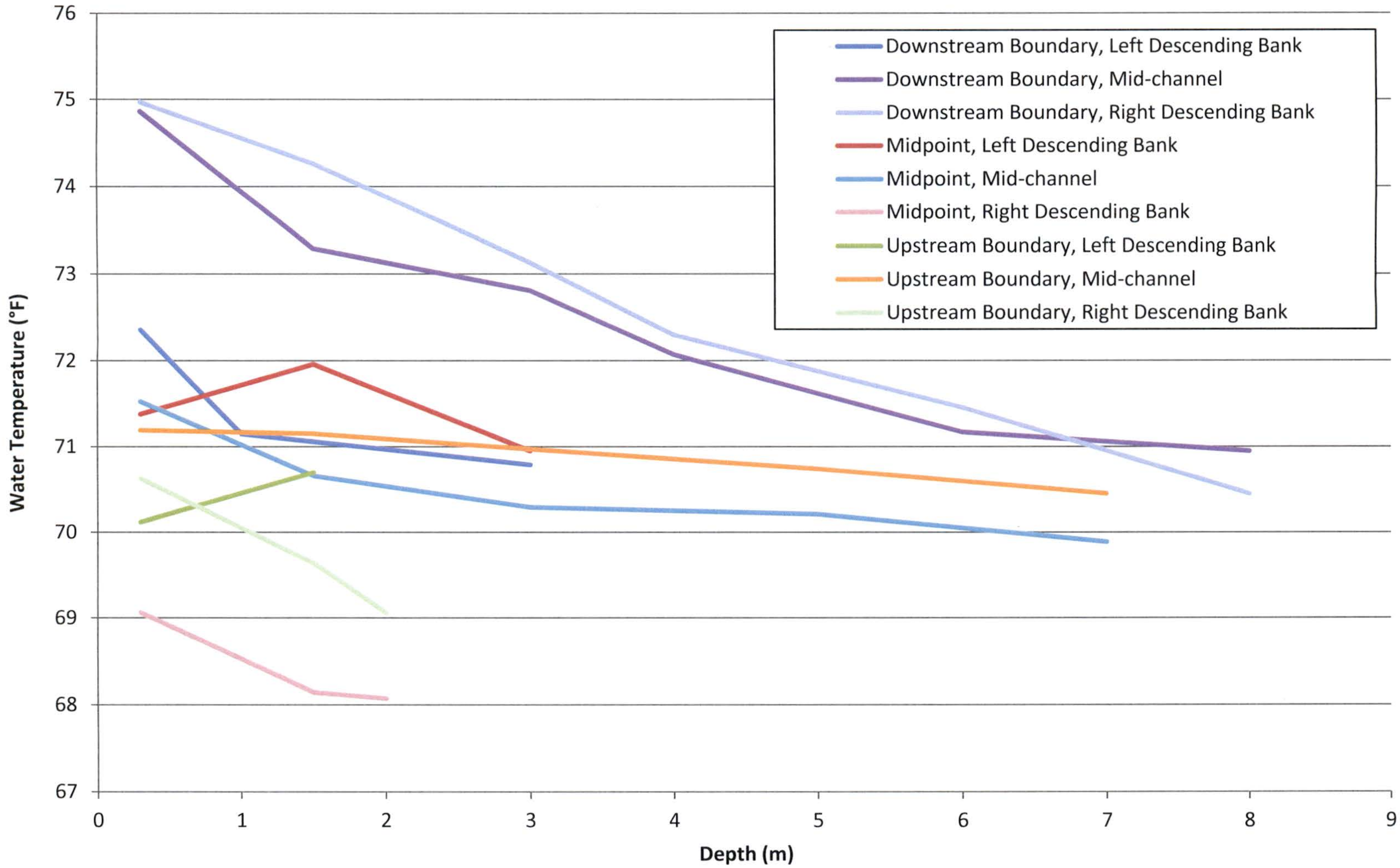

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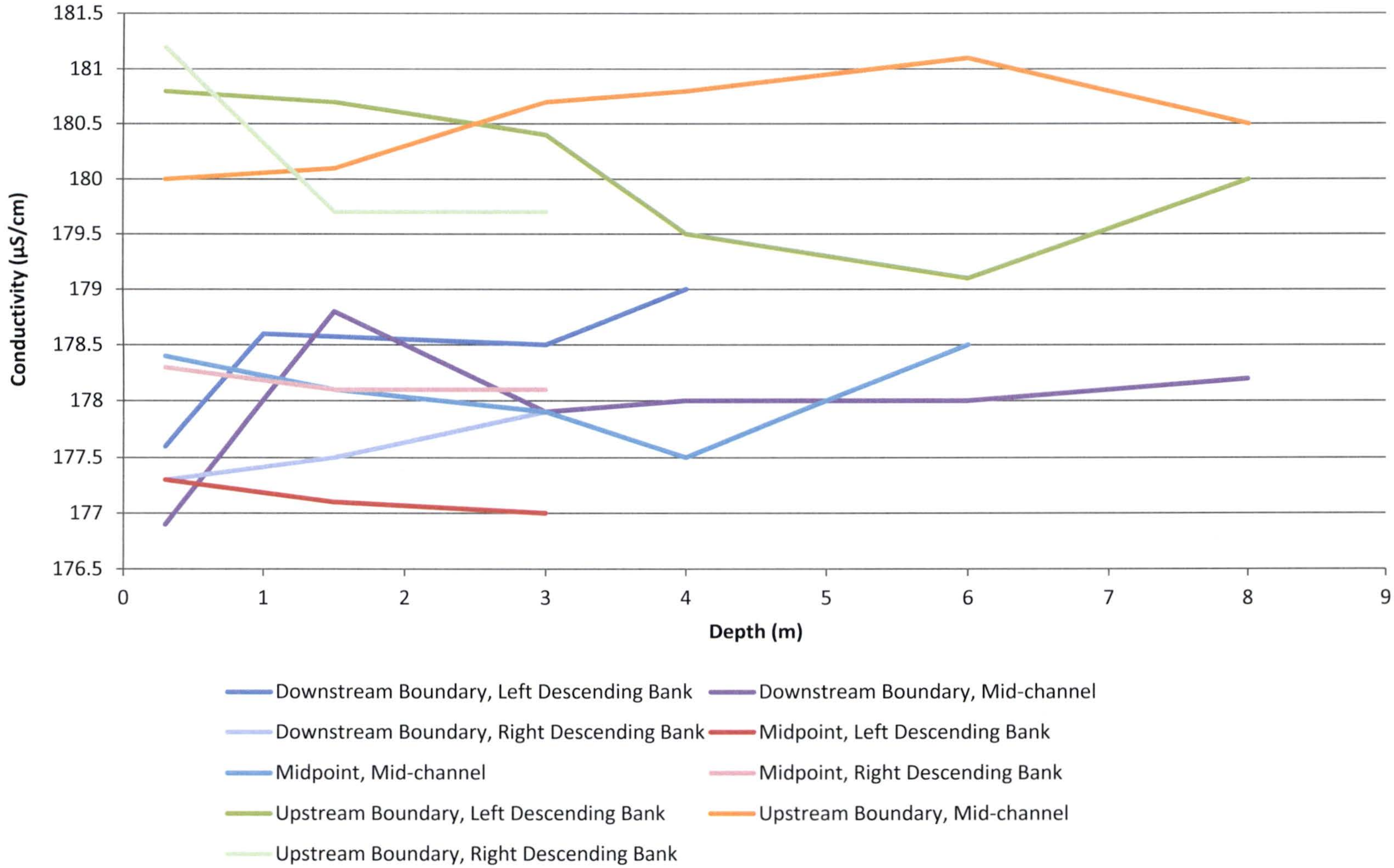

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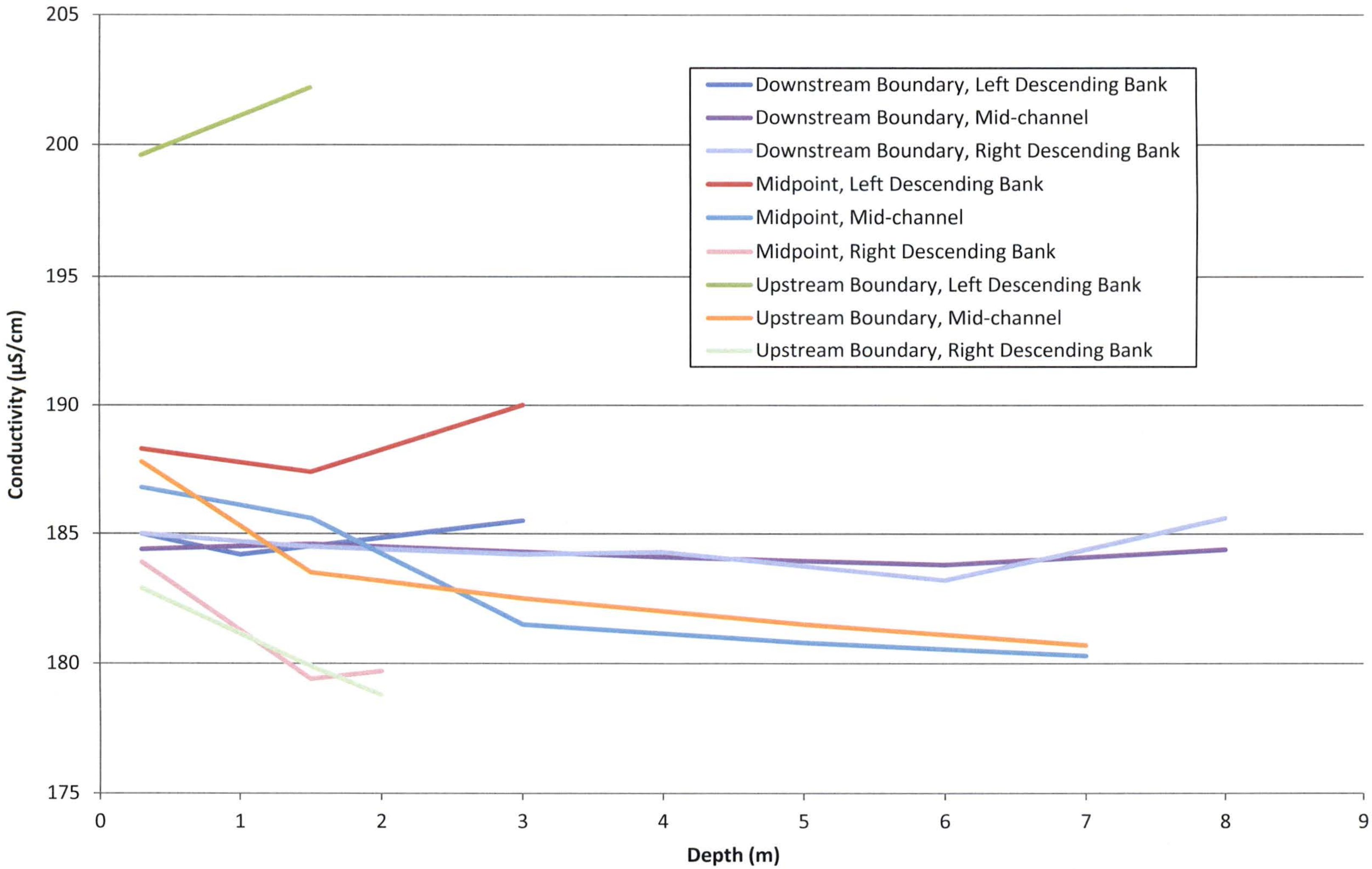

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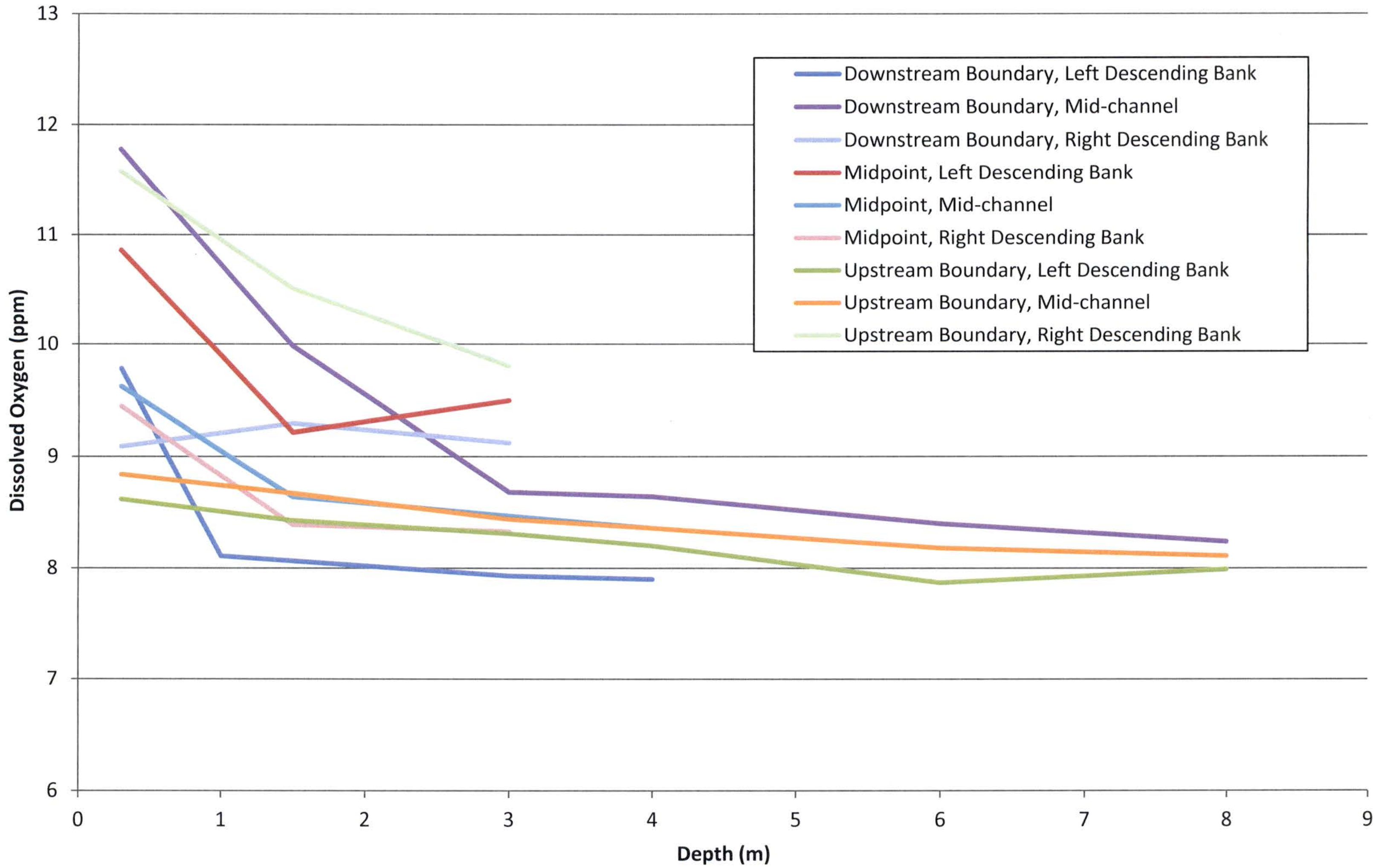

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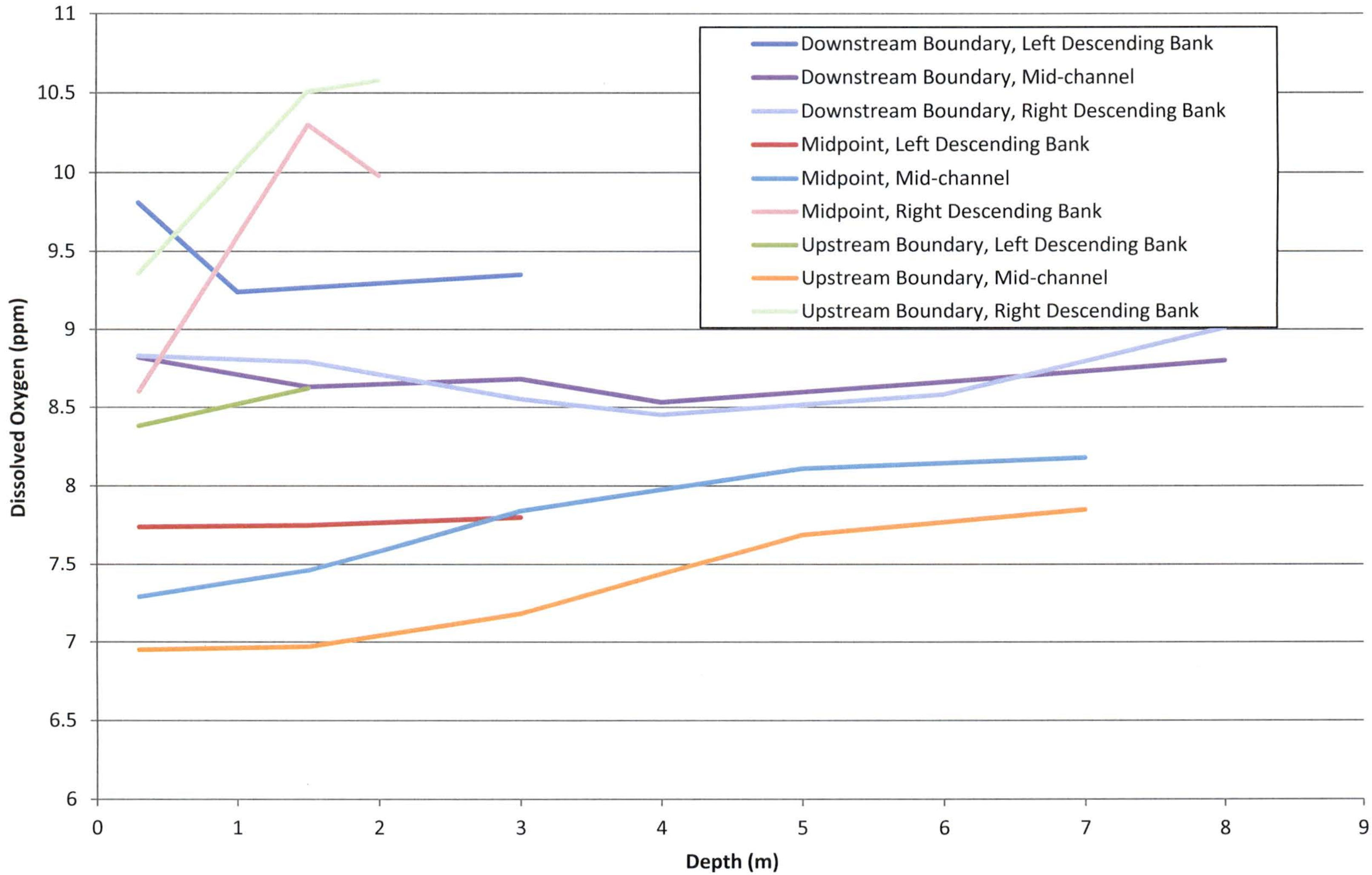

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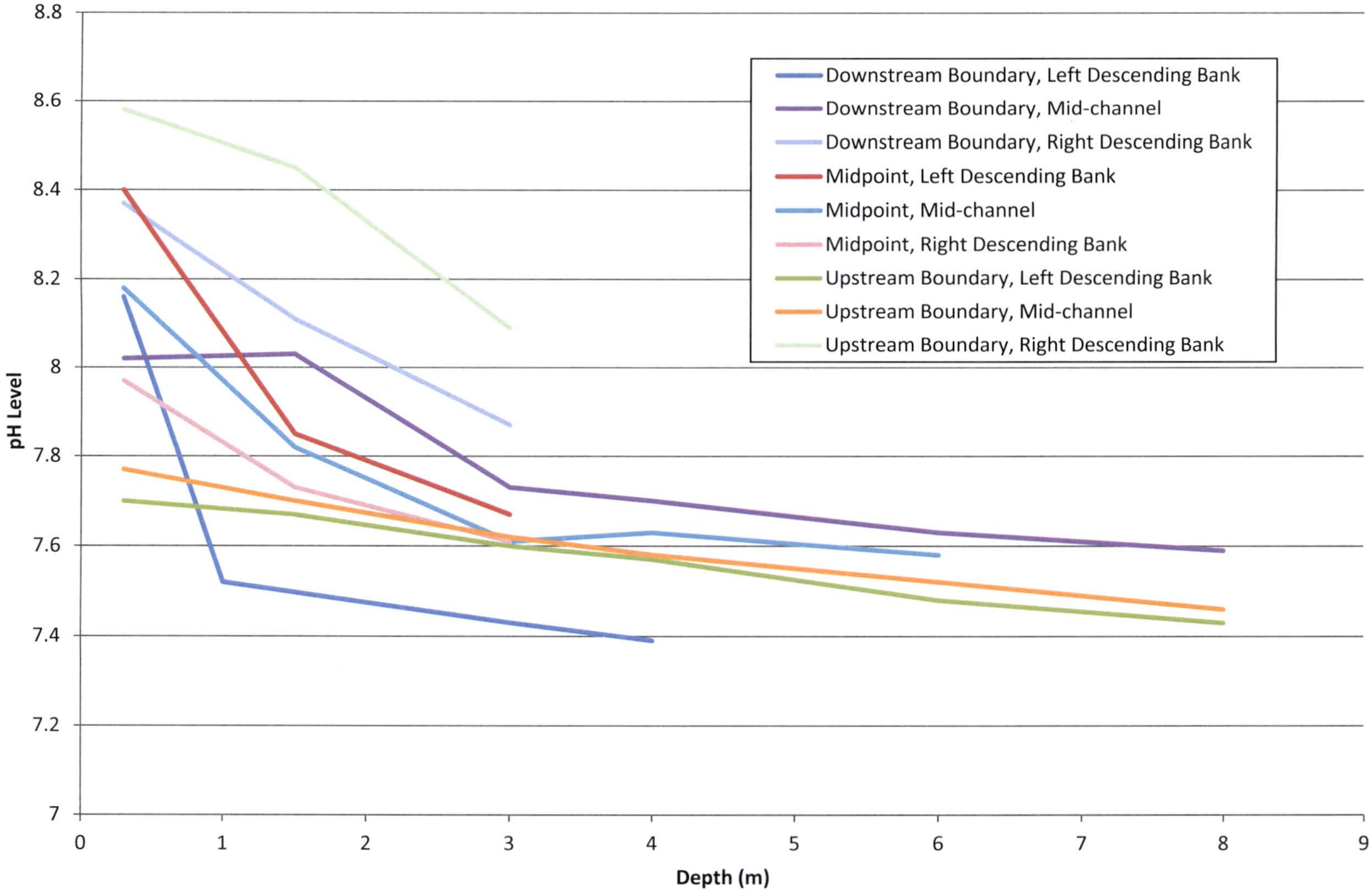

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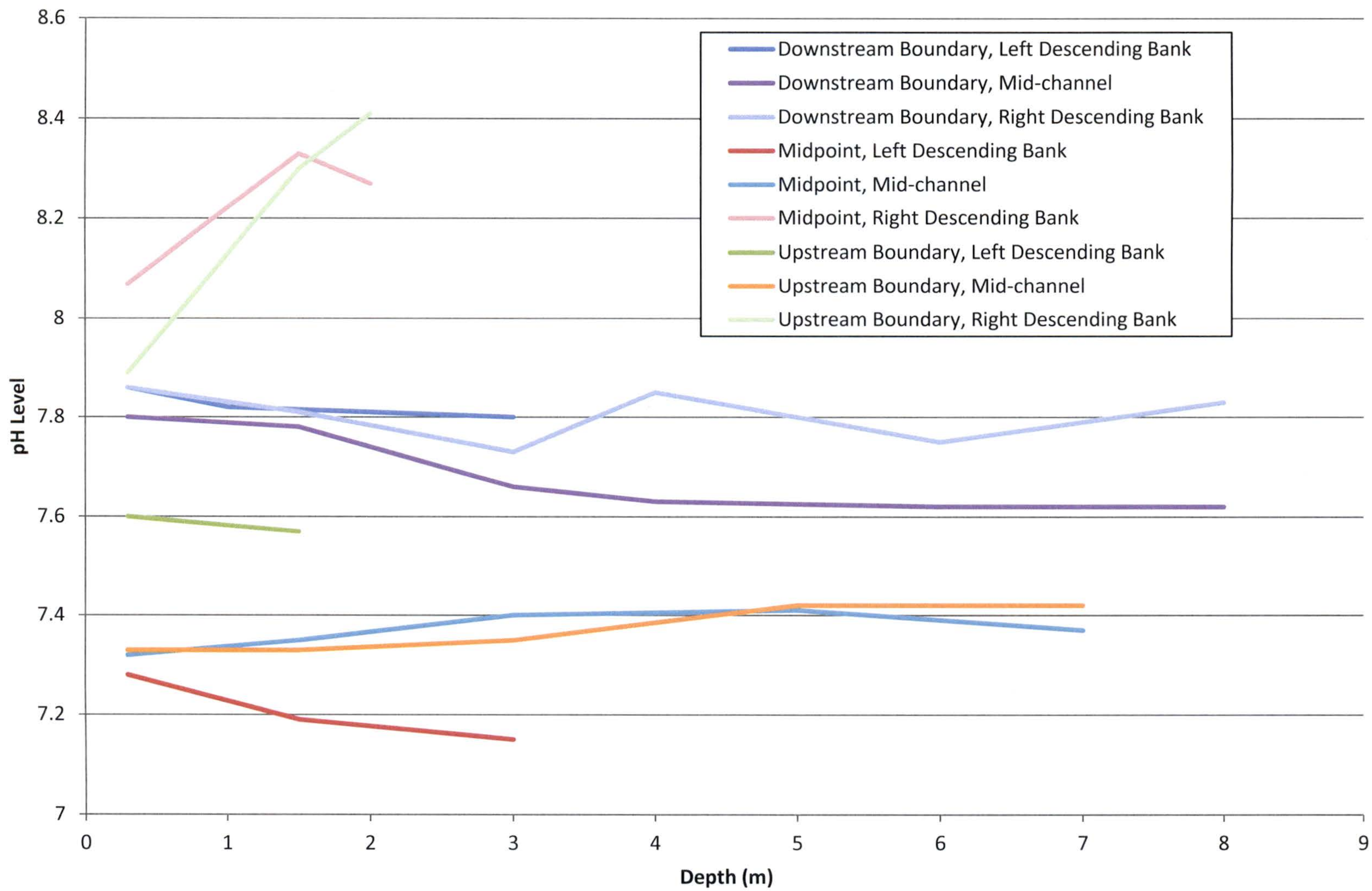
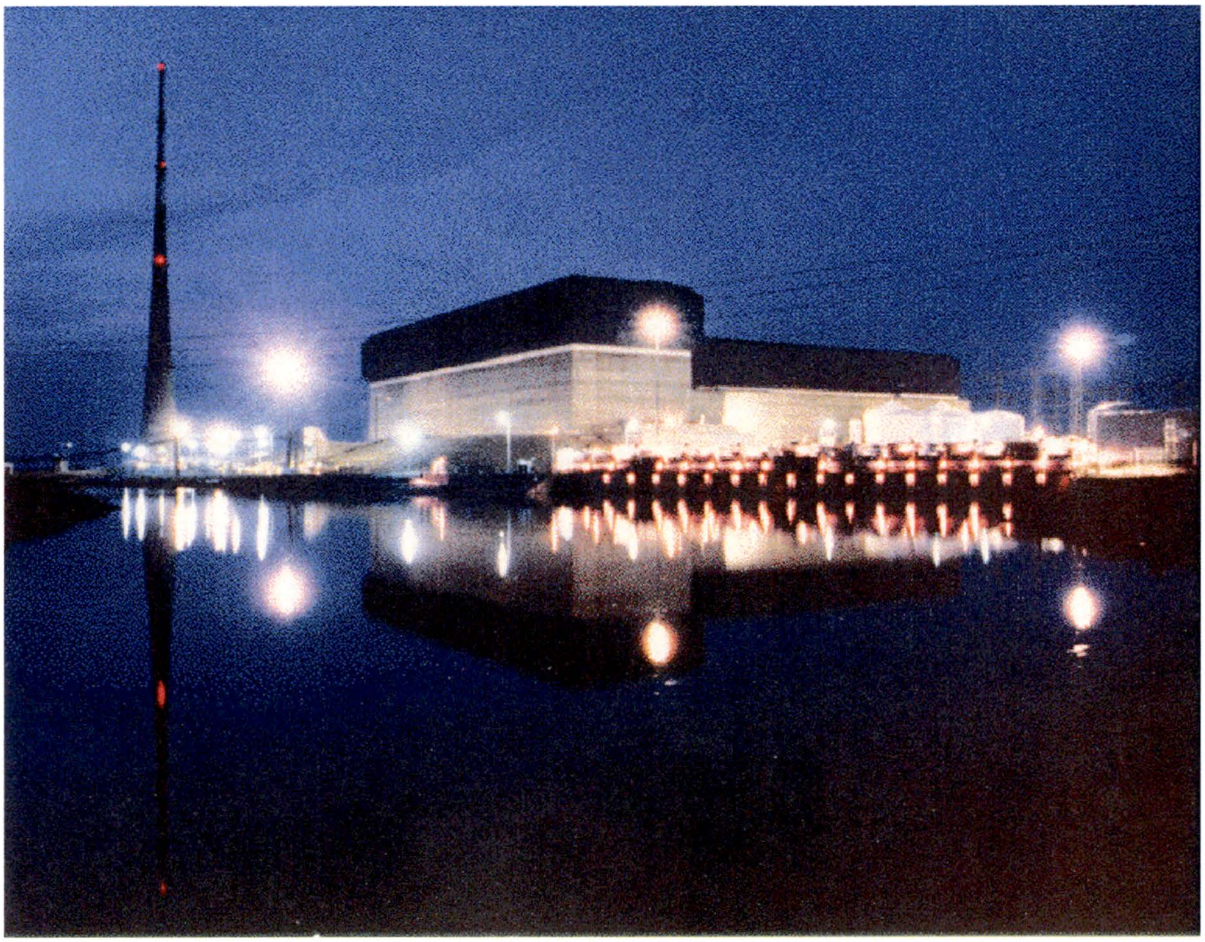


Figure 26. Level of acidity (pH) along vertical depth profiles at nine locations within the sampling station centered at TRM 295.9, upstream of Brown's Ferry Nuclear Power Plant, October 2011.

ATTACHMENT 9

Reference TVA. 2012b.
Entrainment of Ichthyoplankton at Browns Ferry Nuclear Plant During 2008–2009. Knoxville, Tennessee: TVA Biological and Water Resources.

ENTRAINMENT OF ICHTHYOPLANKTON AT BROWNS FERRY NUCLEAR PLANT DURING 2008-2009



2012

ENVIRONMENT AND TECHNOLOGY
BIOLOGICAL AND WATER RESOURCES

Knoxville, Tennessee

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ABBREVIATIONS AND ACRONYMS

BFN	Browns Ferry Nuclear Plant
CCW	Condensed cooling water
CWA	Clean Water Act
IRP	Integrated Resource Plan
NPDES	National Pollutant Discharge Elimination System
NRC	Nuclear Regulatory Commission
RFAI	Reservoir Fish Assemblage Index
SEIS	Supplemental Environmental Impact Statement
TVA	Tennessee Valley Authority

EXECUTIVE SUMMARY

The BFN Supplemental Environmental Impact Statement (SEIS) for Power Up-Rate committed to evaluate effects of the 21.5% increase in condenser cooling water (CCW) flow on rate of entrainment of fish eggs and larvae. Unit 1 was returned to service in 2007. A consequence of the increased generation capacity is an increase in the quantity of CCW required during normal operation. Prior to 1980, extensive biological and hydrological studies were conducted to assess the effects of CCW withdrawal on the aquatic community in Wheeler Reservoir. These studies demonstrated CCW withdrawal at BFN had no significant impact on the aquatic community. TVA conducted a two-year entrainment and impingement study in 2003 and 2004 to evaluate effects of two-unit operation on the aquatic fish community and update baseline data prior to the restart of Unit 1. To evaluate the effect of the return of Unit 1 and the Power Up-Rate to 110%, TVA conducted additional entrainment monitoring during 2008 and 2009. Results of that monitoring and comparisons with historical monitoring results are presented in this report.

Condenser Cooling Water withdrawn from Wheeler Reservoir potentially affects the fish community by entrainment (small fish and eggs drawn through the intake screens). Densities of fish eggs and larvae in the reservoir near the intake and daily volume of water transported past BFN were compared to daily CCW demand and densities of fish eggs and larvae at the intake skimmer wall to estimate percent entrainment.

Sciaenid (freshwater drum) eggs were the dominant egg taxon and clupeids (skipjack herring, gizzard and threadfin shad) the dominant fish taxon collected in entrainment sampling. Expressed as percent composition, 87 percent of the fish eggs were freshwater drum and 95 percent of the larvae collected in the entrainment samples were clupeids. Species composition of fish collected during the 2008 and 2009 monitoring was similar to results recorded during 2003 and 2004.

The average larval entrainment rate of 9% estimated during 2008 and 2009 was within the range (4.5–11.7%) estimated during 2003 and 2004 for larvae.

Entrainment estimates were higher in 2008 (eggs–18%; larvae–13%) and 2009 (eggs–7%; larvae–9%) than observed in 2003 and 2004 (eggs–1.3%; larvae–4.5%).

Fluctuations in entrainment rates of fish eggs and larvae at BFN are common. Variation in seasonal reservoir flow and the normal cycles in year-class strength of the dominant fish taxa are factors contributing to these fluctuations. Although fluctuations in annual entrainment estimates do occur, the 2008 and 2009 monitoring and recent (2011) Reservoir Fish Assemblage Index (RFAI) evaluations demonstrate Wheeler Reservoir near BFN supports a stable and diverse indigenous fish community with no significant effects from current plant operations.

INTRODUCTION

Browns Ferry Nuclear Plant (BFN) is a three-unit nuclear fueled facility capable of producing 3,440 MW of electricity. BFN is located on 840 acres beside Wheeler Reservoir in Limestone County, Athens, Alabama. BFN's current operation utilizes a once-through condenser cooling water (CCW) system, withdrawing water from the Tennessee River through an intake structure and discharging the water through diffuser pipes located downstream from the plant (Figure 1). The procedure is regulated by BFN's National Pollutant Discharge Elimination System (NPDES) permit, #AL0022080. This document provides current ichthyoplankton (fish eggs and larvae) entrainment estimates associated with the withdrawal of CCW, provides historical comparisons, and updates baseline data collected prior to the Unit 1 restart.

Background and Scope

The Tennessee Valley Authority (TVA) initiated an Integrated Resource Plan (IRP) in 1994 to assess the most cost effective approach to meeting future power demands. In response to the IRP, the current BFN operating license extends the life of each unit an additional twenty years and uprates the units to 120 percent of their original licensed generating levels. After an extended shutdown, Unit 2 returned to service in 1991, Unit 3 in 1995, and Unit 1 in 2007. TVA prepared a Supplemental Environmental Impact Statement (SEIS) (TVA 2001) assessing the potential environmental impacts from the proposed license renewal. However, to more accurately assess potential entrainment impacts from increased CCW demand after the restart of Unit 1, TVA conducted studies in 2003 and 2004 (TVA 2006) to update baseline data. Current monitoring conducted during 2008 and 2009 estimates entrainment of fish eggs and larvae at BFN under full three-unit uprated operation.

Section 316(b) of the Clean Water Act (CWA) provides standards for cooling water intake structures and procedures for assessing impacts. Compliance requires the permittee to characterize the aquatic community in the vicinity of the intake structure prior to operation, monitor during normal operation to assess impacts, and periodically review current operational demands, reservoir operation, and condition of the aquatic community to ensure no significant changes have occurred. One potential impact associated with cooling water intake structures is entrainment of fish eggs and larvae. Entrainment occurs when small organisms are drawn through the intake structure into the plant cooling system.

The BFN's preoperational baseline data include 18 years of reservoir fish standing stock surveys (1949-1961 and 1969-1973), gill and trap net surveys (1970-1973), and ichthyoplankton investigations (1971-1973). Aquatic monitoring continued until 1980 as part of BFN Technical Specifications issued by the Nuclear Regulatory Commission (NRC). In 1980, the NRC eliminated the aquatic monitoring requirement from the BFN Technical Specifications. Since 1980, annual fish standing stock surveys (1980-1997) and Reservoir Fish Assemblage Index (RFAI) ratings (1993-2011) provide a minimum data base on condition of the reservoir fish community in the vicinity of BFN.

RESERVOIR AND PLANT OPERATION DURING 2008 AND 2009

Wheeler Reservoir Operation

River flow past BFN is dependent on the rate water released through Guntersville and Wheeler Dams. TVA's integrated approach to Wheeler Reservoir operation includes winter drawdown for flood control, minimum summer pools, and hydroelectric power generation. Since 1976, average daily release through Guntersville Dam was 40,093 cubic feet per second (cfs). Average daily releases from Guntersville Dam during 2008 and 2009 were 21,760 cfs and 46,259 cfs, respectively (Figure 2).

BFN Operation

BFN Units 1, 2 and 3 were in operation during the study period and combined generation rate for three Units averaged 2,949 megawatts (MW) in 2008 and 3,030 MW in 2009. The average daily withdrawal rate of CCW from Wheeler Reservoir during the two-year study was 121.8 m^3/s. However, CCW demand during entrainment sampling (February through early July) averaged 114.4 m^3/s in 2008 and 112.7 m^3/s in 2009.

METHODS

Sample Collection

Ichthyoplankton samples were collected upstream of BFN at TRM 294.5 to estimate densities of fish eggs and larvae in the water column drifting past the plant and in the intake basin near the skimmer wall. Twenty samples were collected weekly from February 7, 2008 through June 30, 2008 and February 4 through June 25, 2009. Eight reservoir samples (four day and night) were collected at three stations: a full stratum sample on both left and right overbanks and two mid-channel stratified samples (surface to mid-depth and mid-depth to near bottom). Twelve samples (six day and night) were collected in front of the intake basin at the skimmer wall.

Samples were collected with a 0.5 m square beam net, 1.8 m long, with 505 micron "nitex" mesh netting. Nets were equipped with a large-vaned General Oceanics® flowmeter used to measure sample volume. Intake samples were collected in the inflow of the CCW under the skimmer wall gates by lowering the net to the bottom of the skimmer wall opening and retrieving it for ten minutes to the top of the opening equally sampling all strata. Volume filtered during each ten-minute sample was dependent on and varied with intake demand and velocity.

Ichthyoplankton samples during 2008 and 2009 monitoring were collected using the same methods, diel schedule (day and night), and at the same sample locations as those used in 2003 and 2004. Standard procedures for ichthyoplankton sampling are described in TVA (2009), Appendix A.

Sample Processing

In the laboratory, all fish eggs and larvae were removed from each sample, identified to the lowest practical taxon, and enumerated. Taxonomic decisions were based on TVA's "Preliminary Guide to the Identification of Larval Fishes in the Tennessee River" (Hogue et al, 1976, Wallus et al., 1990; Kay et al., 1994; Simon and Wallus, 2003; Simon and Wallus, 2006; Wallus and Simon, 2006; and Wallus and Simon, 2008). Standard procedures for processing ichthyoplankton samples are described in TVA (2009), Appendix B.

Data Analysis

Data were presented and analyzed by type (eggs or larvae), family (taxon), number and relative abundance. Density of fish eggs and larvae was presented as numbers per 1,000 m^3 of water sampled. Estimated entrainment was derived from the formula:

$$E = \frac{100 D_i Q_i}{D_r Q_r},$$

Where D_i was the mean density (number/1000 m^3) of eggs or larvae in intake samples; D_r was the mean density (number/1000 m^3) of eggs or larvae in the reservoir samples; Q_i was the plant intake water demand (m^3/d); and Q_r was the river flow (m^3/d) based on 24-hour daily average release from Guntersville Dam.

Temporal occurrence, relative abundance, average seasonal densities and peak densities were discussed for each significant (constituting >1% of total) taxon. Average seasonal densities were calculated using the formula:

$$D = \frac{1{,}000(\mathit{Total\ number\ fish\ eggs\ or\ larvae\ collected})}{\mathit{Total\ volume\ of\ water\ sampled}}$$

RESULTS

Densities of fish eggs and larvae were expressed as number per volume of water sampled. To evaluate volume filtered per sample period in the intake and reservoir, the total volume of water filtered in the twelve intake samples was compared to the total volume filtered in the eight reservoir samples. In 2008, an average of 473.9 m^3 of water was filtered per sample period in the intake and 594.1 m^3 in the reservoir. Total water filtered during 2009 intake sampling averaged 451.2 m^3 per sample period and 541.6 m^3 in the reservoir (Table 1).

Table 2 presents scientific and common names of families of fish eggs and larvae collected during 2008 and 2009 and the taxonomic resolution used in identification. Although identification to subfamily, genus, or species was possible for some individuals, results are presented by family for comparative analysis. Table 3 presents percent composition by family collected during 2008 and 2009 and for the two years combined.

Fish Eggs

Total fish eggs collected during 2008 was 2,043 and 1,377 in reservoir and intake samples, respectively, and in 2009 was 2,537 in reservoir samples and 2,033 in intake samples (Table 4). Sciaenid (freshwater drum) eggs constituted 86.7% of the total eggs collected during the two years combined (Table 3). The only other fish eggs collected in significant numbers were those of clupeids at 13.3% during 2008 and 2009 combined (Table 3). During 2009, five catostomid eggs were also collected (Table 4). Fish eggs were collected from late April through June both years. During both years, peak density of eggs occurred during the first week of June, with a smaller peak occurring the first week of May (Figure 3).

Greater numbers of drum and shad eggs were collected in reservoir samples than in intake samples in 2008; however, in 2009 numbers were similar in both intake and reservoir samples (Table 4). Average seasonal densities were slightly lower in 2008 (138/1,000 m^3 in the intake basin and 164/1,000 m^3 in the reservoir) than observed in 2009 (204/1,000 m^3 and 234/1,000 m^3, in the intake and reservoir, respectively) (Table 4).

Larval and Juvenile Fish

A total of 50,179 and 26,567 larval fish representing eleven families was collected during 2008 in reservoir and intake samples, respectively. During 2009, 24,207 and 20,237 larvae representing nine families were collected in reservoir and intake samples, respectively. The two families not collected during 2009 were Belonidae (Atlantic needlefish) and Poeciliidae (Mosquitofish). During 2008, clupeids (shad) represented 96.3% of larvae collected in reservoir samples and 94.1% in intake samples. In 2009, clupeid larvae were 93.0% and 92.8% of those collected in reservoir and intake samples, respectively. Other families contributing at least 1% of the total (2008 and 2009 combined) collected were Moronidae (temperate basses) at 2.3% in intake samples and 2.6% in reservoir samples and Centrarchidae (sunfishes) at 1.5% in intake samples and 1.0% in reservoir samples (Table 3). In both years, larvae were first collected the third week of March. Peak densities (reservoir) were observed during the first week of May through the first week of June during 2008 and an early peak the fifth week of April and second peak the fourth week of May during 2009 (Figure 4).

In reservoir samples, average seasonal densities of all larvae averaged 4,022/1,000 m^3 in 2008 and 2,235/1,000 m^3 in 2009. Average seasonal densities in intake samples were 2,670/1,000 m^3 and 2,039/1,000 m^3 during 2008 and 2009, respectively (Table 4).

Clupeid larvae were collected from mid-April through June in both 2008 and 2009. In 2008 densities peaked on June 12 at 16,128/1,000 m^3 in intake samples and 12,725/1,000 m^3 in reservoir samples. In 2009, peak densities of 8,454/1,000 m^3 in intake samples and 9,556/1,000 m^3 in reservoir samples occurred during the second and fourth week of May, respectively (Table 4, Figure 6).

Temperate basses (*Morone*) in Wheeler Reservoir include three *Morone* species: striped bass, yellow bass, and white bass. *Morone* were collected during late March or early April through early June in both 2008 and 2009. Typically, *Morone* are among the earlier spawners in Wheeler Reservoir. Densities were greater in April and early May in both 2008 and 2009 with a peak

density of 465/1,000 m^3 occurring in reservoir samples the first week in April, 2008 and 439/1,000 m^3 in intake samples the first week of May, 2009 (Table 4, Figure 7).

In 2008, centrarchid larvae (sunfishes, crappie, and black basses) averaged 37 and 36/1,000 m^3 in intake and reservoir samples and 32 and 30/1,000 m^3 in 2009, respectively. Peak centrarchid densities in 2008 occurred the second week of June in intake (342/1,000 m^3) and reservoir (473/1,000 m^3) samples. In 2009, peak densities were recorded the fourth week of June in both intake (283/1,000 m^3) and reservoir (298/1,000 m^3) samples (Table 4, Figure 8).

Freshwater drum (sciaenid) larvae were collected from late April through June with unusually low numbers (16) collected in 2008 in intake and reservoir samples combined. In 2009, 285 larvae were collected in reservoir samples and 124 in intake samples with peak density (128/1,000 m^3) occurring in intake samples the fourth week of June (Table 4, Figure 9).

In 2008, silversides larvae averaged 55 and 6/1,000 m^3 in intake and reservoir samples, respectively. In 2009, silversides averaged 16 and 9/1,000 m^3 in intake and reservoir samples, respectively. Silversides were collected from mid-April through June with a peak density of 503/1,000 m^3 occurring the first week of June in intake samples in 2008 and 141/1,000 m^3 in intake samples in 2009 (Table 4, Figure 10). Both brook and Mississippi silversides occur in Wheeler Reservoir; however, all late post-yolk sac larvae and juveniles collected were Mississippi silversides. Mississippi silversides are not native to the Tennessee River but have invaded from the Mississippi River drainage and are out-competing the native brook silversides.

Hydraulic Entrainment Estimates

The hydraulic entrainment estimate for all sample periods, 2008 and 2009 combined, averaged 13.0%. In 2008, hydraulic entrainment averaged 15.7% (range 6.1 to 63.9%) and in 2009 averaged 11.0% (range 2.2 to 26.5%). Estimated daily CCW intake volumes were consistent during sampling in 2008 and 2009. Likewise, average daily volume transported past BFN was 1.34×10^9 m^3/day in 2008 and 1.96×10^9 m^3/day in 2009 (Table 5).

Entrainment Estimates for Eggs and Larvae

The entrainment rate for fish eggs was 18% in 2008 and 7% in 2009. The average entrainment for both years averaged 10% for fish eggs. The high entrainment estimate (15,898%) for shad eggs in 2008 was a result of 597 shad eggs collected in intake samples and only one in reservoir samples (Tables 4 and 6). Whenever numbers of eggs or larvae collected in intake samples are higher than those in reservoir samples, entrainment estimates can be artificially elevated. Usually such events are attributed to actual spawning by taxa which are either resident in the intake basin or migrate there to spawn. An estimated 13% of fish larvae transported past BFN was entrained in 2008 compared to 7% in 2009 and averaged 9% for both years (Table 6).

HISTORICAL COMPARISONS

Hydraulic entrainment estimates in 2008 (15.7%) and 2009 (11%) were higher than that observed in 2003 (6.2%) and similar to that observed in 2004 (12.7%) (TVA 2006) (Table 5).

The 2008 and 2009 average entrainment estimate for larvae (9.0%) was similar to the average (10.8%) for 2003 and 2004 (TVA 2006). Domination by clupeid larvae was almost identical during 2003 and 2004 (94.5%) to that observed during 2008 and 2009 (94.6%). Based on historical and 2008 and 2009 data, fluctuations in the annual entrainment estimates, particularly for specific taxa at BFN, are common and often the result of annual variation in spawning success, variable reservoir flow past the plant, and rate of CCW hydraulic entrainment.

CONCLUSIONS

Both historical data and the 2008 and 2009 monitoring results demonstrate the variability in the occurrence, abundance and temporal distribution of ichthyoplankton in Wheeler Reservoir near BFN. This variability translates into significant fluctuation in the entrainment rates for individual families or species. Factors contributing to these fluctuations include spawning habits and success, life history variables of individual species, and the physical parameters of Wheeler Reservoir in the vicinity of BFN.

The location of BFN is probably a contributing factor to the fluctuations in the annual entrainment estimates. Reservoirs are characterized by three zones; the inflow having characteristics more riverine, the forebay is a more lacustrine area immediately upstream from a dam, and the transition zone provides a buffer in the middle of the reservoir. As water flows downstream from the inflow, velocity decreases as the cross-sectional area of the reservoir increases. Areas within the transition zone may exhibit high flow, low flow, or even negative flow depending on the rate water is released through the upstream and downstream dams. The area of Wheeler Reservoir near BFN is characterized as a transition zone where the velocity of water flowing past BFN depends on the rate water is released through Guntersville and Wheeler Dams. The rate of water flow past BFN increases and the reservoir surface elevation decreases when the rate of water released through Wheeler Dam exceeds the release through Guntersville Dam. Inversely, the surface elevation increases and rate of flow decreases near BFN when rate of water released through Guntersville Dam exceeds the release in Wheeler Reservoir. CCW demand for BFN remains fairly constant during normal three-unit operation; therefore, hydraulic and fish entrainment estimates will increase as reservoir flow past BFN decreases.

Entrainment at BFN is also influenced by the large overbank area located immediately upstream from the intake structure. Historical hydrodynamic studies show 53 to 63 percent of the CCW used by BFN is drawn from this overbank and the quantity of flow along the overbank varies with reservoir stage and flow (TVA, 2001).

TVA's valley-wide Vital Signs monitoring program is an additional tool used to evaluate the condition of the fish community near BFN. The RFAI, a component of TVA's Vital Signs monitoring program, is used to evaluate reservoir health by rating the fish community structure and function. A RFAI sampling station was established upstream from BFN at TRM 295.9 in 1992 and a second transition zone station added downstream at TRM 292.5 in 2000. Based on RFAI scoring criteria from reservoirs throughout the Tennessee Valley, scores of 51-60 are classified as excellent, 41-50 as good, 21-40 as fair, and 22-31 as poor. Annual RFAI scores for

the fish community near BFN in the last ten years (2000-2010) have averaged a score of 41 ("Good") (TVA, 2011).

The 2008 and 2009 entrainment estimates and recent fish community assessments (TVA, 2011) in Wheeler Reservoir near BFN show no significant impacts from current operation of BFN on the fish community near the plant. Both estimated ichthyoplankton entrainment percentages and RFAI fish community scores were comparable to historical levels. Results demonstrate annual variations in the relative abundance and temporal distribution of fish and fluctuations in reservoir flow are common in the vicinity of BFN. Life cycles of the dominant fish species and fluctuation in reservoir flow past BFN are significant factors influencing variations observed in the annual entrainment estimates. Based on the annual RFAI scores for Wheeler Reservoir, a viable and balanced indigenous fish community is present in Wheeler Reservoir in the vicinity of BFN.

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Table 1. Total Volume of Water Filtered by Sample Period at BFN during 2008 and 2009 to Estimate Entrainment of Fish Eggs and Larvae.

	2008			2009		
Week	Intake m^3	Reservoir m^3	Total m^3	Intake m^3	Reservoir m^3	Total m^3
1	867.7	573.3	1,441.0	222.3	317.3	539.6
2	*	596.3	596.3	484.6	362.5	847.1
3	446.8	580.1	1,026.9	489.1	299.1	788.3
4	450.4	*	450.4	461.6	602.4	1,064.0
5	489.0	598.0	1,087.0	545.5	609.5	1,154.9
6	453.9	625.6	1,079.5	489.4	583.1	1,072.5
7	453.0	302.7	755.8	484.2	604.6	1,088.8
8	459.5	592.7	1,052.2	493.2	*	493.2
9	459.7	604.1	1,063.8	399.4	631.1	1,030.4
10	462.3	595.6	1,057.9	459.9	535.0	994.9
11	461.0	612.8	1,073.8	448.1	622.4	1,070.6
12	446.6	609.0	1,055.7	445.1	628.0	1,073.1
13	451.2	608.5	1,059.6	431.3	590.2	1,021.5
14	444.4	621.1	1,065.5	436.9	402.5	839.5
15	429.1	611.3	1,040.4	450.9	*	450.9
16	442.9	672.1	1,115.0	449.3	604.1	1,053.4
17	444.3	630.0	1,074.2	440.2	604.7	1,044.9
18	469.6	605.4	1,074.9	467.4	603.0	1,070.3
19	452.9	610.5	1,063.4	462.4	625.7	1,088.1
20	477.9	601.3	1,079.2	449.3	664.7	1,114.0
21	444.4	605.6	1,050.0	459.9	623.6	1,083.5
22	445.2	621.1	1,066.3	456.4	318.9	775.3
TOTAL	**9,951.8**	**12,477.0**	**22,428.8**	**9,926.2**	**10,832.4**	**20,758.7**
AVERAGE	**473.9**	**594.1**	**1,019.5**	**451.2**	**541.6**	**943.6**

*- no sample

Table 2. List of Fish Eggs and Larvae by Family Collected at BFN in 2008 and 2009 Entrainment Samples and Lowest Level of Taxonomic Resolution for each Family.

Scientific Name	Common Name	Lowest Level of Taxonomic Identification
Eggs		
Catostomidae	Suckers	Family - Catostomid eggs
Clupeidae	Shad	Family - all Clupeid eggs
Sciaenidae	Drums	Species - Freshwater Drum eggs
Larvae		
Atherinopsidae	Silversides	Family - silverside Species - Mississippi silverside
Belonidae	Atlantic Needlefish	Species - Atlantic needlefish
Catostomidae	Suckers	Subfamily - ictiobines (buffalo and carpsuckers) Genus - larger individual to buffalo or spotted sucker
Centrarchidae	Sunfishes	Genus - crappie, lepomids (sunfishes), and black bass (not smallmouth bass) Species - larger individuals to bluegill
Clupeidae	Shad	Family - all larvae <20 mm TL Species - larger individuals to gizzard and threadfin shad
Cyprinidae	Minnows and Carps	Family - most minnows, shiners, and chubs Genus or Species - *Pimephales* spp., bullhead minnow
Ictaluridae	Catfishes	Family - catfish Species - blue catfish
Moronidae	Temperate Basses	Genus - *Morone* spp. or *Morone* type, but not *saxatilis* Species- white and yellow bass
Percidae	Darters	Genus - *P.caprodes* type, not *P. caprodes* type Species - logperch
Poeciliidae	Livebearers	Species - western mosquitofish
Sciaenidae	Drums	Species - freshwater drum

Table 3. Percent Composition of Fish Eggs and Larvae by Family Collected in Entrainment Samples at BFN during 2008 and 2009.

	Intake Samples			Reservoir Samples			
	2008 %	2009 %	Combined 2008-2009 %	2008 %	2009 %	Combined 2008-2009 %	All Samples %
Eggs							
Catostomidae	0.0	T	T	0.0	0.2	0.1	0.1
Clupeidae	43.4	10.0	23.5	T	10.2	5.7	13.3
Sciaenidae	56.6	90.0	76.5	99.9	89.6	94.2	86.7
Larvae							
Atherinopsidae	2.1	0.8	1.5	0.2	0.4	0.2	0.7
Belonidae	T	0.0	T	T	0.0	T	T
Catostomidae	0.2	0.8	0.5	0.3	0.7	0.4	0.4
Centrarchidae	1.4	1.6	1.5	0.9	1.3	1.0	1.2
Clupeidae	94.1	92.8	93.5	96.3	93.0	95.2	94.6
Cyprinidae	T	0.1	0.1	T	0.1	T	0.1
Ictaluridae	T	0.1	T	T	T	T	T
Moronidae	1.9	2.9	2.3	2.3	3.2	2.6	2.5
Percidae	0.2	0.3	0.2	T	0.1	0.1	0.1
Poeciliidae	T	0.0	T	0.0	0.0	0.0	T
Sciaenidae	T	0.6	0.3	T	1.2	0.4	0.4

T – Taxon was collected in samples but composition was less than 0.1%.

Table 4. Number, Average Seasonal and Peak Density, and Percent Composition by Family of Fish Eggs and Larvae Collected at Browns Ferry Nuclear Plant during 2008 and 2009.

	2008					
	NUMBER		Average Seasonal DENSITY No./1000m^3		Peak DENSITY No./1000m^3	
Family	**Intake**	**Reservoir**	**Intake**	**Reservoir**	**Intake**	**Reservoir**
Eggs						
Clupeidae	597	1	60	0.1	1,177	2
Sciaenidae	780	2,042	78	164	1,252	651
TOTAL	**1,377**	**2,043**	**138**	**164**		
Larvae						
Atherinopsidae	551	76	55	6	503	34
Belonidae	2	1	0.2	0.1	2	2
Catostomidae	59	140	6	11	104	235
Centrarchidae	372	453	37	36	342	473
Clupeidae	24,989	48,312	2,511	3,872	16,128	12,725
Cyprinidae	9	11	1	1	6	5
Ictaluridae	9	9	1	1	11	6
Moronidae	515	1,154	52	92	291	465
Percidae	49	14	5	1	45	8
Poeciliidae	5	0	1	0	11	0
Sciaenidae	7	9	1	1	7	8
TOTAL	**26,567**	**50,179**	**2,670**	**4,022**		

Table 4. (continued)

	2009					
	NUMBER		Average Seasonal DENSITY No./1,000m^3		Peak DENSITY No./1,000m^3	
Family	Intake	Reservoir	Intake	Reservoir	Intake	Reservoir
Eggs						
Catostomidae	1	4	T	1	2	10
Clupeidae	203	259	20	24	457	457
Sciaenidae	1,829	2,274	184	210	1,767	1,068
TOTAL	**2,033**	**2,537**	**204**	**234**		
Larvae						
Atherinopsidae	154	101	16	9	141	66
Belonidae	0	0	0	0	0	0
Catostomidae	165	158	17	15	250	132
Centrarchidae	322	325	32	30	283	298
Clupeidae	18,787	22,507	1,893	2,078	8,454	9,556
Cyprinidae	30	16	3	1	33	10
Ictaluridae	11	7	1	1	11	6
Moronidae	579	778	58	72	439	295
Percidae	65	30	7	3	45	13
Poeciliidae	0	0	0	0	0	0
Sciaenidae	124	285	12	26	128	107
TOTAL	**20,237**	**24,207**	**2,039**	**2,235**		

T – Taxon was collected in samples but density averaged less than 1 individual per 1,000m^3

Table 5. Estimated Daily Hydraulic Entrainment at Browns Ferry Nuclear Plant by Sample Period during 2008 and 2009.

	2008				2009				2008-2009		
Week	Intake (m^3/day) Q_i	Reservoir (m^3/day) Q_r	Entrained %		Intake (m^3/day) Q_i	Reservoir (m^3/day) Q_r	Entrained %		Intake (m^3/day) Q_i	Reservoir (m^3/day) Q_r	Entrained %
1	1.06E+07	1.10E+08	9.6		1.15E+07	8.74E+07	13.1		1.09E+07	1.02E+08	10.6
2	1.11E+07	1.10E+08	10.1		1.15E+07	6.27E+07	18.3		1.13E+07	8.63E+07	13.1
3	1.06E+07	9.46E+07	11.2		1.06E+07	5.74E+07	18.5		1.06E+07	7.23E+07	14.6
4	1.07E+07	8.93E+07	12.0		9.78E+06	7.75E+07	12.6		1.03E+07	8.46E+07	12.2
5	1.14E+07	8.19E+07	13.9		1.05E+07	8.70E+07	12.0		1.10E+07	8.39E+07	13.1
6	1.03E+07	1.14E+08	9.0		1.05E+07	6.27E+07	16.7		1.04E+07	8.84E+07	11.7
7	8.94E+06	1.19E+08	7.5		1.05E+07	9.19E+07	11.4		9.70E+06	1.06E+08	9.2
8	6.22E+06	1.03E+08	6.1		1.05E+07	9.91E+07	10.6		8.36E+06	1.01E+08	8.3
9	7.64E+06	4.10E+07	18.6		1.05E+07	7.82E+07	13.4		9.05E+06	5.96E+07	15.2
10	7.64E+06	7.16E+07	10.7		9.99E+06	6.90E+07	14.5		8.81E+06	7.03E+07	12.5
11	7.64E+06	3.77E+07	20.2		9.63E+06	6.74E+07	14.3		8.96E+06	5.75E+07	15.6
12	7.64E+06	3.53E+07	21.6		9.88E+06	6.64E+07	14.9		8.76E+06	5.08E+07	17.2
13	7.64E+06	3.02E+07	25.3		7.54E+06	3.05E+07	24.7		7.59E+06	3.03E+07	25.0
14	7.64E+06	3.49E+07	21.9		6.71E+06	3.02E+08	2.2		7.17E+06	1.69E+08	4.3
15	7.64E+06	3.55E+07	21.5		6.85E+06	1.11E+08	6.2		7.25E+06	7.34E+07	9.9
16	7.61E+06	2.46E+07	30.9		6.86E+06	1.48E+08	4.6		7.31E+06	7.38E+07	9.9
17	1.15E+07	1.79E+07	63.9		8.27E+06	8.52E+07	9.7		9.86E+06	5.16E+07	19.1
18	1.15E+07	4.46E+07	25.7		1.03E+07	9.28E+07	11.1		1.10E+07	6.39E+07	17.2
19	1.15E+07	3.38E+07	33.9		1.05E+07	7.97E+07	13.1		1.10E+07	5.67E+07	19.3
20	1.15E+07	3.69E+07	31.0		1.05E+07	7.63E+07	13.7		1.10E+07	5.66E+07	19.4
21	1.15E+07	3.31E+07	34.6		1.13E+07	8.51E+07	13.3		1.14E+07	5.91E+07	19.3
22	1.15E+07	3.98E+07	28.8		1.13E+07	4.27E+07	26.5		1.14E+07	4.12E+07	27.6
Totals	**2.10E+08**	**1.34E+09**	**15.7**		**2.15E+08**	**1.96E+09**	**11.0**		**2.13E+08**	**1.64E+09**	**13.0**

Table 6. Entrainment Estimates for Fish Eggs and Larvae Collected at Browns Ferry Nuclear Plant during 2008 and 2009.

Taxa	2008			2009			2008-2009		
	Intake	Reservoir		Intake	Reservoir		Intake	Reservoir	
	Number Entrained per day	Total Number per day	Entrainment Estimate	Number Entrained per day	Total Number per day	Entrainment Estimate	Number Entrained per day	Total Number per day	Entrainment Estimate
	$Q_i \times D_i$	$Q_r \times D_r$	%	$Q_i \times D_i$	$Q_r \times D_r$	%	$Q_i \times D_i$	$Q_r \times D_r$	%
Eggs									
Catostomidae	*	*	*	1.2E+06	5.3E+07	2	2.5E+06	7.7E+07	3
Clupeidae	7.73E+08	4.86E+06	15,898	2.4E+08	3.4E+09	7	2.0E+09	5.0E+09	39
Sciaenidae	1.01E+09	9.92E+09	10	2.1E+09	3.0E+10	7	6.4E+09	7.5E+10	9
Totals:	**1.8E+09**	**9.9E+09**	**18**	**2.4E+09**	**3.4E+10**	**7**	**8.4E+09**	**8.1E+10**	**10**
Larvae									
Atherinopsidae	4.9E+08	2.7E+08	179	1.2E+08	9.2E+08	13	3.9E+07	7.5E+07	53
Belonidae	1.8E+06	3.6E+06	49	*	*	0	1.1E+05	3.9E+05	0
Catostomidae	5.2E+07	5.0E+08	10	1.3E+08	1.4E+09	9	1.2E+07	1.2E+08	10
Centrarchidae	3.3E+08	1.6E+09	20	2.5E+08	3.0E+09	9	3.9E+07	3.2E+08	12
Clupeidae	2.2E+10	1.7E+11	13	1.5E+10	2.0E+11	7	2.4E+09	2.9E+10	8
Cyprinidae	7.9E+06	3.9E+07	20	2.4E+07	1.5E+08	16	2.2E+06	1.1E+07	19
Ictaluridae	7.9E+06	3.2E+07	25	8.7E+06	6.4E+07	14	1.1E+06	6.6E+06	17
Moronidae	4.5E+08	4.1E+09	11	4.6E+08	7.1E+09	6	6.1E+07	7.9E+08	8
Percidae	4.3E+07	5.0E+07	86	5.1E+07	2.7E+08	19	6.4E+06	1.9E+07	34
Poeciliidae	4.4E+06	*	0	*	*	0	2.8E+05	*	0
Sciaenidae	6.2E+06	3.2E+07	19	9.8E+07	2.6E+09	4	7.3E+06	1.3E+08	6
Totals:	**2.3E+10**	**1.8E+11**	**13**	**1.6E+10**	**2.2E+11**	**7**	**2.6E+09**	**3.0E+10**	**9**

***- Not collected.**

Figure 1. Location of Condenser Cooling Water (CCW) Intake, Skimmer Wall, and Discharge at Browns Ferry Nuclear Plant (TRM 294).

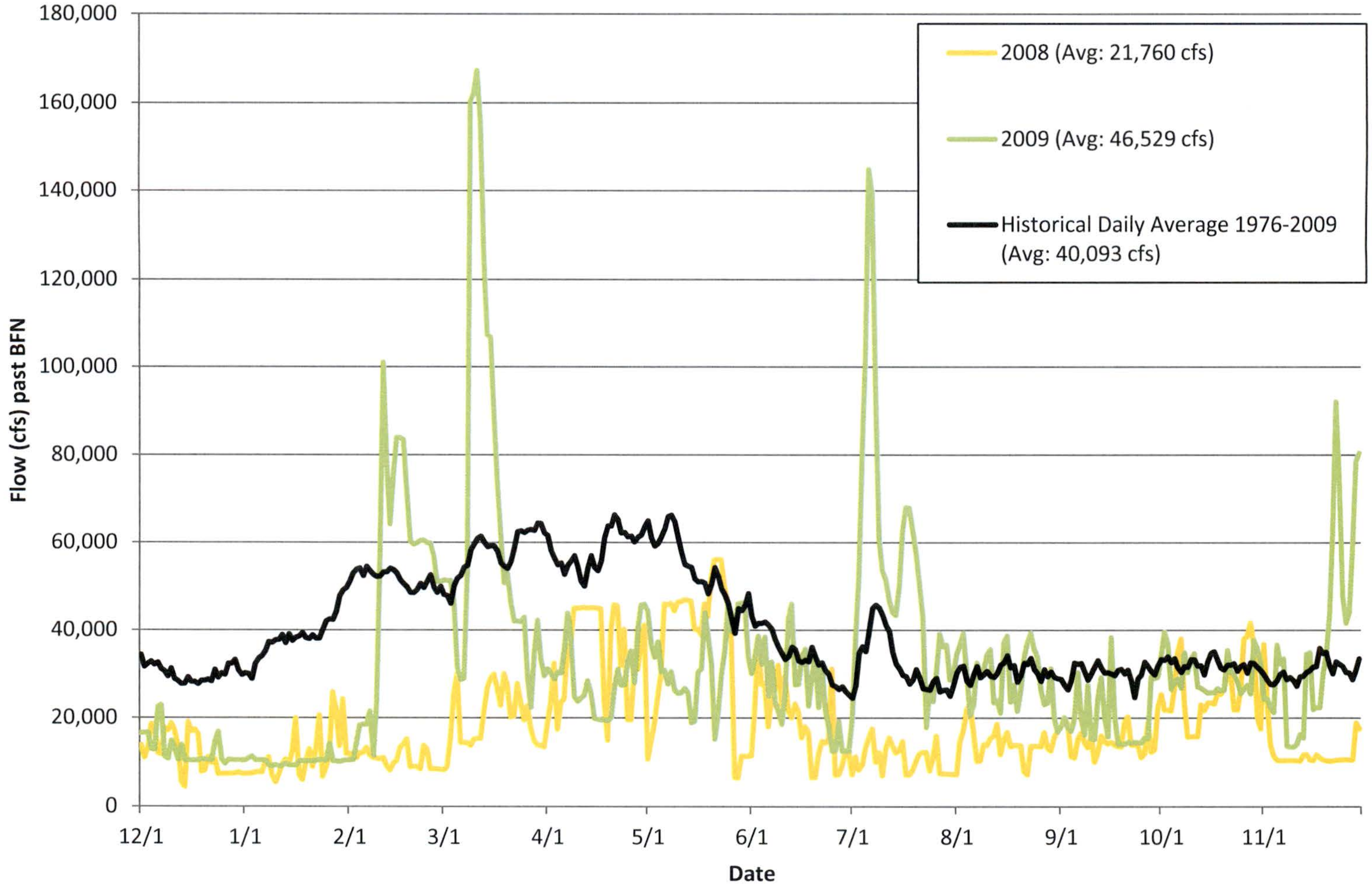

Figure 2. Actual daily releases during 2008 and 2009 and historical (1976-2009) daily average releases from Guntersville Dam (TRM 349).

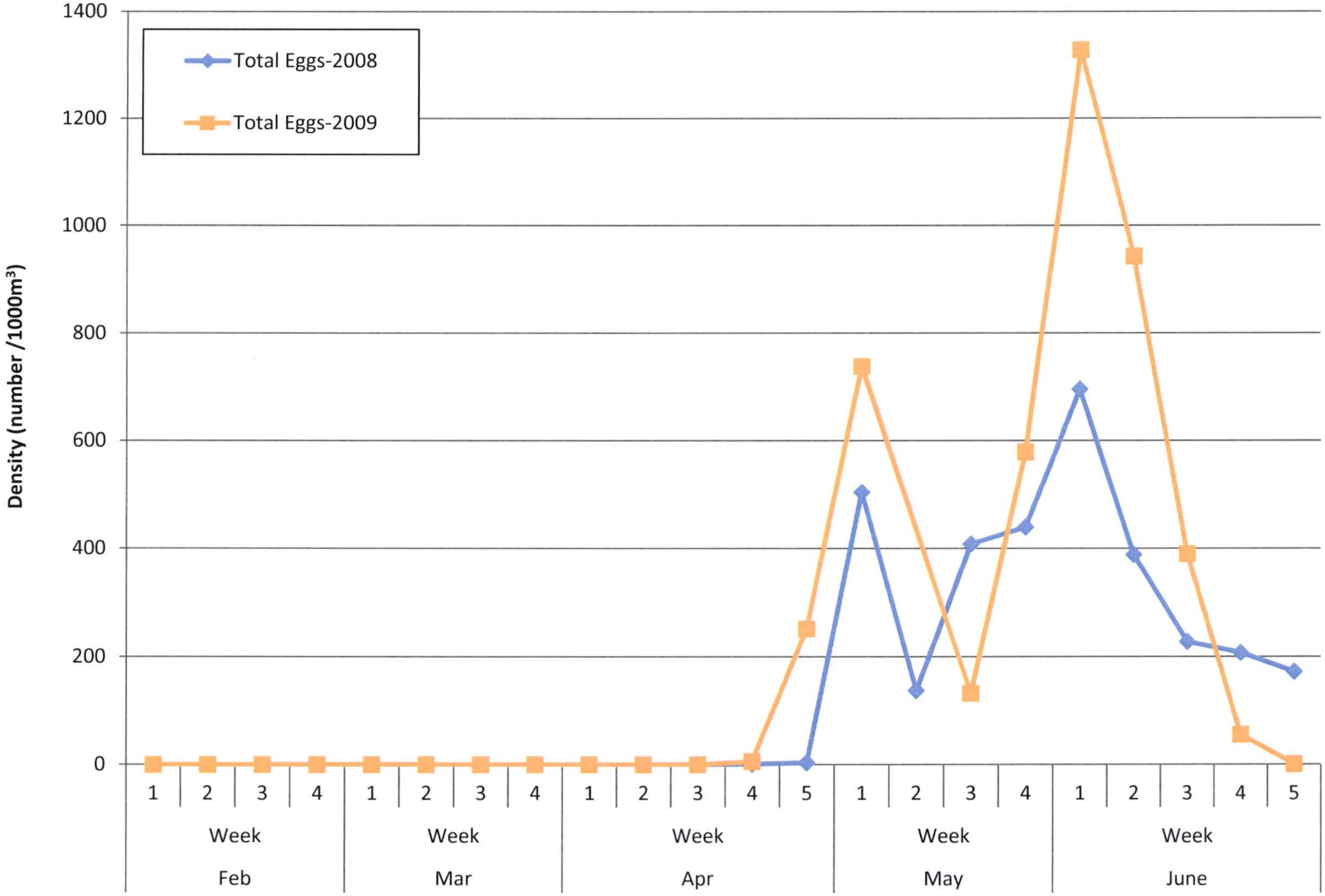

Figure 3. Weekly Densities of Fish Eggs Collected in Reservoir and Intake Samples Combined at Browns Ferry Nuclear Plant (TRM 294) During 2008 and 2009.

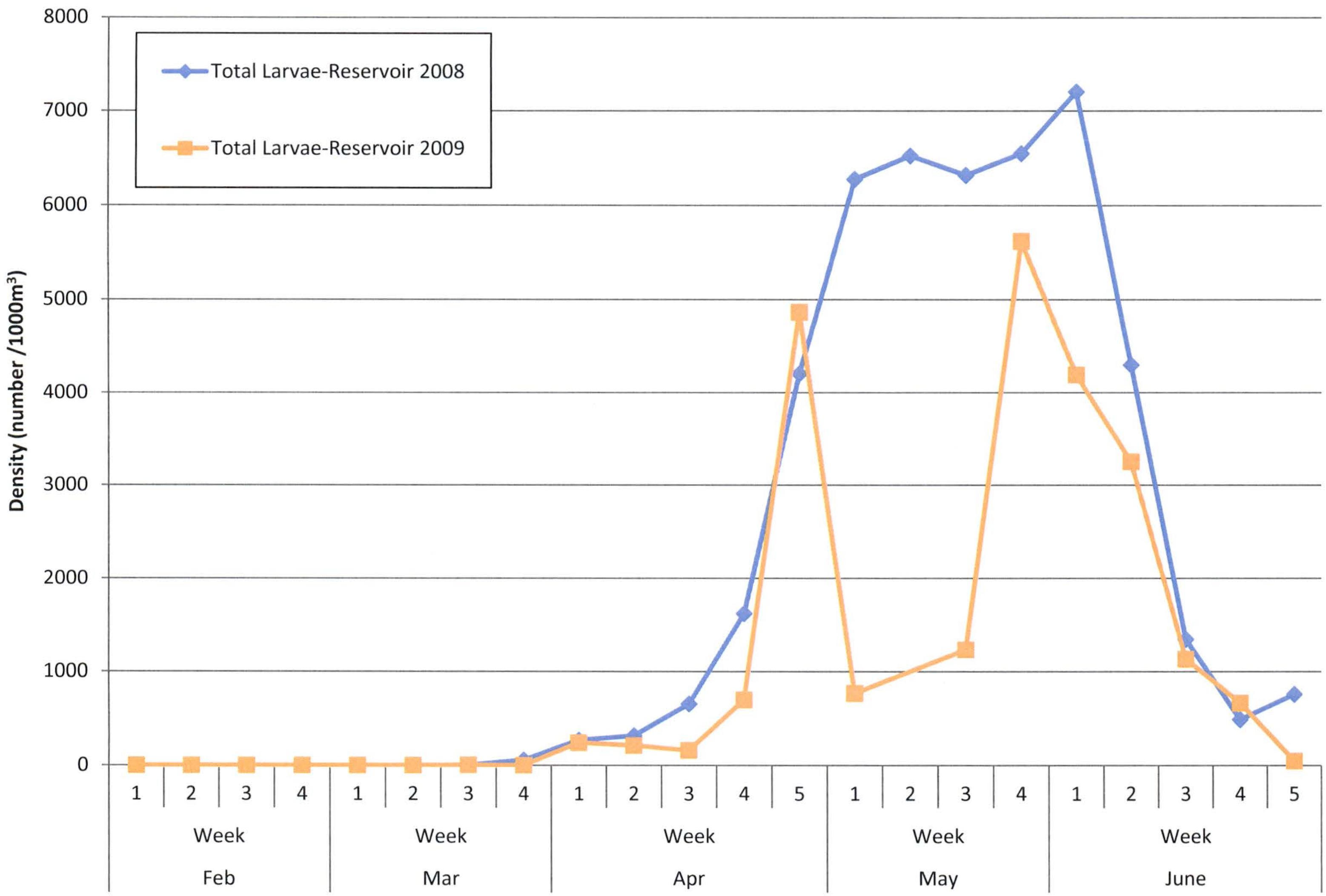

Figure 4. Weekly Densities of Fish Larvae Collected in Reservoir Samples at Browns Ferry Nuclear Plant (TRM 294) During 2008 and 2009.

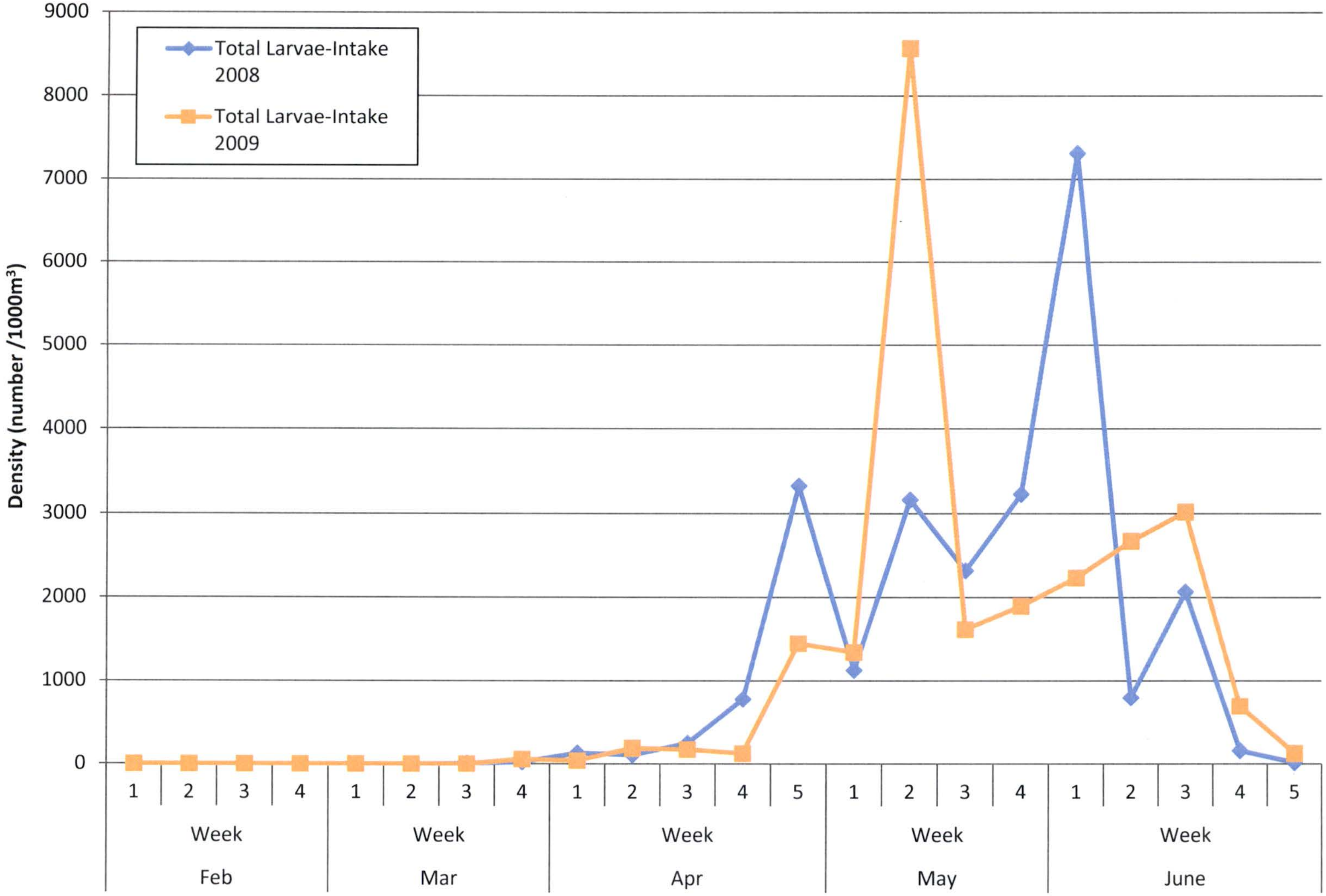

Figure 5. Weekly Densities of Fish Larvae Collected in Intake Samples at Browns Ferry Nuclear Plant (TRM 294) During 2008 and 2009.

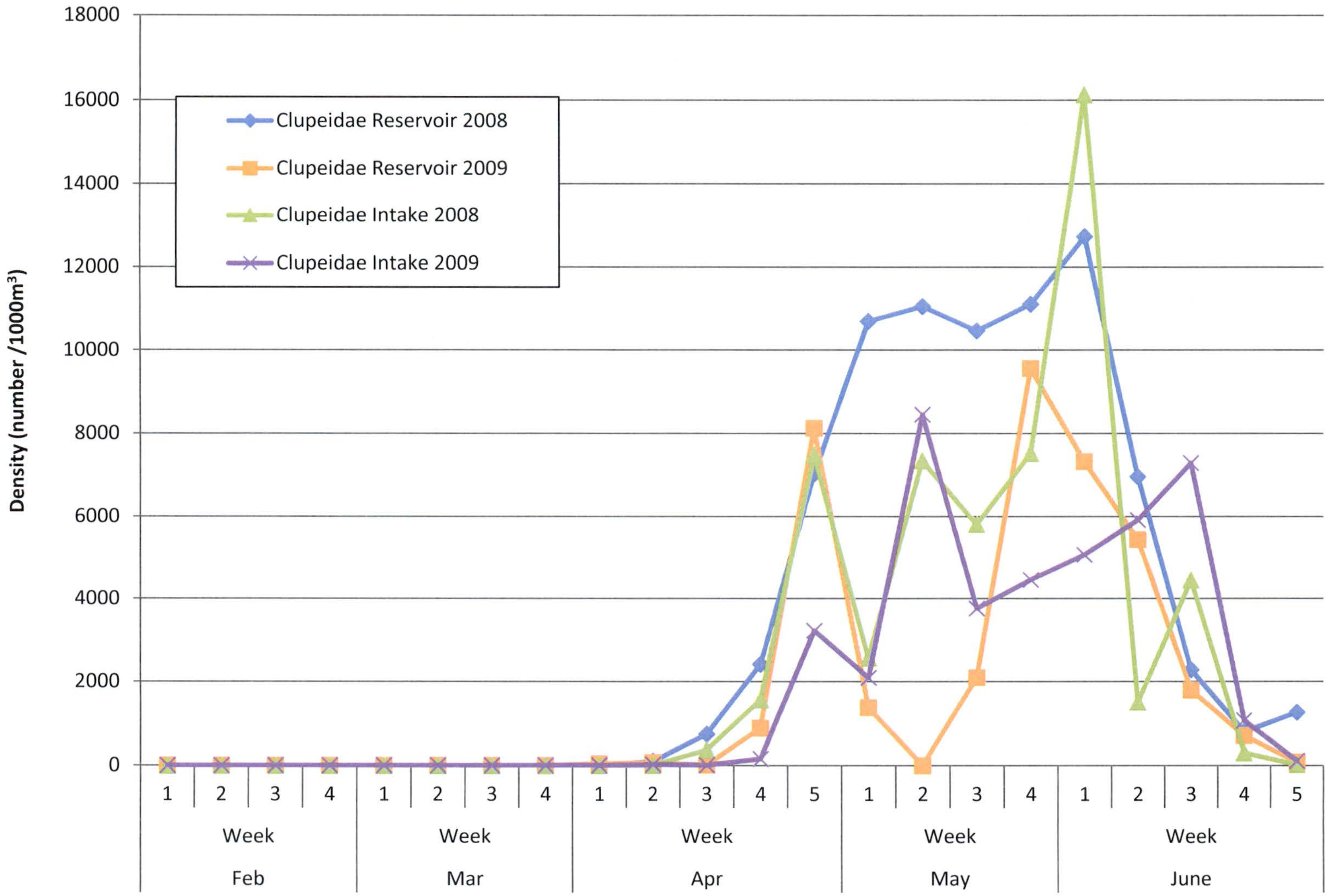

Figure 6. Weekly Densities of Clupeidae Larvae Collected in Reservoir and Intake Samples at Browns Ferry Nuclear Plant (TRM 294) During 2008 and 2009.

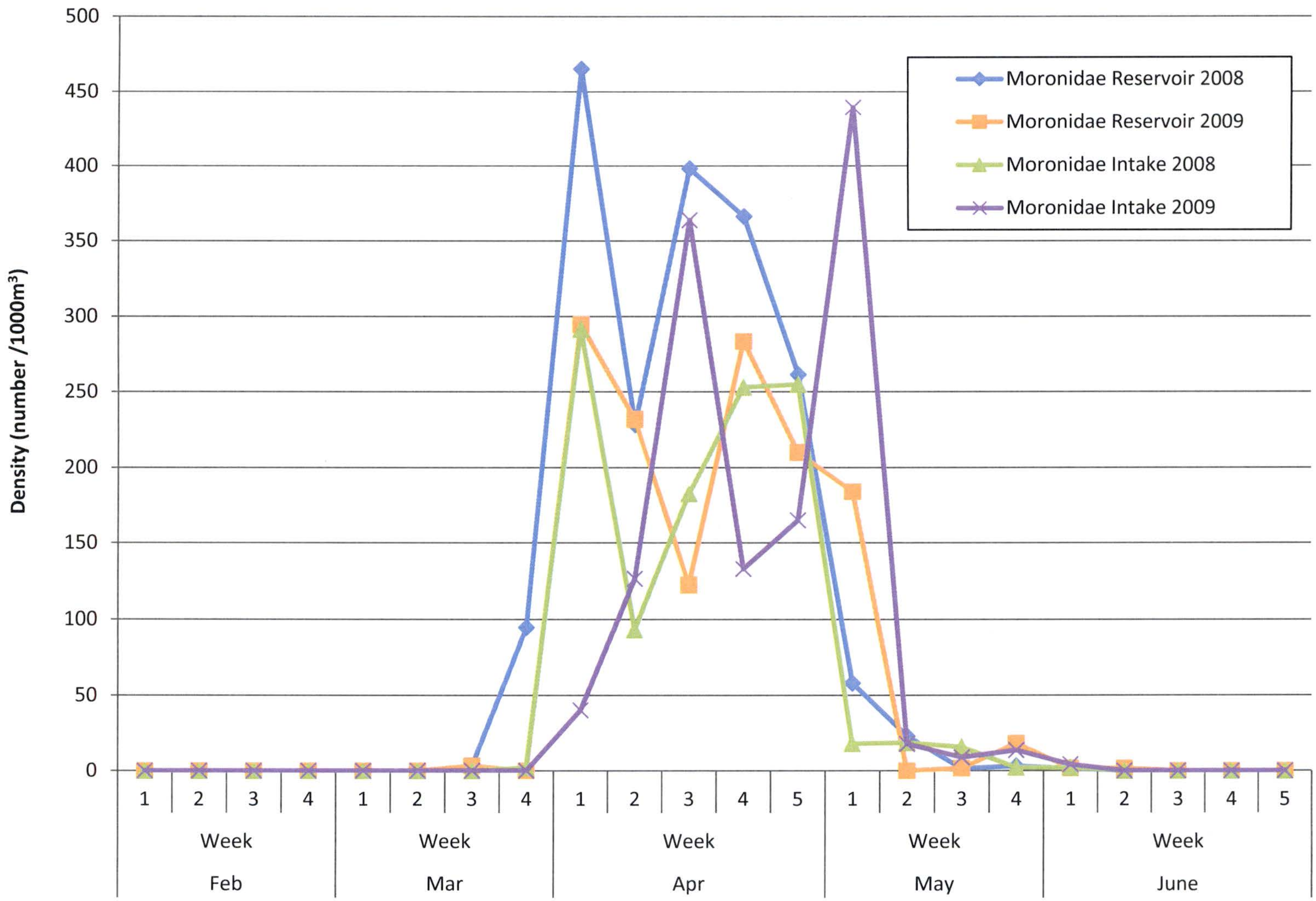

Figure 7. Weekly Densities of Moronidae Larvae Collected in Reservoir and Intake Samples at Browns Ferry Nuclear Plant (TRM 294) During 2008 and 2009.

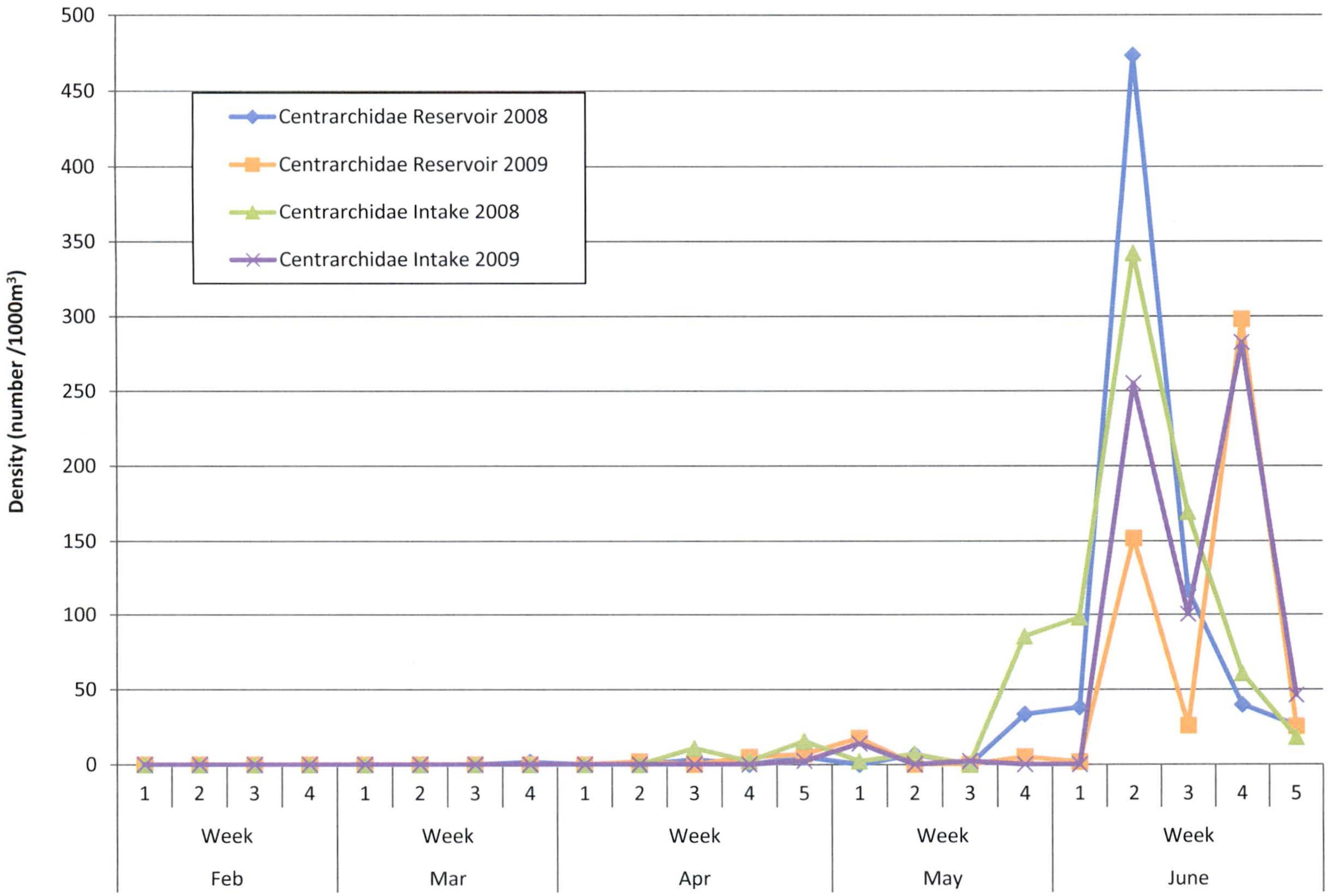

Figure 8. Weekly Densities of Centrarchidae Larvae Collected in Reservoir and Intake Samples at Browns Ferry Nuclear Plant (TRM 294) During 2008 and 2009.

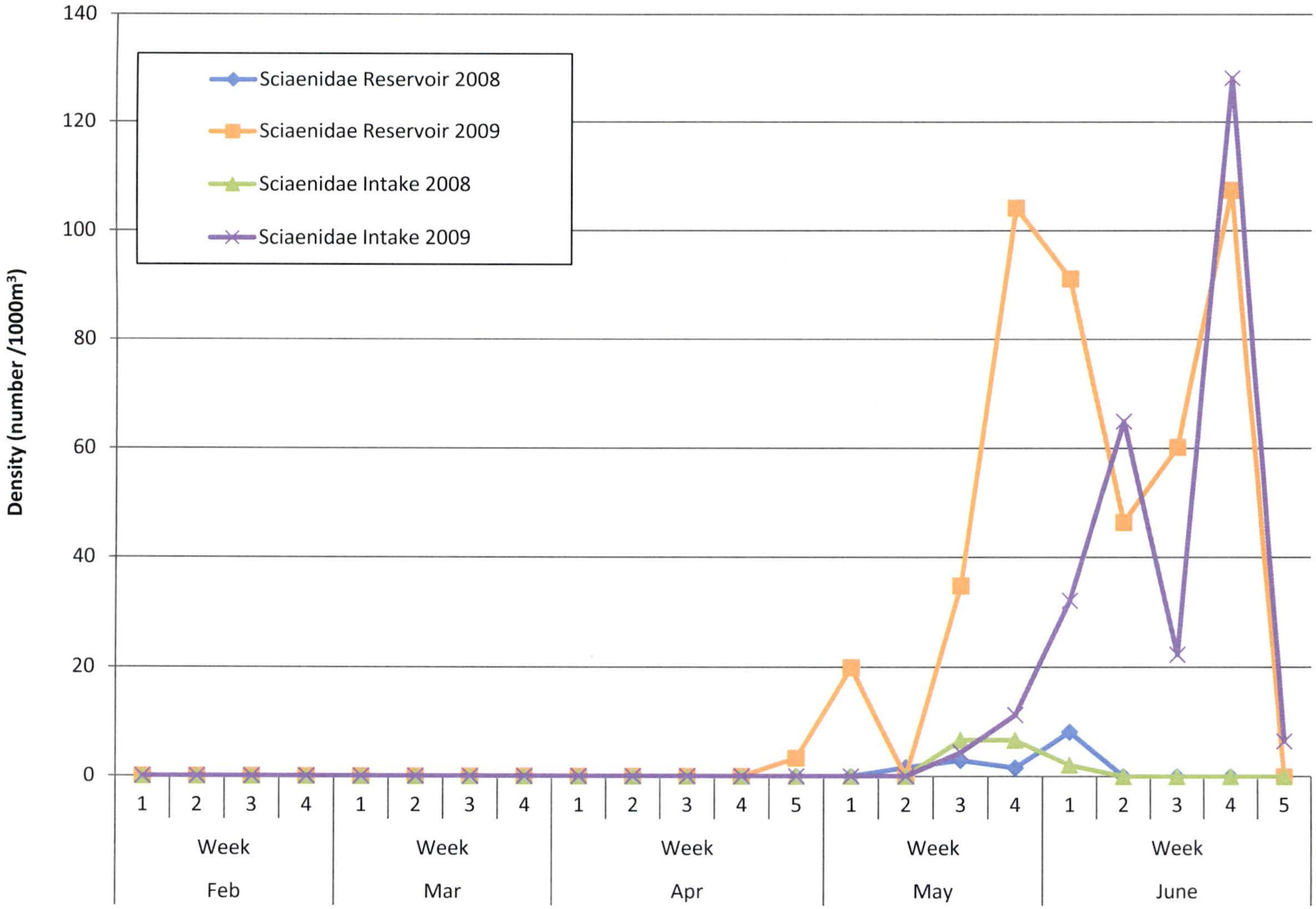

Figure 9. Weekly Densities of Sciaenidae Larvae Collected in Reservoir and Intake Samples at Browns Ferry Nuclear Plant (TRM 294) During 2008 and 2009.

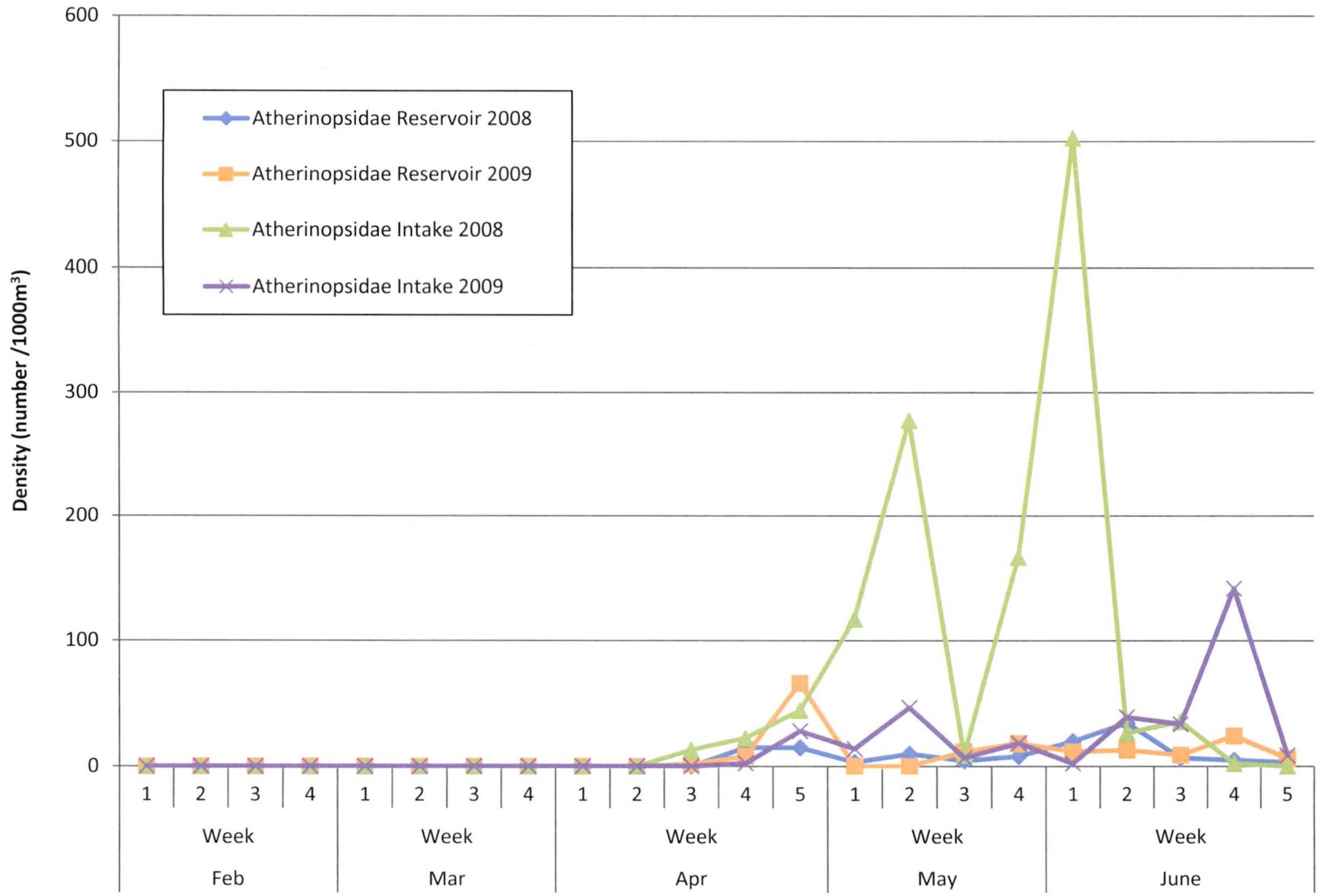

Figure 10. Weekly Densities of Atherinopsidae Larvae Collected in Reservoir and Intake Samples at Browns Ferry Nuclear Plant (TRM 294) During 2008 and 2009.

ATTACHMENT 10

Reference TVA. 2013.
Biological Monitoring of the Tennessee River
Near Browns Ferry Nuclear Plant Discharge, Autumn 2013.

Biological Monitoring of the Tennessee River Near Browns Ferry Nuclear Plant Discharge Autumn 2013

May 2014

Tennessee Valley Authority
River and Reservoir Compliance Monitoring Program
Knoxville, Tennessee

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Acronyms and Abbreviations

ATL	Alternate Thermal Limit
BIP	Balanced Indigenous Community
BFN	Browns Ferry Nuclear Power Plant
CCW	Condenser Cooling Water
CWA	Clean Water Act
LDB	Left Descending Bank
NPDES	National Pollutant Discharge Elimination System
QA	Quality Assurance
RBI	Reservoir Benthic Macroinvertebrate Index
RDB	Right Descending Bank
RFAI	Reservoir Fish Assemblage Index
RIS	Representative Important Species
SAHI	Shoreline Assessment Habitat Index
TRM	Tennessee River Mile
TVA	Tennessee Valley Authority
VS	Vital Signs

Executive Summary

In 2013, samples of the ecological community upstream and downstream of Brown's Ferry Nuclear Plant were collected, analyzed, and compared to historical data to determine the effects, if any, of the thermal effluent from the plant, in compliance with §316(a) of the Clean Water Act.

Shoreline aquatic habitat assessed along both banks was rated "Fair". Assessment of river bottom habitat indicated that three dominant substrates observed at both sites were silt, mollusk shell, and sand.

The fish communities upstream and downstream of BFN, analyzed using RFAI methodology, both showed fair diversity of species and moderate percentages of pollution tolerant individuals. The downstream community supported lower diversity of top carnivore species, but otherwise, was generally similar to that upstream and was not adversely affected by thermal effluent from BFN. Benthic communities for both downstream sites, at TRM 293.2 within the thermal plume from BFN discharge, and at TRM 290.4 downstream of the thermal plume, were considered similar to the upstream benthic community. All three sites received RBI ratings of "Excellent".

A visual wildlife survey was conducted to assess bird, reptile, and mammal populations around BFN. Turtles and a variety of birds were encountered at both locations.

Water quality analysis indicated that daily mean flow past BFN was noticeably higher in 2013 than historic values, but that daily mean temperatures were similar upstream and downstream of the plant. Depth profiles of water temperature, conductivity, dissolved oxygen concentration, and acidity (pH) indicated that values of all these parameters were within acceptable levels both upstream and downstream of BFN.

Introduction

Section 316(a) of the Clean Water Act (CWA) authorizes alternate thermal limits (ATL) for the control of the thermal component of a point source discharge so long as the limits will assure the protection of Balanced Indigenous Populations (BIP) of aquatic life. The term "balanced indigenous population," as defined by Environmental Protection Agency regulations, describes a biotic community that is typically characterized by:

(1) diversity appropriate to the ecoregion;

(2) the capacity to sustain itself through cyclic seasonal changes;

(3) the presence of necessary food chain species; and

(4) the lack of domination by pollution-tolerant species.

Prior to 2000, the Tennessee Valley Authority's (TVA) Browns Ferry Nuclear Plant (BFN) was operating under an ATL that had been continued with each permit renewal based on studies conducted in the mid-1970s. In 1999, EPA Region IV began requesting additional data in conjunction with National Pollutant Discharge Elimination System (NPDES) permit renewal applications to verify that BIP was being maintained at TVA's thermal plants with ATLs. TVA proposed that its existing Vital Signs (VS) monitoring program, supplemented with additional fish and benthic macroinvertebrate community monitoring upstream and downstream of thermal plants with ATLs, was appropriate for that purpose. The VS monitoring program began in 1990 in the Tennessee River System. This program was implemented to evaluate ecological health conditions in major reservoirs as part of TVA's stewardship role. One of the 5 indicators used in the VS program to evaluate reservoir health is the Reservoir Fish Assemblage Index (RFAI) methodology which incorporates fish species richness and composition, trophic composition, and fish abundance and health. RFAI has been thoroughly tested on TVA and other reservoirs and published in peer-reviewed literature (Jennings, et al., 1995; Hickman and McDonough, 1996; McDonough and Hickman, 1999). Fish communities are used to evaluate ecological conditions because of their importance in the aquatic food web and because fish life cycles are long enough to integrate conditions over time. Benthic macroinvertebrate populations are assessed using the Reservoir Benthic Index (RBI) methodology. Because benthic macroinvertebrates are relatively

immobile, negative impacts to aquatic ecosystems can be detected earlier in benthic macroinvertebrate communities than in fish communities. These data are used to supplement RFAI results to provide a more thorough examination of differences in aquatic communities upstream and downstream of thermal discharges.

During 2000-2010, TVA initiated a study to evaluate fish and benthic macroinvertebrate communities in areas immediately upstream and downstream of BFN using RFAI and RBI multi-metric evaluation techniques. The study was continued in 2011 and broadened to include additional data for analyses requested by the EPA. Reported here are the results of biological monitoring and water quality data collected upstream and downstream of BFN during 2013, with appropriate comparisons to data collected at these sites during previous autumn samples.

Plant Description

BFN is a three-unit nuclear-fueled facility with a total generating capacity of 3,300 megawatts. Unit One, which remained idle for several years, returned to service June 2007. BFN is located on Wheeler Reservoir, approximately 18 miles upstream of Wheeler Dam at Tennessee River Mile (TRM) 294 in Limestone County, Alabama (Figure 1). Current operation utilizes a once-through condenser cooling water (CCW) system, withdrawing water from the Tennessee River through an intake structure at TRM 294.3 and discharging the water through a multi-port diffuser located downstream from the plant at TRM 293.6 (Figure 2). Maximum flow rate of the CCW is approximately 3,468 million gallons per day.

Methods

Fish and Benthic Macroinvertebrate Sample Locations Upstream and Downstream of BFN

Thermal discharge from BFN enters the Tennessee River at TRM 293.6 in Wheeler Reservoir (Figure 2). Two reaches were selected to sample the fish community: one centered at TRM 295.9, upstream of the plant's intake (Figure 3), and one centered at TRM 292.5, downstream of the cooling water discharge (Figure 4).

From 2000 to 2010, to assess the benthic macroinvertebrate community in the vicinity of BFN data was collected along transects established across the full width of Wheeler reservoir at two sites in the transition zone, one at TRM 295.9, upstream of the intake, and one at TRM 291.7, downstream of the BFN discharge. Prior to this time, a sampling site in the forebay zone of Wheeler Reservoir (TRM 277) was used as the downstream comparison site. Because other factors, unrelated to influence from BFN, kept benthic communities depressed, both at the forebay site and in the Elk River embayment (Wheeler Reservoir, Elk River Mile [ERM] 6 – between BFN and the forebay site), the downstream site was moved into the transition zone two miles downstream from the BFN diffuser at TRM 291.7 in 2000. Benthic scores and community composition from this site were used through 2010 for downstream comparisons to the upstream benthic site at TRM 295.9.

Beginning in 2011, samples were collected in the reservoir's transition zone along transects established at three sites. One site, upstream of the plant intake, was maintained at TRM 295.9 (Figure 3). Two sites were selected downstream to more accurately assess possible effects of BFN discharge on the downstream benthic communities: one at TRM 293.2, within the thermal plume from the BFN discharge, and a second at TRM 290.4 downstream of the thermal plume (Figure 4).

Aquatic Habitat in the Vicinity of BFN

Shoreline and river bottom habitat data presented in this report were collected during autumn 2009. TVA assumes habitat data to be valid for five years, barring any major changes to the river/reservoir (e.g. major flood event). No significant changes have occurred in the river system from the initial characterization, but in the event of a major change to the river/reservoir, habitat would be re-evaluated during the following sample period.

Shoreline Aquatic Habitat Assessment

An integrative multi-metric index (Shoreline Aquatic Habitat Index or SAHI), including several habitat parameters important to resident fish species, was used to measure existing fish habitat quality in the vicinity of BFN. Using the general format developed by Plafkin et al. (1989),

seven metrics were established to characterize selected physical habitat attributes important to reservoir resident fish populations which rely heavily on the littoral (shoreline) zone for reproductive success, juvenile development, and adult feeding (Table 1). Habitat Suitability Indices (US Fish and Wildlife Service), along with other sources of information on biology and habitat requirements (Etnier and Starnes 1993), were consulted to develop "reference" criteria or "expected" conditions from a high quality environment for each parameter. Some generalizations were necessary in setting up scoring criteria to cover the various requirements of all species within a single index.

When possible, the quality of shoreline aquatic habitat was assessed while traveling parallel to the shoreline in a boat and evaluating the habitat within 10 vertical feet of full pool. Transects were established across the width of Wheeler reservoir within the fish community sampling reaches upstream and downstream of BFN (Figure 5). At each transect, near-shore aquatic habitat was assessed along sections of shoreline corresponding to the left descending bank (LDB) and right descending bank (RDB). For each shoreline section (16 upstream and 16 downstream of BFN), percentages of aquatic macrophytes in the littoral areas were estimated, then each section was scored by comparing the observed conditions associated with each individual metric to the "reference" conditions and assigning the metric a corresponding value: "Good" 5; "Fair" 3; or "Poor" 1 (Table 1). These scores for each of the seven metrics were summed to obtain the SAHI value for the shoreline section, and this value was assigned a habitat quality descriptor based on trisecting the range of potential SAHI values ("Poor" 7-16, "Fair" 17-26, and "Good" 27-35).

River Bottom Habitat

Along each transect described above, 10 benthic grab samples were collected with a Ponar sampler at points equally spaced from the LDB to the RDB. Substrate material collected with the Ponar was emptied into a screen, and percent composition of each substrate was estimated to determine existing benthic habitat across the width of the river. Water depths (feet) at each sample location were recorded. If no substrate was collected after multiple Ponar drops, it was assumed that the substrate was bedrock. For example, when the Ponar sampler was pulled shut,

collectors could feel substrate consistency. If it shut easily and was not embedded in the substrate on numerous drops within the same location, the substrate was recorded as bedrock.

Fish Community Sampling Methods and Data Analysis for Sites Upstream and Downstream of BFN

Fish sampling methods included boat electrofishing and gill netting (Hubert 1996; Reynolds 1996). Electrofishing methodology consisted of fifteen boat electrofishing runs near the shoreline, each 300 meters long and of approximately 10 minutes duration. The total near-shore area sampled was approximately 4,500 meters (15,000 feet).

Experimental gill nets (so called because of their use for research as opposed to commercial fishing) were used as an additional gear type to collect fish from deeper habitats not effectively sampled by electrofishing. Each experimental gill net consists of five 6.1 meter panels for a total length of 30.5 meters (100.1 feet). The distinguishing characteristic of experimental gill nets is mesh size that varies between panels. For this application, each net has panels with mesh sizes of 2.5, 5.1, 7.6, 10.2, and 12.7 cm. Experimental gill nets are typically set perpendicular to river flow, extending from near-shore to the main channel of the reservoir. Ten overnight experimental gill net sets were used at each area.

Fish collected were identified by species, counted, and examined for anomalies (such as disease, deformations, parasites or hybridization). The resulting data were analyzed using RFAI methodology.

The RFAI uses 12 fish community metrics from four general categories: Species Richness and Composition; Trophic Composition; Abundance; and Fish Health. Individual species can be utilized for more than one metric, though hybrid species and non-indigenous species are excluded from metrics counting numbers of individual species. Together, these 12 metrics provide a balanced evaluation of fish community integrity. The individual metrics are shown below, grouped by category:

Species Richness and Composition

(1) **Total number of species** – Greater numbers of species are considered representative of healthier aquatic ecosystems. As conditions degrade, numbers of species at an area decline.

(2) **Number of centrarchid species** – Sunfish species (excluding black basses) are invertivores and a high diversity of this group is indicative of reduced siltation and suitable sediment quality in littoral areas.

(3) **Number of benthic invertivore species** – Due to the special dietary requirements of this species group and the limitations of their food source in degraded environments, numbers of benthic invertivore species increase with better environmental quality.

(4) **Number of intolerant species** – A group made up of species that are particularly intolerant of physical, chemical, and thermal habitat degradation. Higher numbers of intolerant species suggest the presence of fewer environmental stressors.

(5) **Percentage of tolerant individuals** (excluding young-of-year) – An increased proportion of individuals tolerant of degraded conditions signifies poorer water quality.

(6) **Percent dominance by one species** – Ecological quality is considered reduced if one species inordinately dominates the resident fish community.

(7) **Percentage of non-indigenous species** – Based on the assumption that non-indigenous species reduce the quality of resident fish communities.

(8) **Number of top carnivore species** – Higher diversity of piscivores is indicative of the availability of diverse and plentiful forage species and the presence of suitable habitat.

Trophic Composition

(9) **Percent top carnivores** – A measure of the functional aspect of top carnivores which feed on major planktivore populations.

(10) **Percent omnivores** – Omnivores are less sensitive to environmental stresses due to their ability to vary their diets. As trophic links are disrupted due to degraded conditions, specialist species such as insectivores decline while opportunistic omnivorous species increase in relative abundance.

Abundance

(11) **Average number per run** (number of individuals) – Based on the assumption that high quality fish assemblages support large numbers of individuals.

Fish Health

(12) **Percent anomalies** – Incidence of diseases, lesions, tumors, external parasites, deformities, blindness, and natural hybridization is noted for all fish collected, with higher incidence indicating less favorable environmental conditions.

RFAI methodology addresses all four attributes or characteristics of a "balanced indigenous population" (BIP), defined by the CWA as described below:

(1) **A biotic community characterized by diversity appropriate to the ecoregion**: Diversity is addressed by the metrics in the Species Richness and Composition category, especially metric 1 – "Number of species." Determination of reference conditions based on the

transition zones of lower mainstem Tennessee River reservoirs (as described below) ensures appropriate species expectations for the ecoregion.

(2) **The capacity for the community to sustain itself through cyclic seasonal change**: TVA uses an autumn data collection period for biological indicators, both VS and upstream/downstream monitoring. Autumn monitoring is used to document community condition or health after being subjected to the wide variety of stressors throughout the year.

One of the main benefits of using biological indicators is their ability to integrate stressors through time. Examining the condition or health of a community at the end of the "biological year" (i.e., autumn) provides insights into how well the community has dealt with the stresses through an annual seasonal cycle. Likewise, evaluation of the condition of individuals in the community (in this case, individual fish as reflected in Metric 12) provides insights into how well the community can be expected to withstand stressors through winter. Further, multiple sampling years during the permit renewal cycle add to the evidence of whether the autumn monitoring approach has correctly demonstrated the ability of the community to sustain itself through repeated seasonal changes.

(3) **The presence of necessary food chain species:** Integrity of the food chain is measured by the Trophic Composition metrics, with support from the Abundance metric and Species Richness and Composition metrics. A healthy fish community is comprised of species that utilize complex feeding mechanisms extending into multiple levels of the aquatic food web.

Three dominant fish trophic levels exist within Tennessee River reservoirs: insectivores, omnivores, and top carnivores. To determine the presence of necessary food chain species, these three groups should be well represented within the overall fish community. Other fish trophic levels include benthic invertivores, planktivores, herbivores, and parasitic species. Insectivores include most sunfish, minnows, and silversides. Omnivores include gizzard shad, common carp, carpsuckers, buffalo, and channel and blue catfish. Top carnivores include bass, gar, skipjack herring, crappie, flathead catfish, sauger, and walleye. Benthic invertivores include freshwater drum, suckers, and darters. Planktivores include alewife,

threadfin shad, and paddlefish. Herbivores include largescale stonerollers. Lampreys in the genus *Ichthyomyzon* are the only parasitic species occurring in Tennessee River reservoirs.

To establish expected proportions of each trophic guild and the expected number of species included in each guild occurring in transition zones in lower mainstem Tennessee River reservoirs (Kentucky, Pickwick, Wilson, Wheeler, and Guntersville reservoirs), data collected from 1993 to 2010 were analyzed for each reservoir zone (inflow, transition, forebay). Samples collected in the downstream vicinity of thermal discharges were not included in this analysis so that accurate expectations could be calculated with the assumption that these data represent what should occur in lower mainstem Tennessee River reservoirs absent from point source effects (i.e. power plant discharges). Data from 900 electrofishing runs (a total of 405,000 meters of shoreline sampled) and from 600 overnight experimental gill net sets were included in this analysis for transition areas in lower mainstem Tennessee River reservoirs. From these data, the range of proportional values for each trophic level and the range of the number of species included in each trophic level were trisected. These trisections were intended to show less than expected, expected, and above expected values for trophic level proportions and species occurring within transition reservoir zones in lower mainstem Tennessee River reservoirs. The data were also averaged and bound by confidence intervals (95%) to further evaluate expectations for proportions of each trophic level and the number of species representing each trophic level (Table 2).

(4) **A lack of domination by pollution-tolerant species**: Domination by pollution-tolerant species is determined by metrics 3 ("Number of benthic invertivore species"), 4 ("Number of intolerant species"), 5 ("Percent tolerant individuals"), 6 ("Percent dominance by one species"), and 10 ("Percent omnivores").

Scoring categories are based on "expected" fish community characteristics in the absence of human-induced impacts other than impoundment of the reservoir. These categories were developed from historical fish assemblage data representative of transition zones from lower mainstem Tennessee River reservoirs (Hickman and McDonough, 1996). Attained values for each of the 12 metrics were compared to the scoring criteria and assigned scores to represent

relative degrees of degradation: least degraded (5); intermediately degraded (3); and most degraded (1). Scoring criteria for lower mainstem Tennessee River reservoirs are shown in Table 3.

If a metric was calculated as a percentage (e.g., "Percent tolerant individuals"), the data from electrofishing and gill netting were scored separately and allotted half the total score for that individual metric. Individual metric scores for a sampling area (i.e., upstream or downstream) were summed to obtain the RFAI score for the area.

TVA uses RFAI results to determine maintenance of BIP using two approaches. One is "absolute" in that it compares the RFAI scores and individual metrics to predetermined values. The other is "relative" in that it compares RFAI scores attained downstream to the upstream control site. The "absolute" approach is based on Jennings et al. (1995) who suggested that favorable comparisons of the RFAI score attained from the potential impact zone to a predetermined criterion can be used to identify the presence of normal community structure and function, and hence existence of BIP. For multi-metric indices, TVA uses two criteria to ensure a conservative screening of BIP. First, if an RFAI score reaches 70% of the highest attainable score of 60 (adjusted upward to include sample variability as described below), and second, if fewer than half of RFAI metrics receive a low (1) or moderate (3) score, then community structure and function are considered normal, indicating that BIP had been maintained and no further evaluation would be needed.

RFAI scores range from 12 to 60. Ecological health ratings (12-21 "Very Poor", 22-31 "Poor", 32-40 "Fair", 41-50 "Good", or 51-60 "Excellent") are then applied to scores. As discussed in detail below, the average variation for RFAI scores in TVA reservoirs is 6 (± 3). Therefore, any location that attains a RFAI score of 45 (75% of the highest score) or higher would be considered to have BIP. It must be stressed that scores below this threshold do not necessarily reflect an adversely impacted fish community. The threshold is used to serve as a conservative screening level; i.e., any fish community that meets these criteria is obviously not adversely impacted. RFAI scores below this level require a more in-depth look to determine if BIP exists. An inspection of individual RFAI metric results and species of fish used in each metric are an initial

step to help identify if operation of BFN is a contributing factor. This approach is appropriate because a validated multi-metric index is being used and scoring criteria applicable to the zone of study are available.

A comparison of RFAI scores from the area downstream of BFN to those from the upstream (control) area is one basis for determining if operation of the plant has had any impacts on the resident fish community. The definition of "similar" is integral to accepting the validity of these interpretations. The Quality Assurance (QA) component of the VS monitoring program deals with how well the RFAI scores can be repeated and is accomplished by collecting a second set of samples at 15%-20% of the areas each year. Comparison of paired-sample QA data collected over seven years shows that the difference in RFAI index scores ranges from 0 to 18 points. The mean difference between these 54 paired scores is 4.6 points with 95% confidence limits of 3.4 and 5.8. The 75th percentile of the sample differences is 6, and the 90th percentile is 12. Based on these results, a difference of 6 points or less in the overall RFAI scores is the value selected for defining "similar" scores between upstream and downstream fish communities. That is, if the downstream RFAI score is within 6 points of the upstream score and if there are no major differences in overall fish community composition, then the two locations are considered similar. It is important to bear in mind that differences greater than 6 points can be expected simply due to method variation (25% of the QA paired sample sets exceeded that value). An examination of the 12 metrics (with emphases on fish species used for each metric) is conducted to analyze any difference in scores and the potential for the difference to be thermally related.

Statistical Analyses

In addition to RFAI analyses, data were analyzed using traditional statistical methods. Data from the survey were used to calculate catch per unit effort (CPUE), expressed as number of fish per electrofishing run or fish per net night. CPUE values were calculated by pollution tolerance, trophic guilds (e.g., benthic invertivores, top carnivores, etc.), thermal sensitivity (Yoder et al. 2006), and indigenous status. CPUE, diversity, and species richness values were computed for each electrofishing effort (to maximize sample size; n = 30) and compared upstream and downstream to assess potential effects of power plant discharges.

Diversity was quantified using two commonly applied indices: Shannon diversity index (Shannon 1948) and Simpson diversity index (Simpson 1949). Both indices account for the number of species present, as well as the relative abundance of each species.

Shannon diversity index values were computed using the formula:

$$H' = -\sum_{i=1}^{S}\left(\frac{n_i}{N}\right)\ln\left(\frac{n_i}{N}\right)$$

where:

S = total number of species

N = total number of individuals

n_i = total number of individuals in the i^{th} species

The Simpson diversity index was calculated as follows:

$$D_S = \left(\sum_{i=1}^{S}\left(\frac{n_i}{N}\right)^2\right) - 1$$

where:

S = total number of species

N = total number of individuals

n_i = total number of individuals in the i^{th} species

An independent two-sample *t*-test was used to test for differences in CPUE, species richness, and diversity values upstream and downstream of BFN ($\alpha = 0.05$). Before statistical tests were performed using this method, data were analyzed for normality using the Shapiro-Wilk test (Shapiro and Wilk, 1965) and homogeneity of variance using Levene's test (Levene 1960). Non-normal data or data with unequal variances were transformed using either square root conversion or the ln(x+1) transformation. Transformed data were reanalyzed for normal distribution and equal variances. If transformation normalized the data or resulted in homogeneous variances, transformed data were tested using an independent two-sample *t*-test. If transformed data were

not normally distributed or had unequal variances, statistical analysis was conducted using the Wilcoxon-Mann-Whitney test (Mann and Whitney 1947; Wilcoxon 1945).

Benthic Macroinvertebrate Community Sampling Methods and Data Analysis for Sites Upstream and Downstream of BFN

During autumn 2013, benthic macroinvertebrate data were collected in the transition zone of Wheeler Reservoir along three transects established across the reservoir's width as described above. The upstream transect (TRM 295.9) was used as a control site to compare to benthic community composition potentially affected by the BFN thermal effluent. One downstream transect (TRM 293.2) was within the thermal plume and one transect (TRM 290.4) was located just below the downstream extent of the plume. A Ponar sampler (area per sample 0.06 m^2) was used to collect benthic samples at ten points equally spaced along each transect. When heavier substrate was encountered, a Peterson sampler (area per sample 0.11 m^2) was used. Sediments from each sample were washed on a 533μ screen, and organisms were picked from the screen and from any remaining substrate. Samples were fixed in formalin and sent to an independent consultant who identified each organism collected to the lowest possible taxonomic level.

Benthic samples were evaluated using seven metrics that represented characteristics of the benthic community. Results for each metric were assigned a rating of 1, 3, or 5, based upon comparison to reference conditions developed for VS reservoir inflow sample sites (Table 4). For each sample site, the ratings for the seven metrics were then summed to produce an RBI score. Potential RBI scores ranged from 7 to 35. Ecological health ratings derived from the range of potential values (7-12 "Very Poor", 13-18 "Poor", 19-23 "Fair", 24-29 "Good", or 30-35 "Excellent") were then applied to scores. The individual metrics are described below:

(1) Average number of taxa — Calculated by averaging the total number of taxa present in each sample at a site. Greater taxa richness indicates better conditions than lower taxa richness.

(2) **Proportion of samples with long-lived organisms** — A presence/absence metric that is evaluated based on the proportion of samples with at least one long-lived organism (*Corbicula, Hexagenia*, mussels, or snails) present. The presence of long-lived taxa is indicative of conditions that allow long-term survival.

(3) **Average number of EPT taxa** — Calculated by averaging the number of *Ephemeroptera* (mayfly), *Plecoptera* (stonefly), and *Trichoptera* (caddis fly) taxa present in each sample at a site. Higher diversity of these taxa indicates good water quality and better habitat conditions.

(4) **Percentage of oligochaetes** — Calculated by averaging the percentage of oligochaetes in each sample at a site. Oligochaetes are considered tolerant organisms, so a higher proportion indicates poorer water quality.

(5) **Percentage as dominant taxa** — Used as an evenness indicator, this metric is calculated by selecting the two most abundant taxa in a sample, summing the number of individuals in those two taxa, dividing that sum by the total number of animals in the sample, and converting to a percentage for that sample. The percentage is then averaged for the 10 samples at each site. Because the most abundant taxa often differ among the 10 samples at a site, this approach allows more discretion to identify imbalances at a site than developing an average for a single dominant taxon for all samples at a site. Dominance of one or two taxa indicates poor conditions.

(6) **Average density excluding chironomids and oligochaetes** — Calculated by first summing the number of organisms – excluding chironomids and oligochaetes – present in each sample and then averaging these densities for the 10 samples at a site. This metric examines the community, excluding taxa which often dominate under adverse conditions. Higher abundance of taxa other than chironomids and oligochaetes indicates good water quality conditions.

(7) **Zero-samples: Proportion of samples containing no organisms** — For each site, the proportion of samples which have no organisms present. "Zero-samples" indicate living

conditions unsuitable to support aquatic life (i.e. toxicity, unsuitable substrate, etc.). A site with no zero samples was assigned a score of five. Any site with one or more zero samples was assigned a score of one.

A similar or higher benthic index score at the downstream sites compared to the upstream site was used as the basis for determining absence of impact on the benthic macroinvertebrate community related to BFN's thermal discharge. The QA component of VS monitoring compared benthic index scores from 49 paired sample sets collected over seven years. Differences between these paired sets ranged from 0 to 14 points; the 75th percentile was four, the 90th percentile was six. The mean difference between these 49 paired scores was 3.1 points with 95% confidence limits of 2.2 and 4.1. Based on these results, a difference of four points or less was the value selected for defining "similar" scores between upstream and downstream benthic communities. That is, if benthic scores at the downstream sites are within four points of the upstream score, the communities are considered similar. However, differences greater than four points can be expected simply due to method variation (25% of the QA paired sample sets exceeded that value). Any difference in scores of greater than four points between communities is examined on a metric-by-metric basis to determine what caused the difference and the potential for the difference to be thermally related.

Visual Encounter Survey (Wildlife Observations)

Permanent survey sites were established on both the right and left descending banks at one location upstream of the BFN thermal discharge, centered at TRM 295.9 (Figure 3), and at a second location downstream of the discharge, centered at TRM 292.5 (Figure 4). Each survey site spanned a distance of 2,100 m along the shoreline, and the beginning and ending points were marked using GPS for relocation.

Surveys were conducted by steadily traversing the site by boat, at approximately 30 m offshore and parallel to the shoreline, and simultaneously recording observations of wildlife. The sampling frame of each survey generally followed the strip or belt transect concept: from the center-line of each transect landward to an area that included the shoreline and riparian zone (i.e.,

belt width generally averages 60 m where vision is not obscured), all individuals observed were enumerated. Wildlife observed visually or detected audibly was identified to the lowest taxonomic trophic level, and a direct count of individuals observed per trophic level was recorded. If a flock of a species or a mixed flock of a group of species was observed, numbers of individuals present of each species were estimated. Time was recorded at the start and end points of each survey to provide a general measure of effort expended. Variation of observation times among surveys was primarily due to the difficulty of approaching some wildlife species without inadvertently flushing them from basking or perching sites.

The principal objective of the surveys was to provide a preliminary set of observations to verify that trophic levels of birds, mammals and reptiles were not affected by thermal effects from the BFN discharge. If expected trophic levels were not represented, further investigation will be used to target particular species and/or species groups (guilds) in an attempt to determine the cause.

Wheeler Reservoir Flow and BFN Temperature

Total discharge from Guntersville Dam was used to describe the amount of water flowing past BFN and was obtained from TVA's River Operations database.

Water temperature data were also obtained from TVA's River Operations database. Locations of water temperature monitoring sites used to measure water temperatures upstream of BFN intake and downstream of BFN discharge are depicted in Figure 6. Ambient temperatures upstream of the BFN intake were measured at Site 4, located at TRM 297.8. Upstream daily mean temperatures were calculated by averaging temperatures collected at depths of 3, 5, and 7 feet. Temperatures downstream of BFN discharge were measured at Sites 1, 16, and 17, all located at TRM 293.5. Downstream temperatures were calculated by first averaging temperatures at each site across depths of 3, 5, and 7 feet. The resultant values from each site were then averaged together to obtain overall mean daily water temperatures downstream of BFN.

Thermal Plume Characterization

Physical measurements to characterize and map the BFN thermal plume were collected concurrent with biological field sampling. The plume was characterized under representative thermal maxima and seasonally-expected low flow conditions. Measurements were collected during periods of normal operation of BFN, as reasonably practicable, to capture the thermal plume under existing river flow/reservoir elevation conditions. This effort evaluated potential impacts on recreation and water supply uses and allowed general delineation of the "Primary Study Area" – per the EPA (1977) draft guidance defined as the "*entire geographic area bounded annually by the locus of the 2°C above ambient surface isotherms as these isotherms are distributed throughout an annual period*" – ensuring placement of the biological sampling locations within thermally influenced areas.

However, it is important to emphasize that the ≥2°C isopleth boundary is not a bright line; it is dynamic, changing geometrically in response to changes in ambient river flows and temperatures and BFN operations. As such, samples collected outside of, but generally proximate to the Primary Study Area boundary cannot be considered free of thermal influence and thus should not be discounted. Every effort was made to collect biological samples in thermally affected areas as guided by the Primary Study Area definition.

Depth profiles of temperature from the river surface to the bottom were collected at points along transects crossing the plume. One transect was located proximate to the thermal discharge point; subsequent downstream transects were concentrated in the near field area of the plume where the change in plume temperature was expected to be most rapid. The distance between transects in the remainder of the Primary Study Area increased with distance downstream (or away from the discharge point). The farthest downstream transect was just outside of the Primary Study Area. A transect upstream of the discharge, in an area not affected by the thermal plume, was included for determining ambient temperature conditions. The total number of transects needed to fully characterize and delineate the plume was determined in the field.

Collection of temperature profiles along a given transect began at or near the shoreline from which the discharge originated and continued until the far shore was reached. Measurements across a transect were typically conducted at points 10%, 30%, 50%, 70%, and 90% from the

originating shoreline, though the number of measurement points along transects was sometimes increased in proportion to the magnitude of the temperature change across a given transect. The distances between transects, and between measurement points along each transect, depended on the size of the discharge plume.

Temperature data were compiled and analyzed to present the horizontal and vertical dimensions of the BFN thermal plume using spatial analysis techniques to yield plume cross-sections, which can be used to demonstrate the existence of a zone of passage for fish and other aquatic species under or around the plume.

Water Quality Parameters at Fish Sampling Sites during RFAI Samples

Water quality conditions were measured using a Hydrolab® that provided readings for water temperature (°C), conductivity (μS/cm), dissolved oxygen (mg/L), and pH. Within each of the electrofishing sample reaches upstream and downstream of BFN, transects were established across the river at the most upstream boundary, at mid-reach, and at the most downstream boundary. Along each transect, samples were collected at the RDB, in mid-channel, and at the LDB by recording readings along a vertical gradient from just above the bottom of the river to approximately 0.3 meters from the surface at one- to two-meter intervals.

Results and Discussion

Aquatic Habitat in the Vicinity of BFN

Shoreline Aquatic Habitat Assessment

SAHI methodology was used to evaluate shoreline habitat for eight transects located within each of the RFAI sample reaches upstream and downstream of BFN. Shoreline transects were sampled on each bank (Figure 5).

Of the sixteen shoreline transects sampled upstream of BFN, 19% (3 transects) scored as good, 8% (12 transects) scored as fair, and 6% (1 transect) scored as poor. The average score for

transects on the left descending bank was 24 ("Fair"), while scores for transects on the right descending bank averaged 23 ("Fair"). No aquatic macrophytes were observed on either shoreline (Table 5).

Of the sixteen shoreline transects sampled downstream of BFN, 0% scored as good, 88% (14 transects) scored as fair, and 12% (2 transects) scored as poor. The average scores for transects on the left bank descending were equal to those on the right bank descending (20, "Fair"). No aquatic macrophytes were observed on either shoreline (Table 6).

River Bottom Habitat

Figures 7-10 compare substrate proportions at each sample point along each of the eight transects upstream of BFN during autumn 2009. Figures 11-14 compare substrate proportions at each sample point along each of the eight transects downstream of BFN during autumn 2009 (Figure 5). Transects in Figures 7-14 are depicted at an exaggerated slant from bank to bank, in order to fit all of the data on the figure. Actual river bottom habitat sampling upstream and downstream of BFN was conducted in a straight line from the left descending bank to the right descending bank.

The three most dominant substrate types encountered along the eight transects upstream of BFN were silt (51.1%), mollusk shell (32.0%), and sand (5.1%). Though in slightly different proportions – silt (65.1%), mollusk shell (19.4%), and sand (5.4%) – these three substrates were also the most prominent downstream of BFN.

Fish Community

The total RFAI score for the fish community upstream of BFN was 46 ("Good"). The score for the community downstream was 40 ("Fair"). Because the difference between these scores was within the 6-point range of acceptable variation, the communities were considered similar during autumn 2013.

Below, the two communities are compared in further detail, utilizing the four characteristics of a BIP. Discussion of this comparison includes the metrics appropriate for each characteristic.

(1) A biotic community characterized by diversity appropriate to the ecoregion

Total number of species (highest rating requires > 30)

Thirty-three indigenous species were collected upstream, earning the highest score (5). Downstream, 27 indigenous species were collected earning a mid-range score (3) (Table 8). Seven species – longnose gar (six specimens), golden shiner (six), white crappie (one), northern hogsucker (one), white bass (two), orangespotted sunfish (three), and spotted bass (one) – were collected only upstream. One individual of stripetail darter was collected only downstream (Tables 9, 10).

Number of centrarchid species (highest rating requires > 2)

Eight centrarchid species were collected upstream and six were collected downstream, resulting in the highest score (5) for both sites (Table 8). White crappie and orangespotted sunfish were collected only upstream (Tables 9, 10).

Number of benthic invertivore species (highest rating requires > 7)

Five benthic invertivore species were collected upstream and four downstream, resulting in mid-range scores (3) for both sites (Table 8). Spotted sucker, black redhorse, logperch, and freshwater drum were collected at both sites; northern hogsucker was collected only upstream (Tables 9, 10).

Number of intolerant species (highest rating requires > 4)

Six intolerant species were collected upstream and five collected downstream. Both sites earned the highest score (5) (Table 8). Skipjack herring, spotted sucker, black redhorse, longear sunfish, and smallmouth bass were collected at both sites; northern hogsucker was collected only upstream (Tables 9, 10).

Number of top carnivore species (highest rating requires > 7)

Twelve top carnivore species were collected upstream, and eight were collected downstream. Both sites earned the highest score (5) (Table 8). Longnose gar, white crappie, white bass and spotted bass were collected only upstream (Tables 9, 10).

Summary

Both the upstream control site and the site downstream of the BFN discharge earned identical scores for four of the five metrics discussed. The upstream site earned a higher score for only metric 1, "Total number of species".

(2) The capacity for the community to sustain itself through cyclic seasonal change

Maintenance of diversity can often be indicative of the ability of a fish community to withstand the stressors of an annual seasonal cycle. Autumn RFAI sampling has been conducted at the site upstream of BFN since 1993, except during 1996, 1998, and 2012. Autumn sampling has been conducted at the site downstream since 2000, except during 2012. Average scores calculated over the history of sampling are identical for both sites (41, "Good") (Table 11).

Figure 15 shows the numbers of indigenous species collected during autumn RFAI samples upstream and downstream of BFN from 2000 through 2013. Over this time period, the numbers collected at the upstream site ranged from 24 to 33, with an average of 29 species. Downstream, numbers collected ranged from 23 to 28, with an average of 27 species. Collections upstream have generally been higher than those downstream: more species were collected upstream during nine years, while the same number of species was collected at both sites during 2003, 2007, and 2008, and more species were collected downstream than upstream during only 2009. The numbers of indigenous species collected during autumn 2013 (33 upstream, 27 downstream) showed the greatest difference between the sites over the history of sampling.

Percentage of anomalies (highest rating requires < 2 %)

Anomalies (i.e. visible lesions, bacterial and fungal infections, parasites, muscular and skeletal deformities, and hybridization) observed in a fish community can also be an indicator of the

ability of the community to sustain itself over an annual seasonal cycle. A greater percentage of anomalies (3.3%) was observed in the electrofishing sample at the upstream site, and the site earned a lower partial score than the downstream site, which exhibited only 1.1% anomalies. No anomalies were observed in the gill net portion of the sample at either site, and both earned the highest partial score for this portion of the metric (Table 8).

Summary

Average RFAI scores, determined over the history of autumn sampling around BFN, were identical upstream and downstream. Though more indigenous species were collected upstream during most years, the average numbers of species – calculated over the years during which sampling occurred at both sites – were similar upstream and downstream. The electrofishing catch upstream exhibited a greater percentage of anomalies than that downstream, but no anomalies were observed in the gill net catch at either site.

(3) The presence of necessary food chain species

Estimates of the trophic compositions of the fish communities upstream and downstream of BFN were calculated from the collection data (Tables 9, 10) as the proportion of the total sample made up by each trophic guild. In direct comparison of the communities upstream and downstream of BFN, the proportions of benthic invertivores and planktivores were somewhat similar. The proportions of other trophic guilds were notably different. However, omnivores and top carnivores were collected in greater proportion upstream, while insectivores were collected in greater proportion downstream. One additional guild – specialized insectivore – was represented downstream but not upstream. No parasitic or herbivore species were collected at either site. The numbers of species collected of four guilds were similar upstream and downstream, but notably more top carnivore species were collected upstream, and one species of specialized insectivore was collected only downstream (Table 2).

In comparison to expected values for transition zones in lower mainstem Tennessee River reservoirs (Table 2), upstream proportions of benthic invertivores and insectivores were within the range of expected values, while the proportions of top carnivores, omnivores, and planktivores were poorer than expected. Downstream, insectivores comprised an unusually high

proportion of the sample (60.0%), primarily due to the collection of large numbers of two species: Mississippi silverside comprised more than 33% of the total catch, and spotfin shiner comprised more than 11% (Table 9, 10). The proportions of benthic invertivores and omnivores were within the expected ranges, while the proportions of top carnivores and planktivores were below expectations. The collection downstream also included one specimen of "Specialized Insectivore" – the stripetail darter (Table 10) – representing the guild as 0.1% of the sample. Upstream, the numbers of benthic invertivore, insectivore, top carnivore and planktivore species met or exceeded expectations, while the number of omnivore species was poorer (more species) than expected. Downstream, the numbers of species representing all six trophic guilds met or exceeded expectations (Table 2).

Summary

Trophic composition of the fish community upstream was not similar to that downstream. Proportions of insectivores, top carnivores, omnivores, and specialized insectivores were different between the sites. Although proportions were different between sites, further analysis revealed that numbers collected were similar for all trophic guilds except insectivore and top carnivore. The difference of insectivore proportions between sites was due to larger numbers of Mississippi silverside collected at the downstream site; this species schools, and therefore can be collected in large numbers.

(4) A lack of domination by pollution-tolerant species

Number of benthic invertivore species

Five benthic invertivore species were collected upstream, and four were collected downstream. Both sites earned highest scores (5).

Number of intolerant species (highest rating requires > 4)

Six intolerant species were collected upstream, and five were collected downstream. Both sites received the highest score (5). Skipjack herring, spotted sucker, black redhorse, longear sunfish, and smallmouth bass were collected at both sites; northern hogsucker was collected only upstream (Tables 8-10).

Percentage of tolerant individuals (highest rating requires < 27 % electrofishing; < 15 % gill net)

The upstream site earned mid-range scores for both portions of the sample: 49.5% of the electrofishing sample and 26.9% of the gill net sample were tolerant individuals. Downstream, 39.0% of the electrofishing sample – a mid-range partial score – and 33.3% of the gill net sample – the lowest partial score – were tolerant individuals (Table 8).

Seven tolerant species – gizzard shad, common carp, spotfin shiner, redbreast sunfish, green sunfish, bluegill, and largemouth bass – were collected at both sites. Longnose gar, golden shiner, white crappie, and northern hogsucker were collected only upstream. Gizzard shad and longnose gar were caught in equal percentages (9.6%) in gill nets upstream, but gizzard shad was clearly the most abundant species collected by electrofishing upstream (26.6%) and by either method downstream (17.0% of the electrofishing catch, 25.5% of the gill net catch) (Table 8).

Percent dominance by one species (highest rating requires < 29 % electrofishing; < 17 % gill net)

The upstream site earned the highest score for both portions of the sample. Gizzard shad was the most prevalent species in the electrofishing catch (26.6%) and channel catfish was most prevalent in the gill net catch (11.5%). The downstream site earned mid-range scores for both portions of the sample, with Mississippi silverside most prevalent in the electrofishing sample (35.1%) and gizzard shad most prevalent in the gill net sample (25.5%) (Table 8).

Percentage of omnivores (highest rating requires < 24 % electrofishing; < 16 % gill net)

The electrofishing catch upstream consisted of a higher percentage of omnivores (39.0%) and earned a lower partial score (1.5) than that downstream, which consisted of 22.4% omnivores and earned the highest partial score (2.5). Gill net portions of the samples at both sites contained high percentages of omnivores (42.3% upstream, 39.2% downstream), and both earned lowest partial scores (Table 8). Six omnivore species – common carp, gizzard shad, smallmouth buffalo, black buffalo, blue catfish, and channel catfish – were collected at both sites. Golden shiner was collected only upstream (Tables 9, 10).

Summary

Based on RFAI metric scores, the sites upstream and downstream of BFN both exhibited similarly moderate diversity of benthic invertivore species and similarly high diversity of intolerant species. Electrofishing samples at both sites exhibited moderate percentages of tolerant individuals, and gill net samples at both sites exhibited high percentages of omnivores. The community downstream was more heavily dominated by a single species than that upstream, though the most prevalent species collected upstream were different for both gear types than those collected downstream. The gill net sample downstream contained a greater percentage of tolerant individuals, but the electrofishing sample contained a lower percentage of omnivores.

Statistical Analyses

Statistical comparison of the fish communities upstream and downstream of BFN showed no significant differences in overall species diversity per run, based on either the Simpson or the Shannon diversity indices. Potential differences in diversity between the two communities were also analyzed by parsing the data into nine species parameters. These tests indicated that significantly more top carnivore species were collected per run upstream than downstream, but numbers of species for the other eight parameters were not significantly different between the communities (Table 11).

The same nine parameters were also tested for differences in richness (numbers of individuals per run, or CPUE) between the two communities. Greater numbers of individual top carnivores were collected per run upstream; greater numbers of intolerant species were collected per run downstream (Table 11).

Fish Community Summary

Thirty-seven representative important species (RIS) were collected at the site upstream of BFN, compared to 31 RIS downstream (Tables 9, 10). RIS are defined in EPA guidance as those species which are representative in terms of their biological requirements of a balanced, indigenous community of fish, shellfish, and wildlife in the body of water into which the discharge is made (EPA and NRC, 1977). RIS often include non-indigenous species. A species

is designated as "thermally sensitive" if specimens exhibit avoidance behavior or are subject to mortality at water temperatures equal to or greater than 32.2°C (90°F) (Yoder et al., 2006). The same three thermally sensitive species – emerald shiner, spotted sucker, and logperch – were collected at both sites. Two aquatic nuisance species, common carp and Mississippi silverside, were also collected at both sites (Tables 9, 10).

Commercially valuable species are defined by the Alabama Department of Conservation and Natural Resources (2013) as any of the following non-game fish: drum, buffalo, carp, channel catfish, all members of the catfish family, paddlefish (spoonbill), spotted sucker, all members of the sucker family including the species known as redhorse and black horse, bowfin and all members of the gar family, and mullet. Recreationally valuable species are those that are targeted by anglers or are used as bait. Among the RIS collected upstream were 17 commercially valuable species and 23 recreationally valuable species, compared to 15 commercially valuable and 17 recreationally valuable species downstream (Tables 9, 10).

Total RFAI scores for the sampling sites upstream and downstream differed by six points, indicating no substantial differences in ecological structure or balance between the two communities. As previously discussed, RFAI scores have an intrinsic variability of ± 3 points. This variability comes from several sources, including annual variations in air temperature and stream flow; variations in pollutant loadings from nonpoint sources; changes in habitat, such as extent and density of aquatic vegetation; natural population cycles and movements of the species being measured (TWRC, 2006). Another source of variability arises from the fact that nearly any practical measurement, lethal or non-lethal, of a biological community is a sample rather than a measurement of the entire population.

Accordingly, a thorough comparison of the fish communities upstream and downstream of BFN was conducted by examining each of the twelve individual RFAI metrics as a component of the appropriate characteristic of a BIP. This analysis indicated that the two communities were both poor in abundance (both received low scores for the metric "Average number per run"), but similar in diversity and in their sustainability over an annual cycle. The numbers of species representing the major trophic guilds were generally similar, but distinct differences in

proportional trophic composition between the sites were evident. The two sites showed similarly moderate dominance by pollution tolerant species, but the downstream community was more heavily dominated by a single species. This was at least partially due to the collection downstream of an especially large number (33.2% of the total sample) of Mississippi silverside, a species that is often collected in large schools (Table 10). It is also noted that the species of dominance was different upstream and downstream for each type of collection gear (Table 8).

To provide additional information about the health of the fish community throughout Wheeler reservoir, Table 12 compares RFAI scores for the sites upstream and downstream of BFN with those from additional VS sites in the reservoir. However, aquatic communities at these sites are not subject to thermal effects from BFN and are not used in determination of BIP in relation to the plant. Average RFAI scores of these additional VS sites were all in the range of a "Good" rating.

Statistical tests indicated that, within the upstream site, more top carnivore species were collected per run and greater numbers of individual top carnivores were collected per run, supporting the observations that this group was both more diverse and comprised a greater proportion of the total sample upstream. Greater numbers of intolerant individuals were collected per run downstream, indicating that conditions below BFN discharge were suitable for sensitive species.

In conclusion, though this discussion revealed some differences between the fish communities upstream and downstream of BFN during autumn 2013, there was no indication that these differences were related to thermal effluent from BFN.

Benthic Macroinvertebrate Community

As discussed previously, data to assess the benthic macroinvertebrate community around BFN were collected from three sites in autumn 2013. RBI metrics for all three sites were scored using evaluation criteria for lab-processed samples collected in the transition reservoir zone (Table 4). Data collected at TRM 290.4, downstream of the thermal plume, produced an overall RBI score of 31 ("Excellent") and data from TRM 293.2, within the thermal plume, produced an overall

RBI score of 35 ("Excellent"). Data from the upstream site, TRM 295.9, produced an overall RBI score of 35 ("Excellent") (Table 13).

The upstream site was considered a control site and a difference of 4 points or less was used to define "similar" conditions between the upstream and downstream sites. Because the RBI scores for the two downstream sites were within 4 points of the RBI score for the upstream site, conditions among the three sites were considered "similar" and BIP was maintained. Results for the autumn 2013 benthic macroinvertebrate sampling can be found in Tables 13 and 16. Results were compared between the downstream (TRM's 290.4 and 293.2) and upstream (TRM 295.9) sites and are briefly discussed below for each RBI metric.

Average number of taxa (highest rating requires > 6.6)

In autumn 2013, averages of 7.8 and 10.6 taxa were observed for sites downstream of BFN. The site upstream of BFN averaged 11 taxa per sample. All three sites received the highest score of 5 for this metric (Table 13).

Proportion of samples with long-lived organisms (highest rating requires > 0.9)

The metric "proportion of samples with long-lived organisms" received the highest score of 5 at both downstream sites with 100% containing long-lived organisms (proportion of 1.0). The proportion of samples with long-lived organisms was 100% at the upstream site which also received the highest score for the metric (Table 13).

Average number of EPT taxa (highest rating requires > 1.4)

An average of 1.2 EPT taxa was collected at the most downstream site, TRM 290.4, resulting in the mid-range score of 3. Within the plume at TRM 293.2, an average of 1.8 EPT taxa was collected and upstream of BFN at TRM 295.9, an average of 1.7 EPT was collected. Both sites received the highest score (Table 13).

Average proportion of oligochaete individuals (highest rating requires < 11%)

Oligochaetes are considered tolerant of poor water quality conditions; therefore a low proportion of oligochaetes in the samples is an indication of good water quality condition. All three sites had low proportions of oligochaetes and received the highest score (5) for the autumn 2013 samples, which included averages of 2.7 % and 8.3 % oligochaetes for the two downstream sites and an average of 3.6 % oligochaetes for the upstream site (Table 13).

Proportion of total abundance comprised by two dominant taxa (highest rating requires < 77.8%)

The two dominant taxa made up 81.1 % of the samples at the most downstream site, TRM 290.4, which received the mid-range score (3) for this metric (Table 13). Total abundance of the two dominant taxa was 66.7 % for the site within the plume, TRM 293.2, and was 67.3 % upstream of BFN at TRM 295.9 resulting in the highest score for both sites. *Hexagenia* mayflies (Ephemeridae) and Asiatic clams (Corbiculidae) were the two most abundant taxa at all three sites (Table 16a).

Average density excluding chironomids and oligochaetes (highest rating requires > $609.9/m^2$)

At the downstream sites, average densities excluding chironomids and oligochaetes were $1,161.7/m^2$ and $1,228.3/m^2$. Both sites received the highest score (5). Average density excluding chironomids and oligochaetes at the upstream site was $1,111.7/m^2$, also resulting in the highest score (Table 13).

Proportion of samples containing no organisms (highest rating requires that all samples contain organisms)

In autumn 2013, there were no samples at any site which were void of organisms. All sites received the highest score (Table 13).

Benthic Macroinvertebrate Community Summary

Monitoring results for autumn 2013 support the conclusion that a BIP of benthic macroinvertebrates was maintained downstream of BFN (Table 13). The site within the thermal

plume, TRM 293.2, received the same RBI total score of 35 as the site upstream of BFN and both rated “Excellent”. The downstream site below the plume, TRM 290.4, received a slightly lower RBI total score of 31. However, this score also rated “Excellent” and was within four points when compared with the scores for the other two sites. Thus, the benthic community at the most downstream site was also considered similar to the upstream benthic community.

Individual metrics and RBI total scores for benthic community samples from TRM 291.7 (downstream) and TRM 295.9 (upstream) are provided in Tables 14 and 15 for referencing results from 2000 to 2010. Benthic samples from these two locations were field processed every year monitored through 2010, and during some of the years samples were also laboratory processed. Since 2011, samples have been lab processed which produces a more accurate depiction of the benthic community. Although the locations presently used as the downstream sites (TRMs 290.4 and 293.2) are proximate to the downstream transect sampled from 2000 to 2010 (TRM 291.7), RBI laboratory-processed scores for 2011 and 2013 cannot be directly compared to RBI field processed scores from 2000 to 2010 without inference.

To provide additional data on the overall health of the benthic macroinvertebrate community in Wheeler Reservoir, RBI scores for VS monitoring locations - inflow, forebay, and Elk River embayment sites - were included in Table 17. Please note that comparison of these scores to current RBI scores at the sites around BFN is limited for two reasons. First, data from these sites were scored from field-based criteria and cannot be closely compared to lab-based scores. Second, these sites are many river miles away from BFN. The inflow site is 53 river miles upstream, and the forebay sampling site is located 17 river miles downstream. The Elk River embayment site is located 6 river miles upstream of the confluence with the Tennessee River, which in turn is 10 river miles downstream of BFN. Because of these distances from the plant, poor scores at these sites cannot be considered indicative of thermal effects from BFN.

The Wheeler inflow site (TRM 347) has produced RBI scores of “Good” or “Excellent” for 11 of the 14 years sampled (Table 17). The forebay (TRM 277) and Elk River embayment sites (ERM 6.0) have produced “Poor” scores most years sampled.

Visual Encounter Survey (Wildlife Observations)

Wildlife observed from linear shoreline surveys conducted upstream and downstream of BFN during autumn 2013 are presented in Table 18. Observations along the upstream survey site consisted of a variety of birds commonly associated with riparian habitat, map turtles, and one Eastern grey squirrel seen along the right descending bank. Observations downstream consisted of a similar variety of birds and map turtles. No mammals were observed downstream.

It is important to note that a Visual Encounter Survey provides a preliminary near shore wildlife assessment to determine if the thermally affected area downstream of a power plant has adversely affected the bird, reptile, or mammal communities. The diversity of bird groups recorded indicated that a healthy ecological community existed both upstream and downstream of WBN during 2013. However, because determination of the presence and diversity of reptiles and mammals using these methods is made difficult by their typical behaviors, observations of these taxa were limited. If an adverse environmental impact is suspected, sampling strategies of a more quantitative nature, such as trapping or netting, active search, investigation of mammal tracks along shoreline areas, long-term observation from blinds, or the use of cameras will be proposed to more accurately estimate the presence and diversity of these groups.

Wheeler Reservoir Flow and BFN Water Temperature

Daily mean flows from Guntersville Dam over the fiscal year 2013 (October 2012 through November 2013) are compared in Figure 16 to historic daily mean flows over the same fiscal year period, averaged from 1976 to 2012. From October to November 2012 and August to November 2013, flows were similar to historical averages. During December 2012, flows remained lower than historical. Flows were generally higher than historical from January to July 2013.

Figure 17 compares daily average water temperatures recorded upstream of BFN intake and downstream of BFN discharge during October 2012 through November 2013. Water temperatures were similar at both sites through this period.

Thermal Plume Characterization

Plume temperatures (water temperatures 3.6°F or greater above ambient) began at the BFN discharge (TRM 294.0) and continued downstream to TRM 291.8. At the discharge, the plume extended from the RDB to 30% of the width of the river and from the surface to 1.5 m depth. Downstream (TRM 293.8), the plume extended to a maximum depth of 7 m but did not extend farther than 50% of the width of the river from the RDB. At TRM 291.8, plume temperatures were observed only along the RDB, from the surface to 3 m depth. No plume temperatures were detected downstream of this point (Table 19).

These profiles indicate that, at maximum, the thermal effluent from BFN was confined to the upper two-thirds of the water column from mid-channel to the RDB, and that a sufficient zone of passage for aquatic wildlife existed around BFN during autumn 2013.

Water Quality Parameters at Fish Sampling Sites during RFAI Samples

Water temperatures observed at the upstream site, centered around TRM 295.9, ranged from 71.9 to 78.4 °F, with the highest temperatures occurring in mid-channel at the surface, along the downstream boundary of the sample reach. Water temperatures at the downstream site, centered around TRM 292.5, ranged from 74.0 to 83.9 °F, with the highest temperatures occurring at the surface along the RDB at the upstream boundary of the sample reach. Values for pH, conductivity, and dissolved oxygen concentration fell within narrow and similar ranges upstream and downstream (Table 20).

The values of these parameters indicate that pH, conductivity, and dissolved oxygen concentrations surrounding BFN during autumn 2013 were of sufficient quality to support a BIP of the type expected for this reservoir, and that they were not affected by thermal effluent from BFN. The most elevated temperatures within the downstream site were observed along the RDB at the upper boundary, just downstream of the BFN discharge, and are consistent with temperatures recorded at similar locations during plume determination (Table 19). The most elevated temperatures within the upstream site were observed at the surface along the lower boundary of the site. This lower boundary is less than one mile upstream of the discharge, and

considering the width of the reservoir and the relatively low velocity of the river at this point, these elevated temperatures can be attributed to diffusion of heated water upstream from the discharge. Discussion above indicated that a zone of passage for aquatic life existed around BFN. Therefore, overall water quality around BFN was not negatively impacted by the thermal effluent.

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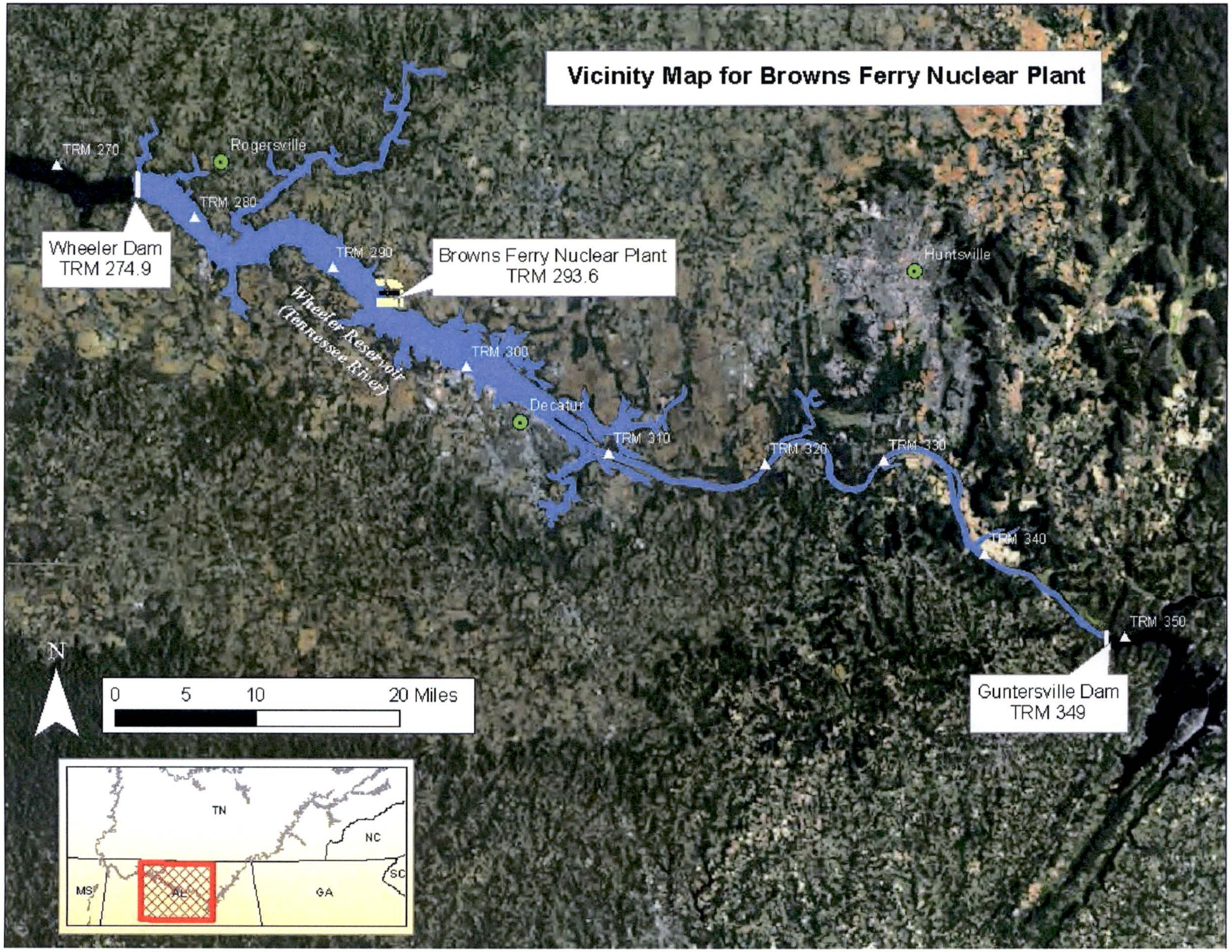

Figure 1. Location of Browns Ferry Nuclear Plant on Wheeler Reservoir.

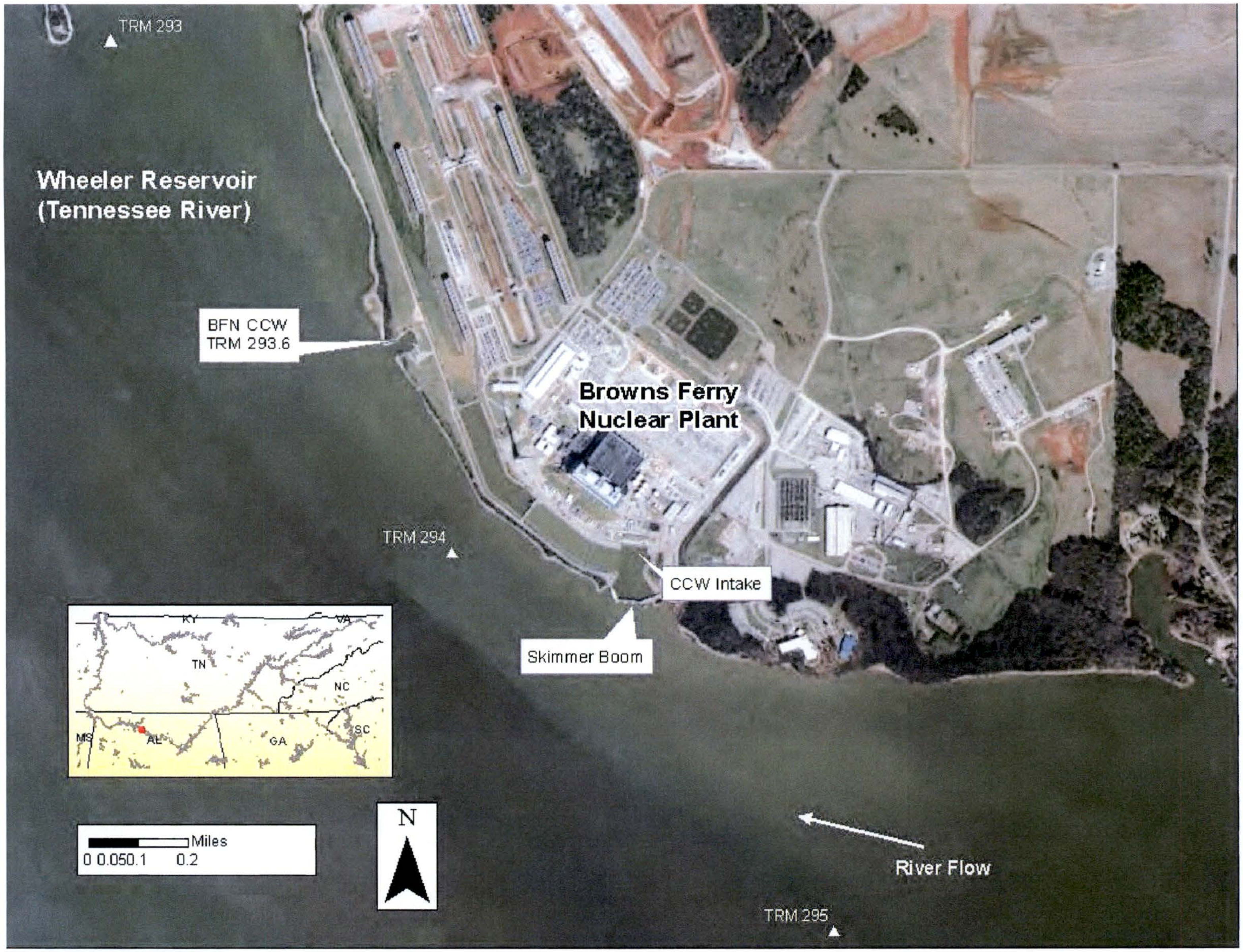

Figure 2. Location of Condenser Cooling Water (CCW) intake and discharge at Browns Ferry Nuclear Plant.

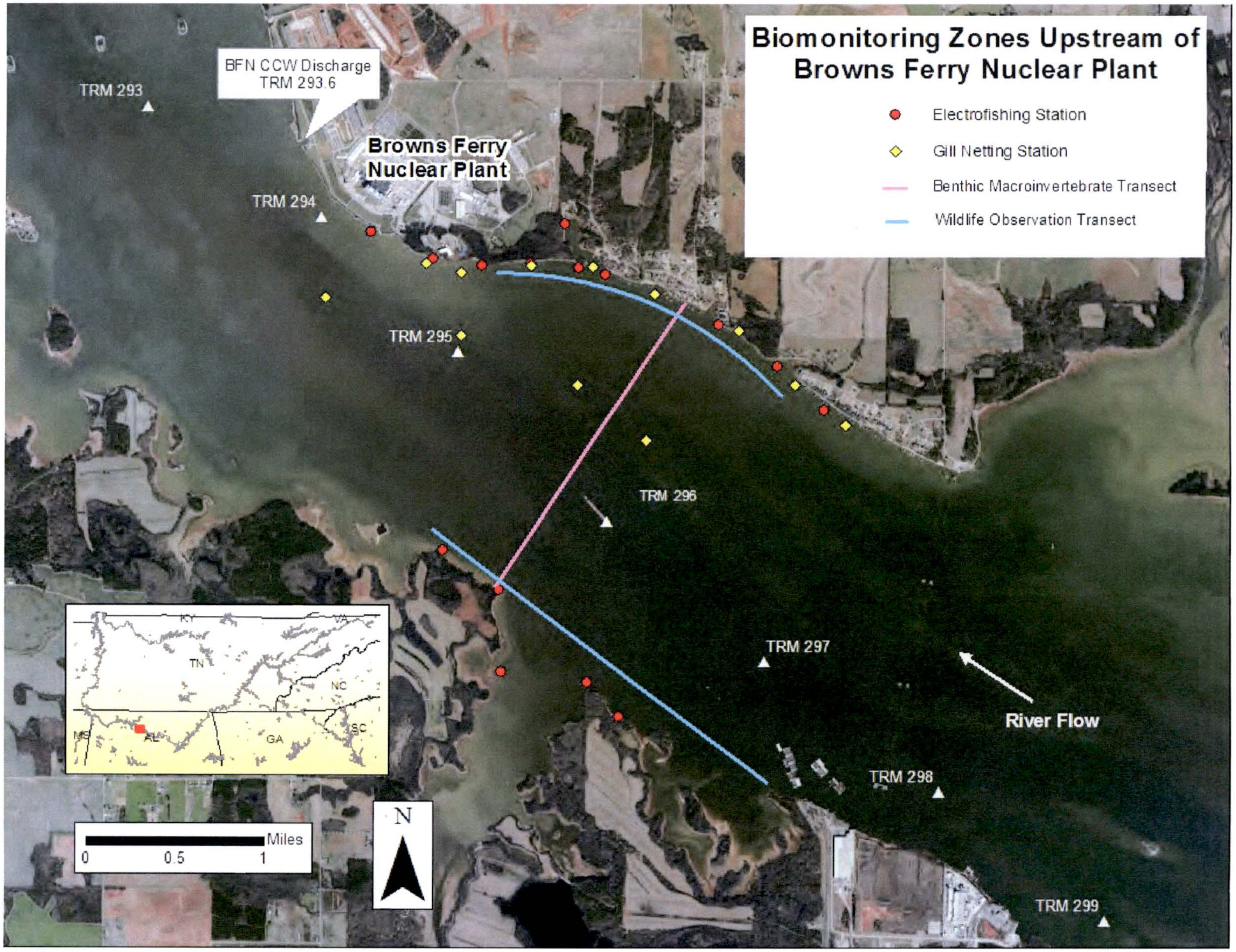

Figure 3. Locations of biomonitoring sites upstream of Browns Ferry Nuclear Plant.

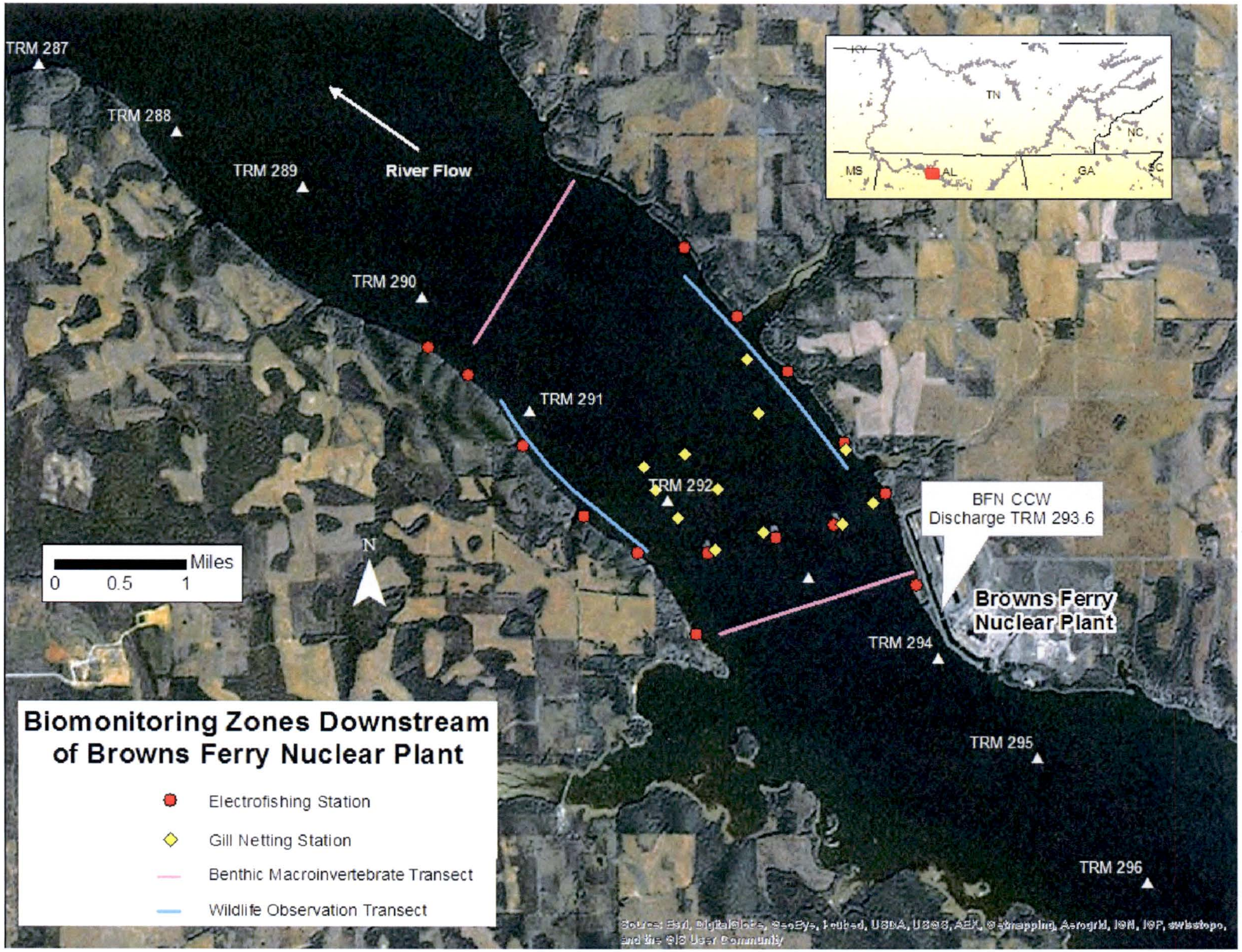

Figure 4. Locations of biomonitoring sites downstream of Browns Ferry Nuclear Plant.

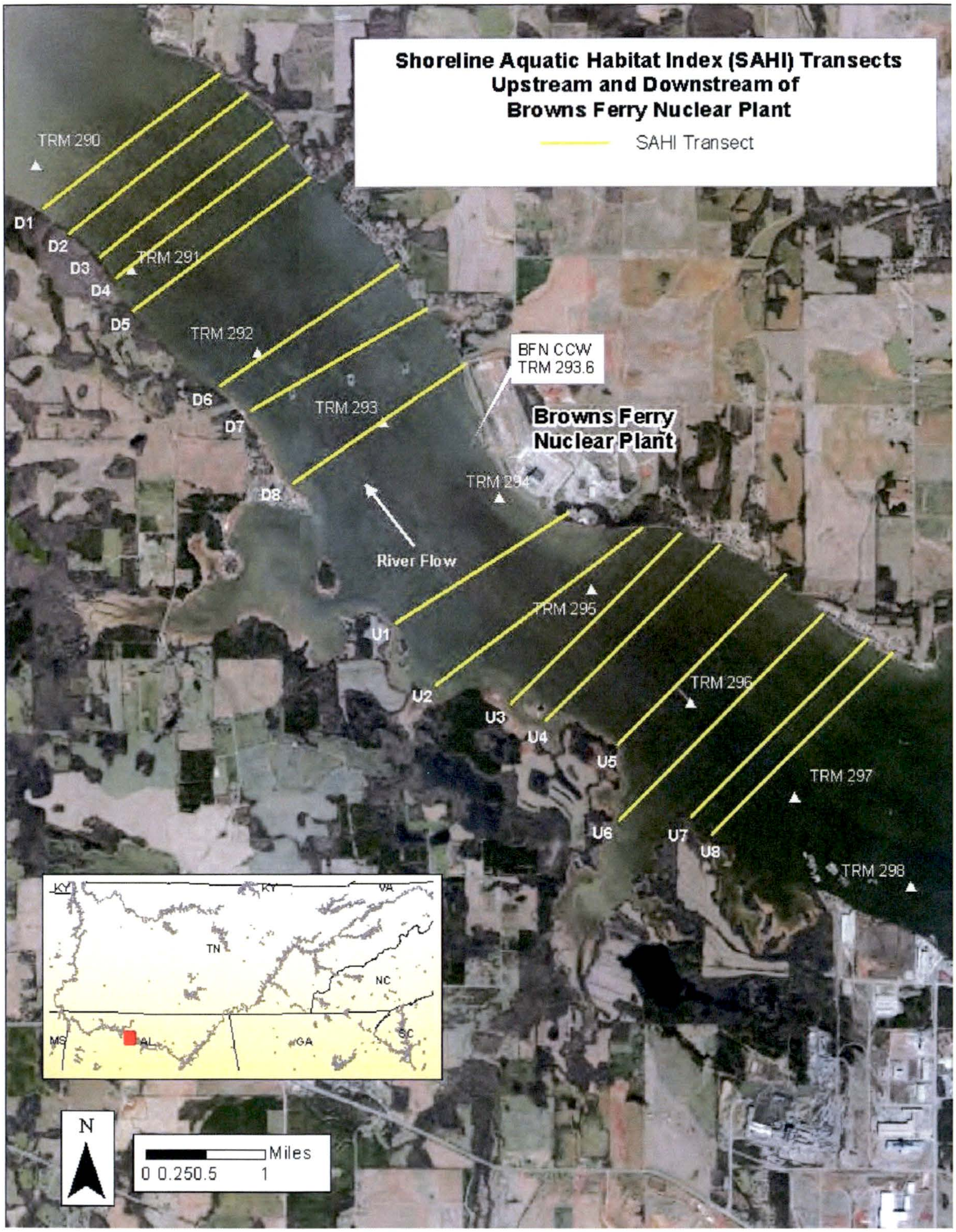

Figure 5. Locations of transects used to characterize shoreline and river bottom habitat upstream and downstream of Browns Ferry Nuclear Plant.

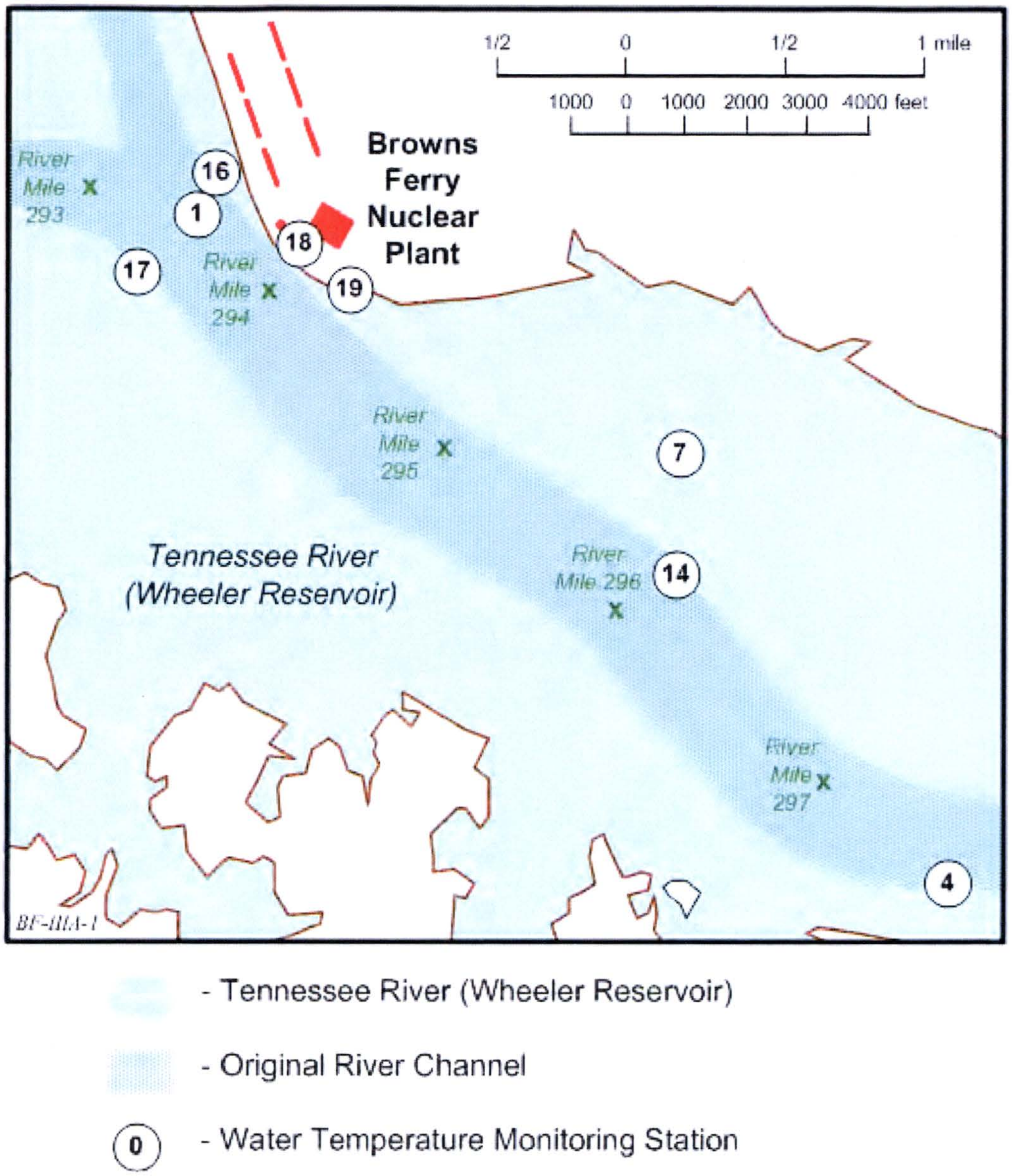

Figure 6. Locations of water temperature monitoring sites used to compare water temperatures upstream of Browns Ferry Nuclear Plant (BFN) intake and downstream of BFN discharge. Site 4 was used for upstream ambient temperatures of the BFN intake and was located at TRM 297.8. Sites 1, 16, and 17 were used for temperatures downstream of BFN discharge and were each located at TRM 293.5. This figure originated in the technical report: Browns Ferry Nuclear Plant Module III, Water Temperature Monitoring.

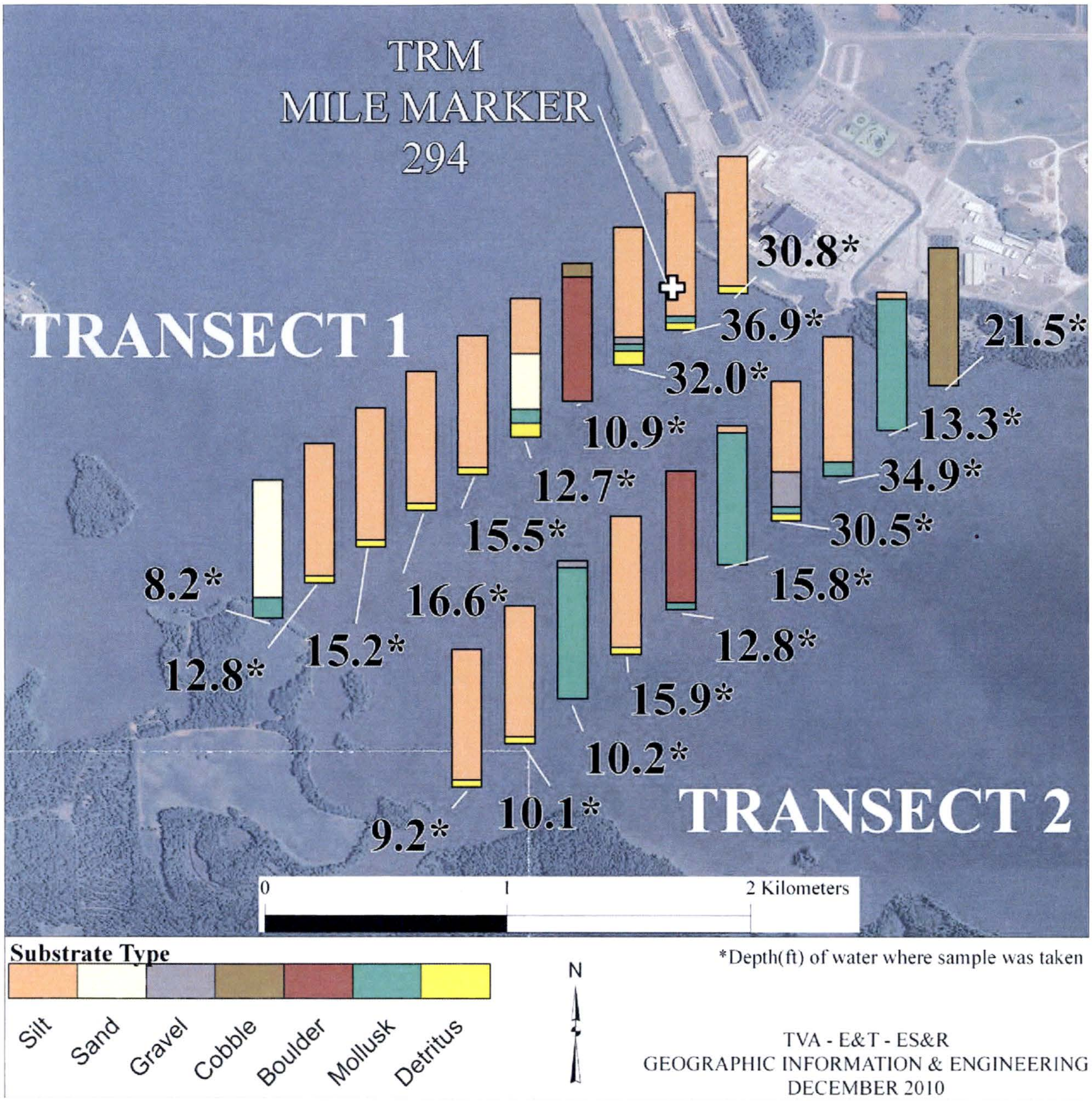

Figure 7. Substrate composition at ten equally spaced points per transect across the Tennessee River upstream of Browns Ferry Nuclear Plant. ***Water depth (ft) at each point is denoted. Of the eight transects established upstream of Browns Ferry Nuclear Plant, transects 1 and 2 are the closest to the plant.**

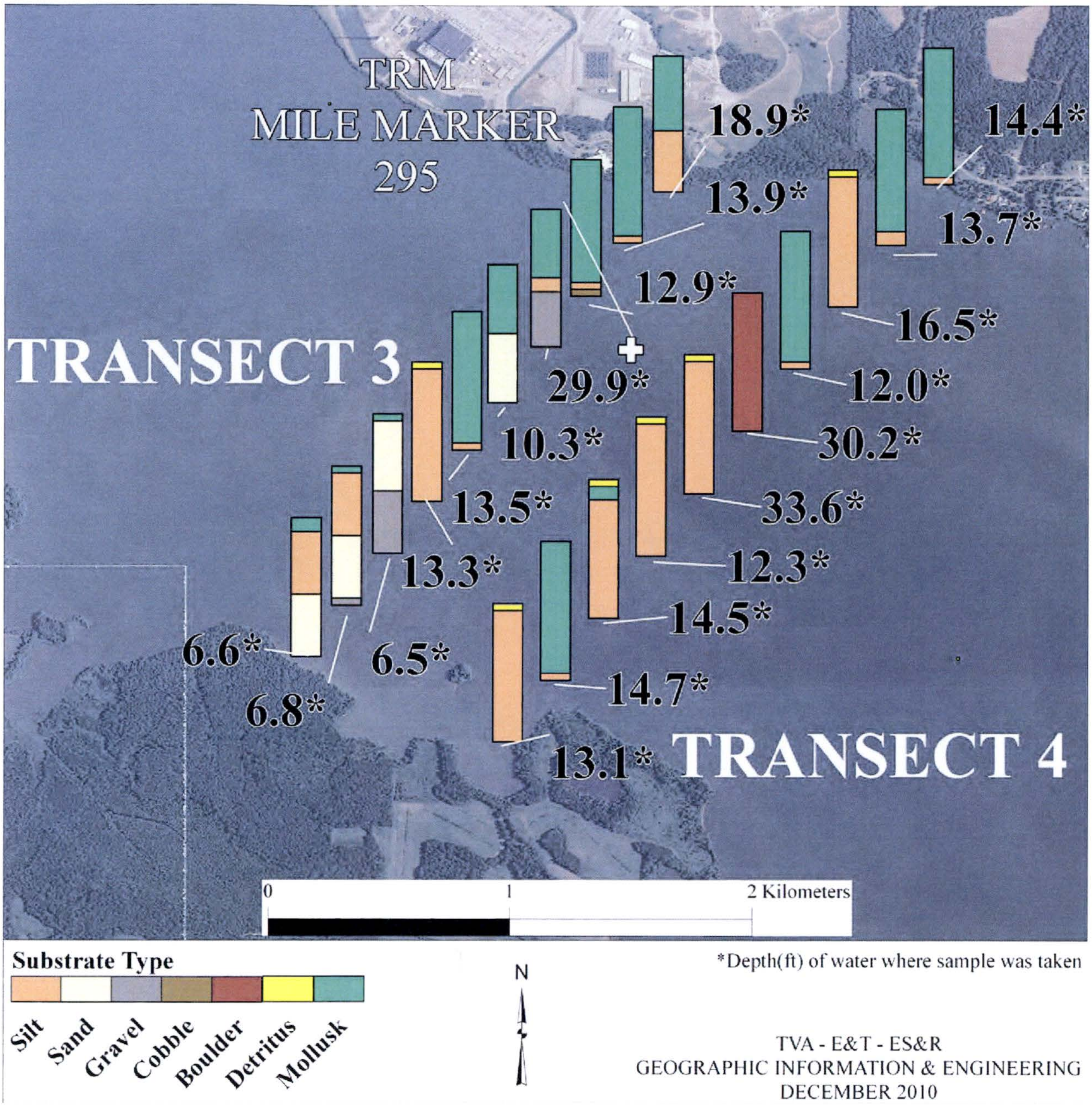

Figure 8. Substrate composition at ten equally spaced points per transect across the Tennessee River upstream of Browns Ferry Nuclear Plant. *Water depth (ft) at each point is denoted.

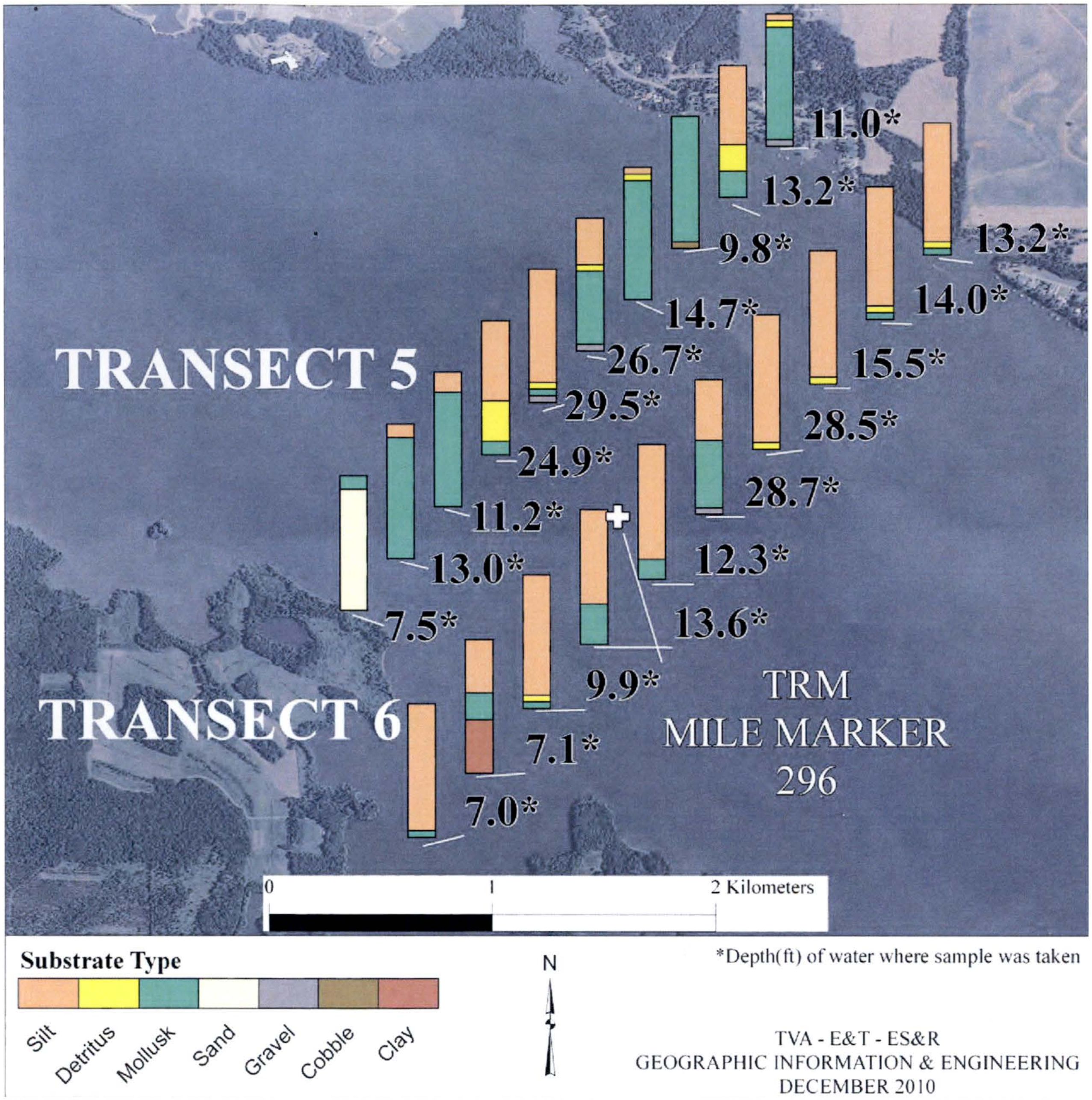

Figure 9. Substrate composition at ten equally spaced points per transect across the Tennessee River upstream of Browns Ferry Nuclear Plant. ***Water depth (ft) at each point is denoted.**

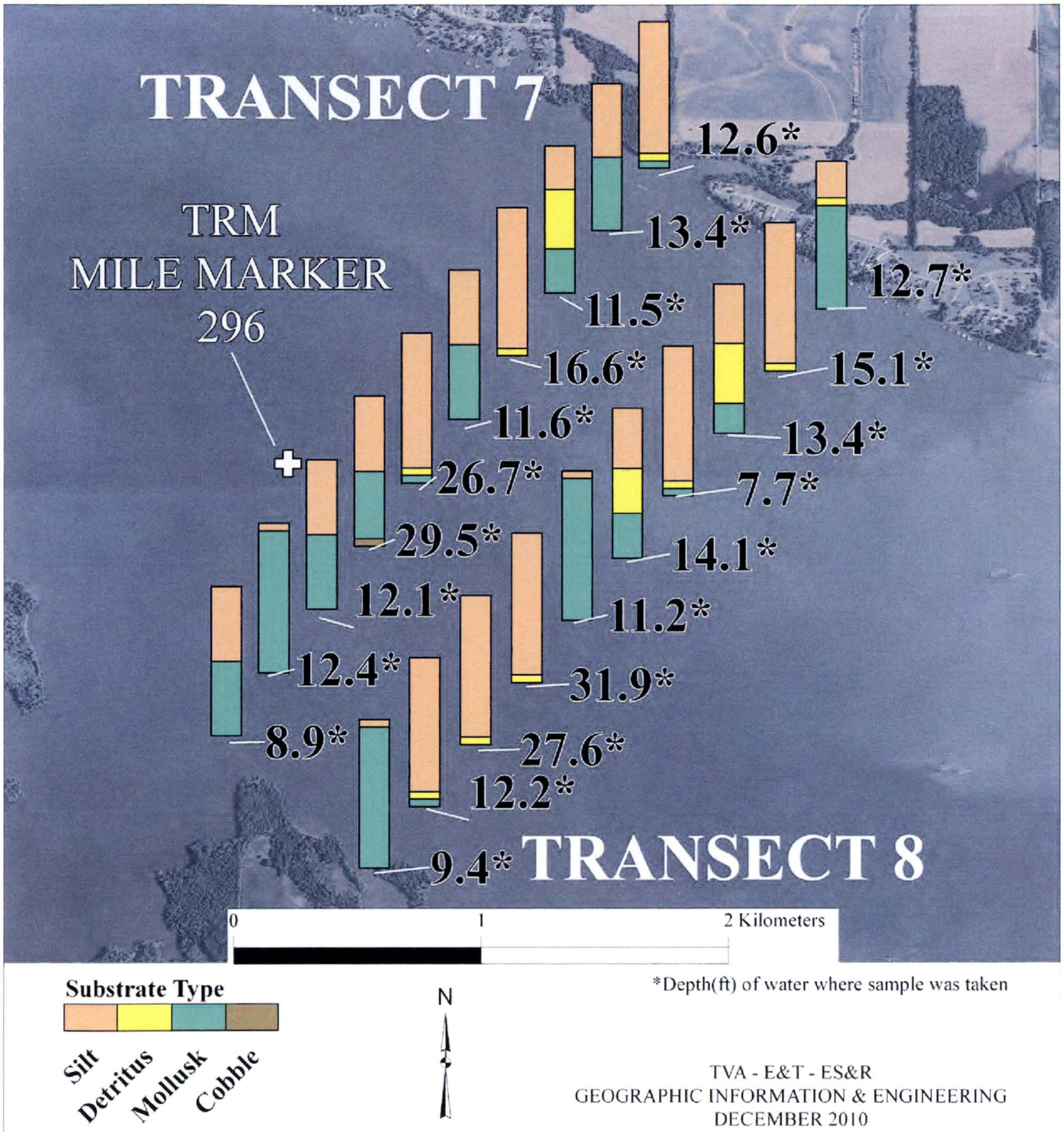

Figure 10. Substrate composition at ten equally spaced points per transect across the Tennessee River upstream of Browns Ferry Nuclear Plant. ***Water depth (ft) at each point is denoted.**

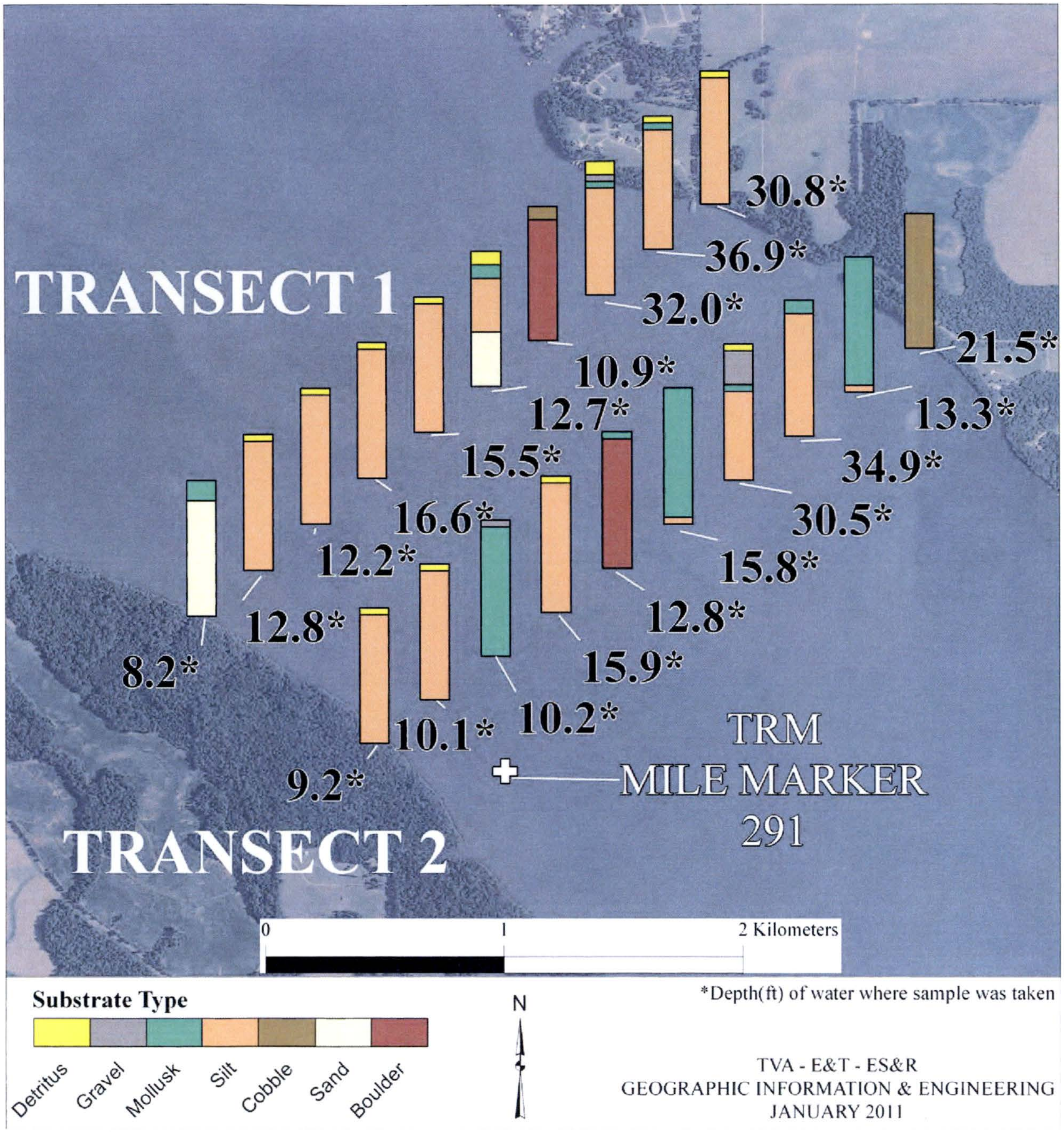

Figure 11. Substrate composition at ten equally spaced points per transect across the Tennessee River downstream of Browns Ferry Nuclear Plant. ***Water depth (ft) at each point is denoted. Transects 1 and 2 are the farthest downstream of the eight transects established downstream of Browns Ferry Nuclear Plant.**

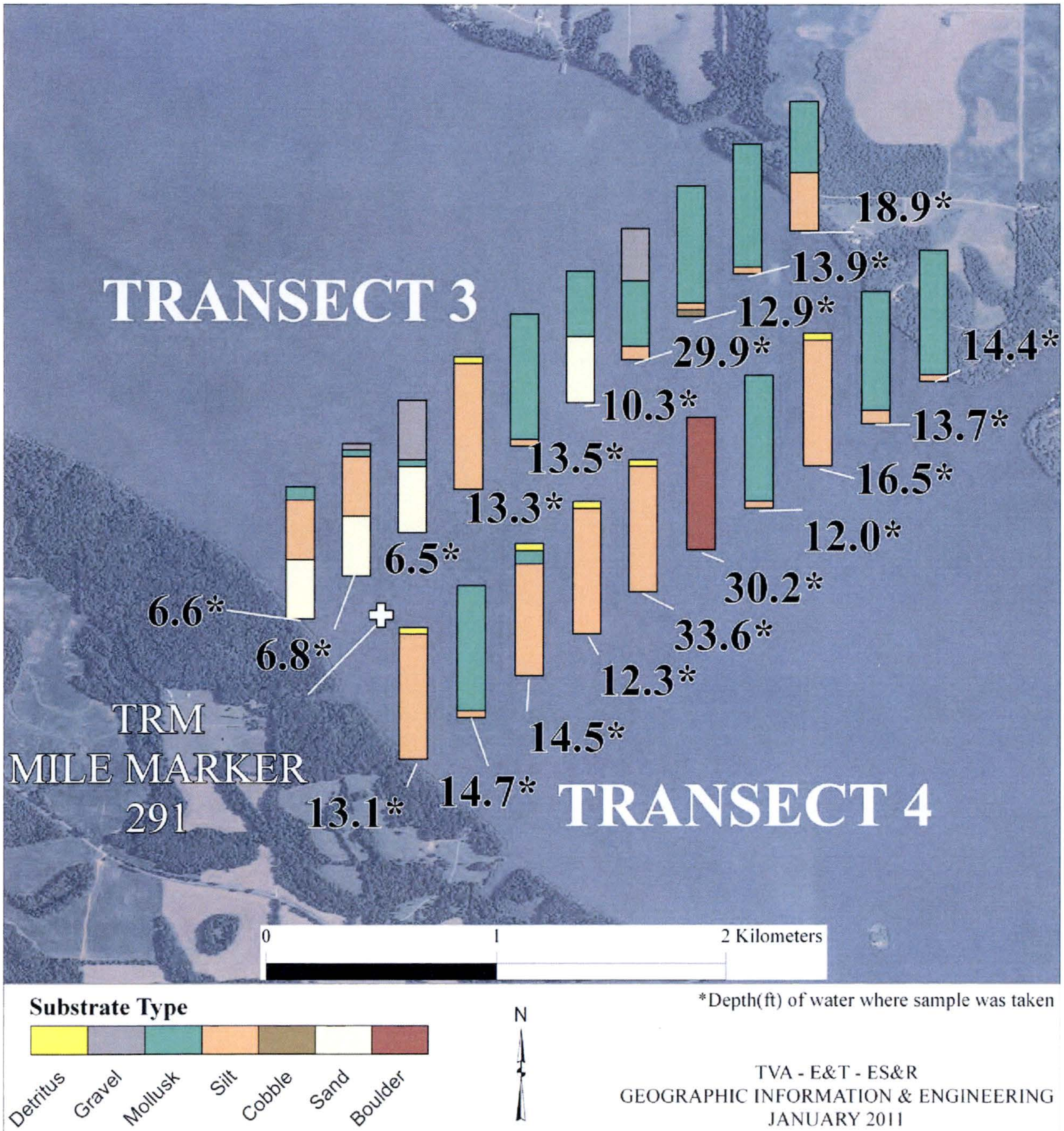

Figure 12. Substrate composition at ten equally spaced points per transect across the Tennessee River downstream of Browns Ferry Nuclear Plant. ***Water depth (ft) at each point is denoted.**

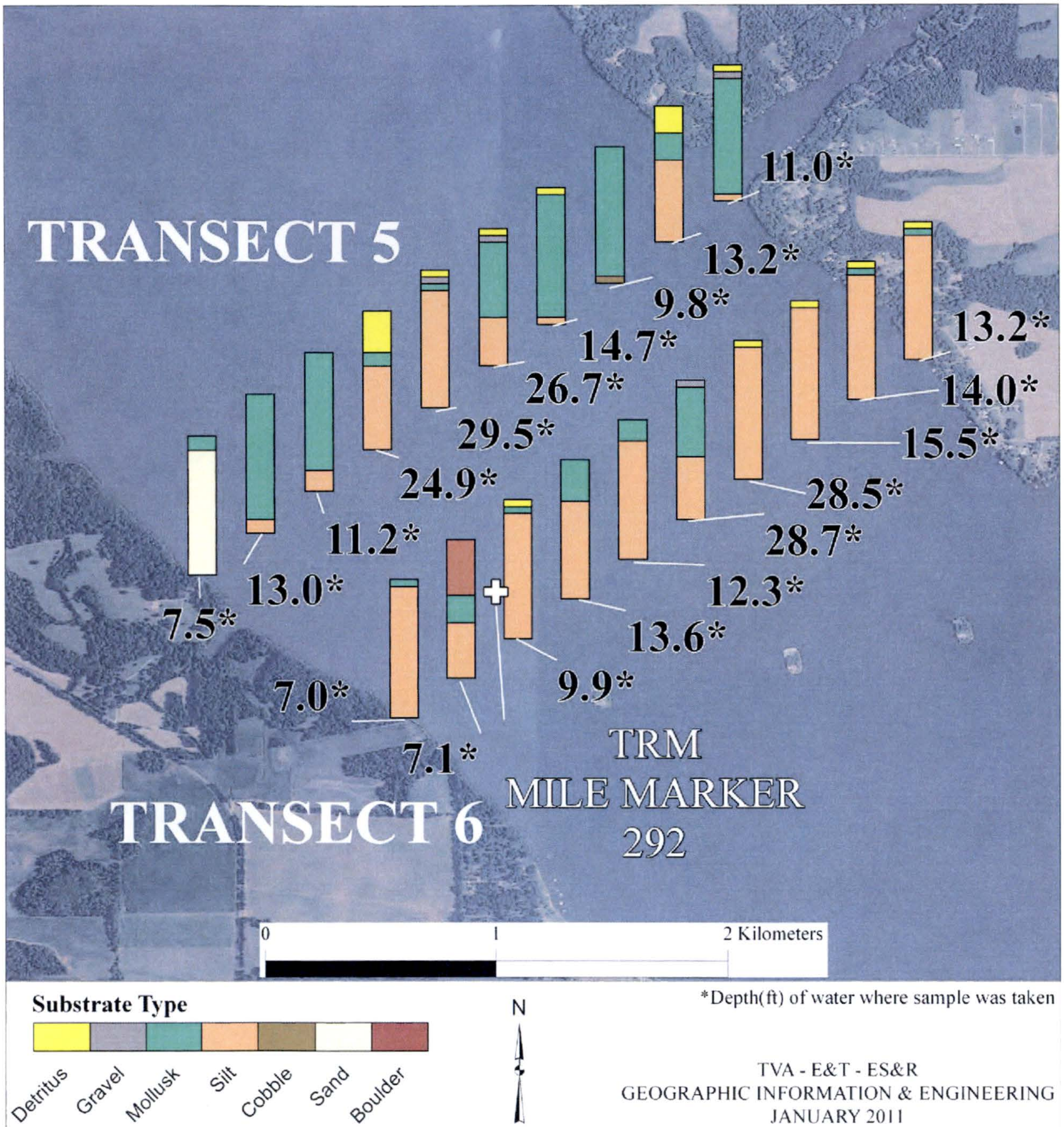

Figure 13. Substrate composition at ten equally spaced points per transect across the Tennessee River downstream of Browns Ferry Nuclear Plant. ***Water depth (ft) at each point is denoted.**

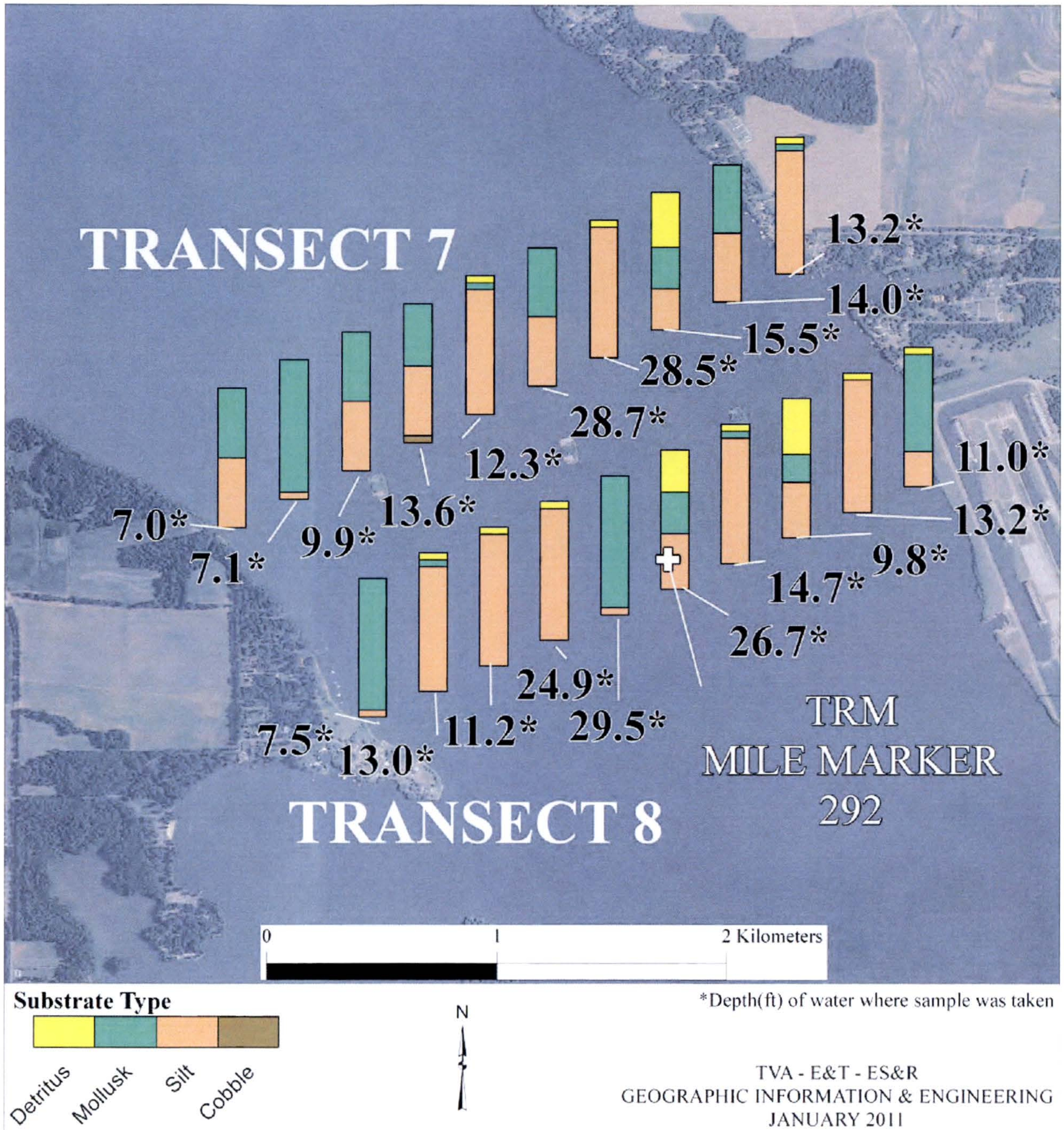

Figure 14. Substrate composition at ten equally spaced points per transect across the Tennessee River downstream of Browns Ferry Nuclear Plant. ***Water depth (ft) at each point is denoted.**

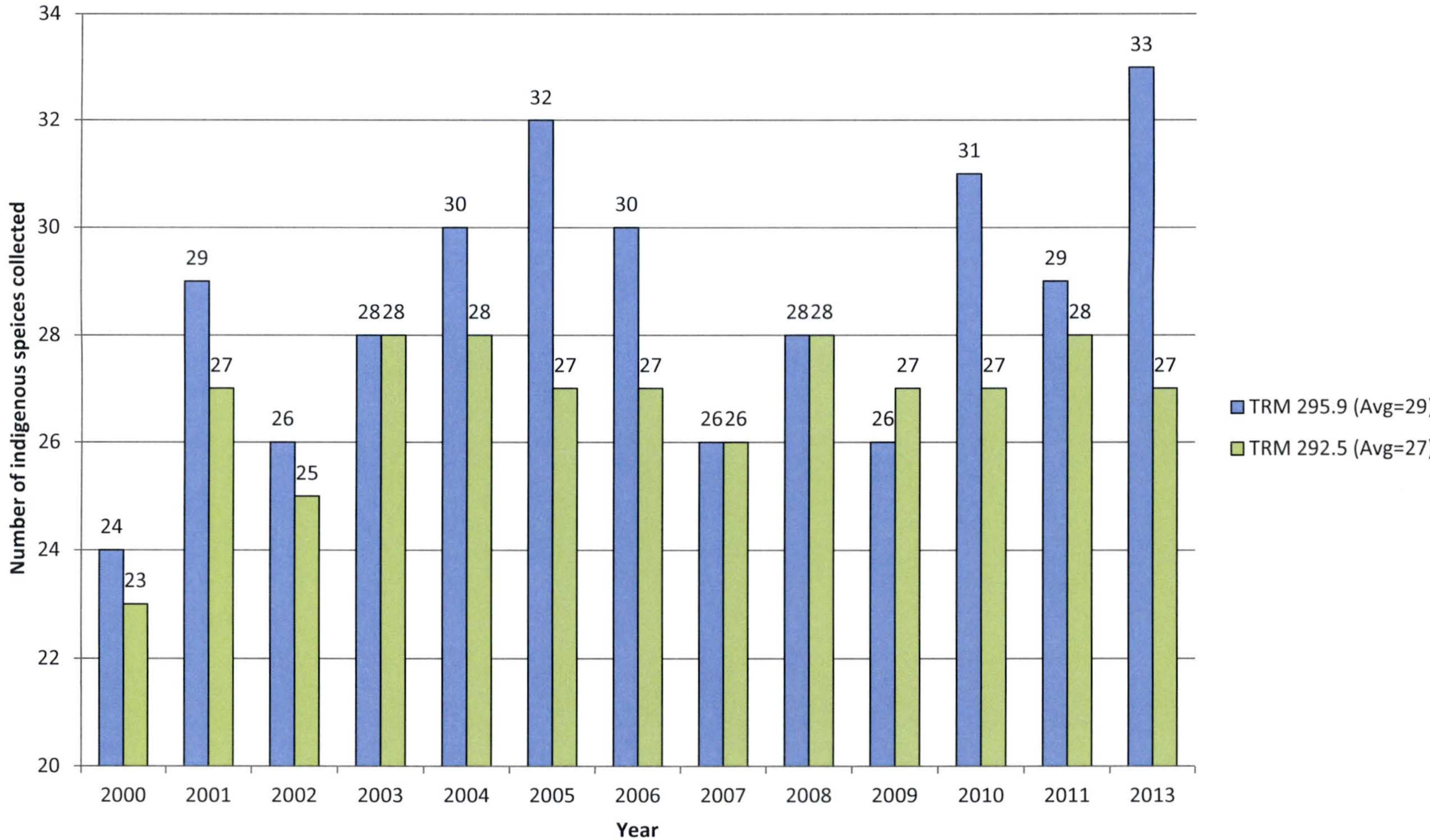

Figure 15. Comparison of observed values for the Reservoir Fish Assemblage Index metric "Number of Indigenous Species", over 13 years of autumn sampling at the sites upstream (TRM 295.9) and downstream (TRM 292.5) of Brown's Ferry Nuclear Plant.

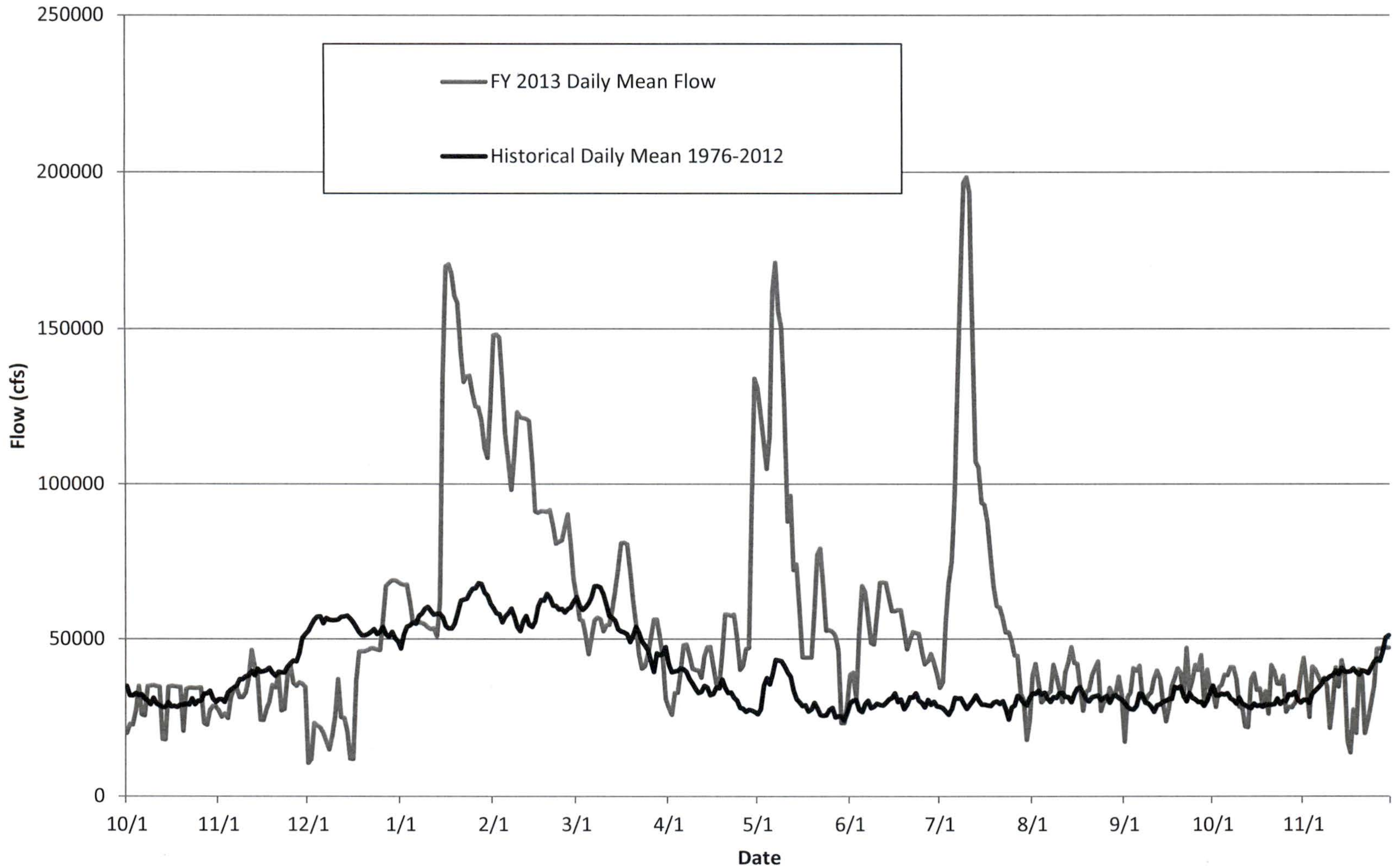

Figure 16. Daily mean flows from Guntersville Dam, October 2012 through November 2013, and historic daily flows for the same fiscal year period, averaged over the years 1976-2012.

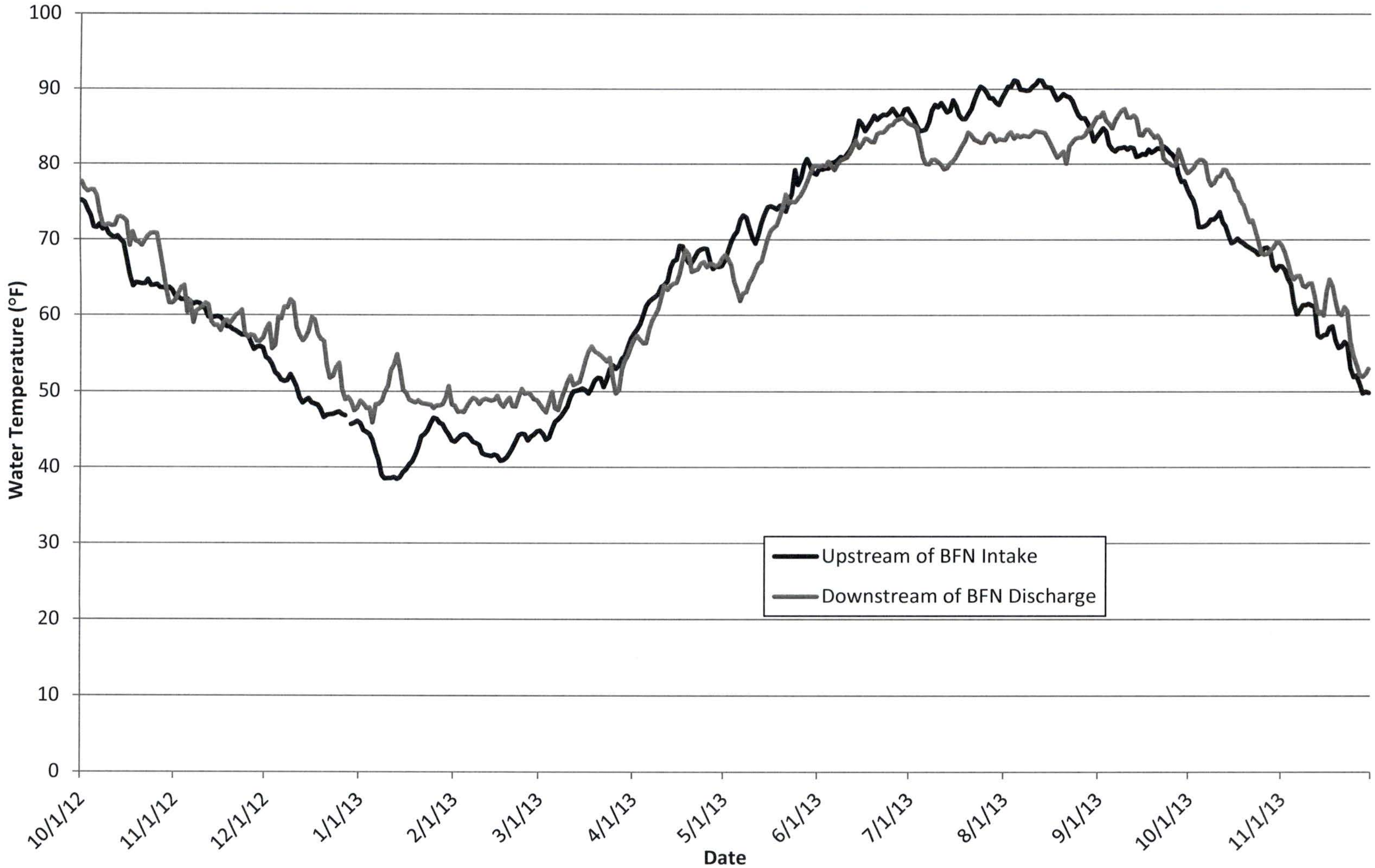

Figure 17. Daily water temperatures averaged over depth (3, 5, and 7 feet) upstream of Browns Ferry Nuclear Power Plant (BFN) intake and downstream of BFN discharge — October 2012 through November 2013.

Table 1. Shoreline Aquatic Habitat Index (SAHI) metrics and scoring criteria.

Metric	Scoring Criteria	Score
Cover	Stable cover (boulders, rootwads, brush, logs, aquatic vegetation, artificial structures) in 25 to 75% of the drawdown zone	5
	Stable cover in 10 to 25% or > 75% of the drawdown zone	3
	Stable Cover in < 10% of the drawdown zone	1
Substrate	Percent of drawdown zone with gravel substrate > 40	5
	Percent of drawdown zone with gravel substrate between 10 and 40	3
	Percent substrate gravel < 10	1
Erosion	Little or no evidence of erosion or bank failure. Most bank surfaces stabilized by woody vegetation.	5
	Areas of erosion small and infrequent. Potential for increased erosion due to less desirable vegetation cover (grasses) on > 25% of bank surfaces.	3
	Areas of erosion extensive, exposed or collapsing banks occur along > 30% of shoreline.	1
Canopy Cover	Tree or shrub canopy > 60% along adjacent bank	5
	Tree or shrub canopy 30 to 60% along adjacent bank	3
	Tree or shrub canopy < 30% along adjacent bank	1
Riparian Zone	Width buffered > 18 meters	5
	Width buffered between 6 and 18 meters	3
	Width buffered < 6 meters	1
Habitat	Habitat diversity optimum. All major habitats (logs, brush, native vegetation, boulders, gravel) present in proportions characteristic of high quality, sufficient to support all life history aspects of target species. Ready access to deeper sanctuary areas present.	5
	Habitat diversity less than optimum. Most major habitats present, but proportion of one is less than desirable, reducing species diversity. No ready access to deeper sanctuary areas.	3
	Habitat diversity is nearly lacking. One habitat dominates, leading to lower species diversity. No ready access to deeper sanctuary areas.	1
Gradient	Drawdown zone gradient abrupt (> 1 meter per 10 meters). Less than 10% of shoreline with abrupt gradient due to dredging.	5
	Drawdown zone gradient abrupt. (> 1 meter per 10 meters) in 10 to 40% of the shoreline resulting from dredging. Rip-rap used to stabilize bank along > 10% of the shoreline.	3
	Drawdown zone gradient abrupt in > 40 % of the shoreline resulting from dredging. Seawalls used to stabilize bank along > 10 % of the shoreline.	1

Table 2. **Expected trophic guild proportions* and expected numbers of species* in lower mainstem Tennessee River reservoir transition zones, compared to values observed during 2013 monitoring at BFN.**

	Lower Mainstem Tennessee River Transition Zones								Observed Upstream of BFN (TRM 295.9)		Observed Downstream of BFN (TRM 292.5)	
	Proportion (%)				Number of species							
	Trisected range [a]			Average [b]	Trisected range [a]			Average [b]				
Trophic Guild	-	Expected	+		-	Expected	+		Proportion (%)	Number of Species	Proportion (%)	Number of Species
Benthic Invertivore	< 6.7	6.4 to 13.4	> 13.4	5.5 ± 1.2	< 3	3 to 5	> 5	5 ± 1	10.7	5	8.3	4
Insectivore	< 24.6	24.6 to 49.1	> 49.1	40.0 ± 4.5	< 4	4 to 8	> 8	8 ± 1	32.5	12	60.0	11
Top Carnivore	< 15.1	15.1 to 30.2	> 30.2	18.3 ± 2.2	< 4	4 to 8	> 8	10 ± 1	14.4	12	7.1	8
Omnivore	>38.5	19.3 to 38.5	<19.3	28.7 ± 3.3	> 6	3 to 6	< 3	6 ± 1	39.2	7	23.3	6
Planktivore	< 9.4	9.4 to 18.7	>18.7	6.4 ± 2.6	0	1	> 1	1 ± 1	3.2	1	1.2	1
Parasitic	< 0.1	0.1 to 0.2	> 0.2	0.1 ± 0.04	0	1	> 1	1 ± 0	--	--	--	--
Herbivore	<1.8	1.8 to 3.6	>3.6	0.6 ± 0.4	0	1	> 1	1 ± 0	--	--	--	--
Specialized Insectivore	--	--	--	--	--	--	--	--	--	--	0.1	1

**Expected values were calculated from data collected over 900 electrofishing runs and 600 overnight experimental gill net sets in transition areas of lower mainstem Tennessee River reservoirs.*

[a] Trisected ranges are intended to show below expected (-), expected, and above expected (+) values for trophic level proportions and species occurring within the transition zones in upper mainstem Tennessee River reservoirs.

[b] Average expected values are bound by 95% confidence intervals.

Table 3. RFAI scoring criteria (2002) for inflow, transition, and forebay sections of lower mainstem reservoirs* in the Tennessee River system.

		Scoring Criteria								
		Inflow			Transition			Forebay		
Metric	Gear	1	3	5	1	3	5	1	3	5
1. Total species	Combined	< 14	14-27	> 27	< 16	16-30	>30	< 14	14-27	> 27
2. Number of centrarchid species	Combined	< 2	2-4	> 4	< 2	2-2	> 2	< 2	2-3	> 3
3. Number of benthic invertivores	Combined	< 4	4-7	> 7	< 4	4-7	> 7	< 4	4-6	> 6
4. Number of intolerant species	Combined	< 3	3-6	> 6	< 3	3-4	> 4	< 2	2-4	> 4
5. Percent tolerant individuals	Electrofishing	>51%	26-51%	< 26%	>54%	27-54%	< 27%	> 61%	30-61%	< 30%
	Gill netting				>30%	15-30%	< 15%	>46%	22-46%	< 22%
6. Percent dominance by one species	Electrofishing	>47%	24-47%	< 24%	>58%	29-58%	< 29%	>59%	30-59%	< 30%
	Gill netting				>34%	17-34%	< 17%	>43%	21-43%	< 21%
7. Percent non-indigenous species	Electrofishing	>4%	2-4%	< 2%	>2%	1-2%	< 1%	>2%	2-2%	< 2%
	Gill netting				>2%	1-2%	< 1%	>2%	1-2%	< 1%
8. Number of top carnivore species	Combined	< 4	4-7	>7	< 4	4-7	>7	< 4	4-7	>7
9. Percent top carnivores	Electrofishing	< 15%	15-29%	>29%	< 5%	5-10%	>10%	< 6%	6-12%	>12%
	Gill netting				< 20%	20-39%	>39%	< 25%	25-49%	>49%
10. Percent omnivores	Electrofishing	>48%	24-48%	< 24%	>48%	24-48%	< 24%	>59%	30-59%	< 30%
	Gill netting				>33%	16-33%	< 16%	>49%	24-49%	< 24%
11. Average number per run	Electrofishing	< 68	68-136	>136	< 243	243-487	>487	< 170	170-341	>341
	Gill netting				< 11	11-22	>22	< 20	20-40	>40
12. Percent anomalies	Electrofishing	>5%	2-5%	< 2%	>5%	2-5%	< 2%	>5%	2-5%	< 2%
	Gill netting				>5%	2-5%	< 2%	>5%	2-5%	< 2%

**Lower mainstem Tennessee River reservoirs include Guntersville, Wheeler, Wilson, Pickwick, and Kentucky.*

Transition scoring criteria were used to score sites upstream and downstream of BFN.

Table 4. Scoring criteria for laboratory-processed benthic macroinvertebrate community samples from inflow, transition, and forebay zones of mainstem Tennessee River reservoirs.

Benthic Community Metrics	Scoring Criteria								
	Inflow			Transition			Forebay		
	1	3	5	1	3	5	1	3	5
1. Average number of taxa	<4.2	4.2-8.3	>8.3	<3.3	3.3-6.6	>6.6	<2.8	2.8-5.5	>5.5
2. Proportion of samples with long-lived organisms	<0.6	0.6-0.8	>0.8	<0.6	0.6-0.9	>0.9	<0.6	0.6-0.8	>0.8
3. Average number of EPT taxa	<0.9	0.9-1.9	>1.9	<0.6	0.6-1.4	>1.4	<0.6	0.6-0.9	>0.9
4. Average proportion of oligochaete individuals	>23.9	23.9-12.0	<12.0	>21.9	21.9-11.0	<11.0	>41.9	41.9-21.0	<21.0
5. Average proportion of total abundance comprised by the two most abundant taxa	>86.2	86.2-73.1	<73.1	>87.9	87.9-77.8	<77.8	>90.3	90.3-81.7	<81.7
6. Average density excluding chironomids and oligochaetes	<400.0	400.0-799.9	>799.9	<305.0	305.0-609.9	>609.9	<125.0	125.0-249.9	>249.9
7. Zero Samples: proportion of samples containing no organisms	>0	-	0	>0	-	0	>0	-	0

Transition scoring criteria were used to score sites upstream and downstream of BFN.

Table 5. SAHI scores for shoreline habitat assessments conducted within the RFAI sample reach upstream of BFN, autumn 2009.

	Transects								
Left Descending Bank	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Avg.**
Latitude	34.68917	34.6832	34.6806	34.67959	34.67709	34.66978	34.67027	34.66841	
Longitude	-87.13621	-87.13172	-87.12188	-87.1183	-87.10876	-87.10915	-87.10009	-87.09753	
Aquatic Macrophytes	0%	0%	0%	0%	0%	0%	0%	0%	0%
SAHI Variables									
Cover	3	1	3	5	1	3	3	3	3
Substrate	1	5	3	3	5	1	1	1	3
Erosion	3	5	5	3	3	3	3	3	4
Canopy Cover	5	5	5	5	5	5	5	5	5
Riparian Zone	1	5	5	5	3	5	5	5	4
Habitat	3	3	1	3	1	3	1	1	2
Slope	1	5	5	1	3	5	1	1	3
Total	17	29	27	25	21	25	19	19	24
Rating	Fair	Good	Good	Fair	Fair	Fair	Fair	Fair	Fair

	Transects								
Right Descending Bank	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Avg.**
Latitude	34.70109	34.69937	34.69862	34.6986	34.69566	34.69302	34.69062	34.68843	
Longitude	-87.11896	-87.11535	-87.10973	-87.10061	-87.09157	-87.08836	-87.08452	-87.08094	
Aquatic Macrophytes	0%	0%	0%	0%	0%	0%	0%	0%	0%
SAHI Variables									
Cover	3	3	5	5	1	1	5	5	4
Substrate	1	5	1	5	5	5	5	5	4
Erosion	5	5	5	5	5	1	5	5	5
Canopy Cover	1	5	5	1	1	5	1	1	3
Riparian Zone	1	5	5	1	1	5	1	1	3
Habitat	3	1	3	1	1	1	1	1	2
Slope	1	3	1	1	3	1	1	1	2
Total	15	27	25	19	17	19	19	19	23
Rating	Poor	Good	Fair	Fair	Fair	Fair	Fair	Fair	Fair

Scoring criteria: poor (7-16), fair (17-26), good (27-35)

Table 6. SAHI scores for shoreline habitat assessments conducted within the RFAI sample reach downstream of BFN, autumn 2009.

Left Descending Bank	Transects 1	2	3	4	5	6	7	8	Avg.
Latitude	34.72824	34.72603	34.72398	34.72068	34.71496	34.7128	34.71082	34.70351	
Longitude	-87.1759	-87.1728	-87.1704	-87.1678	-87.4621	-87.1577	-87.1543	-87.1488	
Aquatic Macrophytes	0%	0%	0%	0%	0%	0%	0%	0%	0%
SAHI Variables									
Cover	1	3	1	1	1	1	1	3	2
Substrate	5	1	1	5	5	5	5	5	4
Erosion	1	5	5	1	1	1	5	5	3
Canopy Cover	5	5	5	5	5	5	3	1	4
Riparian Zone	5	5	5	5	5	5	3	1	4
Habitat	3	3	1	1	1	1	1	1	2
Slope	1	1	1	1	1	1	1	3	1
Total	21	23	19	19	19	19	19	19	20
Rating	Fair	Fair	Fair	Fair	Fair	Fair	Fair	Fair	Fair

Right Descending Bank	Transects 1	2	3	4	5	6	7	8	Avg.
Latitude	34.74369	34.74081	34.73891	34.73519	34.73081	34.7266	34.72058	34.71239	
Longitude	-87.1565	-87.1522	-87.1507	-87.1475	-87.1428	-87.1376	-87.1325	-87.1275	
Aquatic Macrophytes	0%	0%	0%	0%	0%	0%	0%	0%	0%
SAHI Variables									
Cover	3	3	3	1	5	5	5	1	3
Substrate	1	1	5	5	1	5	1	5	3
Erosion	5	1	1	1	5	5	5	5	4
Canopy Cover	5	5	5	5	3	3	1	1	4
Riparian Zone	3	5	3	5	1	1	1	1	3
Habitat	3	1	1	1	3	1	1	1	2
Slope	1	1	1	1	1	1	1	1	1
Total	21	17	19	19	19	21	15	15	20
Rating	Fair	Fair	Fair	Fair	Fair	Fair	Poor	Poor	Fair

Scoring criteria: poor (7-16), fair (17-26), good (27-35)

Table 7. Substrate percentages and average water depth (ft) per transect upstream and downstream of BFN, autumn 2009.

	% Substrate per transect upstream of BFN								
Substrate Type	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Avg.**
Silt	68.5	45.0	25.5	49.0	27.1	79.5	56.0	58.0	51.1
Mollusk Shell	3.5	30.5	45.5	38.5	56.8	13.5	38.0	30.0	32.0
Sand	12.5	0	19.0	0	9.0	0	0	0	5.1
Detritus	4.0	2.0	0.5	2.5	7.5	2.5	5.5	10.0	4.3
Boulder	9.0	9.5	0	10.0	0	0	0	0	3.6
Gravel	0.5	0.5	9.0	0	1.5	0.5	0.5	0	1.6
Cobble	1.0	10.0	0.5	0	0.5	0	0	0	1.5
Clay	0	0	0	0	0	0	4.0	0	0.5
Average Depth (ft)	19.2	17.4	13.3	17.5	16.2	15.0	15.5	15.5	16.2
Actual Depth Range: 6.5 to 36.9 ft									

	% Substrate per transect downstream of BFN								
Substrate Type	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Avg.**
Silt	75.4	80.5	77.0	56.3	69.5	55.5	44.0	62.5	65.1
Mollusk Shell	22.6	12.5	14.5	32.0	7.0	11.5	26.0	29.0	19.4
Sand	0	0	0.0	9.1	9.0	9.0	17.0	0.0	5.5
Detritus	2.0	6.5	8.0	2.5	0.5	1.0	2.5	4.5	3.4
Bedrock	0	0	0.0	0.0	9.0	0.0	10.0	0.0	2.4
Boulder	0	0	0.0	0.0	0.0	10.0	0.0	0.0	1.3
Cobble	0	0	0.0	0.0	1.0	0.0	0.0	4.0	0.6
Gravel	0	0	1.0	0.0	0.0	0.0	0.5	0.0	0.2
Clay	0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Average Depth (ft)	21.0	20.0	20.2	18.7	18.3	18.9	20.6	20.2	19.7
Actual Depth Range: 9.1 to 31.7 ft									

Table 8. Individual metric scores and the overall RFAI scores upstream (TRM 295.9) and downstream (TRM 292.5) of Browns Ferry Nuclear plant, autumn 2013.

Autumn 2013		TRM 295.9		TRM 292.5	
Metric		**Obs**	**Score**	**Obs**	**Score**
A. Species richness and composition					
1. Number of indigenous species (See Tables 9 and 10)	Combined	**33**	**5**	**27**	**3**
2. Number of centrarchid species (less *Micropterus*)	Combined	**8** Black crappie Bluegill Green sunfish Longear sunfish Orangespotted sunfish Redear sunfish Warmouth White crappie	**5**	**6** Black crappie Bluegill Green sunfish Longear sunfish Redear sunfish Warmouth	**5**
3. Number of benthic invertivore species	Combined	**5** Black redhorse Freshwater drum Logperch Northern hog sucker Spotted sucker	**3**	**4** Black redhorse Freshwater drum Logperch Spotted sucker	**3**
4. Number of intolerant species	Combined	**6** Black redhorse Longear sunfish Northern hog sucker Skipjack herring Smallmouth bass Spotted sucker	**5**	**5** Black redhorse Longear sunfish Skipjack herring Smallmouth bass Spotted sucker	**5**

Table 8. (Continued)

Autumn 2013 Metric		TRM 295.9 Obs		Score	TRM 292.5 Obs		Score
5. Percent tolerant individuals	Electrofishing	**49.5%**		1.5	**39.0%**		1.5
		Bluegill	10.7%		Bluegill	3.3%	
		Common carp	0.9%		Common carp	0.2%	
		Gizzard shad	26.6%		Gizzard shad	17.%	
		Golden shiner	0.9%		Green sunfish	4.7%	
		Green sunfish	1.8%		Largemouth bass	2.1%	
		Largemouth bass	5.3%		Redbreast sunfish	0.1%	
		Longnose gar	0.2%		Spotfin shiner	11.7%	
		Redbreast sunfish	0.2%				
		Spotfin shiner	2.9%				
		White crappie	0.2%				
	Gill Netting	**26.9%**		1.5	**33.3%**		0.5
		Gizzard shad	9.6%		Bluegill	3.9%	
		Largemouth bass	7.7%		Common carp	2.0%	
		Longnose gar	9.6%		Gizzard shad	25.5%	
					Largemouth bass	2.0%	
6. Percent dominance by one species	Electrofishing	**26.6%**		2.5	**35.1%**		1.5
		Gizzard shad			Mississippi silverside		
	Gill Netting	**11.5%**		2.5	**25.5%**		1.5
		Channel catfish			Gizzard shad		
7. Percent non-indigenous species	Electrofishing	**11.2%**		0.5	**35.4%**		0.5
		Common carp	0.9%		Common carp	0.2%	
		Mississippi silverside	10.1%		Mississippi silverside	35.1%	
		Redbreast sunfish	0.2%		Redbreast sunfish	0.1%	
	Gill Netting	**NA**		2.5	**2.0%**		1.5
					Common carp		

Table 8. (Continued)

Autumn 2013 Metric		TRM 295.9 Obs		Score	TRM 292.5 Obs		Score
8. Number of top carnivore species	Combined	**12**		**5**	**8**		**5**
		Black crappie			Black crappie		
		Flathead catfish			Flathead catfish		
		Largemouth bass			Largemouth bass		
		Longnose gar			Sauger		
		Sauger			Skipjack herring		
		Skipjack herring			Smallmouth bass		
		Smallmouth bass			Spotted gar		
		Spotted bass			Yellow bass		
		Spotted gar					
		White bass					
		White crappie					
		Yellow bass					
B. Trophic composition							
9. Percent top carnivores	Electrofishing	**12.1%**		**2.5**	**4.8%**		**0.5**
		Black crappie	0.2%		Largemouth bass	2.1%	
		Flathead catfish	0.2%		Smallmouth bass	2.5%	
		Largemouth bass	5.3%		Yellow bass	0.2%	
		Longnose gar	0.2%				
		Smallmouth bass	1.4%				
		Spotted bass	0.2%				
		Spotted gar	0.8%				
		White bass	2.4%				
		White crappie	0.2%				
		Yellow bass	1.5%				
	Gill Netting	**44.2%**		**2.5**	**49.0%**		**2.5**
		Flathead catfish	1.9%		Black crappie	2.0%	
		Largemouth bass	7.7%		Flathead catfish	7.8%	
		Longnose gar	9.6%		Largemouth bass	2.0%	
		Sauger	7.7%		Sauger	5.9%	
		Skipjack herring	11.5%		Skipjack herring	23.5%	
		Spotted gar	1.9%		Spotted gar	3.9%	
		White bass	3.8%		Yellow bass	3.9%	

Table 8. (Continued)

Autumn 2013 Metric		TRM 295.9 Obs		Score	TRM 292.5 Obs		Score
10. Percent omnivores	Electrofishing	**39.0%**		**1.5**	**22.4%**		**2.5**
		Black buffalo	0.2%		Channel catfish	2.3%	
		Channel catfish	6.2%		Common carp	0.2%	
		Common carp	0.9%		Gizzard shad	17.0%	
		Gizzard shad	26.6%		Smallmouth buffalo	2.9%	
		Golden shiner	0.9%				
		Smallmouth buffalo	4.2%				
	Gill Netting	**42.3%**		**0.5**	**39.2%**		**0.5**
		Black buffalo	3.8%		Black buffalo	2.0%	
		Blue catfish	7.7%		Blue catfish	3.9%	
		Channel catfish	11.5%		Channel catfish	2.0%	
		Gizzard shad	9.6%		Common carp	2.0%	
		Smallmouth buffalo	9.6%		Gizzard shad	25.5%	
					Smallmouth buffalo	3.9%	
C. Fish abundance and health							
11. Average number per run	Electrofishing	**44.1**		**0.5**	**61.2**		**0.5**
	Gill Netting	**5.2**		**0.5**	**5.1**		**0.5**
12. Percent anomalies	Electrofishing	**3.3%**		**1.5**	**1.1%**		**2.5**
	Gill Netting	**0.0%**		**2.5**	**0.0%**		**2.5**
Overall RFAI Score				**46 Good**			**40 Fair**

Table 9. Species collected, ecological and recreational designation and corresponding electrofishing (EF) and gill net (GN) catch per unit effort upstream (TRM 295.9) of Browns Ferry Nuclear Plant discharge – Autumn 2013.

Common Name	Scientific name	Trophic level	Native species	Tolerance	Thermally Sensitive Species	Comm. Valuable Species	Rec. Valuable Species	EF Catch Per Run	EF Catch Per Hr	Total fish EF	GN Catch Per Net Night	Total Fish GN	Total fish Combined	Percent Composition
Longnose gar	*Lepisosteus osseus*	TC	X	TOL	.	X	.	0.07	0.25	1	0.50	5	6	0.8
Gizzard shad	*Dorosoma cepedianum*	OM	X	TOL	.	X	X	11.73	44.67	176	0.50	5	181	25.4
Common carp*	*Cyprinus carpio*	OM	.	TOL	.	X	.	0.40	1.52	6	.	.	6	0.8
Golden shiner	*Notemigonus crysoleucas*	OM	X	TOL	.	X	X	0.40	1.52	6	.	.	6	0.8
Spotfin shiner	*Cyprinella spiloptera*	IN	X	TOL	.	.	.	1.27	4.82	19	.	.	19	2.7
Redbreast sunfish*	*Lepomis auritus*	IN	.	TOL	.	.	X	0.07	0.25	1	.	.	1	0.1
Green sunfish	*Lepomis cyanellus*	IN	X	TOL	.	.	X	0.80	3.05	12	.	.	12	1.7
Bluegill	*Lepomis macrochirus*	IN	X	TOL	.	.	X	4.73	18.02	71	.	.	71	9.9
Largemouth bass	*Micropterus salmoides*	TC	X	TOL	.	.	X	2.33	8.88	35	0.40	4	39	5.5
White crappie	*Pomoxis annularis*	TC	X	TOL	.	.	X	0.07	0.25	1	.	.	1	0.1
Skipjack herring	*Alosa chrysochloris*	TC	X	INT	.	X	.	.	.	.	0.60	6	6	0.8
Northern hog sucker	*Hypentelium nigricans*	BI	X	INT	.	.	.	0.07	0.25	1	.	.	1	0.1
Spotted sucker	*Minytrema melanops*	BI	X	INT	X	X	.	1.13	4.31	17	0.10	1	18	2.5
Black redhorse	*Moxostoma duquesnei*	BI	X	INT	.	X	.	0.07	0.25	1	.	.	1	0.1
Longear sunfish	*Lepomis megalotis*	IN	X	INT	.	.	X	1.13	4.31	17	.	.	17	2.4
Smallmouth bass	*Micropterus dolomieu*	TC	X	INT	.	.	X	0.60	2.28	9	.	.	9	1.3
Spotted gar	*Lepisosteus oculatus*	TC	X	.	.	X	.	0.33	1.27	5	0.10	1	6	0.8
Threadfin shad	*Dorosoma petenense*	PK	X	.	.	X	X	1.53	5.84	23	.	.	23	3.2
Emerald shiner	*Notropis atherinoides*	IN	X	.	X	.	.	0.07	0.25	1	.	.	1	0.1
Bullhead minnow	*Pimephales vigilax*	IN	X	.	.	.	X	0.47	1.78	7	.	.	7	1.0
Smallmouth buffalo	*Ictiobus bubalus*	OM	X	.	.	X	.	1.87	7.11	28	0.50	5	33	4.6
Black buffalo	*Ictiobus niger*	OM	X	.	.	X	.	0.07	0.25	1	0.20	2	3	0.4
Blue catfish	*Ictalurus furcatus*	OM	X	.	.	X	X	.	.	.	0.40	4	4	0.6
Channel catfish	*Ictalurus punctatus*	OM	X	.	.	X	X	2.73	10.41	41	0.60	6	47	6.6
Flathead catfish	*Pylodictis olivaris*	TC	X	.	.	X	X	0.07	0.25	1	0.10	1	2	0.3
White bass	*Morone chrysops*	TC	X	.	.	.	X	1.07	4.06	16	0.20	2	18	2.5
Yellow bass	*Morone mississippiensis*	TC	X	.	.	X	X	0.67	2.54	10	.	.	10	1.4
Warmouth	*Lepomis gulosus*	IN	X	.	.	.	X	0.07	0.25	1	.	.	1	0.1
Orangespotted sunfish	*Lepomis humilis*	IN	X	.	.	.	X	0.20	0.76	3	.	.	3	0.4
Redear sunfish	*Lepomis microlophus*	IN	X	.	.	.	X	1.73	6.60	26	0.40	4	30	4.2

Table 9. (Continued)

Common Name	Scientific name	Trophic level	Native species	Tolerance	Thermally Sensitive Species	Comm. Valuable Species	Rec. Valuable Species	EF Catch Per Run	EF Catch Per Hr	Total fish EF	GN Catch Per Net Night	Total Fish GN	Total fish Combined	Percent Composition
Hybrid sunfish	Hybrid *Lepomis spp.*	IN	X	.	.	.	.	0.20	0.76	3	.	.	3	0.4
Spotted bass	*Micropterus punctulatus*	TC	X	.	.	.	X	0.07	0.25	1	.	.	1	0.1
Black crappie	*Pomoxis nigromaculatus*	TC	X	.	.	.	X	0.07	0.25	1	.	.	1	0.1
Logperch	*Percina caprodes*	BI	X	.	X	.	.	2.33	8.88	35	.	.	35	4.9
Sauger	*Sander canadensis*	TC	X	.	.	.	X	.	.	.	0.40	4	4	0.6
Freshwater drum	*Aplodinotus grunniens*	BI	X	.	.	X	.	1.27	4.82	19	0.20	2	21	2.9
Mississippi silverside*	*Menidia audens*	IN	.	.	.	X	X	4.47	17.01	67	.	.	67	9.4
Total			**34**		**3**	**17**	**23**	**44.16**	**167.97**	**662**	**5.20**	**52**	**714**	**100.0**
Number Samples								**15**			**10**			
Species Collected								**34**			**15**			

Trophic level: benthic invertivore (BI), herbivore (HB), insectivore (IN), omnivore (OM), planktivore (PK), parasitic (PS), specialized insectivore (SP), top carnivore (TC);
Tolerance: tolerant species (TOL), intolerant species (INT);Comm.-Commercially, Rec.-Recreationally.
**Denotes aquatic nuisance species next to common name. All species are considered representative important species. No species collected have a Federal Threatened or Endangered status.*

Table 10. Species collected, ecological and recreational designation and corresponding electrofishing (EF) and gill net (GN) catch per unit effort downstream (TRM 292.5) of Browns Ferry Nuclear Plant discharge – Autumn 2013.

Common Name	Scientific name	Trophic level	Native species	Tolerance	Thermally Sensitive Species	Comm. Valuable Species	Rec. Valuable Species	EF Catch Per Run	EF Catch Per Hr	Total fish EF	GN Catch Per Net Night	Total Fish GN	Total fish Combined	Percent Composition
Gizzard shad	*Dorosoma cepedianum*	OM	X	TOL	.	X	X	10.40	40.10	156	1.30	13	169	17.4
Common carp*	*Cyprinus carpio*	OM	.	TOL	.	X	.	0.13	0.51	2	0.10	1	3	0.3
Spotfin shiner	*Cyprinella spiloptera*	IN	X	TOL	.	.	.	7.13	27.51	107	.	.	107	11.0
Redbreast sunfish*	*Lepomis auritus*	IN	.	TOL	.	.	X	0.07	0.26	1	.	.	1	0.1
Green sunfish	*Lepomis cyanellus*	IN	X	TOL	.	.	X	2.87	11.05	43	.	.	43	4.4
Bluegill	*Lepomis macrochirus*	IN	X	TOL	.	.	X	2.00	7.71	30	0.20	2	32	3.3
Largemouth bass	*Micropterus salmoides*	TC	X	TOL	.	.	X	1.27	4.88	19	0.10	1	20	2.1
Skipjack herring	*Alosa chrysochloris*	TC	X	INT	.	X	.	.	.	.	1.20	12	12	1.2
Spotted sucker	*Minytrema melanops*	BI	X	INT	X	X	.	0.20	0.77	3	.	.	3	0.3
Black redhorse	*Moxostoma duquesnei*	BI	X	INT	.	X	.	0.07	0.26	1	.	.	1	0.1
Longear sunfish	*Lepomis megalotis*	IN	X	INT	.	.	X	4.00	15.42	60	.	.	60	6.2
Smallmouth bass	*Micropterus dolomieu*	TC	X	INT	.	.	X	1.53	5.91	23	.	.	23	2.4
Spotted gar	*Lepisosteus oculatus*	TC	X	.	.	X	.	.	.	.	0.20	2	2	0.2
Threadfin shad	*Dorosoma petenense*	PK	X	.	.	X	X	0.80	3.08	12	.	.	12	1.2
Emerald shiner	*Notropis atherinoides*	IN	X	.	X	.	.	0.20	0.77	3	.	.	3	0.3
Bullhead minnow	*Pimephales vigilax*	IN	X	.	.	.	.	0.33	1.29	5	.	.	5	0.5
Smallmouth buffalo	*Ictiobus bubalus*	OM	X	.	.	X	.	1.80	6.94	27	0.20	2	29	3.0
Black buffalo	*Ictiobus niger*	OM	X	.	.	X	.	.	.	.	0.10	1	1	0.1
Blue catfish	*Ictalurus furcatus*	OM	X	.	.	X	X	.	.	.	0.20	2	2	0.2
Channel catfish	*Ictalurus punctatus*	OM	X	.	.	X	X	1.40	5.40	21	0.10	1	22	2.3
Flathead catfish	*Pylodictis olivaris*	TC	X	.	.	X	X	.	.	.	0.40	4	4	0.4
Yellow bass	*Morone mississippiensis*	TC	X	.	.	X	X	0.13	0.51	2	0.20	2	4	0.4
Warmouth	*Lepomis gulosus*	IN	X	.	.	.	X	0.13	0.51	2	.	.	2	0.2
Redear sunfish	*Lepomis microlophus*	IN	X	.	.	.	X	0.27	1.03	4	.	.	4	0.4

Table 10. (Continued)

Common Name	Scientific name	Trophic level	Native species	Tolerance	Thermally Sensitive Species	Comm. Valuable Species	Rec. Valuable Species	EF Catch Per Run	EF Catch Per Hr	Total fish EF	GN Catch Per Net Night	Total Fish GN	Total fish Combined	Percent Composition
Hybrid sunfish	Hybrid *Lepomis spp.*	IN	X	.	.	.	.	0.13	0.51	2	.	.	2	0.2
Black crappie	*Pomoxis nigromaculatus*	TC	X	.	.	.	X	.	.	.	0.10	1	1	0.1
Stripetail darter	*Etheostoma kennicotti*	SP	X	.	.	.	.	0.07	0.26	1	.	.	1	0.1
Logperch	*Percina caprodes*	BI	X	.	X	.	.	1.87	7.20	28	.	.	28	2.9
Sauger	*Sander canadensis*	TC	X	.	.	.	X	.	.	.	0.30	3	3	0.3
Freshwater drum	*Aplodinotus grunniens*	BI	X	.	.	X	.	2.93	11.31	44	0.40	4	48	5.0
Mississippi silverside*	*Menidia audens*	IN	.	.	.	X	X	21.47	82.78	322	.	.	322	33.2
Total			**28**		**3**	**15**	**17**	**61.20**	**235.97**	**918**	**5.10**	**51**	**969**	**100**
Number Samples								**15**			**10**			
Species Collected								**24**			**15**			

Trophic level: benthic invertivore (BI), herbivore (HB), insectivore (IN), omnivore (OM), planktivore (PK), parasitic (PS), specialized insectivore (SP), top carnivore (TC);
Tolerance: tolerant species (TOL), intolerant species (INT);Comm.-Commercially, Rec.-Recreationally.
**Denotes aquatic nuisance species next to common name. All species are considered representative important species. No species collected have a Federal Threatened or Endangered status.*

Table 11. Spatial statistical comparisons of numbers of species, mean electrofishing catch per unit effort values (number/run), tolerance designations, trophic levels, and non-indigenous individuals, including species richness and Simpson and Shannon diversity values, for samples collected near Browns Ferry Nuclear Plant, autumn 2013.

	Mean (Standard Deviation)				
Parameter	**Upstream (TRM 295.9)**	**Downstream (TRM 292.5)**	**Significant Difference**	**Test Statistic**	**P Value**
Number of species (per run)					
Total (Species richness)	11.1 (3.9)	10.3 (2.1)	No	Z= -1.01	0.31
Benthic invertivores	1.5 (1.0)	1.5 (0.6)	No	Z= 0.52	0.60
Insectivores	3.9 (1.8)	4.8 (1.6)	No	t= 1.49	0.15
Omnivores	2.9 (1.2)	2.1 (1.1)	No	t= -1.97	0.06
Top carnivores	2.6 (1.4)	1.5 (0.6)	Yes	Z= -2.26	0.02
Non-indigenous	1.1 (0.7)	0.9 (0.7)	No	Z= -0.75	0.46
Tolerant	3.7 (1.5)	4.1 (1.2)	No	Z= 0.65	0.52
Intolerant	1.2 (0.9)	1.6 (0.5)	No	Z= 1.22	0.22
Thermally sensitive	0.9 (0.7)	0.9 (0.5)	No	Z= -0.22	0.83
CPUE (per run)					
Total	2.9 (1.7)	4.1 (2.8)	No	Z= 0.79	0.43
Benthic invertivores	0.2 (0.2)	0.1 (0.1)	No	Z= 0.52	0.60
Insectivores	1.0 (0.8)	2.6 (2.4)	No	Z= 1.42	0.16
Omnivores	1.1 (1.1)	0.9 (0.7)	No	Z= -0.19	0.85
Top Carnivores	0.4 (0.2)	0.2 (0.1)	Yes	Z= -2.12	0.03
Non-indigenous	0.3 (0.4)	1.4 (1.8)	No	Z= 1.11	0.27
Tolerant	1.5 (1.1)	1.6 (1.1)	No	Z= 0.60	0.55
Intolerant	0.2 (0.4)	0.4 (0.3)	Yes	Z= 2.70	0.01
Thermally sensitive	0.2 (0.3)	0.2 (0.1)	No	Z= -0.11	0.92
Diversity indices (per run)					
Simpson	0.8 (0.1)	0.8 (0.1)	No	Z= -1.12	0.26
Shannon	8.1 (5.2)	7.4 (6.0)	No	t= -0.46	0.65

Table 12. Summary of autumn RFAI scores from sites located directly upstream and downstream of BFN and scores from sampling conducted during 1993-2013* as part of the Vital Signs monitoring program in Wheeler Reservoir.

Site	Location	1993	1994	1995	1997	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2013	1993-2011 Avg.
Inflow	TRM 348.0	46	48	42	48	36	-	38	42	38	44	44	42	38	38	40	40	46	40	**42**
Transition BFN Upstream	TRM 295.9	45	45	34	40	30	41	37	43	39	43	46	41	39	42	39	44	42	46	**41**
Transition BFN Downstream	TRM 292.5	-	-	-	-	-	43	40	41	43	43	36	42	42	45	36	38	38	40	**41**
Forebay	TRM 277.0	52	44	48	45	42	-	41	45	44	43	45	46	49	46	47	40	46	43	**45**
Elk River Embayment	ERM 6.0	43	47	36	49	36	-	49	-	44	49	47	-	39	-	42	-	43	39	**44**

*No data were collected at BFN (TRMs 295.9 and 292.5) during 1996, 1998, or 2012.*Some scores have changed when compared to previous reports. Redbreast sunfish was changed to non-indigenous which may have affected scores for metrics 1 and 7.*

RFAI Scores: 12-21 ("Very Poor"), 22-31 ("Poor"), 32-40 ("Fair"), 41-50 ("Good"), or 51-60 ("Excellent")

Table 13. Comparison of RBI metric ratings and total scores for laboratory-processed samples collected upstream and downstream of Browns Ferry Nuclear Plant, Wheeler Reservoir, autumn 2013.

	Downstream TRM 290.4		Downstream TRM 293.2		Upstream TRM 295.9	
Metric	**Obs**	**Rating**	**Obs**	**Rating**	**Obs**	**Rating**
1. Average number of taxa	7.8	5	10.6	5	11	5
2. Proportion of samples with long-lived organisms	1.0	5	1.0	5	1.0	5
3. Average number of EPT taxa	1.2	3	1.8	5	1.7	5
4. Average proportion of oligochaete individuals	2.7	5	8.3	5	3.6	5
5. Average proportion of total abundance comprised by the two most abundant taxa	81.1	3	66.7	5	67.3	5
6. Average density excluding chironomids and oligochaetes	1,161.7	5	1,228.3	5	1,111.7	5
7. Zero-samples – proportion of samples containing no organisms	0	5	0	5	0	5
Benthic Index Score		**31**		**35**		**35**
Ecological Health Rating		**Excellent**		**Excellent**		**Excellent**

Reservoir Benthic Index Scores: 7-12 ("Very Poor"), 13-18 ("Poor"), 19-23 ("Fair"), 24-29 ("Good"), 30-35 ("Excellent")

Table 14. Metric scores and overall RBI scores determined from field processing criteria, for sites upstream and downstream of Browns Ferry Nuclear Plant, Wheeler Reservoir, autumn 2000-2010.

Downstream – TRM 291.7

	Avg No. Taxa		% Long-Lived		Avg. No. EPT taxa		% Oligochaetes		% Dominant Taxa		Density excl chiro and oligo		Zero Samples		Overall Score
Sample Year	Obs	Score	Obs	Score	Obs	Score	Obs	Score	Obs	Score	Obs	Score	Obs	Score	
2000	4	3	1	5	0.8	5	6.4	5	79.6	3	125	1	0	5	**27**
2001	5.6	5	1	5	1.1	5	5.7	5	43	5	230	1	0	5	**31**
2002	5.7	5	1	5	0.8	5	7.4	5	88.1	1	120	1	0	5	**27**
2003	6.5	5	1	5	1	5	0.3	5	76.1	5	1270	5	0	5	**35**
2004	6.7	5	1	5	1	5	1.4	5	74.4	5	523.3	3	0	5	**33**
2005	5.5	5	1	5	0.8	5	3.6	5	80.3	3	508.3	3	0	5	**31**
2006	6.2	5	1	5	0.1	5	2.3	5	77.3	5	272.3	1	0	5	**31**
2007	6.4	5	1	5	0.8	5	12.4	5	80.2	3	166.7	1	0	5	**29**
2008	6.3	5	0.9	5	1.1	5	7.2	5	81.5	3	181.7	1	0	5	**29**
2009	5	5	0.7	3	0.6	3	4.6	5	90.3	1	83.3	1	0	5	**23**
2010	4.6	5	0.7	3	0.6	3	0.3	5	94.8	1	126.7	1	0	5	**23**
Mean:	5.7		0.9		0.8		4.7		78.7		327.9		0.0		**29**
Maximum:	6.7		1		1.1		12.4		94.8		1270		0		
Minimum:	4		0.7		0.1		0.3		43		83.3		0		

Table 14. (Continued)

Upstream – TRM 295.9

Sample Year	Avg No. Taxa Obs	Avg No. Taxa Score	% Long-Lived Obs	% Long-Lived Score	Avg. No. EPT taxa Obs	Avg. No. EPT taxa Score	% Oligochaetes Obs	% Oligochaetes Score	% Dominant Taxa Obs	% Dominant Taxa Score	Density excl chiro and oligo Obs	Density excl chiro and oligo Score	Zero Samples Obs	Zero Samples Score	**Overall Score**
2000	4.6	5	1	5	0.8	5	6.6	5	77.6	5	190	1	0	5	**31**
2001	5.3	5	1	5	1	5	2.7	5	79.8	3	188.3	1	0	5	**29**
2002	6.5	5	1	5	0.8	5	7.2	5	75.6	5	266.7	1	0	5	**31**
2003	5.1	5	0.8	5	1	5	0.8	5	84.1	3	456.7	3	0	5	**31**
2004	6.2	5	1	5	0.9	5	1.1	5	73.7	5	353.6	3	0	5	**33**
2005	5.6	5	1	5	1.2	5	2.3	5	85.4	3	490	3	0	5	**31**
2006	5.9	5	0.8	5	0.7	3	7	5	75	5	348.3	3	0	5	**31**
2007	6.5	5	0.9	5	0.9	5	1.9	5	74.2	5	353.3	3	0	5	**33**
2008	5.8	5	0.7	3	0.5	3	7.8	5	85.4	3	220	1	0	5	**25**
2009	5.1	5	1	5	0.4	3	12.2	5	75.2	5	133.3	1	0	5	**29**
2010	4.2	3	1	5	0.8	5	2.1	5	92	1	108.3	1	0	5	**25**
Mean:	5.5		0.9		0.8		4.7		79.8		282.6		0		**30**
Maximum:	6.5		1		1.2		12.2		92		490		0		
Minimum:	4.2		0.7		0.4		0.8		73.7		108.3		0		

Table 15. Metric scores and overall RBI scores determined from lab processing criteria, for sites upstream and downstream of Browns Ferry Nuclear Plant, Wheeler Reservoir, 2001-2006.

Downstream – TRM 291.7

	Avg No. Taxa		% Long-Lived		Avg. No. EPT taxa		% Oligochaetes		% Dominant Taxa		Density excl chiro and oligo		Zero Samples		Overall Score
Sample Year	Obs	Score	Obs	Score	Obs	Score	Obs	Score	Obs	Score	Obs	Score	Obs	Score	
2001	7.8	5	1	5	1.1	3	7.6	5	71.7	5	315	3	0	5	**31**
2002	5.4	3	1	5	0.9	3	10.9	5	88.2	1	106.7	1	0	5	**23**
2003	7.3	5	1	5	1	3	0.4	5	73.2	5	1270	5	0	5	**33**
2004	7.9	5	1	5	1	3	1.6	5	73.5	5	551.7	3	0	5	**31**
2006	9.4	5	1	5	1.6	5	2.3	5	78.1	3	448.2	3	0	5	**31**
Mean:	7.56		1		1.12		4.56		76.94		538.32		0		**30**
Maximum:	9.4		1		1.6		10.9		88.2		1270		0		
Minimum:	5.4		1		0.9		0.4		71.7		106.7		0		

Upstream – TRM 295.9

	Avg No. Taxa		% Long-Lived		Avg. No. EPT taxa		% Oligochaetes		% Dominant Taxa		Density excl chiro and oligo		Zero Samples		Overall Score
Sample Year	Obs	Score	Obs	Score	Obs	Score	Obs	Score	Obs	Score	Obs	Score	Obs	Score	
2001	7.4	5	1	5	1	3	6.9	5	75.6	5	281.7	1	0	5	**29**
2002	6.8	5	1	5	1.1	3	5	5	74.1	5	281.7	1	0	5	**29**
2003	6.3	3	1	5	0.9	3	0.6	5	82.2	3	583.3	3	0	5	**27**
2004	6.2	3	1	5	0.8	3	1.1	5	72.2	5	336.2	3	0	5	**29**
2006	9.2	5	0.8	3	1.2	3	5.1	5	78.6	3	1273.3	5	0	5	**29**
2011	8.4	5	0.7	3	1	3	6.3	5	81.1	3	430	3	0	5	**27**
Mean:	7.4		0.9		1.0		4.2		77.3		531.0		0		**28**
Maximum:	9.2		1		1.2		6.9		82.2		1273.3		0		
Minimum:	6.2		0.7		0.8		0.6		72.2		281.7		0		

Table 16a. Mean density per square meter of benthic taxa collected upstream and downstream of Browns Ferry Nuclear Plant, autumn 2013. All taxa listed contributed to individual RBI metrics and total scores.

Taxa	BFN Downstream TRM 290.4	BFN Downstream TRM 293.2	BFN Upstream TRM 295.9
ANNELIDA			
Hirudinea			
Rhynchobdellida			
Glossiphoniidae			
Actinobdella sp.	---	2	---
Actinobdella inequiannulata	2	---	---
Helobdella elongata	---	---	2
Helobdella stagnalis	7	8	8
Oligochaeta			
Haplotaxida			
Naididae	---	---	2
Tubificinae	30	78	20
Branchiura sowerbyi	3	7	5
Limnodrilus hoffmeisteri	5	7	18
ARTHROPODA			
Crustacea			
Malacostraca			
Amphipoda			
Corophiidae			
Apocorophium lacustre	167	38	282
Gammaridae			
Gammarus sp.	---	2	5
Hexapoda			
Insecta			
Coleoptera			
Elmidae			
Dubiraphia sp.	---	2	---
Diptera			
Ceratopogonidae	2	---	---
Chironomidae			
Orthocladiinae			
Chironominae	---	---	2
Axarus sp.	5	32	45
Chironomus sp.	43	28	70
Cryptochironomus sp.	---	7	5

Table 16a. (Continued).

Taxa	BFN Downstream TRM 290.4	BFN Downstream TRM 293.2	BFN Upstream TRM 295.9
Dicrotendipes neomodestus	---	---	7
Glyptotendipes sp.	---	---	3
Harnischia sp.	---	---	2
Microchironomus sp.	---	2	---
Polypedilum halterale gp.	---	3	2
Stempellina sp.	---	2	---
Xenochironomus xenolabis	---	---	5
Epoicocladius flavens	2	---	---
Thienemanniella lobapodema	---	2	---
Tanypodinae			
Ablabesmyia annulata	33	13	32
Ablabesmyia mallochi	---	---	2
Coelotanypus sp.	97	263	145
Paramerina sp.	---	30	---
Procladius sp.	---	2	7
Ephemeroptera			
Ephemeridae			
Hexagenia sp. <10mm	262	230	163
Hexagenia sp. >10mm	262	213	100
Trichoptera			
Leptoceridae	---	2	---
Oecetis sp.	2	37	28
Polycentropodidae			
Cyrnellus fraternus	18	---	32
MOLLUSCA			
Gastropoda			
Architaenioglossa			
Viviparidae			
Campeloma decisum	---	2	2
Lioplax sulculosa	---	3	3
Viviparus sp.	5	3	12
Neotaenioglossa			
Hydrobiidae			
Amnicola limosa	5	113	53
Somatogyrus sp.	---	3	2
Pleuroceridae			
Pleurocera canaliculata	---	---	3

Table 16a. (Continued).

Taxa	BFN Downstream TRM 290.4	BFN Downstream TRM 293.2	BFN Upstream TRM 295.9
Bivalvia			
Veneroida			
Corbiculidae			
Corbicula fluminea <10mm	263	312	278
Corbicula fluminea >10mm	---	3	40
Sphaeriidae			
Eupera cubensis	5	---	---
Musculium transversum	158	233	85
Pisidium compressum	2	---	---
Unionidae			
Truncilla donaciformis	---	---	3
Utterbackia imbecillis	---	---	2
NEMATODA	---	22	3
PLATYHELMINTHES			
Turbellaria			
Tricladida			
Planariidae			
Dugesia tigrina	3	2	5
Number of samples	**10**	**10**	**10**
Mean-Density per meter^2	**1,380**	**1,703**	**1,482**
Taxa Richness	**21**	**29**	**34**
Sum of area sampled (meter^2)	**0.6**	**0.6**	**0.6**

Table 16b. Mean density per square meter of benthic taxa collected but not included in individual RBI metrics or total scores for sites upstream and downstream of BFN, autumn 2013.

Taxa	BFN Downstream TRM 290.4	BFN Downstream TRM 293.2	BFN Upstream TRM 295.9
ARTHROPODA			
Crustacea			
Branchiopoda			
Cladocera			
Sididae			
Diaphanosoma sp.	---	---	7
Sida crystallina	---	---	5
Maxillopoda			
Cyclopoida			
Cyclopidae			
Macrocyclops albidus	5	5	---
Mesocyclops edax	---	7	2
Ostracoda			
Candoniidae			
Candona sp.	20	27	3
Hexapoda			
Insecta			
Diptera			
Chaoboridae			
Chaoborus punctipennis	5	10	---
Chelicerata			
Arachnida			
Acariformes			
Arrenuridae			
Arrenurus sp.	---	3	---
Unionicolidae			
Unionicola sp.	2	2	3
CNIDARIA			
Medusozoa			
Hydrozoa			
Hydridae			
Hydra sp.	8	3	5
Number of samples	**10**	**10**	**10**
Mean-Density per meter²	**40**	**57**	**25**
Taxa Richness	**5**	**8**	**6**
Sum of area sampled (meter²)	**0.6**	**0.6**	**0.6**

Table 17. RBI scores from sites directly upstream and downstream of Browns Ferry Nuclear Plant and from sites sampled as part of the Vital Signs monitoring program on Wheeler Reservoir. LTA-Long term average.

Site	Location	1994	1995	1997	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Autumn LTA	2013
Inflow	*TRM 347	31	21	25	23	---	21	25	31	31	31	33	33	---	31	---	27	**28**	31
BFN Upstream (Transition)	TRM 295.9	33	25	31	31	31	29	31	31	33	31	31	33	25	29	25	27	**30**	35
BFN Downstream (Transition)	TRM 291.7	---	---	---	---	27	31	27	35	33	31	31	29	29	23	23	---	**29**	---
BFN Downstream (Transition)	TRM 293.2	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	23	**23**	35
BFN Downstream (Transition)	TRM 290.4	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	21	**21**	31
Forebay	*TRM 277	19	15	23	17	---	17	15	15	19	15	13	13	15	13	---	13	**13**	17
Embayment	*ERM 6	15	13	15	15	---	15	---	15	---	17	---	13	---	13	---	13	**13**	13

Reservoir Benthic Index Scores: 7-12 ("Very Poor"), 13-18 ("Poor"), 19-23 ("Fair"), 24-29 ("Good"), 30-35 ("Excellent")

*** = sites with field-processed scores all years. All other sites, 1994 – 2010 are field-processed scores and 2011 forward are lab-processed scores.**

Table 18. Wildlife observed along 2100 m transects parallel to the Tennessee River shoreline, upstream and downstream of Browns Ferry Nuclear Plant, October 2013.

Survey Site		Birds	Obs.	Reptile/Amphibian	Obs.	Mammals	Obs.
TRM 295.9 (US)	RDB	Blue Jay	5	Map Turtle	37	Eastern Grey Squirrel	2
		Great Blue Heron	6				
		Carolina Chickadee	1				
		Belted Kingfisher	4				
		American Crow	1				
		American Robin	1				
		Unidentified Songbird	1				
		Double-crested Cormorant	2				
		Brown Thrasher	1				
		Mockingbird	1				
		Mallard	2				
	LDB	Ring-billed Gull	1	Map Turtle	26		
		Common Snipe	1				
		Turkey Vulture	2				
		Unidentified Songbird	8				
		Great Blue Heron	2				
		Mallard	12				
		Belted Kingfisher	1				
		Pileated Woodpecker	1				
		Killdeer	2				
TRM 292.5 (DS)	RDB	Blue Jay	5	Map Turtle	2		
		American Robin	2				
		Downy Woodpecker	2				
		American Crow	1				
		Belted Kingfisher	3				
		Turkey Vulture	2				
		American Coot	4				
		Great Blue Heron	2				
		Nuthatch	1				
		Mallard	2				
		European Starling	10				
		Unidentified Songbird	2				
	LDB	Belted Kingfisher	2	Map Turtle	69		
		Great Blue Heron	4				
		Pied-billed Grebe	2				
		Least Flycatcher	1				
		Unidentified Songbird	3				
		Blue Jay	1				
		Mockingbird	2				

RDB – right descending bank; LDB – left descending bank

Table 19. Water temperature (°F) depth profiles collected to determine the extent of the thermal plume from BFN during 2013.

October 2013	Transect and Profile Location (width from right descending bank)																								
	Ambient-TRM 294.4					BFN Discharge-TRM 294.0					Below Discharge-TRM 293.8					Mid-plume TRM 291.8					End of Plume-TRM 289.9				
Depth (m)	10%	30%	50%	70%	90%	10%	30%	50%	70%	90%	10%	30%	50%	70%	90%	10%	30%	50%	70%	90%	10%	30%	50%	70%	90 %
0.3	74.9	74.1	74.2	74.1	73.8	83.9	82.0	74.0	74.7	74.8	80.2	79.9	79.9	74.0	74.9	77.5	76.6	75.4	75.6	76.4	77.0	76.6	76.5	76.7	76.8
1.5	74.8	74.1	74.2	74.1	73.7	83.2	79.5	74.1	74.7	74.8	81.9	79.8	79.8	74.0	74.8	77.5	76.6	75.4	75.5	76.4	76.8	76.5	76.4	76.7	76.7
2													77.8												
3	74.8	74.1	74.2	74.0		74.6	76.3	74.1	74.7		80.8	79.6		74.0		77.5	76.6	75.4	75.5	76.3	76.7	76.5	76.3	76.6	76.3
4																						76.5			
5		74.1	74.2			74.5					80.2	79.3						75.4					76.2		
6						74.5												75.3							
7		74.1	73.6									78.7													
9		74.1										76.3													

Shaded numbers represent temperatures 3.6°F (2°C) or greater above ambient temperature.

Table 20. Water quality parameters collected along vertical depth profiles at three transects within the RFAI sample areas upstream and downstream of BFN during 2013.

October, 2013	LDB						Mid-channel						RDB					
TRM 295.9	**Depth**	**°C**	**°F**	**pH**	**Cond**	**DO**	**Depth**	**°C**	**°F**	**pH**	**Cond**	**DO**	**Depth**	**°C**	**°F**	**pH**	**Cond**	**DO**
Upstream	0.3	22.84	73.11	7.38	173.6	6.92	0.3	22.50	72.50	7.52	167.1	7.89	0.3	22.72	72.90	7.78	162.6	7.98
Boundary	1.5	22.85	73.13	7.38	173.3	6.92	1.5	22.49	72.48	7.50	166.7	7.86	1.5	22.72	72.90	7.76	162.6	7.97
	2.5	22.77	72.99	7.38	173.3	6.89	3	22.50	72.50	7.48	166.4	7.85	3	22.61	72.70	7.73	161.9	7.83
Mid-site	0.3	22.45	72.41	7.79	177.7	7.60	0.3	22.94	73.29	7.40	167.0	6.87	0.3	22.94	73.29	7.82	162.3	7.69
	1.5	22.47	72.45	7.79	178.1	7.59	1.5	22.89	73.20	7.39	167.2	6.92	1.5	22.92	73.26	7.81	162.2	7.71
													3	22.91	73.24	7.79	162.5	7.66
Downstream	0.3	22.15	71.87	7.52	170.4	7.15	0.3	25.77	78.39	7.61	165.7	7.44	0.3	25.16	77.29	7.70	164.4	7.60
Boundary							1.5	23.49	74.28	7.46	166.5	7.07	1.5	23.44	74.19	7.76	162.5	7.64
							3	23.14	73.65	7.45	166.7	7.03	3	23.04	73.47	7.80	162.1	7.76
							5	23.05	73.49	7.43	167.6	6.99						
							7	22.97	73.35	7.41	168.0	6.97						
TRM 292.5	**Depth**	**°C**	**°F**	**pH**	**Cond**	**DO**	**Depth**	**°C**	**°F**	**pH**	**Cond**	**DO**	**Depth**	**°C**	**°F**	**pH**	**Cond**	**DO**
Upstream	0.3	23.77	74.79	7.79	171.9	7.83	0.3	23.38	74.08	7.46	169.1	6.98	0.3	28.85	83.93	7.82	166.4	7.82
Boundary	1	23.76	74.77	7.75	171.9	7.82	1.5	23.38	74.08	7.47	168.4	6.95	1.5	28.46	83.23	7.80	166.1	7.74
							3	23.34	74.01	7.40	168.0	6.83	3	23.66	74.59	7.89	164.0	8.12
													5	23.6	74.48	7.82	164.5	8.00
													6	23.6	74.48	7.83	164.6	8.02
Mid-site	0.3	24.66	76.39	7.60	167.1	7.17	0.3	24.12	75.42	7.62	167.8	7.63	0.3	25.27	77.49	7.90	164.7	8.02
	1.5	24.65	76.37	7.61	166.8	7.19	1.5	24.10	75.38	7.62	167.7	7.34	1.5	25.27	77.49	7.91	165.0	8.03
	3	24.59	76.26	7.64	166.7	7.20	3	24.10	75.38	7.62	167.3	7.33	3	25.27	77.49	7.88	165	7.99
							5	24.10	75.38	7.62	168.0	7.36						
							6	24.07	75.33	7.62	169.0	7.35						
Downstream	0.3	24.90	76.82	7.72	166.2	7.59	0.3	24.74	76.53	7.70	164.3	7.66	0.3	24.98	76.96	7.81	165.2	7.80
Boundary	1.5	24.85	76.73	7.59	165.5	6.92	1.5	24.69	76.44	7.69	164.3	7.63	1.5	24.91	76.84	7.80	165.4	7.80
	3	24.62	76.32	7.52	165.7	6.54	3	24.63	76.33	7.66	164.7	7.56	3	24.85	76.73	7.82	165.2	7.87
							5	24.53	76.15	7.62	163.8	7.37						

Abbreviations: °C –Temperature in degrees Celsius, °F – Temperature in degrees Fahrenheit, Cond – Conductivity, DO – Dissolved Oxygen

ATTACHMENT 11

Reference TVA. 2014.
Biological Monitoring of the Tennessee River
Near Browns Ferry Nuclear Plant Discharge, Autumn 2013. Knoxville,
Tennessee: River and Reservoir Compliance Monitoring Program.

Biological Monitoring of the Tennessee River Near Browns Ferry Nuclear Plant Discharge Autumn 2013

December 2014

Tennessee Valley Authority
River and Reservoir Compliance Monitoring Program
Knoxville, Tennessee

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Acronyms and Abbreviations

ATL	Alternate Thermal Limit
BIP	Balanced Indigenous Community
BFN	Browns Ferry Nuclear Power Plant
CCW	Condenser Cooling Water
CWA	Clean Water Act
LDB	Left Descending Bank
NPDES	National Pollutant Discharge Elimination System
QA	Quality Assurance
RBI	Reservoir Benthic Macroinvertebrate Index
RDB	Right Descending Bank
RFAI	Reservoir Fish Assemblage Index
RIS	Representative Important Species
SAHI	Shoreline Assessment Habitat Index
TRM	Tennessee River Mile
TVA	Tennessee Valley Authority
VS	Vital Signs

Executive Summary

In 2013, samples of the ecological community upstream and downstream of Brown's Ferry Nuclear Plant were collected, analyzed, and compared to historical data to determine the effects, if any, of the thermal effluent from the plant, in compliance with §316(a) of the Clean Water Act.

Shoreline aquatic habitat assessed along both banks was rated "Fair". Assessment of river bottom habitat indicated that three dominant substrates observed at both sites were silt, mollusk shell, and sand.

The fish communities upstream and downstream of BFN, analyzed using RFAI methodology, both showed fair diversity of species and moderate percentages of pollution tolerant individuals. The downstream community supported lower diversity of top carnivore species, but otherwise, was generally similar to that upstream and was not adversely affected by thermal effluent from BFN. Benthic communities for both downstream sites, at TRM 293.2 within the thermal plume from BFN discharge, and at TRM 290.4 downstream of the thermal plume, were considered similar to the upstream benthic community. All three sites received RBI ratings of "Excellent".

A visual wildlife survey was conducted to assess bird, reptile, and mammal populations around BFN. Turtles and a variety of birds were encountered at both locations.

Water quality analysis indicated that daily mean flow past BFN was noticeably higher in 2013 than historic values, but that daily mean temperatures were similar upstream and downstream of the plant. Depth profiles of water temperature, conductivity, dissolved oxygen concentration, and acidity (pH) indicated that values of all these parameters were within acceptable levels both upstream and downstream of BFN.

Introduction

Section 316(a) of the Clean Water Act (CWA) authorizes alternate thermal limits (ATL) for the control of the thermal component of a point source discharge so long as the limits will assure the protection of Balanced Indigenous Populations (BIP) of aquatic life. The term "balanced indigenous population," as defined by Environmental Protection Agency regulations, describes a biotic community that is typically characterized by:

(1) diversity appropriate to the ecoregion;

(2) the capacity to sustain itself through cyclic seasonal changes;

(3) the presence of necessary food chain species; and

(4) the lack of domination by pollution-tolerant species.

Prior to 2000, the Tennessee Valley Authority's (TVA) Browns Ferry Nuclear Plant (BFN) was operating under an ATL that had been continued with each permit renewal based on studies conducted in the mid-1970s. In 1999, EPA Region IV began requesting additional data in conjunction with National Pollutant Discharge Elimination System (NPDES) permit renewal applications to verify that BIP was being maintained at TVA's thermal plants with ATLs. TVA proposed that its existing Vital Signs (VS) monitoring program, supplemented with additional fish and benthic macroinvertebrate community monitoring upstream and downstream of thermal plants with ATLs, was appropriate for that purpose. The VS monitoring program began in 1990 in the Tennessee River System. This program was implemented to evaluate ecological health conditions in major reservoirs as part of TVA's stewardship role. One of the 5 indicators used in the VS program to evaluate reservoir health is the Reservoir Fish Assemblage Index (RFAI) methodology which incorporates fish species richness and composition, trophic composition, and fish abundance and health. RFAI has been thoroughly tested on TVA and other reservoirs and published in peer-reviewed literature (Jennings, et al., 1995; Hickman and McDonough, 1996; McDonough and Hickman, 1999). Fish communities are used to evaluate ecological conditions because of their importance in the aquatic food web and because fish life cycles are long enough to integrate conditions over time. Benthic macroinvertebrate populations are assessed using the Reservoir Benthic Index (RBI) methodology. Because benthic macroinvertebrates are relatively

immobile, negative impacts to aquatic ecosystems can be detected earlier in benthic macroinvertebrate communities than in fish communities. These data are used to supplement RFAI results to provide a more thorough examination of differences in aquatic communities upstream and downstream of thermal discharges.

During 2000-2010, TVA initiated a study to evaluate fish and benthic macroinvertebrate communities in areas immediately upstream and downstream of BFN using RFAI and RBI multi-metric evaluation techniques. The study was continued in 2011 and broadened to include additional data for analyses requested by the EPA. Reported here are the results of biological monitoring and water quality data collected upstream and downstream of BFN during 2013, with appropriate comparisons to data collected at these sites during previous autumn samples.

Plant Description

BFN is a three-unit nuclear-fueled facility with a total generating capacity of 3,300 megawatts. Unit One, which remained idle for several years, returned to service June 2007. BFN is located on Wheeler Reservoir, approximately 18 miles upstream of Wheeler Dam at Tennessee River Mile (TRM) 294 in Limestone County, Alabama (Figure 1). Current operation utilizes a once-through condenser cooling water (CCW) system, withdrawing water from the Tennessee River through an intake structure at TRM 294.3 and discharging the water through a multi-port diffuser located downstream from the plant at TRM 293.6 (Figure 2). Maximum flow rate of the CCW is approximately 3,468 million gallons per day.

Methods

Fish and Benthic Macroinvertebrate Sample Locations Upstream and Downstream of BFN

Thermal discharge from BFN enters the Tennessee River at TRM 293.6 in Wheeler Reservoir (Figure 2). The fish community was sampled at two sites to evaluate similarities and differences in the fish community in the vicinity of BFN. One site was centered at TRM 295.9, upstream of the plant's intake (Figure 3), and served as a reference site unaffected by the thermal discharge.

The second site was centered at TRM 292.5, downstream of the cooling water discharge (Figure 4).

From 2000 to 2010, to assess the benthic macroinvertebrate community in the vicinity of BFN data was collected along transects established across the full width of Wheeler reservoir at two sites in the transition zone, one at TRM 295.9, upstream of the intake, and one at TRM 291.7, downstream of the BFN discharge. Prior to this time, a sampling site in the forebay zone of Wheeler Reservoir (TRM 277) was used as the downstream comparison site. Because other factors, unrelated to influence from BFN, kept benthic communities depressed, both at the forebay site and in the Elk River embayment (Wheeler Reservoir, Elk River Mile [ERM] 6 – between BFN and the forebay site), the downstream site was moved into the transition zone two miles downstream from the BFN diffuser at TRM 291.7 in 2000. Benthic scores and community composition from this site were used through 2010 for downstream comparisons to the upstream benthic site at TRM 295.9.

Beginning in 2011, samples were collected in the reservoir's transition zone along transects established at three sites. One site, upstream of the plant intake, was maintained at TRM 295.9 (Figure 3). Two sites were selected downstream to more accurately assess possible effects of BFN discharge on the downstream benthic communities: one at TRM 293.2, within the thermal plume from the BFN discharge, and a second at TRM 290.4 downstream of the thermal plume (Figure 4).

Aquatic Habitat in the Vicinity of BFN

Shoreline and river bottom habitat data presented in this report were collected during autumn 2009. TVA assumes habitat data to be valid for five years, barring any major changes to the river/reservoir (e.g. major flood event). No significant changes have occurred in the river system from the initial characterization, but in the event of a major change to the river/reservoir, habitat would be re-evaluated during the following sample period.

Shoreline Aquatic Habitat Assessment

An integrative multi-metric index (Shoreline Aquatic Habitat Index or SAHI), including several habitat parameters important to resident fish species, was used to measure existing fish habitat quality in the vicinity of BFN. Using the general format developed by Plafkin et al. (1989), seven metrics were established to characterize selected physical habitat attributes important to reservoir resident fish populations which rely heavily on the littoral (shoreline) zone for reproductive success, juvenile development, and adult feeding (Table 1). Habitat Suitability Indices (US Fish and Wildlife Service), along with other sources of information on biology and habitat requirements (Etnier and Starnes 1993), were consulted to develop "reference" criteria or "expected" conditions from a high quality environment for each parameter. Some generalizations were necessary in setting up scoring criteria to cover the various requirements of all species within a single index.

When possible, the quality of shoreline aquatic habitat was assessed while traveling parallel to the shoreline in a boat and evaluating the habitat within 10 vertical feet of full pool. Transects were established across the width of Wheeler reservoir within the fish community sampling reaches upstream and downstream of BFN (Figure 5). At each transect, near-shore aquatic habitat was assessed along sections of shoreline corresponding to the left descending bank (LDB) and right descending bank (RDB). For each shoreline section (16 upstream and 16 downstream of BFN), percentages of aquatic macrophytes in the littoral areas were estimated, then each section was scored by comparing the observed conditions associated with each individual metric to the "reference" conditions and assigning the metric a corresponding value: "Good" 5; "Fair" 3; or "Poor" 1 (Table 1). These scores for each of the seven metrics were summed to obtain the SAHI value for the shoreline section, and this value was assigned a habitat quality descriptor based on trisecting the range of potential SAHI values ("Poor" 7-16, "Fair" 17-26, and "Good" 27-35).

River Bottom Habitat

Along each transect described above, 10 benthic grab samples were collected with a Ponar sampler at points equally spaced from the LDB to the RDB. Substrate material collected with the Ponar was emptied into a screen, and percent composition of each substrate was estimated to

determine existing benthic habitat across the width of the river. Water depths (feet) at each sample location were recorded. If no substrate was collected after multiple Ponar drops, it was assumed that the substrate was bedrock. For example, when the Ponar sampler was pulled shut, collectors could feel substrate consistency. If it shut easily and was not embedded in the substrate on numerous drops within the same location, the substrate was recorded as bedrock.

Fish Community Sampling Methods and Data Analysis for Sites Upstream and Downstream of BFN

Fish sampling methods included boat electrofishing and gill netting (Hubert 1996; Reynolds 1996). Electrofishing methodology consisted of fifteen boat electrofishing runs near the shoreline, each 300 meters long and of approximately 10 minutes duration. The total near-shore area sampled was approximately 4,500 meters (15,000 feet).

Experimental gill nets (so called because of their use for research as opposed to commercial fishing) were used as an additional gear type to collect fish from deeper habitats not effectively sampled by electrofishing. Each experimental gill net consists of five 6.1 meter panels for a total length of 30.5 meters (100.1 feet). The distinguishing characteristic of experimental gill nets is mesh size that varies between panels. For this application, each net has panels with mesh sizes of 2.5, 5.1, 7.6, 10.2, and 12.7 cm. Experimental gill nets are typically set perpendicular to river flow, extending from near-shore to the main channel of the reservoir. Ten overnight experimental gill net sets were used at each area.

Fish collected were identified by species, counted, and examined for anomalies (such as disease, deformations, parasites or hybridization). The resulting data were analyzed using RFAI methodology.

The RFAI uses 12 fish community metrics from four general categories: Species Richness and Composition; Trophic Composition; Abundance; and Fish Health. Individual species can be utilized for more than one metric, though hybrid species and non-indigenous species are excluded from metrics counting numbers of individual species. Together, these 12 metrics

provide a balanced evaluation of fish community integrity. The individual metrics are shown below, grouped by category:

Species Richness and Composition

(1) **Total number of species** – Greater numbers of species are considered representative of healthier aquatic ecosystems. As conditions degrade, numbers of species at an area decline.

(2) **Number of centrarchid species** – Sunfish species (excluding black basses) are invertivores and a high diversity of this group is indicative of reduced siltation and suitable sediment quality in littoral areas.

(3) **Number of benthic invertivore species** – Due to the special dietary requirements of this species group and the limitations of their food source in degraded environments, numbers of benthic invertivore species increase with better environmental quality.

(4) **Number of intolerant species** – A group made up of species that are particularly intolerant of physical, chemical, and thermal habitat degradation. Higher numbers of intolerant species suggest the presence of fewer environmental stressors.

(5) **Percentage of tolerant individuals** (excluding young-of-year) – An increased proportion of individuals tolerant of degraded conditions signifies poorer water quality.

(6) **Percent dominance by one species** – Ecological quality is considered reduced if one species inordinately dominates the resident fish community.

(7) **Percentage of non-indigenous species** – Based on the assumption that non-indigenous species reduce the quality of resident fish communities.

(8) **Number of top carnivore species** – Higher diversity of piscivores is indicative of the availability of diverse and plentiful forage species and the presence of suitable habitat.

Trophic Composition

(9) **Percent top carnivores** – A measure of the functional aspect of top carnivores which feed on major planktivore populations.

(10) **Percent omnivores** – Omnivores are less sensitive to environmental stresses due to their ability to vary their diets. As trophic links are disrupted due to degraded conditions, specialist species such as insectivores decline while opportunistic omnivorous species increase in relative abundance.

Abundance

(11) **Average number per run** (number of individuals) – Based on the assumption that high quality fish assemblages support large numbers of individuals.

Fish Health

(12) **Percent anomalies** – Incidence of diseases, lesions, tumors, external parasites, deformities, blindness, and natural hybridization is noted for all fish collected, with higher incidence indicating less favorable environmental conditions.

RFAI methodology addresses all four attributes or characteristics of a "balanced indigenous population" (BIP), defined by the CWA as described below:

(1) **A biotic community characterized by diversity appropriate to the ecoregion**: Diversity is addressed by the metrics in the Species Richness and Composition category, especially metric 1 – "Number of species." Determination of reference conditions based on the transition zones of lower mainstem Tennessee River reservoirs (as described below) ensures appropriate species expectations for the ecoregion.

(2) **The capacity for the community to sustain itself through cyclic seasonal change**: TVA uses an autumn data collection period for biological indicators, both VS and upstream/downstream monitoring. Autumn monitoring is used to document community condition or health after being subjected to the wide variety of stressors throughout the year.

One of the main benefits of using biological indicators is their ability to integrate stressors through time. Examining the condition or health of a community at the end of the "biological year" (i.e., autumn) provides insights into how well the community has dealt with the stresses through an annual seasonal cycle. Likewise, evaluation of the condition of individuals in the community (in this case, individual fish as reflected in Metric 12) provides insights into how well the community can be expected to withstand stressors through winter. Further, multiple sampling years during the permit renewal cycle add to the evidence of whether the autumn monitoring approach has correctly demonstrated the ability of the community to sustain itself through repeated seasonal changes.

(3) **The presence of necessary food chain species:** Integrity of the food chain is measured by the Trophic Composition metrics, with support from the Abundance metric and Species Richness and Composition metrics. A healthy fish community is comprised of species that utilize complex feeding mechanisms extending into multiple levels of the aquatic food web.

Three dominant fish trophic levels exist within Tennessee River reservoirs: insectivores, omnivores, and top carnivores. To determine the presence of necessary food chain species, these three groups should be well represented within the overall fish community. Other fish trophic levels include benthic invertivores, planktivores, herbivores, and parasitic species. Insectivores include most sunfish, minnows, and silversides. Omnivores include gizzard shad, common carp, carpsuckers, buffalo, and channel and blue catfish. Top carnivores

include bass, gar, skipjack herring, crappie, flathead catfish, sauger, and walleye. Benthic invertivores include freshwater drum, suckers, and darters. Planktivores include alewife, threadfin shad, and paddlefish. Herbivores include largescale stonerollers. Lampreys in the genus *Ichthyomyzon* are the only parasitic species occurring in Tennessee River reservoirs.

To establish expected proportions of each trophic guild and the expected number of species included in each guild occurring in transition zones in lower mainstem Tennessee River reservoirs (Kentucky, Pickwick, Wilson, Wheeler, and Guntersville reservoirs), data collected from 1993 to 2010 were analyzed for each reservoir zone (inflow, transition, forebay). Samples collected in the downstream vicinity of thermal discharges were not included in this analysis so that accurate expectations could be calculated with the assumption that these data represent what should occur in lower mainstem Tennessee River reservoirs absent from point source effects (i.e. power plant discharges). Data from 900 electrofishing runs (a total of 405,000 meters of shoreline sampled) and from 600 overnight experimental gill net sets were included in this analysis for transition areas in lower mainstem Tennessee River reservoirs. From these data, the range of proportional values for each trophic level and the range of the number of species included in each trophic level were trisected. These trisections were intended to show less than expected, expected, and above expected values for trophic level proportions and species occurring within transition reservoir zones in lower mainstem Tennessee River reservoirs. The data were also averaged and bound by confidence intervals (95%) to further evaluate expectations for proportions of each trophic level and the number of species representing each trophic level (Table 2).

(4) A lack of domination by pollution-tolerant species: Domination by pollution-tolerant species is determined by metrics 3 ("Number of benthic invertivore species"), 4 ("Number of intolerant species"), 5 ("Percent tolerant individuals"), 6 ("Percent dominance by one species"), and 10 ("Percent omnivores").

Scoring categories are based on "expected" fish community characteristics in the absence of human-induced impacts other than impoundment of the reservoir. These categories were developed from historical fish assemblage data representative of transition zones from lower

mainstem Tennessee River reservoirs (Hickman and McDonough, 1996). Attained values for each of the 12 metrics were compared to the scoring criteria and assigned scores to represent relative degrees of degradation: least degraded (5); intermediately degraded (3); and most degraded (1). Scoring criteria for lower mainstem Tennessee River reservoirs are shown in Table 3.

If a metric was calculated as a percentage (e.g., "Percent tolerant individuals"), the data from electrofishing and gill netting were scored separately and allotted half the total score for that individual metric. Individual metric scores for a sampling area (i.e., upstream or downstream) were summed to obtain the RFAI score for the area.

TVA uses RFAI results to determine maintenance of BIP using two approaches. One is "absolute" in that it compares the RFAI scores and individual metrics to predetermined values. The other is "relative" in that it compares RFAI scores attained downstream to the upstream control site. The "absolute" approach is based on Jennings et al. (1995) who suggested that favorable comparisons of the RFAI score attained from the potential impact zone to a predetermined criterion can be used to identify the presence of normal community structure and function, and hence existence of BIP. For multi-metric indices, TVA uses two criteria to ensure a conservative screening of BIP. First, if an RFAI score reaches 70% of the highest attainable score of 60 (adjusted upward to include sample variability as described below), and second, if fewer than half of RFAI metrics receive a low (1) or moderate (3) score, then community structure and function are considered normal, indicating that BIP had been maintained and no further evaluation would be needed.

RFAI scores range from 12 to 60. Ecological health ratings (12-21 "Very Poor", 22-31 "Poor", 32-40 "Fair", 41-50 "Good", or 51-60 "Excellent") are then applied to scores. As discussed in detail below, the average variation for RFAI scores in TVA reservoirs is 6 (± 3). Therefore, any location that attains a RFAI score of 45 (75% of the highest score) or higher would be considered to have BIP. It must be stressed that scores below this threshold do not necessarily reflect an adversely impacted fish community. The threshold is used to serve as a conservative screening level; i.e., any fish community that meets these criteria is obviously not adversely impacted.

RFAI scores below this level require a more in-depth look to determine if BIP exists. An inspection of individual RFAI metric results and species of fish used in each metric are an initial step to help identify if operation of BFN is a contributing factor. This approach is appropriate because a validated multi-metric index is being used and scoring criteria applicable to the zone of study are available.

A comparison of RFAI scores from the area downstream of BFN to those from the upstream (control) area is one basis for determining if operation of the plant has had any impacts on the resident fish community. The definition of "similar" is integral to accepting the validity of these interpretations. The Quality Assurance (QA) component of the VS monitoring program deals with how well the RFAI scores can be repeated and is accomplished by collecting a second set of samples at 15%-20% of the areas each year. Comparison of paired-sample QA data collected over seven years shows that the difference in RFAI index scores ranges from 0 to 18 points. The mean difference between these 54 paired scores is 4.6 points with 95% confidence limits of 3.4 and 5.8. The 75^{th} percentile of the sample differences is 6, and the 90^{th} percentile is 12. Based on these results, a difference of 6 points or less in the overall RFAI scores is the value selected for defining "similar" scores between upstream and downstream fish communities. That is, if the downstream RFAI score is within 6 points of the upstream score and if there are no major differences in overall fish community composition, then the two locations are considered similar. It is important to bear in mind that differences greater than 6 points can be expected simply due to method variation (25% of the QA paired sample sets exceeded that value). An examination of the 12 metrics (with emphases on fish species used for each metric) is conducted to analyze any difference in scores and the potential for the difference to be thermally related.

Statistical Analyses

In addition to RFAI analyses, data were analyzed using traditional statistical methods. Data from the survey were used to calculate catch per unit effort (CPUE), expressed as number of fish per electrofishing run or fish per net night. CPUE values were calculated by pollution tolerance, trophic guilds (e.g., benthic invertivores, top carnivores, etc.), thermal sensitivity (Yoder et al. 2006), and indigenous status. CPUE, diversity, and species richness values were computed for each electrofishing effort (to maximize sample size; n = 30) and compared upstream and downstream to assess potential effects of power plant discharges.

Diversity was quantified using two commonly applied indices: Shannon diversity index (Shannon 1948) and Simpson diversity index (Simpson 1949). Both indices account for the number of species present, as well as the relative abundance of each species.

Shannon diversity index values were computed using the formula:

$$H' = -\sum_{i=1}^{S} \left(\frac{n_i}{N}\right) \ln\left(\frac{n_i}{N}\right).$$

where:

S = total number of species

N = total number of individuals

n_i = total number of individuals in the i^{th} species

The Simpson diversity index was calculated as follows:

$$D_S = \left(\sum_{i=1}^{S} \left(\frac{n_i}{N}\right)^2\right) - 1$$

where:

S = total number of species

N = total number of individuals

n_i = total number of individuals in the i^{th} species

An independent two-sample *t*-test was used to test for differences in CPUE, species richness, and diversity values upstream and downstream of BFN ($\alpha = 0.05$). Before statistical tests were performed using this method, data were analyzed for normality using the Shapiro-Wilk test (Shapiro and Wilk, 1965) and homogeneity of variance using Levene's test (Levene 1960). Non-normal data or data with unequal variances were transformed using either square root conversion or the ln(x+1) transformation. Transformed data were reanalyzed for normal distribution and equal variances. If transformation normalized the data or resulted in homogeneous variances, transformed data were tested using an independent two-sample *t*-test. If transformed data were

not normally distributed or had unequal variances, statistical analysis was conducted using the Wilcoxon-Mann-Whitney test (Mann and Whitney 1947; Wilcoxon 1945).

Benthic Macroinvertebrate Community Sampling Methods and Data Analysis for Sites Upstream and Downstream of BFN

During autumn 2013, benthic macroinvertebrate data were collected in the transition zone of Wheeler Reservoir along three transects established across the reservoir's width as described above. The upstream transect (TRM 295.9) was used as a control site to compare to benthic community composition potentially affected by the BFN thermal effluent. One downstream transect (TRM 293.2) was within the thermal plume and one transect (TRM 290.4) was located just below the downstream extent of the plume. A Ponar sampler (area per sample 0.06 m^2) was used to collect benthic samples at ten points equally spaced along each transect. When heavier substrate was encountered, a Peterson sampler (area per sample 0.11 m^2) was used. Sediments from each sample were washed on a 533µ screen, and organisms were picked from the screen and from any remaining substrate. Samples were fixed in formalin and sent to an independent consultant who identified each organism collected to the lowest possible taxonomic level.

Benthic samples were evaluated using seven metrics that represented characteristics of the benthic community. Results for each metric were assigned a rating of 1, 3, or 5, based upon comparison to reference conditions developed for VS reservoir inflow sample sites (Table 4). For each sample site, the ratings for the seven metrics were then summed to produce an RBI score. Potential RBI scores ranged from 7 to 35. Ecological health ratings derived from the range of potential values (7-12 "Very Poor", 13-18 "Poor", 19-23 "Fair", 24-29 "Good", or 30-35 "Excellent") were then applied to scores. The individual metrics are described below:

(1) Average number of taxa — Calculated by averaging the total number of taxa present in each sample at a site. Greater taxa richness indicates better conditions than lower taxa richness.

(2) Proportion of samples with long-lived organisms — A presence/absence metric that is evaluated based on the proportion of samples with at least one long-lived organism (*Corbicula, Hexagenia,* mussels, or snails) present. The presence of long-lived taxa is indicative of conditions that allow long-term survival.

(3) Average number of EPT taxa — Calculated by averaging the number of *Ephemeroptera* (mayfly), *Plecoptera* (stonefly), and *Trichoptera* (caddis fly) taxa present in each sample at a site. Higher diversity of these taxa indicates good water quality and better habitat conditions.

(4) Percentage of oligochaetes — Calculated by averaging the percentage of oligochaetes in each sample at a site. Oligochaetes are considered tolerant organisms, so a higher proportion indicates poorer water quality.

(5) Percentage as dominant taxa — Used as an evenness indicator, this metric is calculated by selecting the two most abundant taxa in a sample, summing the number of individuals in those two taxa, dividing that sum by the total number of animals in the sample, and converting to a percentage for that sample. The percentage is then averaged for the 10 samples at each site. Because the most abundant taxa often differ among the 10 samples at a site, this approach allows more discretion to identify imbalances at a site than developing an average for a single dominant taxon for all samples at a site. Dominance of one or two taxa indicates poor conditions.

(6) Average density excluding chironomids and oligochaetes — Calculated by first summing the number of organisms – excluding chironomids and oligochaetes – present in each sample and then averaging these densities for the 10 samples at a site. This metric examines the community, excluding taxa which often dominate under adverse conditions. Higher abundance of taxa other than chironomids and oligochaetes indicates good water quality conditions.

(7) Zero-samples: Proportion of samples containing no organisms — For each site, the proportion of samples which have no organisms present. "Zero-samples" indicate living

conditions unsuitable to support aquatic life (i.e. toxicity, unsuitable substrate, etc.). A site with no zero samples was assigned a score of five. Any site with one or more zero samples was assigned a score of one.

A similar or higher benthic index score at the downstream sites compared to the upstream site was used as the basis for determining absence of impact on the benthic macroinvertebrate community related to BFN's thermal discharge. The QA component of VS monitoring compared benthic index scores from 49 paired sample sets collected over seven years. Differences between these paired sets ranged from 0 to 14 points; the 75th percentile was four, the 90th percentile was six. The mean difference between these 49 paired scores was 3.1 points with 95% confidence limits of 2.2 and 4.1. Based on these results, a difference of four points or less was the value selected for defining "similar" scores between upstream and downstream benthic communities. That is, if benthic scores at the downstream sites are within four points of the upstream score, the communities are considered similar. However, differences greater than four points can be expected simply due to method variation (25% of the QA paired sample sets exceeded that value). Any difference in scores of greater than four points between communities is examined on a metric-by-metric basis to determine what caused the difference and the potential for the difference to be thermally related.

Visual Encounter Survey (Wildlife Observations)

Permanent survey sites were established on both the right and left descending banks at one location upstream of the BFN thermal discharge, centered at TRM 295.9 (Figure 3), and at a second location downstream of the discharge, centered at TRM 292.5 (Figure 4). Each survey site spanned a distance of 2,100 m along the shoreline, and the beginning and ending points were marked using GPS for relocation.

Surveys were conducted by steadily traversing the site by boat, at approximately 30 m offshore and parallel to the shoreline, and simultaneously recording observations of wildlife. The sampling frame of each survey generally followed the strip or belt transect concept: from the center-line of each transect landward to an area that included the shoreline and riparian zone (i.e.,

belt width generally averages 60 m where vision is not obscured), all individuals observed were enumerated. Wildlife observed visually or detected audibly was identified to the lowest taxonomic trophic level, and a direct count of individuals observed per trophic level was recorded. If a flock of a species or a mixed flock of a group of species was observed, numbers of individuals present of each species were estimated. Time was recorded at the start and end points of each survey to provide a general measure of effort expended. Variation of observation times among surveys was primarily due to the difficulty of approaching some wildlife species without inadvertently flushing them from basking or perching sites.

The principal objective of the surveys was to provide a preliminary set of observations to verify that trophic levels of birds, mammals and reptiles were not affected by thermal effects from the BFN discharge. If expected trophic levels were not represented, further investigation will be used to target particular species and/or species groups (guilds) in an attempt to determine the cause.

Wheeler Reservoir Flow and BFN Temperature

Total discharge from Guntersville Dam was used to describe the amount of water flowing past BFN and was obtained from TVA's River Operations database.

Water temperature data were also obtained from TVA's River Operations database. Locations of water temperature monitoring sites used to measure water temperatures upstream of BFN intake and downstream of BFN discharge are depicted in Figure 6. Ambient temperatures upstream of the BFN intake were measured at Site 4, located at TRM 297.8. Upstream daily mean temperatures were calculated by averaging temperatures collected at depths of 3, 5, and 7 feet. Temperatures downstream of BFN discharge were measured at Sites 1, 16, and 17, all located at TRM 293.5. Downstream temperatures were calculated by first averaging temperatures at each site across depths of 3, 5, and 7 feet. The resultant values from each site were then averaged together to obtain overall mean daily water temperatures downstream of BFN.

Thermal Plume Characterization

Physical measurements to characterize and map the BFN thermal plume were collected concurrent with biological field sampling. The plume was characterized under representative thermal maxima and seasonally-expected low flow conditions. Measurements were collected during periods of normal operation of BFN, as reasonably practicable, to capture the thermal plume under existing river flow/reservoir elevation conditions. This effort evaluated potential impacts on recreation and water supply uses and allowed general delineation of the "Primary Study Area" – per the EPA (1977) draft guidance defined as the "*entire geographic area bounded annually by the locus of the 2°C above ambient surface isotherms as these isotherms are distributed throughout an annual period*" – ensuring placement of the biological sampling locations within thermally influenced areas.

However, it is important to emphasize that the ≥2°C isopleth boundary is not a bright line; it is dynamic, changing geometrically in response to changes in ambient river flows and temperatures and BFN operations. As such, samples collected outside of, but generally proximate to the Primary Study Area boundary cannot be considered free of thermal influence and thus should not be discounted. Every effort was made to collect biological samples in thermally affected areas as guided by the Primary Study Area definition.

Depth profiles of temperature from the river surface to the bottom were collected at points along transects crossing the plume. One transect was located proximate to the thermal discharge point; subsequent downstream transects were concentrated in the near field area of the plume where the change in plume temperature was expected to be most rapid. The distance between transects in the remainder of the Primary Study Area increased with distance downstream (or away from the discharge point). The farthest downstream transect was just outside of the Primary Study Area. A transect upstream of the discharge, in an area not affected by the thermal plume, was included for determining ambient temperature conditions. The total number of transects needed to fully characterize and delineate the plume was determined in the field.

Collection of temperature profiles along a given transect began at or near the shoreline from which the discharge originated and continued until the far shore was reached. Measurements across a transect were typically conducted at points 10%, 30%, 50%, 70%, and 90% from the

originating shoreline, though the number of measurement points along transects was sometimes increased in proportion to the magnitude of the temperature change across a given transect. The distances between transects, and between measurement points along each transect, depended on the size of the discharge plume.

Temperature data were compiled and analyzed to present the horizontal and vertical dimensions of the BFN thermal plume using spatial analysis techniques to yield plume cross-sections, which can be used to demonstrate the existence of a zone of passage for fish and other aquatic species under or around the plume.

Water Quality Parameters at Fish Sampling Sites during RFAI Samples

Water quality conditions were measured using a Hydrolab® that provided readings for water temperature (°C), conductivity (µS/cm), dissolved oxygen (mg/L), and pH. Within each of the electrofishing sample reaches upstream and downstream of BFN, transects were established across the river at the most upstream boundary, at mid-reach, and at the most downstream boundary. Along each transect, samples were collected at the RDB, in mid-channel, and at the LDB by recording readings along a vertical gradient from just above the bottom of the river to approximately 0.3 meters from the surface at one- to two-meter intervals.

Results and Discussion

Aquatic Habitat in the Vicinity of BFN

Shoreline Aquatic Habitat Assessment

SAHI methodology was used to evaluate shoreline habitat for eight transects located within each of the RFAI sample reaches upstream and downstream of BFN. Shoreline transects were sampled on each bank (Figure 5).

Of the sixteen shoreline transects sampled upstream of BFN, 19% (3 transects) scored as good, 8% (12 transects) scored as fair, and 6% (1 transect) scored as poor. The average score for

transects on the left descending bank was 24 ("Fair"), while scores for transects on the right descending bank averaged 23 ("Fair"). No aquatic macrophytes were observed on either shoreline (Table 5).

Of the sixteen shoreline transects sampled downstream of BFN, 0% scored as good, 88% (14 transects) scored as fair, and 12% (2 transects) scored as poor. The average scores for transects on the left bank descending were equal to those on the right bank descending (20, "Fair"). No aquatic macrophytes were observed on either shoreline (Table 6).

River Bottom Habitat

Figures 7-10 compare substrate proportions at each sample point along each of the eight transects upstream of BFN during autumn 2009. Figures 11-14 compare substrate proportions at each sample point along each of the eight transects downstream of BFN during autumn 2009 (Figure 5). Transects in Figures 7-14 are depicted at an exaggerated slant from bank to bank, in order to fit all of the data on the figure. Actual river bottom habitat sampling upstream and downstream of BFN was conducted in a straight line from the left descending bank to the right descending bank.

The three most dominant substrate types encountered along the eight transects upstream of BFN were silt (51.1%), mollusk shell (32.0%), and sand (5.1%). Though in slightly different proportions – silt (65.1%), mollusk shell (19.4%), and sand (5.4%) – these three substrates were also the most prominent downstream of BFN.

Fish Community

The total RFAI score for the fish community upstream of BFN was 46 ("Good"). The score for the community downstream was 40 ("Fair"). Because the difference between these scores was within the 6-point range of acceptable variation, the communities were considered similar during autumn 2013.

Below, the two communities are compared in further detail, utilizing the four characteristics of a BIP. Discussion of this comparison includes the metrics appropriate for each characteristic.

(1) A biotic community characterized by diversity appropriate to the ecoregion

Total number of species (highest rating requires > 30)

Thirty-three indigenous species were collected upstream, earning the highest score (5). Downstream, 27 indigenous species were collected earning a mid-range score (3) (Table 8). Seven species – longnose gar (six specimens), golden shiner (six), white crappie (one), northern hogsucker (one), white bass (two), orangespotted sunfish (three), and spotted bass (one) – were collected only upstream. One individual of stripetail darter was collected only downstream (Tables 9, 10).

Number of centrarchid species (highest rating requires > 2)

Eight centrarchid species were collected upstream and six were collected downstream, resulting in the highest score (5) for both sites (Table 8). White crappie and orangespotted sunfish were collected only upstream (Tables 9, 10).

Number of benthic invertivore species (highest rating requires > 7)

Five benthic invertivore species were collected upstream and four downstream, resulting in mid-range scores (3) for both sites (Table 8). Spotted sucker, black redhorse, logperch, and freshwater drum were collected at both sites; northern hogsucker was collected only upstream (Tables 9, 10).

Number of intolerant species (highest rating requires > 4)

Six intolerant species were collected upstream and five collected downstream. Both sites earned the highest score (5) (Table 8). Skipjack herring, spotted sucker, black redhorse, longear sunfish, and smallmouth bass were collected at both sites; northern hogsucker was collected only upstream (Tables 9, 10).

Number of top carnivore species (highest rating requires > 7)

Twelve top carnivore species were collected upstream, and eight were collected downstream. Both sites earned the highest score (5) (Table 8). Longnose gar, white crappie, white bass and spotted bass were collected only upstream (Tables 9, 10).

Summary

Both the upstream control site and the site downstream of the BFN discharge earned identical scores for four of the five metrics discussed. The upstream site earned a higher score for only metric 1, "Total number of species".

(2) The capacity for the community to sustain itself through cyclic seasonal change

Maintenance of diversity can often be indicative of the ability of a fish community to withstand the stressors of an annual seasonal cycle. Autumn RFAI sampling has been conducted at the site upstream of BFN since 1993, except during 1996, 1998, and 2012. Autumn sampling has been conducted at the site downstream since 2000, except during 2012. Average scores calculated over the history of sampling are identical for both sites (41, "Good") (Table 11).

Figure 15 shows the numbers of indigenous species collected during autumn RFAI samples upstream and downstream of BFN from 2000 through 2013. Over this time period, the numbers collected at the upstream site ranged from 24 to 33, with an average of 29 species. Downstream, numbers collected ranged from 23 to 28, with an average of 27 species. Collections upstream have generally been higher than those downstream: more species were collected upstream during nine years, while the same number of species was collected at both sites during 2003, 2007, and 2008, and more species were collected downstream than upstream during only 2009. The numbers of indigenous species collected during autumn 2013 (33 upstream, 27 downstream) showed the greatest difference between the sites over the history of sampling.

Percentage of anomalies (highest rating requires < 2 %)

Anomalies (i.e. visible lesions, bacterial and fungal infections, parasites, muscular and skeletal deformities, and hybridization) observed in a fish community can also be an indicator of the

ability of the community to sustain itself over an annual seasonal cycle. A greater percentage of anomalies (3.3%) was observed in the electrofishing sample at the upstream site, and the site earned a lower partial score than the downstream site, which exhibited only 1.1% anomalies. No anomalies were observed in the gill net portion of the sample at either site, and both earned the highest partial score for this portion of the metric (Table 8).

Summary

Average RFAI scores, determined over the history of autumn sampling around BFN, were identical upstream and downstream. Though more indigenous species were collected upstream during most years, the average numbers of species – calculated over the years during which sampling occurred at both sites – were similar upstream and downstream. The electrofishing catch upstream exhibited a greater percentage of anomalies than that downstream, but no anomalies were observed in the gill net catch at either site.

(3) The presence of necessary food chain species

Estimates of the trophic compositions of the fish communities upstream and downstream of BFN were calculated from the collection data (Tables 9, 10) as the proportion of the total sample made up by each trophic guild. In direct comparison of the communities upstream and downstream of BFN, the proportions of benthic invertivores and planktivores were somewhat similar. The proportions of other trophic guilds were notably different. However, omnivores and top carnivores were collected in greater proportion upstream, while insectivores were collected in greater proportion downstream. One additional guild – specialized insectivore – was represented downstream but not upstream. No parasitic or herbivore species were collected at either site. The numbers of species collected of four guilds were similar upstream and downstream, but notably more top carnivore species were collected upstream, and one species of specialized insectivore was collected only downstream (Table 2).

In comparison to expected values for transition zones in lower mainstem Tennessee River reservoirs (Table 2), upstream proportions of benthic invertivores and insectivores were within the range of expected values, while the proportions of top carnivores, omnivores, and planktivores were poorer than expected. Downstream, insectivores comprised an unusually high

proportion of the sample (60.0%), primarily due to the collection of large numbers of two species: Mississippi silverside comprised more than 33% of the total catch, and spotfin shiner comprised more than 11% (Table 9, 10). The proportions of benthic invertivores and omnivores were within the expected ranges, while the proportions of top carnivores and planktivores were below expectations. The collection downstream also included one specimen of "Specialized Insectivore" – the stripetail darter (Table 10) – representing the guild as 0.1% of the sample. Upstream, the numbers of benthic invertivore, insectivore, top carnivore and planktivore species met or exceeded expectations, while the number of omnivore species was poorer (more species) than expected. Downstream, the numbers of species representing all six trophic guilds met or exceeded expectations (Table 2).

Summary

Trophic composition of the fish community upstream was not similar to that downstream. Proportions of insectivores, top carnivores, omnivores, and specialized insectivores were different between the sites. Although proportions were different between sites, further analysis revealed that numbers collected were similar for all trophic guilds except insectivore and top carnivore. The difference of insectivore proportions between sites was due to larger numbers of Mississippi silverside collected at the downstream site; this species schools, and therefore can be collected in large numbers.

(4) A lack of domination by pollution-tolerant species

Number of benthic invertivore species

Five benthic invertivore species were collected upstream, and four were collected downstream. Both sites earned highest scores (5).

Number of intolerant species (highest rating requires > 4)

Six intolerant species were collected upstream, and five were collected downstream. Both sites received the highest score (5). Skipjack herring, spotted sucker, black redhorse, longear sunfish, and smallmouth bass were collected at both sites; northern hogsucker was collected only upstream (Tables 8-10).

Percentage of tolerant individuals (highest rating requires < 27 % electrofishing; < 15 % gill net)

The upstream site earned mid-range scores for both portions of the sample: 49.5% of the electrofishing sample and 26.9% of the gill net sample were tolerant individuals. Downstream, 39.0% of the electrofishing sample – a mid-range partial score – and 33.3% of the gill net sample – the lowest partial score – were tolerant individuals (Table 8).

Seven tolerant species – gizzard shad, common carp, spotfin shiner, redbreast sunfish, green sunfish, bluegill, and largemouth bass – were collected at both sites. Longnose gar, golden shiner, white crappie, and northern hogsucker were collected only upstream. Gizzard shad and longnose gar were caught in equal percentages (9.6%) in gill nets upstream, but gizzard shad was clearly the most abundant species collected by electrofishing upstream (26.6%) and by either method downstream (17.0% of the electrofishing catch, 25.5% of the gill net catch) (Table 8).

Percent dominance by one species (highest rating requires < 29 % electrofishing; < 17 % gill net)

The upstream site earned the highest score for both portions of the sample. Gizzard shad was the most prevalent species in the electrofishing catch (26.6%) and channel catfish was most prevalent in the gill net catch (11.5%). The downstream site earned mid-range scores for both portions of the sample, with Mississippi silverside most prevalent in the electrofishing sample (35.1%) and gizzard shad most prevalent in the gill net sample (25.5%) (Table 8).

Percentage of omnivores (highest rating requires < 24 % electrofishing; < 16 % gill net)

The electrofishing catch upstream consisted of a higher percentage of omnivores (39.0%) and earned a lower partial score (1.5) than that downstream, which consisted of 22.4% omnivores and earned the highest partial score (2.5). Gill net portions of the samples at both sites contained high percentages of omnivores (42.3% upstream, 39.2% downstream), and both earned lowest partial scores (Table 8). Six omnivore species – common carp, gizzard shad, smallmouth buffalo, black buffalo, blue catfish, and channel catfish – were collected at both sites. Golden shiner was collected only upstream (Tables 9, 10).

Summary

Based on RFAI metric scores, the sites upstream and downstream of BFN both exhibited similarly moderate diversity of benthic invertivore species and similarly high diversity of intolerant species. Electrofishing samples at both sites exhibited moderate percentages of tolerant individuals, and gill net samples at both sites exhibited high percentages of omnivores. The community downstream was more heavily dominated by a single species than that upstream, though the most prevalent species collected upstream were different for both gear types than those collected downstream. The gill net sample downstream contained a greater percentage of tolerant individuals, but the electrofishing sample contained a lower percentage of omnivores.

Statistical Analyses

Statistical comparison of the fish communities upstream and downstream of BFN showed no significant differences in overall species diversity per run, based on either the Simpson or the Shannon diversity indices. Potential differences in diversity between the two communities were also analyzed by parsing the data into nine species parameters. These tests indicated that significantly more top carnivore species were collected per run upstream than downstream, but numbers of species for the other eight parameters were not significantly different between the communities (Table 11).

The same nine parameters were also tested for differences in richness (numbers of individuals per run, or CPUE) between the two communities. Greater numbers of individual top carnivores were collected per run upstream; greater numbers of intolerant species were collected per run downstream (Table 11).

Fish Community Summary

Thirty-seven representative important species (RIS) were collected at the site upstream of BFN, compared to 31 RIS downstream (Tables 9, 10). RIS are defined in EPA guidance as those species which are representative in terms of their biological requirements of a balanced, indigenous community of fish, shellfish, and wildlife in the body of water into which the discharge is made (EPA and NRC, 1977). RIS often include non-indigenous species. A species

is designated as "thermally sensitive" if specimens exhibit avoidance behavior or are subject to mortality at water temperatures equal to or greater than 32.2°C (90°F) (Yoder et al., 2006). The same three thermally sensitive species – emerald shiner, spotted sucker, and logperch – were collected at both sites. Two aquatic nuisance species, common carp and Mississippi silverside, were also collected at both sites (Tables 9, 10).

Commercially valuable species are defined by the Alabama Department of Conservation and Natural Resources (2013) as any of the following non-game fish: drum, buffalo, carp, channel catfish, all members of the catfish family, paddlefish (spoonbill), spotted sucker, all members of the sucker family including the species known as redhorse and black horse, bowfin and all members of the gar family, and mullet. Recreationally valuable species are those that are targeted by anglers or are used as bait. Among the RIS collected upstream were 17 commercially valuable species and 23 recreationally valuable species, compared to 15 commercially valuable and 17 recreationally valuable species downstream (Tables 9, 10).

Total RFAI scores for the sampling sites upstream and downstream differed by six points, indicating no substantial differences in ecological structure or balance between the two communities. As previously discussed, RFAI scores have an intrinsic variability of ± 3 points. This variability comes from several sources, including annual variations in air temperature and stream flow; variations in pollutant loadings from nonpoint sources; changes in habitat, such as extent and density of aquatic vegetation; natural population cycles and movements of the species being measured (TWRA, 2014). Another source of variability arises from the fact that nearly any practical measurement, lethal or non-lethal, of a biological community is a sample rather than a measurement of the entire population.

Accordingly, a thorough comparison of the fish communities upstream and downstream of BFN was conducted by examining each of the twelve individual RFAI metrics as a component of the appropriate characteristic of a BIP. This analysis indicated that the two communities were both poor in abundance (both received low scores for the metric "Average number per run"), but similar in diversity and in their sustainability over an annual cycle. The numbers of species representing the major trophic guilds were generally similar, but distinct differences in

proportional trophic composition between the sites were evident. The two sites showed similarly moderate dominance by pollution tolerant species, but the downstream community was more heavily dominated by a single species. This was at least partially due to the collection downstream of an especially large number (33.2% of the total sample) of Mississippi silverside, a species that is often collected in large schools (Table 10). It is also noted that the species of dominance was different upstream and downstream for each type of collection gear (Table 8).

To provide additional information about the health of the fish community throughout Wheeler reservoir, Table 12 compares RFAI scores for the sites upstream and downstream of BFN with those from additional VS sites in the reservoir. However, aquatic communities at these sites are not subject to thermal effects from BFN and are not used in determination of BIP in relation to the plant. Average RFAI scores of these additional VS sites were all in the range of a "Good" rating.

Statistical tests indicated that, within the upstream site, more top carnivore species were collected per run and greater numbers of individual top carnivores were collected per run, supporting the observations that this group was both more diverse and comprised a greater proportion of the total sample upstream. Greater numbers of intolerant individuals were collected per run downstream, indicating that conditions below BFN discharge were suitable for sensitive species.

In conclusion, though this discussion revealed some differences between the fish communities upstream and downstream of BFN during autumn 2013, there was no indication that these differences were related to thermal effluent from BFN.

Benthic Macroinvertebrate Community

As discussed previously, data to assess the benthic macroinvertebrate community around BFN were collected from three sites in autumn 2013. RBI metrics for all three sites were scored using evaluation criteria for lab-processed samples collected in the transition reservoir zone (Table 4). Data collected at TRM 290.4, downstream of the thermal plume, produced an overall RBI score of 31 ("Excellent") and data from TRM 293.2, within the thermal plume, produced an overall

RBI score of 35 ("Excellent"). Data from the upstream site, TRM 295.9, produced an overall RBI score of 35 ("Excellent") (Table 13).

The upstream site was considered a control site and a difference of 4 points or less was used to define "similar" conditions between the upstream and downstream sites. Because the RBI scores for the two downstream sites were within 4 points of the RBI score for the upstream site, conditions among the three sites were considered "similar" and BIP was maintained. Results for the autumn 2013 benthic macroinvertebrate sampling can be found in Tables 13 and 16. Results were compared between the downstream (TRM's 290.4 and 293.2) and upstream (TRM 295.9) sites and are briefly discussed below for each RBI metric.

Average number of taxa (highest rating requires > 6.6)

In autumn 2013, averages of 7.8 and 10.6 taxa were observed for sites downstream of BFN. The site upstream of BFN averaged 11 taxa per sample. All three sites received the highest score of 5 for this metric (Table 13).

Proportion of samples with long-lived organisms (highest rating requires > 0.9)

The metric "proportion of samples with long-lived organisms" received the highest score of 5 at both downstream sites with 100% containing long-lived organisms (proportion of 1.0). The proportion of samples with long-lived organisms was 100% at the upstream site which also received the highest score for the metric (Table 13).

Average number of EPT taxa (highest rating requires > 1.4)

An average of 1.2 EPT taxa was collected at the most downstream site, TRM 290.4, resulting in the mid-range score of 3. Within the plume at TRM 293.2, an average of 1.8 EPT taxa was collected and upstream of BFN at TRM 295.9, an average of 1.7 EPT was collected. Both sites received the highest score (Table 13).

Average proportion of oligochaete individuals (highest rating requires < 11%)

Oligochaetes are considered tolerant of poor water quality conditions; therefore a low proportion of oligochaetes in the samples is an indication of good water quality condition. All three sites had low proportions of oligochaetes and received the highest score (5) for the autumn 2013 samples, which included averages of 2.7 % and 8.3 % oligochaetes for the two downstream sites and an average of 3.6 % oligochaetes for the upstream site (Table 13).

Proportion of total abundance comprised by two dominant taxa (highest rating requires < 77.8%)

The two dominant taxa made up 81.1 % of the samples at the most downstream site, TRM 290.4, which received the mid-range score (3) for this metric (Table 13). Total abundance of the two dominant taxa was 66.7 % for the site within the plume, TRM 293.2, and was 67.3 % upstream of BFN at TRM 295.9 resulting in the highest score for both sites. *Hexagenia* mayflies (Ephemeridae) and Asiatic clams (Corbiculidae) were the two most abundant taxa at all three sites (Table 16a).

Average density excluding chironomids and oligochaetes (highest rating requires > 609.9/m^2)

At the downstream sites, average densities excluding chironomids and oligochaetes were 1,161.7/m^2 and 1,228.3/m^2. Both sites received the highest score (5). Average density excluding chironomids and oligochaetes at the upstream site was 1,111.7/m^2, also resulting in the highest score (Table 13).

Proportion of samples containing no organisms (highest rating requires that all samples contain organisms)

In autumn 2013, there were no samples at any site which were void of organisms. All sites received the highest score (Table 13).

Benthic Macroinvertebrate Community Summary

Monitoring results for autumn 2013 support the conclusion that a BIP of benthic macroinvertebrates was maintained downstream of BFN (Table 13). The site within the thermal

plume, TRM 293.2, received the same RBI total score of 35 as the site upstream of BFN and both rated "Excellent". The downstream site below the plume, TRM 290.4, received a slightly lower RBI total score of 31. However, this score also rated "Excellent" and was within four points when compared with the scores for the other two sites. Thus, the benthic community at the most downstream site was also considered similar to the upstream benthic community.

Individual metrics and RBI total scores for benthic community samples from TRM 291.7 (downstream) and TRM 295.9 (upstream) are provided in Tables 14 and 15 for referencing results from 2000 to 2010. Benthic samples from these two locations were field processed every year monitored through 2010, and during some of the years samples were also laboratory processed. Since 2011, samples have been lab processed which produces a more accurate depiction of the benthic community. Although the locations presently used as the downstream sites (TRMs 290.4 and 293.2) are proximate to the downstream transect sampled from 2000 to 2010 (TRM 291.7), RBI laboratory-processed scores for 2011 and 2013 cannot be directly compared to RBI field processed scores from 2000 to 2010 without inference.

To provide additional data on the overall health of the benthic macroinvertebrate community in Wheeler Reservoir, RBI scores for VS monitoring locations - inflow, forebay, and Elk River embayment sites - were included in Table 17. Please note that comparison of these scores to current RBI scores at the sites around BFN is limited for two reasons. First, data from these sites were scored from field-based criteria and cannot be closely compared to lab-based scores. Second, these sites are many river miles away from BFN. The inflow site is 53 river miles upstream, and the forebay sampling site is located 17 river miles downstream. The Elk River embayment site is located 6 river miles upstream of the confluence with the Tennessee River, which in turn is 10 river miles downstream of BFN. Because of these distances from the plant, poor scores at these sites cannot be considered indicative of thermal effects from BFN.

The Wheeler inflow site (TRM 347) has produced RBI scores of "Good" or "Excellent" for 11 of the 14 years sampled (Table 17). The forebay (TRM 277) and Elk River embayment sites (ERM 6.0) have produced "Poor" scores most years sampled.

Visual Encounter Survey (Wildlife Observations)

Wildlife observed from linear shoreline surveys conducted upstream and downstream of BFN during autumn 2013 are presented in Table 18. Observations along the upstream survey site consisted of a variety of birds commonly associated with riparian habitat, map turtles, and one Eastern grey squirrel seen along the right descending bank. Observations downstream consisted of a similar variety of birds and map turtles. No mammals were observed downstream.

It is important to note that a Visual Encounter Survey provides a preliminary near shore wildlife assessment to determine if the thermally affected area downstream of a power plant has adversely affected the bird, reptile, or mammal communities. The diversity of bird groups recorded indicated that a healthy ecological community existed both upstream and downstream of WBN during 2013. However, because determination of the presence and diversity of reptiles and mammals using these methods is made difficult by their typical behaviors, observations of these taxa were limited. If an adverse environmental impact is suspected, sampling strategies of a more quantitative nature, such as trapping or netting, active search, investigation of mammal tracks along shoreline areas, long-term observation from blinds, or the use of cameras will be proposed to more accurately estimate the presence and diversity of these groups.

Wheeler Reservoir Flow and BFN Water Temperature

Daily mean flows from Guntersville Dam over the fiscal year 2013 (October 2012 through November 2013) are compared in Figure 16 to historic daily mean flows over the same fiscal year period, averaged from 1976 to 2012. From October to November 2012 and August to November 2013, flows were similar to historical averages. During December 2012, flows remained lower than historical. Flows were generally higher than historical from January to July 2013.

Figure 17 compares daily average water temperatures recorded upstream of BFN intake and downstream of BFN discharge during October 2012 through November 2013. Water temperatures were similar at both sites through this period.

Thermal Plume Characterization

Plume temperatures (water temperatures 3.6°F or greater above ambient) began at the BFN discharge (TRM 294.0) and continued downstream to TRM 291.8. At the discharge, the plume extended from the RDB to 30% of the width of the river and from the surface to 1.5 m depth. Downstream (TRM 293.8), the plume extended to a maximum depth of 7 m but did not extend farther than 50% of the width of the river from the RDB. At TRM 291.8, plume temperatures were observed only along the RDB, from the surface to 3 m depth. No plume temperatures were detected downstream of this point (Table 19).

These profiles indicate that, at maximum, the thermal effluent from BFN was confined to the upper two-thirds of the water column from mid-channel to the RDB, and that a sufficient zone of passage for aquatic wildlife existed around BFN during autumn 2013.

Water Quality Parameters at Fish Sampling Sites during RFAI Samples

Water temperatures observed at the upstream site, centered at TRM 295.9, ranged from 71.9 to 78.4 °F, with the highest temperatures occurring in mid-channel at the surface, along the downstream boundary of the sample reach. Water temperatures at the downstream site, centered at TRM 292.5, ranged from 74.0 to 83.9 °F, with the highest temperatures occurring at the surface along the RDB at the upstream boundary of the sample reach. Values for pH, conductivity, and dissolved oxygen concentration fell within narrow and similar ranges upstream and downstream (Table 20).

The values of these parameters indicate that pH, conductivity, and dissolved oxygen concentrations surrounding BFN during autumn 2013 were of sufficient quality to support a BIP of the type expected for this reservoir, and that they were not affected by thermal effluent from BFN. The most elevated temperatures within the downstream site were observed along the RDB at the upper boundary, just downstream of the BFN discharge, and are consistent with temperatures recorded at similar locations during plume determination (Table 19). The most elevated temperatures within the upstream site were observed at the surface along the lower boundary of the site. This lower boundary is less than one mile upstream of the discharge, and

considering the width of the reservoir and the relatively low velocity of the river at this point, these elevated temperatures can be attributed to diffusion of heated water upstream from the discharge. Discussion above indicated that a zone of passage for aquatic life existed around BFN. Therefore, overall water quality around BFN was not negatively impacted by the thermal effluent.

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Figures

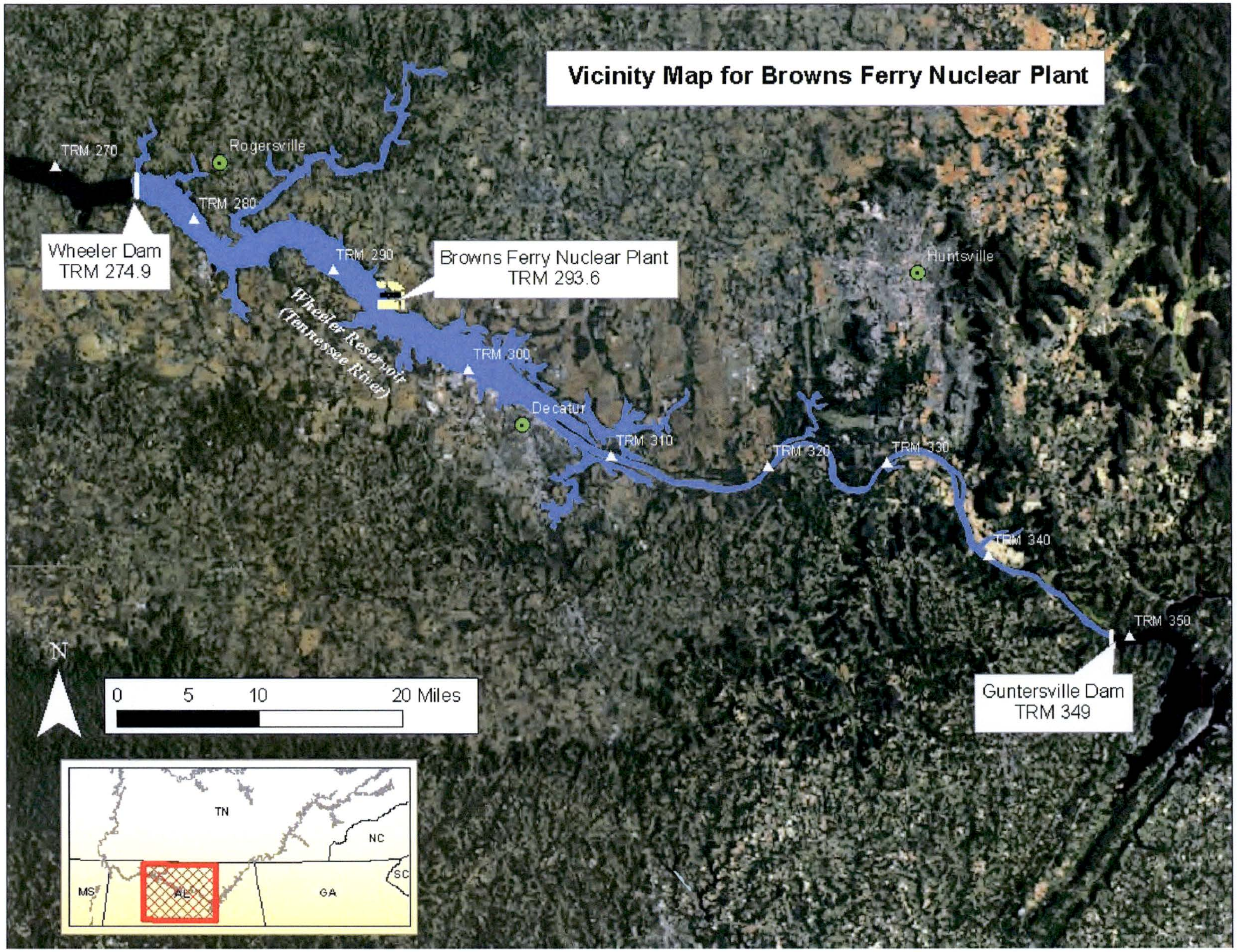


Figure 1. Location of Browns Ferry Nuclear Plant on Wheeler Reservoir.

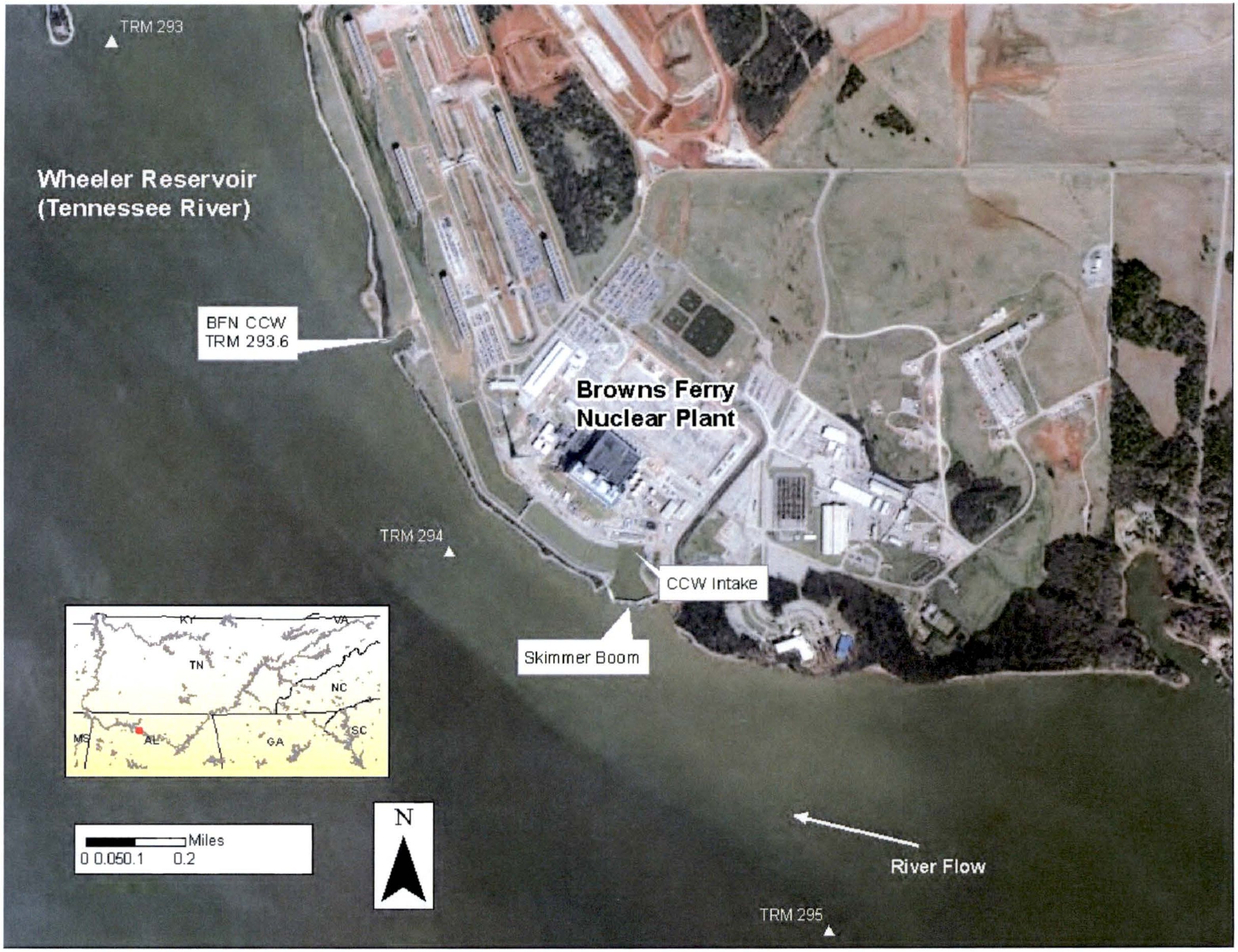


Figure 2. Location of Condenser Cooling Water (CCW) intake and discharge at Browns Ferry Nuclear Plant.

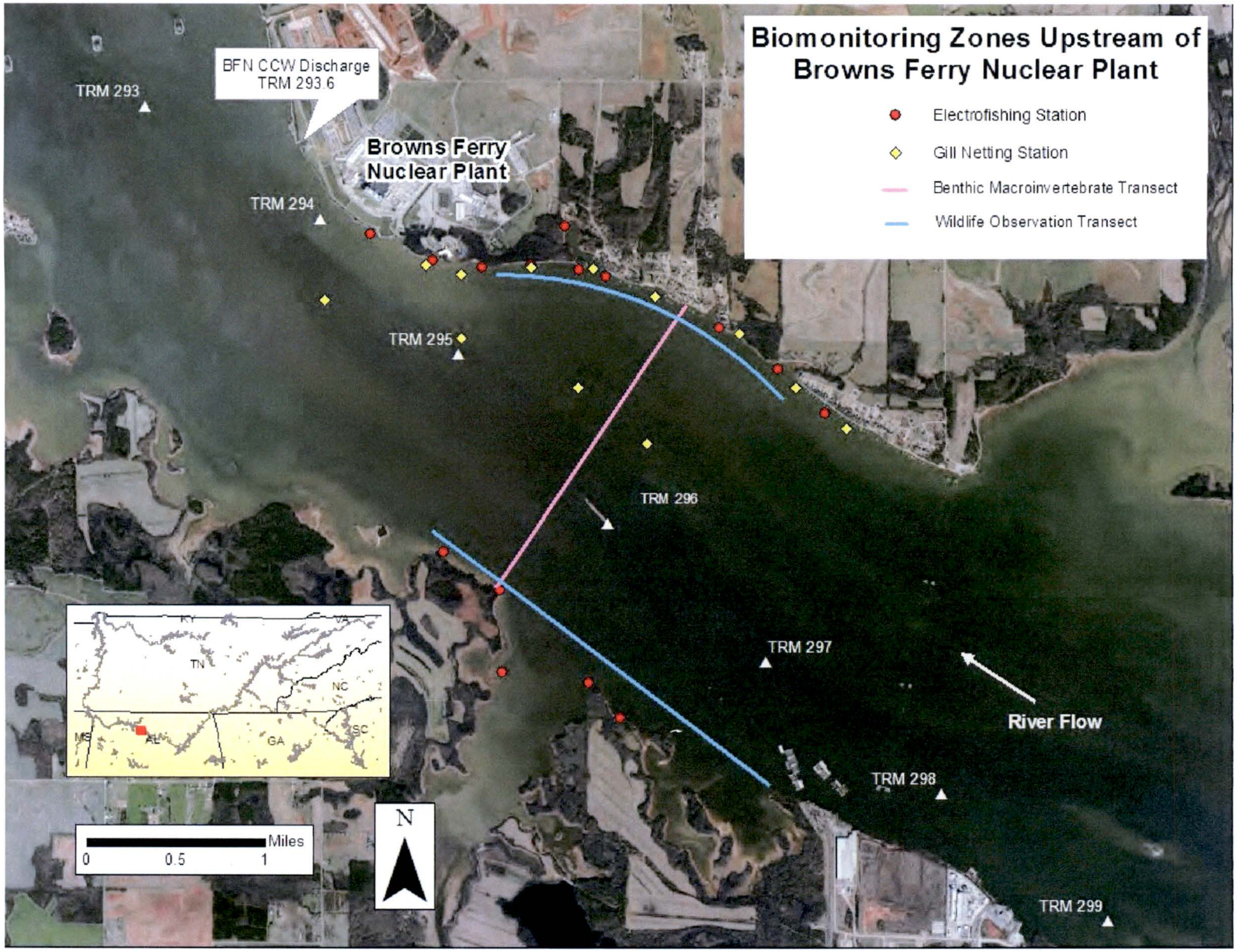


Figure 3. Locations of biomonitoring sites upstream of Browns Ferry Nuclear Plant.

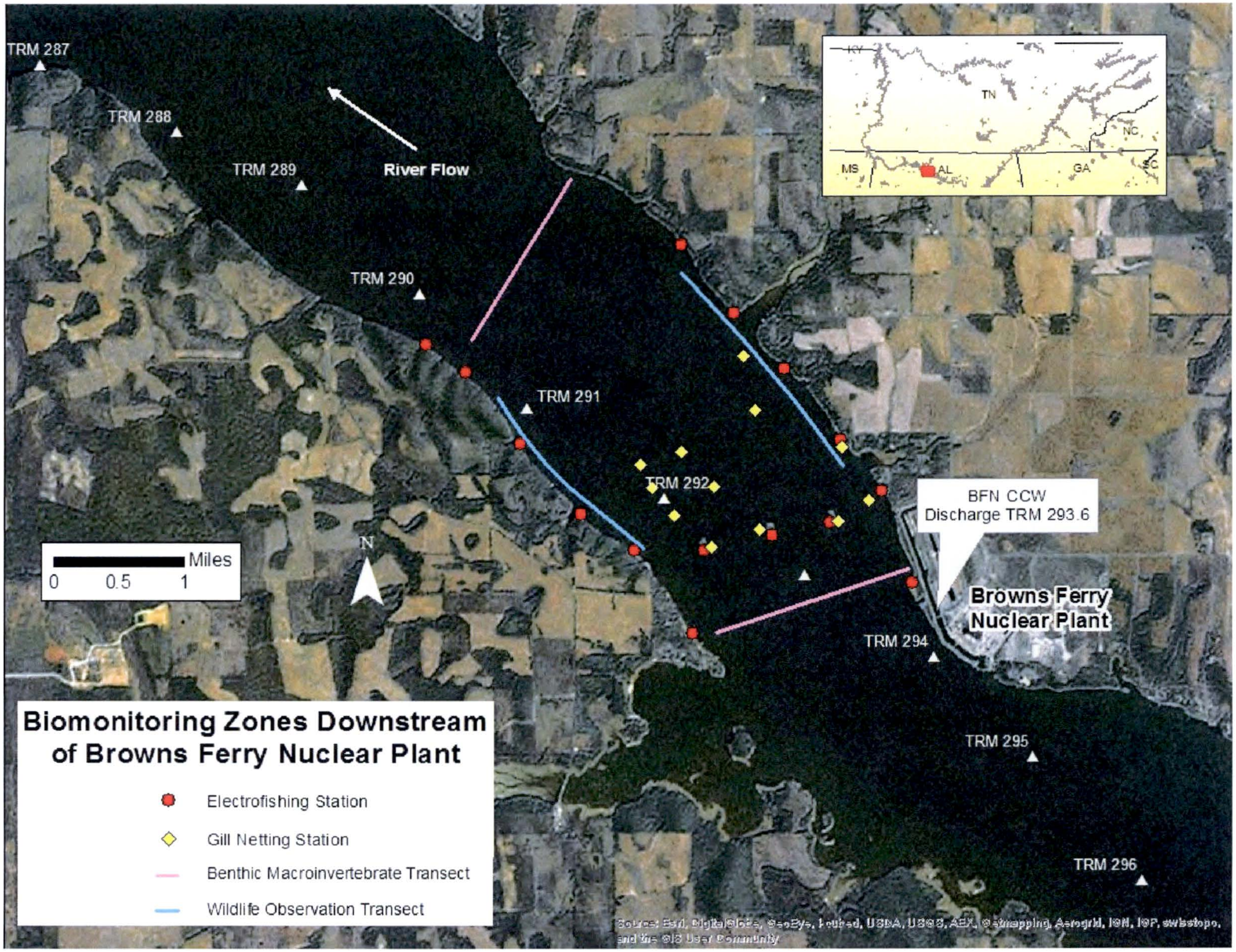


Figure 4. Locations of biomonitoring sites downstream of Browns Ferry Nuclear Plant.

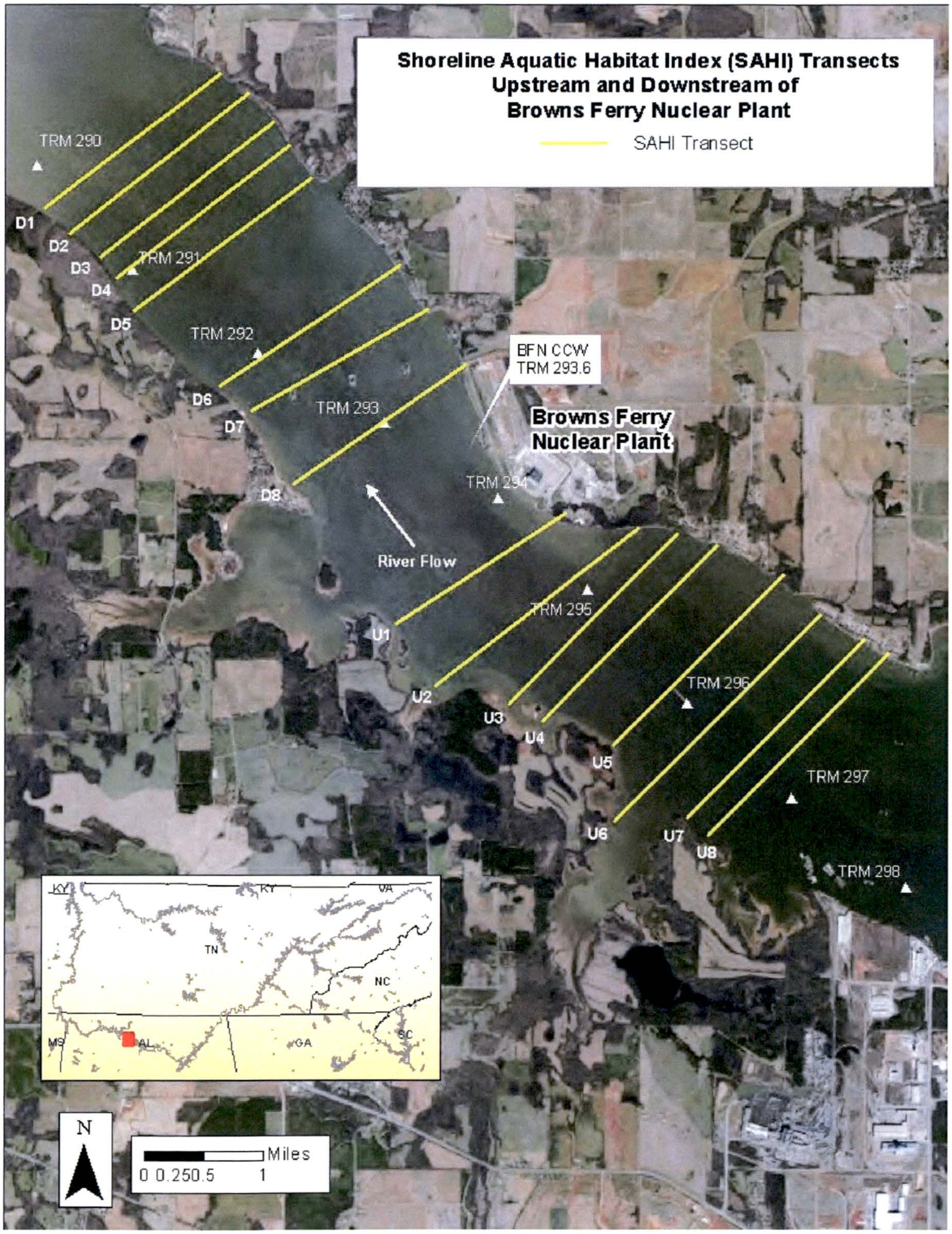


Figure 5. Locations of transects used to characterize shoreline and river bottom habitat upstream and downstream of Browns Ferry Nuclear Plant.

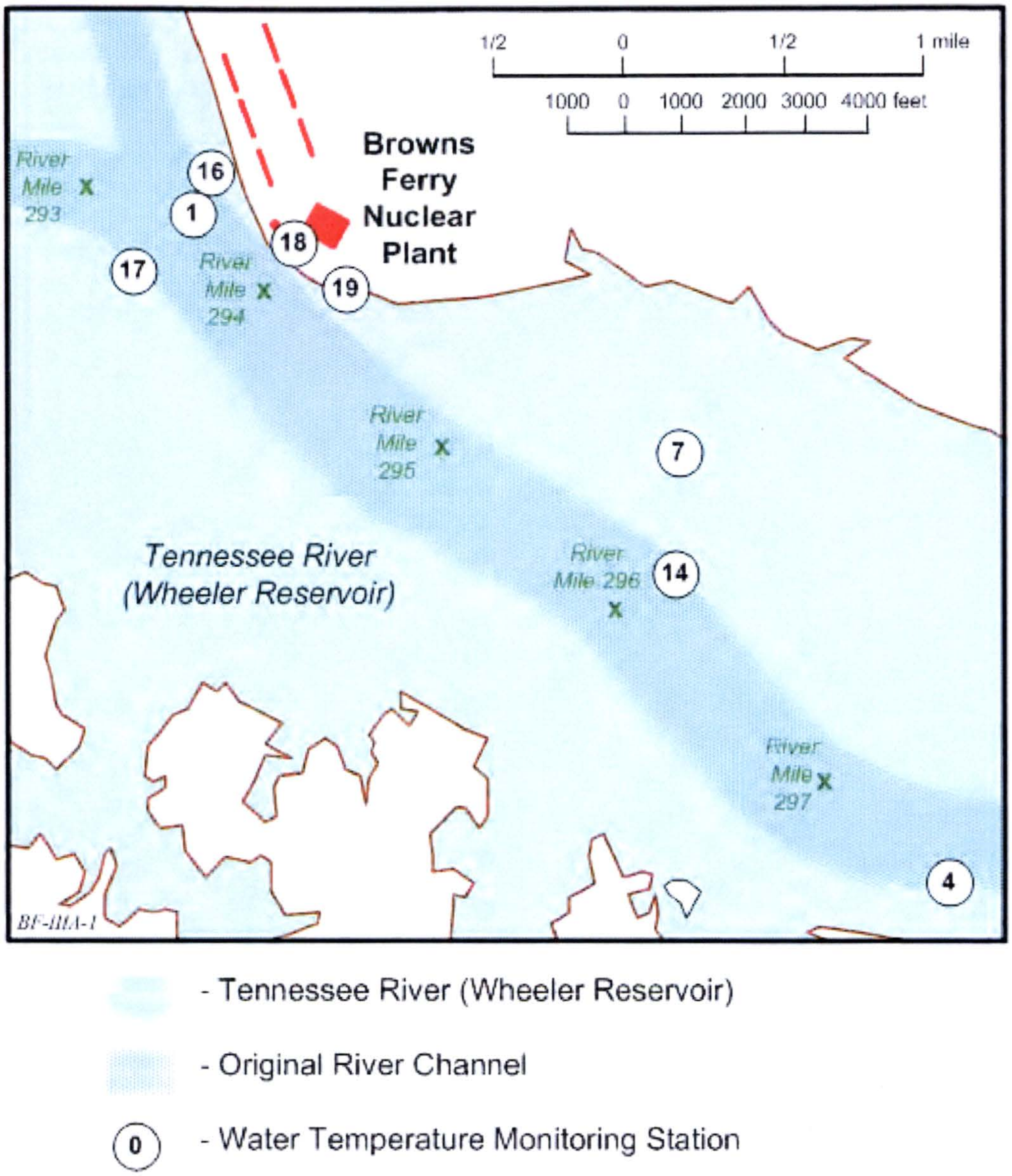


Figure 6. Locations of water temperature monitoring sites used to compare water temperatures upstream of Browns Ferry Nuclear Plant (BFN) intake and downstream of BFN discharge. Site 4 was used for upstream ambient temperatures of the BFN intake and was located at TRM 297.8. Sites 1, 16, and 17 were used for temperatures downstream of BFN discharge and were each located at TRM 293.5. This figure originated in the technical report: Browns Ferry Nuclear Plant Module III, Water Temperature Monitoring.

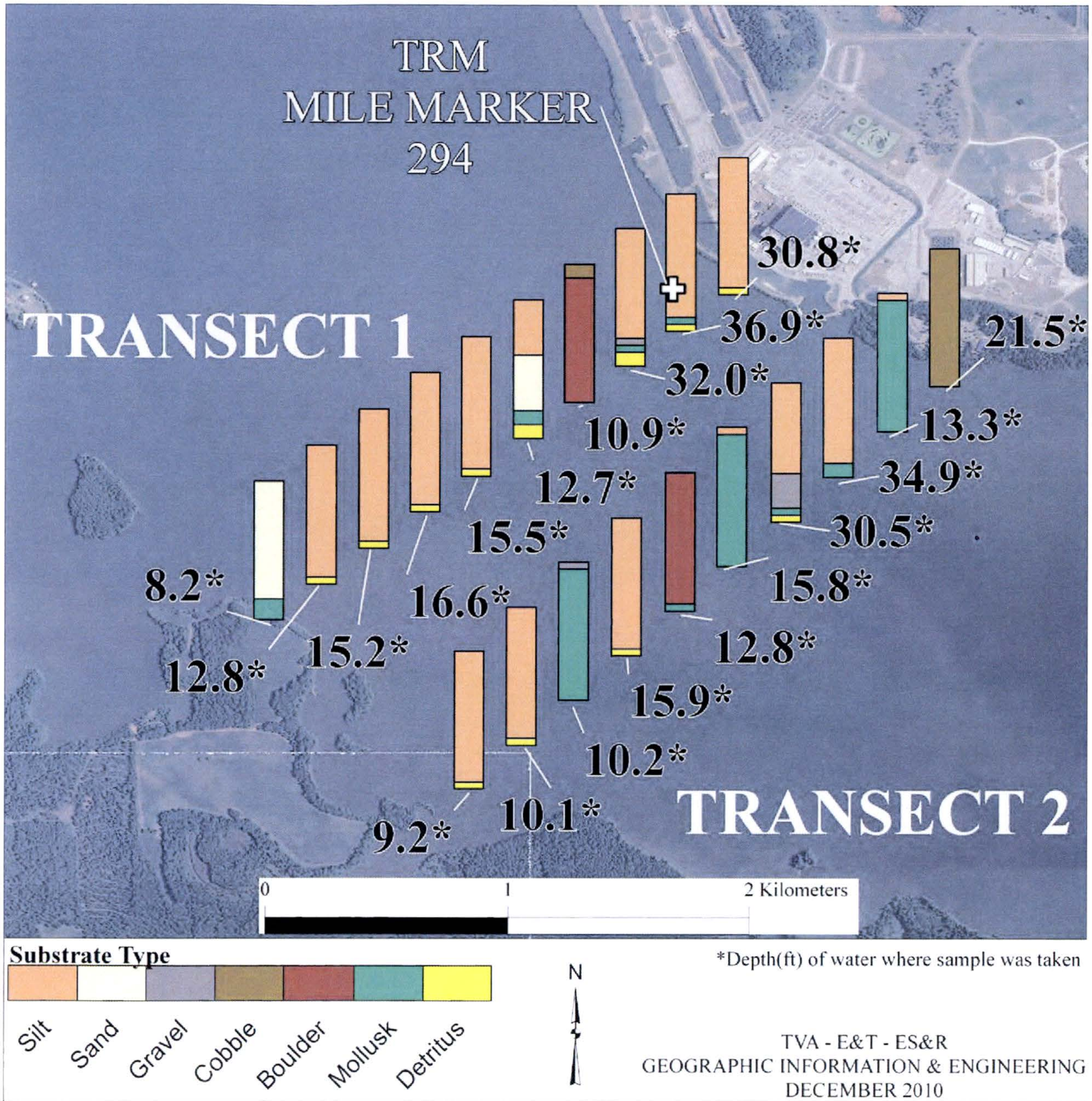


Figure 7. Substrate composition at ten equally spaced points per transect across the Tennessee River upstream of Browns Ferry Nuclear Plant. ***Water depth (ft) at each point is denoted. Of the eight transects established upstream of Browns Ferry Nuclear Plant, transects 1 and 2 are the closest to the plant.**

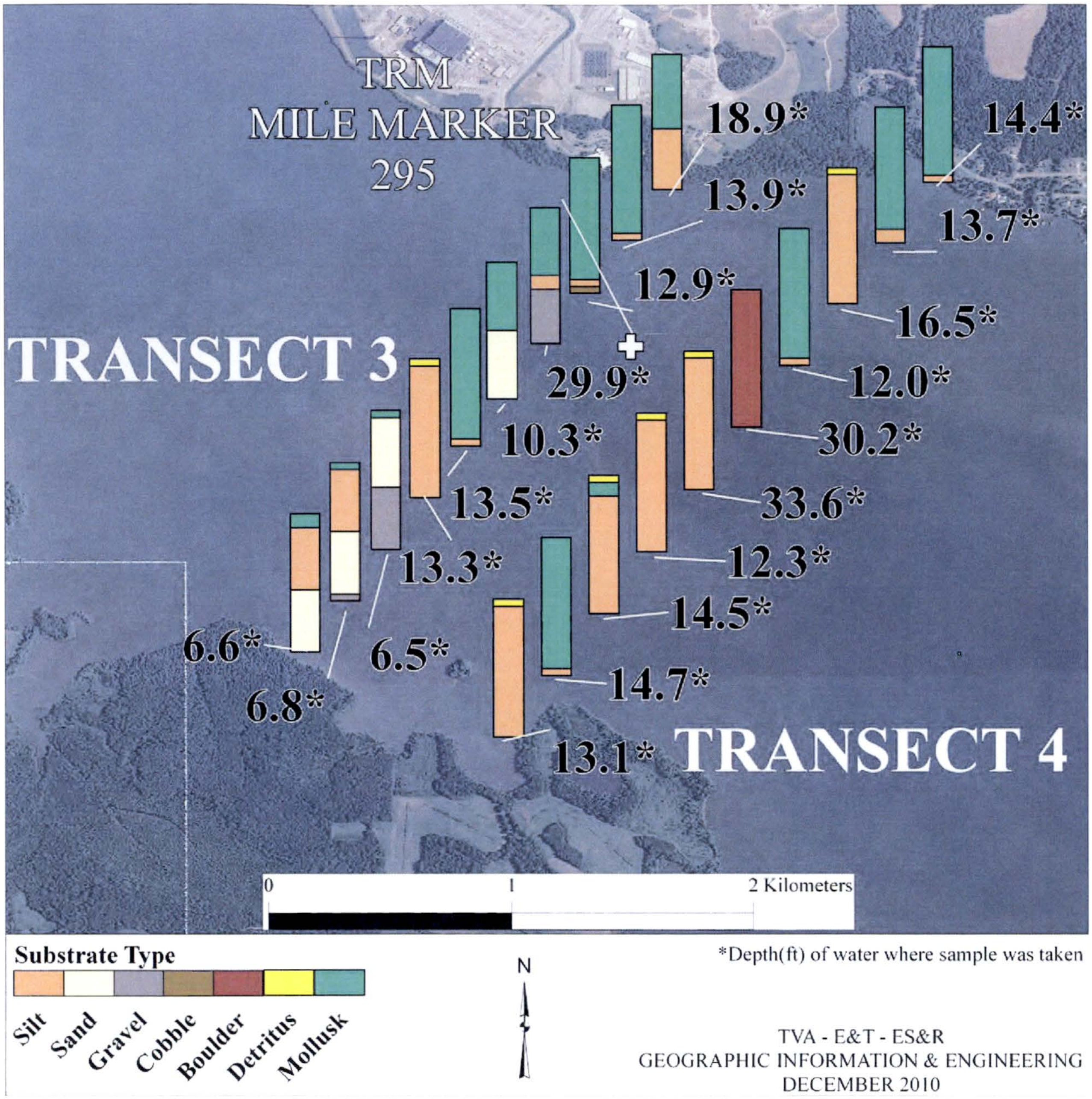


Figure 8. Substrate composition at ten equally spaced points per transect across the Tennessee River upstream of Browns Ferry Nuclear Plant. *Water depth (ft) at each point is denoted.

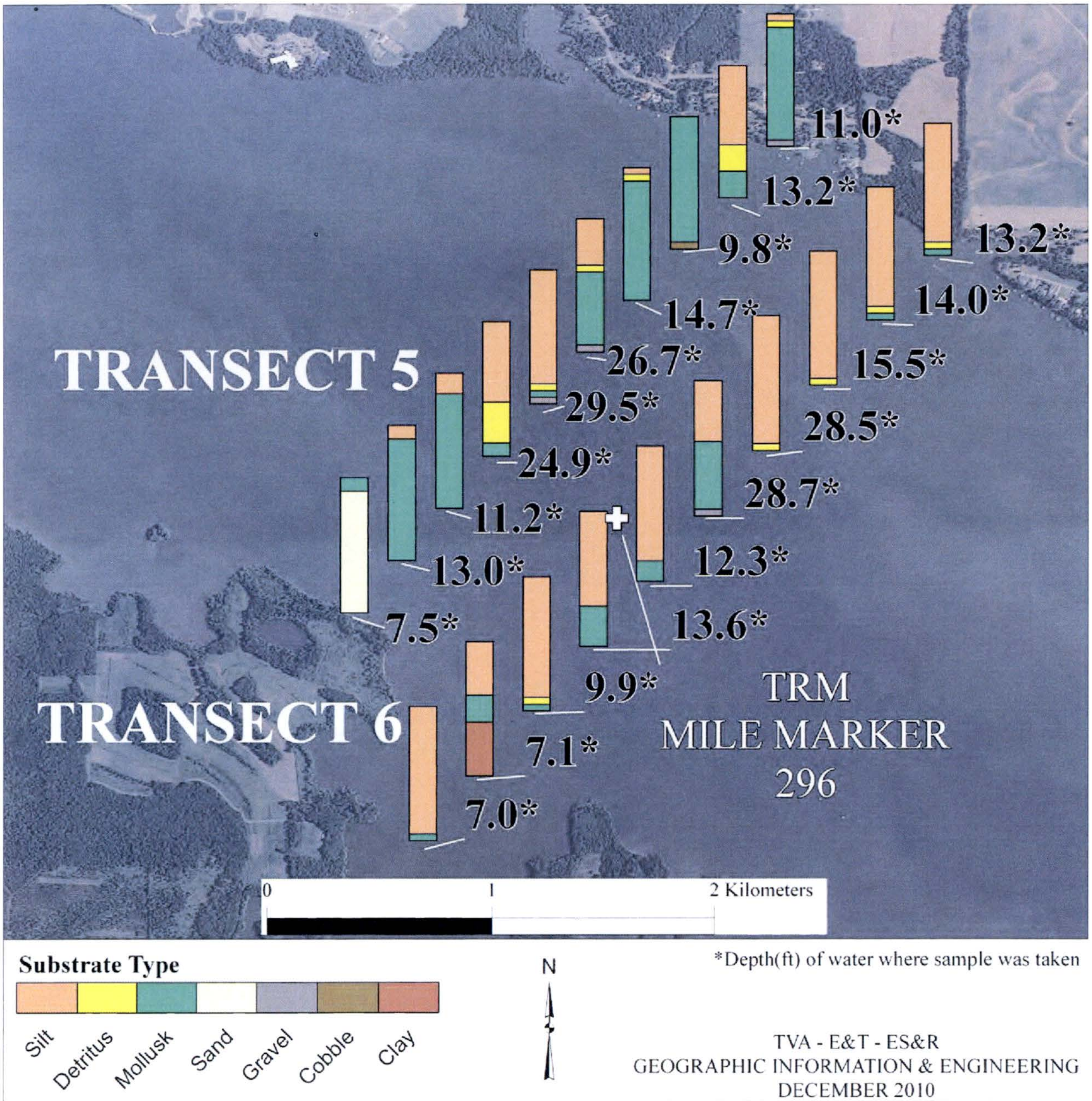


Figure 9. Substrate composition at ten equally spaced points per transect across the Tennessee River upstream of Browns Ferry Nuclear Plant. ***Water depth (ft) at each point is denoted.**

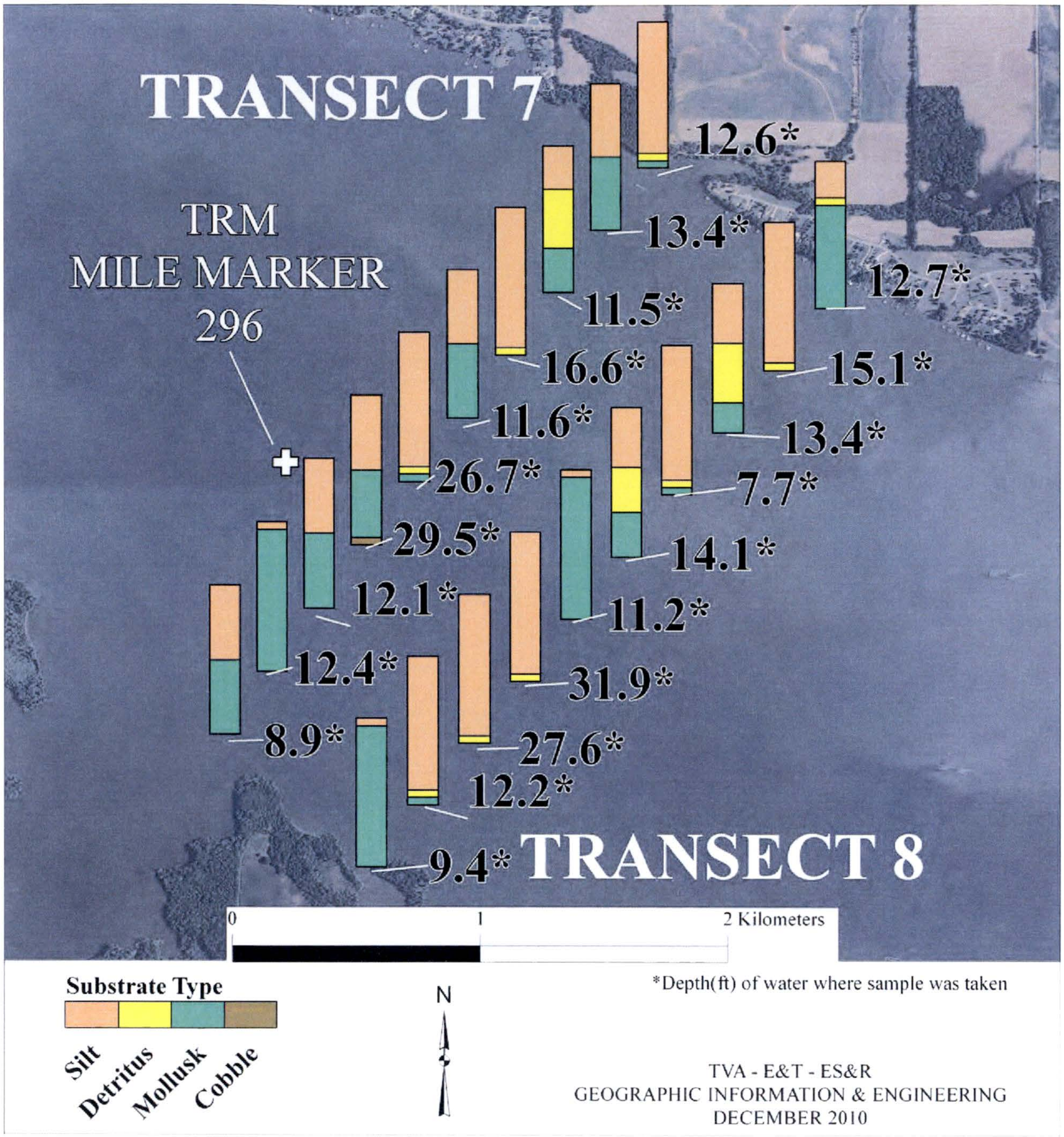


Figure 10. Substrate composition at ten equally spaced points per transect across the Tennessee River upstream of Browns Ferry Nuclear Plant. ***Water depth (ft) at each point is denoted.**

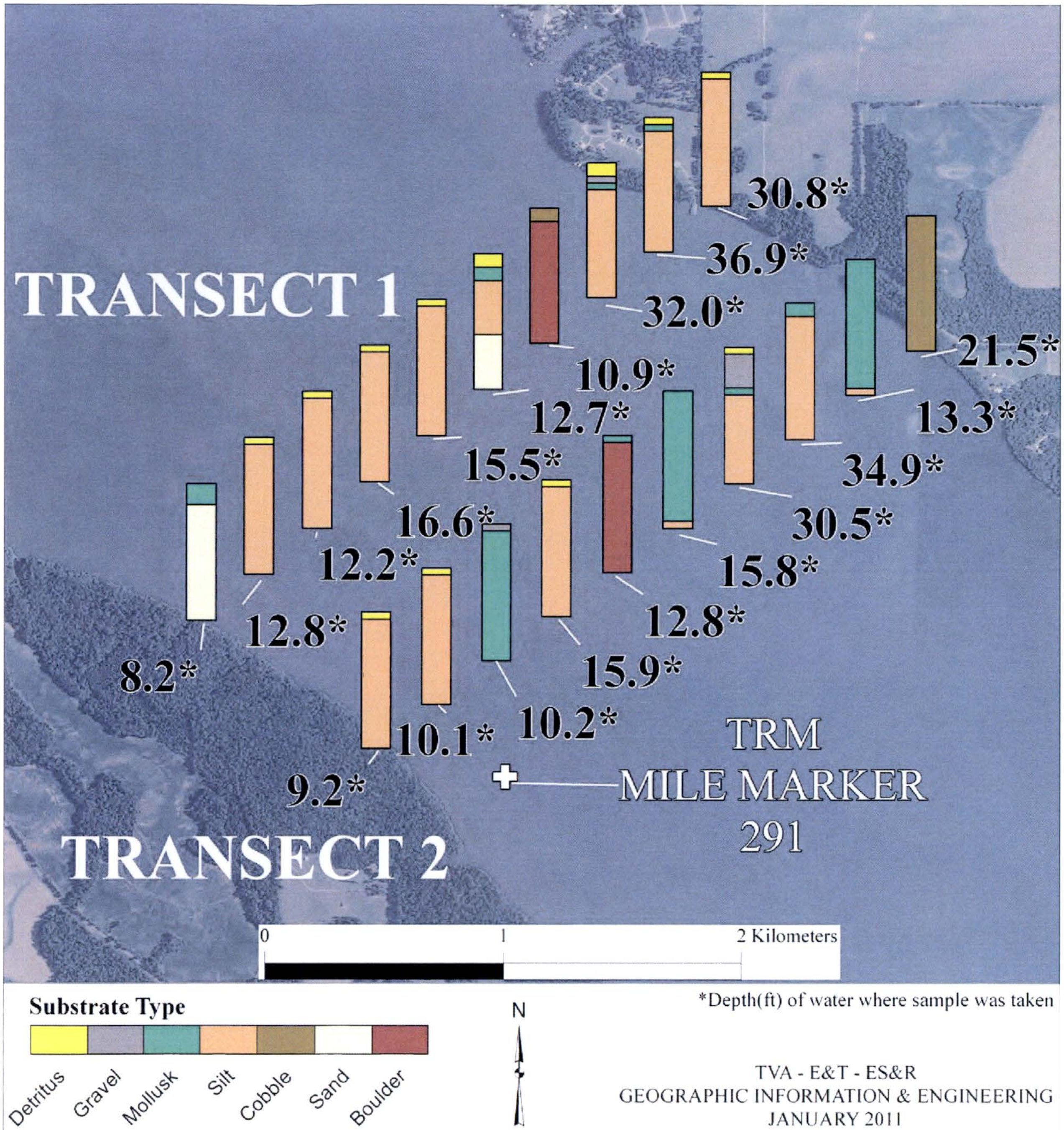


Figure 11. Substrate composition at ten equally spaced points per transect across the Tennessee River downstream of Browns Ferry Nuclear Plant. ***Water depth (ft) at each point is denoted. Transects 1 and 2 are the farthest downstream of the eight transects established downstream of Browns Ferry Nuclear Plant.**

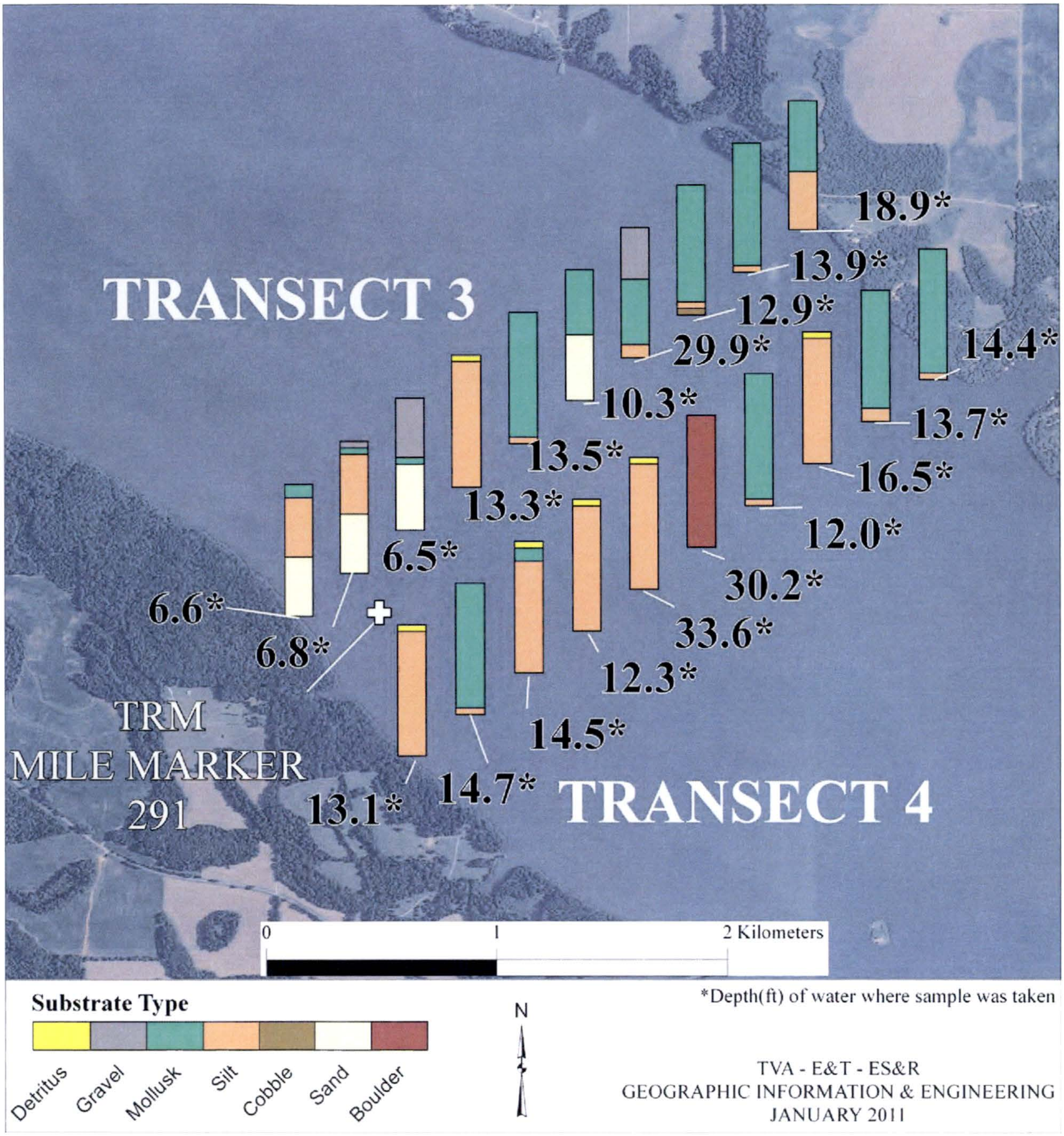


Figure 12. Substrate composition at ten equally spaced points per transect across the Tennessee River downstream of Browns Ferry Nuclear Plant. ***Water depth (ft) at each point is denoted.**

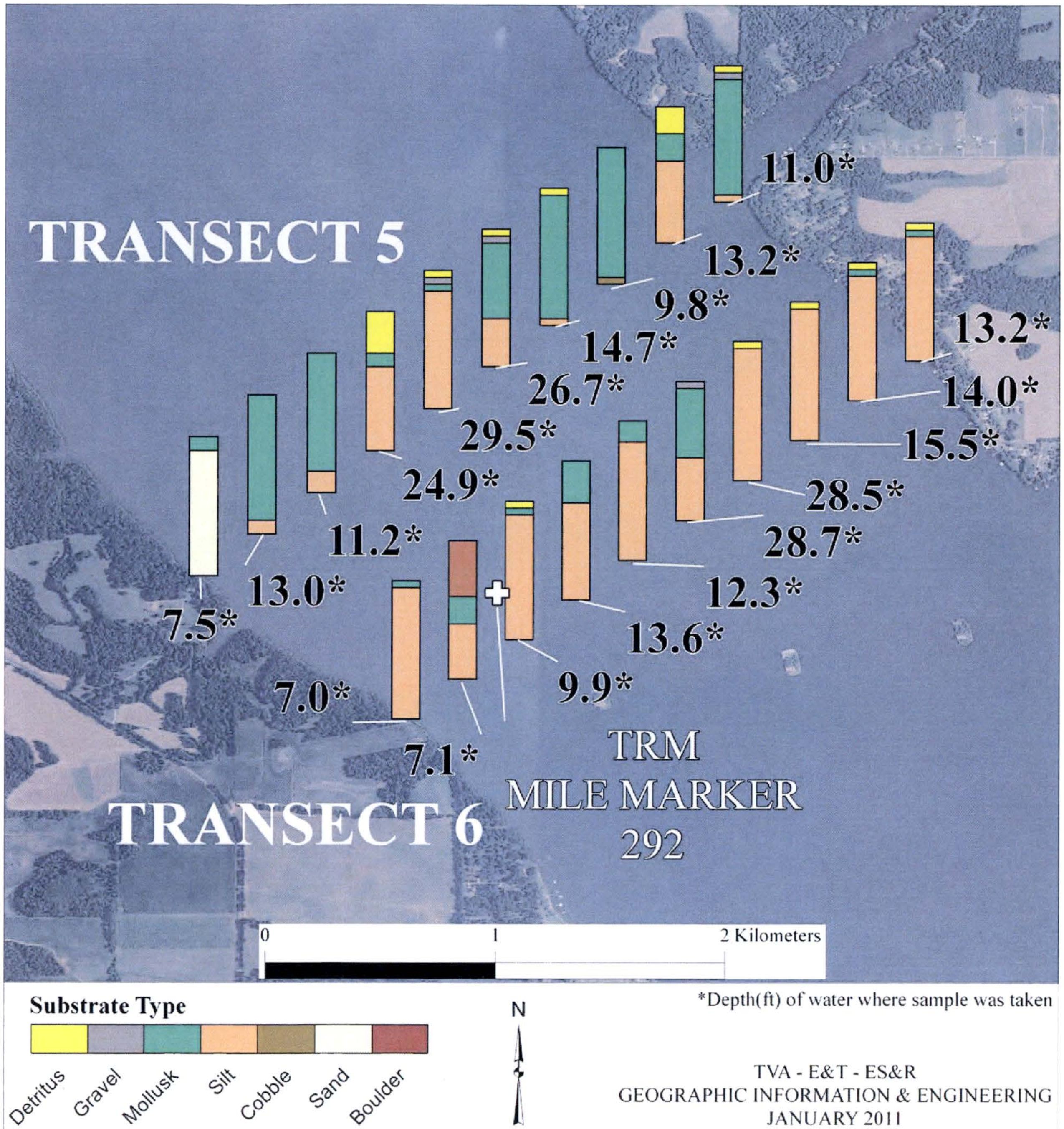


Figure 13. Substrate composition at ten equally spaced points per transect across the Tennessee River downstream of Browns Ferry Nuclear Plant. ***Water depth (ft) at each point is denoted.**

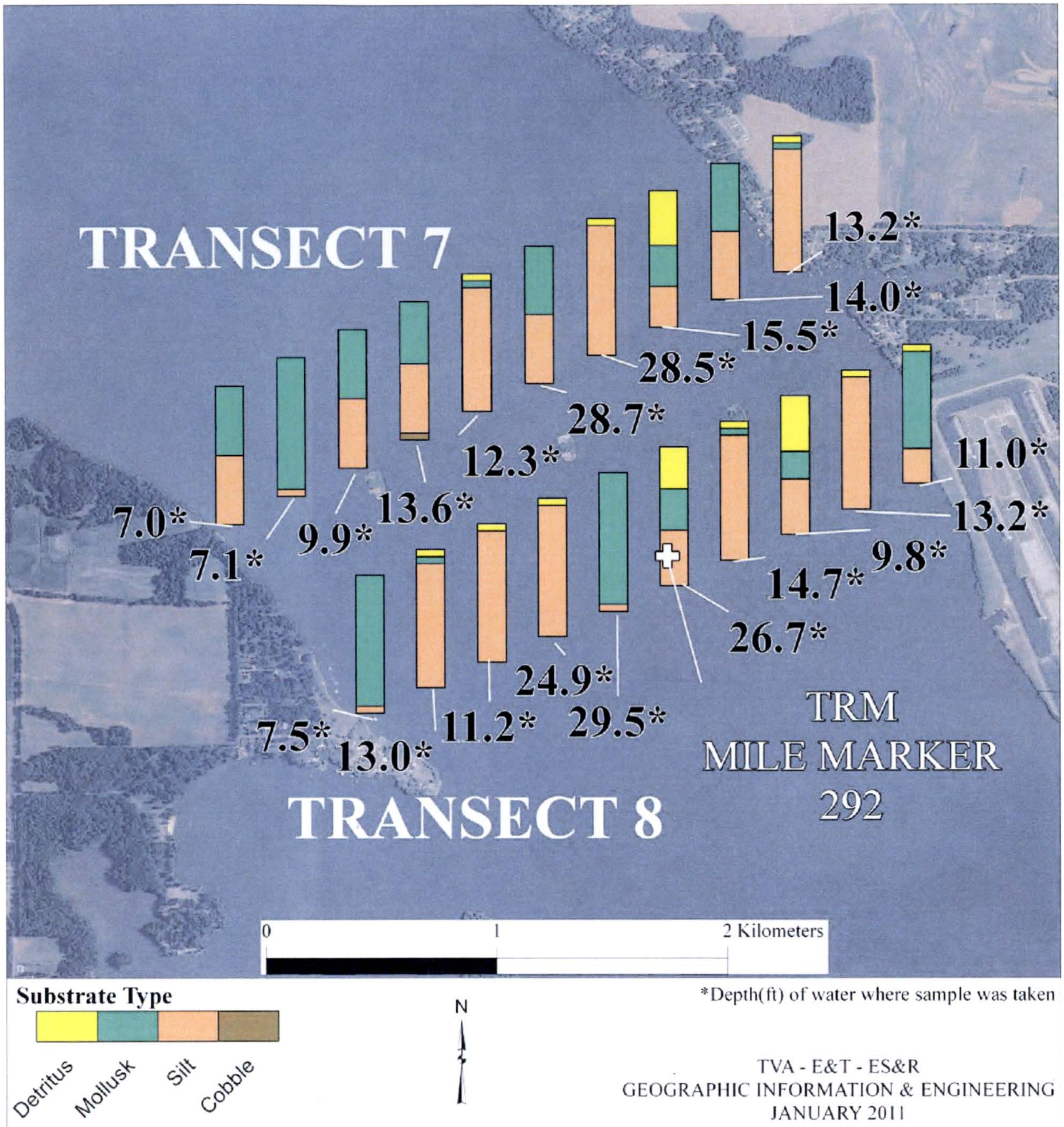


Figure 14. Substrate composition at ten equally spaced points per transect across the Tennessee River downstream of Browns Ferry Nuclear Plant. ***Water depth (ft) at each point is denoted.**

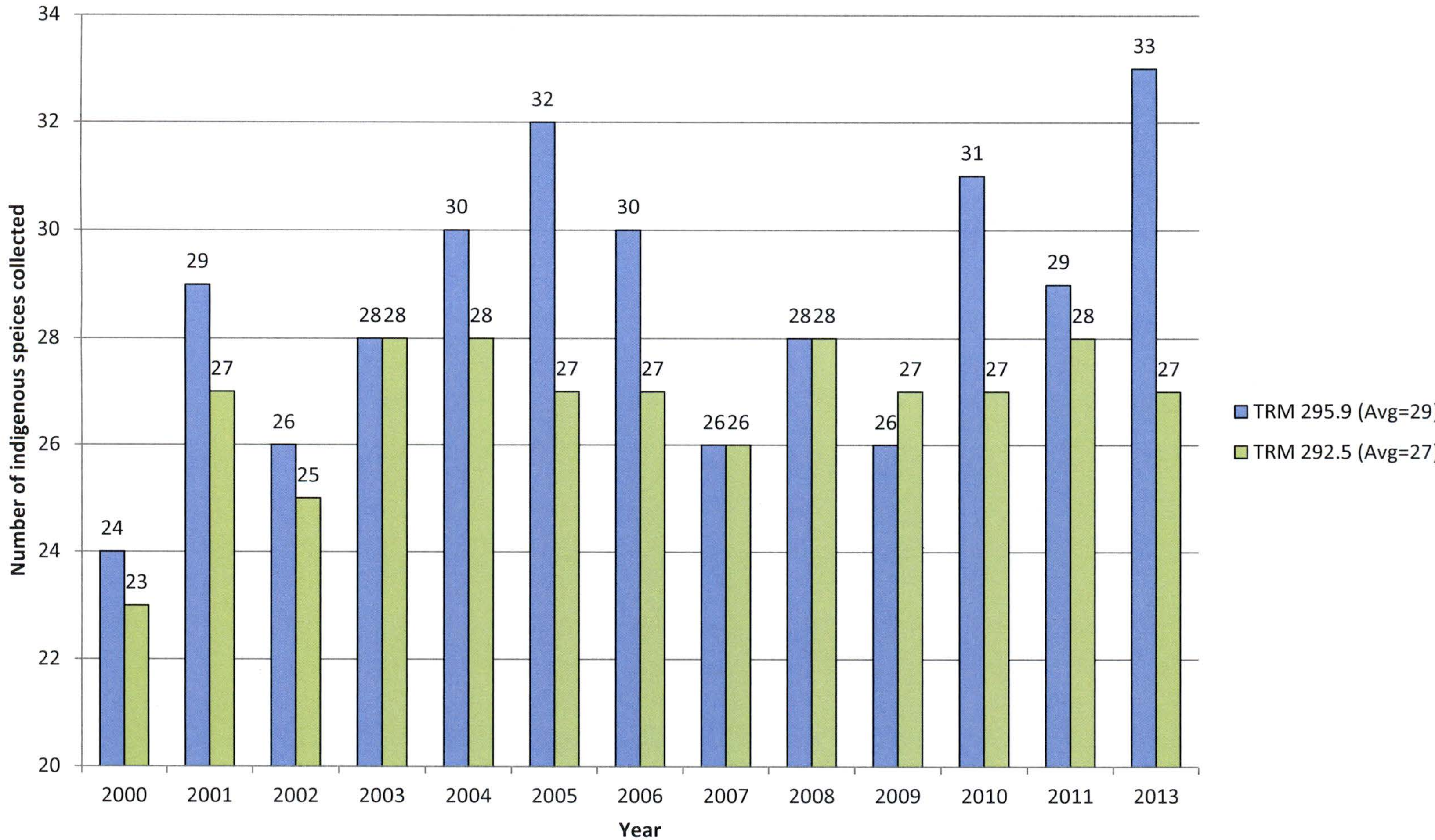


Figure 15. Comparison of observed values for the Reservoir Fish Assemblage Index metric "Number of Indigenous Species", over 13 years of autumn sampling at the sites upstream (TRM 295.9) and downstream (TRM 292.5) of Brown's Ferry Nuclear Plant.

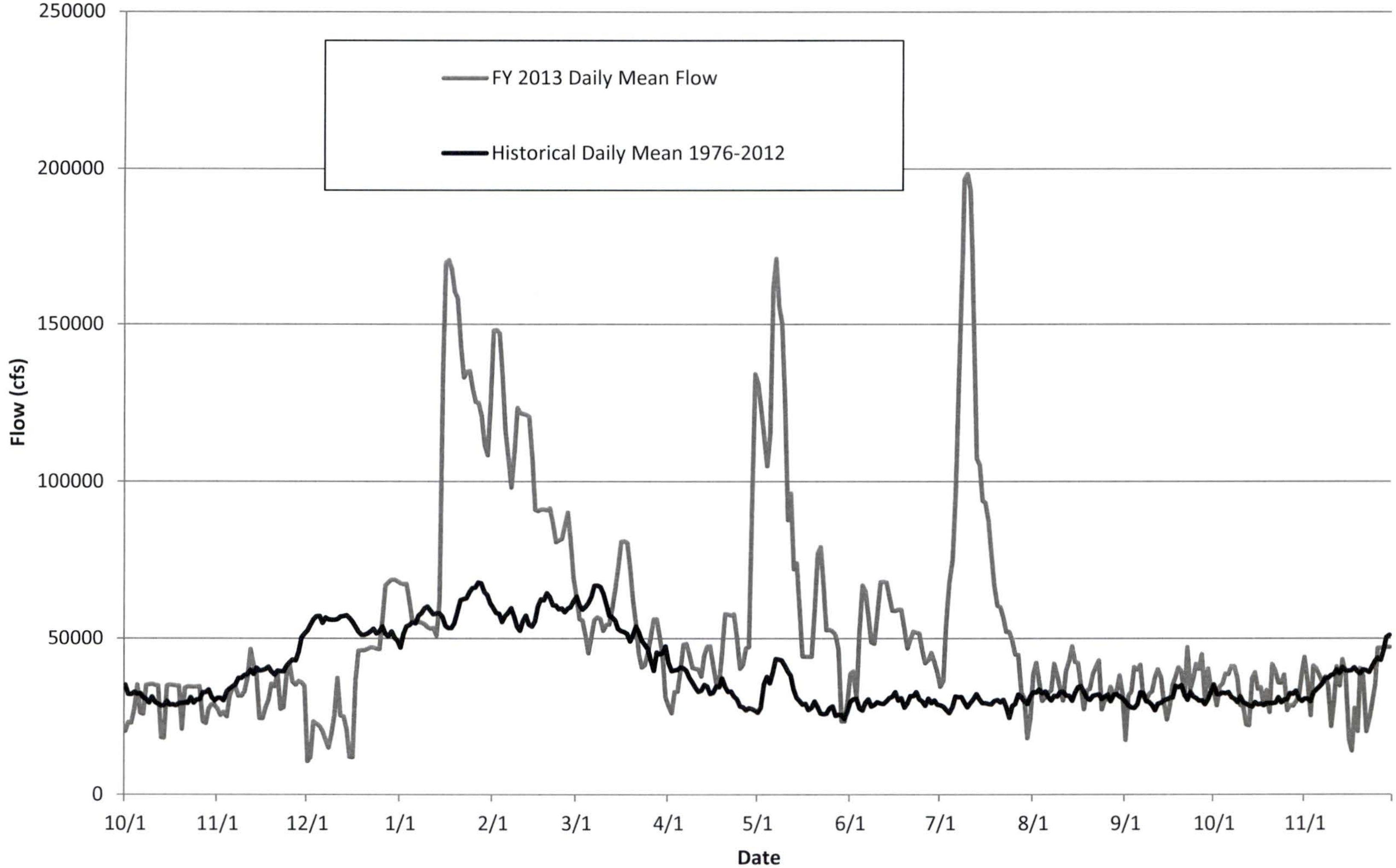


Figure 16. Daily mean flows from Guntersville Dam, October 2012 through November 2013, and historic daily flows for the same fiscal year period, averaged over the years 1976-2012.

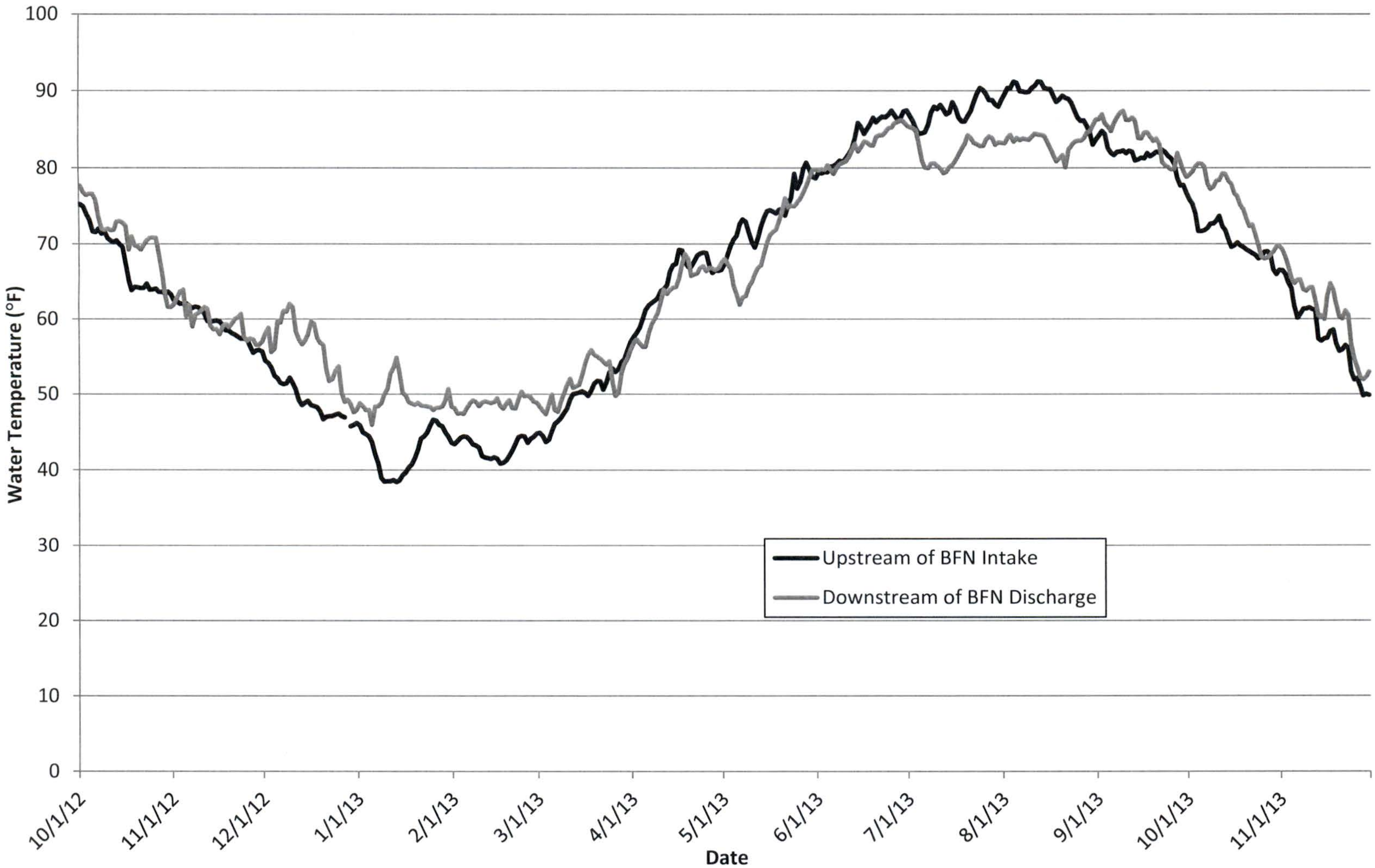


Figure 17. Daily water temperatures averaged over depth (3, 5, and 7 feet) upstream of Browns Ferry Nuclear Power Plant (BFN) intake and downstream of BFN discharge — October 2012 through November 2013.

Tables

Table 1. Shoreline Aquatic Habitat Index (SAHI) metrics and scoring criteria.

Metric	Scoring Criteria	Score
Cover	Stable cover (boulders, rootwads, brush, logs, aquatic vegetation, artificial structures) in 25 to 75% of the drawdown zone	5
	Stable cover in 10 to 25% or > 75% of the drawdown zone	3
	Stable Cover in < 10% of the drawdown zone	1
Substrate	Percent of drawdown zone with gravel substrate > 40	5
	Percent of drawdown zone with gravel substrate between 10 and 40	3
	Percent substrate gravel < 10	1
Erosion	Little or no evidence of erosion or bank failure. Most bank surfaces stabilized by woody vegetation.	5
	Areas of erosion small and infrequent. Potential for increased erosion due to less desirable vegetation cover (grasses) on > 25% of bank surfaces.	3
	Areas of erosion extensive, exposed or collapsing banks occur along > 30% of shoreline.	1
Canopy Cover	Tree or shrub canopy > 60% along adjacent bank	5
	Tree or shrub canopy 30 to 60% along adjacent bank	3
	Tree or shrub canopy < 30% along adjacent bank	1
Riparian Zone	Width buffered > 18 meters	5
	Width buffered between 6 and 18 meters	3
	Width buffered < 6 meters	1
Habitat	Habitat diversity optimum. All major habitats (logs, brush, native vegetation, boulders, gravel) present in proportions characteristic of high quality, sufficient to support all life history aspects of target species. Ready access to deeper sanctuary areas present.	5
	Habitat diversity less than optimum. Most major habitats present, but proportion of one is less than desirable, reducing species diversity. No ready access to deeper sanctuary areas.	3
	Habitat diversity is nearly lacking. One habitat dominates, leading to lower species diversity. No ready access to deeper sanctuary areas.	1
Gradient	Drawdown zone gradient abrupt (> 1 meter per 10 meters). Less than 10% of shoreline with abrupt gradient due to dredging.	5
	Drawdown zone gradient abrupt. (> 1 meter per 10 meters) in 10 to 40% of the shoreline resulting from dredging. Rip-rap used to stabilize bank along > 10% of the shoreline.	3
	Drawdown zone gradient abrupt in > 40 % of the shoreline resulting from dredging. Seawalls used to stabilize bank along > 10 % of the shoreline.	1

Table 2. Expected trophic guild proportions* and expected numbers of species* in lower mainstem Tennessee River reservoir transition zones, compared to values observed during 2013 monitoring at BFN.

	Lower Mainstem Tennessee River Transition Zones								Observed Upstream of BFN (TRM 295.9)		Observed Downstream of BFN (TRM 292.5)	
	Proportion (%)				Number of species							
	Trisected range [a]			Average [b]	Trisected range [a]			Average [b]				
Trophic Guild	-	Expected	+		-	Expected	+		Proportion (%)	Number of Species	Proportion (%)	Number of Species
Benthic Invertivore	< 6.7	6.4 to 13.4	> 13.4	5.5 ± 1.2	< 3	3 to 5	> 5	5 ± 1	10.7	5	8.3	4
Insectivore	< 24.6	24.6 to 49.1	> 49.1	40.0 ± 4.5	< 4	4 to 8	> 8	8 ± 1	32.5	12	60.0	11
Top Carnivore	< 15.1	15.1 to 30.2	> 30.2	18.3 ± 2.2	< 4	4 to 8	> 8	10 ± 1	14.4	12	7.1	8
Omnivore	>38.5	19.3 to 38.5	<19.3	28.7 ± 3.3	> 6	3 to 6	< 3	6 ± 1	39.2	7	23.3	6
Planktivore	< 9.4	9.4 to 18.7	>18.7	6.4 ± 2.6	0	1	> 1	1 ± 1	3.2	1	1.2	1
Parasitic	< 0.1	0.1 to 0.2	> 0.2	0.1 ± 0.04	0	1	> 1	1 ± 0	--	--	--	--
Herbivore	<1.8	1.8 to 3.6	>3.6	0.6 ± 0.4	0	1	> 1	1 ± 0	--	--	--	--
Specialized Insectivore	--	--	--	--	--	--	--	--	--	--	0.1	1

**Expected values were calculated from data collected over 900 electrofishing runs and 600 overnight experimental gill net sets in transition areas of lower mainstem Tennessee River reservoirs.*

[a] *Trisected ranges are intended to show below expected (-), expected, and above expected (+) values for trophic level proportions and species occurring within the transition zones in upper mainstem Tennessee River reservoirs.*

[b] *Average expected values are bound by 95% confidence intervals.*

Table 3. RFAI scoring criteria (2002) for inflow, transition, and forebay sections of lower mainstem reservoirs* in the Tennessee River system.

		Scoring Criteria								
		Inflow			Transition			Forebay		
Metric	**Gear**	**1**	**3**	**5**	**1**	**3**	**5**	**1**	**3**	**5**
1. Total species	Combined	< 14	14-27	> 27	< 16	16-30	>30	< 14	14-27	> 27
2. Number of centrarchid species	Combined	< 2	2-4	> 4	< 2	2-2	> 2	< 2	2-3	> 3
3. Number of benthic invertivores	Combined	< 4	4-7	> 7	< 4	4-7	> 7	< 4	4-6	> 6
4. Number of intolerant species	Combined	< 3	3-6	> 6	< 3	3-4	> 4	< 2	2-4	> 4
5. Percent tolerant individuals	Electrofishing	>51%	26-51%	< 26%	>54%	27-54%	< 27%	> 61%	30-61%	< 30%
	Gill netting				>30%	15-30%	< 15%	>46%	22-46%	< 22%
6. Percent dominance by one species	Electrofishing	>47%	24-47%	< 24%	>58%	29-58%	< 29%	>59%	30-59%	< 30%
	Gill netting				>34%	17-34%	< 17%	>43%	21-43%	< 21%
7. Percent non-indigenous species	Electrofishing	>4%	2-4%	< 2%	>2%	1-2%	< 1%	>2%	2-2%	< 2%
	Gill netting				>2%	1-2%	< 1%	>2%	1-2%	< 1%
8. Number of top carnivore species	Combined	< 4	4-7	>7	< 4	4-7	>7	< 4	4-7	>7
9. Percent top carnivores	Electrofishing	< 15%	15-29%	>29%	< 5%	5-10%	>10%	< 6%	6-12%	>12%
	Gill netting				< 20%	20-39%	>39%	< 25%	25-49%	>49%
10. Percent omnivores	Electrofishing	>48%	24-48%	< 24%	>48%	24-48%	< 24%	>59%	30-59%	< 30%
	Gill netting				>33%	16-33%	< 16%	>49%	24-49%	< 24%
11. Average number per run	Electrofishing	< 68	68-136	>136	< 243	243-487	>487	< 170	170-341	>341
	Gill netting				< 11	11-22	>22	< 20	20-40	>40
12. Percent anomalies	Electrofishing	>5%	2-5%	< 2%	>5%	2-5%	< 2%	>5%	2-5%	< 2%
	Gill netting				>5%	2-5%	< 2%	>5%	2-5%	< 2%

**Lower mainstem Tennessee River reservoirs include Guntersville, Wheeler, Wilson, Pickwick, and Kentucky.*

Transition scoring criteria were used to score sites upstream and downstream of BFN.

Table 4. Scoring criteria for laboratory-processed benthic macroinvertebrate community samples from inflow, transition, and forebay zones of mainstem Tennessee River reservoirs.

Benthic Community Metrics	Scoring Criteria								
	Inflow			Transition			Forebay		
	1	3	5	1	3	5	1	3	5
1. Average number of taxa	<4.2	4.2-8.3	>8.3	<3.3	3.3-6.6	>6.6	<2.8	2.8-5.5	>5.5
2. Proportion of samples with long-lived organisms	<0.6	0.6-0.8	>0.8	<0.6	0.6-0.9	>0.9	<0.6	0.6-0.8	>0.8
3. Average number of EPT taxa	<0.9	0.9-1.9	>1.9	<0.6	0.6-1.4	>1.4	<0.6	0.6-0.9	>0.9
4. Average proportion of oligochaete individuals	>23.9	23.9-12.0	<12.0	>21.9	21.9-11.0	<11.0	>41.9	41.9-21.0	<21.0
5. Average proportion of total abundance comprised by the two most abundant taxa	>86.2	86.2-73.1	<73.1	>87.9	87.9-77.8	<77.8	>90.3	90.3-81.7	<81.7
6. Average density excluding chironomids and oligochaetes	<400.0	400.0-799.9	>799.9	<305.0	305.0-609.9	>609.9	<125.0	125.0-249.9	>249.9
7. Zero Samples: proportion of samples containing no organisms	>0	-	0	>0	-	0	>0	-	0

Transition scoring criteria were used to score sites upstream and downstream of BFN.

Table 5. SAHI scores for shoreline habitat assessments conducted within the RFAI sample reach upstream of BFN, autumn 2009.

Left Descending Bank	Transects 1	2	3	4	5	6	7	8	Avg.
Latitude	34.68917	34.6832	34.6806	34.67959	34.67709	34.66978	34.67027	34.66841	
Longitude	-87.13621	-87.13172	-87.12188	-87.1183	-87.10876	-87.10915	-87.10009	-87.09753	
Aquatic Macrophytes	0%	0%	0%	0%	0%	0%	0%	0%	0%
SAHI Variables									
Cover	3	1	3	5	1	3	3	3	3
Substrate	1	5	3	3	5	1	1	1	3
Erosion	3	5	5	3	3	3	3	3	4
Canopy Cover	5	5	5	5	5	5	5	5	5
Riparian Zone	1	5	5	5	3	5	5	5	4
Habitat	3	3	1	3	1	3	1	1	2
Slope	1	5	5	1	3	5	1	1	3
Total	17	29	27	25	21	25	19	19	24
Rating	Fair	Good	Good	Fair	Fair	Fair	Fair	Fair	Fair

Right Descending Bank	Transects 1	2	3	4	5	6	7	8	Avg.
Latitude	34.70109	34.69937	34.69862	34.6986	34.69566	34.69302	34.69062	34.68843	
Longitude	-87.11896	-87.11535	-87.10973	-87.10061	-87.09157	-87.08836	-87.08452	-87.08094	
Aquatic Macrophytes	0%	0%	0%	0%	0%	0%	0%	0%	0%
SAHI Variables									
Cover	3	3	5	5	1	1	5	5	4
Substrate	1	5	1	5	5	5	5	5	4
Erosion	5	5	5	5	5	1	5	5	5
Canopy Cover	1	5	5	1	1	5	1	1	3
Riparian Zone	1	5	5	1	1	5	1	1	3
Habitat	3	1	3	1	1	1	1	1	2
Slope	1	3	1	1	3	1	1	1	2
Total	15	27	25	19	17	19	19	19	23
Rating	Poor	Good	Fair	Fair	Fair	Fair	Fair	Fair	Fair

Scoring criteria: poor (7-16), fair (17-26), good (27-35)

Table 6. SAHI scores for shoreline habitat assessments conducted within the RFAI sample reach downstream of BFN, autumn 2009.

Left Descending Bank	Transects								
	1	2	3	4	5	6	7	8	Avg.
Latitude	34.72824	34.72603	34.72398	34.72068	34.71496	34.7128	34.71082	34.70351	
Longitude	-87.1759	-87.1728	-87.1704	-87.1678	-87.4621	-87.1577	-87.1543	-87.1488	
Aquatic Macrophytes	0%	0%	0%	0%	0%	0%	0%	0%	0%
SAHI Variables									
Cover	1	3	1	1	1	1	1	3	2
Substrate	5	1	1	5	5	5	5	5	4
Erosion	1	5	5	1	1	1	5	5	3
Canopy Cover	5	5	5	5	5	5	3	1	4
Riparian Zone	5	5	5	5	5	5	3	1	4
Habitat	3	3	1	1	1	1	1	1	2
Slope	1	1	1	1	1	1	1	3	1
Total	21	23	19	19	19	19	19	19	20
Rating	Fair	Fair	Fair	Fair	Fair	Fair	Fair	Fair	Fair

Right Descending Bank	Transects								
	1	2	3	4	5	6	7	8	Avg.
Latitude	34.74369	34.74081	34.73891	34.73519	34.73081	34.7266	34.72058	34.71239	
Longitude	-87.1565	-87.1522	-87.1507	-87.1475	-87.1428	-87.1376	-87.1325	-87.1275	
Aquatic Macrophytes	0%	0%	0%	0%	0%	0%	0%	0%	0%
SAHI Variables									
Cover	3	3	3	1	5	5	5	1	3
Substrate	1	1	5	5	1	5	1	5	3
Erosion	5	1	1	1	5	5	5	5	4
Canopy Cover	5	5	5	5	3	3	1	1	4
Riparian Zone	3	5	3	5	1	1	1	1	3
Habitat	3	1	1	1	3	1	1	1	2
Slope	1	1	1	1	1	1	1	1	1
Total	21	17	19	19	19	21	15	15	20
Rating	Fair	Fair	Fair	Fair	Fair	Fair	Poor	Poor	Fair

Scoring criteria: poor (7-16), fair (17-26), good (27-35)

Table 7. Substrate percentages and average water depth (ft) per transect upstream and downstream of BFN, autumn 2009.

	% Substrate per transect upstream of BFN								
Substrate Type	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Avg.**
Silt	68.5	45.0	25.5	49.0	27.1	79.5	56.0	58.0	51.1
Mollusk Shell	3.5	30.5	45.5	38.5	56.8	13.5	38.0	30.0	32.0
Sand	12.5	0	19.0	0	9.0	0	0	0	5.1
Detritus	4.0	2.0	0.5	2.5	7.5	2.5	5.5	10.0	4.3
Boulder	9.0	9.5	0	10.0	0	0	0	0	3.6
Gravel	0.5	0.5	9.0	0	1.5	0.5	0.5	0	1.6
Cobble	1.0	10.0	0.5	0	0.5	0	0	0	1.5
Clay	0	0	0	0	0	0	4.0	0	0.5
Average Depth (ft)	19.2	17.4	13.3	17.5	16.2	15.0	15.5	15.5	16.2
Actual Depth Range: 6.5 to 36.9 ft									

	% Substrate per transect downstream of BFN								
Substrate Type	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Avg.**
Silt	75.4	80.5	77.0	56.3	69.5	55.5	44.0	62.5	65.1
Mollusk Shell	22.6	12.5	14.5	32.0	7.0	11.5	26.0	29.0	19.4
Sand	0	0	0.0	9.1	9.0	9.0	17.0	0.0	5.5
Detritus	2.0	6.5	8.0	2.5	0.5	1.0	2.5	4.5	3.4
Bedrock	0	0	0.0	0.0	9.0	0.0	10.0	0.0	2.4
Boulder	0	0	0.0	0.0	0.0	10.0	0.0	0.0	1.3
Cobble	0	0	0.0	0.0	1.0	0.0	0.0	4.0	0.6
Gravel	0	0	1.0	0.0	0.0	0.0	0.5	0.0	0.2
Clay	0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Average Depth (ft)	21.0	20.0	20.2	18.7	18.3	18.9	20.6	20.2	19.7
Actual Depth Range: 9.1 to 31.7 ft									

Table 8. Individual metric scores and the overall RFAI scores upstream (TRM 295.9) and downstream (TRM 292.5) of Browns Ferry Nuclear plant, autumn 2013.

Autumn 2013		TRM 295.9		TRM 292.5	
Metric		**Obs**	**Score**	**Obs**	**Score**
A. Species richness and composition					
1. Number of indigenous species (See Tables 9 and 10)	Combined	**33**	**5**	**27**	**3**
2. Number of centrarchid species (less *Micropterus*)	Combined	**8** Black crappie Bluegill Green sunfish Longear sunfish Orangespotted sunfish Redear sunfish Warmouth White crappie	**5**	**6** Black crappie Bluegill Green sunfish Longear sunfish Redear sunfish Warmouth	**5**
3. Number of benthic invertivore species	Combined	**5** Black redhorse Freshwater drum Logperch Northern hog sucker Spotted sucker	**3**	**4** Black redhorse Freshwater drum Logperch Spotted sucker	**3**
4. Number of intolerant species	Combined	**6** Black redhorse Longear sunfish Northern hog sucker Skipjack herring Smallmouth bass Spotted sucker	**5**	**5** Black redhorse Longear sunfish Skipjack herring Smallmouth bass Spotted sucker	**5**

Table 8. (Continued)

Autumn 2013 Metric		TRM 295.9 Obs	Score	TRM 292.5 Obs	Score
5. Percent tolerant individuals	Electrofishing	**49.5%** Bluegill 10.7% Common carp 0.9% Gizzard shad 26.6% Golden shiner 0.9% Green sunfish 1.8% Largemouth bass 5.3% Longnose gar 0.2% Redbreast sunfish 0.2% Spotfin shiner 2.9% White crappie 0.2%	**1.5**	**39.0%** Bluegill 3.3% Common carp 0.2% Gizzard shad 17.% Green sunfish 4.7% Largemouth bass 2.1% Redbreast sunfish 0.1% Spotfin shiner 11.7%	**1.5**
	Gill Netting	**26.9%** Gizzard shad 9.6% Largemouth bass 7.7% Longnose gar 9.6%	**1.5**	**33.3%** Bluegill 3.9% Common carp 2.0% Gizzard shad 25.5% Largemouth bass 2.0%	**0.5**
6. Percent dominance by one species	Electrofishing	**26.6%** Gizzard shad	**2.5**	**35.1%** Mississippi silverside	**1.5**
	Gill Netting	**11.5%** Channel catfish	**2.5**	**25.5%** Gizzard shad	**1.5**
7. Percent non-indigenous species	Electrofishing	**11.2%** Common carp 0.9% Mississippi silverside 10.1% Redbreast sunfish 0.2%	**0.5**	**35.4%** Common carp 0.2% Mississippi silverside 35.1% Redbreast sunfish 0.1%	**0.5**
	Gill Netting	**NA**	**2.5**	**2.0%** Common carp	**1.5**

Table 8. (Continued)

Autumn 2013 Metric		TRM 295.9 Obs		Score	TRM 292.5 Obs		Score
8. Number of top carnivore species	Combined	**12**		5	**8**		5
		Black crappie			Black crappie		
		Flathead catfish			Flathead catfish		
		Largemouth bass			Largemouth bass		
		Longnose gar			Sauger		
		Sauger			Skipjack herring		
		Skipjack herring			Smallmouth bass		
		Smallmouth bass			Spotted gar		
		Spotted bass			Yellow bass		
		Spotted gar					
		White bass					
		White crappie					
		Yellow bass					
B. Trophic composition							
9. Percent top carnivores	Electrofishing	**12.1%**		2.5	**4.8%**		0.5
		Black crappie	0.2%		Largemouth bass	2.1%	
		Flathead catfish	0.2%		Smallmouth bass	2.5%	
		Largemouth bass	5.3%		Yellow bass	0.2%	
		Longnose gar	0.2%				
		Smallmouth bass	1.4%				
		Spotted bass	0.2%				
		Spotted gar	0.8%				
		White bass	2.4%				
		White crappie	0.2%				
		Yellow bass	1.5%				
	Gill Netting	**44.2%**		2.5	**49.0%**		2.5
		Flathead catfish	1.9%		Black crappie	2.0%	
		Largemouth bass	7.7%		Flathead catfish	7.8%	
		Longnose gar	9.6%		Largemouth bass	2.0%	
		Sauger	7.7%		Sauger	5.9%	
		Skipjack herring	11.5%		Skipjack herring	23.5%	
		Spotted gar	1.9%		Spotted gar	3.9%	
		White bass	3.8%		Yellow bass	3.9%	

Table 8. (Continued)

Autumn 2013 Metric		TRM 295.9 Obs		Score	TRM 292.5 Obs		Score
10. Percent omnivores	Electrofishing	**39.0%**		1.5	**22.4%**		2.5
		Black buffalo	0.2%		Channel catfish	2.3%	
		Channel catfish	6.2%		Common carp	0.2%	
		Common carp	0.9%		Gizzard shad	17.0%	
		Gizzard shad	26.6%		Smallmouth buffalo	2.9%	
		Golden shiner	0.9%				
		Smallmouth buffalo	4.2%				
	Gill Netting	**42.3%**		0.5	**39.2%**		0.5
		Black buffalo	3.8%		Black buffalo	2.0%	
		Blue catfish	7.7%		Blue catfish	3.9%	
		Channel catfish	11.5%		Channel catfish	2.0%	
		Gizzard shad	9.6%		Common carp	2.0%	
		Smallmouth buffalo	9.6%		Gizzard shad	25.5%	
					Smallmouth buffalo	3.9%	
C. Fish abundance and health							
11. Average number per run	Electrofishing	**44.1**		**0.5**	**61.2**		**0.5**
	Gill Netting	**5.2**		**0.5**	**5.1**		**0.5**
12. Percent anomalies	Electrofishing	**3.3%**		**1.5**	**1.1%**		**2.5**
	Gill Netting	**0.0%**		**2.5**	**0.0%**		**2.5**
Overall RFAI Score				**46 Good**			**40 Fair**

Table 9. Species collected, ecological and recreational designation and corresponding electrofishing (EF) and gill net (GN) catch per unit effort upstream (TRM 295.9) of Browns Ferry Nuclear Plant discharge – Autumn 2013.

Common Name	Scientific name	Trophic level	Native species	Tolerance	Thermally Sensitive Species	Comm. Valuable Species	Rec. Valuable Species	EF Catch Per Run	EF Catch Per Hr	Total fish EF	GN Catch Per Net Night	Total Fish GN	Total fish Combined	Percent Composition
Longnose gar	*Lepisosteus osseus*	TC	X	TOL	.	X	.	0.07	0.25	1	0.50	5	6	0.8
Gizzard shad	*Dorosoma cepedianum*	OM	X	TOL	.	X	X	11.73	44.67	176	0.50	5	181	25.4
Common carp*	*Cyprinus carpio*	OM	.	TOL	.	X	.	0.40	1.52	6	.	.	6	0.8
Golden shiner	*Notemigonus crysoleucas*	OM	X	TOL	.	X	X	0.40	1.52	6	.	.	6	0.8
Spotfin shiner	*Cyprinella spiloptera*	IN	X	TOL	.	.	.	1.27	4.82	19	.	.	19	2.7
Redbreast sunfish*	*Lepomis auritus*	IN	.	TOL	.	.	X	0.07	0.25	1	.	.	1	0.1
Green sunfish	*Lepomis cyanellus*	IN	X	TOL	.	.	X	0.80	3.05	12	.	.	12	1.7
Bluegill	*Lepomis macrochirus*	IN	X	TOL	.	.	X	4.73	18.02	71	.	.	71	9.9
Largemouth bass	*Micropterus salmoides*	TC	X	TOL	.	.	X	2.33	8.88	35	0.40	4	39	5.5
White crappie	*Pomoxis annularis*	TC	X	TOL	.	.	X	0.07	0.25	1	.	.	1	0.1
Skipjack herring	*Alosa chrysochloris*	TC	X	INT	.	X	.	.	.	.	0.60	6	6	0.8
Northern hog sucker	*Hypentelium nigricans*	BI	X	INT	.	.	.	0.07	0.25	1	.	.	1	0.1
Spotted sucker	*Minytrema melanops*	BI	X	INT	X	X	.	1.13	4.31	17	0.10	1	18	2.5
Black redhorse	*Moxostoma duquesnei*	BI	X	INT	.	X	.	0.07	0.25	1	.	.	1	0.1
Longear sunfish	*Lepomis megalotis*	IN	X	INT	.	.	X	1.13	4.31	17	.	.	17	2.4
Smallmouth bass	*Micropterus dolomieu*	TC	X	INT	.	.	X	0.60	2.28	9	.	.	9	1.3
Spotted gar	*Lepisosteus oculatus*	TC	X	.	.	X	.	0.33	1.27	5	0.10	1	6	0.8
Threadfin shad	*Dorosoma petenense*	PK	X	.	.	X	X	1.53	5.84	23	.	.	23	3.2
Emerald shiner	*Notropis atherinoides*	IN	X	.	X	.	.	0.07	0.25	1	.	.	1	0.1
Bullhead minnow	*Pimephales vigilax*	IN	X	.	.	.	X	0.47	1.78	7	.	.	7	1.0
Smallmouth buffalo	*Ictiobus bubalus*	OM	X	.	.	X	.	1.87	7.11	28	0.50	5	33	4.6
Black buffalo	*Ictiobus niger*	OM	X	.	.	X	.	0.07	0.25	1	0.20	2	3	0.4
Blue catfish	*Ictalurus furcatus*	OM	X	.	.	X	X	.	.	.	0.40	4	4	0.6
Channel catfish	*Ictalurus punctatus*	OM	X	.	.	X	X	2.73	10.41	41	0.60	6	47	6.6
Flathead catfish	*Pylodictis olivaris*	TC	X	.	.	X	X	0.07	0.25	1	0.10	1	2	0.3
White bass	*Morone chrysops*	TC	X	.	.	.	X	1.07	4.06	16	0.20	2	18	2.5
Yellow bass	*Morone mississippiensis*	TC	X	.	.	X	X	0.67	2.54	10	.	.	10	1.4
Warmouth	*Lepomis gulosus*	IN	X	.	.	.	X	0.07	0.25	1	.	.	1	0.1
Orangespotted sunfish	*Lepomis humilis*	IN	X	.	.	.	X	0.20	0.76	3	.	.	3	0.4
Redear sunfish	*Lepomis microlophus*	IN	X	.	.	.	X	1.73	6.60	26	0.40	4	30	4.2

Table 9. (Continued)

Common Name	Scientific name	Trophic level	Native species	Tolerance	Thermally Sensitive Species	Comm. Valuable Species	Rec. Valuable Species	EF Catch Per Run	EF Catch Per Hr	Total fish EF	GN Catch Per Net Night	Total Fish GN	Total fish Combined	Percent Composition
Hybrid sunfish	Hybrid *Lepomis* sp.	IN	X	.	.	.	.	0.20	0.76	3	.	.	3	0.4
Spotted bass	*Micropterus punctulatus*	TC	X	.	.	.	X	0.07	0.25	1	.	.	1	0.1
Black crappie	*Pomoxis nigromaculatus*	TC	X	.	.	.	X	0.07	0.25	1	.	.	1	0.1
Logperch	*Percina caprodes*	BI	X	.	X	.	.	2.33	8.88	35	.	.	35	4.9
Sauger	*Sander canadensis*	TC	X	.	.	.	X	.	.	.	0.40	4	4	0.6
Freshwater drum	*Aplodinotus grunniens*	BI	X	.	.	X	.	1.27	4.82	19	0.20	2	21	2.9
Mississippi silverside*	*Menidia audens*	IN	.	.	.	X	X	4.47	17.01	67	.	.	67	9.4
Total			**34**		**3**	**17**	**23**	**44.16**	**167.97**	**662**	**5.20**	**52**	**714**	**100.0**
Number Samples								**15**			**10**			
Species Collected								**34**			**15**			

Trophic level: benthic invertivore (BI), herbivore (HB), insectivore (IN), omnivore (OM), planktivore (PK), parasitic (PS), specialized insectivore (SP), top carnivore (TC);
Tolerance: tolerant species (TOL), intolerant species (INT);Comm.-Commercially, Rec.-Recreationally.
**Denotes aquatic nuisance species next to common name. All species are considered representative important species. No species collected have a Federal Threatened or Endangered status.*

Table 10. Species collected, ecological and recreational designation and corresponding electrofishing (EF) and gill net (GN) catch per unit effort downstream (TRM 292.5) of Browns Ferry Nuclear Plant discharge – Autumn 2013.

Common Name	Scientific name	Trophic level	Native species	Tolerance	Thermally Sensitive Species	Comm. Valuable Species	Rec. Valuable Species	EF Catch Per Run	EF Catch Per Hr	Total fish EF	GN Catch Per Net Night	Total Fish GN	Total fish Combined	Percent Composition
Gizzard shad	*Dorosoma cepedianum*	OM	X	TOL	.	X	X	10.40	40.10	156	1.30	13	169	17.4
Common carp*	*Cyprinus carpio*	OM	.	TOL	.	X	.	0.13	0.51	2	0.10	1	3	0.3
Spotfin shiner	*Cyprinella spiloptera*	IN	X	TOL	.	.	.	7.13	27.51	107	.	.	107	11.0
Redbreast sunfish*	*Lepomis auritus*	IN	.	TOL	.	.	X	0.07	0.26	1	.	.	1	0.1
Green sunfish	*Lepomis cyanellus*	IN	X	TOL	.	.	X	2.87	11.05	43	.	.	43	4.4
Bluegill	*Lepomis macrochirus*	IN	X	TOL	.	.	X	2.00	7.71	30	0.20	2	32	3.3
Largemouth bass	*Micropterus salmoides*	TC	X	TOL	.	.	X	1.27	4.88	19	0.10	1	20	2.1
Skipjack herring	*Alosa chrysochloris*	TC	X	INT	.	X	.	.	.	.	1.20	12	12	1.2
Spotted sucker	*Minytrema melanops*	BI	X	INT	X	X	.	0.20	0.77	3	.	.	3	0.3
Black redhorse	*Moxostoma duquesnei*	BI	X	INT	.	X	.	0.07	0.26	1	.	.	1	0.1
Longear sunfish	*Lepomis megalotis*	IN	X	INT	.	.	X	4.00	15.42	60	.	.	60	6.2
Smallmouth bass	*Micropterus dolomieu*	TC	X	INT	.	.	X	1.53	5.91	23	.	.	23	2.4
Spotted gar	*Lepisosteus oculatus*	TC	X	.	.	X	.	.	.	.	0.20	2	2	0.2
Threadfin shad	*Dorosoma petenense*	PK	X	.	.	X	X	0.80	3.08	12	.	.	12	1.2
Emerald shiner	*Notropis atherinoides*	IN	X	.	X	.	.	0.20	0.77	3	.	.	3	0.3
Bullhead minnow	*Pimephales vigilax*	IN	X	.	.	.	.	0.33	1.29	5	.	.	5	0.5
Smallmouth buffalo	*Ictiobus bubalus*	OM	X	.	.	X	.	1.80	6.94	27	0.20	2	29	3.0
Black buffalo	*Ictiobus niger*	OM	X	.	.	X	.	.	.	.	0.10	1	1	0.1
Blue catfish	*Ictalurus furcatus*	OM	X	.	.	X	X	.	.	.	0.20	2	2	0.2
Channel catfish	*Ictalurus punctatus*	OM	X	.	.	X	X	1.40	5.40	21	0.10	1	22	2.3
Flathead catfish	*Pylodictis olivaris*	TC	X	.	.	X	X	.	.	.	0.40	4	4	0.4
Yellow bass	*Morone mississippiensis*	TC	X	.	.	X	X	0.13	0.51	2	0.20	2	4	0.4
Warmouth	*Lepomis gulosus*	IN	X	.	.	.	X	0.13	0.51	2	.	.	2	0.2
Redear sunfish	*Lepomis microlophus*	IN	X	.	.	.	X	0.27	1.03	4	.	.	4	0.4

Table 10. (Continued)

Common Name	Scientific name	Trophic level	Native species	Tolerance	Thermally Sensitive Species	Comm. Valuable Species	Rec. Valuable Species	EF Catch Per Run	EF Catch Per Hr	Total fish EF	GN Catch Per Net Night	Total Fish GN	Total fish Combined	Percent Composition
Hybrid sunfish	Hybrid *Lepomis* sp.	IN	X	.	.	.	.	0.13	0.51	2	.	.	2	0.2
Black crappie	*Pomoxis nigromaculatus*	TC	X	.	.	.	X	.	.	.	0.10	1	1	0.1
Stripetail darter	*Etheostoma kennicotti*	SP	X	.	.	.	.	0.07	0.26	1	.	.	1	0.1
Logperch	*Percina caprodes*	BI	X	.	X	.	.	1.87	7.20	28	.	.	28	2.9
Sauger	*Sander canadensis*	TC	X	.	.	.	X	.	.	.	0.30	3	3	0.3
Freshwater drum	*Aplodinotus grunniens*	BI	X	.	.	X	.	2.93	11.31	44	0.40	4	48	5.0
Mississippi silverside*	*Menidia audens*	IN	.	.	.	X	X	21.47	82.78	322	.	.	322	33.2
Total			**28**		**3**	**15**	**17**	**61.20**	**235.97**	**918**	**5.10**	**51**	**969**	**100**
Number Samples								**15**			**10**			
Species Collected								**24**			**15**			

Trophic level: benthic invertivore (BI), herbivore (HB), insectivore (IN), omnivore (OM), planktivore (PK), parasitic (PS), specialized insectivore (SP), top carnivore (TC); Tolerance: tolerant species (TOL), intolerant species (INT);Comm.-Commercially, Rec.-Recreationally.
**Denotes aquatic nuisance species next to common name. All species are considered representative important species. No species collected have a Federal Threatened or Endangered status.*

Table 11. Spatial statistical comparisons of numbers of species, mean electrofishing catch per unit effort values (number/run), tolerance designations, trophic levels, and non-indigenous individuals, including species richness and Simpson and Shannon diversity values, for samples collected near Browns Ferry Nuclear Plant, autumn 2013.

Parameter	Mean (Standard Deviation) Upstream (TRM 295.9)	Downstream (TRM 292.5)	Significant Difference	Test Statistic	P Value
Number of species (per run)					
Total (Species richness)	11.1 (3.9)	10.3 (2.1)	No	Z= -1.01	0.31
Benthic invertivores	1.5 (1.0)	1.5 (0.6)	No	Z= 0.52	0.60
Insectivores	3.9 (1.8)	4.8 (1.6)	No	t= 1.49	0.15
Omnivores	2.9 (1.2)	2.1 (1.1)	No	t= -1.97	0.06
Top carnivores	2.6 (1.4)	1.5 (0.6)	Yes	Z= -2.26	0.02
Non-indigenous	1.1 (0.7)	0.9 (0.7)	No	Z= -0.75	0.46
Tolerant	3.7 (1.5)	4.1 (1.2)	No	Z= 0.65	0.52
Intolerant	1.2 (0.9)	1.6 (0.5)	No	Z= 1.22	0.22
Thermally sensitive	0.9 (0.7)	0.9 (0.5)	No	Z= -0.22	0.83
CPUE (per run)					
Total	2.9 (1.7)	4.1 (2.8)	No	Z= 0.79	0.43
Benthic invertivores	0.2 (0.2)	0.1 (0.1)	No	Z= 0.52	0.60
Insectivores	1.0 (0.8)	2.6 (2.4)	No	Z= 1.42	0.16
Omnivores	1.1 (1.1)	0.9 (0.7)	No	Z= -0.19	0.85
Top Carnivores	0.4 (0.2)	0.2 (0.1)	Yes	Z= -2.12	0.03
Non-indigenous	0.3 (0.4)	1.4 (1.8)	No	Z= 1.11	0.27
Tolerant	1.5 (1.1)	1.6 (1.1)	No	Z= 0.60	0.55
Intolerant	0.2 (0.4)	0.4 (0.3)	Yes	Z= 2.70	0.01
Thermally sensitive	0.2 (0.3)	0.2 (0.1)	No	Z= -0.11	0.92
Diversity indices (per run)					
Simpson	0.8 (0.1)	0.8 (0.1)	No	Z= -1.12	0.26
Shannon	8.1 (5.2)	7.4 (6.0)	No	t= -0.46	0.65

Table 12. Summary of autumn RFAI scores from sites located directly upstream and downstream of BFN and scores from sampling conducted during 1993-2013 as part of the Vital Signs monitoring program in Wheeler Reservoir.

Site	Location	1993	1994	1995	1997	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2013	1993-2013 Avg.
Inflow	TRM 348.0	46	48	42	48	36	-	36	40	38	42	44	42	32	38	40	40	46	40	**42**
Transition BFN Upstream	TRM 295.9	45	43	34	40	30	41	37	43	39	43	46	41	39	42	39	43	40	46	**41**
Transition BFN Downstream	TRM 292.5	-	-	-	-	-	43	40	41	43	43	36	42	42	45	36	38	38	40	**41**
Forebay	TRM 277.0	52	44	48	45	42	-	41	45	44	43	45	44	49	46	47	40	46	43	**45**
Elk River Embayment	ERM 6.0	41	47	36	49	36	-	49	-	44	49	47	-	39	-	42	-	43	39	**44**

RFAI Scores: 12-21 ("Very Poor"), 22-31 ("Poor"), 32-40 ("Fair"), 41-50 ("Good"), or 51-60 ("Excellent")

Table 13. Comparison of RBI metric ratings and total scores for laboratory-processed samples collected upstream and downstream of Browns Ferry Nuclear Plant, Wheeler Reservoir, autumn 2013.

Metric	Downstream TRM 290.4		Downstream TRM 293.2		Upstream TRM 295.9	
	Obs	Rating	Obs	Rating	Obs	Rating
1. Average number of taxa	7.8	5	10.6	5	11	5
2. Proportion of samples with long-lived organisms	1.0	5	1.0	5	1.0	5
3. Average number of EPT taxa	1.2	3	1.8	5	1.7	5
4. Average proportion of oligochaete individuals	2.7	5	8.3	5	3.6	5
5. Average proportion of total abundance comprised by the two most abundant taxa	81.1	3	66.7	5	67.3	5
6. Average density excluding chironomids and oligochaetes	1,161.7	5	1,228.3	5	1,111.7	5
7. Zero-samples – proportion of samples containing no organisms	0	5	0	5	0	5
Benthic Index Score		**31**		**35**		**35**
Ecological Health Rating		**Excellent**		**Excellent**		**Excellent**

Reservoir Benthic Index Scores: 7-12 ("Very Poor"), 13-18 ("Poor"), 19-23 ("Fair"), 24-29 ("Good"), 30-35 ("Excellent")

Table 14. Metric scores and overall RBI scores determined from field processing criteria, for sites upstream and downstream of Browns Ferry Nuclear Plant, Wheeler Reservoir, autumn 2000-2010.

Downstream – TRM 291.7

Sample Year	Avg No. Taxa Obs	Avg No. Taxa Score	% Long-Lived Obs	% Long-Lived Score	Avg. No. EPT taxa Obs	Avg. No. EPT taxa Score	% Oligochaetes Obs	% Oligochaetes Score	% Dominant Taxa Obs	% Dominant Taxa Score	Density excl chiro and oligo Obs	Density excl chiro and oligo Score	Zero Samples Obs	Zero Samples Score	Overall Score
2000	4	3	1	5	0.8	5	6.4	5	79.6	3	125	1	0	5	**27**
2001	5.6	5	1	5	1.1	5	5.7	5	43	5	230	1	0	5	**31**
2002	5.7	5	1	5	0.8	5	7.4	5	88.1	1	120	1	0	5	**27**
2003	6.5	5	1	5	1	5	0.3	5	76.1	5	1270	5	0	5	**35**
2004	6.7	5	1	5	1	5	1.4	5	74.4	5	523.3	3	0	5	**33**
2005	5.5	5	1	5	0.8	5	3.6	5	80.3	3	508.3	3	0	5	**31**
2006	6.2	5	1	5	0.1	5	2.3	5	77.3	5	272.3	1	0	5	**31**
2007	6.4	5	1	5	0.8	5	12.4	5	80.2	3	166.7	1	0	5	**29**
2008	6.3	5	0.9	5	1.1	5	7.2	5	81.5	3	181.7	1	0	5	**29**
2009	5	5	0.7	3	0.6	3	4.6	5	90.3	1	83.3	1	0	5	**23**
2010	4.6	5	0.7	3	0.6	3	0.3	5	94.8	1	126.7	1	0	5	**23**
Mean:	5.7		0.9		0.8		4.7		78.7		327.9		0.0		**29**
Maximum:	6.7		1		1.1		12.4		94.8		1270		0		
Minimum:	4		0.7		0.1		0.3		43		83.3		0		

Table 14. (Continued)

Upstream – TRM 295.9

Sample Year	Avg No. Taxa		% Long-Lived		Avg. No. EPT taxa		% Oligochaetes		% Dominant Taxa		Density excl chiro and oligo		Zero Samples		**Overall Score**
	Obs	Score	Obs	Score	Obs	Score	Obs	Score	Obs	Score	Obs	Score	Obs	Score	
2000	4.6	5	1	5	0.8	5	6.6	5	77.6	5	190	1	0	5	**31**
2001	5.3	5	1	5	1	5	2.7	5	79.8	3	188.3	1	0	5	**29**
2002	6.5	5	1	5	0.8	5	7.2	5	75.6	5	266.7	1	0	5	**31**
2003	5.1	5	0.8	5	1	5	0.8	5	84.1	3	456.7	3	0	5	**31**
2004	6.2	5	1	5	0.9	5	1.1	5	73.7	5	353.6	3	0	5	**33**
2005	5.6	5	1	5	1.2	5	2.3	5	85.4	3	490	3	0	5	**31**
2006	5.9	5	0.8	5	0.7	3	7	5	75	5	348.3	3	0	5	**31**
2007	6.5	5	0.9	5	0.9	5	1.9	5	74.2	5	353.3	3	0	5	**33**
2008	5.8	5	0.7	3	0.5	3	7.8	5	85.4	3	220	1	0	5	**25**
2009	5.1	5	1	5	0.4	3	12.2	5	75.2	5	133.3	1	0	5	**29**
2010	4.2	3	1	5	0.8	5	2.1	5	92	1	108.3	1	0	5	**25**
Mean:	5.5		0.9		0.8		4.7		79.8		282.6		0		**30**
Maximum:	6.5		1		1.2		12.2		92		490		0		
Minimum:	4.2		0.7		0.4		0.8		73.7		108.3		0		

Table 15. Metric scores and overall RBI scores determined from lab processing criteria, for sites upstream and downstream of Browns Ferry Nuclear Plant, Wheeler Reservoir, 2001-2006.

Downstream – TRM 291.7

	Avg No. Taxa		% Long-Lived		Avg. No. EPT taxa		% Oligochaetes		% Dominant Taxa		Density excl chiro and oligo		Zero Samples		Overall Score
Sample Year	Obs	Score	Obs	Score	Obs	Score	Obs	Score	Obs	Score	Obs	Score	Obs	Score	
2001	7.8	5	1	5	1.1	3	7.6	5	71.7	5	315	3	0	5	**31**
2002	5.4	3	1	5	0.9	3	10.9	5	88.2	1	106.7	1	0	5	**23**
2003	7.3	5	1	5	1	3	0.4	5	73.2	5	1270	5	0	5	**33**
2004	7.9	5	1	5	1	3	1.6	5	73.5	5	551.7	3	0	5	**31**
2006	9.4	5	1	5	1.6	5	2.3	5	78.1	3	448.2	3	0	5	**31**
Mean:	7.56		1		1.12		4.56		76.94		538.32		0		**30**
Maximum:	9.4		1		1.6		10.9		88.2		1270		0		
Minimum:	5.4		1		0.9		0.4		71.7		106.7		0		

Upstream – TRM 295.9

	Avg No. Taxa		% Long-Lived		Avg. No. EPT taxa		% Oligochaetes		% Dominant Taxa		Density excl chiro and oligo		Zero Samples		Overall Score
Sample Year	Obs	Score	Obs	Score	Obs	Score	Obs	Score	Obs	Score	Obs	Score	Obs	Score	
2001	7.4	5	1	5	1	3	6.9	5	75.6	5	281.7	1	0	5	**29**
2002	6.8	5	1	5	1.1	3	5	5	74.1	5	281.7	1	0	5	**29**
2003	6.3	3	1	5	0.9	3	0.6	5	82.2	3	583.3	3	0	5	**27**
2004	6.2	3	1	5	0.8	3	1.1	5	72.2	5	336.2	3	0	5	**29**
2006	9.2	5	0.8	3	1.2	3	5.1	5	78.6	3	1273.3	5	0	5	**29**
2011	8.4	5	0.7	3	1	3	6.3	5	81.1	3	430	3	0	5	**27**
Mean:	7.4		0.9		1.0		4.2		77.3		531.0		0		**28**
Maximum:	9.2		1		1.2		6.9		82.2		1273.3		0		
Minimum:	6.2		0.7		0.8		0.6		72.2		281.7		0		

Table 16a. Mean density per square meter of benthic taxa collected upstream and downstream of Browns Ferry Nuclear Plant, autumn 2013. All taxa listed contributed to individual RBI metrics and total scores.

Taxa	BFN Downstream TRM 290.4	BFN Downstream TRM 293.2	BFN Upstream TRM 295.9
ANNELIDA			
Hirudinea			
Rhynchobdellida			
Glossiphoniidae			
Actinobdella sp.	---	2	---
Actinobdella inequiannulata	2	---	---
Helobdella elongata	---	---	2
Helobdella stagnalis	7	8	8
Oligochaeta			
Haplotaxida			
Naididae	---	---	2
Tubificinae	30	78	20
Branchiura sowerbyi	3	7	5
Limnodrilus hoffmeisteri	5	7	18
ARTHROPODA			
Crustacea			
Malacostraca			
Amphipoda			
Corophiidae			
Apocorophium lacustre	167	38	282
Gammaridae			
Gammarus sp.	---	2	5
Hexapoda			
Insecta			
Coleoptera			
Elmidae			
Dubiraphia sp.	---	2	---
Diptera			
Ceratopogonidae	2	---	---
Chironomidae			
Orthocladiinae			
Chironominae	---	---	2
Axarus sp.	5	32	45
Chironomus sp.	43	28	70
Cryptochironomus sp.	---	7	5

Table 16a. (Continued).

Taxa	BFN Downstream TRM 290.4	BFN Downstream TRM 293.2	BFN Upstream TRM 295.9
Dicrotendipes neomodestus	---	---	7
Glyptotendipes sp.	---	---	3
Harnischia sp.	---	---	2
Microchironomus sp.	---	2	---
Polypedilum halterale gp.	---	3	2
Stempellina sp.	---	2	---
Xenochironomus xenolabis	---	---	5
Epoicocladius flavens	2	---	---
Thienemanniella lobapodema	---	2	---
Tanypodinae			
Ablabesmyia annulata	33	13	32
Ablabesmyia mallochi	---	---	2
Coelotanypus sp.	97	263	145
Paramerina sp.	---	30	---
Procladius sp.	---	2	7
Ephemeroptera			
Ephemeridae			
Hexagenia sp. <10mm	262	230	163
Hexagenia sp. >10mm	262	213	100
Trichoptera			
Leptoceridae	---	2	---
Oecetis sp.	2	37	28
Polycentropodidae			
Cyrnellus fraternus	18	---	32
MOLLUSCA			
Gastropoda			
Architaenioglossa			
Viviparidae			
Campeloma decisum	---	2	2
Lioplax sulculosa	---	3	3
Viviparus sp.	5	3	12
Neotaenioglossa			
Hydrobiidae			
Amnicola limosa	5	113	53
Somatogyrus sp.	---	3	2
Pleuroceridae			
Pleurocera canaliculata	---	---	3

Table 16a. (Continued).

Taxa	BFN Downstream TRM 290.4	BFN Downstream TRM 293.2	BFN Upstream TRM 295.9
Bivalvia			
Veneroida			
Corbiculidae			
Corbicula fluminea <10mm	263	312	278
Corbicula fluminea >10mm	---	3	40
Sphaeriidae			
Eupera cubensis	5	---	---
Musculium transversum	158	233	85
Pisidium compressum	2	---	---
Unionidae			
Truncilla donaciformis	---	---	3
Utterbackia imbecillis	---	---	2
NEMATODA	---	22	3
PLATYHELMINTHES			
Turbellaria			
Tricladida			
Planariidae			
Dugesia tigrina	3	2	5
Number of samples	**10**	**10**	**10**
Mean-Density per meter^2	**1,380**	**1,703**	**1,482**
Taxa Richness	**21**	**29**	**34**
Sum of area sampled (meter^2)	**0.6**	**0.6**	**0.6**

Table 16b. Mean density per square meter of benthic taxa collected but not included in individual RBI metrics or total scores for sites upstream and downstream of BFN, autumn 2013.

Taxa	BFN Downstream TRM 290.4	BFN Downstream TRM 293.2	BFN Upstream TRM 295.9
ARTHROPODA			
Crustacea			
Branchiopoda			
Cladocera			
Sididae			
Diaphanosoma sp.	---	---	7
Sida crystallina	---	---	5
Maxillopoda			
Cyclopoida			
Cyclopidae			
Macrocyclops albidus	5	5	---
Mesocyclops edax	---	7	2
Ostracoda			
Candoniidae			
Candona sp.	20	27	3
Hexapoda			
Insecta			
Diptera			
Chaoboridae			
Chaoborus punctipennis	5	10	---
Chelicerata			
Arachnida			
Acariformes			
Arrenuridae			
Arrenurus sp.	---	3	---
Unionicolidae			
Unionicola sp.	2	2	3
CNIDARIA			
Medusozoa			
Hydrozoa			
Hydridae			
Hydra sp.	8	3	5
Number of samples	**10**	**10**	**10**
Mean-Density per meter^2	**40**	**57**	**25**
Taxa Richness	**5**	**8**	**6**
Sum of area sampled (meter^2)	**0.6**	**0.6**	**0.6**

Table 17. RBI scores from sites directly upstream and downstream of Browns Ferry Nuclear Plant and from sites sampled as part of the Vital Signs monitoring program on Wheeler Reservoir. LTA-Long term average.

Site	Location	1994	1995	1997	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2013	LTA
Inflow	*TRM 347	31	21	25	23	---	21	25	31	31	31	33	33	---	31	---	27	31	**28**
BFN Upstream (Transition)	TRM 295.9	33	25	31	31	31	29	31	31	33	31	31	33	25	29	25	27	35	**30**
BFN Downstream (Transition)	TRM 291.7	---	---	---	---	27	31	27	35	33	31	31	29	29	23	23	---	---	**29**
BFN Downstream (Transition)	TRM 293.2	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	23	35	**N/A**
BFN Downstream (Transition)	TRM 290.4	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	21	31	**N/A**
Forebay	*TRM 277	19	15	23	17	---	17	15	15	19	15	13	13	15	13	---	13	17	**13**
Embayment	*ERM 6	15	13	15	15	---	15	---	15	---	17	---	13	---	13	---	13	13	**13**

Reservoir Benthic Index Scores: 7-12 ("Very Poor"), 13-18 ("Poor"), 19-23 ("Fair"), 24-29 ("Good"), 30-35 ("Excellent")

*** = sites with field-processed scores all years. All other sites, 1994 – 2010 are field-processed scores and 2011 forward are lab-processed scores.**

Table 18. Wildlife observed along 2100 m transects parallel to the Tennessee River shoreline, upstream and downstream of Browns Ferry Nuclear Plant, October 2013.

Survey Site		Birds	Obs.	Reptile/Amphibian	Obs.	Mammals	Obs.
TRM 295.9 (US)	RDB	Blue Jay	5	Map Turtle	37	Eastern Grey Squirrel	2
		Great Blue Heron	6				
		Carolina Chickadee	1				
		Belted Kingfisher	4				
		American Crow	1				
		American Robin	1				
		Unidentified Songbird	1				
		Double-crested Cormorant	2				
		Brown Thrasher	1				
		Mockingbird	1				
		Mallard	2				
	LDB	Ring-billed Gull	1	Map Turtle	26		
		Common Snipe	1				
		Turkey Vulture	2				
		Unidentified Songbird	8				
		Great Blue Heron	2				
		Mallard	12				
		Belted Kingfisher	1				
		Pileated Woodpecker	1				
		Killdeer	2				
TRM 292.5 (DS)	RDB	Blue Jay	5	Map Turtle	2		
		American Robin	2				
		Downy Woodpecker	2				
		American Crow	1				
		Belted Kingfisher	3				
		Turkey Vulture	2				
		American Coot	4				
		Great Blue Heron	2				
		Nuthatch	1				
		Mallard	2				
		European Starling	10				
		Unidentified Songbird	2				
	LDB	Belted Kingfisher	2	Map Turtle	69		
		Great Blue Heron	4				
		Pied-billed Grebe	2				
		Least Flycatcher	1				
		Unidentified Songbird	3				
		Blue Jay	1				
		Mockingbird	2				

RDB – right descending bank; LDB – left descending bank

Table 19. Water temperature (°F) depth profiles collected to determine the extent of the thermal plume from BFN during 2013.

October 2013	Transect and Profile Location (width from right descending bank)																								
	Ambient-TRM 294.4					BFN Discharge-TRM 294.0					Below Discharge-TRM 293.8					Mid-plume TRM 291.8					End of Plume-TRM 289.9				
Depth (m)	10%	30%	50%	70%	90%	10%	30%	50%	70%	90%	10%	30%	50%	70%	90%	10%	30%	50%	70%	90%	10%	30%	50%	70%	90 %
0.3	74.9	74.1	74.2	74.1	73.8	83.9	82.0	74.0	74.7	74.8	80.2	79.9	79.9	74.0	74.9	77.5	76.6	75.4	75.6	76.4	77.0	76.6	76.5	76.7	76.8
1.5	74.8	74.1	74.2	74.1	73.7	83.2	79.5	74.1	74.7	74.8	81.9	79.8	79.8	74.0	74.8	77.5	76.6	75.4	75.5	76.4	76.8	76.5	76.4	76.7	76.7
2													77.8												
3	74.8	74.1	74.2	74.0		74.6	76.3	74.1	74.7		80.8	79.6		74.0		77.5	76.6	75.4	75.5	76.3	76.7	76.5	76.3	76.6	76.3
4																						76.5			
5		74.1	74.2			74.5					80.2	79.3						75.4					76.2		
6						74.5												75.3							
7		74.1	73.6									78.7													
9		74.1										76.3													

Shaded numbers represent temperatures 3.6°F (2°C) or greater above ambient temperature.

Table 20. Water quality parameters collected along vertical depth profiles at three transects within the RFAI sample areas upstream and downstream of BFN during 2013.

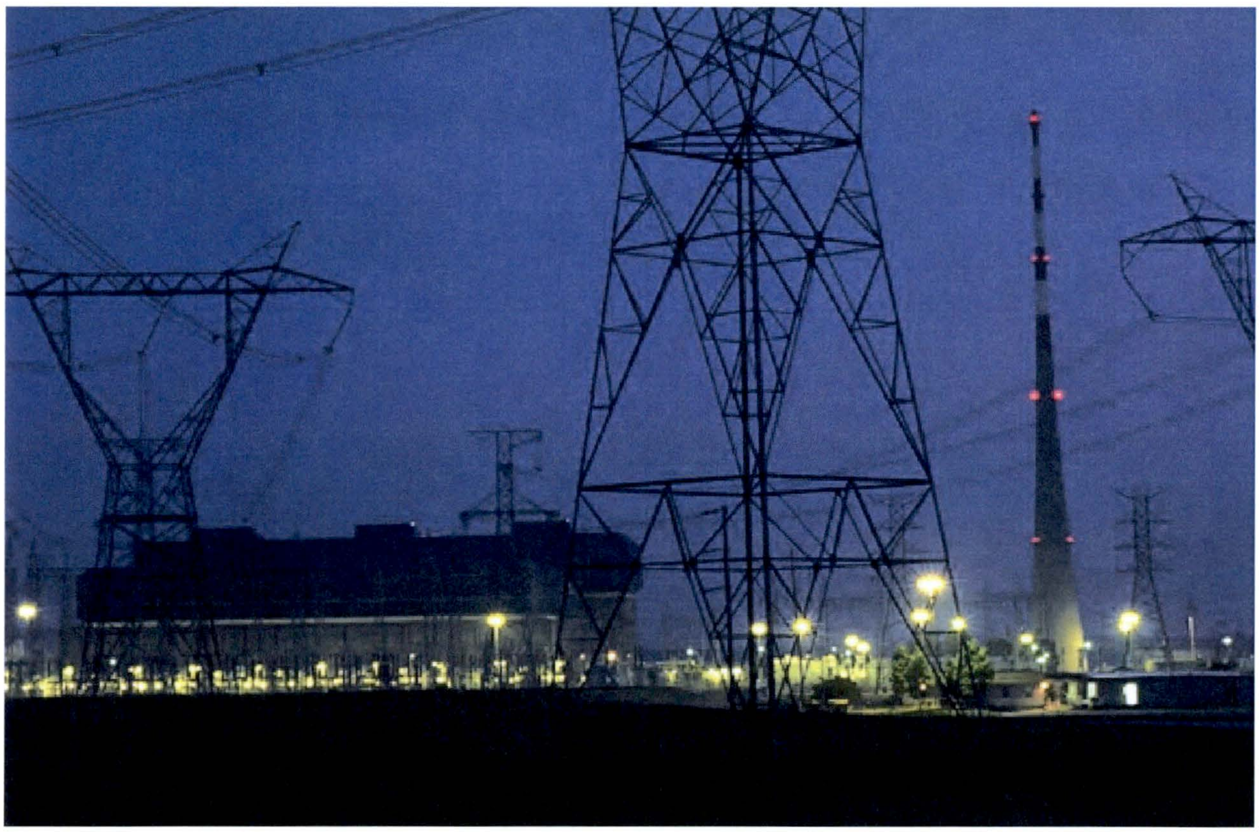
October, 2013	LDB						Mid-channel						RDB					
TRM 295.9	**Depth**	**°C**	**°F**	**pH**	**Cond**	**DO**	**Depth**	**°C**	**°F**	**pH**	**Cond**	**DO**	**Depth**	**°C**	**°F**	**pH**	**Cond**	**DO**
Upstream Boundary	0.3	22.84	73.11	7.38	173.6	6.92	0.3	22.50	72.50	7.52	167.1	7.89	0.3	22.72	72.90	7.78	162.6	7.98
	1.5	22.85	73.13	7.38	173.3	6.92	1.5	22.49	72.48	7.50	166.7	7.86	1.5	22.72	72.90	7.76	162.6	7.97
	2.5	22.77	72.99	7.38	173.3	6.89	3	22.50	72.50	7.48	166.4	7.85	3	22.61	72.70	7.73	161.9	7.83
Mid-site	0.3	22.45	72.41	7.79	177.7	7.60	0.3	22.94	73.29	7.40	167.0	6.87	0.3	22.94	73.29	7.82	162.3	7.69
	1.5	22.47	72.45	7.79	178.1	7.59	1.5	22.89	73.20	7.39	167.2	6.92	1.5	22.92	73.26	7.81	162.2	7.71
													3	22.91	73.24	7.79	162.5	7.66
Downstream Boundary	0.3	22.15	71.87	7.52	170.4	7.15	0.3	25.77	78.39	7.61	165.7	7.44	0.3	25.16	77.29	7.70	164.4	7.60
							1.5	23.49	74.28	7.46	166.5	7.07	1.5	23.44	74.19	7.76	162.5	7.64
							3	23.14	73.65	7.45	166.7	7.03	3	23.04	73.47	7.80	162.1	7.76
							5	23.05	73.49	7.43	167.6	6.99						
							7	22.97	73.35	7.41	168.0	6.97						
TRM 292.5	**Depth**	**°C**	**°F**	**pH**	**Cond**	**DO**	**Depth**	**°C**	**°F**	**pH**	**Cond**	**DO**	**Depth**	**°C**	**°F**	**pH**	**Cond**	**DO**
Upstream Boundary	0.3	23.77	74.79	7.79	171.9	7.83	0.3	23.38	74.08	7.46	169.1	6.98	0.3	28.85	83.93	7.82	166.4	7.82
	1	23.76	74.77	7.75	171.9	7.82	1.5	23.38	74.08	7.47	168.4	6.95	1.5	28.46	83.23	7.80	166.1	7.74
							3	23.34	74.01	7.40	168.0	6.83	3	23.66	74.59	7.89	164.0	8.12
													5	23.6	74.48	7.82	164.5	8.00
													6	23.6	74.48	7.83	164.6	8.02
Mid-site	0.3	24.66	76.39	7.60	167.1	7.17	0.3	24.12	75.42	7.62	167.8	7.63	0.3	25.27	77.49	7.90	164.7	8.02
	1.5	24.65	76.37	7.61	166.8	7.19	1.5	24.10	75.38	7.62	167.7	7.34	1.5	25.27	77.49	7.91	165.0	8.03
	3	24.59	76.26	7.64	166.7	7.20	3	24.10	75.38	7.62	167.3	7.33	3	25.27	77.49	7.88	165	7.99
							5	24.10	75.38	7.62	168.0	7.36						
							6	24.07	75.33	7.62	169.0	7.35						
Downstream Boundary	0.3	24.90	76.82	7.72	166.2	7.59	0.3	24.74	76.53	7.70	164.3	7.66	0.3	24.98	76.96	7.81	165.2	7.80
	1.5	24.85	76.73	7.59	165.5	6.92	1.5	24.69	76.44	7.69	164.3	7.63	1.5	24.91	76.84	7.80	165.4	7.80
	3	24.62	76.32	7.52	165.7	6.54	3	24.63	76.33	7.66	164.7	7.56	3	24.85	76.73	7.82	165.2	7.87
							5	24.53	76.15	7.62	163.8	7.37						

Abbreviations: °C –Temperature in degrees Celsius, °F – Temperature in degrees Fahrenheit, Cond – Conductivity, DO – Dissolved Oxygen

ATTACHMENT 12

Biological Monitoring of the Tennessee River Near Browns Ferry Nuclear Plant Discharge, Autumn 2015.

Biological Monitoring of the Tennessee River near Browns Ferry Nuclear Plant Discharge Autumn 2015



March 2016

Tennessee Valley Authority
River and Reservoir Compliance Monitoring Program
Knoxville, Tennessee

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Acronyms and Abbreviations

ATL	Alternate Thermal Limit
BIP	Balanced Indigenous Community
BFN	Browns Ferry Nuclear Power Plant
CCW	Condenser Cooling Water
CWA	Clean Water Act
NPDES	National Pollutant Discharge Elimination System
QA	Quality Assurance
RBI	Reservoir Benthic Macroinvertebrate Index
RFAI	Reservoir Fish Assemblage Index
RIS	Representative Important Species
SAHI	Shoreline Assessment Habitat Index
TRM	Tennessee River Mile
TVA	Tennessee Valley Authority
VS	Vital Signs

Executive Summary

In 2015, samples of the ecological community upstream and downstream of Brown's Ferry Nuclear Plant were collected, analyzed, and compared to historical data to determine the effects, if any, of the thermal effluent from the plant, in compliance with §316(a) of the Clean Water Act.

Shoreline aquatic habitat assessed along both banks received an average rating of "Fair". Assessment of river bottom habitat indicated three dominant substrates upstream: silt, mollusk shell, and clay. Downstream, silt, mollusk shell, and sand were most prominent.

The fish communities upstream and downstream of BFN were analyzed and compared using RFAI methodology. Both communities supported similar numbers of indigenous species; higher diversity evident in the upstream community was due primarily to the presence of hybrids and of non-indigenous species. Due to large collections of two schooling species, the downstream community exhibited greater dominance by a single species, higher percentages of omnivores and of pollution tolerant fishes than that upstream. However, there is no evidence indicating that these differences were due to thermal effluent from BFN. Benthic communities in 2015 for both downstream sites, at TRM 293.2 within the thermal plume from BFN discharge, and at TRM 290.4 downstream of the thermal plume, were considered similar to the upstream benthic community. All three sites received RBI ratings of "Excellent".

A visual wildlife survey was conducted to assess bird, reptile, and mammal populations around BFN. Turtles and a variety of birds were encountered at both locations.

Water quality analysis indicated that daily mean flow past BFN was generally similar to historic flows in 2015, and that daily mean temperatures were similar upstream and downstream of the plant. Depth profiles of, conductivity, dissolved oxygen concentration, and acidity (pH) indicated that values of all these parameters were within acceptable levels both upstream and downstream of BFN. Profiles of water temperature indicated some recirculation of thermal effluent from BFN upstream of the discharge along the right descending bank.

Introduction

Section 316(a) of the Clean Water Act (CWA) authorizes alternate thermal limits (ATL) for the control of the thermal component of a point source discharge so long as the limits will assure the protection of Balanced Indigenous Populations (BIP) of aquatic life. The term "balanced indigenous population," as defined by Environmental Protection Agency regulations, describes a biotic community that is typically characterized by:

(1) diversity appropriate to the ecoregion;

(2) the capacity to sustain itself through cyclic seasonal changes;

(3) the presence of necessary food chain species; and

(4) the lack of domination by pollution-tolerant species.

Prior to 2000, the Tennessee Valley Authority's (TVA) Browns Ferry Nuclear Plant (BFN) was operating under an ATL that had been continued with each permit renewal based on studies conducted in the mid-1970s. In 1999, EPA Region IV began requesting additional data in conjunction with National Pollutant Discharge Elimination System (NPDES) permit renewal applications to verify that BIP was being maintained at TVA's thermal plants with ATLs. TVA proposed that its existing Vital Signs (VS) monitoring program, supplemented with additional fish and benthic macroinvertebrate community monitoring upstream and downstream of thermal plants with ATLs, was appropriate for that purpose. The VS monitoring program began in 1990 in the Tennessee River System. This program was implemented to evaluate ecological health conditions in major reservoirs as part of TVA's stewardship role. One of the 5 indicators used in the VS program to evaluate reservoir health is the Reservoir Fish Assemblage Index (RFAI) methodology which incorporates fish species richness and composition, trophic composition, and fish abundance and health. RFAI has been thoroughly tested on TVA and other reservoirs and published in peer-reviewed literature (Jennings, et al., 1995; Hickman and McDonough, 1996; McDonough and Hickman, 1999). Fish communities are used to evaluate ecological conditions because of their importance in the aquatic food web and because fish life cycles are long enough to integrate conditions over time. Benthic macroinvertebrate populations are assessed using the Reservoir Benthic Index (RBI) methodology. Because benthic macroinvertebrates are relatively

immobile, negative impacts to aquatic ecosystems can be detected earlier in benthic macroinvertebrate communities than in fish communities. These data are used to supplement RFAI results to provide a more thorough examination of differences in aquatic communities upstream and downstream of thermal discharges.

During 2000 through 2010, TVA initiated a study to evaluate fish and benthic macroinvertebrate communities in areas immediately upstream and downstream of BFN using RFAI and RBI multi-metric evaluation techniques. The study was broadened in 2011 to include additional data for analyses (i.e., shoreline wildlife observations) requested by the EPA. Reported here are the results of biological monitoring and water quality data collected upstream and downstream of BFN during 2015, with appropriate comparisons to data collected at these sites during previous autumn samples.

Plant Description

BFN is a three-unit nuclear-fueled facility with a total generating capacity of 3,300 megawatts. Unit One, which remained idle for several years, returned to service June 2007. BFN is located on Wheeler Reservoir, approximately 18 miles upstream of Wheeler Dam at Tennessee River Mile (TRM) 294 in Limestone County, Alabama (Figure 1). Current operation utilizes a once-through condenser cooling water (CCW) system, withdrawing water from the Tennessee River through an intake structure at TRM 294.3 and discharging the water through a submerged multi-port diffuser located at TRM 294.0 (Figure 2). Maximum flow rate of the CCW is approximately 3,468 million gallons per day.

Methods

Evaluation of Plant Operating Conditions

Data describing the operation of BFN during the course of biological monitoring—specifically daily averages of power generation, water temperatures at the cooling water system intake and discharge, the intake flow of cooling water and the discharge flow returned to the river—were

collected, compiled, analyzed and compared to available historical operational data to assist in the interpretation of thermal plume characteristics and biological community information.

Aquatic Habitat in the Vicinity of BFN

Shoreline and river bottom habitat data presented in this report were collected during autumn 2015. TVA assumes habitat data to be valid for five years, barring any major changes to the river/reservoir (e.g. major flood event). In the event of a major change to the river/reservoir, habitat would be re-evaluated during the following sample period.

Shoreline Aquatic Habitat Assessment

An integrative multi-metric index (Shoreline Aquatic Habitat Index or SAHI), including several habitat parameters important to resident fish species, was used to measure existing fish habitat quality in the vicinity of BFN. Using the general format developed by Plafkin et al. (1989), seven metrics were established to characterize selected physical habitat attributes important to reservoir resident fish populations which rely heavily on the littoral (shoreline) zone for reproductive success, juvenile development, and adult feeding (Table 1). Habitat Suitability Indices (U.S. Fish and Wildlife Service), along with other sources of information on biology and habitat requirements (Etnier and Starnes 1993), were consulted to develop "reference" criteria or "expected" conditions from a high quality environment for each parameter. Some generalizations were necessary in setting up scoring criteria to cover the various requirements of all species within a single index.

When possible, the quality of shoreline aquatic habitat was assessed while traveling parallel to the shoreline in a boat and evaluating the habitat within 10 vertical feet of full pool. Transects were established across the width of Wheeler Reservoir within the fish community sampling reaches upstream and downstream of BFN (Figure 3). At each transect, near-shore aquatic habitat was assessed along sections of shoreline corresponding to the left descending bank (LDB) and right descending bank (RDB). For each shoreline section (16 upstream and 16 downstream of BFN), percentages of aquatic macrophytes in the littoral areas were estimated, then each section was scored by comparing the observed conditions associated with each

individual metric to the "reference" conditions and assigning the metric a corresponding value: "Good" – 5; "Fair" – 3; or "Poor" – 1 (Table 1). The scores for each of the seven metrics were summed to obtain the SAHI value for the shoreline section, and this value was assigned a habitat quality descriptor based on trisecting the range of potential SAHI values ("Poor", 7-16; "Fair", 17-26; and "Good", 27-35).

River Bottom Habitat

Along each transect described above, a benthic grab sample was collected with a Ponar sampler at each of ten points equally spaced from the LDB to the RDB. Substrate material collected with the Ponar was emptied into a screen, and percent composition of each substrate was estimated to determine existing benthic habitat across the width of the river. Water depths (feet) at each sample location were recorded (Figure 3). If no substrate was collected after multiple Ponar drops, it was assumed that the substrate was bedrock. For example, when the Ponar sampler was pulled shut, collectors could feel substrate consistency. If it shut easily and was not embedded in the substrate on numerous drops within the same location, the substrate was recorded as bedrock.

Fish Community Sampling Methods and Data Analysis for Sites Upstream and Downstream of BFN

Thermal discharge from BFN enters Wheeler Reservoir (Tennessee River) at TRM 294.0 (Figure 2). To evaluate the fish community in the vicinity of BFN, two sample sites were selected. One site was centered at TRM 295.9, upstream of the plant's intake (Figure 4), and served as a reference site unaffected by the thermal discharge. The second site was centered at TRM 292.5, downstream of the cooling water discharge (Figure 5).

Fish sampling methods included boat electrofishing and gill netting (Hubert 1996; Reynolds 1996). Electrofishing methodology consisted of fifteen boat electrofishing runs near the shoreline, each 300 meters long and of approximately 10 minutes duration. The total near-shore area sampled was approximately 4,500 meters (15,000 feet).

Experimental gill nets (so called because of their use for research as opposed to commercial fishing) were used as an additional gear type to collect fish from deeper habitats not effectively sampled by electrofishing. Each experimental gill net consists of five 6.1 meter panels for a total length of 30.5 meters (100.1 feet). The distinguishing characteristic of experimental gill nets is mesh size that varies between panels. For this application, each net has panels with mesh sizes of 2.5, 5.1, 7.6, 10.2, and 12.7 cm. Experimental gill nets are typically set perpendicular to river flow, extending from near-shore to the main channel of the reservoir. Ten overnight experimental gill net sets were used at each sample site.

Fish collected were identified by species, counted, and examined for anomalies (such as disease, deformations, parasites or hybridization). The resulting data were analyzed using RFAI methodology.

The RFAI uses 12 fish community metrics from four general categories: Species Richness and Composition; Trophic Composition; Abundance; and Fish Health. Individual species can be utilized for more than one metric, though hybrid species and non-indigenous species are excluded from metrics counting numbers of individual species. Together, these 12 metrics provide a balanced evaluation of fish community integrity. The individual metrics are shown below, grouped by category:

Species Richness and Composition

(1) **Total number of species** – Greater numbers of species are considered representative of healthier aquatic ecosystems. As conditions degrade, numbers of species at an area decline.

(2) **Number of centrarchid species** – Sunfish species (excluding black basses) are invertivores and a high diversity of this group is indicative of reduced siltation and suitable sediment quality in littoral areas.

(3) **Number of benthic invertivore species** – Due to the special dietary requirements of this species group and the limitations of their food source in degraded environments, numbers of benthic invertivore species increase with better environmental quality.

(4) **Number of intolerant species** – A group made up of species that are particularly intolerant of physical, chemical, and thermal habitat degradation. Higher numbers of intolerant species suggest the presence of fewer environmental stressors.

(5) **Percentage of tolerant individuals** (excluding young-of-year) – An increased proportion of individuals tolerant of degraded conditions signifies poorer water quality.

(6) **Percent dominance by one species** – Ecological quality is considered reduced if one species inordinately dominates the resident fish community.

(7) **Percentage of non-indigenous species** – Based on the assumption that non-indigenous species reduce the quality of resident fish communities.

(8) **Number of top carnivore species** – Higher diversity of piscivores is indicative of the availability of diverse and plentiful forage species and the presence of suitable habitat.

Trophic Composition

(9) **Percent top carnivores** – A measure of the functional aspect of top carnivores which feed on major planktivore populations.

(10) **Percent omnivores** – Omnivores are less sensitive to environmental stresses due to their ability to vary their diets. As trophic links are disrupted due to

degraded conditions, specialist species such as insectivores decline while opportunistic omnivorous species increase in relative abundance.

Abundance

(11) Average number per run (number of individuals) – Based on the assumption that high quality fish assemblages support large numbers of individuals.

Fish Health

(12) Percent anomalies – Incidence of diseases, lesions, tumors, external parasites, deformities, blindness, and natural hybridization is noted for all fish collected, with higher incidence indicating less favorable environmental conditions.

RFAI methodology addresses all four attributes or characteristics of a "balanced indigenous population" (BIP), defined by the CWA as described below:

(1) A biotic community characterized by diversity appropriate to the ecoregion: Diversity is addressed by the metrics in the Species Richness and Composition category, especially metric 1 – "Number of species." Determination of reference conditions based on the transition zones of lower mainstem Tennessee River reservoirs (as described below) ensures appropriate species expectations for the ecoregion.

(2) The capacity for the community to sustain itself through cyclic seasonal change: TVA uses an autumn data collection period for biological indicators, both VS and upstream/downstream monitoring. Autumn monitoring is used to document community condition or health after being subjected to the wide variety of stressors throughout the year.

One of the main benefits of using biological indicators is their ability to integrate stressors through time. Examining the condition or health of a community at the end of the "biological year" (i.e., autumn) provides insights into how well the community has dealt with the stresses through an annual seasonal cycle. Likewise, evaluation of the condition of individuals in the

community (in this case, individual fish as reflected in Metric 12) provides insights into how well the community can be expected to withstand stressors through winter. Further, multiple sampling years during the permit renewal cycle add to the evidence of whether the autumn monitoring approach has correctly demonstrated the ability of the community to sustain itself through repeated seasonal changes.

(3) **The presence of necessary food chain species:** Integrity of the food chain is measured by the Trophic Composition metrics, with support from the Abundance metric and Species Richness and Composition metrics. A healthy fish community is comprised of species that utilize complex feeding mechanisms extending into multiple levels of the aquatic food web.

Three dominant fish trophic levels exist within Tennessee River reservoirs: insectivores, omnivores, and top carnivores. To determine the presence of necessary food chain species, these three groups should be well represented within the overall fish community. Other fish trophic levels include benthic invertivores, planktivores, herbivores, and parasitic species. Insectivores include most sunfish, minnows, and silversides. Omnivores include gizzard shad, common carp, carpsuckers, buffalo, and channel and blue catfish. Top carnivores include bass, gar, skipjack herring, crappie, flathead catfish, sauger, and walleye. Benthic invertivores include freshwater drum, suckers, and darters. Planktivores include alewife, threadfin shad, and paddlefish. Herbivores include largescale stonerollers. Lampreys in the genus *Ichthyomyzon* are the only parasitic species occurring in Tennessee River reservoirs.

To establish expected proportions of each trophic guild and the expected number of species included in each guild occurring in transition zones in lower mainstem Tennessee River reservoirs (Kentucky, Pickwick, Wilson, Wheeler, and Guntersville reservoirs), data collected from 1993 to 2010 were analyzed for each reservoir zone (inflow, transition, forebay). Samples collected in the downstream vicinity of thermal discharges were not included in this analysis so that accurate expectations could be calculated with the assumption that these data represent what should occur in lower mainstem Tennessee River reservoirs absent from point source effects (i.e. power plant discharges). Data from 900 electrofishing runs (a total of 405,000 meters of shoreline sampled) and from 600 overnight experimental gill net sets were included in this analysis for transition areas in lower

mainstem Tennessee River reservoirs. From these data, the range of proportional values for each trophic level and the range of the number of species included in each trophic level were trisected. These trisections were intended to show less than expected, expected, and above expected values for trophic level proportions and species occurring within each reservoir zone in lower mainstem Tennessee River reservoirs. The data were also averaged and bound by confidence intervals (95%) to further evaluate expectations for proportions of each trophic level and the number of species representing each trophic level (Table 2).

(4) **A lack of domination by pollution-tolerant species**: Domination by pollution-tolerant species is determined by metrics 3 ("Number of benthic invertivore species"), 4 ("Number of intolerant species"), 5 ("Percent tolerant individuals"), 6 ("Percent dominance by one species"), and 10 ("Percent omnivores").

Scoring categories are based on "expected" fish community characteristics in the absence of human-induced impacts other than impoundment of the reservoir. These categories were developed from historical fish assemblage data representative of transition zones from lower mainstem Tennessee River reservoirs (Hickman and McDonough, 1996). Attained values for each of the 12 metrics were compared to the scoring criteria and assigned scores to represent relative degrees of degradation: least degraded (5); intermediately degraded (3); and most degraded (1). Scoring criteria for lower mainstem Tennessee River reservoirs are shown in Table 3.

If a metric was calculated as a percentage (e.g., "Percent tolerant individuals"), the data from electrofishing and gill netting were scored separately and allotted half the total score for that individual metric. Individual metric scores for a sampling area (i.e., upstream or downstream) were summed to obtain the RFAI score for the area.

TVA uses RFAI results to determine maintenance of BIP using two approaches. One is "absolute" in that it compares the RFAI scores and individual metrics to predetermined values. The other is "relative" in that it compares RFAI scores attained downstream to the upstream control site. The "absolute" approach is based on Jennings et al. (1995) who suggested that

favorable comparisons of the RFAI score attained from the potential impact zone to a predetermined criterion can be used to identify the presence of normal community structure and function and hence existence of BIP. For multi-metric indices, TVA uses two criteria to ensure a conservative screening of BIP. First, if an RFAI score reaches 70% of the highest attainable score of 60 (adjusted upward to include sample variability as described below), and second, if fewer than half of RFAI metrics receive a low (1) or moderate (3) score, then community structure and function are considered normal, indicating that BIP had been maintained and no further evaluation would be needed.

RFAI scores range from 12 to 60. Ecological health ratings (12-21 "Very Poor", 22-31 "Poor", 32-40 "Fair", 41-50 "Good", or 51-60 "Excellent") are then applied to scores. As discussed in detail below, the average variation for RFAI scores in TVA reservoirs is 6 (± 3). Therefore, any location that attains a RFAI score of 45 (75% of the highest score) or higher would be considered to have BIP. It must be stressed that scores below this threshold do not necessarily reflect an adversely impacted fish community. The threshold is used to serve as a conservative screening level; i.e., any fish community that meets these criteria is obviously not adversely impacted. RFAI scores below this level require a more in-depth look to determine if BIP exists. An inspection of individual RFAI metric results and species of fish used in each metric are an initial step to help identify if operation of BFN is a contributing factor. This approach is appropriate because a validated multi-metric index is being used and scoring criteria applicable to the zone of study are available.

A comparison of RFAI scores from the area downstream of BFN to those from the upstream (control) area is one basis for determining if operation of the plant has had any impacts on the resident fish community. The definition of "similar" is integral to accepting the validity of these interpretations. The Quality Assurance (QA) component of the VS monitoring program deals with how well the RFAI scores can be repeated and is accomplished by collecting a second set of samples at 15%-20% of the areas each year. Comparison of paired-sample QA data collected over seven years shows that the difference in RFAI index scores ranges from 0 to 18 points. The mean difference between these 54 paired scores is 4.6 points with 95% confidence limits of 3.4 and 5.8. The 75th percentile of the sample differences is 6, and the 90th percentile is 12. Based

on these results, a difference of 6 points or less in the overall RFAI scores is the value selected for defining "similar" scores between upstream and downstream fish communities. That is, if the downstream RFAI score is within 6 points of the upstream score and if there are no major differences in overall fish community composition, then the two locations are considered similar. It is important to bear in mind that differences greater than 6 points can be expected simply due to method variation (25% of the QA paired sample sets exceeded that value). An examination of the 12 metrics (with emphases on fish species used for each metric) is conducted to analyze any difference in scores and the potential for the difference to be thermally related.

Statistical Analyses

In addition to RFAI analyses, data were analyzed using traditional statistical methods. Data from the survey were used to calculate catch per unit effort (CPUE), expressed as number of fish per electrofishing run or fish per net night. CPUE values were calculated by pollution tolerance, trophic guilds (e.g., benthic invertivores, top carnivores, etc.), thermal sensitivity (Yoder et al. 2006), and indigenous status. CPUE, diversity, and species richness values were computed for each electrofishing effort (to maximize sample size; n = 30) and compared upstream and downstream to assess potential effects of power plant discharges.

Diversity was quantified using two commonly applied indices: Shannon diversity index (Shannon 1948) and Simpson diversity index (Simpson 1949). Both indices account for the number of species present, as well as the relative abundance of each species.

Shannon diversity index values were computed using the formula:

$$H' = -\sum_{i=1}^{S} \left(\frac{n_i}{N}\right) \ln \left(\frac{n_i}{N}\right)$$

where:

S = total number of species

N = total number of individuals

n_i = total number of individuals in the i^{th} species

The Simpson diversity index was calculated as follows:

$$D_S = \left(\sum_{i=1}^{S} \left(\frac{n_i}{N}\right)^2\right) - 1$$

where:

S = total number of species

N = total number of individuals

n_i = total number of individuals in the i^{th} species

An independent two-sample *t*-test was used to test for differences in CPUE, species richness, and diversity values upstream and downstream of BFN ($\alpha = 0.05$). Before statistical tests were performed using this method, data were analyzed for normality using the Shapiro-Wilk test (Shapiro and Wilk, 1965) and homogeneity of variance using Levene's test (Levene 1960). Non-normal data or data with unequal variances were transformed using either square root conversion or the ln(x+1) transformation. Transformed data were reanalyzed for normal distribution and equal variances. If transformation normalized the data or resulted in homogeneous variances, transformed data were tested using an independent two-sample *t*-test. If transformed data were not normally distributed or had unequal variances, statistical analysis was conducted using the Wilcoxon-Mann-Whitney test (Mann and Whitney 1947; Wilcoxon 1945).

Benthic Macroinvertebrate Community Sampling Methods and Data Analysis for Sites Upstream and Downstream of BFN

To assess the benthic macroinvertebrate community in the vicinity of BFN from 2000 to 2010, data were collected along transects established across the full width of Wheeler reservoir at two sites in the transition zone—one at TRM 295.9 upstream of the intake and one at TRM 291.7 downstream of the BFN discharge. Prior to this time, a sampling site in the forebay zone of Wheeler Reservoir (TRM 277) was used as the downstream comparison site. Because other factors unrelated to influence from BFN depressed benthic communities at both the forebay site and in the Elk River embayment (Wheeler Reservoir, Elk River Mile [ERM] 6 – between BFN and the forebay site), the downstream site was moved into the transition zone two miles downstream from the BFN diffuser at TRM 291.7 in 2000. Benthic scores and community

composition from this site were used through 2010 for downstream comparisons to the upstream benthic site at TRM 295.9.

Beginning in 2011, samples were collected in the reservoir's transition zone along transects established across the full width of the reservoir at three sites. One site upstream of the plant intake was maintained at TRM 295.9 (Figure 4). To more accurately assess any possible effects of the BFN discharge on the benthic communities downstream, two sites were selected: one at TRM 293.2, within the thermal plume from the BFN discharge, and a second at TRM 290.4, downstream of the thermal plume (Figure 5).

During autumn 2015, benthic macroinvertebrate data were collected along these three transects. The upstream transect was used as a control site for comparison to the downstream benthic communities potentially affected by the BFN thermal effluent. A Ponar sampler (area per sample 0.06 m^2) was used to collect benthic samples at ten points equally spaced along each transect. When heavier substrate was encountered, a Peterson sampler (area per sample 0.11 m^2) was used. Sediments from each sample were washed on a 533μ screen, and organisms were picked from the screen and from any remaining substrate. Samples were fixed in formalin and sent to an independent consultant who identified each organism collected to the lowest possible taxonomic level.

Benthic samples were evaluated using seven metrics that represent characteristics of the benthic community. Results for each metric were assigned a rating of 1, 3, or 5, based on comparison to reference conditions developed for VS reservoir transition sample sites (Table 4). For each sample site, the ratings for the seven metrics were then summed to produce an RBI score. Potential RBI scores ranged from 7 to 35. Ecological health ratings derived from the range of potential values (7-12 "Very Poor", 13-18 "Poor", 19-23 "Fair", 24-29 "Good", or 30-35 "Excellent") were then applied to scores. The individual metrics are described below:

(1) Average number of taxa — Calculated by averaging the total number of taxa present in each sample at a site. Greater taxa richness indicates better conditions than lower taxa richness.

(2) Proportion of samples with long-lived organisms — A presence/absence metric that is evaluated based on the proportion of samples with at least one long-lived organism (*Corbicula, Hexagenia*, mussels, or snails) present. The presence of long-lived taxa is indicative of conditions that allow long-term survival.

(3) Average number of EPT taxa — Calculated by averaging the number of *Ephemeroptera* (mayfly), *Plecoptera* (stonefly), and *Trichoptera* (caddis fly) taxa present in each sample at a site. Higher diversity of these taxa indicates good water quality and better habitat conditions.

(4) Percentage of oligochaetes — Calculated by averaging the percentage of oligochaetes in each sample at a site. Oligochaetes are considered tolerant organisms, so a higher proportion indicates poorer water quality.

(5) Percentage as dominant taxa — Used as an evenness indicator, this metric is calculated by selecting the two most abundant taxa in a sample, summing the number of individuals in those two taxa, dividing that sum by the total number of animals in the sample, and converting to a percentage for that sample. The percentage is then averaged for the 10 samples at each site. Because the most abundant taxa often differ among the 10 samples at a site, this approach allows more discretion to identify imbalances at a site than developing an average for a single dominant taxon for all samples at a site. Dominance of one or two taxa indicates poor conditions.

(6) Average density excluding chironomids and oligochaetes — Calculated by first summing the number of organisms – excluding chironomids and oligochaetes – present in each sample and then averaging these densities for the 10 samples at a site. This metric examines the community, excluding taxa which often dominate under adverse conditions. Higher abundance of taxa other than chironomids and oligochaetes indicates good water quality conditions.

(7) Zero-samples: Proportion of samples containing no organisms — For each site, the proportion of samples in which no organisms are present. "Zero-samples" indicate living conditions unsuitable to support aquatic life (i.e. toxicity, unsuitable substrate, etc.). A site with no zero samples was assigned a score of five. Any site with one or more zero samples was assigned a score of one.

A similar or higher benthic index score at the downstream sites compared to the upstream site was used as the basis for determining absence of impact on the benthic macroinvertebrate community related to BFN's thermal discharge. The QA component of VS monitoring compared benthic index scores from 49 paired sample sets collected over seven years. Differences between these paired sets ranged from 0 to 14 points; the 75th percentile was four points, the 90th percentile was six points. The mean difference between these 49 paired scores was 3.1 points with 95% confidence limits of 2.2 and 4.1. Based on these results, a difference of four points or less was the value selected for defining "similar" scores between upstream and downstream benthic communities. That is, if benthic scores at the downstream sites are within four points of the upstream score, the communities are considered similar. However, differences greater than four points can be expected simply due to method variation (25% of the QA paired sample sets exceeded that value). Any difference in scores of four points or greater between communities is examined on a metric-by-metric basis to determine what caused the difference in scores and the potential for the difference to be thermally related.

Visual Encounter Survey (Wildlife Observations)

Permanent survey sites were established on both the right and left descending banks at one location upstream of the BFN thermal discharge, centered at TRM 295.9 (Figure 4), and at a second location downstream of the discharge, centered at TRM 292.5 (Figure 5). Each survey site spanned a distance of 2,100 m along the shoreline, and the beginning and ending points were marked using GPS for relocation.

Surveys were conducted by steadily traversing the site by boat, at approximately 30 m offshore and parallel to the shoreline, and simultaneously recording observations of wildlife. The

sampling frame of each survey generally followed the strip or belt transect concept: from the center-line of each transect landward to an area that included the shoreline and riparian zone (i.e., belt width generally averages 60 m where vision is not obscured), all individuals observed were enumerated. Wildlife observed visually or detected audibly was identified to the lowest taxonomic trophic level, and a direct count of individuals observed per trophic level was recorded. If a flock of a species or a mixed flock of a group of species was observed, numbers of individuals present of each species were estimated. Time was recorded at the start and end points of each survey to provide a general measure of effort expended. Variation of observation times among surveys was primarily due to the difficulty of approaching some wildlife species without inadvertently flushing them from basking or perching sites.

The principal objective of the surveys was to provide a preliminary set of observations to verify that trophic levels of birds, mammals and reptiles were not affected by thermal effects from the BFN discharge. If expected trophic levels were not represented, further investigation will be used to target particular species and/or species groups (guilds) in an attempt to determine the cause.

Wheeler Reservoir Flow and BFN Temperature

Total daily average discharge from Guntersville Dam was used to describe the amount of water flowing past BFN and was obtained from TVA's River Operations database.

Water temperature data were also obtained from TVA's River Operations database. Locations of water temperature monitoring stations used to compare water temperatures upstream of BFN intake and downstream of BFN discharge are depicted in Figure 6. Ambient temperatures upstream of the BFN intake were measured at Site 4, located at TRM 297.8. Upstream daily mean temperatures were calculated by averaging temperatures collected at depths of 3, 5, and 7 feet. Temperatures downstream of BFN discharge were measured at Sites 1, 16, and 17, all located at TRM 293.5. Downstream temperatures were calculated by first averaging temperatures at each site across depths of 3, 5, and 7 feet. The resultant values from each site were then averaged together to obtain overall mean daily water temperatures downstream of BFN.

Thermal Plume Characterization

Physical measurements to characterize and map the BFN thermal plume were collected concurrent with biological field sampling. The plume was characterized under representative thermal maxima and seasonally-expected low flow conditions. Measurements were collected during periods of normal operation of BFN, as reasonably practicable, to capture the thermal plume under existing river flow/reservoir elevation conditions. This effort evaluated potential impacts on recreation and water supply uses and allowed general delineation of the "Primary Study Area" – per the EPA (1977) draft guidance defined as the "*entire geographic area bounded annually by the locus of the 2°C above ambient surface isotherms as these isotherms are distributed throughout an annual period*" – ensuring placement of the biological sampling locations within thermally influenced areas.

However, it is important to emphasize that the $\geq$2°C isopleth boundary is not a bright line; it is dynamic, changing geometrically in response to changes in ambient river flows and temperatures and BFN operations. As such, samples collected outside of, but generally proximate to the Primary Study Area boundary cannot be considered free of thermal influence and thus should not be discounted. Every effort was made to collect biological samples in thermally affected areas as guided by the Primary Study Area definition.

Depth profiles of temperature from the river surface to the bottom were collected at points along transects crossing the plume. One transect was located proximate to the thermal discharge point; subsequent downstream transects were concentrated in the near field area of the plume where the change in plume temperature was expected to be most rapid. The distance between transects in the remainder of the Primary Study Area increased with distance downstream (or away from the discharge point). The farthest downstream transect was just outside of the Primary Study Area. A transect upstream of the discharge, in an area not affected by the thermal plume, was included for determining ambient temperature conditions. The total number of transects needed to fully characterize and delineate the plume was determined in the field.

Collection of temperature profiles along a given transect began at or near the shoreline from which the discharge originated and continued until the far shore was reached. Measurements across a transect were typically conducted at points 10%, 30%, 50%, 70%, and 90% from the

originating shoreline, though the number of measurement points along transects was sometimes increased in proportion to the magnitude of the temperature change across a given transect. The distances between transects, and between points of measurement along each transect, depended on the size of the discharge plume.

Temperature data were compiled and analyzed to present the horizontal and vertical dimensions of the BFN thermal plume using spatial analysis techniques to yield plume cross-sections, which can be used to demonstrate the existence of a zone of passage for fish and other aquatic species under or around the plume.

Water Quality Parameters at Fish Sampling Sites during RFAI Samples

Water quality conditions were measured using a Hydrolab® that provided readings for water temperature (°C), conductivity (μS/cm), dissolved oxygen (mg/L), and pH. Within each of the electrofishing sample reaches upstream and downstream of BFN, transects were established across the river at the most upstream boundary, at mid-reach, and at the most downstream boundary. Along each transect, samples were collected at the RDB, in mid-channel, and at the LDB by recording readings at one- to two-meter intervals along a vertical gradient from just above the bottom of the river to approximately 0.3 meters from the surface.

Results and Discussion

Evaluation of Plant Operating Conditions

Relevant plant operational data—mean daily temperatures at the CCW intake and discharge, mean daily flow through the CCW system, and mean daily power generation by the three nuclear units at BFN—were compiled from 2010 through 2015.

Biological monitoring was conducted upstream and downstream of BFN on October 21 and 22 and on November 5. Daily mean generation for these three days was 3,409 MW; 3,401 MW; and 3,390 MW, respectively, from 15 to 17% greater than the historical daily averages. Daily

mean intake temperatures for these dates were 66.6, 68.6, and 68.2 °F, respectively, which were between 0 and 15% higher than historical means for these dates (67.8, 66.5, and 59.2 °F). Daily mean discharge temperatures were 71.8, 73.5, and 71.8 °F, respectively, from 1 to 11% higher than historical means (71.4, 71.1, and 64.9 °F). Daily flow rates were not available, but were assumed to be similar to monthly averages (Table 5, Figure 7).

During 2015, daily mean generation ranged from 1995 to 3460 MW, with an annual average of 3201 MW. Through the year, mean daily generation was on average, 8% higher than the historical daily mean. Monthly mean CCW flow ranged from 2428 to 3097 mgd (3,757 to 4,792 cfs). The annual average of 2,867 mgd (4,436 cfs) was 7% greater than the historical average. Daily mean intake temperatures ranged from 34.6 to 88.9 °F, with an annual average of 67.7 °F. Daily mean discharge temperatures ranged from 41.2 to 89.1 °F, with an annual average of 70.1 °F. Both daily mean intake and discharge temperatures were, over the course of the year, an average of 2% higher than historical daily means (Table 5, Figure 8).

Aquatic Habitat in the Vicinity of BFN

Shoreline Aquatic Habitat Assessment

Of the sixteen shoreline transects sampled upstream of BFN, 12.5% (two transects) scored as good, 75% (12 transects) scored as fair, and 6% (one transect) scored as poor. The average score for transects on the left descending bank was 24 ("Fair"), while scores for transects on the right descending bank averaged 20 ("Fair"). No aquatic macrophytes were observed on either shoreline (Table 6).

Of the sixteen shoreline transects sampled downstream of BFN, 31% (five transects) scored as good, 56% (nine transects) scored as fair, and 12% (two transects) scored as poor. The average score for transects on the left descending bank was 24 ("Fair"), and the average score for transects on the right descending bank was 22 ("Fair"). No aquatic macrophytes were observed on either shoreline (Table 7).

River Bottom Habitat

Figures 9-12 compare substrate proportions and water depth at each sample point along the eight transects upstream of BFN. Figures 13-16 compare substrate proportions at each sample point along the eight transects downstream of BFN. Relative locations of all sixteen transects are shown in Figure 3.

The three most dominant substrate types encountered along the eight transects upstream of BFN were silt (59.0%) and mollusk shell (23.0%), and clay (4.1%). Downstream of BFN, silt (65.7%), mollusk shell (16.0%), and sand (8.4%) were the most prominent (Table 8).

Fish Community

The total RFAI score for the fish community upstream of BFN was 49 ("Good"). The score for the community downstream was 44 ("Fair") (Table 9). Because the difference between these scores was within the 6-point range of acceptable variation, the communities were considered similar during autumn 2015.

Below, the two communities are compared in further detail, utilizing each of the four characteristics of a BIP. Discussion of this comparison includes the metrics appropriate for each characteristic.

(1) A biotic community characterized by diversity appropriate to the ecoregion

Total number of species (highest rating requires > 30)

Thirty-five indigenous species were collected upstream, compared to 31 species downstream. Both sites earned the highest score (5) (Table 9). Eight species – longnose gar (five specimens), northern hogsucker (two), spotted gar (18), black buffalo (two), blackspotted topminnow (one), orangespotted sunfish (one), spotted bass (one), and snubnose darter (one) – were collected only upstream (It should be noted that, in records since 2003, blackspotted topminnow and snubnose darter have not been collected in any previous sample at either site). Four species – black

redhorse (one specimen), bowfin (one), bullhead minnow (two), and black crappie (one) – were collected only downstream (Tables 10 and 11).

Number of centrarchid species (highest rating requires > 2)
Both sites earned the highest score (5), with seven centrarchid species collected in each sample reach. Orangespotted sunfish was collected only upstream; black crappie was collected only downstream (Table 9).

Number of benthic invertivore species (highest rating requires > 7)

Five benthic invertivore species were collected at both sites, resulting in mid-range scores (3). Spotted sucker, river darter, logperch, and freshwater drum were collected at both sites; northern hogsucker was collected only upstream; black redhorse was collected only downstream (Table 9).

Number of intolerant species (highest rating requires > 4)

Five intolerant species were collected at both sites, and both earned the highest score (5). Longear sunfish, skipjack herring, smallmouth bass, and spotted sucker were collected at both sites; northern hogsucker was collected only upstream, black redhorse was collected only downstream (Table 9).

Percent non-indigenous species (highest rating requires <1% for electrofishing, <1% for gill netting)
Both sites received the lowest score for the electrofishing portion of the sample, due mostly to unusually large collections of Mississippi silverside (27.3% of the upstream sample, 32.2% of the downstream sample). Two other non-indigenous species were collected at each site in minor proportions: upstream—striped bass (0.3%) and common carp (0.2%); downstream—redbreast sunfish (0.1%) and yellow perch (0.1%).

Both sites received the highest score for the gill netting portion of the sample. Striped bass made up 0.8% of the sample upstream, and no aquatic nuisance species were captured in gill nets downstream.

Number of top carnivore species (highest rating requires > 7)

Eleven top carnivore species were collected upstream, and ten were collected downstream. Both sites earned the highest score (5). Longnose gar, spotted bass and spotted gar were collected only upstream; black crappie and bowfin were collected only downstream (Table 9).

Summary

Scores for the upstream site were identical to those for the downstream site for all metrics discussed. Both sites earned highest scores for four metrics and for the gill netting portion of "Percent non-indigenous species". Scores for the electrofishing portion of this metric were heavily influenced by large collections of Mississippi silverside at both sites. Both sites earned mid-range scores for "Number of benthic invertivore species".

(2) The capacity for the community to sustain itself through cyclic seasonal change

Maintenance of diversity can often be indicative of the ability of a fish community to withstand the stressors of an annual seasonal cycle. Autumn RFAI sampling has been conducted at the site upstream of BFN since 1993, except during 1996, 1998, 2012 and 2014. Autumn sampling has been conducted at the site downstream since 2000, except during 2012 and 2014. Average scores calculated over the history of sampling are identical for both sites (41, "Good") (Table 13).

Figure 17 shows the numbers of indigenous species collected during autumn RFAI samples upstream and downstream of BFN from 2000 through 2015. Over this period, the numbers collected at the upstream site ranged from 24 to 35, with an average of 29 species. Downstream, numbers collected ranged from 23 to 31, with an average of 27 species. Collections upstream have generally been higher than those downstream: more species were collected upstream during ten sample years, while the same number of species was collected at both sites during 2003,

2007, and 2008; more species were collected downstream than upstream during only 2009. The numbers of indigenous species collected during autumn 2015 (35 upstream, 31 downstream) were the highest ever for both sites.

Average number per run (highest rating requires > 487 for electrofishing, > 22 for gill netting)
For the electrofishing portion of the sample, an average of 70.1 fish was collected per effort upstream, and an average of 114.8 fish was collected per effort downstream, resulting in lowest scores for both sites. An average of 13.3 fish was collected per net-night upstream, resulting in a mid-range score. An average of 5.4 fish was collected per net-night downstream, resulting in the lowest score.

Percentage of anomalies (highest rating requires < 2 %)
Anomalies (i.e. visible lesions, bacterial and fungal infections, parasites, muscular and skeletal deformities, and hybridization) observed in a fish community can also be an indicator of the ability of the community to sustain itself over an annual seasonal cycle. The two sites earned highest scores for both the electrofishing and gill net portions of the samples, though slightly greater percentages of anomalies were observed in both portions of the sample at the upstream site (1.1% EF; 0.8% GN), than at the downstream site (0.3% EF; 0.0 % GN) (Table 9).

Summary
Average RFAI scores, determined over the history of autumn sampling around BFN, are identical upstream and downstream. Though more indigenous species were collected upstream during most years, the average numbers of species – calculated over the years during which sampling occurred at both sites – were similar upstream and downstream. Average catch per effort was poor at both sites for electrofishing; average gill net catch upstream was moderate, but the downstream average was also poor. The upstream site exhibited a greater percentage of anomalies than that downstream during 2015, but both sites earned the highest score for this metric.

(3) The presence of necessary food chain species

Estimates of the trophic compositions of the fish communities upstream and downstream of BFN were calculated from the collection data (Tables 10 and 11) as the proportion of the total sample made up by each trophic guild. In direct comparison of the communities upstream and downstream of BFN, the proportions of benthic invertivores, insectivores, and planktivores were generally similar, but the upstream sample contained a greater proportion of top carnivores and a smaller proportion of omnivores. Two additional guilds – herbivore and specialized insectivore – were represented in both samples, though in slightly higher proportions upstream. No parasitic species were collected at either site. The same numbers of benthic invertivore species, insectivore, species, and planktivore species were collected upstream and downstream, but more species of top carnivore, omnivore, and specialized insectivore were collected upstream (Table 2).

In comparison to expected values for transition zones in lower mainstem Tennessee River reservoirs (Table 2), both sites exhibited proportions of top carnivores and herbivores that were poorer than expectations, but the proportions of all other guilds were within or better than the expected ranges. Upstream, the numbers of omnivore species were poorer than expected (more species), but the numbers of species representing all other guilds met or exceeded expectations. Downstream, the numbers of species representing all six trophic guilds met or exceeded expectations (Table 2).

Percent top carnivores (highest rating requires >10% for electrofishing, <39% for gill netting) Seven top carnivore species comprised 9.4% of the electrofishing catch upstream, earning a mid-range score. The most abundant species were largemouth bass (5.6%) and smallmouth bass (1.2%). The other five species made up less than 1% each. Downstream, eight top carnivore species made up 4.5% of the sample, and the site earned the lowest score. Smallmouth bass (2.9%) and largemouth bass (0.8%) were the most abundant species; the six others comprised less than 0.5% each.

Both sites earned the highest score for the gill netting portion of the sample. Nine species made up 59.4% of the sample upstream; white bass (16.5%) and skipjack herring (14.3%) were most

abundant. Eight species made up 53.7% of the sample downstream; skipjack herring (25.9%) and largemouth bass (7.4%) were most abundant.

Percent omnivores (highest rating requires < 24% for electrofishing, < 16% for gill netting)
Both sites earned highest scores for the electrofishing portion of the sample. Seven omnivore species made up 11.7% of the sample upstream; gizzard shad (5.5%), channel catfish (2.9%), and smallmouth buffalo (2.2%) were most abundant. Five omnivore species made up 22.0% of the sample downstream; gizzard shad (20.2%) was overwhelmingly the most abundant species collected.

Both sites earned lowest scores for the gill netting portion of the sample. The same four species—blue catfish, channel catfish, gizzard shad, and smallmouth buffalo—were collected in similar proportions at each site, totaling 35.3% of the catch upstream and 35.2% of the catch downstream.

Summary

Both sites exhibited relative proportions and diversity (number of species collected) of most trophic guilds that met or exceeded expected values, though the proportion of top carnivores was poorer than expected at both sites. The number of omnivore species collected upstream was poorer (more species) than expected, but the general trophic compositions of the fish communities at the two sites were considered similar. Electrofishing yielded more individual top carnivores upstream than downstream, but gill netting efforts collected similarly high proportions at both sites. Both sites showed low proportions of omnivores collected by electrofishing and high proportions collected in gill nets.

(4) A lack of domination by pollution-tolerant species

Number of benthic invertivore species

Five benthic invertivore species were collected at both sites, and both earned mid-range scores of 3 (Table 9).

Number of intolerant species (highest rating requires > 4)
Five intolerant species were collected at both sites, and both received the highest score (5). Longear sunfish, skipjack herring, smallmouth bass and spotted sucker were collected at both sites; northern hogsucker was collected only upstream; black redhorse was collected only downstream (Table 9).

Percentage of tolerant individuals (highest rating requires < 27% electrofishing; < 15% gill net)
At the upstream site, eight tolerant species comprised 23.9% of the electrofishing sample, and the site earned the highest partial score (2.5). The gill net sample included 21.1% tolerant fishes of three species, earning a mid-range partial score (1.5). Downstream, tolerant fishes of eight species made up 30.1% of the electrofishing sample, and four tolerant species made up 29.6% of the gill net sample. The downstream site earned mid-range scores for both portions (Table 9).

Seven tolerant species – bluegill, gizzard shad, golden shiner, green sunfish, largemouth bass, spotfin shiner, and striped shiner – were collected at both sites. Common carp and longnose gar were collected only upstream; redbreast sunfish and white crappie were collected only downstream. Gizzard shad was the most abundant species collected in gill nets at either site, and was collected in similar percentages upstream (16.5%) and downstream (18.5%). It was also the most abundant species collected by electrofishing downstream (20.2%). In the electrofishing catch upstream, bluegill (7.1%), gizzard shad (5.5%), largemouth bass (5.6%), and green sunfish (4.2%) were each collected in similar percentages (Table 9).

Percent dominance by one species (highest rating requires < 29% electrofishing; < 17% gill net)
The upstream site earned highest scores for both portions of the sample. Mississippi silverside was the most prevalent species in the electrofishing catch (27.3%), and gizzard shad in the gill net catch (16.5%). The downstream site earned mid-range scores for both portions of the sample. Mississippi silverside was most prevalent in the electrofishing sample (32.2%) and skipjack herring was most prevalent in the gill net sample (25.9%) (Table 9).

Percentage of omnivores (highest rating requires < 24% electrofishing; < 16% gill net)
Both sites earned highest scores for the electrofishing catch. The proportion of omnivores in the upstream sample was 11.7%, made up primarily of gizzard shad (5.5%), channel catfish (2.9%), and smallmouth buffalo (2.2%). The proportion in the downstream sample was nearly twice that upstream (22.0%) and consisted almost entirely of gizzard shad (20.2%). Gill net samples at both sites contained similar proportions (35.3% upstream; 35.2% downstream) of the same four omnivore species, and both sites earned the lowest partial scores (Table 9).

Summary
Both sites exhibited moderate diversity of benthic invertivore species and relatively high diversity of intolerant species, but the downstream sample was more heavily dominated by single species in both portions of the collection. Mississippi silverside was the most abundant single species collected downstream, but a large collection of gizzard shad (20.1% of the total catch) resulted in higher proportions of tolerant individuals and omnivores than those observed upstream.

Statistical Analyses

Both the Simpson and Shannon diversity indices revealed significantly greater diversity per run in the fish community upstream of BFN compared to that downstream (Table 12).

Potential differences in species richness between the two communities were also analyzed by parsing the data into nine species parameters, and statistical tests of each of these revealed no significant differences between the two communities. The same nine parameters were also tested for differences in abundance (numbers of individuals per run, or CPUE), and results indicated that greater numbers of omnivores and greater numbers of tolerant species were collected per run downstream (Table 12).

Fish Community Summary

Resident important species (RIS) are defined in EPA guidance as those species which are representative in terms of their biological requirements of a balanced, indigenous community of

fish, shellfish, and wildlife in the body of water into which the discharge is made (EPA and NRC, 1977). RIS often include non-indigenous species. Thirty-nine RIS were collected at the site upstream of BFN, compared to 34 RIS downstream (Tables 10 and 11).

Species that experience avoidance behavior or mortality at water temperatures equal to or greater than 32.2°C (90°F) are designated as "thermally sensitive" (Yoder et al., 2006). The same thermally sensitive species – logperch – was collected at both sites. The aquatic nuisance species common carp, striped bass, and Mississippi silverside were collected upstream; redbreast sunfish and Mississippi silverside were collected downstream (Tables 10 and 11). Commercially valuable species are defined by the Alabama Department of Conservation and Natural Resources (2013) as any of the following non-game fish: drum, buffalo, carp, channel catfish, all members of the catfish family, paddlefish (spoonbill), spotted sucker, all members of the sucker family including the species known as redhorse and black horse, bowfin and all members of the gar family, and mullet. Recreationally valuable species are those that are targeted by anglers or are used as bait. Among the RIS collected upstream were 14 commercially valuable species and 22 recreationally valuable species, compared to 12 commercially valuable and 18 recreationally valuable species downstream (Tables 10 and 11).

Total RFAI scores for the sampling sites upstream and downstream differed by five points, indicating that the two communities exhibited similar ecological structure and balance. As previously discussed, RFAI scores have an intrinsic variability of ± 3 points (6-point range). This variability comes from several sources, including annual variations in air temperature and stream flow; variations in pollutant loadings from nonpoint sources; changes in habitat, such as extent and density of aquatic vegetation; natural population cycles and movements of the species being measured (TWRC 2006). Another source of variability arises from the fact that nearly any practical measurement, lethal or non-lethal, of a biological community is a sample rather than a measurement of the entire population.

The effects of these sources of variability on the sample data could have generated a difference in scores due simply to method variation. Accordingly, a thorough comparison of the fish

communities upstream and downstream of BFN was conducted by examining each of the twelve individual RFAI metrics as a component of the appropriate characteristic of a BIP.

Measures of diversity were similarly high for both communities, except diversity of benthic invertivores, which was moderate for both sites. Abundance was generally poor (both sites received low scores for the metric "Average number per run"), but both sites exhibited strong sustainability over an annual cycle and similar trophic composition. The downstream community was more heavily dominated by a single species, and included higher proportions of tolerant individuals and of omnivores than were observed upstream.

To provide additional information about the health of the fish community throughout Wheeler Reservoir, Table 12 compares RFAI scores for the sites upstream and downstream of BFN with those from additional VS sites in the reservoir. Average RFAI scores of these additional VS sites, determined across all years sampled, are in the "Good" range. However, aquatic communities at these sites are not subject to thermal effects from BFN and are not used in determination of BIP in relation to the plant.

Individual metric scores, overall RFAI scores, species collected, and catch per effort from electrofishing and gill netting conducted upstream and downstream of BFN during 1999 through 2013 are included in TVA (2011) and TVA (2014).

Statistical tests of nine species parameters indicated that no significant differences existed between the upstream and downstream communities in number of species collected per run, but that significantly more omnivores and tolerant fishes were collected per run downstream. These results support similar observations made in the RFAI analysis. The results of both the Simpson and Shannon diversity analyses show significantly greater diversity in the upstream samples. The RFAI metric "Number of indigenous species" indicates similar total numbers collected at both sites. However, review of the total collections shows that eight indigenous species were collected only upstream, while four others were collected only downstream. When non-indigenous species and hybrids are included, a total of 11 taxa were collected upstream that were not found downstream, compared to six taxa collected only downstream (Tables 10 and 11).

In conclusion, the community downstream of BFN was found to be less diverse and more heavily dominated by a single species than that upstream, with higher proportions of omnivores and tolerant fishes. However, large collections of Mississippi silverside and gizzard shad, two species which are known to form large schools, significantly influenced the downstream results. There was no evidence indicating the differences between the communities were caused by thermal effluent from BFN.

Benthic Macroinvertebrate Community

As discussed previously, data to assess the benthic macroinvertebrate community around BFN were collected from three sites in autumn 2015. RBI metrics for all three sites were scored using evaluation criteria for lab-processed samples collected in the transition reservoir zone (Table 4). Data collected at TRM 290.4, downstream of the thermal plume, produced an overall RBI score of 33 ("Excellent") and data from TRM 293.2, within the thermal plume, produced an overall RBI score of 31 ("Excellent"). Data from the upstream site, TRM 295.9, produced an overall RBI score of 33 ("Excellent") (Table 14).

The upstream site was considered a control site and a difference of 4 points or less was used to define "similar" conditions between the upstream and downstream sites. Because the RBI scores for the two downstream sites were within 4 points of the RBI score for the upstream site, conditions among the three sites were considered "similar" and BIP was maintained. Results for the autumn 2015 benthic macroinvertebrate sampling can be found in Tables 14 and 17. Results were compared between the downstream (TRM's 290.4 and 293.2) and upstream (TRM 295.9) sites and are briefly discussed below for each RBI metric.

Average number of taxa (highest rating requires > 6.6)

In autumn 2015, averages of 9.2 and 10.4 taxa were observed for sites downstream of BFN. The site upstream of BFN averaged 9.5 taxa per sample. All three sites received the highest score of 5 for this metric (Table 14).

Proportion of samples with long-lived organisms (highest rating requires > 0.9)

The metric "proportion of samples with long-lived organisms" received the highest score of 5 at both downstream sites with 100% containing long-lived organisms (proportion of 1.0). The proportion of samples with long-lived organisms was 100% at the upstream site which also received the highest score for the metric (Table 14).

Average number of EPT taxa (highest rating requires > 1.4)

An average of 1.5 EPT taxa was collected at the most downstream site, TRM 290.4, resulting in the highest score (5). Within the plume at TRM 293.2, an average of 1.3 EPT taxa was collected and upstream of BFN at TRM 295.9, an average of 1.4 EPT was collected. Both sites received the mid-range score of 3 (Table 14).

Average proportion of oligochaete individuals (highest rating requires < 11%)

The two downstream sites, TRM's 290.4 and 293.2, received the mid-range score for the autumn 2015 samples, which included averages of 12.6% and 19.1% oligochaetes, respectively. The average proportion of oligochaetes in upstream samples was lower with 8.1%, resulting in the highest score for the upstream site, TRM 295.9 (Table 14).

Proportion of total abundance comprised by two dominant taxa (highest rating requires < 77.8%)

The two downstream sites, TRM's 290.4 and 293.2, received the highest score for this metric, with the two dominant taxa making up 67.5% and 66.4% of the samples, respectively. The upstream site also received the highest score and total abundance of the two dominant taxa was 66.8% (Table 14).

At the most downstream site, TRM 290.4, chironomid midge *Coelotanypus* sp. (Chironomidae) and Asiatic clams (Corbiculidae) were the two most abundant taxa. *Coelotanypus* sp. and the fingernail clam *Musculium transversum* (Sphaeriidae) were the two most abundant taxa at both the site within the thermal plume, TRM 293.2 and at the upstream site, TRM 295.9 (Table 17a).

Average density excluding chironomids and oligochaetes (highest rating requires > 609.9/m^2)

At the downstream sites, average densities excluding chironomids and oligochaetes were 613.3/m^2 and 736.7/m^2. Both sites received the highest score. Average density excluding chironomids and oligochaetes at the upstream site was 991.7/m^2, also resulting in the highest score (Table 14).

Proportion of samples containing no organisms (highest rating requires that all samples contain organisms)

In autumn 2015, there were no samples at any site which were void of organisms. All sites received the highest score (Table 14).

Benthic Macroinvertebrate Community Summary

Monitoring results for autumn 2015 support the conclusion that a BIP of benthic macroinvertebrates was maintained downstream of BFN. The site within the thermal plume, TRM 293.2, and the site downstream of the thermal plume, TRM 290.4, received RBI total scores of 31 and 33, respectively, and both received ecological health ratings of "Excellent". The upstream control site, TRM 295.9, received an RBI total score of 33 and "Excellent" rating also. Benthic communities at the downstream sites were considered similar with one another and with the upstream control site, whose RBI score was within four points when compared with RBI scores for the downstream sites (Table 14).

Individual metrics and RBI total scores for benthic community samples from TRM 291.7 (downstream) and TRM 295.9 (upstream) are provided in Tables 15 and 16 for referencing results from 2000 to 2010. Benthic samples from these two locations were field processed every year monitored through 2010, and during some of the years samples were also laboratory processed. Since 2011, samples have been lab-processed which produces a more accurate depiction of the benthic community. Although the locations presently used as the downstream sites (TRMs 290.4 and 293.2) are proximate to the downstream transect sampled from 2000 to 2010 (TRM 291.7), laboratory-processed RBI scores for 2011 and forward cannot be directly compared to field-processed RBI scores from 2000 to 2010 without inference.

To provide additional data on the overall health of the benthic macroinvertebrate community in Wheeler Reservoir, RBI scores for VS monitoring locations–inflow, forebay, and Elk River embayment sites–were included in Table 18. Please note that comparison of these scores to current RBI scores at the sites around BFN is limited for two reasons. First, data from these sites were scored from field-based criteria and cannot be closely compared to lab-based scores. Second, these sites are many river miles away from BFN. The inflow site is 53 river miles upstream, and the forebay sampling site is located 17 river miles downstream. The Elk River embayment site is located 6 river miles upstream of the confluence with the Tennessee River, which in turn is 10 river miles downstream of BFN. Because of these distances from the plant, poor scores at these sites cannot be considered indicative of thermal effects from BFN.

RBI scores for VS monitoring locations in 2015 were considered similar to their respective long term average scores, differing by three points or less. The Wheeler inflow site (TRM 347) has produced RBI scores of "Good" or "Excellent" for 12 of the 15 years sampled. The forebay (TRM 277) and Elk River embayment sites (ERM 6.0) have produced "Poor" scores most years sampled (Table 18).

Visual Encounter Survey (Wildlife Observations)

During autumn 2015, observations of shoreline wildlife upstream of BFN included 295 birds of twelve species and 52 turtles of two species. Observations downstream included 217 birds of 15 species and 26 turtles of a single species. No mammals were observed at either location. Six species of birds – great blue heron, European starling, mallard, blue jay, American robin, and double-crested cormorant – and one species of turtle – map turtle – were observed at both stations. Belted kingfisher, mockingbird, American crow, common flicker, white pelican, Carolina wren and painted turtle were observed only upstream. Golden eagle, bald eagle, Carolina chickadee, common grackle, pileated woodpecker, American coot, red-tailed hawk, pied-billed grebe, and osprey were observed only downstream (Table 19).

Table 20 compares the wildlife species observed along the same transects since 2011. Some species–belted kingfisher, blue jay, great blue heron, mallard, map turtle–were recorded along all

transects upstream and downstream during each year and can be considered common. Others were observed intermittently, along a single transect or during only one sample year. It is important to note that a Visual Encounter Survey provides a preliminary near shore wildlife assessment to determine if the thermally affected area downstream of a power plant has adversely affected the bird, reptile, or mammal communities. Using the methods described for these surveys, determination of the presence and diversity of small, perching bird species, reptiles and mammals is made difficult by their typical behaviors. Other factors contributing to the limited observations of some taxa include ecological status (e.g. top-level predators– raptors such as red-tailed hawk, osprey, bald eagle, etc.–are less abundant than species at lower trophic levels), and migratory habits. The diversity of bird groups recorded indicates that a healthy ecological community has existed both upstream and downstream of BFN since 2011 and that the shoreline wildlife community downstream has not been adversely affected by the operation of the plant. If, after any survey an adverse environmental impact is suspected, sampling strategies of a more quantitative nature, such as trapping or netting, active search, investigation of mammal tracks along shoreline areas, long-term observation from blinds, or the use of cameras will be proposed to more accurately estimate the presence and diversity of these groups.

Wheeler Reservoir Flow and BFN Water Temperature

Daily mean flows from Guntersville Dam during 2015 are compared in Figure 18 to historic daily mean flows averaged from 1976 to 2014 over the same period. From early to mid-January and mid-July through November 2015, flows were similar to historical averages. Flows were generally lower than historical averages from mid-January through February, in early April and from May through July 2015. Flows were slightly higher than historical averages during March, April, and early July and considerably higher during December 2015.

Figure 19 compares daily average water temperatures recorded upstream of BFN intake and downstream of BFN discharge during 2015. Water temperatures were similar at both sites through this period.

Thermal Plume Characterization

Plume temperatures (water temperatures 3.6°F [2°C] or greater above ambient) were detected at the BFN discharge (TRM 293.5) along the right descending bank, extending approximately 30% across the width of the river and from the surface to 1.5 m depth. The plume continued downstream of the discharge along the right descending bank, and at TRM 291.7 it extended to 3 m depth. At TRM 290.2, downstream of the sample area, the plume extended to 50% of the width of the river and to a maximum depth of 4 m (Table 21).

These profiles indicate that, at maximum, the thermal effluent from BFN was confined to the upper half of the water column from the right descending bank to mid-channel, and that a sufficient zone of passage for aquatic wildlife existed around BFN during autumn 2015.

Water Quality Parameters at Fish Sampling Sites during RFAI Samples

Water temperatures observed at the upstream site centered at TRM 295.9, ranged from 65.8 to 76.2 °F. The highest temperature observed was at the surface on the right descending bank along the downstream boundary of the sample reach. Surface temperatures of all other profiles ranged from 69.7 to 71.2 °F. This indicates that the plume of heated effluent from BFN includes some flow upstream of the discharge along this bank. Water temperatures at the downstream site, centered at TRM 292.5, ranged from 66.7 to 72.8 °F. Temperatures generally increased from the left to the right descending bank, and the highest temperatures occurred at the surface in midchannel and along the RDB of the mid-station transect. This indicated that the plume from BFN dissipated along the RDB downstream of the discharge, but did not extend beyond midchannel (Table 22).

Values for pH, conductivity, and dissolved oxygen concentration were similar in both the upstream and downstream sample reaches, falling within narrow ranges: values for pH were from 7.1 to 7.7 upstream and from 7.2 to 7.8 downstream; conductivity was between 207.4 and 218.8 μS/cm upstream and between 207.3 and 214.6 μS/cm downstream; DO concentrations were between 7.7 and 9.4 mg/L upstream and between 8.1 and 9.6 mg/L downstream (Table 22).

The values of these parameters indicate that pH, conductivity, and dissolved oxygen concentrations surrounding BFN during autumn 2015 were of sufficient quality to support a BIP of the type expected for this reservoir, and that they were not affected by thermal effluent from BFN. The most elevated temperatures within the downstream site were observed along the right descending bank at the surface, and are consistent with temperatures recorded at similar locations during plume determination (Table 20). The most elevated temperatures within the upstream site were observed at the surface along the lower boundary of the site. This lower boundary is less than one mile upstream of the discharge, and considering the width of the reservoir, the curvature of the river bed, and the relatively low velocity of the river at this point, these elevated temperatures can be attributed to a recirculation of heated water upstream from the discharge. Discussion above indicated that a zone of passage for aquatic life existed from midchannel to the left descending bank around BFN. Therefore, overall water quality around BFN was not negatively impacted by the thermal effluent.

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Figures

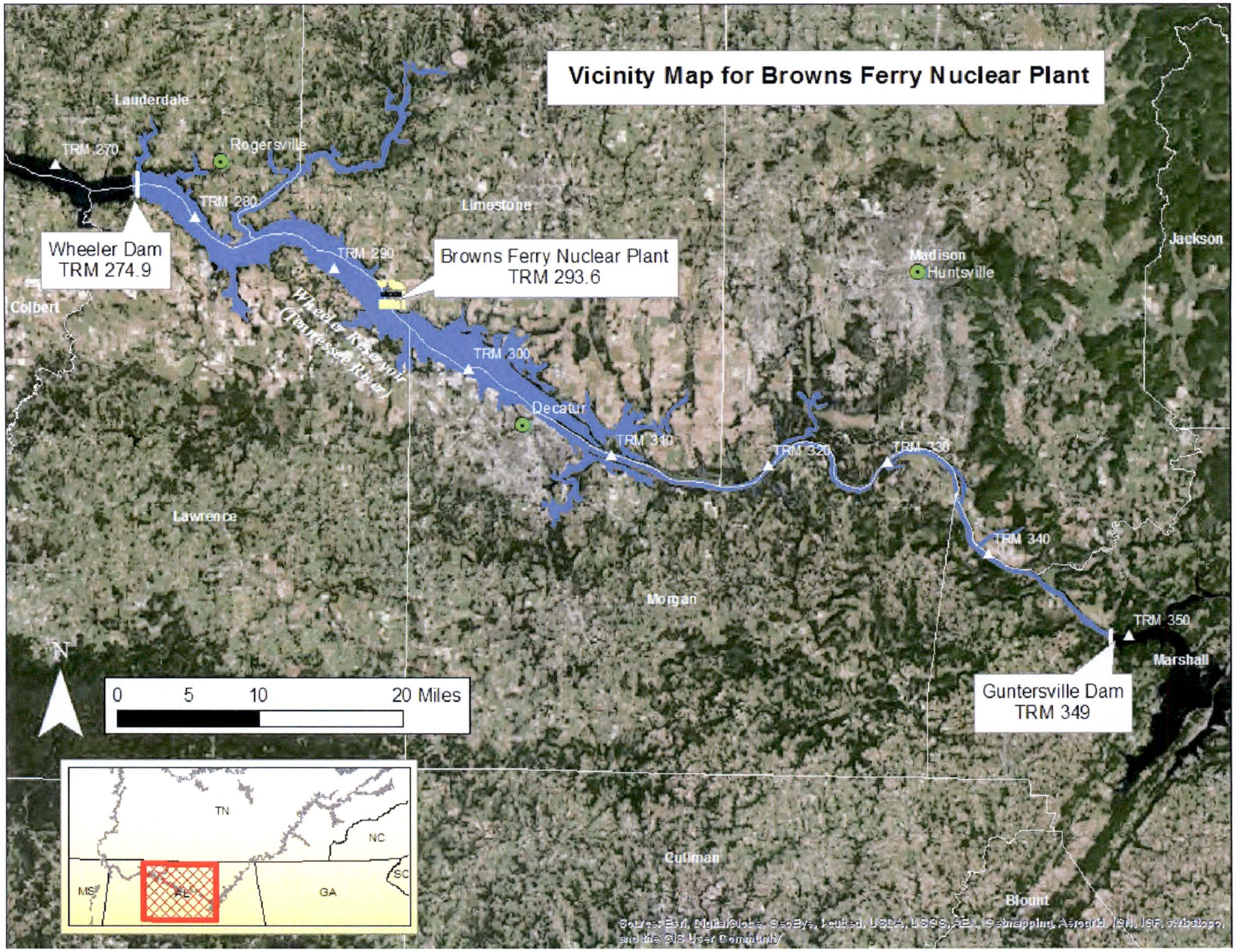

Figure 1. Location of Browns Ferry Nuclear Plant on Wheeler Reservoir.

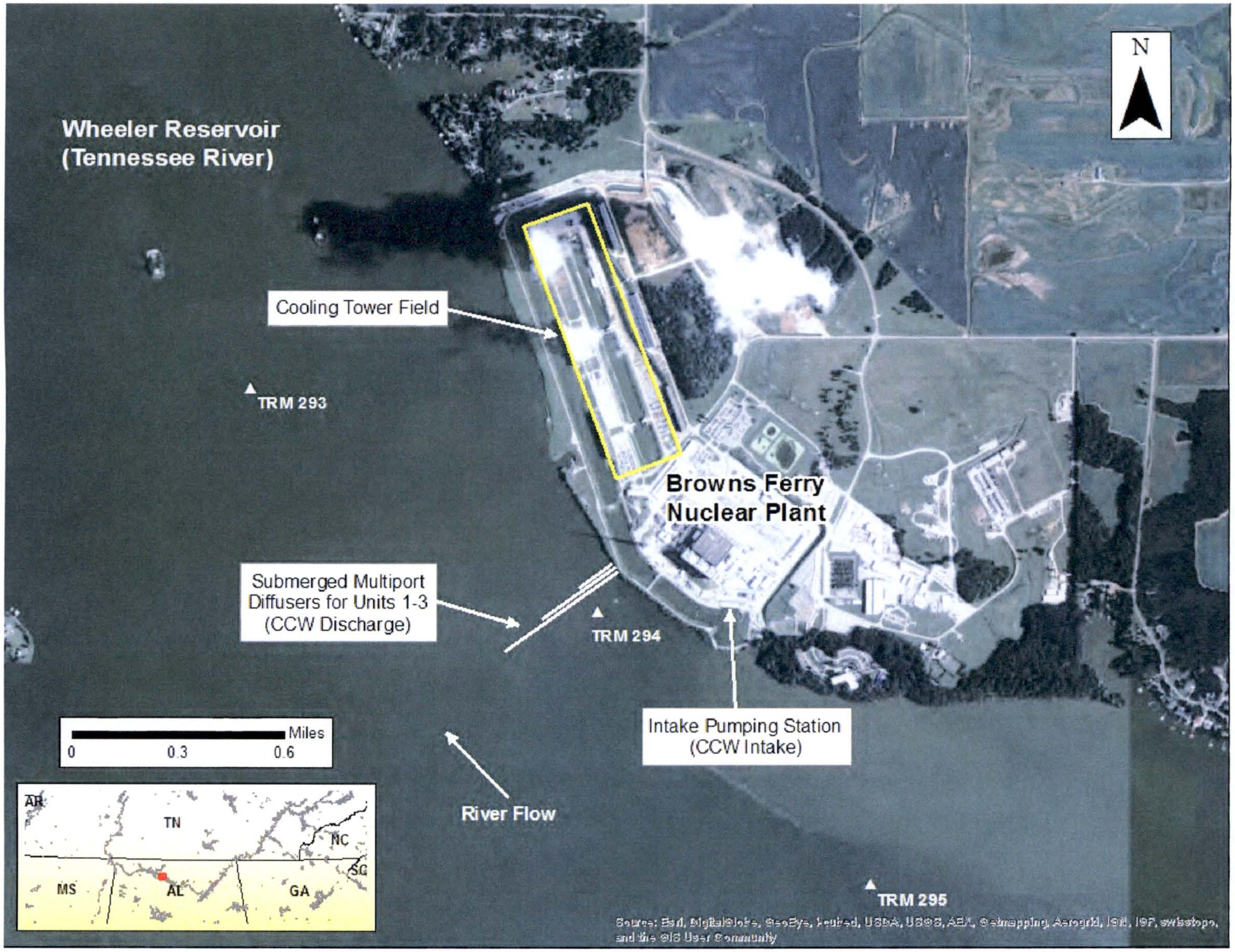

Figure 2. Location of Condenser Cooling Water (CCW) intake and discharge at Browns Ferry Nuclear Plant.

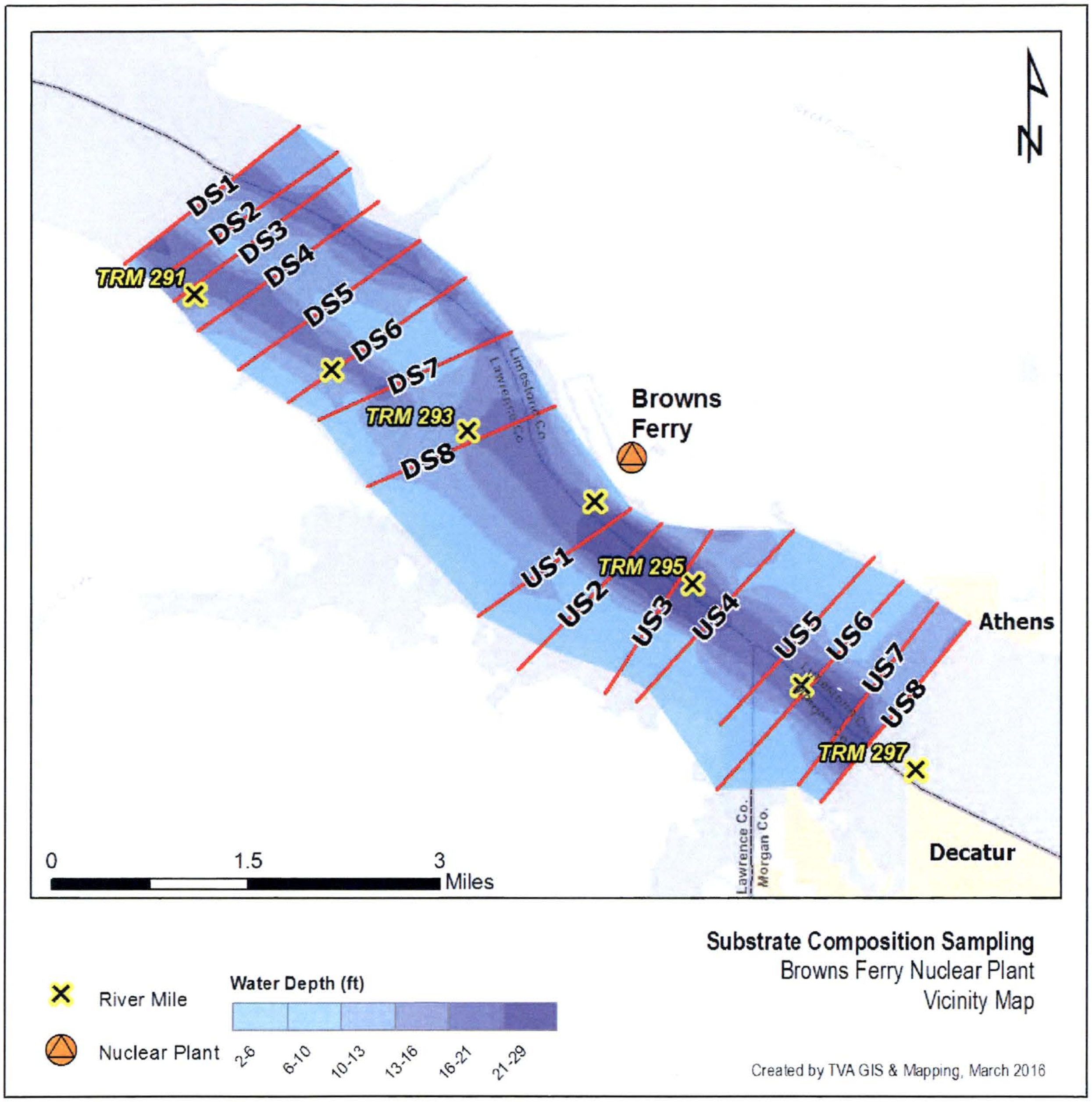

Figure 3. Locations of transects used to characterize shoreline and river bottom habitat upstream and downstream of Browns Ferry Nuclear Plant, and water depths within the two sample reaches.

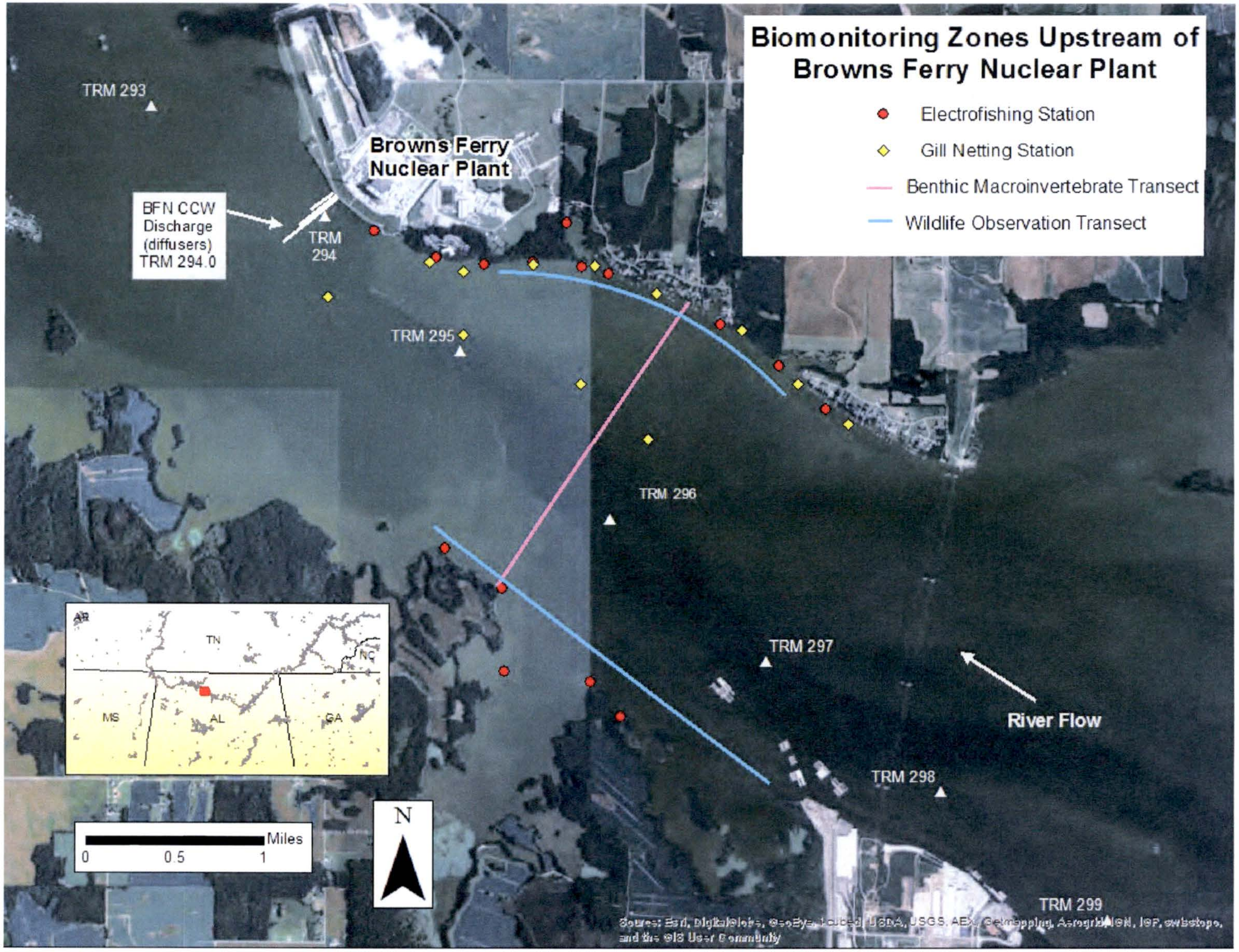

Figure 4. Locations of biomonitoring sites upstream of Browns Ferry Nuclear Plant.

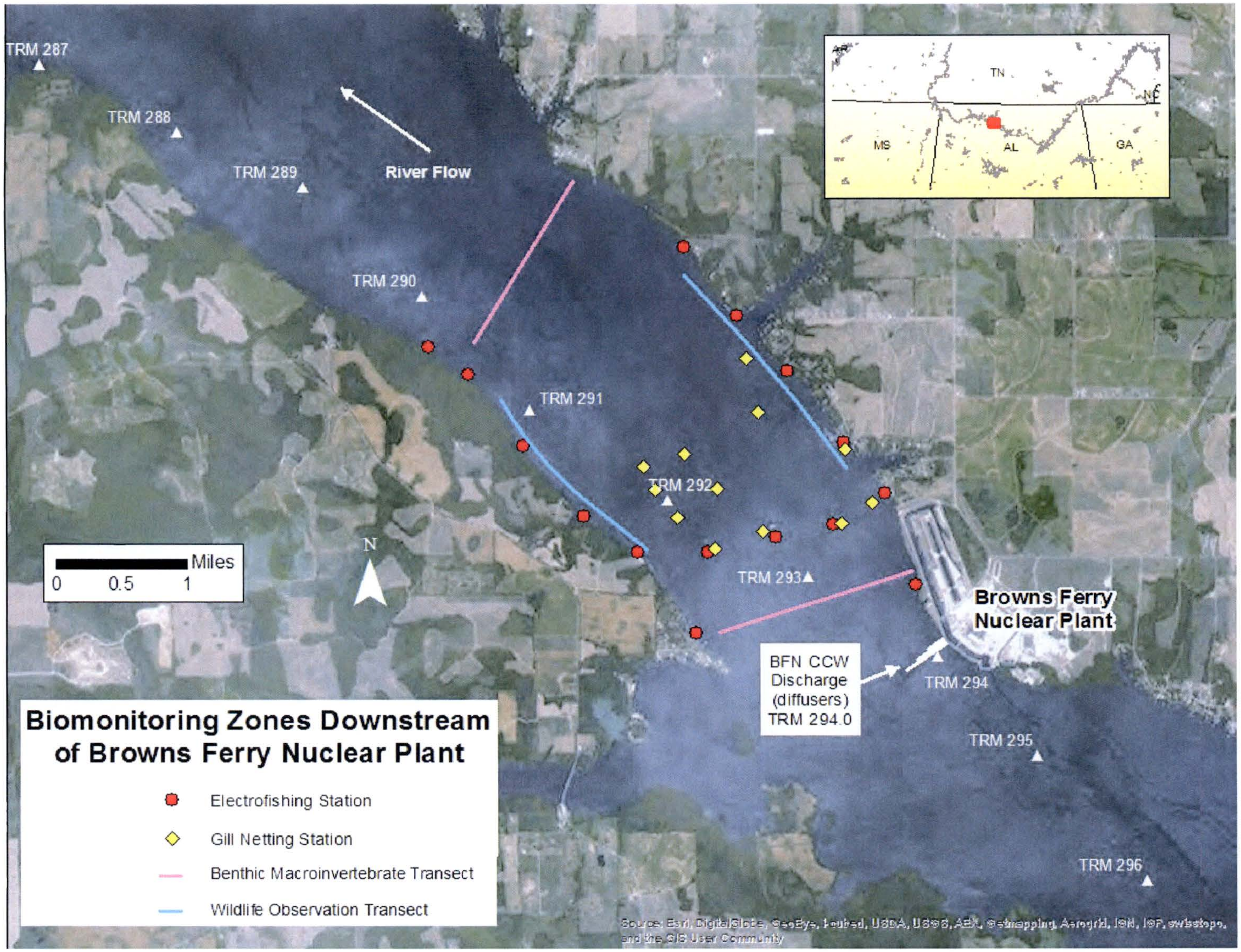

Figure 5. Locations of biomonitoring sites downstream of Browns Ferry Nuclear Plant.

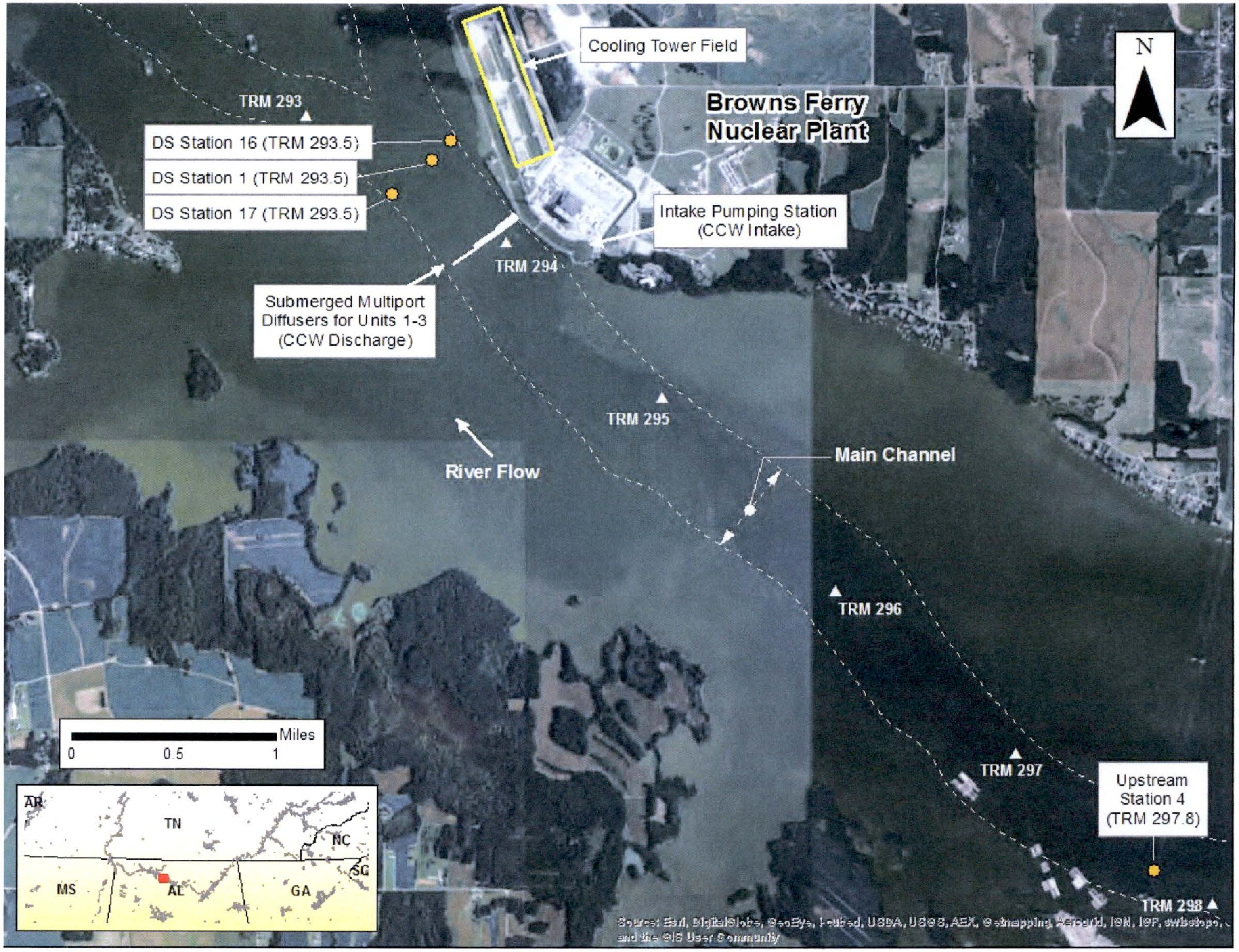

Figure 6. Locations of water temperature monitoring stations used to compare water temperatures upstream of Browns Ferry Nuclear Plant (BFN) intake and downstream of BFN discharge. Station 4 was used for upstream ambient temperatures of the BFN intake. Stations 1, 16, and 17 were used for temperatures downstream of BFN discharge.

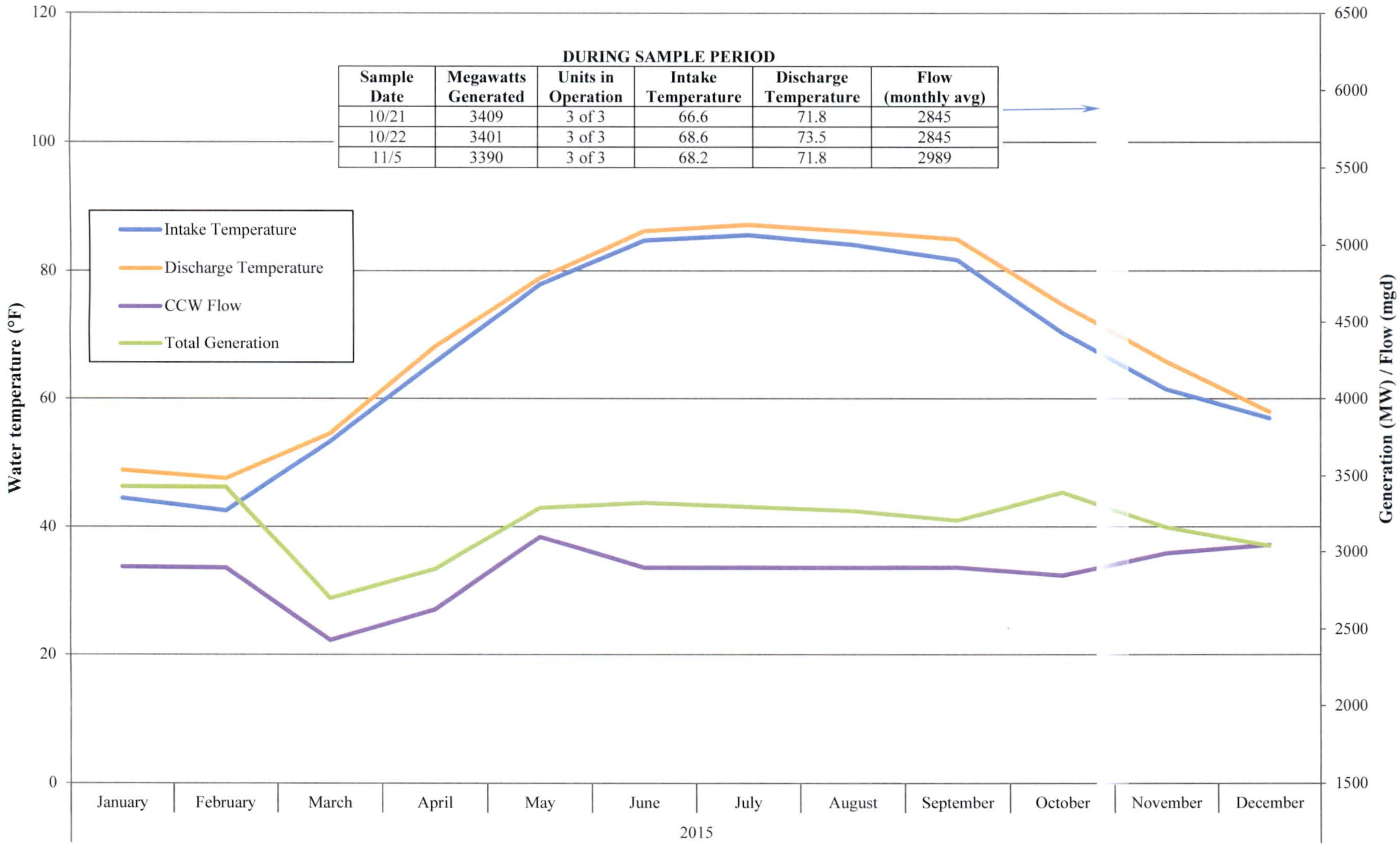

Figure 7. Megawatts generated, water temperatures of the intake and discharge and flow through the condenser cooling water (CCW) system at Browns Ferry Nuclear Plant during 2015.

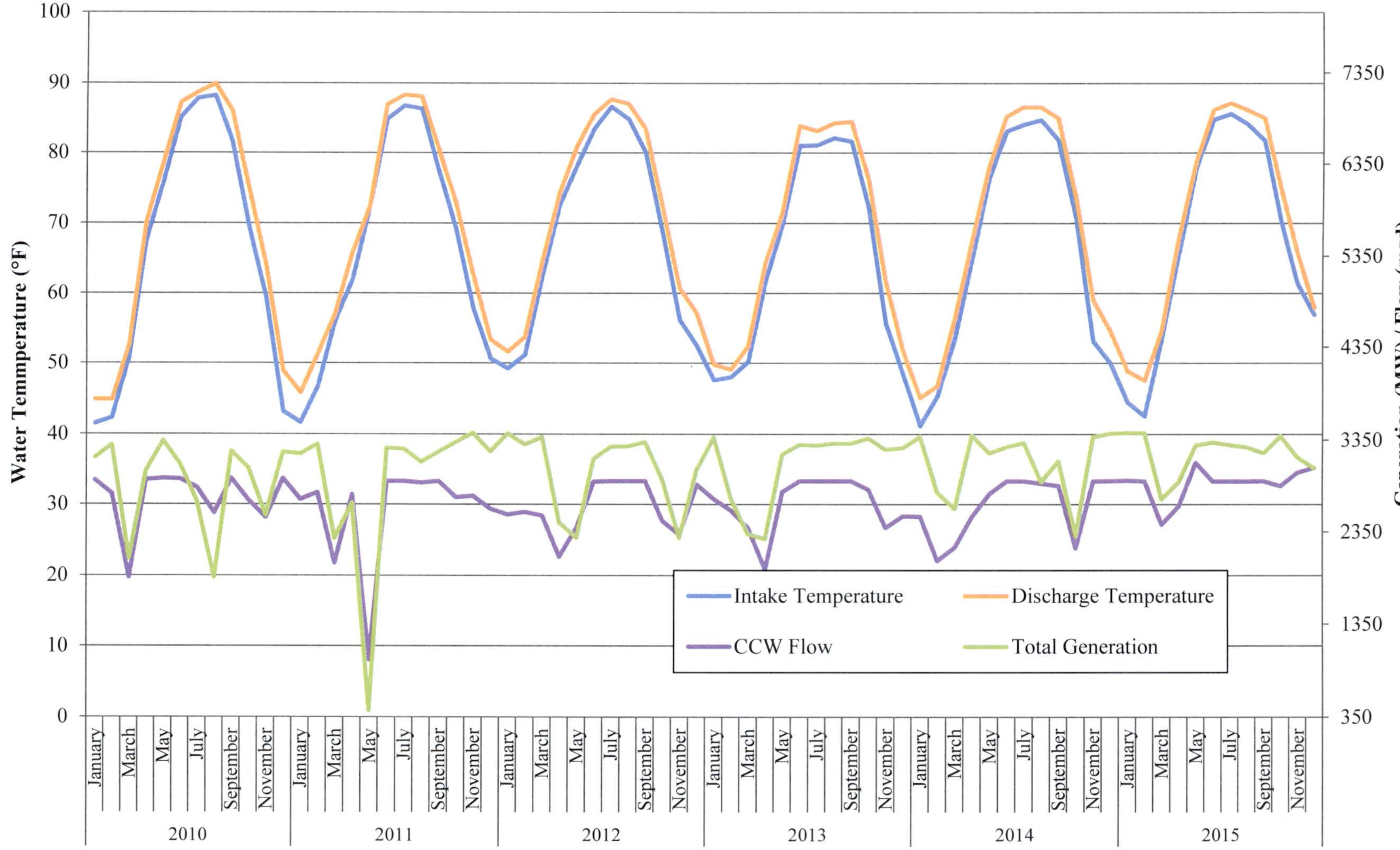

Figure 8. Megawatts generated, water temperatures of the intake and discharge and flow through the condenser cooling water (CCW) system at Browns Ferry Nuclear Plant during the five years prior to the survey (2010-2014).

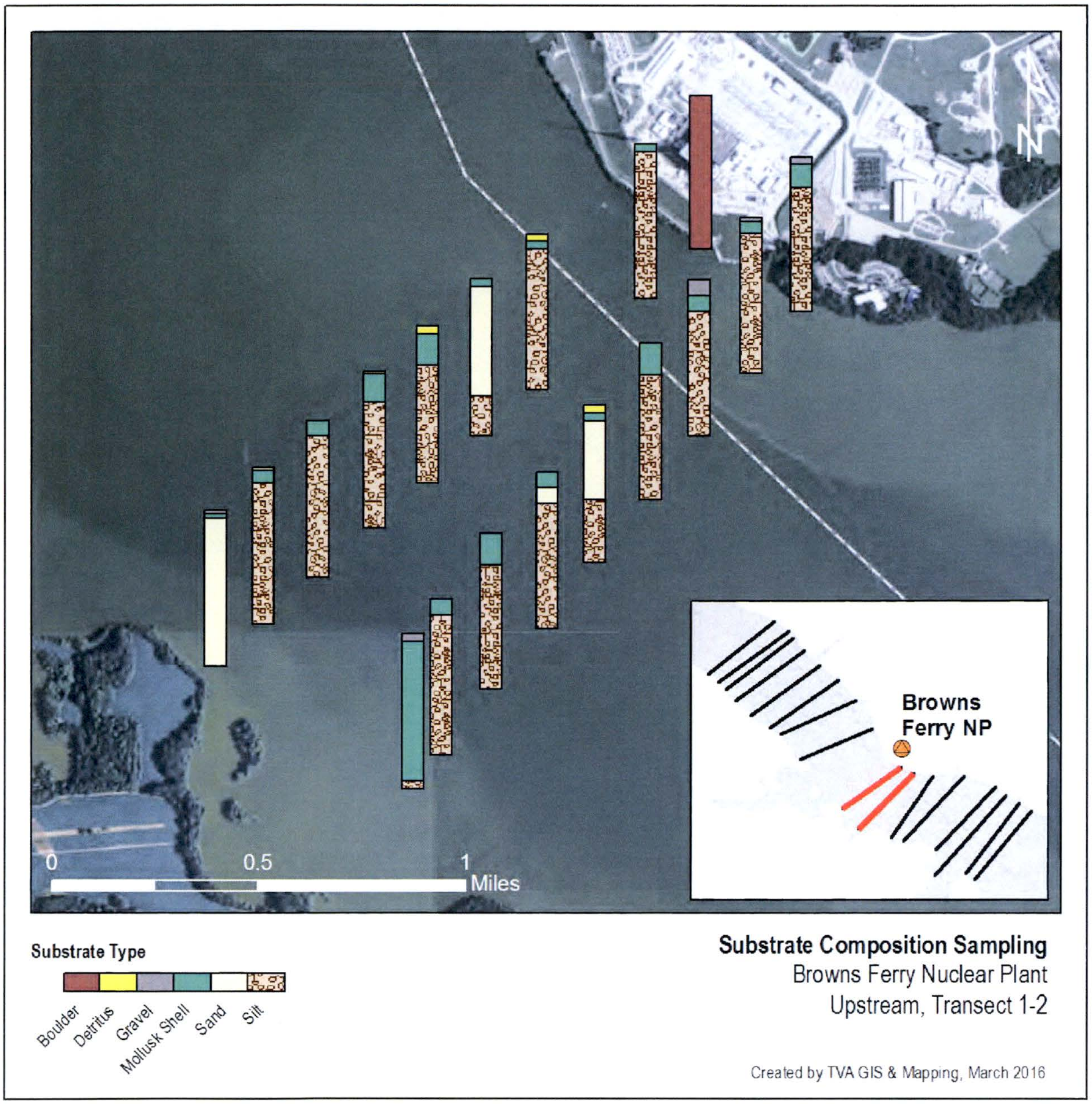

Figure 9. Composition of substrate samples collected at ten points equally spaced along each of transects 1 and 2 upstream of Browns Ferry Nuclear Plant.

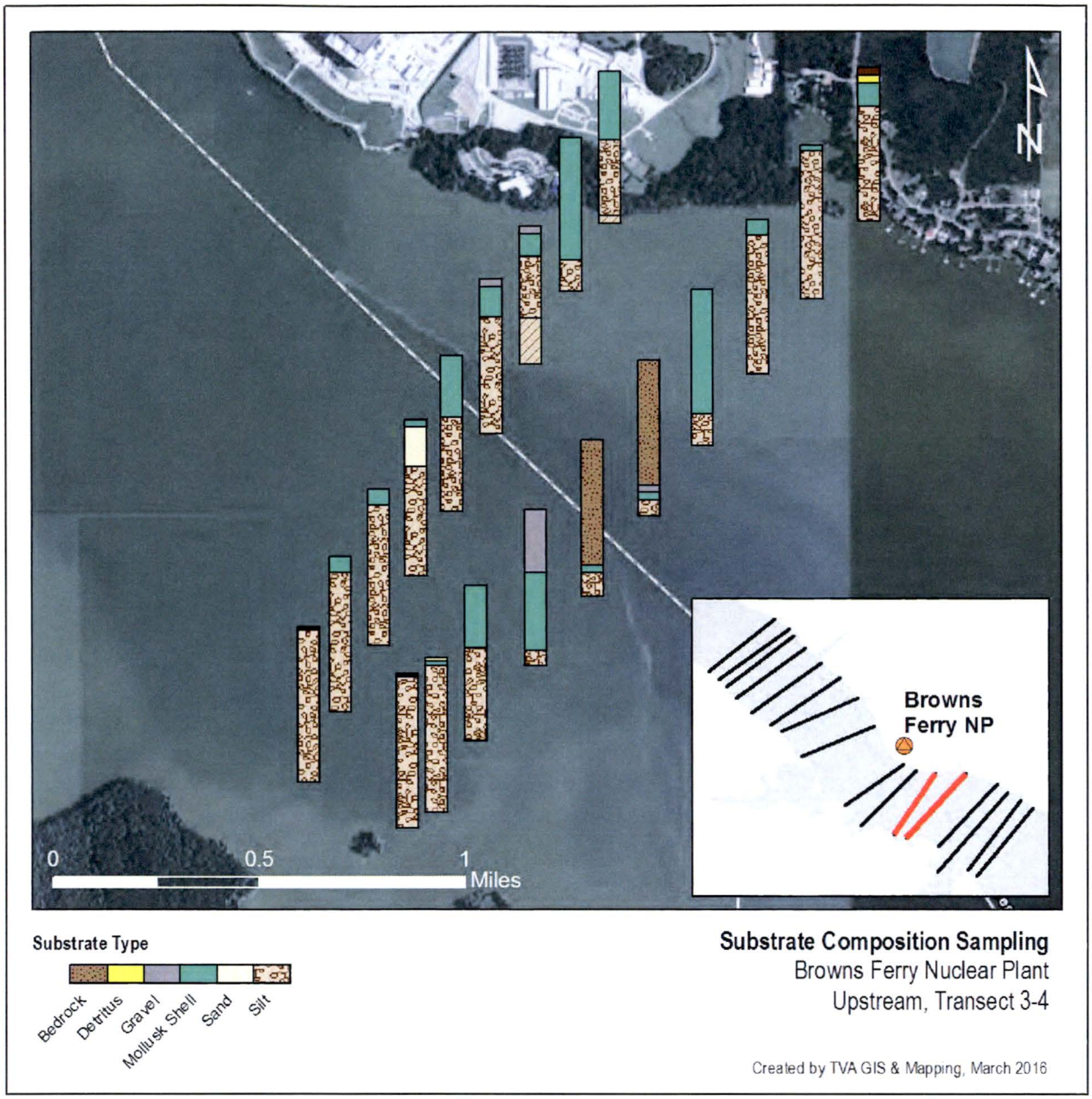

Figure 10. Composition of substrate samples collected at ten points equally spaced along each of transects 3 and 4 upstream of Browns Ferry Nuclear Plant.

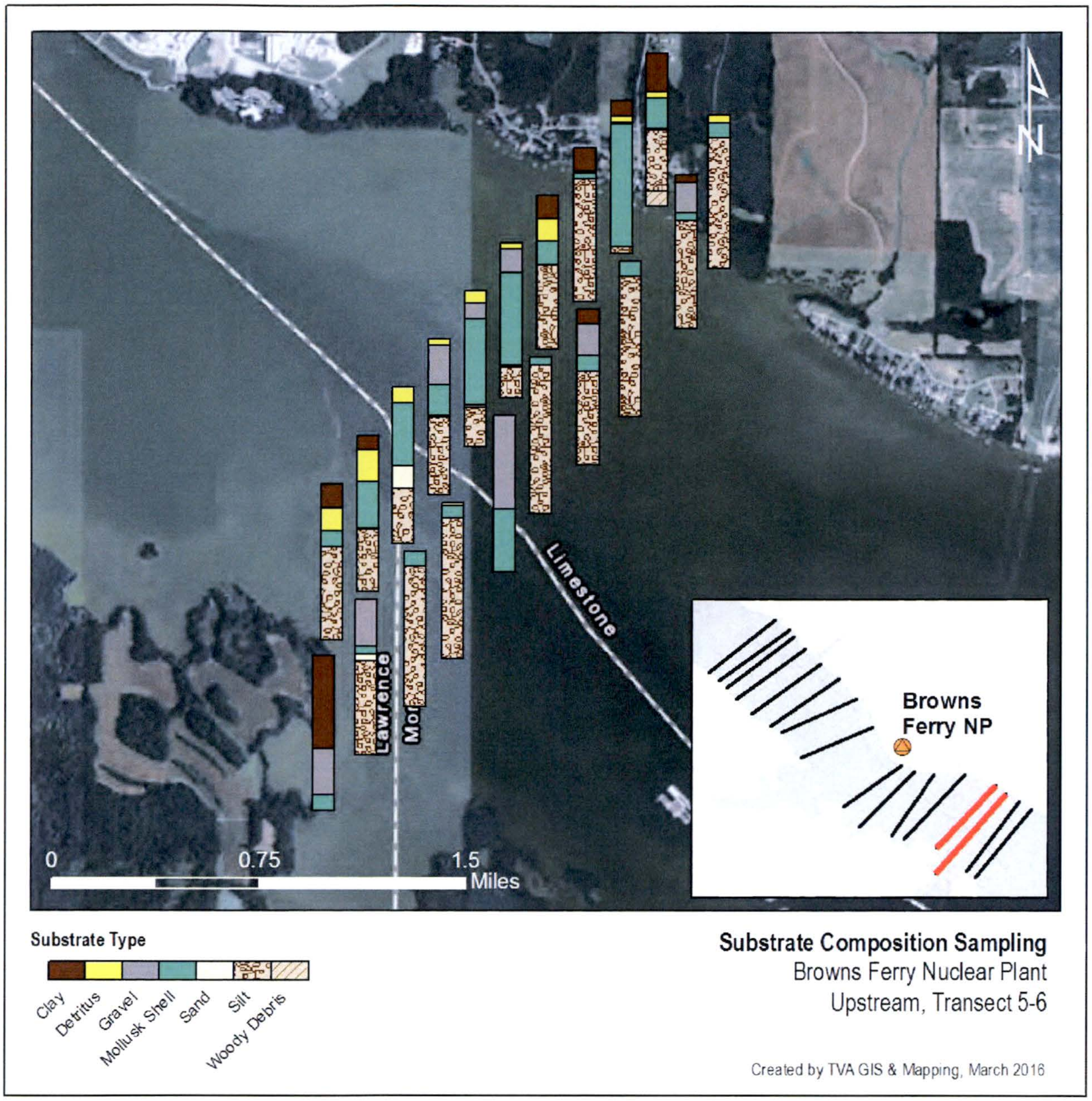

Figure 11. Composition of substrate samples collected at ten points equally spaced along each of transects 5 and 6 upstream of Browns Ferry Nuclear Plant.

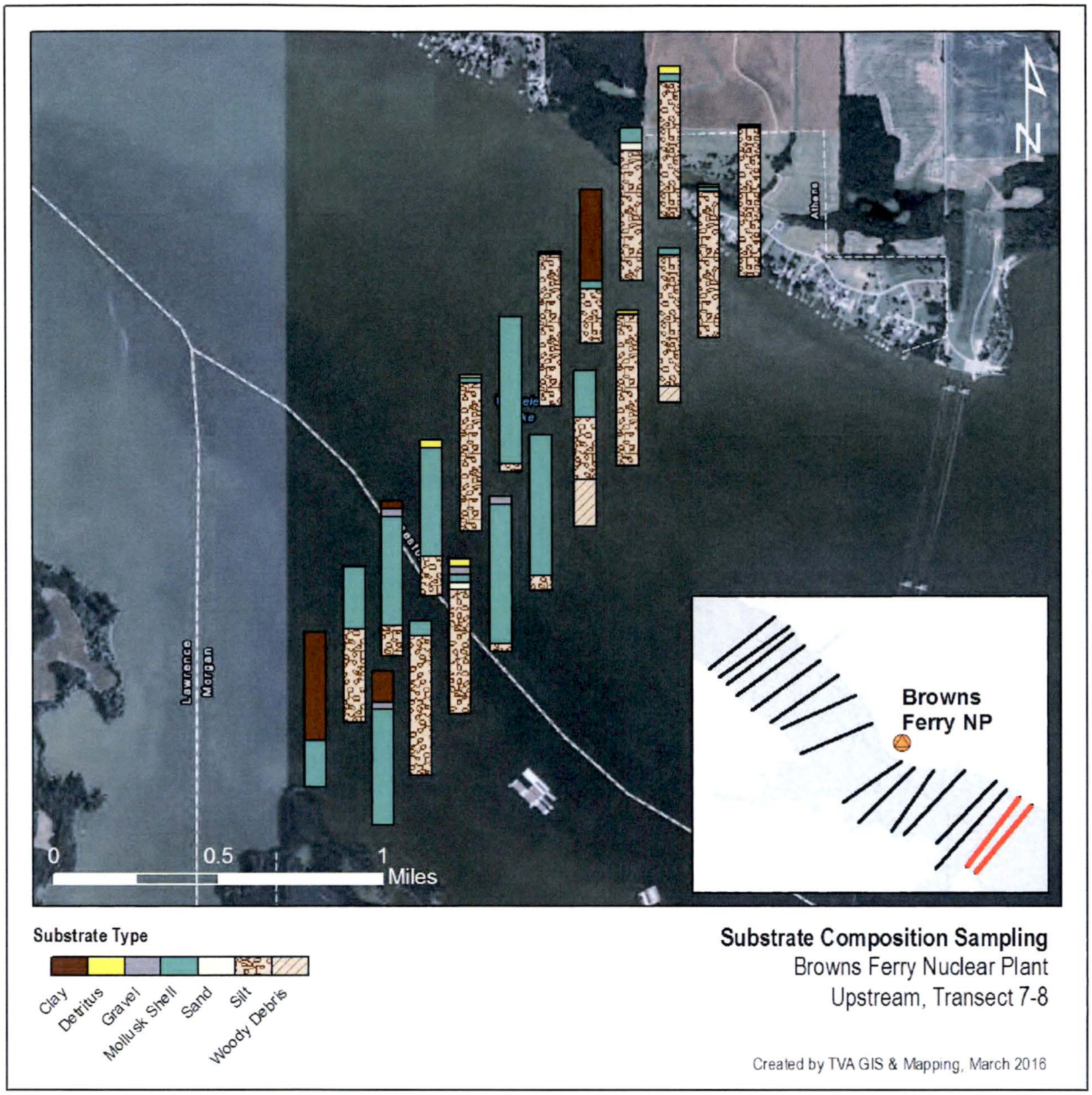

Figure 12. Composition of substrate samples collected at ten points equally spaced along each of transects 7 and 8 upstream of Browns Ferry Nuclear Plant.

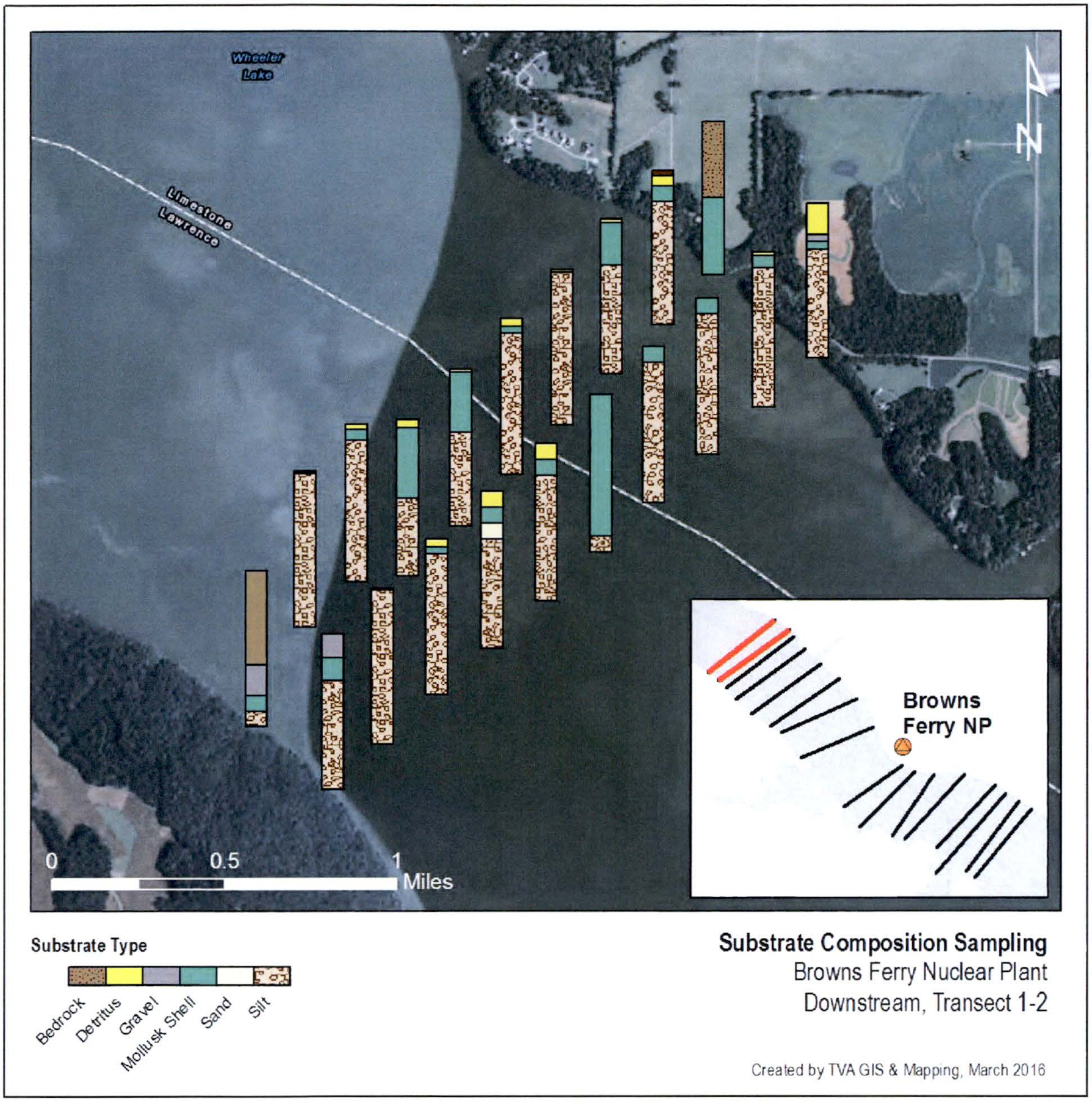

Figure 13. Composition of substrate samples collected at ten points equally spaced along each of transects 1 and 2 downstream of Browns Ferry Nuclear Plant.

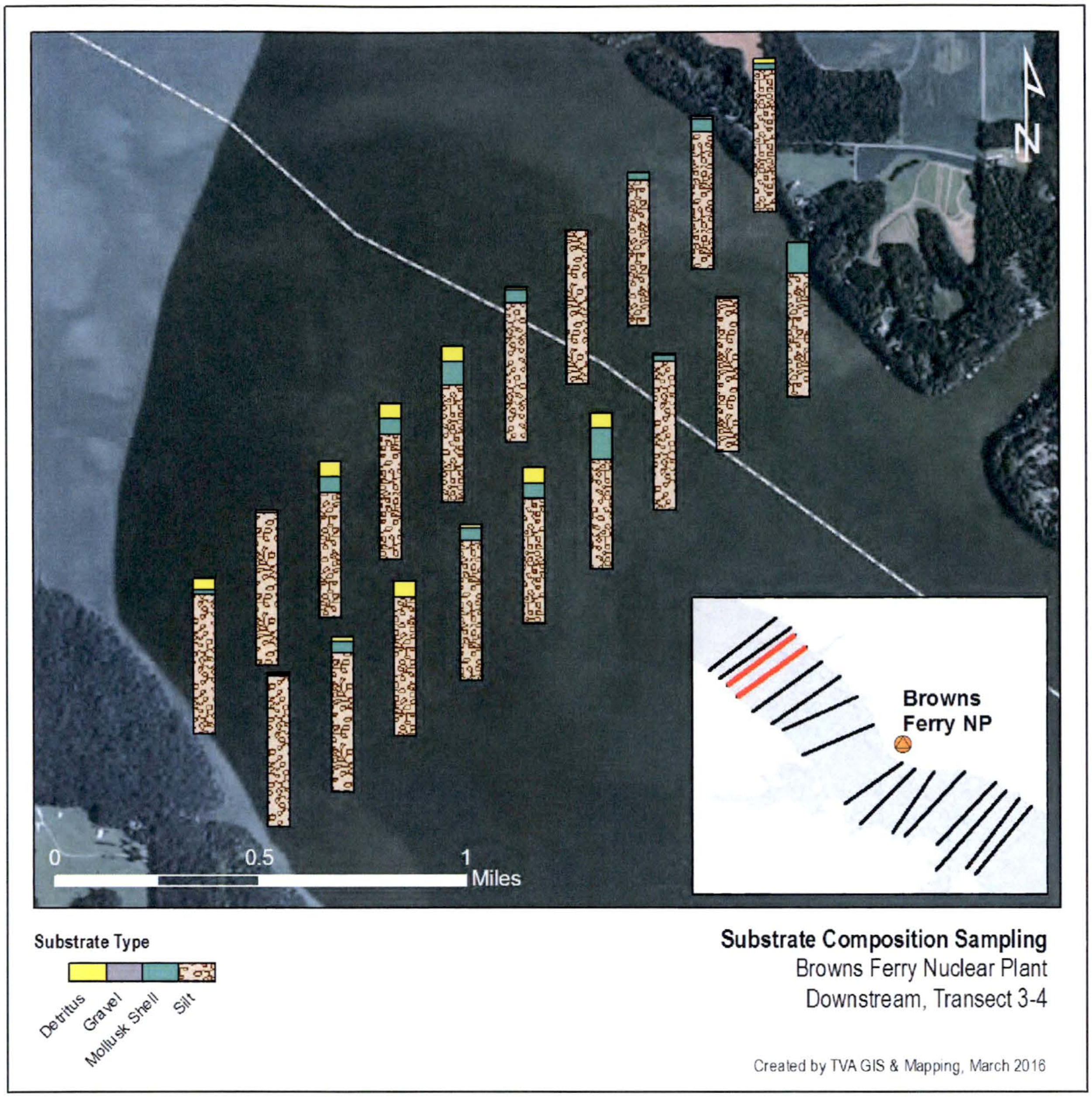

Figure 14. Composition of substrate samples collected at ten points equally spaced along each of transects 3 and 4 downstream of Browns Ferry Nuclear Plant.

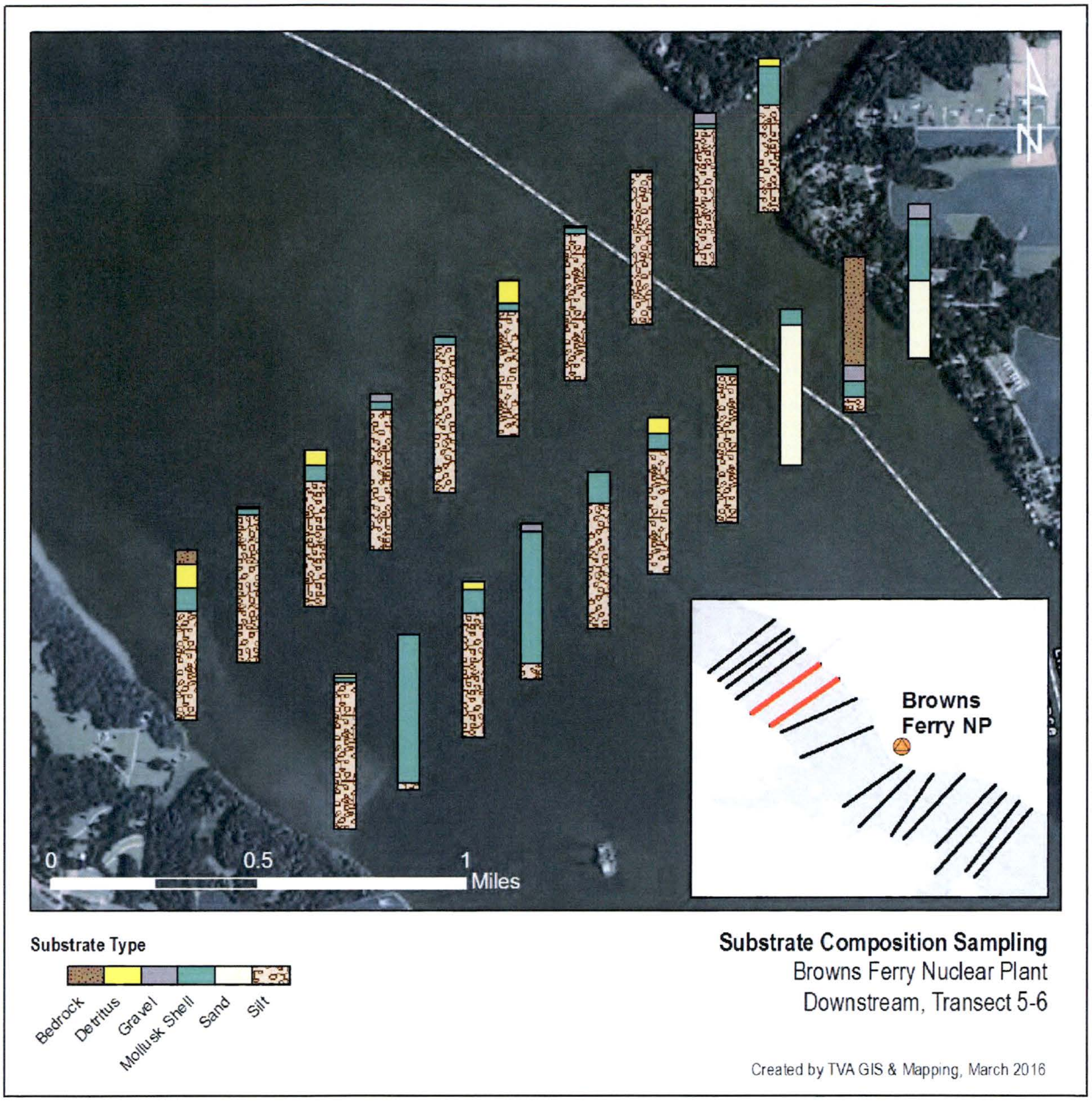

Figure 15. Composition of substrate samples collected at ten points equally spaced along each of transects 5 and 6 downstream of Browns Ferry Nuclear Plant.

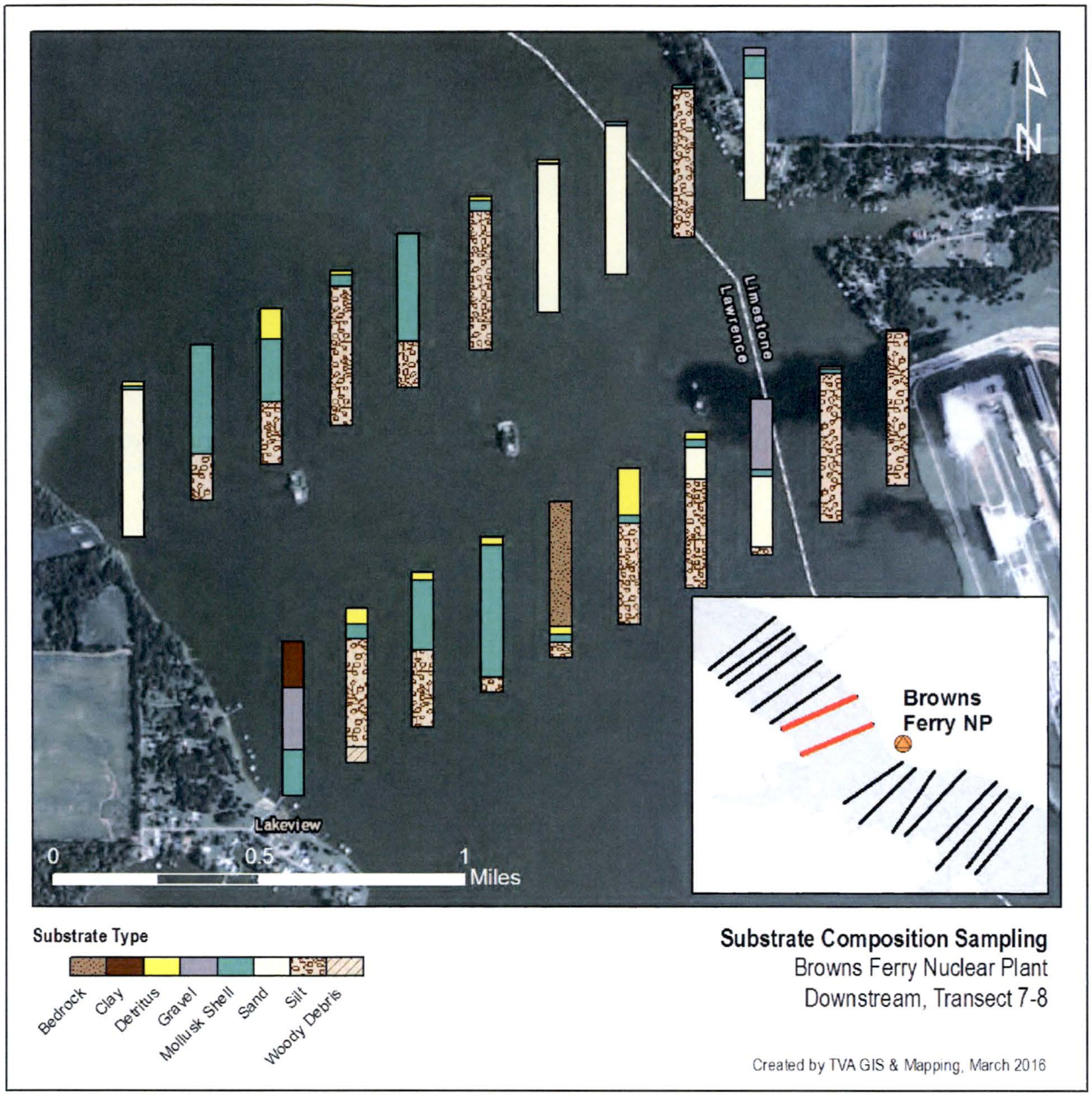

Figure 16. Composition of substrate samples collected at ten points equally spaced along each of transects 7 and 8 downstream of Browns Ferry Nuclear Plant.

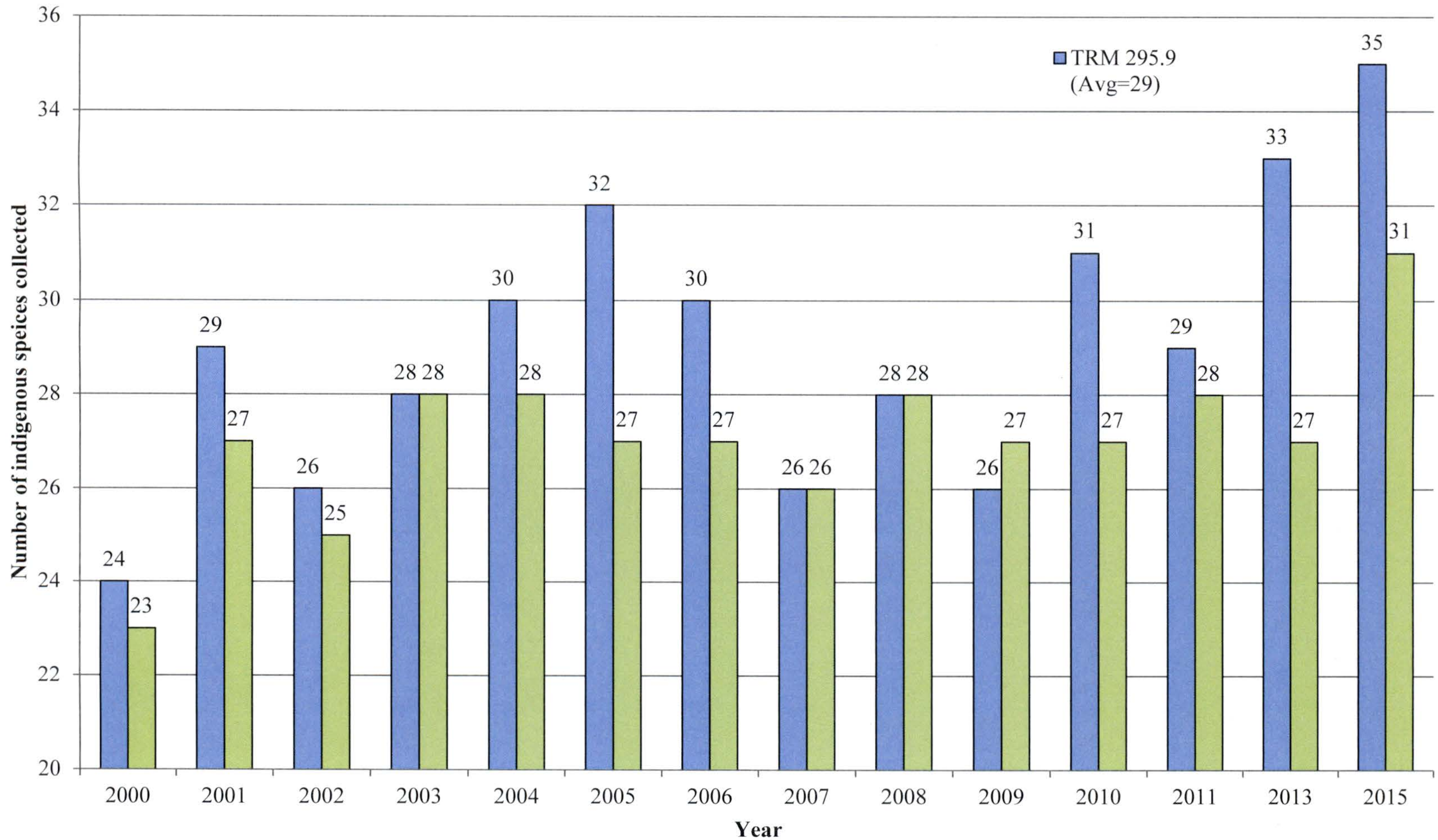

Figure 17. Comparison of observed values for the Reservoir Fish Assemblage Index metric "Number of Indigenous Species", over 14 years of autumn sampling at the sites upstream (TRM 295.9) and downstream (TRM 292.5) of Brown's Ferry Nuclear Plant.

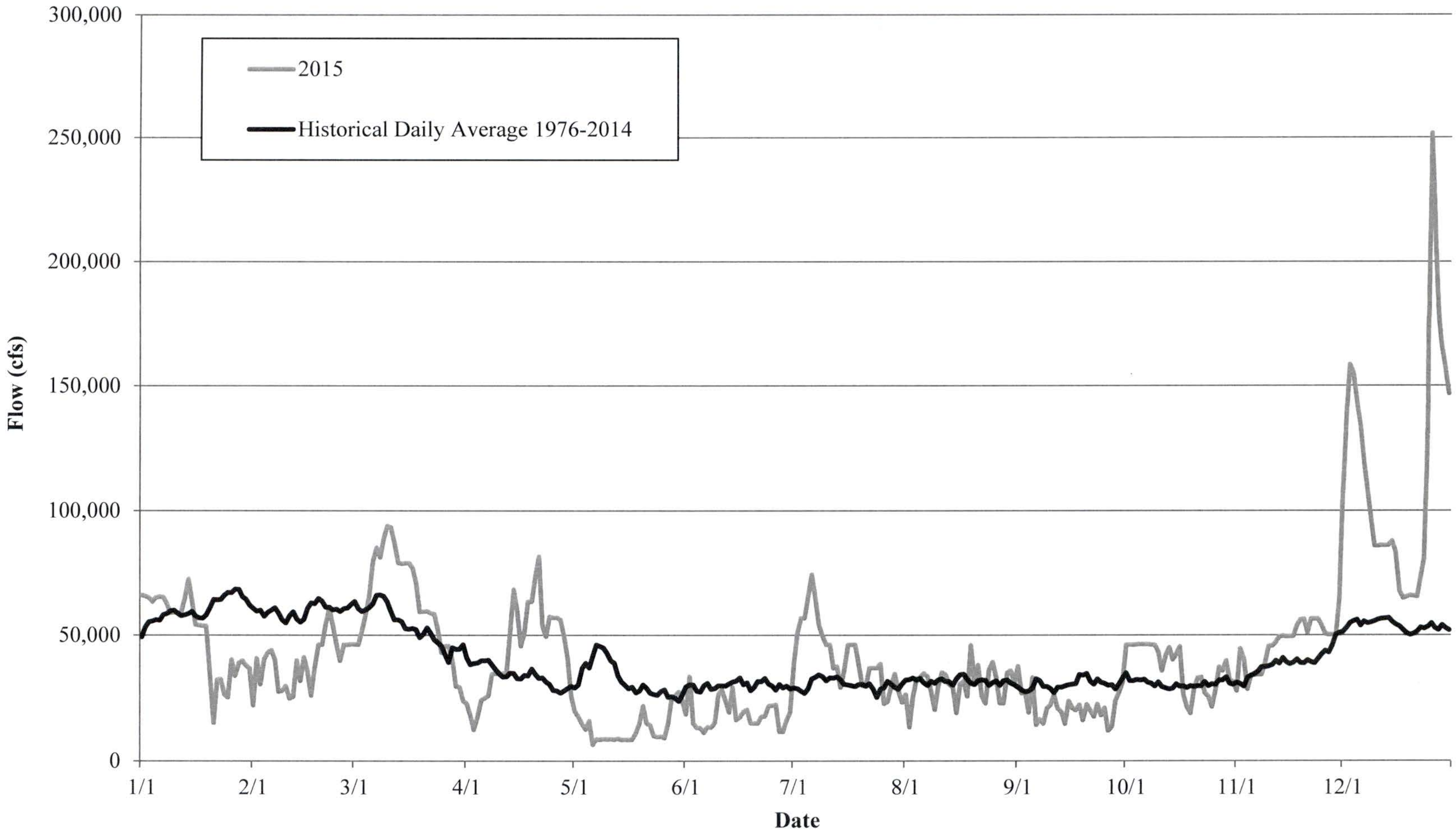

Figure 18. Daily mean flows from Guntersville Dam during 2015, and historic daily flows for the same period averaged from 1976 to 2014.

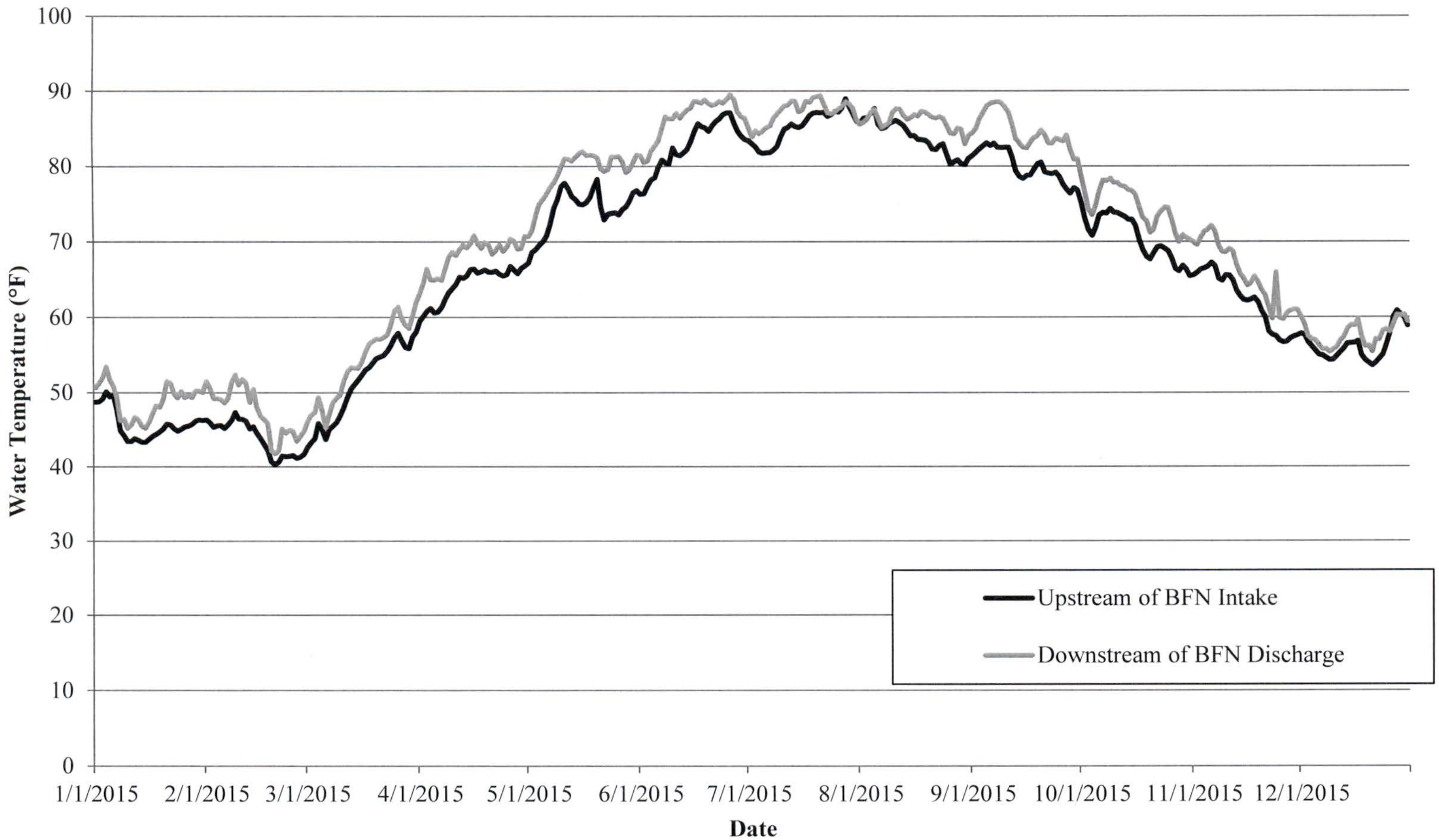

Figure 19. Daily water temperatures averaged over depth (3, 5, and 7 feet) upstream of Browns Ferry Nuclear Plant (BFN) intake and downstream of BFN discharge during 2015.

Tables

Table 1. Shoreline Aquatic Habitat Index (SAHI) metrics and scoring criteria.

Metric	Scoring Criteria	Score
Cover	Stable cover (boulders, rootwads, brush, logs, aquatic vegetation, artificial structures) in 25 to 75% of the drawdown zone	5
	Stable cover in 10 to 25% or > 75% of the drawdown zone	3
	Stable Cover in < 10% of the drawdown zone	1
Substrate	Percent of drawdown zone with gravel substrate > 40	5
	Percent of drawdown zone with gravel substrate between 10 and 40	3
	Percent substrate gravel < 10	1
Erosion	Little or no evidence of erosion or bank failure. Most bank surfaces stabilized by woody vegetation.	5
	Areas of erosion small and infrequent. Potential for increased erosion due to less desirable vegetation cover (grasses) on > 25% of bank surfaces.	3
	Areas of erosion extensive, exposed or collapsing banks occur along > 30% of shoreline.	1
Canopy Cover	Tree or shrub canopy > 60% along adjacent bank	5
	Tree or shrub canopy 30 to 60% along adjacent bank	3
	Tree or shrub canopy < 30% along adjacent bank	1
Riparian Zone	Width buffered > 18 meters	5
	Width buffered between 6 and 18 meters	3
	Width buffered < 6 meters	1
Habitat	Habitat diversity optimum. All major habitats (logs, brush, native vegetation, boulders, gravel) present in proportions characteristic of high quality, sufficient to support all life history aspects of target species. Ready access to deeper sanctuary areas present.	5
	Habitat diversity less than optimum. Most major habitats present, but proportion of one is less than desirable, reducing species diversity. No ready access to deeper sanctuary areas.	3
	Habitat diversity is nearly lacking. One habitat dominates, leading to lower species diversity. No ready access to deeper sanctuary areas.	1
Gradient	Drawdown zone gradient abrupt (> 1 meter per 10 meters). Less than 10% of shoreline with abrupt gradient due to dredging.	5
	Drawdown zone gradient abrupt. (> 1 meter per 10 meters) in 10 to 40% of the shoreline resulting from dredging. Rip-rap used to stabilize bank along > 10% of the shoreline.	3
	Drawdown zone gradient abrupt in > 40 % of the shoreline resulting from dredging. Seawalls used to stabilize bank along > 10 % of the shoreline.	1

Table 2. **Expected trophic guild proportions* and expected numbers of species* in lower mainstem Tennessee River reservoir transition zones, compared to values observed during 2013 monitoring at BFN.**

	Lower Mainstem Tennessee River Transition Zones								2015			
	Proportion (%)				Number of species				Observed Upstream of BFN (TRM 295.9)		Observed Downstream of BFN (TRM 292.5)	
	Trisected range [a]			Average [b]	Trisected range [a]			Average [b]				
Trophic Guild	-	Expected	+		-	Expected	+		Proportion (%)	Number of Species	Proportion (%)	Number of Species
Benthic Invertivore	< 6.7	6.4 to 13.4	> 13.4	5.5 ± 1.2	< 3	3 to 5	> 5	5 ± 1	13.8	5	11.1	5
Insectivore	< 24.6	24.6 to 49.1	> 49.1	40.0 ± 4.5	< 4	4 to 8	> 8	8 ± 1	40.1	10	43.2	10
Top Carnivore	< 15.1	15.1 to 30.2	> 30.2	18.3 ± 2.2	< 4	4 to 8	> 8	10 ± 1	15.0	12	6.0	10
Omnivore	>38.5	19.3 to 38.5	<19.3	28.7 ± 3.3	> 6	3 to 6	< 3	6 ± 1	14.4	8	22.4	6
Planktivore	< 9.4	9.4 to 18.7	>18.7	6.4 ± 2.6	0	1	> 1	1 ± 1	16.2	1	17.2	1
Parasitic	< 0.1	0.1 to 0.2	> 0.2	0.1 ± 0.04	0	1	> 1	1 ± 0	--	--	--	--
Herbivore	<1.8	1.8 to 3.6	>3.6	0.6 ± 0.4	0	1	> 1	1 ± 0	0.3	1	0.1	1
Specialized Insectivore	--	--	--	--	--	--	--	--	0.3	2	0.1	1

**Expected values were calculated from data collected over 900 electrofishing runs and 600 overnight experimental gill net sets in transition areas of lower mainstem Tennessee River reservoirs.*

[a] *Trisected ranges are intended to show below expected (-), expected, and above expected (+) values for trophic level proportions and species occurring within the transition zones in upper mainstem Tennessee River reservoirs.*

[b] *Average expected values are bound by 95% confidence intervals.*

Table 3. RFAI scoring criteria (2002) for inflow, transition, and forebay sections of lower mainstem reservoirs* in the Tennessee River system.

		Scoring Criteria								
		Inflow			Transition			Forebay		
Metric	**Gear**	**1**	**3**	**5**	**1**	**3**	**5**	**1**	**3**	**5**
1. Total species	Combined	< 14	14-27	> 27	< 16	16-30	>30	< 14	14-27	> 27
2. Number of centrarchid species	Combined	< 2	2-4	> 4	< 2	2-2	> 2	< 2	2-3	> 3
3. Number of benthic invertivores	Combined	< 4	4-7	> 7	< 4	4-7	> 7	< 4	4-6	> 6
4. Number of intolerant species	Combined	< 3	3-6	> 6	< 3	3-4	> 4	< 2	2-4	> 4
5. Percent tolerant individuals	Electrofishing	>51%	26-51%	< 26%	>54%	27-54%	< 27%	> 61%	30-61%	< 30%
	Gill netting				>30%	15-30%	< 15%	>46%	22-46%	< 22%
6. Percent dominance by one species	Electrofishing	>47%	24-47%	< 24%	>58%	29-58%	< 29%	>59%	30-59%	< 30%
	Gill netting				>34%	17-34%	< 17%	>43%	21-43%	< 21%
7. Percent non-indigenous species	Electrofishing	>4%	2-4%	< 2%	>2%	1-2%	< 1%	>2%	2-2%	< 2%
	Gill netting				>2%	1-2%	< 1%	>2%	1-2%	< 1%
8. Number of top carnivore species	Combined	< 4	4-7	>7	< 4	4-7	>7	< 4	4-7	>7
9. Percent top carnivores	Electrofishing	< 15%	15-29%	>29%	< 5%	5-10%	>10%	< 6%	6-12%	>12%
	Gill netting				< 20%	20-39%	>39%	< 25%	25-49%	>49%
10. Percent omnivores	Electrofishing	>48%	24-48%	< 24%	>48%	24-48%	< 24%	>59%	30-59%	< 30%
	Gill netting				>33%	16-33%	< 16%	>49%	24-49%	< 24%
11. Average number per run	Electrofishing	< 68	68-136	>136	< 243	243-487	>487	< 170	170-341	>341
	Gill netting				< 11	11-22	>22	< 20	20-40	>40
12. Percent anomalies	Electrofishing	>5%	2-5%	< 2%	>5%	2-5%	< 2%	>5%	2-5%	< 2%
	Gill netting				>5%	2-5%	< 2%	>5%	2-5%	< 2%

**Lower mainstem Tennessee River reservoirs include Guntersville, Wheeler, Wilson, Pickwick, and Kentucky.*

Transition scoring criteria were used to score sites upstream and downstream of BFN.

Table 4. Scoring criteria for laboratory-processed benthic macroinvertebrate community samples from inflow, transition, and forebay zones of mainstem Tennessee River reservoirs.

Benthic Community Metrics	Scoring Criteria								
	Inflow			Transition			Forebay		
	1	3	5	1	3	5	1	3	5
1. Average number of taxa	<4.2	4.2-8.3	>8.3	<3.3	3.3-6.6	>6.6	<2.8	2.8-5.5	>5.5
2. Proportion of samples with long-lived organisms	<0.6	0.6-0.8	>0.8	<0.6	0.6-0.9	>0.9	<0.6	0.6-0.8	>0.8
3. Average number of EPT taxa	<0.9	0.9-1.9	>1.9	<0.6	0.6-1.4	>1.4	<0.6	0.6-0.9	>0.9
4. Average proportion of oligochaete individuals	>23.9	23.9-12.0	<12.0	>21.9	21.9-11.0	<11.0	>41.9	41.9-21.0	<21.0
5. Average proportion of total abundance comprised by the two most abundant taxa	>86.2	86.2-73.1	<73.1	>87.9	87.9-77.8	<77.8	>90.3	90.3-81.7	<81.7
6. Average density excluding chironomids and oligochaetes	<400.0	400.0-799.9	>799.9	<305.0	305.0-609.9	>609.9	<125.0	125.0-249.9	>249.9
7. Zero Samples: proportion of samples containing no organisms	>0	-	0	>0	-	0	>0	-	0

Transition scoring criteria were used to score sites upstream and downstream of BFN.

Table 5. **Intake and discharge water temperatures (°F), megawatts generated, and flow* (mgd) of the condenser circulating water (CCW) system at Browns Ferry Nuclear Plant during 2015.**

Date	Intake Temp	Discharge Temp	Flow	MW	Date	Intake Temp	Discharge Temp	Flow	MW	Date	Intake Temp	Discharge Temp	Flow	MW
1/1/2015	45.02	50.27		3459.3	2/26/2015	39.22	43.24		3411	4/23/2015	66.32	69.48		3430.4
1/2/2015	45.73	51.09		3459.6	2/27/2015	40.31	44.15		3405.5	4/24/2015	65.84	68.90		3429.5
1/3/2015	48.00	51.64		3459.7	2/28/2015	41.91	44.82	2895	3395.4	4/25/2015	66.43	69.49		3427.9
1/4/2015	52.39	53.56		3328.6	3/1/2015	44.64	46.22		3102.2	4/26/2015	67.51	70.51		3423.7
1/5/2015	49.89	51.84		3454.6	3/2/2015	46.09	47.60		3346.7	4/27/2015	66.92	70.16		3424.6
1/6/2015	46.85	50.45		3456.8	3/3/2015	47.41	47.75		3384	4/28/2015	66.56	69.06		2806.2
1/7/2015	45.32	49.08		3401.3	3/4/2015	50.47	49.82		3377.8	4/29/2015	66.54	69.11		2273.7
1/8/2015	40.43	45.31		3435.5	3/5/2015	49.05	47.37		3372	4/30/2015	67.41	70.77	2626	2273.1
1/9/2015	37.65	46.19		3436.5	3/6/2015	41.58	44.99		3365.4	5/1/2015	66.95	70.36		2269.5
1/10/2015	37.38	45.04		3435.7	3/7/2015	42.39	46.74		3168	5/2/2015	68.66	71.02		2611.7
1/11/2015	38.10	45.48		3436.2	3/8/2015	45.80	49.14		3359.5	5/3/2015	70.93	73.02		3207.4
1/12/2015	41.21	46.54		3396.3	3/9/2015	47.68	49.71		3355.2	5/4/2015	73.70	74.41		3336.8
1/13/2015	43.03	46.17		3453.4	3/10/2015	49.12	49.57		3348.7	5/5/2015	74.37	75.04		3289
1/14/2015	41.74	45.19		3459.4	3/11/2015	51.69	52.69		3340.2	5/6/2015	75.09	75.80		3379.7
1/15/2015	40.24	45.04		3458.8	3/12/2015	53.79	53.79		3329.8	5/7/2015	76.86	76.61		3375.1
1/16/2015	40.08	45.87		3460.3	3/13/2015	54.00	54.44		2851.3	5/8/2015	78.85	77.05		3371.8
1/17/2015	41.99	47.19		3363.6	3/14/2015				2306.3	5/9/2015	79.62	78.22		3368.3
1/18/2015	44.69	48.20		3437.2	3/15/2015	54.56	54.35		2305.1	5/10/2015	80.51	79.35		3361.2
1/19/2015	46.05	47.96		3436.8	3/16/2015	55.88	55.38		2303.3	5/11/2015	82.52	80.78		3350.4
1/20/2015	47.44	49.59		3436.5	3/17/2015	57.06	56.83		2302.1	5/12/2015	78.87	80.87		3361.3
1/21/2015	47.79	51.74		3436.4	3/18/2015	57.71	57.31		2302.1	5/13/2015	78.28	80.48		3364.5
1/22/2015	47.29	51.24		3436.4	3/19/2015	56.99	57.44		2302.7	5/14/2015	80.20	80.89		3358
1/23/2015	46.21	50.08		3438.1	3/20/2015	56.71	57.98		2274.6	5/15/2015	82.91	81.51		3324.4
1/24/2015	44.83	49.59		3407.4	3/21/2015	56.73	57.79		2025.5	5/16/2015	83.03	81.92		3146.7
1/25/2015	44.56	50.22		3433.9	3/22/2015	56.71	58.04		2190.6	5/17/2015	82.02	81.27		3346.1
1/26/2015	44.70	49.56		3434.4	3/23/2015	56.97	58.53		2286	5/18/2015	80.02	81.39		3364.5
1/27/2015	44.90	49.96		3435.4	3/24/2015	58.98	59.69		2298.8	5/19/2015	79.84	81.46		3371.3
1/28/2015	45.22	49.53		3432.3	3/25/2015	60.52	60.89		2298.1	5/20/2015	80.71	81.04		3370.7
1/29/2015	46.35	50.19		3426.8	3/26/2015	61.34	61.61		2297.9	5/21/2015	76.76	79.48		3384.4
1/30/2015	47.16	50.26		3307.4	3/27/2015	59.05	60.55		2300.8	5/22/2015	75.64	79.28		3396.4
1/31/2015	46.56	50.25	2902	3439.5	3/28/2015	56.51	59.42		2303.4	5/23/2015	77.72	79.42		3390.8
2/1/2015	46.43	51.74		3451.4	3/29/2015	54.61	58.76		2304.6	5/24/2015	81.09	81.25		3378.9
2/2/2015	47.33	50.41		3445.3	3/30/2015	57.33	60.28		2302.8	5/25/2015	79.75	81.17		3377.8
2/3/2015	43.98	49.46		3441.8	3/31/2015	59.14	62.13	2428	2291.6	5/26/2015	81.65	81.31		3372.5
2/4/2015	43.18	49.38		3438.6	4/1/2015	61.48	62.65		2283.2	5/27/2015	80.31	80.51		3375.8
2/5/2015	44.06	49.24		3431.8	4/2/2015	62.74	64.32		2275.8	5/28/2015	75.56	78.89		3385.1
2/6/2015	43.71	48.82		3419.3	4/3/2015	65.42	66.44		2272.7	5/29/2015	76.40	79.42		3356.4
2/7/2015	44.42	49.24		3269.5	4/4/2015	61.90	64.74		2286	5/30/2015	77.72	80.36		3301.3
2/8/2015	46.79	51.48		3431.8	4/5/2015	62.43	64.63		2293.9	5/31/2015	78.57	81.41	3097	3377
2/9/2015	48.83	52.58		3433.6	4/6/2015	62.01	64.95		2294.3	6/1/2015	78.02	81.43		3377
2/10/2015	48.21	51.14		3434	4/7/2015	62.17	64.96		2293.3	6/2/2015	76.82	80.42		3384.5
2/11/2015	47.42	51.98		3433.3	4/8/2015	64.11	65.94		2221.9	6/3/2015	76.69	80.63		3386.4
2/12/2015	46.79	50.95		3431.5	4/9/2015	65.80	67.19		1995	6/4/2015	78.43	81.88		3378
2/13/2015	44.25	48.86		3434.3	4/10/2015	66.86	68.53		2415.9	6/5/2015	80.48	82.68		3359.6
2/14/2015	44.14	50.37		3434.2	4/11/2015	65.21	67.89		2594.7	6/6/2015	81.15	83.46		3213.7
2/15/2015	42.39	48.07		3434.9	4/12/2015	65.90	68.38		3053.9	6/7/2015	84.92	85.03		3339.8
2/16/2015	39.73	46.69		3436	4/13/2015	67.20	69.47		3314.9	6/8/2015	87.20	86.55		3324.1
2/17/2015	39.44	46.76		3437.1	4/14/2015	67.41	69.46		3294.4	6/9/2015	84.30	86.57		3338.3
2/18/2015	38.27	46.08		3438.5	4/15/2015	68.09	70.09		3262.3	6/10/2015	86.17	86.17		3327.1
2/19/2015	36.02	41.99		3439.1	4/16/2015	68.46	70.32		3419.6	6/11/2015	85.12	86.90		3326.3
2/20/2015	34.62	41.22		3438.4	4/17/2015	66.76	69.66		3420.8	6/12/2015	83.62	86.47		3338.1
2/21/2015	35.65	42.18		3437.5	4/18/2015	66.49	69.21		3418.4	6/13/2015	85.76	86.97		3336
2/22/2015	41.10	45.17		3430.1	4/19/2015	67.93	70.23		3423.8	6/14/2015	85.51	87.46		3336.2
2/23/2015	41.81	44.71		3425	4/20/2015	67.73	69.96		3426.2	6/15/2015	85.93			3327.9
2/24/2015	41.19	45.10		3419.4	4/21/2015	66.08	68.53		3431.5	6/16/2015	87.84	88.62		3317.2
2/25/2015	40.00	45.08		3415	4/22/2015	66.27	69.27		3430	6/17/2015	88.63	88.43		3302.6

*Flow values are monthly averages

Table 5. (Continued).

Date	Intake Temp	Discharge Temp	Flow	MW	Date	Intake Temp	Discharge Temp	Flow	MW	Date	Intake Temp	Discharge Temp	Flow	MW
6/18/2015	87.29	88.12		3299.6	8/23/2015	84.06	86.80		3314.4	10/28/2015	65.88	70.67		3418.4
6/19/2015	87.34	89.11		3297.3	8/24/2015	82.92	86.56		3350.3	10/29/2015	66.72	71.45		3414.4
6/20/2015	86.29			3311.9	8/25/2015	81.60	85.62		3354.2	10/30/2015	66.27	70.88		3412.9
6/21/2015	86.36	88.09		3314.5	8/26/2015	80.33	84.62		3360.6	10/31/2015	65.46	70.38	2845	3417.4
6/22/2015	86.70	88.04		3310.6	8/27/2015	80.39	84.37		3363.1	11/1/2015	65.04	70.33		3418.8
6/23/2015	86.78	88.67		3308.6	8/28/2015	81.70	85.09		3340.3	11/2/2015	64.74	69.91		3414.1
6/24/2015	86.76	88.37		3307.1	8/29/2015	81.63	84.88		3119.2	11/3/2015	66.34	70.98		3408.1
6/25/2015	87.34			3296.9	8/30/2015	79.33	83.16		2680.2	11/4/2015	67.58	71.42		3390.4
6/26/2015	88.39			3283	8/31/2015	81.83	84.03	2895	3079.5	11/5/2015	68.16	71.79		3390.4
6/27/2015	86.96	89.11		3301	9/1/2015	81.60	84.56		2625.2	11/6/2015	69.67	72.50		3386.9
6/28/2015	85.11	87.34		3318.7	9/2/2015	82.22	85.10		2688.3	11/7/2015	68.33	71.64		3357.1
6/29/2015	85.29	86.76		3321	9/3/2015	83.88	86.47		3273.3	11/8/2015	65.28	69.57		3404.5
6/30/2015	83.93	86.29	2895	3331.3	9/4/2015	85.29	87.27		3265	11/9/2015	62.34	68.83		3411.2
7/1/2015	82.26	84.68		3343.3	9/5/2015	84.95	88.05		3323.7	11/10/2015	63.18	68.80		3407.9
7/2/2015	80.58	83.90		3352.9	9/6/2015	86.37	88.49		3320.9	11/11/2015	63.68	69.18		3406
7/3/2015	80.34	84.82		3354.9	9/7/2015	85.97	88.55		3320.3	11/12/2015	65.08	69.76		3410.9
7/4/2015	79.47	84.70		3361.3	9/8/2015	85.81	88.67		3319.1	11/13/2015	62.24	67.32		3417.5
7/5/2015	80.81	85.07		3353.9	9/9/2015	86.86	88.52		3315.7	11/14/2015	58.96	65.79		3427.1
7/6/2015	81.46	85.39		3345	9/10/2015	85.36	88.17		3322.9	11/15/2015	58.12	65.12		3080.4
7/7/2015	82.73	85.63		3337.6	9/11/2015	84.30	87.47		3289.2	11/16/2015	58.07	64.06		2279
7/8/2015	83.54	86.41		3330.6	9/12/2015	81.44	85.88		3009.2	11/17/2015	60.17	64.31		2265.4
7/9/2015	83.95	87.00		3325.8	9/13/2015	78.89	83.76		3032.1	11/18/2015	62.58	65.60		2257.6
7/10/2015	84.41	87.41		3321.4	9/14/2015	79.91	83.23		3281.5	11/19/2015	61.75	64.64		2262.7
7/11/2015	85.16	87.67		3313.1	9/15/2015	79.35	82.64		3377.3	11/20/2015	60.07	63.28		2417.4
7/12/2015	86.39	87.88		3304.3	9/16/2015	79.38	82.52		3366.5	11/21/2015	58.07	62.96		3183
7/13/2015	87.12	88.41		3298.9	9/17/2015	80.38	83.38		3369.4	11/22/2015	56.04	61.42		3086.7
7/14/2015	87.39	88.62		3280.1	9/18/2015	80.33	83.94		3352	11/23/2015	53.03	59.41		3139.4
7/15/2015	85.74	86.82		3305.3	9/19/2015	81.35	84.26		3359.3	11/24/2015	52.67	60.28		3313.4
7/16/2015	86.18	86.96		3297.3	9/20/2015	81.38	85.03		3360	11/25/2015	53.32	59.75		3321
7/17/2015	86.72	88.32		3295.1	9/21/2015	80.48	84.38		2998	11/26/2015	54.83	59.60		3170.7
7/18/2015	87.31	88.11		3293.2	9/22/2015	79.83	83.37		2697.1	11/27/2015		60.73		3366.4
7/19/2015	87.88	88.79		3232	9/23/2015	79.23	83.29		2701	11/28/2015		61.45		3385.5
7/20/2015	88.86	88.86		3142.2	9/24/2015	80.47	84.05		3140.7	11/29/2015		61.70		3404.4
7/21/2015	88.24	89.14		3242.7	9/25/2015	79.51	83.79		3301.1	11/30/2015	59.84	61.68	2989	3258.6
7/22/2015	87.62	87.92		3290.1	9/26/2015	80.11	83.70		3296	12/1/2015	59.58	60.36		3342
7/23/2015	86.88	87.29		3273.2	9/27/2015	82.52	84.46		3364.2	12/2/2015	57.87	58.89		3394.4
7/24/2015	86.50	87.11		3293.3	9/28/2015	80.48	82.52		3372.9	12/3/2015	55.68	56.97		3388.9
7/25/2015	86.98	87.11		3290.2	9/29/2015	76.82	81.25		3382.7	12/4/2015	54.65	56.65		3382.8
7/26/2015	87.48	87.63		3289	9/30/2015	76.60	81.19	2897	3384.6	12/5/2015		56.57		3373.9
7/27/2015	88.18	88.15		3284	10/1/2015	74.32	78.73		3393.8	12/6/2015		56.18		2938.5
7/28/2015	88.87	88.67		3254.6	10/2/2015	71.18	76.69		3403.4	12/7/2015	54.87	56.22		2234.7
7/29/2015	88.44	88.41		3230.6	10/3/2015	68.24	74.45		3412.2	12/8/2015	54.62	56.03		2229.2
7/30/2015	87.77	87.73		3267.6	10/4/2015	67.70	73.83		3413.8	12/9/2015	54.18	55.33		2225.4
7/31/2015	86.35	86.19	2895	3292.4	10/5/2015	71.48	74.86		3380.3	12/10/2015	54.25	55.83		2222.7
8/1/2015	85.46	85.69		3302.5	10/6/2015	72.70	76.72		3350.1	12/11/2015	55.50	56.82		2215.6
8/2/2015	86.14	85.95		3301	10/7/2015	75.20	78.20		3354.9	12/12/2015	57.43	58.17		2207.5
8/3/2015	86.21	86.27		3293.3	10/8/2015	75.61	78.43		3363.4	12/13/2015	58.62	58.36		2426.2
8/4/2015	87.37	87.23		3287.3	10/9/2015	75.46	78.64		3349.3	12/14/2015	59.65	58.75		3127.3
8/5/2015	87.48	87.58		3283	10/10/2015	74.70	77.94		3282.7	12/15/2015	58.55	58.97		3157.4
8/6/2015	86.08	86.61		3296.6	10/11/2015	73.51	77.83		3393.7	12/16/2015	57.61	58.92		3204.8
8/7/2015	84.07	85.30		3313.5	10/12/2015	72.84	77.33		3396.8	12/17/2015	58.03	59.86		3316.8
8/8/2015	84.89	85.37		3307.7	10/13/2015	72.73	77.41		3396.4	12/18/2015	54.05	57.29		3324.1
8/9/2015	86.55	85.86		3300.3	10/14/2015	72.31	76.94		3396.6	12/19/2015	49.97	55.51		3313.8
8/10/2015	86.66	87.03		3291.3	10/15/2015	71.57	76.69		3397.2	12/20/2015	49.68	55.86		3314.1
8/11/2015	85.97	87.36		3293.9	10/16/2015	71.60	76.26		3396.1	12/21/2015	50.34	55.18		3313.4
8/12/2015	85.53	87.41		3298	10/17/2015	69.60	74.63		3403.8	12/22/2015	53.43	57.55		3302.1
8/13/2015	84.66	86.43		3304.2	10/18/2015	67.75	73.30		3410.5	12/23/2015	56.75	57.56		3297.2
8/14/2015	84.35	85.99		3286.1	10/19/2015	66.60	72.82		3409.6	12/24/2015	60.30	59.48		3282.9
8/15/2015	83.86	86.31		3187.3	10/20/2015	64.42	71.26		3414.6	12/25/2015	61.30	59.69		3268.8
8/16/2015	84.42	86.65		3329.5	10/21/2015	66.62	71.82		3409.2	12/26/2015	62.23	58.91		3237.7
8/17/2015	83.70	86.58		3334.1	10/22/2015	68.62	73.54		3401.1	12/27/2015	61.64	59.58		3237.5
8/18/2015	84.71	87.30		3331.3	10/23/2015	69.93	74.12		3382.3	12/28/2015	61.99	60.71		3232.2
8/19/2015	84.73	87.18		3332.7	10/24/2015	72.05	74.64		3351.4	12/29/2015	60.72	60.22		3214.2
8/20/2015	82.90	86.97		3338.4	10/25/2015	70.56	74.50		3403.6	12/30/2015	59.57	60.61		3230.8
8/21/2015	83.06	86.51		3304.2	10/26/2015	68.84	73.07		3407.7	12/31/2015	58.29	59.45	3044	3223.4
8/22/2015	83.29	86.33		3120.4	10/27/2015	69.12	70.97		3410.7					

Table 6. SAHI scores for shoreline habitat assessments conducted within the RFAI sample reach upstream of Browns Ferry Nuclear plant, autumn 2015.

Left Descending Bank	Transects								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Avg.**
Aquatic Macrophytes	0%	0%	0%	0%	0%	0%	0%	0%	**0%**
SAHI Variables									
Cover	5	1	1	1	1	1	3	3	**2**
Substrate	3	3	3	3	1	5	5	3	**3**
Erosion	1	5	5	5	3	5	1	1	**3**
Canopy Cover	5	5	5	5	5	5	5	5	**5**
Riparian Zone	5	5	5	3	5	5	5	5	**5**
Habitat	1	1	1	1	3	1	1	1	**1**
Slope	5	5	5	5	3	5	3	5	**5**
Total Rating	25 Fair	25 Fair	25 Fair	23 Fair	21 Fair	27 Good	23 Fair	23 Fair	**24 Fair**

Right Descending Bank	Transects								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Avg.**
Aquatic Macrophytes	0%	0%	0%	0%	0%	0%	0%	0%	**0%**
SAHI Variables									
Cover	3	1	3	3	3	1	3	5	**3**
Substrate	1	5	3	3	3	5	5	5	**4**
Erosion	1	5	5	1	3	1	5	5	**3**
Canopy Cover	5	5	5	5	1	5	1	1	**4**
Riparian Zone	1	5	5	5	1	5	1	1	**3**
Habitat	1	1	1	1	1	1	1	1	**1**
Slope	3	5	1	1	1	5	1	1	**2**
Total Rating	15 Poor	27 Good	23 Fair	19 Fair	13 Poor	23 Fair	17 Fair	19 Fair	**20 Fair**

Scoring criteria: poor (7-16), fair (17-26), good (27-35)

Table 7. SAHI scores for shoreline habitat assessments conducted within the RFAI sample reach downstream of Browns Ferry Nuclear plant, autumn 2015.

	Transects								
Left Descending Bank	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Avg.**
Aquatic Macrophytes	0%	0%	0%	0%	0%	0%	0%	0%	**0%**
SAHI Variables									
Cover	1	3	5	1	3	1	1	5	**3**
Substrate	5	1	1	5	5	5	5	5	**4**
Erosion	5	5	5	1	5	1	5	5	**4**
Canopy Cover	5	5	5	5	5	5	3	1	**4**
Riparian Zone	5	5	5	5	5	5	3	1	**4**
Habitat	1	3	3	1	1	1	1	1	**2**
Slope	5	1	1	5	5	5	5	1	**4**
Total	27	23	25	23	29	23	23	19	**24**
Rating	Good	Fair	Fair	Fair	Good	Fair	Fair	Fair	**Fair**
	Transects								
Right Descending Bank	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Avg.**
Aquatic Macrophytes	0%	0%	0%	0%	0%	0%	0%	0%	**0%**
SAHI Variables									
Cover	5	3	1	5	5	3	1	3	**3**
Substrate	1	1	5	3	1	3	3	3	**3**
Erosion	5	5	1	1	5	5	5	5	**4**
Canopy Cover	5	5	3	5	3	1	1	5	**4**
Riparian Zone	5	5	3	5	1	1	1	1	**3**
Habitat	5	3	1	3	3	1	1	1	**2**
Slope	5	5	5	5	3	1	1	3	**4**
Total	31	27	19	27	21	15	13	21	**22**
Rating	Good	Good	Fair	Good	Fair	Poor	Poor	Fair	**Fair**

Scoring criteria: poor (7-16), fair (17-26), good (27-35)

Table 8. Substrate percentages and average water depth (ft) per transect upstream and downstream of BFN, autumn 2015.

	% Substrate per transect upstream of BFN								
Substrate Type	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Avg.**
Silt	63.5	69.4	65.9	57.0	41.0	64.0	51.3	60.0	**59.0**
Mollusk Shell	7.9	20.9	25.1	21.2	33.4	11.3	32.9	31.0	**23.0**
Sand	16.5	6.7	2.9	0.1	2.1	0.5	0.5	0.5	**3.7**
Detritus	1.9	0.6	0.0	0.7	8.5	0.7	1.3	1.0	**1.8**
Bedrock	0.0	0.0	0.0	16.0	0.0	0.0	0.0	0.0	**2.0**
Boulder	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**1.3**
Gravel	0.2	2.4	1.1	4.5	5.1	16.0	0.5	1.5	**3.9**
Clay	0.0	0.0	0.0	0.5	8.9	7.5	13.5	2.0	**4.1**
Wood	0.0	0.0	3.9	0.0	1.0	0.0	0.0	4.0	**1.1**
Average Depth (ft)	12.9	13.0	13.6	10.6	12.5	9.9	13.8	14.3	**12.6**
Actual Depth Range:	2.2 to 29.1 ft								

	% Substrate per transect downstream of BFN								
Substrate Type	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Avg.**
Silt	64.6	75.9	89.1	79.2	86.4	45.5	37.8	47.4	**65.7**
Mollusk Shell	19.4	16.3	6.3	8.1	7.6	29.3	21.6	19.3	**16.0**
Sand	0.0	1.0	0.0	9.0	0.0	14.0	37.0	6.5	**8.4**
Detritus	2.7	4.8	4.4	3.7	4.8	1.7	3.1	6.3	**3.9**
Bedrock	5.0	0.0	0.0	0.0	0.0	7.0	0.0	8.0	**2.5**
Boulder	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
Cobble	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.8**
Gravel	2.0	2.0	0.2	0.0	1.2	2.5	0.5	8.5	**2.1**
Clay	0.3	0.0	0.0	0.0	0.0	0.0	0.0	3.0	**0.4**
Wood	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	**0.1**
Average Depth (ft)	14.0	13.0	14.1	13.2	13.2	10.9	11.4	12.8	**12.8**
Actual Depth Range:	2.0 to 25.3 ft								

Table 9. Individual metric scores and the overall RFAI scores upstream (TRM 295.9) and downstream (TRM 292.5) of Browns Ferry Nuclear plant during 2015.

Autumn 2015		TRM 295.9		TRM 292.5	
Metric		Obs	Score	Obs	Score
A. Species richness and composition					
1. Number of indigenous species (Tables 9 and 10)	Combined	**35**	**5**	**31**	**5**
2. Number of centrarchid species (less *Micropterus*)	Combined	**7** Bluegill Green sunfish Longear sunfish Orangespotted sunfish Redear sunfish Warmouth White crappie	**5**	**7** Black crappie Bluegill Green sunfish Longear sunfish Redear sunfish Warmouth White crappie	**5**
3. Number of benthic invertivore species	Combined	**5** Freshwater drum Logperch Northern hog sucker River darter Spotted sucker	**3**	**5** Black redhorse Freshwater drum Logperch River darter Spotted sucker	**3**
4. Number of intolerant species	Combined	**5** Longear sunfish Northern hog sucker Skipjack herring Smallmouth bass Spotted sucker	**5**	**5** Black redhorse Longear sunfish Skipjack herring Smallmouth bass Spotted sucker	**5**

Table 9. (Continued).

Autumn 2015 Metric		TRM 295.9 Obs		Score	TRM 292.5 Obs		Score
5. Percent tolerant individuals	Electrofishing	**23.9%**		2.5	**30.1%**		1.5
		Bluegill	7.1%		Bluegill	2.1%	
		Common carp	0.2%		Gizzard shad	20.2%	
		Gizzard shad	5.5%		Golden shiner	0.1%	
		Golden shiner	0.5%		Green sunfish	5.7%	
		Green sunfish	4.2%		Largemouth bass	0.8%	
		Largemouth bass	5.6%		Redbreast sunfish	0.1%	
		Spotfin shiner	0.5%		Spotfin shiner	1.0%	
		Striped shiner	0.3%		Striped shiner	0.1%	
	Gill Netting	**21.1%**		1.5	**29.6%**		1.5
		Bluegill	0.8%		Bluegill	0.9%	
		Gizzard shad	16.5%		Gizzard shad	18.5%	
		Longnose gar	3.8%		Largemouth bass	7.4%	
					White crappie	1.9%	
6. Percent dominance by one species	Electrofishing	**27.3%** Mississippi silverside		2.5	**32.2%** Mississippi silverside		1.5
	Gill Netting	**16.5%** Gizzard shad		2.5	**25.9%** Skipjack herring		1.5
7. Percent non-indigenous species	Electrofishing	**27.8%**		0.5	**32.3%**		0.5
		Common carp	0.2%		Mississippi silverside	32.2%	
		Mississippi silverside	27.3%		Redbreast sunfish	0.1%	
		Striped bass	0.3%		Yellow perch	0.1%	
	Gill Netting	**0.8%** Striped bass		2.5	**NA**		2.5

Table 9. (Continued).

Autumn 2015 Metric		TRM 295.9 Obs		Score	TRM 292.5 Obs		Score
8. Number of top carnivore species	Combined	**11**		**5**	**10**		**5**
		Flathead catfish			Black crappie		
		Largemouth bass			Bowfin		
		Longnose gar			Flathead catfish		
		Sauger			Largemouth bass		
		Skipjack herring			Sauger		
		Smallmouth bass			Skipjack herring		
		Spotted bass			Smallmouth bass		
		Spotted gar			White bass		
		White bass			White crappie		
		White crappie			Yellow bass		
		Yellow bass					
B. Trophic composition							
9. Percent top carnivores	Electrofishing	**9.4%**		**1.5**	**4.5%**		**0.5**
		Flathead catfish	0.5%		Black crappie	0.1%	
		Largemouth bass	5.6%		Bowfin	0.1%	
		Smallmouth bass	1.2%		Flathead catfish	0.2%	
		Spotted gar	0.9%		Largemouth bass	0.8%	
		Striped bass	0.3%		Skipjack herring	0.1%	
		White bass	0.9%		Smallmouth bass	2.9%	
		Yellow bass	0.1%		White bass	0.2%	
					Yellow bass	0.1%	
	Gill Netting	**59.4%**		**2.5**	**53.7%**		**2.5**
		Flathead catfish	9.8%		Flathead catfish	3.7%	
		Longnose gar	3.8%		Largemouth bass	7.4%	
		Sauger	4.5%		Sauger	5.6%	
		Skipjack herring	14.3%		Skipjack herring	25.9%	
		Spotted bass	0.8%		Smallmouth bass	1.9%	
		Spotted gar	6.8%		White bass	3.7%	
		Striped bass	0.8%		White crappie	1.9%	
		White bass	16.5%		Yellow bass	3.7%	
		Yellow bass	2.3%				

Table 9. (Continued).

Autumn 2015 Metric		TRM 295.9 Obs		Score	TRM 292.5 Obs		Score
10. Percent omnivores	Electrofishing	**11.7%**		**2.5**	**22.0%**		**2.5**
		Black buffalo	0.2%		Channel catfish	1.0%	
		Channel catfish	2.9%		Gizzard shad	20.2%	
		Common carp	0.2%		Golden shiner	0.1%	
		Gizzard shad	5.5%		Smallmouth buffalo	0.7%	
		Golden shiner	0.5%		Striped shiner	0.1%	
		Smallmouth buffalo	2.2%				
		Striped shiner	0.3%				
	Gill Netting	**35.3%**		**0.5**	**35.2%**		**0.5**
		Blue catfish	6.0%		Blue catfish	5.6%	
		Channel catfish	8.3%		Channel catfish	3.7%	
		Gizzard shad	16.5%		Gizzard shad	18.5%	
		Smallmouth buffalo	4.5%		Smallmouth buffalo	7.4%	
C. Fish abundance and health							
11. Average number per run	Electrofishing	**70.1**		**0.5**	**114.8**		**0.5**
	Gill Netting	**13.3**		**1.5**	**5.4**		**0.5**
12. Percent anomalies	Electrofishing	**1.1%**		**2.5**	**0.3%**		**2.5**
	Gill Netting	**0.8%**		**2.5**	**0.0%**		**2.5**
Overall RFAI Score				**49 Good**			**44 Good**

Table 10. Species collected, ecological and recreational designation and corresponding electrofishing (EF) and gill net (GN) catch per unit effort upstream (TRM 295.9) of Browns Ferry Nuclear Plant discharge – Autumn 2015.

Common Name	Scientific name	Trophic level	Native species	Tolerance	Thermally Sensitive Species	Comm. Valuable Species	Rec. Valuable Species	EF Catch Per Run	EF Catch Per Hr	Total fish EF	GN Catch Per Net Night	Total Fish GN	Total fish Combined	Percent Composition
Longnose gar	*Lepisosteus osseus*	TC	X	TOL	.	X	.	.	.	.	0.5	5	5	0.42
Gizzard shad	*Dorosoma cepedianum*	OM	X	TOL	.	X	X	3.87	17.42	58	2.2	22	80	6.76
Common carp*	*Cyprinus carpio*	OM	.	TOL	.	X	.	0.13	0.6	2	.	.	2	0.17
Golden shiner	*Notemigonus crysoleucas*	OM	X	TOL	.	.	X	0.33	1.5	5	.	.	5	0.42
Spotfin shiner	*Cyprinella spiloptera*	IN	X	TOL	.	.	.	0.33	1.5	5	.	.	5	0.42
Striped shiner	*Luxilus chrysocephalus*	OM	X	TOL	.	.	.	0.2	0.9	3	.	.	3	0.25
Green sunfish	*Lepomis cyanellus*	IN	X	TOL	.	.	X	2.93	13.21	44	.	.	44	3.72
Bluegill	*Lepomis macrochirus*	IN	X	TOL	.	.	X	5	22.52	75	0.1	1	76	6.42
Largemouth bass	*Micropterus salmoides*	TC	X	TOL	.	.	X	3.93	17.72	59	.	.	59	4.98
White crappie	*Pomoxis annularis*	TC	X	TOL	.	.	X	.	.	.	.	.	0	0.00
Skipjack herring	*Alosa chrysochloris*	TC	X	INT	.	X	.	.	.	.	1.9	19	19	1.60
Northern hog sucker	*Hypentelium nigricans*	BI	X	INT	.	.	.	0.13	0.6	2	.	.	2	0.17
Spotted sucker	*Minytrema melanops*	BI	X	INT	.	X	.	2.07	9.31	31	.	.	31	2.62
Longear sunfish	*Lepomis megalotis*	IN	X	INT	.	.	X	2.4	10.81	36	.	.	36	3.04
Smallmouth bass	*Micropterus dolomieu*	TC	X	INT	.	.	X	0.87	3.9	13	.	.	13	1.10
Spotted gar	*Lepisosteus oculatus*	TC	X	.	.	X	.	0.6	2.7	9	0.9	9	18	1.52
Threadfin shad	*Dorosoma petenense*	PK	X	.	.	X	X	12.8	57.66	192	.	.	192	16.22
Largescale stoneroller	*Campostoma oligolepis*	HB	X	.	.	.	.	0.2	0.9	3	.	.	3	0.25
Smallmouth buffalo	*Ictiobus bubalus*	OM	X	.	.	X	.	1.53	6.91	23	0.6	6	29	2.45
Black buffalo	*Ictiobus niger*	OM	X	.	.	X	.	0.13	0.6	2	.	.	2	0.17
Blue catfish	*Ictalurus furcatus*	OM	X	.	.	X	X	.	.	.	0.8	8	8	0.68
Channel catfish	*Ictalurus punctatus*	OM	X	.	.	X	X	2	9.01	30	1.1	11	41	3.46
Flathead catfish	*Pylodictis olivaris*	TC	X	.	.	X	X	0.33	1.5	5	1.3	13	18	1.52
Blackspotted	*Fundulus olivaceus*	IN	X	.	.	.	.	0.07	0.3	1	.	.	1	0.08
White bass	*Morone chrysops*	TC	X	.	.	.	X	0.6	2.7	9	2.2	22	31	2.62
Yellow bass	*Morone mississippiensis*	TC	X	.	.	.	X	0.07	0.3	1	0.3	3	4	0.34
Striped bass*	*Morone saxatilis*	TC	.	.	.	.	X	0.2	0.9	3	0.1	1	4	0.34
Warmouth	*Lepomis gulosus*	IN	X	.	.	.	X	0.47	2.1	7	.	.	7	0.59
Orangespotted sunfish	*Lepomis humilis*	IN	X	.	.	.	X	0.07	0.3	1	.	.	1	0.08
Redear sunfish	*Lepomis microlophus*	IN	X	.	.	.	X	0.67	3	10	0.5	5	15	1.27
Hybrid sunfish	*Lepomis* spp.	IN	X	.	.	.	X	0.2	0.9	3	.	.	3	0.25
Spotted bass	*Micropterus punctulatus*	TC	X	.	.	.	X	.	.	.	0.1	1	1	0.08

Table 10. (Continued).

Common Name	Scientific name	Trophic level	Native species	Tolerance	Thermally Sensitive Species	Comm. Valuable Species	Rec. Valuable Species	EF Catch Per Run	EF Catch Per Hr	Total fish EF	GN Catch Per Net Night	Total Fish GN	Total fish Combined	Percent Composition
Stripetail darter	*Etheostoma kennicotti*	SP	X	.	.	.	.	0.13	0.6	2	.	.	2	0.17
Snubnose darter	*Etheostoma simoterum*	SP	X	.	.	.	.	0.07	0.3	1	.	.	1	0.08
Logperch	*Percina caprodes*	BI	X	.	X	.	.	7.67	34.53	115	.	.	115	9.71
River darter	*Percina shumardi*	BI	X	.	.	.	.	0.07	0.3	1	.	.	1	0.08
Sauger	*Sander canadense*	TC	X	.	.	.	X	.	.	.	0.6	6	6	0.51
Freshwater drum	*Aplodinotus grunniens*	BI	X	.	.	X	.	0.87	3.9	13	0.1	1	14	1.18
Mississippi silverside*	*Menidia audens*	IN	.	.	.	X	X	19.13	86.19	287	.	.	287	24.24
Total			**36**		**1**	**14**	**22**	**70.07**	**315.59**	**1,051**	**13.3**	**133**	**1,184**	**100**
Number Samples								**15**			**10**			
Species Collected								**33**			**16**			

An asterisk (*) denotes aquatic nuisance species. Trophic level: benthic invertivore (BI), herbivore (HB), insectivore (IN), omnivore (OM), planktivore (PK), parasitic (PS), specialized insectivore (SP), top carnivore (TC); Tolerance: tolerant species (TOL), intolerant species (INT);Comm.-Commercially, Rec.-Recreationally.
All species are considered representative important species. No species collected have a Federal Threatened or Endangered status.

Table 11. Species collected, ecological and recreational designation and corresponding electrofishing (EF) and gill net (GN) catch per unit effort downstream (TRM 292.5) of Browns Ferry Nuclear Plant discharge – Autumn 2015.

Common Name	Scientific name	Trophic level	Native species	Tolerance	Thermally Sensitive Species	Comm. Valuable Species	Rec. Valuable Species	EF Catch Per Run	EF Catch Per Hr	Total fish EF	GN Catch Per Net Night	Total Fish GN	Total fish Combined	Percent Composition
Gizzard shad	*Dorosoma cepedianum*	OM	X	TOL	.	X	X	23.13	104.52	347	1	10	357	20.10
Golden shiner	*Notemigonus crysoleucas*	OM	X	TOL	.	.	.	0.07	0.3	1	.	.	1	0.06
Spotfin shiner	*Cyprinella spiloptera*	IN	X	TOL	.	.	.	1.2	5.42	18	.	.	18	1.01
Striped shiner	*Luxilus chrysocephalus*	OM	X	TOL	.	.	.	0.13	0.6	2	.	.	2	0.11
Redbreast sunfish*	*Lepomis auritus*	IN	.	TOL	.	.	X	0.07	0.3	1	.	.	1	0.06
Green sunfish	*Lepomis cyanellus*	IN	X	TOL	.	.	X	6.6	29.82	99	.	.	99	5.57
Bluegill	*Lepomis macrochirus*	IN	X	TOL	.	.	X	2.4	10.84	36	0.1	1	37	2.08
Largemouth bass	*Micropterus salmoides*	TC	X	TOL	.	.	X	0.93	4.22	14	0.4	4	18	1.01
White crappie	*Pomoxis annularis*	TC	X	TOL	.	.	X	.	.	.	0.1	1	1	0.06
Skipjack herring	*Alosa chrysochloris*	TC	X	INT	.	X	.	0.13	0.6	2	1.4	14	16	0.90
Spotted sucker	*Minytrema melanops*	BI	X	INT	.	X	.	0.47	2.11	7	0.1	1	8	0.45
Black redhorse	*Moxostoma duquesnei*	BI	X	INT	.	X	.	0.07	0.3	1	.	.	1	0.06
Longear sunfish	*Lepomis megalotis*	IN	X	INT	.	.	.	3.07	13.86	46	.	.	46	2.59
Smallmouth bass	*Micropterus dolomieu*	TC	X	INT	.	.	.	3.33	15.06	50	0.1	1	51	2.87
Bowfin	*Amia calva*	TC	X	.	.	X	X	0.07	0.3	1	.	.	1	0.06
Threadfin shad	*Dorosoma petenense*	PK	X	.	.	X	.	20.33	91.87	305	.	.	305	17.17
Largescale stoneroller	*Campostoma oligolepis*	HB	X	.	.	.	.	0.07	0.3	1	.	.	1	0.06
Bullhead minnow	*Pimephales vigilax*	IN	X	.	.	.	.	0.13	0.6	2	.	.	2	0.11
Smallmouth buffalo	*Ictiobus bubalus*	OM	X	.	.	X	.	0.8	3.61	12	0.4	4	16	0.90
Blue catfish	*Ictalurus furcatus*	OM	X	.	.	X	X	.	.	.	0.3	3	3	0.17
Channel catfish	*Ictalurus punctatus*	OM	X	.	.	X	X	1.13	5.12	17	0.2	2	19	1.07
Flathead catfish	*Pylodictis olivaris*	TC	X	.	.	X	X	0.27	1.2	4	0.2	2	6	0.34
White bass	*Morone chrysops*	TC	X	.	.	.	X	0.27	1.2	4	0.2	2	6	0.34
Yellow bass	*Morone mississippiensis*	TC	X	.	.	.	X	0.07	0.3	1	0.2	2	3	0.17
Warmouth	*Lepomis gulosus*	IN	X	.	.	.	X	0.27	1.2	4	.	.	4	0.23
Redear sunfish	*Lepomis microlophus*	IN	X	.	.	.	X	0.27	1.2	4	.	.	4	0.23
Black crappie	*Pomoxis nigromaculatus*	TC	X	.	.	.	X	0.07	0.3	1	.	.	1	0.06
Stripetail darter	*Etheostoma kennicotti*	SP	X	.	.	.	.	0.13	0.6	2	.	.	2	0.11

Table 11. (Continued).

Common Name	Scientific name	Trophic level	Native species	Tolerance	Thermally Sensitive Species	Comm. Valuable Species	Rec. Valuable Species	EF Catch Per Run	EF Catch Per Hr	Total fish EF	GN Catch Per Net Night	Total Fish GN	Total fish Combined	Percent Composition
Yellow perch*	*Perca flavescens*	IN	.	.	.	.	X	0.13	0.6	2	.	.	2	0.11
Logperch	*Percina caprodes*	BI	X	.	X	.	.	11.4	51.51	171	.	.	171	9.63
River darter	*Percina shumardi*	BI	X	.	.	.	.	0.13	0.6	2	.	.	2	0.11
Sauger	*Sander canadense*	TC	X	.	.	.	X	.	.	.	0.3	3	3	0.17
Freshwater drum	*Aplodinotus grunniens*	BI	X	.	.	X	.	0.73	3.31	11	0.4	4	15	0.84
Mississippi silverside*	*Menidia audens*	IN	.	.	.	X	X	36.93	166.87	554	.	.	554	31.19
Total			**31**		**1**	**12**	**18**	**114.8**	**518.64**	**1,722**	**5.4**	**54**	**1,776**	**100**
Number Samples								**15**			**10**			
Species Collected								**31**			**15**			

An asterisk (*) denotes aquatic nuisance species. Trophic level: benthic invertivore (BI), herbivore (HB), insectivore (IN), omnivore (OM), planktivore (PK), parasitic (PS), specialized insectivore (SP), top carnivore (TC); Tolerance: tolerant species (TOL), intolerant species (INT);Comm.-Commercially, Rec.-Recreationally.
All species are considered representative important species. No species collected have a Federal Threatened or Endangered status.

Table 12. Spatial statistical comparisons of numbers of species, mean electrofishing catch per unit effort values (number/run), tolerance designations, trophic levels, and non-indigenous individuals, including species richness and Simpson and Shannon diversity values, for samples collected near Browns Ferry Nuclear Plant, autumn 2015.

Parameter	Mean (Standard Deviation) Downstream (TRM 292.5)	Upstream (TRM 295.9)	Significant Difference	Test Statistic	P Value
Number of species (per run)					
Total (Species richness)	11.1 (3.4)	12.7 (5.1)	No	t= -0.96	0.34
Benthic invertivores	1.9 (1.1)	2.3 (1.3)	No	Z= -0.94	0.34
Insectivores	4.0 (2.0)	3.9 (1.8)	No	t= 0.20	0.85
Omnivores	2.6 (1.0)	3.3 (1.8)	No	Z= -0.95	0.34
Top carnivores	3.2 (1.6)	3.8 (2.4)	No	t= -0.80	0.43
Non-indigenous	0.9 (0.5)	1.2 (0.4)	No	Z= -1.58	0.11
Tolerant	3.5 (1.4)	3.6 (2.0)	No	t= -0.11	0.92
Intolerant	2.3 (0.9)	2.2 (1.3)	No	Z= 0.26	0.79
Thermally sensitive	1.1 (0.6)	1.4 (0.7)	No	Z= -1.16	0.25
CPUE (per run)					
Total	5.6 (2.5)	4.3 (2.6)	No	t= 1.39	0.17
Benthic invertivores	0.9 (0.8)	0.7 (0.5)	No	Z= 0.35	0.72
Insectivores	3.4 (3.1)	2.2 (2.4)	No	Z= 0.58	0.56
Omnivores	1.9 (1.5)	0.9 (0.7)	Yes	Z= 2.28	0.02
Top Carnivores	0.6 (0.3)	1.0 (0.8)	No	Z= -1.58	0.11
Non-indigenous	2.5 (2.9)	1.3 (1.6)	No	Z= 0.79	0.43
Tolerant	2.4 (1.4)	1.3 (1.0)	Yes	Z= 2.37	0.02
Intolerant	0.6 (0.4)	0.5 (0.4)	No	t= 0.67	0.51
Thermally sensitive	0.8 (0.8)	0.6 (0.5)	No	Z= 0.31	0.76
Diversity indices (per run)					
Simpson	0.7 (0.1)	0.8 (0.1)	Yes	Z= -2.98	0.002
Shannon	5.2 (1.8)	7.9 (2.5)	Yes	t= 3.33	0.003

Table 13. Summary of autumn RFAI scores from sites located directly upstream and downstream of Browns Ferry Nuclear Plant and scores from sampling conducted during 1993-2015 as part of the Vital Signs monitoring program in Wheeler Reservoir.

Site	Location	1993	1994	1995	1997	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2013	2015	1993-2015 Avg.
Inflow	TRM 348.0	46	48	42	48	36	-	36	40	38	42	44	42	32	38	40	40	46	40	44	**41**
Transition BFN Upstream	TRM 295.9	45	43	34	40	30	41	37	43	39	43	46	41	39	42	39	43	40	46	49	**41**
Transition BFN Downstream	TRM 292.5	-	-	-	-	-	43	40	41	43	43	36	42	42	45	36	38	38	40	44	**41**
Forebay	TRM 277.0	52	44	48	45	42	-	41	45	44	43	45	44	49	46	47	40	46	43	46	**45**
Elk River Embayment	ERM 6.0	41	47	36	49	36	-	49	-	44	49	47	-	39	-	42	-	43	39	46	**43**

RFAI Scores: 12-21 (“Very Poor”), 22-31 (“Poor”), 32-40 (“Fair”), 41-50 (“Good”), or 51-60 (“Excellent”)

Table 14. Comparison of RBI metric ratings and total scores for laboratory-processed samples collected upstream and downstream of Browns Ferry Nuclear Plant, Wheeler Reservoir, autumn 2015.

	Downstream TRM 290.4		Downstream TRM 293.2		Upstream TRM 295.9	
Metric	**Obs**	**Rating**	**Obs**	**Rating**	**Obs**	**Rating**
1. Average number of taxa	9.2	5	10.4	5	9.5	5
2. Proportion of samples with long-lived organisms	1	5	1	5	1	5
3. Average number of EPT taxa	1.5	5	1.3	3	1.4	3
4. Average proportion of oligochaete individuals	12.6	3	19.1	3	8.1	5
5. Average proportion of total abundance comprised by the two most abundant taxa	67.5	5	66.4	5	66.8	5
6. Average density excluding chironomids and oligochaetes	613.3	5	736.7	5	991.7	5
7. Zero-samples – proportion of samples containing no organisms	0	5	0	5	0	5
Benthic Index Score		**33**		**31**		**33**
Ecological Health Rating		**Excellent**		**Excellent**		**Excellent**

Reservoir Benthic Index Scores: 7-12 ("Very Poor"), 13-18 ("Poor"), 19-23 ("Fair"), 24-29 ("Good"), 30-35 ("Excellent")

Table 15. Metric scores and overall RBI scores determined from field processing criteria, for sites upstream and downstream of Browns Ferry Nuclear Plant, Wheeler Reservoir, autumn 2000-2010.

Downstream – TRM 291.7

Sample Year	Avg No. Taxa		% Long-Lived		Avg. No. EPT taxa		% Oligochaetes		% Dominant Taxa		Density excl chiro and oligo		Zero Samples		Overall Score
	Obs	Score	Obs	Score	Obs	Score	Obs	Score	Obs	Score	Obs	Score	Obs	Score	
2000	4	3	1	5	0.8	5	6.4	5	79.6	3	125	1	0	5	**27**
2001	5.6	5	1	5	1.1	5	5.7	5	43	5	230	1	0	5	**31**
2002	5.7	5	1	5	0.8	5	7.4	5	88.1	1	120	1	0	5	**27**
2003	6.5	5	1	5	1	5	0.3	5	76.1	5	1270	5	0	5	**35**
2004	6.7	5	1	5	1	5	1.4	5	74.4	5	523.3	3	0	5	**33**
2005	5.5	5	1	5	0.8	5	3.6	5	80.3	3	508.3	3	0	5	**31**
2006	6.2	5	1	5	0.1	5	2.3	5	77.3	5	272.3	1	0	5	**31**
2007	6.4	5	1	5	0.8	5	12.4	5	80.2	3	166.7	1	0	5	**29**
2008	6.3	5	0.9	5	1.1	5	7.2	5	81.5	3	181.7	1	0	5	**29**
2009	5	5	0.7	3	0.6	3	4.6	5	90.3	1	83.3	1	0	5	**23**
2010	4.6	5	0.7	3	0.6	3	0.3	5	94.8	1	126.7	1	0	5	**23**
Mean:	5.7		0.9		0.8		4.7		78.7		327.9		0.0		**29**
Maximum:	6.7		1		1.1		12.4		94.8		1270		0		
Minimum:	4		0.7		0.1		0.3		43		83.3		0		

Table 15. (Continued)

Upstream – TRM 295.9

Sample Year	Avg No. Taxa Obs	Avg No. Taxa Score	% Long-Lived Obs	% Long-Lived Score	Avg. No. EPT taxa Obs	Avg. No. EPT taxa Score	% Oligochaetes Obs	% Oligochaetes Score	% Dominant Taxa Obs	% Dominant Taxa Score	Density excl chiro and oligo Obs	Density excl chiro and oligo Score	Zero Samples Obs	Zero Samples Score	**Overall Score**
2000	4.6	5	1	5	0.8	5	6.6	5	77.6	5	190	1	0	5	**31**
2001	5.3	5	1	5	1	5	2.7	5	79.8	3	188.3	1	0	5	**29**
2002	6.5	5	1	5	0.8	5	7.2	5	75.6	5	266.7	1	0	5	**31**
2003	5.1	5	0.8	5	1	5	0.8	5	84.1	3	456.7	3	0	5	**31**
2004	6.2	5	1	5	0.9	5	1.1	5	73.7	5	353.6	3	0	5	**33**
2005	5.6	5	1	5	1.2	5	2.3	5	85.4	3	490	3	0	5	**31**
2006	5.9	5	0.8	5	0.7	3	7	5	75	5	348.3	3	0	5	**31**
2007	6.5	5	0.9	5	0.9	5	1.9	5	74.2	5	353.3	3	0	5	**33**
2008	5.8	5	0.7	3	0.5	3	7.8	5	85.4	3	220	1	0	5	**25**
2009	5.1	5	1	5	0.4	3	12.2	5	75.2	5	133.3	1	0	5	**29**
2010	4.2	3	1	5	0.8	5	2.1	5	92	1	108.3	1	0	5	**25**
Mean:	5.5		0.9		0.8		4.7		79.8		282.6		0		**30**
Maximum:	6.5		1		1.2		12.2		92		490		0		
Minimum:	4.2		0.7		0.4		0.8		73.7		108.3		0		

Table 16. Metric scores and overall RBI scores determined from lab processing criteria, for sites upstream and downstream of Browns Ferry Nuclear Plant, Wheeler Reservoir, 2001-2006.

Downstream – TRM 291.7

	Avg No. Taxa		% Long-Lived		Avg. No. EPT taxa		% Oligochaetes		% Dominant Taxa		Density excl chiro and oligo		Zero Samples		Overall Score
Sample Year	Obs	Score	Obs	Score	Obs	Score	Obs	Score	Obs	Score	Obs	Score	Obs	Score	
2001	7.8	5	1	5	1.1	3	7.6	5	71.7	5	315	3	0	5	**31**
2002	5.4	3	1	5	0.9	3	10.9	5	88.2	1	106.7	1	0	5	**23**
2003	7.3	5	1	5	1	3	0.4	5	73.2	5	1270	5	0	5	**33**
2004	7.9	5	1	5	1	3	1.6	5	73.5	5	551.7	3	0	5	**31**
2006	9.4	5	1	5	1.6	5	2.3	5	78.1	3	448.2	3	0	5	**31**
Mean:	7.56		1		1.12		4.56		76.94		538.32		0		**30**
Maximum:	9.4		1		1.6		10.9		88.2		1270		0		
Minimum:	5.4		1		0.9		0.4		71.7		106.7		0		

Upstream – TRM 295.9

	Avg No. Taxa		% Long-Lived		Avg. No. EPT taxa		% Oligochaetes		% Dominant Taxa		Density excl chiro and oligo		Zero Samples		Overall Score
Sample Year	Obs	Score	Obs	Score	Obs	Score	Obs	Score	Obs	Score	Obs	Score	Obs	Score	
2001	7.4	5	1	5	1	3	6.9	5	75.6	5	281.7	1	0	5	**29**
2002	6.8	5	1	5	1.1	3	5	5	74.1	5	281.7	1	0	5	**29**
2003	6.3	3	1	5	0.9	3	0.6	5	82.2	3	583.3	3	0	5	**27**
2004	6.2	3	1	5	0.8	3	1.1	5	72.2	5	336.2	3	0	5	**29**
2006	9.2	5	0.8	3	1.2	3	5.1	5	78.6	3	1273.3	5	0	5	**29**
2011	8.4	5	0.7	3	1	3	6.3	5	81.1	3	430	3	0	5	**27**
Mean:	7.4		0.9		1.0		4.2		77.3		531.0		0		**28**
Maximum:	9.2		1		1.2		6.9		82.2		1273.3		0		
Minimum:	6.2		0.7		0.8		0.6		72.2		281.7		0		

Table 17a. Mean density per square meter of benthic taxa collected upstream and downstream of Browns Ferry Nuclear Plant, autumn 2015. All taxa listed contributed to individual RBI metrics and total scores.

Taxa	BFN Downstream TRM 290.4	BFN Downstream TRM 293.2	BFN Upstream TRM 295.9
ANNELIDA			
Hirudinea			
Rhynchobdellida			
Glossiphoniidae			
Actinobdella inequiannulata	---	3	2
Actinobdella sp.	2	2	---
Helobdella stagnalis	7	13	3
Placobdella montifera	2	2	---
Oligochaeta			
Tubificida			
Naididae			
Naidinae	2	---	---
Dero sp.	20	---	---
Nais sp.	---	2	3
Pristina leidyi	---	5	---
Pristina sp.	---	10	---
Slavina appendiculata	---	8	---
Stylaria lacustris	---	3	---
Vejdovskyella comata	2	---	---
Tubificinae whc	---	8	---
Tubificinae wohc	92	182	88
Aulodrilus limnobius	---	2	---
Aulodrilus pigueti	12	7	10
Branchiura sowerbyi	5	3	2
Limnodrilus hoffmeisteri	---	18	3
ARTHROPODA			
Crustacea			
Malacostraca			
Amphipoda			
Corophiidae			
Apocorophium lacustre	10	145	260
Gammaridae			
Gammarus sp.	17	17	12
Talitridae			
Hyalella azteca	---	2	---

Table 17a. (Continued)

Taxa	BFN Downstream TRM 290.4	BFN Downstream TRM 293.2	BFN Upstream TRM 295.9
Hexapoda			
Insecta			
Coleoptera			
Staphylinidae	2	---	---
Diptera			
Ceratopogonidae	---	2	---
Chironomidae			
Ablabesmyia annulata	18	17	7
Ablabesmyia mallochi	2	---	---
Ablabesmyia rhamphe gp.	---	2	---
Chironomus sp.	8	7	28
Coelotanypus sp.	293	245	270
Conchapelopia sp.	---	2	---
Cryptochironomus sp.	---	10	---
Dicrotendipes neomodestus	---	25	---
Dicrotendipes simpsoni	2	---	---
Dicrotendipes sp.	18	2	17
Glyptotendipes sp.	---	5	65
Nanocladius distinctus	---	2	8
Polypedilum halterale gp.	---	5	---
Procladius sp.	---	---	3
Tanytarsus sp.	3	---	---
Ephemeroptera			
Caenidae			
Caenis sp.	---	7	---
Ephemeridae			
Hexagenia sp. <10mm	75	67	52
Hexagenia sp. >10mm	98	97	100
Trichoptera			
Hydroptilidae			
Hydroptila sp.	---	2	---
Leptoceridae			
Oecetis sp.	8	3	5
Polycentropodidae			
Cyrnellus fraternus	13	10	12
MOLLUSCA			
Gastropoda			

Table 17a. (Continued)

Taxa	BFN Downstream TRM 290.4	BFN Downstream TRM 293.2	BFN Upstream TRM 295.9
Architaenioglossa			
Viviparidae			
Lioplax sulculosa	---	---	2
Viviparus sp.	5	3	7
Basommatophora			
Ancylidae			
Ferrissia rivularis	---	7	---
Neotaenioglossa			
Hydrobiidae			
Amnicola limosa	3	7	10
Somatogyrus sp.	2	12	30
Pleuroceridae			
Pleurocera canaliculata	2	---	---
Pleurocera canaliculata excuratum	---	---	10
Bivalvia			
Unionoida			
Unionidae			
Truncilla donaciformis	---	---	7
Veneroida			
Corbiculidae			
Corbicula fluminea <10mm	38	8	40
Corbicula fluminea >10mm	227	127	112
Dreissenidae			
Dreissena polymorpha			
Sphaeriidae	---	3	---
Eupera cubensis	2	---	---
Musculium transversum	88	183	327
PLATYHELMINTHES			
Trepaxonemata			
Neoophora			
Planariidae			
Dugesia tigrina	13	17	3
Number of samples	**10**	**10**	**10**
Mean-Density per meter²	**1090**	**1305**	**1497**
Taxa Richness	**27**	**38**	**27**
Sum of area sampled (meter²)	**0.6**	**0.6**	**0.6**

Table 17b. Mean density per square meter of other benthic taxa collected but not included in individual RBI metrics or total scores for sites upstream and downstream of Browns Ferry Nuclear Plant, autumn 2015.

Taxa	BFN Downstream TRM 290.4	BFN Downstream TRM 293.2	BFN Upstream TRM 295.9
ARTHROPODA			
Crustacea			
Branchiopoda			
Diplostraca			
Sididae			
Sida crystallina	---	---	13
Maxillopoda			
Cyclopoida			
Cyclopidae			
Macrocyclops albidus	---	2	3
Mesocyclops edax	2	10	3
Ostracoda			
Podocopida			
Candonidae			
Candona sp.	15	33	18
Hexapoda			
Insecta			
Diptera			
Chaoboridae			
Chaoborus punctipennis	10	13	5
Chelicerata			
Arachnida			
Acariformes			
Trombidiformes			
Arrenuridae			
Arrenurus sp.	2	3	2
Krendowskiidae			
Krendowskia sp.	---	2	---
Unionicolidae			
Neumania sp.	2	---	---
Unionicola sp.	8	18	3

Table 17b. (Continued)

Taxa	BFN Downstream TRM 290.4	BFN Downstream TRM 293.2	BFN Upstream TRM 295.9
CNIDARIA			
Medusozoa			
Hydrozoa			
Hydroida			
Hydridae			
Hydra sp.	8	3	---
Number of samples	**10**	**10**	**10**
Mean-Density per meter²	**47**	**85**	**48**
Taxa Richness	**7**	**8**	**7**
Sum of area sampled (meter²)	**0.6**	**0.6**	**0.6**

Table 18. Comparison of 2015 RBI scores with LTA scores from sites directly upstream and downstream of Browns Ferry Nuclear Plant and from sites sampled as part of the Vital Signs monitoring program on Wheeler Reservoir. LTA-Long term average, 1994 - 2013.

Site	Location	1994	1995	1997	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2013	LTA	2015
Inflow	*TRM 347	31	21	25	23	---	21	25	31	31	31	33	33	---	31	---	27	31	**28**	31
BFN Upstream (Transition)	TRM 295.9	33	25	31	31	31	29	31	31	33	31	31	33	25	29	25	27	35	**30**	33
BFN Downstream (Transition)	TRM 291.7	---	---	---	---	27	31	27	35	33	31	31	29	29	23	23	---	---	**29**	---
BFN Downstream (Transition)	TRM 293.2	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	23	35	**N/A**	31
BFN Downstream (Transition)	TRM 290.4	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	21	31	**N/A**	33
Forebay	*TRM 277	19	15	23	17	---	17	15	15	19	15	13	13	15	13	---	13	17	**16**	13
Embayment	*ERM 6	15	13	15	15	---	15	---	15	---	17	---	13	---	13	---	13	13	**14**	15

Reservoir Benthic Index Scores: 7-12 ("Very Poor"), 13-18 ("Poor"), 19-23 ("Fair"), 24-29 ("Good"), 30-35 ("Excellent")

*** = sites with field-processed scores all years. All other sites, 1994 – 2010 are field-processed scores and 2011 forward are lab-processed scores.**

Table 19. Wildlife observed during surveys conducted upstream and downstream of TVA's Browns Ferry Nuclear Plant, November 2015.

Survey Site		Birds	Obs.	Reptile/Amphibian	Obs.	Mammals	Obs.
TRM 295 (US)	RDB	Belted kingfisher	5	Map turtle	22		
34.69047		Great blue heron	5				
-87.08415		European starling	230				
		Unspecified perching bird	3				
34.69852		Mallard	1				
-87.10239		Mockingbird	3				
		Blue jay	8				
		American crow	8				
		American robin	6				
		Common flicker	2				
34.68032	LDB	Great blue heron	5	Map turtle	29		
-87.11340		White pelican	11	Painted turtle	1		
		Carolina wren	1				
34.67013		Double-crested cormorant	4				
-87.10204		Blue jay	3				
TRM 292 (DS)	RDB	Great blue heron	5				
34.72314		Blue jay	3				
-87.13579		Unspecified perching bird	3				
		Golden eagle	3				
34.73411		Bald eagle	1				
-87.14642		Carolina chickadee	2				
		American robin	5				
		European starling	30				
		Common grackle	150				
		Mallard	2				
		Pileated woodpecker	1				
		American coot	1				
34.72218	LDB	Red-tailed hawk	1	Map turtle	26		
-87.16943		Great blue heron	4				
		Bald eagle	2				
34.71100		Pied-billed grebe	2				
-87.15496		Double-crested cormorant	1				
		Osprey	1				

RDB – right descending bank; LDB – left descending bank

Table 20. Wildlife observed during visual surveys conducted upstream and downstream of Watts Bar Nuclear Plant, 2011 through 2015.

	TRM 295 RDB			TRM 295 LDB			TRM 292.5 RDB			TRM 292.5 LDB		
Species Observed	**2011**	**2013**	**2015**	**2011**	**2013**	**2015**	**2011**	**2013**	**2015**	**2011**	**2013**	**2015**
Birds												
American crow	6	1	8					1				
American coot							6	4	1			
American robin		1	6					2	5			
Bald eagle									1			2
Belted kingfisher	1	4	5	2	1		1	3			2	
Blue jay		5	8			3		5	3		1	
Brown thrasher		1										
Carolina chickadee		1							2			
Carolina wren						1						
Common flicker			2									
Common grackle							20		150			
Common snipe					1							
Double-crested cormorant	1	2				4						1
Downy Woodpecker								2				
European starling			230					10	30			
Golden eagle									3			
Great blue heron	4	6	5	4	2	5	6	2	5	5	4	4
Least flycatcher											1	
Killdeer					2							
Mallard	5	2	1		12		7	2	2	8		
Mockingbird		1	3								2	
Osprey												1
Pied-billed grebe											2	2
Pileated Woodpecker					1				1			
Red-tailed hawk												1
Ring-billed gull					1							
Sanderling				2								
Turkey vulture					2			2				
Unspecified perching bird	1	1	3		8		2	2	3	5	3	
White pelican						11						
White-breasted nuthatch								1				
Wood duck							8			4		

Table 20. (Continued).

Species Observed	TRM 295 RDB			TRM 295 LDB			TRM 292.5 RDB			TRM 292.5 LDB		
	2011	2013	2015	2011	2013	2015	2011	2013	2015	2011	2013	2015
Reptile/Amphibian												
Map Turtle		37	22		26	29		2			69	26
Painted turtle						1						
Unspecified turtle				20								
Mammals												
Eastern grey squirrel		2										

Table 21. Depth profiles of water temperature (°F) collected to determine the extent of the thermal plume discharged from TVA's Browns Ferry Nuclear Plant during 2015.

October 2015	Ambient-TRM 295.4					Discharge-TRM 293.5					Mid-plume-TRM 291.7					Below Sample Reach TRM 290.2				
Depth (m)	10%	30%	50%	70%	90%	10%	30%	50%	70%	90%	10%	30%	50%	70%	90%	10%	30%	50%	70%	90%
0.3	68.1	67.2	66.7	66.8	67.5	72.4	72.0	66.9	67.1	67.8	71.9	72.0	69.8	69.7	68.0	71.5	71.8	71.2	69.4	68.4
1.5	68.1	67.2	66.6	66.8	67.4	70.9	70.8	67.0	67.0		71.9	72.0	69.7	69.6	67.9	71.3	71.8	71.2	69.3	68.2
2	68.1							66.9												
3		67.2	66.5	66.8		69.8	68.7		66.9		71.9	72.0	69.2	69.5	67.9	71.2	71.8	70.9	69.2	67.9
4														69.4		71.2	71.8			67.8
5			66.4			68.0	68.1						69.0					69.8	69.1	
6													69.0							
7			66.4			67.9	67.9													
8			66.4				67.9													

Shaded numbers represent temperatures 3.6°F (2°C) or greater above ambient temperature.

Table 22. Water quality parameters collected along vertical depth profiles at three transects within the RFAI sample reaches upstream and downstream of Browns Ferry Nuclear Plant during 2015.

October, 2015	LDB						Mid-channel						RDB					
TRM 295	Depth	°C	°F	pH	Cond	DO	Depth	°C	°F	pH	Cond	DO	Depth	°C	°F	pH	Cond	DO
Upstream Boundary	0.3	21.4	70.6	7.5	210.6	8.6	0.3	21.0	69.7	7.6	209.7	7.8	0.3	21.7	71.1	7.3	209.4	8.5
	1.5	21.4	70.5	7.4	210.6	8.6	1.5	20.7	69.3	7.5	209.8	7.7	1.5	20.1	68.2	7.1	207.4	8.4
							3	20.7	69.2	7.4	212.5	7.7						
							5	20.7	69.2	7.4	209.1	7.7						
							6	20.6	69.2	7.4	208.1	7.7						
Mid-station	0.3	21.0	69.8	7.4	210.9	8.1	0.3	20.9	69.6	7.4	218.8	8.2	0.3	20.4	68.7	7.6	207.4	9.2
	1.5	21.0	69.8	7.4	211.2	8.1	1.5	20.6	69.1	7.4	210.7	8.0	1.5	18.8	65.8	7.7	207.5	9.4
							3	20.3	68.6	7.3	212.7	8.0						
							4	20.2	68.4	7.3	211.8	7.9						
							6	20.1	68.1	7.3	210.7	7.8						
Downstream Boundary	0.3	21.7	71.1	7.6	210.1	8.6	0.3	21.8	71.2	7.6	208.4	8.8	0.3	24.6	76.2	7.7	211.5	9.0
	1.5	21.1	70.0	7.5	209.4	8.5	1.5	21.7	71.0	7.6	209.3	8.7	1.5	22.1	71.7	7.6	211.0	8.7
							3	21.7	71.0	7.6	210.7	8.7	3	21.3	70.4	7.5	209.1	8.5
							4	21.4	70.6	7.6	209.0	8.7	4	21.3	70.3	7.5	208.6	8.5
							6	20.9	69.6	7.5	209.1	8.6						
							8	20.4	68.6	7.5	208.6	8.5						
TRM 292	Depth	°C	°F	pH	Cond	DO	Depth	°C	°F	pH	Cond	DO	Depth	°C	°F	pH	Cond	DO
Upstream Boundary	0.3	20.7	69.2	7.7	211.4	9.6	0.3	21.6	70.8	7.5	211.9	8.5	0.3	21.8	71.3	7.6	211.3	8.9
	1.5	19.7	67.5	7.6	211.5	9.5	1.5	20.6	69.1	7.5	211.6	8.3	1.5	21.0	69.8	7.5	210.2	8.7
	3	19.4	66.9	7.6	210.0	9.4	3	20.0	68.0	7.4	210.9	8.2	3	20.7	69.3	7.4	210.1	8.5
							5	19.9	67.8	7.2	207.8	8.1						
Mid-station	0.3	21.8	71.3	7.7	213.2	9.0	0.3	22.7	72.8	7.6	213.8	8.9	0.3	22.5	72.5	7.7	211.7	9.2
	1.5	20.4	68.7	7.8	209.0	9.2	1.5	21.3	70.3	7.5	210.3	8.8	1.5	21.6	70.9	7.6	211.4	9.2
	3	19.7	67.5	7.6	213.4	8.5	3	20.4	68.7	7.5	210.6	8.6	2	21.4	70.6	7.6	209.8	8.8
							4	19.9	67.9	7.4	209.3	8.4						
							6	19.8	67.6	7.4	214.6	8.3						
Downstream Boundary	0.3	20.8	69.4	7.8	210.7	9.4	0.3	21.6	70.9	7.8	210.5	9.1	0.3	21.6	70.9	7.7	210.9	9.2
	1.5	20.0	68.0	7.8	211.6	9.6	1.5	20.0	67.9	7.6	210.3	8.9	1.5	21.2	70.2	7.6	209.9	8.9
	3	19.4	66.8	7.2	210.5	9.4	3	19.7	67.4	7.6	211.2	8.9	3	20.3	68.6	7.5	207.3	8.5
	4	19.3	66.7	7.7	209.5	9.3	4	19.5	67.1	7.6	209.7	9.0						
							6	19.3	66.8	7.6	211.0	8.9						

Abbreviations: °C – Temperature (degrees Celsius), °F – Temperature (degrees Fahrenheit), Cond – Conductivity, DO – Dissolved Oxygen