IMPINGEMENT MORTALITY & ENTRAINMENT STUDY
CLEAN WATER ACT SECTION 316(B) COMPLIANCE
JOHN W. TURK, JR. POWER PLANT

TURK POWER PLANT
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EXECUTIVE SUMMARY

The John W. Turk, Jr. Power Plant (Turk) is a 600-megawatt coal-fired power plant located on 2,875 acres between Fulton and McNab, Hempstead County, Arkansas. Turk withdraws greater than 6,000 gallons of water per minute. Raw water is supplied to the plant from the Little River via a submerged wedgewire screen to a caisson, then into a 161.5-million-gallon makeup pond at the plant by pipeline. The Cooling Water Intake Structure (CWIS) is located on the Little River, Hempstead County, Arkansas, downstream of Allen's Ferry Landing and incorporates a cylindrical wedgewire screen design with a mesh size opening of 0.125 inches (3.175 millimeters). This CWIS design represents the Best Technology Available (BTA). The maximum through-screen design velocity is *less than* 0.5 feet per second.

As part of compliance with Condition No. 15 of Part II of National Pollutant Discharge Elimination System Permit No. AR0051136, Turk began biological monitoring after commencing operation of the CWIS on August 2, 2012. This annual report (Year 5) details the results found during the period of sampling from April 2017 to June 2017.[1] Entrainment samples were collected at Turk to monitor entrainment rates at intervals during the primary period of reproduction. Monthly sampling occurred in April through June 2017.[2] The total sample volume for the three sampling events was 210,192 gallons.

During the Year 5 study period, 41 fish eggs and 93 fish larvae were collected. The taxon comprising the largest number of specimens was the Clupeidae family (Shad family) with additional specimens from *Morone* sp. (Bass), *Pomoxis*-type (Crappie family), as well as Blue Catfish and Freshwater Drum. These determinations were based on body and myomere morphology, pigmentation patterns, water quality characteristics, and the time of year when collected. No federal or state species of concern were positively identified. No shellfish or mussels were observed in any sample collected.[3]

The samples were classified into separate groups, and then further classified into subcategory of Ichthyoplankton — either fish eggs or fish larvae.

While the CWIS design represents BTA, entrainment may still occur with a 3.1-millimeter wedge wire screen intake. Based upon sampling volume, flow rates, and Ichthyoplankton collections, a total of 368,160 fish eggs and larvae were estimated to be entrained over the duration of Year 5 (April 2017 to June 2017). Peak entrainment was observed in June with 70 eggs and larvae (52% of total entrainment). These totals are similar to results seen at other newer coal-fired

[1] "Year 5" refers to the sampling period from April 2017 to June 2017.
[2] Permit monitoring conditions changed via letter from ADEQ dated May 28, 2015 in response to previous sampling review. The revision modified entrainment monitoring frequency from once every two weeks in April through September, to once per month, April through June.
[3] For the purposes of this study, shellfish are crayfish and native freshwater (unionid) mussels and do not include the Asiatic clam (*Corbicula)* or zebra and quagga mussels (*Dreissena*).

power stations employing the cylindrical wedgewire screen and similar operational practices.[4] Yet, entrainment estimates at Turk are as much as 500 times lower than those levels seen in power plants using traveling screens.[5,6,7] The level of entrainment at Turk is considerably lower due to the BTA associated with the facility's CWIS.

As an alternative to conducting monthly impingement sampling, the Arkansas Department of Environmental Quality, in Condition 15(2)(a)(i) of NPDES Permit No. AR0051136, allows Turk to demonstrate Clean Water Act Section 316(b) compliance by operating the air burst system on the intake screen weekly and by performing impingement sampling and visual inspections at least once per quarter. In a letter dated May 28, 2015, the frequency of impingement sampling was reduced from once per quarter, January through December, to once per year, from April through June. Impingement sampling and visual inspection of the intake screen was performed on April 26, 2017. During the visual inspection and impingement sampling, no fish or other aquatic organisms were found to be impinged on the intake structure. The intake screen was cleaned during the visual inspection. Prior videos have shown several small fish swimming next to the intake screen and then swim away. This observation provides a qualitative, visual indicator of the low through-screen velocity for the water entering the intake screen.

[4] Plum Point Energy Station, a 665-MW coal-fired power plant in Osceola, Arkansas, was estimated to have entrained 3,508,160 Ichthyoplankton in 2011 with historic Mississippi River flooding and was estimated to have entrained 2,300,731 Ichthyoplankton in 2012 with historic low water levels on the Mississippi River.

[5] Annual entrainment estimated at 2.4 billion fish eggs and larvae in 2005 and 2006. Ager, D., Darttila, D., & Patrick, P. (2008). Bay Shore Power Plant CWIS Information and I&E Sampling Data. Kinectrics Report 112026-005-RA-0002-R00.

[6] Annual entrainment at a hydroelectric facility on Pensacola Dam, Grand Lake, Oklahoma, was estimated at 100 million fish larvae in 1989. Travnichek V., Zale A., & Fisher, W. (1993). Entrainment of Ichthyoplankton by a warm water hydroelectric facility. *Transactions of the American Fisheries Society*, 709-716.

[7] Annual entrainment estimated at 67.5 million fish eggs and larvae in 1993 and 1994 for Comanche Peak Stream Electric Station, which uses 0.5 inch traveling screens. Spicer, G., O'Shea, T. & Piehler, G. (2000). Entrainment, impingement, and BTA evaluation for an intake located on a cooling water reservoir in the southwest. *Environmental Science & Policy 3*, S323-S331.

1.0 INTRODUCTION

Section 316(b) of the Clean Water Act (CWA) establishes a federal statutory requirement that Cooling Water Intake Structure (CWIS) location, design, capacity, and construction reflect the Best Technology Available (BTA) for minimizing adverse environmental impact. Authority for implementing Section 316(b) resides with the United States Environmental Protection Agency (U.S. EPA) and is addressed through the issuance of National Pollutant Discharge Elimination System (NPDES) permits. The U.S. EPA may delegate this responsibility to the states if a federally-approved permitting program is implemented. Within the State of Arkansas, NPDES permits are issued by (ADEQ) as authorized by the U.S. EPA.

1.1 Rule History and Background

In 1976, U.S. EPA published a final rule implementing CWA Section 316(b). The rule was remanded quickly for failing to properly follow required administrative procedures.[1] U.S. EPA withdrew most of the final rule; however, it did release, in draft form, the *Guidance for Evaluating the Adverse Impact of CWISs on the Aquatic Environment: Section 316(b)*.[2]

The draft guidance outlined an approach for collecting information that would support any determinations made by the permitting authority, but did not establish a national technology-based standard for BTA, as required by the CWA. Following the remand of the 1976 rule, compliance with Section 316(b) varied from state to state, region to region. Many permitting authorities evaluated facility performance on site-specific criteria while most states, such as California, implemented Section 316(b) on a case-by-case basis in lieu of national standards.

In 1993, the Hudson Riverkeepers filed suit against U.S. EPA claiming its failure to establish national technology-based standards violated the CWA. In the plaintiff's view, the case-by-case, site-specific approach created an inconsistent application of the CWA by ignoring the mandate to minimize adverse environmental impacts.

In 1995, the U.S. EPA entered into a consent decree with the Hudson Riverkeepers and other plaintiffs that established a framework for the development and promulgation of national technology-based standards to effectively and finally implement Section 316(b) in three distinct tracks:

- Track I addresses new steam electric and manufacturing facilities.

[1] *Appalachian Power Corp. v. EPA, 566 F. 2d 451 (4th Cir. 1977)*
[2] Retrieved from http://water.epa.gov/lawsregs/lawsguidance/cwa/316b/upload/2006_10_26_316b_1977AEIguid.pdf

- Track II was reserved for large, existing steam electric facilities (those with a design capacity greater than 50 million gallons per day (mgd).

- Track III would address all manufacturing facilities with an intake capacity greater than 2 mgd and steam electric facilities not covered by Track II.

In 2006, the (U.S. Second Court of Appeals remanded much of the rule but left the majority of the Track I requirements for newly built closed-cycle power plants, which applies to Turk. As such, Turk must comply with implementing the requirements of Section 316(b) of the CWA under 40 Code of Federal Regulations §125, Subpart 1.

In 2009, the U.S. Supreme Court in *Entergy v. Riverkeeper* (Riverkeeper II) answered the question of using Cost Benefit Analysis in regards to using BTA to "minimize the adverse environmental impact" and overall affirmed the use of BTA (also referred to as Best Available Technology or BAT) in relation to CWA Section 316(b).

In March 2012, the U.S. EPA proposed a revised 316(b) rule and published the finalized rule on May 19, 2014. Currently, the revised rule states that compliance with new requirements to prevent impingement at existing facilities reverts closer to the original methodology. As published, compliance may be demonstrated through one of seven alternatives, as approved by the state water director. These methods include having, at least, one of these methods in place:

(1) Closed-cycle recirculating system and monitor actual intake flows, at least daily
(2) Through-screen design velocity less than 0.5 feet per second (fps)
(3) Through-screen actual velocity less than 0.5 fps
(4) Existing offshore velocity cap
(5) Modified traveling screens
(6) Systems of technologies as the BTA for impingement mortality
(7) Impingement mortality performance standard[3]

In addition, the U.S. EPA expects closed-cycle recirculating cooling and cylindrical wedgewire, fine mesh screens to be used to control entrainment mortality. Turk employs closed-cycle cooling and has a cylindrical wedgewire, fine mesh screen with through-screen design velocity less than 0.5 fps. These control methodologies, as well as operational controls, avoid impingement and entrainment of aquatic life in the Little River.

[3] §125.94(3)(c)

1.2 Site Description

Turk is a 600-megawatt coal-fired power plant located on 2,875 acres between Fulton and McNab, Hempstead County, Arkansas. Turk has a design intake capacity greater than 6,000 gallons per minute (gpm), of which approximately 5,330 gpm (82%) is used for cooling purposes. Raw water is supplied to the plant from the Little River through the CWIS — a cylindrical, submerged wedgewire screen piped to a caisson, then into a 161.5-million-gallon makeup pond at the plant by pipeline. The intake structure is located on the Little River, Hempstead County, Arkansas, downstream of Allen's Ferry Landing and approximately 2.5 miles upstream of the confluence with the Red River. The intake structure incorporates a cylindrical wedgewire screen design with a mesh size opening of 0.125 inches (3.175 millimeters). The maximum through-screen design velocity is 0.455 fps, which complies with the Tract I requirement of less than 0.5 fps. This design represents BTA and compliance with the revised 316(b) rule.

Turk has a design intake capacity greater than 6,000 gpm. Turk has chosen to comply with the Final Rule under Track I (40 Code of Federal Regulations [CFR] 125.84(b)) for facilities that withdraw greater than or equal to 10 mgd. Two intake pumps (7,500 gpm each) are installed in a pump house on top of the 24-foot diameter caisson and supply water to the water treatment system. Only one pump operates at a time. The maximum through-screen design velocity is estimated at 0.455 fps.[4]

1.3 Compliance with Section 316(b) of the Clean Water Act

The Turk NPDES Permit No. AR0051136 requires compliance with the requirements of 40 CFR Part 125, Subpart 1 for "Track I" facilities (implementing the requirements of Section 316(b) of the CWA). Under Track I, new facilities that withdraw greater than 2 mgd, but ≤10 mgd from a freshwater river or stream, must comply with the following requirements:

1. Maximum through-screen design intake velocity of 0.5 fps.

2. Total design intake flow no greater than 5% of the source water annual mean flow.

3. Select and implement design and construction technologies or operational measures for minimizing *impingement* mortality of fish and shellfish if:

    a. There are threatened or endangered or otherwise protected federal, state, or tribal species, or critical habitat for these species, within the hydraulic zone of influence of the CWIS.

[4] See also AEP. (2010). CWA Section 316(b) Informational Report, Appendix A: Engineering Design Report.

b. Based on information submitted by any fishery management agency(ies) or other relevant information, there are migratory and/or sport or commercial species of impingement concern to the Director that pass through the hydraulic zone of influence of the CWIS.

c. It is determined by the Director, based on information submitted by any fishery management agency(ies) or other relevant information, that the proposed facility, after meeting the technology-based performance requirements, would still contribute unacceptable stress to the protected species, critical habitat of those species, or species of concern.

4. Select and implement design and construction technologies or operational measures for minimizing *entrainment* of entrainable life stages of fish and shellfish.

5. Implement impingement and entrainment sampling using the monitoring frequencies identified below for at least two years after the initial permit issuance:

   a. ***Impingement sampling:*** Collect samples to monitor impingement rates (simple enumeration) for each species over a 24-hour period and no less than once per month when the CWIS is in operation.[5]

   b. ***Entrainment sampling:*** Collect samples to monitor entrainment rates (simple enumeration) for each species over a 24-hour period and no less than monthly during the primary period of reproduction, larval recruitment, and peak abundance (April through June).

Turk must meet the specific intent of Section 316(b) of the CWA, which requires that the location, design, construction, and capacity of the CWIS reflect the BTA for minimizing adverse environmental impact.

[5] While CWA Section 316(b) calls for monthly impingement sampling for Track 1 facilities, alternative sampling methodologies have been approved by regulators on a case-by-case basis under 40 Code of Federal Regulations 125.85. ADEQ authorized annual impingement sampling (April-June) for Turk in NPDES Permit AR0051136. ADEQ authorized impingement sampling for Turk as a valid alternative methodology in NPDES Permit AR AR0051136.

2.0 SOURCE WATER INFORMATION[6]

The Little River, located in southwest Arkansas and southeast Oklahoma, has a drainage area of more than 4,000 square miles and is approximately 220 miles in length. Turk's intake is located approximately 2.5 miles upstream of the confluence of the Little River with the Red River, on the 17-mile stretch of the Little River downstream of Millwood Dam, which creates Millwood Lake (Figure 1). The intake is 1 mile upstream from Turk's Outfall 001 discharge and 500 feet downstream from Allen's Ferry landing. In the vicinity of the intake, the Little River is about 350 feet wide, with depths typically exceeding 20 feet. Gradient is relatively low at this point, at about 0.3 feet/mile, with currents during moderate flow periods typically near 1 fps.

Figure 1 — Drainage Basin of the Little River (Arkansas/Oklahoma)

[6] Much of this information was previously submitted to ADEQ in AEP's "CWA Section 316(b) Information Report," November 2010.

According to the long-term U.S. Geological Survey sampling at Millwood Dam from 1967-1995, the Little River monthly mean temperature ranges from 5.9ºC (42.6ºF) in January to 29.4ºC (84.9ºF) in July, and a monthly mean dissolved oxygen range of 7.8 milligrams/liter (mg/L) in August to 13.7 mg/L in January. Median total suspended solids were 16 mg/L, and the median pH was 7.1. The mean annual flow of the Little River is 5,690 cubic feet per second (3,677 mgd).

Flow data for the Little River monthly mean and minimum flow releases at Millwood Dam from 1989-2010 is presented in Figure 2.

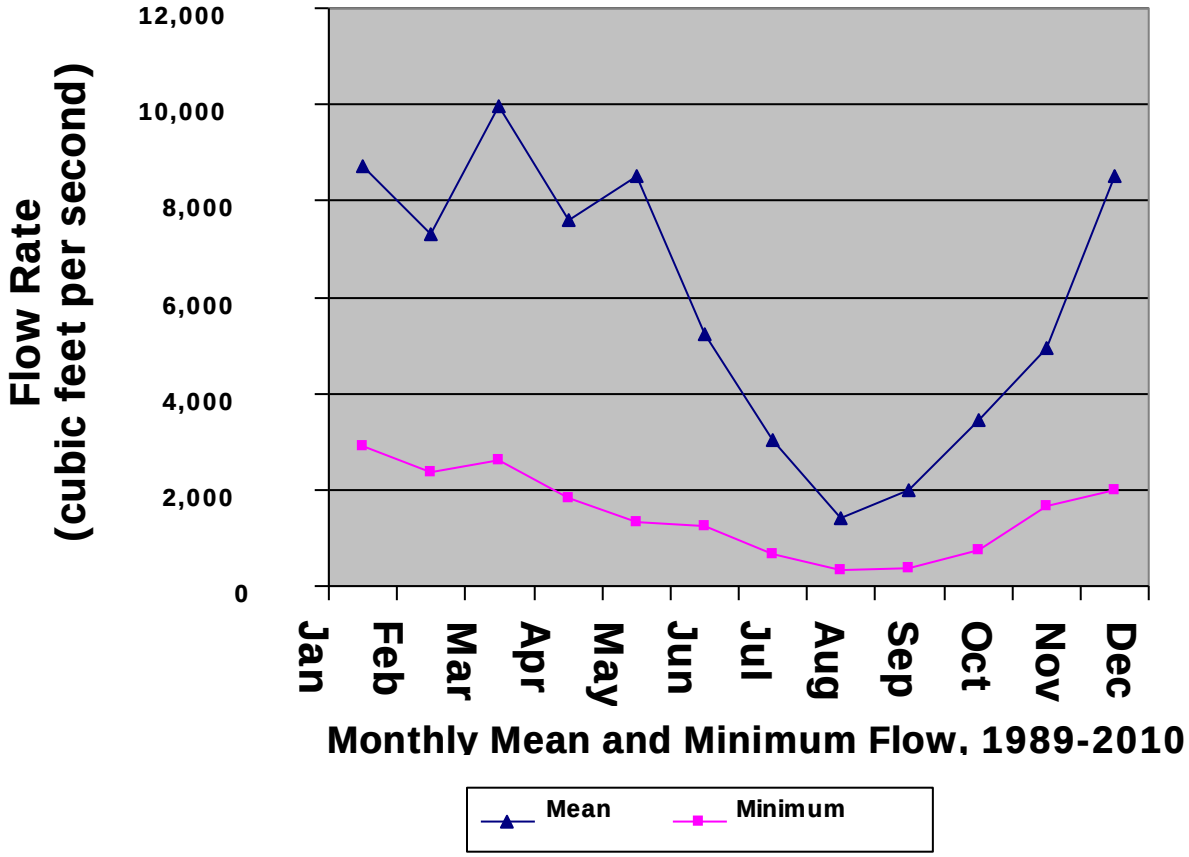


Figure 2 — Little River Monthly Mean and Minimum Flow from Millwood Dam, 1989-2010

Maximum intake flow for Turk (9.36 mgd or 108 gallons per second) represents <0.25% of the annual mean flow of the Little River in the vicinity of the CWIS. This condition demonstrates compliance with the requirement for a total design intake flow to be no greater than 5% of the source water annual mean flow.

For the Year 5 sampling period of April 2017 to June 2017, monthly average flow rates are presented in Figure 3.

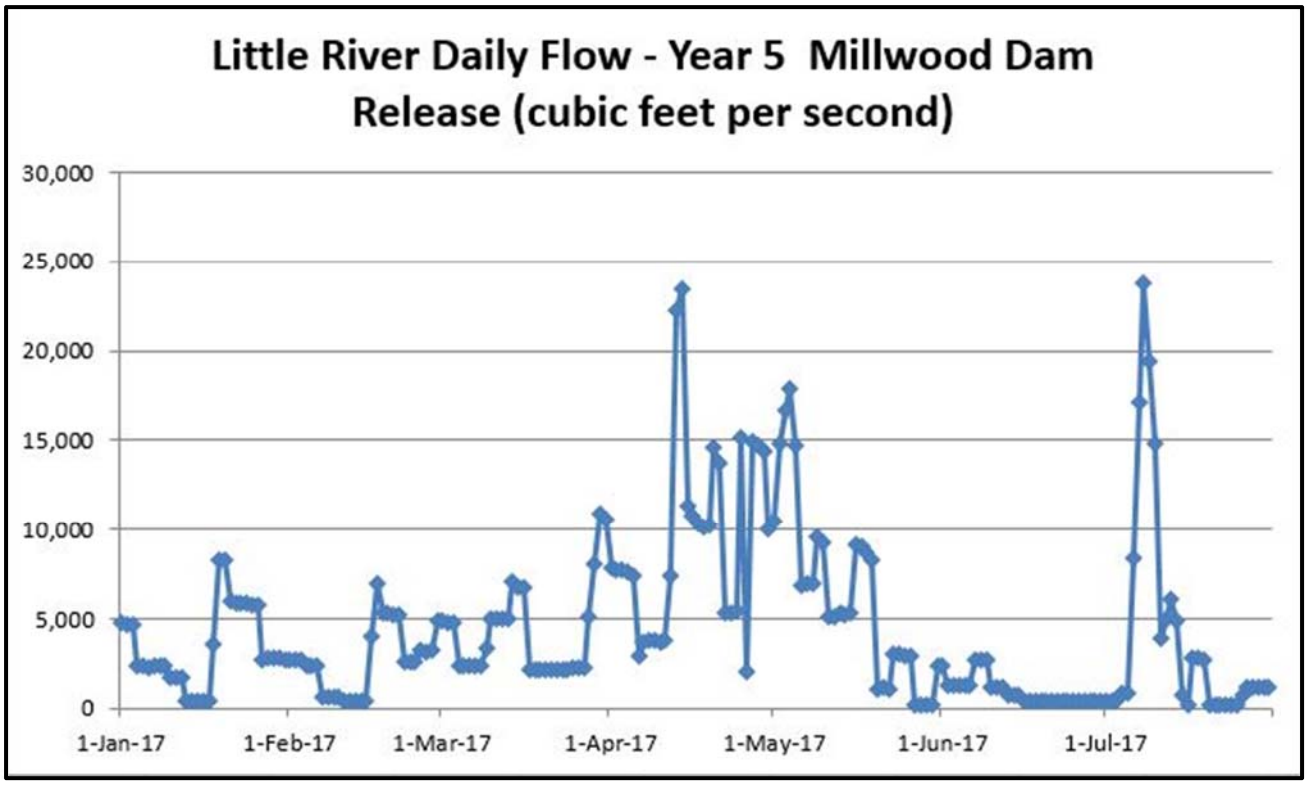


Figure 3 — Little River Monthly Average Flow from Millwood Dam, Year 5[7]

[7] Data provided by US Corps of Engineers — Little Rock Division, March 20, 2018.

3.0 INTAKE STRUCTURE

The intake structure for Turk incorporates a cylindrical wedgewire screen designed to filter water prior to the cooling water system. Wedgewire screens have been effective in reducing entrainment of larvae by an order of magnitude less than unscreened intakes.[8] Appendix A includes the drawings and schematics for the full intake structure. The intake screen is 33.38 inches in diameter and approximately 11 feet long. With its location approximately 14 feet above the river bed and in the middle of the Little River, the intake screen is located in the zone of low biological value.[9] The mesh size opening of the wedgewire screen intake is 0.125 inches (3.175 millimeters). Through-screen velocity of the intake screen has been conservatively calculated as 0.414 fps as an average with a maximum of 0.455 fps. The small mesh screen opening, the placement, and low through-screen velocity of the wedgewire intake structure were designed to eliminate impingement of juvenile and adult fish and significantly reduce entrainment of fish eggs and larvae.

Essentially, water passively drifts into the intake due to the natural flow of the Little River. Any fish that may become impinged against the mesh screen will be swept away by the river as the sweeping velocity is expected to be more than the typical approach velocity. Turk's operational and maintenance practices include weekly backwashing and air bursts that also help prevent impingement.

Photo 1 — Intake Structure with Wedgewire Screen Prior to Installation

[8] Ehrler, C. & Raifsnider, C. (2000). Evaluation of the effectiveness of intake wedgewire screens. *Environmental Science and Policy* 3, S367.
[9] Spicer, G., O'Shea, T. & Piehler, G. (2000). Entrainment, Impingement, and BTA evaluation for an intake located on a cooling water reservoir in the Southwest. *Environmental Science and Policy* 3, S323.

4.0 ENTRAINMENT SAMPLING

4.1 Scientific Permits

The Scientific Collection Permits (Arkansas Game & Fish Commission) to sample fish and entrained organisms at Turk are included in Appendix B.

4.2 Sampling Frequency and Duration

Entrainment samples were collected over a 3-month period to monitor entrainment rates for each species at various intervals during the primary period of reproduction, larval recruitment, and peak abundance. For the Little River, this period has been determined to be April through June.[10] The sampling schedule is presented in Table 1.

Table 1
Entrainment Sampling Schedule — Year 5

Date	Target Sampling Volume (cubic meters) a.m.	p.m.	Total	Events per Month
04/11/2017	100	100	200	1
05/17/2017	100	100	200	1
06/07/2017	100	100	200	1
Year 5 Totals	**300**	**300**	**600**	**3**

Notes:
100 m^3 = 26,417 gallons
200 m^3 = 52,834 gallons
m^3 = Cubic meters

Three sampling events were conducted in 2017. Samples were collected during both the day and night period to characterize the diurnal activity that may occur over a 24-hour period. The target sample volume was at least 200 cubic meters (52,834 gallons) per sampling event.

4.3 Sample Collection

Entrainment samples were collected using a 1-inch tap installed on the circulating water line before it entered the caisson (Figure 4). Water flow from the tap was collected into a 363-micron mesh plankton net. A collection bucket with 363-micron stainless steel mesh was attached to the narrow end of the net to concentrate the sample.

[10] Arkansas NPDES Permit AR0051136 Condition 15(2)(ii)

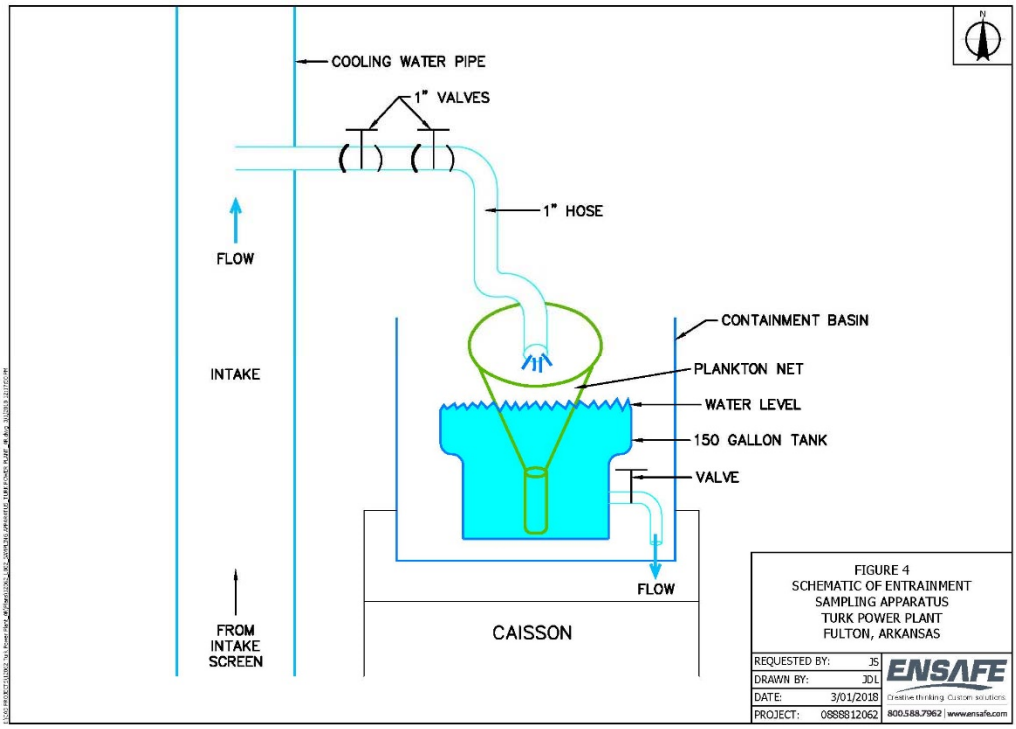


Figure 4 — Schematic of Entrainment Sampling Apparatus

The volume of water flowing through the net was measured at specific intervals during the sample collection period. The following procedures were used to determine the flow rate:

- Open tap installed on circulating water line.
- Dispense water for one minute to allow flow rate to stabilize.
- Record time required to fill a 10.5-gallon container.
- Flow rate (gallons per sec) = Container Volume (gallons)/Time to Fill Container (seconds).
- Repeat procedure three to five times to obtain an average estimate. Coefficient of variation should be less than 20%.

Accuracy of flow rate measurement is expected to be approximately ± 1 second. Flow rates were determined for each collection period and recorded as an overall average during the sampling event.

4.4 Sample Preservation and Labeling

Eggs and larvae were preserved in bottles containing an appropriate preservative (e.g., 34.5% formaldehyde with Rose Bengal stain). Each bottle was labeled per the following convention "TURK-D-mmddyy" or "TURK-N-mmddyy", where:

TURK = Turk Power Plant
D = day
N = night
mmddyy = Date in numeric two digits for month, day, and year

Appropriately preserved sample bottles were saved by the field crew and later evaluated by Ichthyoplankton identification specialists.

4.5 Sample Analysis and Results

Entrainment samples were sorted by qualified personnel at EA Engineering, Science and Technology (EA) and consisted of handpicking and enumerating larval fish, fish eggs, and/or shellfish.[11] For the purpose of this study, shellfish were crayfish and native freshwater (unionid) mussels. Shellfish did not include the Asiatic Clam (*Corbicula)* or zebra and quagga mussels (*Dreissena spp.*).

Upon receipt by the laboratory, all samples were logged on an Ichthyoplankton and Shellfish Sample Control Sheet. Samples were rinsed on a 335-micron mesh sieve to remove any excess detritus, sediment, and formalin. All target organisms were then handpicked from the debris with the aid of a microscope and placed in labeled vials — one vial for Ichthyoplankton (fish eggs and larvae) containing a 5% formalin solution and a second vial for shellfish (unionid mussels and crayfish) containing a 70% ethyl alcohol solution. The Ichthyoplankton vial was labeled with the number of fish eggs (E=#) and fish larvae (L=#) (internal and external), as well as the sample number ("TURK-D-mmddyy" or "TURK-N-mmddyy").

All 6 samples were sorted twice by two different EA personnel to ensure that all Ichthyoplankton and shellfish were removed. The overall sorting efficiency rate was >99% with an error rate of <1% for the 6 samples. The numbers of Ichthyoplankton for each of the sorting events were recorded on sample control sheets. Following each sort, the sorted debris was carefully returned to a re-labeled sample jar ("TURK-D-mmddyy" or "TURK-N-mmddyy"), labeled as sorted, re-preserved in a 10% formalin solution, and saved for potential future analysis.

No unionid mussels or crayfish were found in the 6 samples collected during Year 5 sampling. No federal or state species of concern were positively identified.

[11] Letters to John Siler, EnSafe, from Joe Vondruska, EA Project Manager. EA Project # 1487102. October 3, 2017.

Ichthyoplankton Identifications

Dr. Robert Wallus, a noted Ichthyoplankton expert, was subcontracted to perform the identifications. Wallus noted that most of the specimens in the samples were damaged, "in most cases missing their heads, guts or yolk sacs, fins and finfolds." This resulted in the larvae being characterized as "unidentified larvae." Ichthyoplankton specimens were counted and the life stage and condition of the specimens were recorded. However, all fish eggs and larvae were identified to the lowest practical taxon.

The 6 samples produced a total of 93 fish larvae and 41 fish eggs. The taxon comprising the largest number of specimens was the Clupeidae family (Shad family) and *Morone* sp. (Bass), *Pomoxis*-type (Crappie Family), as well as Blue Catfish and Freshwater Drum. These determinations were based on body and myomere morphology, pigmentation patterns, water quality characteristics, and the time of year when collected. No federal or state species of concern were positively identified. No specimens from Arkansas' Aquatic Species of Concern List, federal or otherwise, were positively identified.

Monthly entrainment estimates were calculated using the following formulae:

$$\text{Monthly Mean Number of Organisms} = \frac{\text{Number Collected per Month}}{\text{Total Sample Volume}} \times \text{Total Monthly Flow}$$

Total amounts of cooling water withdrawn from the Little River are represented as cooling water flow and are presented in Table 2.

Table 2
Monthly Cooling Water Flow for Turk Power Plant — Year 5

Month	Million Gallons
April 2017	206.99
May 2017	135.64
June 2017	212.48

4.6 Physical Conditions

At each collection, water temperature, pH, and dissolved oxygen were measured and recorded on field data sheets. Data collected are summarized in Table 3.

Table 3
Summary of Water Quality

Date	Time of Day (a.m./p.m.)	pH	Temp (°C)	Dissolved Oxygen (milligrams/Liter)
04/11/17	a.m.	7.48	18.85	16.12
04/11/17	p.m.	7.37	18.94	NA
05/17/17	a.m.	7.19	23.78	9.33
05/17/17	p.m.	7.30	24.27	9.93
06/07/17	a.m.	7.27	27.19	7.33
06/07/17	p.m.	7.54	28.40	8.30

4.7 Entrainment Summary

Daily entrainment collections for the Year 5 Period (April 2017 to June 2017) are presented in Table 4. Over the duration of the study, 134 fish larvae and 41 fish eggs were collected. The total sample volume for the 3 sampling events was 210,192 gallons.

Fish larvae were identified by EA and were classified into separate groups, and then further into subcategory of Ichthyoplankton — either fish eggs or fish larvae.

Table 4
Daily Entrainment Collections — Year 5

Event No.	Date	Start Time	Stop Time	Duration (hour)	Flow Rate (gallon/hour)	Volume (gallons)	Time of Day	Larvae[12]	Total #	Density (# of MG)
1	04/11/17	7:00 a.m.	7:00 p.m.	12	2,700	32,400	Day	Unidentified	4	123
1	04/11/17	7:00 a.m.	7:00 p.m.	12	2,700	32,400	Day	Day Total	4	123
1	04/12/17	7:00 p.m.	7:00 a.m.	12	2,700	32,400	Night	Unidentified	13	401
1	04/12/17	7:00 p.m.	7:00 a.m.	12	2,700	32,400	Night	Night Total	13	401
1						64,800		Daily Total	17	262
5	05/17/17	7:00 a.m.	7:00 p.m.	12	3,150	37,800	Night	Unidentified	9	238
5	05/17/17	7:00 a.m.	7:00 p.m.	12	3,150	37,800	Night	Day Total	9	238
5	05/18/17	7:00 p.m.	7:00 a.m.	12	3,150	37,800	Day	Unidentified	38	1,005
5	05/18/17	7:00 p.m.	7:00 a.m.	12	3,150	37,800	Day	Night Total	38	1,005
5						75,600		Daily Total	47	622
6	06/07/17	7:00 a.m.	7:00 p.m.	12	2,908	34,896	Day	Unidentified	13	373
6	06/07/17	7:00 a.m.	7:00 p.m.	12	2,908	34,896	Day	Day Total	13	373
6	06/08/17	7:00 p.m.	7:00 a.m.	12	2,908	34,896	Night	Unidentified	57	1,633
6	06/08/17	7:00 p.m.	7:00 a.m.	12	2,908	34,896	Night	Night Total	57	1,633
6						69,792		Daily Total	70	1,003
					Total Volume	**210,192**		**Total Larvae**	**134**	**1,887**

Notes:
\# = Number of larvae
MG = Million gallons

[12] For summary purposes, all Ichthyoplankton larvae were grouped as unidentified in the initial count.

Monthly entrainment estimates for Turk were estimated based on observed larval densities and monthly cooling water flow (Section 5). Monthly entrainment estimates are summarized in Table 5. Based on the 134 Ichthyoplankton identified in the samples, a total of 368,160 fish eggs and larvae were estimated to be entrained over the duration of the Year 5 study. Peak entrainment was observed in June with an estimated 25,620 larvae entrained (52% of total larvae entrained).

Table 5
Monthly Entrainment of Larval Fish at Turk Power Plant — Year 5

Month	Species/Taxon	Total Number Collected	Sample Volume (Gallons)	Cooling Water (MG)	Total Number Entrained (estimated)	% Total Year 5
April 2017	Unidentified — "*Morone* type" Egg	1	64,800	206.99	3,194	
April 2017	Clupeidae Larvae	5	64,800	206.99	15,971	
April 2017	*Morone* (not Striped Bass) spp. Larvae	1	64,800	206.99	3,194	
April 2017	*Morone* spp. Larvae	4	64,800	206.99	12,777	
April 2017	Unidentified Larvae	6	64,800	206.99	19,166	
April 2017	**Total**	**17**	**64,800**	**206.99**	**54,303**	**12.7**
May 2017	Freshwater Eggs	14	75,600	135.64	25,119	
May 2017	Unidentified — "Cypriniformes type" Egg	5	75,600	135.64	8.971	
May 2017	Clupeidae Larvae	15	75,600	135.64	26,913	
May 2017	*Morone* spp. Larvae	1	75,600	135.64	1,794	
May 2017	Blue Catfish Larvae	1	75,600	135.64	1,794	
May 2017	Unidentified — "Morone/Freshwater Drum type" Larvae	1	75,600	135.64	1,773	
May 2017	Unidentified Larvae	10	75,600	135.64	17,942	
May 2017	**Total**	**47**	**75,600**	**135.64**	**84,326**	**35.1**
June 2017	Freshwater Drum Eggs	20	64,800	212.48	65,850	
June 2017	Unidentified "Type-1" Eggs	1	64,800	212.48	3,279	
June 2017	Clupeidae Larvae	29	64,800	212.48	95,091	
June 2017	*Pomoxis* spp.	1	64,800	212.48	3,279	
June 2017	Unidentified — "Cyprinidae type" Larvae	3	64,800	212.48	9,837	
June 2017	Unidentified — "*Lepomis/Pomoxis* type" Larvae	8	64,800	212.48	26,232	
June 2017	Unidentified Larvae	8	64,800	212.48	26,232	
June 2017	**Total**	**70**	**64,800**	**212.48**	**25,260**	**52.2**
	Year 5 Entrainment Totals	**134**	**205,200**	**555.0**	**368,160**	**100.0**

Note:
MG = Million gallons

5.0 IMPINGEMENT MORTALITY

Under 40 CFR 125.85, ADEQ is authorized to approve methodologies other than monthly sampling for impingement. As an alternate methodology, ADEQ, in Condition 15(2)(a)(i) of NPDES Permit AR0051136, allows Turk to demonstrate CWA 316(b) compliance by operating the air burst system on the intake screen weekly and by performing impingement sampling at least once between April and June. Impingement sampling and visual inspection of the intake screen was performed on April 26, 2017.

During the visual inspection and impingement sampling, no fish were found to be impinged on the intake structure. The inspection found the intake screen to be structurally sound and intact, and largely free of debris. Light marine growth was observed on the screen, which was removed during inspection.

Compliance is also demonstrated with the theoretical conclusion that less than 2% of the river's fish population are or will be impinged on the intake screen for the reasons discussed below. Turk has demonstrated the implementation of BTA, which is proposed as a valid compliance methodology in the U.S. EPA revised 316(b) Rule. From *Riverkeepers II*, the U.S. Supreme Court found that with BTA, no statutory mandated factors exist for evaluation of BTA, thus all factors are available to the Director, Agency, and delegated permitting authority ADEQ. As such, the U.S. EPA draft guidance and practicality are reasonable factors that must be considered in determining compliance with CWA Section 316(b).

A biological impingement monitoring program should not be required given the approach velocities, sweeping velocities, and plant operational practice and maintenance. The U.S. EPA Draft Guidance states, "Generally, the combination of low valve and low flow most likely is a reflection of BTA in location, design, and operation of the intake structure."[13] Turk clearly has implemented BTA and is not expected to impinge fish or shellfish on the intake screen for the reasons described in the following sections. Thus far, eleven inspections have yielded no impinged fish or other aquatic species.

Low Through-Slot Screen Velocities

Fish swimming capability varies primarily by size and water temperature, with small fish and those at cold temperatures performing most poorly. Overall, a fish's ability to avoid impingement depends on its swimming ability relative to the velocities in the flow field and the distance it needs to swim to

[13] http://water.epa.gov/lawsregs/lawsguidance/cwa/316b/upload/2006_10_26_316b_1977AEIguid.pdf

reach a safe area.[14] In the final 316(b) rule described in §125.94(3)(c), the U.S. EPA approves seven methods to demonstrate compliance in preventing impingement. One of these includes having a CWIS with a through-screen design velocity less than 0.5 fps. The estimated through-slot screen velocity was conservatively calculated, at the design pump rating of 7,500 gpm, as 0.414 fps as an average and as 0.455 fps as the maximum through-screen rating. Therefore, estimated velocities for design conditions and one pump operation are less than the 0.5 fps threshold and thus are compliant with NPDES Permit No. AR0051136 condition 15, which states, "The maximum through-screen design intake velocity shall be 0.5 fps."

Sweep Velocities

Sweep velocities are also important in minimizing the probability of fish being impinged on the intake structure. For example, wedgewire screens of 0.125 inch, which is also the slot size at Turk, work best when the sweeping flow exceeds 1.0 fps for an approach through-slot screen velocity of 0.5 fps.[15] The sweeping velocities in the Little River exceed the through-slot velocity at Turk. Obviously, the sweeping velocity will vary seasonally, but is expected to consistently be more than double the approach velocity.

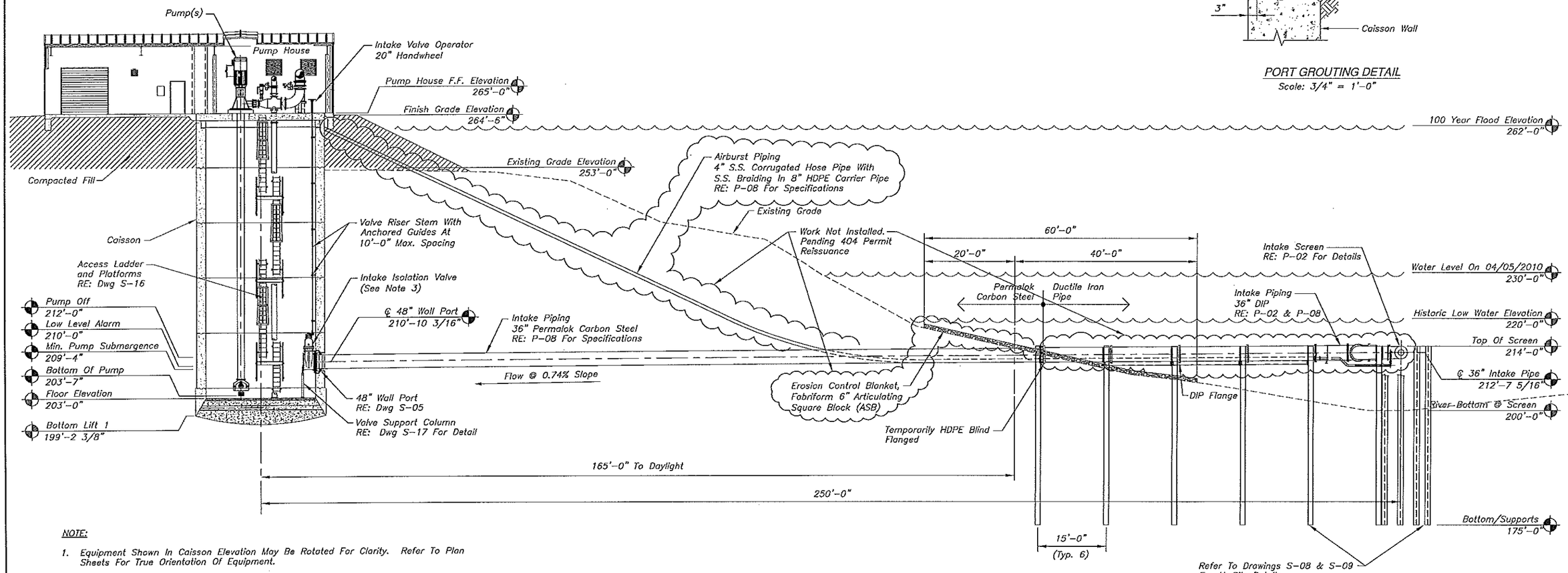
Operational Practice and Maintenance

Weekly, and additionally as needed, Turk manually activates the air burst system through the intake screen during operation of the intake structure. This practice will remove any impinged aquatic life as well as debris on the intake screen.

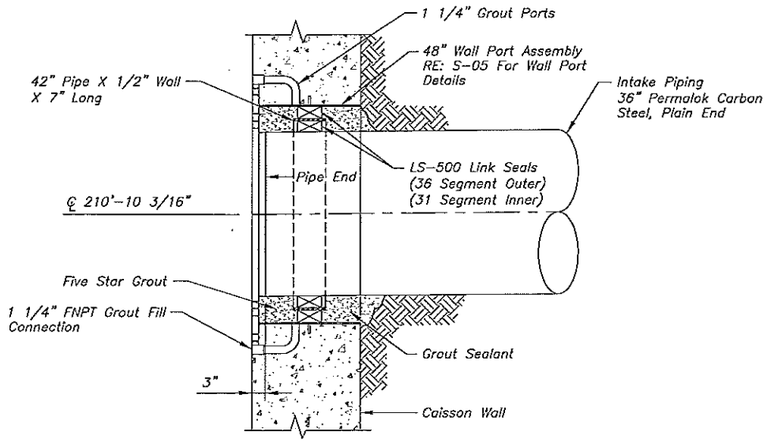
In terms of impingement, Turk's intake design, operational practices, and careful selection of intake location all factor into seeing no evidence of impingement at Turk's intake screen. Additional samples will continue to be collected as specified monthly from April to June in 2018 however, results from Year 5 sampling strongly suggest little to no significant biological impact due to impingement or entrainment.

[14] EPRI. Technical Evaluation of the Utility of Intake Approach Velocity as an Indicator of Potential Adverse Environmental Impact under Clean Water Act Section 316(b). Report No. 1000731.
[15] Turnpenny, A. & O'Keefe, N. (2005). Screening for Intakes and Outfalls: a best practice guide. United Kingdom Environment [sic] Agency, Science Report SC030231.

Appendix A
Intake Screen Assembly



INTAKE PIPING ELEVATION
Scale: 3/32" = 1'-0"



PORT GROUTING DETAIL
Scale: 3/4" = 1'-0"

NOTE:

1. Equipment Shown In Caisson Elevation May Be Rotated For Clarity. Refer To Plan Sheets For True Orientation Of Equipment.
2. Refer To Drawing P-02 For Detailed Intake Screen Plan and Elevation Views and Refer To P-08 For Piping Schedules and Specifications.
3. Intake Isolation Valve: American Flow Control 36" Series 2500 Resilient Wedge Gate Valve, Spur Gearing, AWWA C515 Compliant, With AWWA C207 Class D Flanges, Epoxy Coated, Designed For Limited Use. Refer To Drawing S-01 For Operating Limitations.

DRAWING FILE NAME: P-01.dwg		ORIG. SHEET SIZE: D (22x34)	USER I.D.:
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2	12/28/10	RDS	REISSUED FOR INFORMATION ONLY
3	04/28/11	RDS	REISSUED PER AEP/SHAW COMMENTS
4	07/18/11	RDS	AS BUILT

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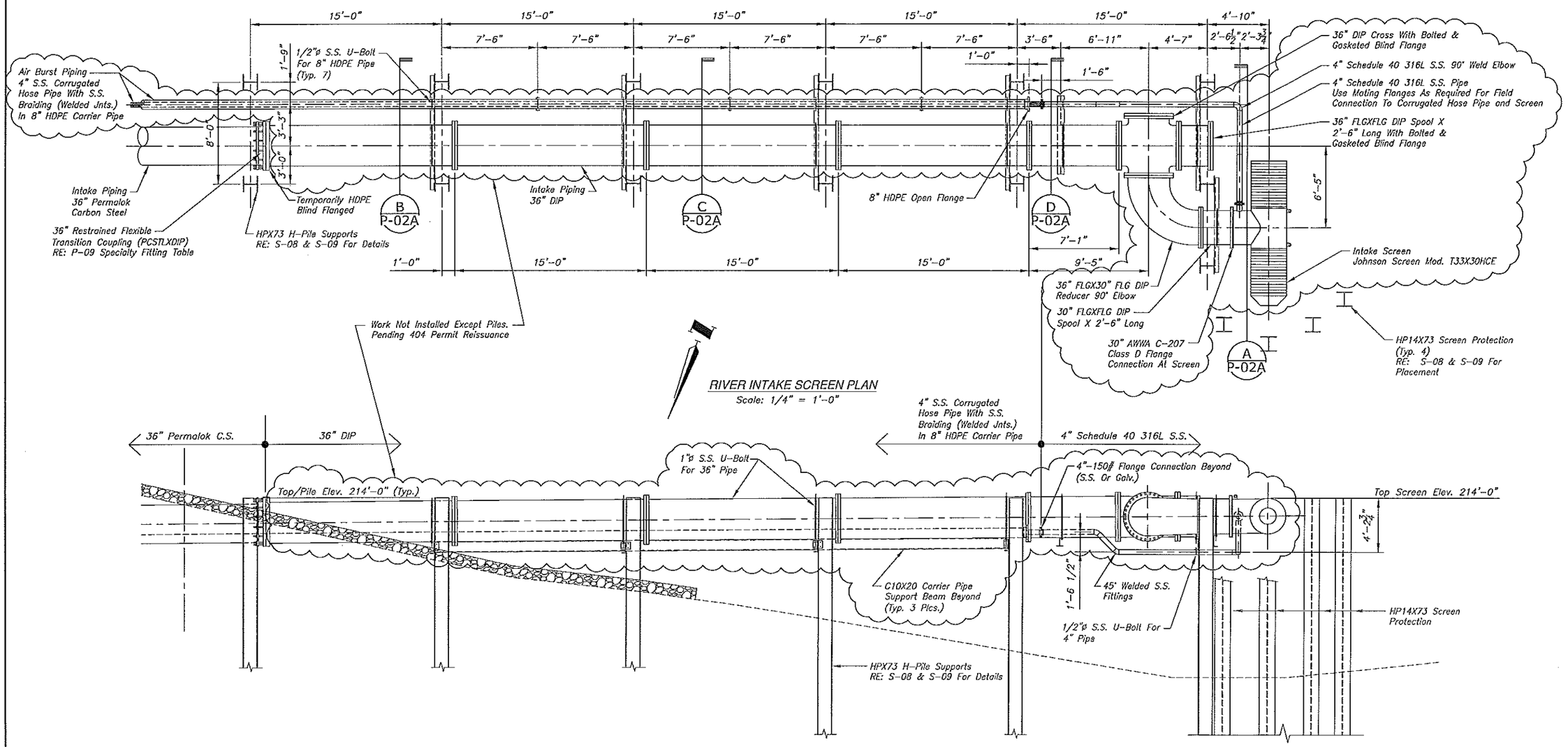
STATE OF ARKANSAS
REGISTERED PROFESSIONAL ENGINEER
No. 14148
RYAN D. SASSER
7-18-2011

JOHN W. TURK JR. POWER PLANT
RIVER WATER INTAKE SUBCONTRACT
FULTON, ARKANSAS
INTAKE PIPING ELEVATION

PROJECT NO.
DRAWING NO. P-01



RIVER INTAKE SCREEN PLAN

Scale: 1/4" = 1'-0"

RIVER INTAKE SCREEN ELEVATION

Scale: 1/4" = 1'-0"

Notes:

1. Refer To Drawings P-08, P-09, and PID-03 For Piping and Valving Schedules and Specifications.

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STATE OF ARKANSAS REGISTERED PROFESSIONAL ENGINEER No. 14148 RYAN D. SAFFELS 7-18-2011

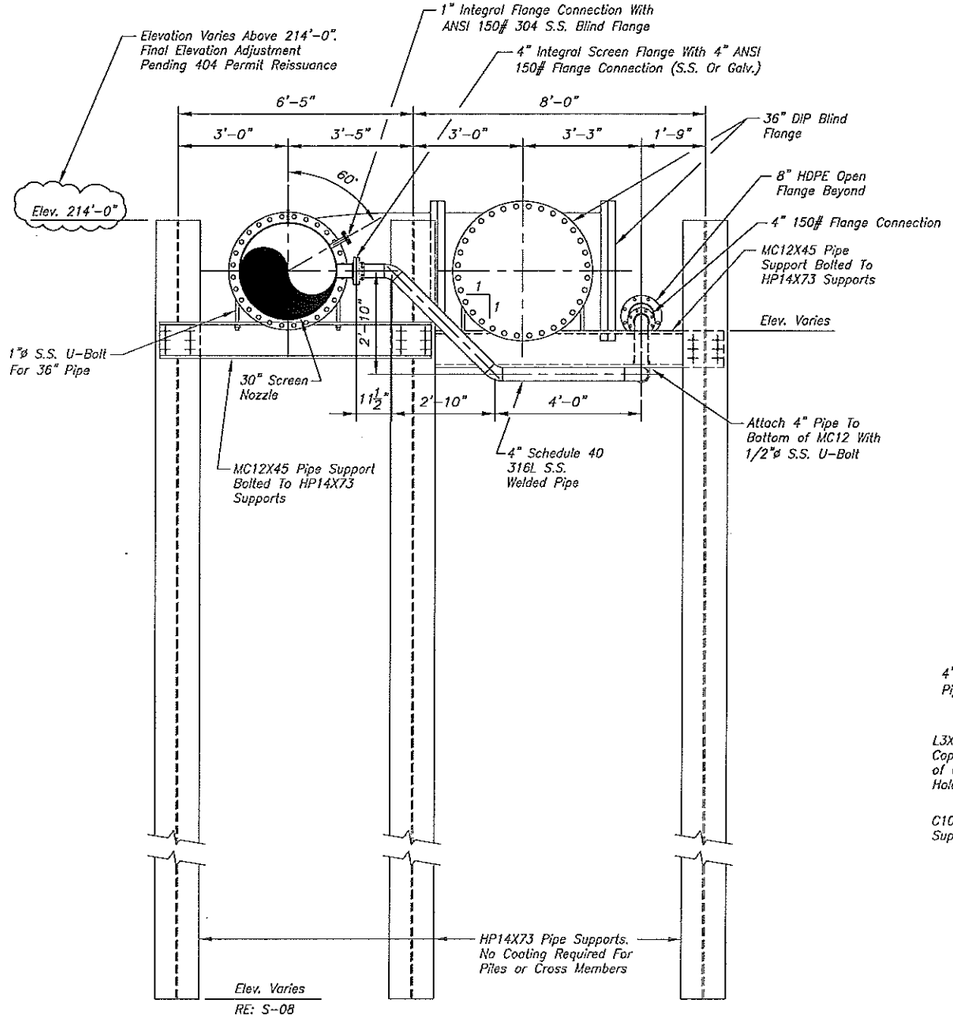
JOHN W. TURK JR. POWER PLANT

RIVER WATER INTAKE SUBCONTRACT
FULTON, ARKANSAS

RIVER INTAKE SCREEN PLAN & ELEVATION

PROJECT NO.

DRAWING NO.
P-02



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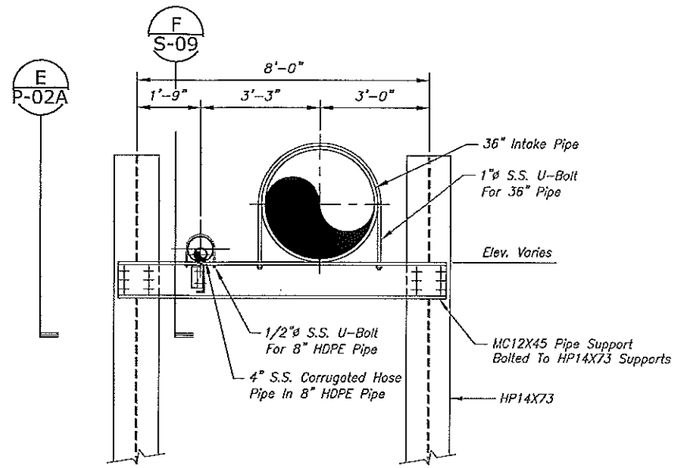

SECTION — B — P-02A
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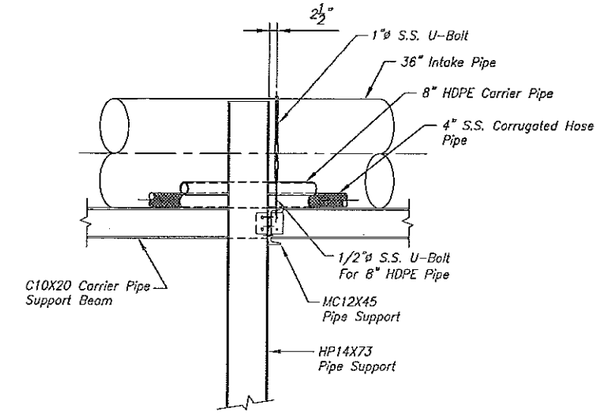
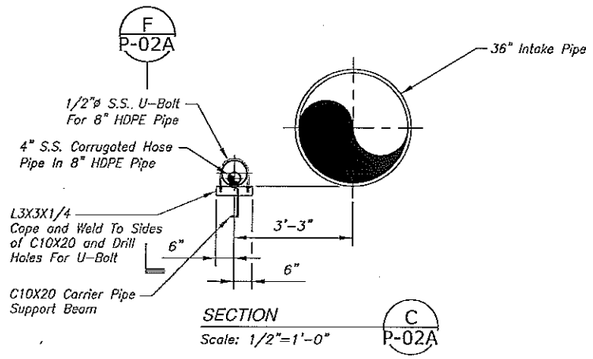


VIEW — E — P-02A
Scale: 1/2"=1'-0"



SECTION — C — P-02A
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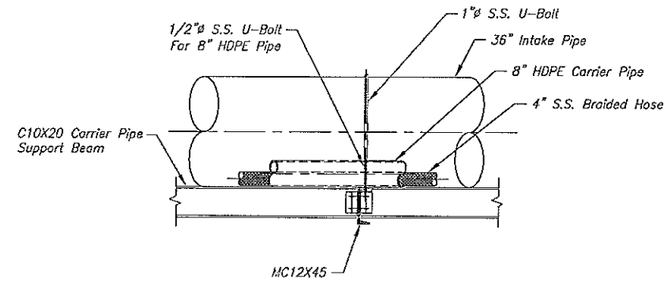
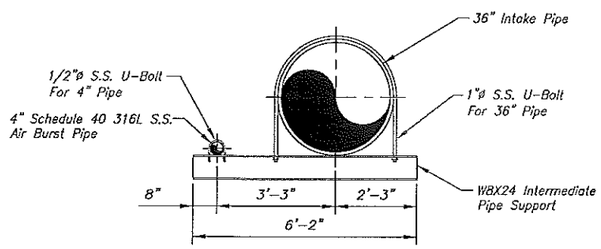


VIEW — F — P-02A
Scale: 1/2"=1'-0"



SECTION — D — P-02A
Scale: 1/2"=1'-0"

All Items This Drawing Except HP14X73 Pipe Supports Are Not Installed. Pending 404 Permit Reissuance

Notes:

1. Refer To Drawings P-08, P-09, and PID-03 For Piping and Valving Schedules and Specifications.

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JOHN W. TURK JR. POWER PLANT
RIVER WATER INTAKE SUBCONTRACT
FULTON, ARKANSAS
RIVER INTAKE SCREEN SECTIONS

PROJECT NO.

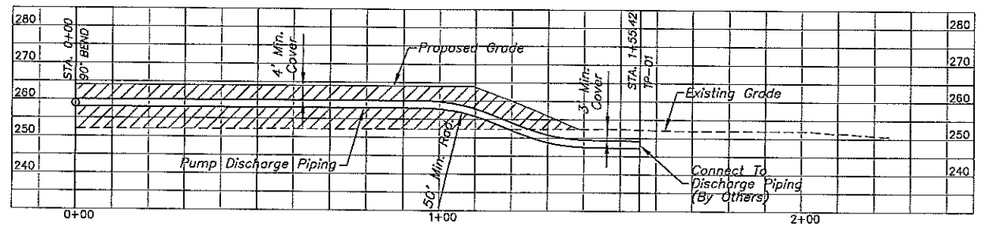
DRAWING NO. P-02A

NOTES:

1. Site Basemap Source Information Provided By Shaw Contractors Inc. (Drawing Number 0-30STE521). Updated River Contouring Has Been Provided By MTG Engineers & Surveyors.
2. Top Of Pump House Finish Floor, Transformer and HVAC Pads Is Elev. 265.00
3. Maintain Minimum Cover of 3'-0" For All Buried Process Piping.

SITE PIPING COORDINATE TABLE
(PLANT COORDINATE SYSTEM)

Point #	Northing	Easting	Decription	℄ Elev
P1	29159.3296	14929.7471	Intake Piping Caisson Centerline	210.85
P2	29145.5810	14938.8052	Discharge Pipe Floor Penetration	260.00
P3	–	–	–	–
P4	29128.3081	14945.4357	Discharge Pipe 90° Bend	260.00
P5	29081.3015	14714.8937	Intake Screen Cross	212.54
P6	29084.1183	14703.8523	Intake Screen	Top 214.00
P7	29164.1613	14940.9338	Top of Caisson	–
P8	29163.6300	14940.9500	Bottom of Caisson	–
TP-01	29184.0044	15090.5287	Discharge Piping Tie-In	36" Cover



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No.	DATE	BY	REVISION
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1	07/23/10	RDS	REISSUED PER AEP/SHAW COMMENTS
2	09/27/10	RDS	REISSUED PER AEP/SHAW COMMENTS
3	11/10/10	RDS	REISSUED WITH UPDATED COORDS.
4	07/15/11	RDS	AS BUILT

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RYAN D. SAFFELS
7-15-2011

JOHN W. TURK JR. POWER PLANT

RIVER WATER INTAKE SUBCONTRACT
FULTON, ARKANSAS

SITE PIPING PLAN

PROJECT NO.

DRAWING NO.
C-06

Appendix B
Scientific Collection Permit

Arkansas Game & Fish Commission

#2 Natural Resources Drive Little Rock, Arkansas 72205

Jeff Crow
Director

Scientific Collection Permit

Permit Number: 032920171

Expiration Date: 4/05/2018

Permittee: John Siler
220 Athens Way, Suite 410
Nashville, TN 37228

Sponsor: Ensafe, Inc.
220 Athens Way, Suite 410
Nashville, TN 37228

Purpose: Biomonitoring/Environmental Assessment

Location(s): Statewide

Species Type:	Collection Methods	Disposition	Removed
Fish	Salvage	Released at point of capture	**20 per spp per location & salvaged fish**

This Permit grants the permittee listed above or the designated sub-permittee listed below with the privileges accorded under AGFC Code 9.09. This permit is issued on the conditions set forth hereon and becomes effective on the date of issue. A Federal Permit is also required for Migratory and/or Threatened/Endangered Species.

This permit does not allow collection of Species of Greatest Conservation Need (SGCN), regulated or threatened / endangered species.

This permit is not valid until signed in ink by the permittee. Signature constitutes acceptance of all rules and requirements pertaining to this permit. This permit is non-transferable. This permit does not authorize trespass or collection on private or other agency lands. **Any illegal violations on all lands mentioned may result in revocation of your collection permit. It is incumbent upon the individual collector to obtain appropriate permission to collect from the landowner, whether private or state/federal government.** Upon expiration of the permit, but no later than sixty (60) days after the expiration date, the permittee shall submit to the Arkansas Game & Fish Commission a complete written or electronic report of all collections. This permit may be suspended or revoked at the discretion of the Director of the Arkansas Game and Fish Commission.

Permittee Signature

AGFC Authorization

Sign here to Authenticate photocopy. *Circle Sub-Permittee, if this copy is assigned to them.*