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GREENIDGE GENERATION
CWWS PILOT STUDY

Prepared for:

Greenidge Generation, LLC.

Prepared by:

ASA Analysis & Communication, Inc.
921 Pike Street, PO Box 303
Lemont, PA 16851

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1. INTRODUCTION

The Greenidge Generation facility is a single unit (Unit 4), 107 MW gas-fired facility located on the western shoreline of Seneca Lake in Dresden, New York. The station's cooling water system withdraws water from Seneca Lake through a 7-ft diameter conduit that extends 650 ft offshore. The intake conduit lies above the surface of Seneca Lake supported on a wooden structure (Figure 1). Greenidge Generation (GG) currently operates the facility under State Pollutant Discharge Elimination System (SPDES) permit number NY0001325, with a 1 October 2017 Effective Date (EDP). The SPDES permit specifies that Best Technology Available (BTA) for the cooling water intake includes the "use of cylindrical wedge-wire screens (slot size 0.5 mm ≤ 1.0 mm)."

Biological Monitoring Requirement (BMR) #4 of the SPDES permit requires an approvable Cylindrical Wedge-Wire Screen Pilot Study Plan be submitted by EDP + 6 months. Consistent with the SPDES permit, the plan must include:

> a. Details on CWWS dimensions and operational specifications [i.e., capacity, through-slot velocities (no greater than 0.5 feet per second (fps)), frequency of operation, proposed air burst/cleaning frequencies];
> b. Frequency of screen operation;
> c. A detailed schedule for the study, plans, drawings, and description of all work to be done for the installation, testing and determination of the efficacy of the intake screens;
> d. Six-month progress reporting, and final report to be submitted within 6 months of the pilot study completion; and
> f. Description of all data analyses, calculations, models, and statistics that may be used to optimize the operations of CWWS.

This report is being submitted to satisfy the requirements of BMR #4. There are many design questions for a CWWS system at GG that need to be answered, which this pilot study plan will attempt to answer, so that a CWWS design and the Technology Installation and Operation Plan in BMR #5 can be completed. Upon receipt of the Department's approval, GG will implement the CWWS pilot study in accordance with this plan.

2. EXISTING COOLING WATER SYSTEM DESCRIPTION

Greenidge Generation is located in Yates County, New York on the western shoreline of Seneca Lake (Figure 2-1). The station formerly consisted of six coal-fired boilers and four turbine generators. Units 1-3 have all been permanently retired and dismantled. Unit 4, which began operation in 1953, and was placed into temporary layup status in 2011. It was converted to use natural gas and resumed operation in March 2017. It has a generating capacity of 107 MW, and a calculated circulating water pump flow rate of 68.0 kgpm when all three circulating water pumps are operating.

Cooling water for Unit 4 enters the station from Seneca Lake via a 7-ft diameter suction pipe extending from the pumphouse to a point 650 feet offshore (Figure 2-1). The intake pipe is elevated above the lake on wood pilings (Figure 2-2) and angled down at the lake end. The pipe withdraws water from a 27-ft x 27-ft steel intake structure composed of 3/16-inch bars on 6-inch centers in about 11 feet of water. The approach velocity at the bar rack is about 0.14 fps. Reversing valves on the condenser wash out any debris that might accumulate on the condenser tube face.

The three Unit 4 circulating water pumps (Figure 2-3) are horizontal, single stage, double suction centrifugal pumps manufactured by Westinghouse Electric Corporation. The pumps are provided with 42-inch diameter suction connections and 36-inch diameter discharge connections. Each pump has a nameplate capacity of 30,400 gpm. Flow tests conducted by NYSEG in 1995 indicate actual flows of approximately 22.67 kgpm per pump. Reported flows are calculated as 22.67 kgpm for one pump operation, 45.3 kgpm for two pump operation, and 68.0 kgpm for three pump operation.

After passing through the Unit 4 condenser, cooling water discharges through a 7 x 10-foot tunnel to the discharge cannel. The discharge canal, which is approximately 900-feet long, empties into the Keuka Outlet about 700 feet upstream from Seneca Lake (Figure 2-1).

Service water is supplied by four house service water pumps (rated at 550 gpm per pump), two hydrogen cooling pumps (rated at 120 gpm per pump), and a dual Hydro-jet pump (rated at 1,300 gpm).

Figure 2-1 Aerial View of the Greenidge Generating Station (lower left) showing Unit 4 intake conduit extending to Seneca Lake.

Figure 2-2 Greenidge Unit 4 intake pipe

Figure 2-3 Greenidge Unit 4 circulating water pump A. Pumps B and C are behind Pump A.

3. WEDGEWIRE SCREENS

Cylindrical wedgewire screens, also called “V” screens or profile screens are a passive intake system. The typical design consists of wedge-shaped wires or bars welded to an internal cylindrical frame that is mounted on a central intake pipe, with the entire structure submerged in the source waterbody. When appropriate conditions are met, these screens exploit physical and hydraulic exclusion mechanisms to achieve consistently high reductions in impingement mortality. Significant entrainment reductions also result from the phenomena of hydraulic bypass, active avoidance by motile life stages, and, when the screen slot size is smaller than limiting dimensions of egg and larval life stages, by physical exclusion.

CWWS for cooling water intakes are designed to have a low, uniform through-slot velocity (less than 0.5 feet per second). The velocity field quickly dissipates as distance from the screen increases due to the cylindrical shape, thus creating a relatively small flow field in the waterbody. This small flow field, together with optimal screen orientation, results in a small system profile and minimizes the potential for contact between the screen and any susceptible organisms that may come under the intake’s hydraulic influence. In addition, in flowing water, the ambient current crossflow carries most free-floating organisms and debris past the screen, and removes organisms that are temporarily in contact with or pinned against the screen. Wedgewire screens may also employ cleaning and de-icing systems, such as brushes or air-burst sparging, or may be constructed with materials that discourage biofouling.

USEPA believes that cylindrical wedgewire screens can be successfully employed by large intake facilities under certain circumstances. The limiting factor for a larger facility may be the availability of sufficient accessible space near the facility itself because additional screen assemblies consume more space on the waterbody floor and can interfere with navigation or other uses of the waterbody. Availability of space and location considerations for placement of wedgewire screens therefore is evaluated before deployment of wedgewire screens.

As with any intake structure, the presence of large debris poses a risk of damage to the structure if not properly managed. Apart from the damage that large debris can cause, smaller debris, such as household trash or organic matter, can build up on the screen surface, altering the through-slot velocity of the screen face and increasing the risk of entrainment and/or impingement of target organisms. Selection of the optimal location in the waterbody may reduce the collection of debris on the structure. Ideally, CWWS are located away from areas with high levels of submerged aquatic vegetation (SAV) and out of known debris channels. Proper placement alone may achieve the desired effect, although technological solutions also exist to physically remove small debris and silt. Automated air-burst systems can be built into the screen assembly and set to deliver a short burst of air from inside and below the structure, or mechanized brush systems can clean both the inside and outside of the screen. Biofouling, growth of biological organism on or inside the screen, can be reduced through use of materials that discourage biofouling.

3.1 CWWS DESIGN ISSUES

A CWWS system for Greenidge Generation will have to be properly sized, located, and constructed in order to function properly to deliver cooling water to Unit 4, while reducing fish entrainment and impingement. Some of the key design issues are:

- Slot width of the screen
- Alloy for screen
- Method of cleaning the screens (air burst or brush)

- Dimensions of the screens
- Orientation of the screens
- Number of screen units
- Mounting (fixed or movable) and array footprint
- Ice damage prevention
- Degree of overdesign required
- Screen failure bypass requirements
- Frazile/Anchor Ice preventative measures (thermal discharge, bubbles, circulation propellers)
- Intake pipe modifications
- Coatings and materials of pipes and structures (Silicone Epoxy, HDPE, etc.)
- Allowable hydraulics for existing intake system
- Access issues (via barge on lake, deck area, divers, etc.)
- Redundancy requirements for operations
- Emergency bypass

To address these design issues additional information on the following is needed:

- Species, life stages, and sizes of organisms to be protected
- Nature, type, and severity of debris fouling
- Type and rapidity of biofouling
- Substrate type and depth
- Ambient water currents (direction and magnitude)
- Water temperatures (year-round)

As an example of a design decision that is necessary is the number of screen modules that should be used. If the system must be able to deliver 68,000 gpm, with a through-slot velocity of no more than 0.5 fps, and a slot width between 0.5 mm and 1 mm, and using ISI brush-cleaned cylindrical T-screens (Figure 2-4) made with standard 1.75 mm width #69 wedgewire,. 25 of the T 30-42 screens with slot width of 0.5 mm would be necessary, but only 16 screens with slot width of 1.0 mm (Table 3-1). At the other end of the screen size scale, the required flow rates could be achieved with five T 72-96 screens with slot width of 0.5 mm, or three screens with 1.0 mm slot width.

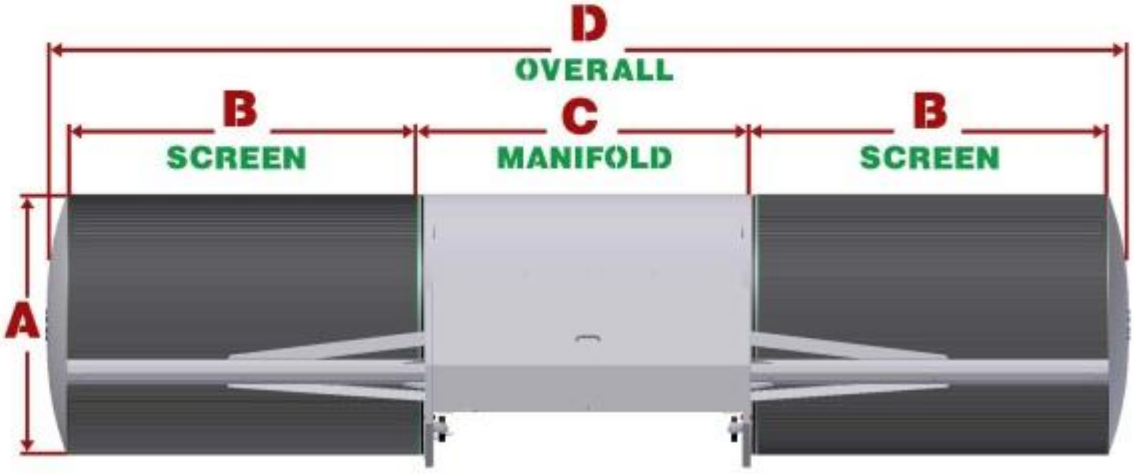

Figure 3-1 General design of standard ISI brush-cleaned cylindrical wedgewire screen modules. (From ISI website).

The screen size decision must accommodate the depth of the withdrawal site, which limits the size of screen that can be used without withdrawing too close to the lake surface, and also the need to over-design the system to account for higher velocities when screens are partially clogged. The number and size of screens required will determine the size and design of the footprint for the system on the lake bottom, and the construction methods required.

Table 3-1 Number of screen modules required to meet 0.5 fps through-slot velocity at 68,000 gpm flow.

ISI Model[a]	Surface Area per Screen (ft^2)	Slot width 0.5 (mm)		Slot width 0.75 (mm)		Slot width 1.0 (mm)	
		Open Area 22%		Open Area 30%		Open Area 36%	
		Velocity (fps)	# Screens	Velocity (fps)	# Screens	Velocity (fps)	# Screens
T 30-42	55	0.50	**25**	0.48	**19**	0.48	**16**
T 36-54	85	0.48	**17**	0.50	**12**	0.50	**10**
T 42-66	121	0.47	**12**	0.46	**9**	0.50	**7**
T 48-72	151	0.46	**10**	0.48	**7**	0.47	**6**
T 60-90	236	0.49	**6**	0.43	**5**	0.45	**4**
T 72-96	302	0.46	**5**	0.42	**4**	0.47	**3**

[a] First number in model name is the screen diameter (dimension A in Figure 2-1) in inches, and second number is the length of the screen section (dimension B in Figure 2-1) in inches.

3.2 CWWS DESIGN ISSUES SPECIFIC TO GREENIDGE GENERATING STATION

The particular location of CWWS at Greenidge Generation near the end of the intake conduit poses several challenges. First, at the lake end of the intake conduit, water depth is only approximately 12ft (Figure 3-2). This shallow depth limits the size of CWWS units because sufficient water must be provided above the units in order for them to function properly. This is particularly critical for GG because a vacuum must be maintained within the conduit in order for the system to function. If screen units are too close to the surface, flow into the screen may be uneven, or may create vortices which could draw air into the system. Thus, the ultimate design for GG may need to opt for many small screen units, rather than fewer large screens. Second, location on this shallow shelf places the screens within an area of dense aquatic vegetation during summer months that provides a high potential for debris fouling, particularly if vegetation removal operations occur nearby, or during fall die-back of vegetation. Third, as a result of both the location on a shelf, and nearby vegetation, currents that could aid in moving debris away from the screen after cleaning will be reduced. A final challenge posed by the shallow depths of the site is that winter water withdrawals will be near the surface where water is colder, increasing the possibility for frazil ice formation or damage and flow interference from surface ice.

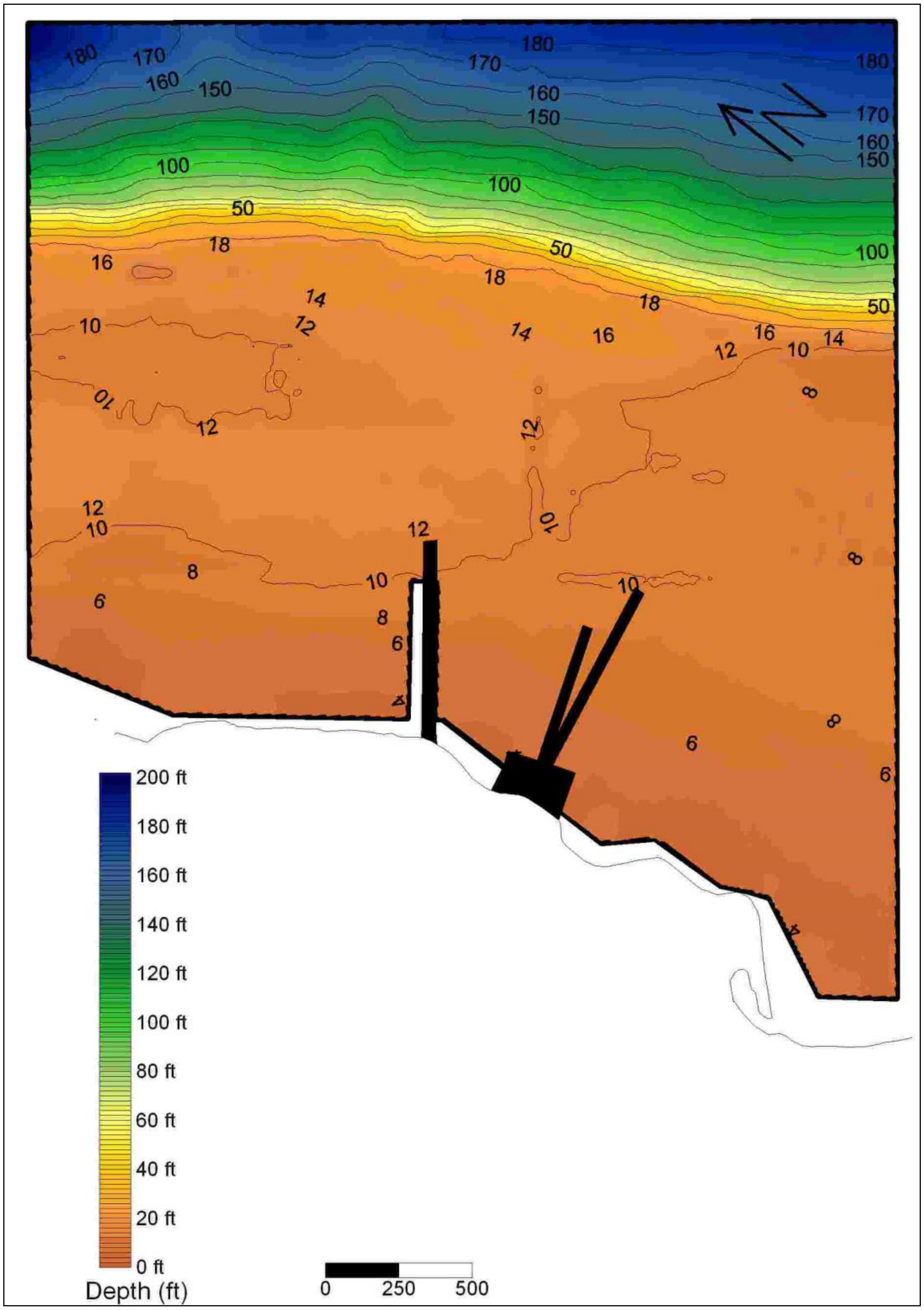

Figure 3-2 Seneca Lake bathymetric contours near Greenidge Generation.

4. CYLINDRICAL WEDGEWIRE SCREEN (CWWS) PILOT STUDY

This pilot study plan seeks to address the questions that need to be answered in order to complete the CWWS design. Some of these questions are biological in nature, and others are physical.

4.1 SPECIES, LIFE STAGE, AND SIZE OF ORGANISMS

One of the modes of effectiveness of wedgewire screens for reducing entrainment is physical exclusion. This may be the primary mode of effectiveness for fish eggs, particularly in a lake environment with low sweeping flows. The ichthyoplankton and entrainment sampling conducted at GG in 2006 indicated that alewife eggs comprised 27% of annual entrainment, with all fish eggs combined being 40% of the annual entrainment of 592,000 fish eggs, larvae, and juveniles (HDR 2007). Entrainment of post yolk-sac larvae and juvenile fish, life stages which could have significant avoidance capability, was 275,000 (46% of total entrainment). Although protection of the eggs through exclusion would require a slot width of 1.0 mm or smaller, the larvae and juveniles might be adequately protected by a larger slot width.

This information on species and life stages entrained, which is a key factor in determining optimal slot width, a driving factor in the CWWS design, is based on a single year of sampling done more than 10 years ago. Therefore, as part of the pilot study, one year of entrainment monitoring will be conducted from April through October in 2019. The advantage of doing one year of monitoring prior to CWWS installation, is that the data can be used to inform the design decisions.

The entrainment study will be conducted according to the following specifications:

- Sampling period
  - April and October – Biweekly
  - May through September – Weekly
- Sampling location – lake end of intake conduit
- Sampling method – Pumped to suspended net collection system, with 0.3 mm mesh
- Sample intensity – 4 samples at 6-hour intervals per week, 100 m^3 per sample

Entrainment sampling will be conducted from a tap off the condenser into a net-in-barrel collection system (Figure 4-1). This method of entrainment sampling is simple to conduct, and does not require passing organisms through a sampling pump (Leonard and Vaughan 1985). In addition, any stratification that existed at the intake structure is removed by turbulence in the cooling system. Sampling will be conducted on a fixed day each week, if any of the three cooling water pumps are operating.

Sample analysis will be conducted to identify all fish eggs and larvae to lowest practical taxon. Measurements of a subsample of eggs (diameter) and larvae/juveniles (length and greatest body dimension) will be recorded.

The one-year entrainment monitoring study will be available to aid in choosing the proper slot width for the CWWS system.

Figure 4-1 Net-in-barrel collection system (white polyethylene barrel) in use at discharge seal well of generating facility.

4.2 NATURE, TYPE, AND SEVERITY OF DEBRIS FOULING

Due to the location of the withdrawal, debris (primarily biological in nature) fouling of the CWWS has the potential to be severe. The severity will determine the type of cleaning technology to be employed, and the frequency with which it must be used. Debris fouling will be monitored on a bi-weekly/weekly basis concurrent with the entrainment study.

For the debris fouling test, water will be pumped through two test screens for 24 hours, with slot widths of 0.5 and 1.0 mm. Screens and sampling apparatus will be those used during the wedgewire test studies conducted by EPRI in 2005 and 2006 (EPRI 2005), with a 0.5 mm slot screen and a 1.0 mm slot screen (Figure 4-4Figure 4-2 and Figure 4-3).

The screens are sized so the through-slot velocity for clean screens would be the same. The 0.5 mm screen is a standard S-16 screen with a diameter of 16 inches, a length of 18 in, and a discharge diameter of 8 in. The porosity of the 0.5 mm screen was 23.8 percent. The 1.0 mm screen was a standard S-12 screen, 12 inches in diameter, 14 in long, and with a discharge diameter of 6 in. The porosity of the 1.0 mm screen was 38.5 percent. The control intake would not be used.

Flow through the screens will be adjusted to 0.5 fps for each. At the conclusion of 24 hours, the debris on each screen will be collected and preserved. Laboratory analysis will examine the types of debris (aquatic vegetation, terrestrial vegetation, etc.) and weight. The density of debris (weight of debris per m^3 of water withdrawn) will be calculated and compared across the screens.

In addition to the debris loading samples taken from the outside of the screens, during the period between 18:00 and 06:00, two 100 m^3 entrainment samples would be collected from the water drawn through each of the screens. If any cooling water pumps are operating, the samples would be timed to correspond with the entrainment samples collected from the condenser tap. Samples would occur at night due to the higher entrainment density typically seen at night to facilitate comparison of organism densities and size frequencies between entrainment and screen samples. The simultaneous collections will provide an empirical demonstration of the efficacy of the wedgewire screens.

Table 4-1 Hourly sample collection of debris loading sample (shaded hours for 0.5 and 1.0 mm screen), and entrainment samples (dark shaded hours). Note, single samples will extend into two hourly periods, resulting in 4 entrainment samples per sample date, and 2 ichthyoplankton samples for each screen per sample date.

	Hour																							
Sample	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
0.5 mm Screen	▓	▓	░	░	░	░	░	░	░	░	░	░	░	░	░	░	░	░	▓	▓	░	░	░	░
1.0 mm Screen	▓	▓	░	░	░	░	░	░	░	░	░	░	░	░	░	░	░	░	▓	▓	░	░	░	░
Entrainment (Condenser)	▓	▓					▓	▓					▓	▓					▓	▓				

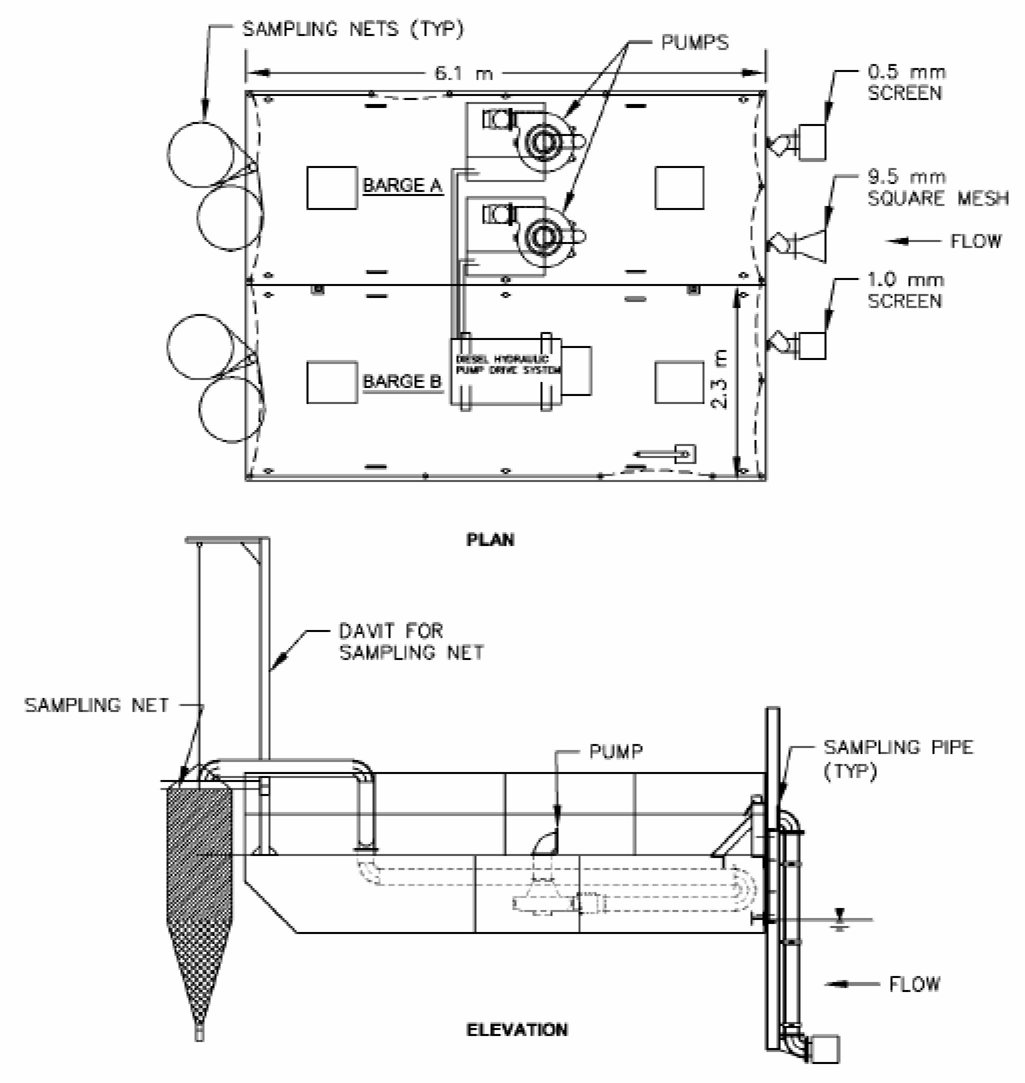

Figure 4-2 Schematic view of sampling barge and apparatus to be used in entrainment and debris fouling aspects of Greenidge pilot study.

Figure 4-3 Two test screens (near and far), with control intake (mid) used in EPRI wedgewire screen testing.

4.3 TYPE AND RAPIDITY OF BIOFOULING

Biofouling of the screens will be examined through use of screen coupons (small samples of actual screen material) inserted into a collection box (Figure 4-4). The collection box will be suspended in the water at the cooling water inlet. Water will be pumped through the box continuously from May through the end of the study, except during inspections, at a nominal flow rate of approximately 0.5 fps through the coupon slots. Coupons will be removed, examined, and photographed weekly during each entrainment sampling event. The order of the coupons will be randomized after each inspection. At the end of the study, coupons will be preserved and examined to determine the magnitude and type of biological growth on the screens. At least 2 different screen alloys (e.g. 304 stainless steel, Z-alloy), and 0.5 and 1.0 mm slot width will be used to examine biofouling severity.

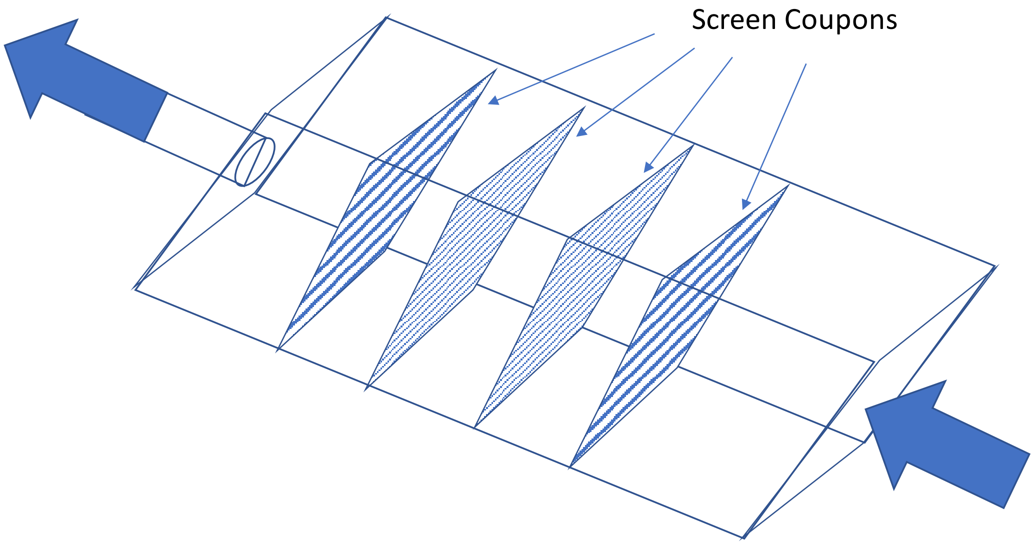

Figure 4-4 Conceptual screen coupon test apparatus.

5. METHODS TO DETERMINE BIOLOGICAL EFFICACY OF WEDGEWIRE SCREENS

Wedgewire screen efficacy will be estimated by comparing densities of ichthyoplankton collected in the condenser entrainment samples, with those from the wedgewire screen samples from the debris fouling study.

Efficacy = 1 – density from screen sample/ density of condenser entrainment sample

Data will be appropriately subset for species, life stages, sizes, or time periods to facilitate understanding of screen efficacy and factors that may affect it.

The empirical efficacy estimate (above) will be compared to an estimated efficacy based solely on physical exclusion estimated by literature-based methods (e.g., physical exclusion based on body morphometry of larvae and egg diameters).

6. SCHEDULE AND PROGRESS REPORTING

The study would start in April 2019, after approval of the study plan by NYSDEC.

April	Initiate entrainment and fouling studies (bi-weekly sampling)
May	Continue entrainment and fouling studies (weekly sampling)
June	Continue entrainment and fouling studies (weekly sampling)
July	Continue entrainment and fouling studies (weekly sampling)
August	Continue entrainment and fouling studies (weekly sampling)
September	Continue entrainment and fouling studies (weekly sampling)
October	Continue entrainment and fouling studies (bi-weekly sampling) Submit report on first 6 months of study
April 2020	Submit report on study results

7. REFERENCES

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