Exhibit E-5 Fisheries Resources

Reservoir Fluctuation Study Plan

RESERVOIR FLUCTUATION STUDY PLAN

PARR HYDROELECTRIC PROJECT

FERC NO. 1894

Prepared for:

South Carolina Electric & Gas Company
Cayce, South Carolina

Prepared by:

Kleinschmidt

Lexington, South Carolina
www.KleinschmidtGroup.com

June 2014

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SOUTH CAROLINA ELECTRIC & GAS COMPANY

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RESERVOIR FLUCTUATION
STUDY PLAN

PARR HYDROELECTRIC PROJECT
FERC NO. 1894

SOUTH CAROLINA ELECTRIC & GAS COMPANY

1.0 INTRODUCTION

South Carolina Electric & Gas Company (SCE&G) is the Licensee of the Parr Hydroelectric Project (FERC No. 1894) (Project). The Project consists of the Parr Hydro Development and the Fairfield Pumped Storage Development. Both developments are located along the Broad River in Fairfield and Newberry Counties, South Carolina.

The Project is currently involved in a relicensing process which involves cooperation and collaboration between SCE&G, as licensee, and a variety of stakeholders including state and federal resource agencies, state and local government, non-governmental organizations (NGOs), and interested individuals. Their collaboration and cooperation is essential to the identification and treatment of operational, economic, and environmental issues associated with a new operating license for the Project. SCE&G has established several Technical Working Committees (TWCs) with members from among the interested stakeholders with the objective of achieving consensus regarding the identification and proper treatment of these issues in the context of a new license.

During issues scoping, the Fisheries TWC identified the potential need for a Reservoir Fluctuation Study on the Parr and Monticello Reservoirs. The operating regime for the Project consists of a lowering and a refilling of the Project's two reservoirs on a daily basis. Although the amount that the Project reservoirs fluctuate varies (based on load demands and system needs), Monticello Reservoir is currently permitted by the FERC license to fluctuate up to 4.5 feet, while Parr Reservoir is permitted to fluctuate up to 10 feet. The magnitude of daily fluctuations varies seasonally in both impoundments. The largest daily fluctuations generally occur in June, July, and August in both reservoirs (see Table 1-1 and Table 1-2).

TABLE 1-1 MONTICELLO RESERVOIR MONTHLY AVERAGE ELEVATIONS: 2005-2013

Monthly Average Res. Elev.			
	Max	**Min**	**Range**
Jan	423.92	422.32	1.60
Feb	423.93	422.45	1.49
Mar	423.82	422.18	1.66
Apr	424.08	421.88	2.22
May	424.42	421.64	2.80
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Oct	424.02	421.83	2.18
Nov	423.61	422.00	1.61
Dec	423.86	422.28	1.58
Average	**424.19**	**421.84**	**2.35**

TABLE 1-2 PARR RESERVOIR MONTHLY AVERAGE ELEVATIONS: 2005-2013

Monthly Average Res. Elev.			
	Max	**Min**	**Range**
Jan	263.04	259.96	3.08
Feb	262.88	260.01	2.87
Mar	263.44	260.32	3.13
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Sep	264.17	258.27	5.90
Oct	263.60	259.14	4.46
Nov	263.53	259.97	3.56
Dec	263.38	260.11	3.28
Average	**263.84**	**259.16**	**4.68**

During February through April, when many fish species are spawning in shallow water habitat, average daily fluctuations range from 1.6-2.4 feet in Monticello Reservoir and from 2.9-4.2 feet in Parr Reservoir (Argentieri presentation 12-19-13; Tables 1 and 2). Resource agencies and stakeholders have expressed concerns of how these daily and seasonal fluctuations are affecting aquatic habitat along the shorelines of the reservoirs.

2.0 EXISTING INFORMATION

Fisheries

The Project area supports warmwater fish communities typical of impounded river reaches in the Piedmont of South Carolina. Recent survey work within the Project area documented 30 species of fish occurring in Parr Reservoir and 24 species in Monticello Reservoir (see Table 2-1).

TABLE 2-1 FISH SPECIES DOCUMENTED AT PARR AND MONTICELLO RESERVOIRS

COMMON NAME	SCIENTIFIC NAME	PARR	MONTICELLO
black crappie	*Pomoxis nigromaculatus*	x	x
blue catfish	*Ictalurus furcatus*	x	x
bluegill	*Lepomis macrochirus*	x	x
channel catfish	*Ictalurus punctatus*	x	x
flat bullhead	*Ameiurus platycephalus*	x	x
flathead catfish	*Pylodictis olivaris*	x	
gizzard shad	*Dorosoma cepedianum*	x	x
golden shiner	*Notemigonus chrysoleucas*	x	x
highfin carpsucker	*Carpiodes velifer*	x	
largemouth bass	*Micropterus salmoides*	x	x
longnose gar	*Lepisosteus osseus*	x	
northern hogsucker	*Hypentelium nigricans*	x	x
notchlip redhorse	*Moxostoma collapsum*	x	x
pumpkinseed	*Lepomis gibbosus*	x	x
quillback	*Carpiodes cyprinus*	x	x
redbreast sunfish	*Lepomis auritus*	x	x
redear sunfish	*Lepomis microlophus*	x	x
robust redhorse	*Moxostoma robustum*	x	x
sandbar shiner	*Notropis scepticus*	x	
shorthead redhorse	*Moxostoma macrolepidotum*	x	x
smallmouth bass	*Micropterus dolomieu*	x	x
snail bullhead	*Ameiurus brunneus*		x
spottail shiner	*Notropis hudsonius*	x	x
threadfin shad	*Dorosoma petenense*	x	x
warmouth	*Lepomis gulosus*	x	
white bass	*Morone chrysops*	x	
white catfish	*Ameiurus catus*	x	x
white perch	*Morone americana*	x	x
whitefin shiner	*Cyprinella nivea*	x	x
yellow bullhead	*Amierus natalis*	x	x
yellow perch	*Perca flavescens*	x	x

Although some seasonal variations in community structure have been documented, the fish communities are generally similar between the two reservoirs, with gizzard shad, blue catfish, bluegill, channel catfish and white perch often being the dominant species (Normandeau 2007, 2008, 2009; SCANA 2013). Important game fish species such as largemouth bass, black crappie, and smallmouth bass (to a lesser extent) are also abundant in the two reservoirs. Life history and spawning preferences can influence the extent to which fish species are affected by reservoir fluctuations. Habitat and spawning preferences of the dominant fish species are briefly considered below.

Gizzard shad are a pelagic species that generally occupy the limnetic zone as well as feed along the littoral zone. Spawning typically occurs in the spring, associated with rapidly rising water levels. Gizzard shad typically spawn in shallow waters, 5 feet deep or less, and prefer recently inundated habitats, when available (Williams and Nelson, 1985). Blue and channel catfish typically occupy deep, protected areas, spawning at sites 6.5 to 13 ft deep (McMahon and Terrell, 1982). Bluegill typically inhabit and spawn within shallow, back-water habitats, at depths of 3 to 6 ft (Stuber et. al., 1982a). White perch also spawn in relatively shallow habitat within reservoirs (0-5 feet). Adult white perch exhibit seasonal movements, utilizing both shallow and deep water habitat (Stanley and Danie, 1983). Largemouth bass typically spawn in gravel, or other substrates such as vegetation, roots, sand, or mud, at depths of 1-3 feet, with a full range 0.5-15 feet (Stuber et. al., 1982b). Smallmouth bass spawning typically occurs over course gravel substrate in close proximity to a boulder, overhead limb, log, or stump, in shallow areas of reservoirs or in protected areas of streams where current is minimal (Edwards, et. al., 1983). Black crappie spawn in backwater habitats or littoral areas in lakes in beds of vegetation on a soft mud, sand, or gravel substrate (Edwards, et. al., 1982a). White crappie tend to spawn at depths from 0.5 to 13.5 ft in river pools or coves and littoral areas of lakes and reservoirs (Edwards, et. al., 1982b). Redear sunfish utilize a wide variety of spawning habitats, with nesting substrates ranging from sand, sand-clay, mud, limestone, shells, and gravel with no vegetation in water depths ranging from several inches to 24 ft deep (Twomey, et. al., 1984). Redbreast sunfish typically spawn in shallow waters (1 to 1.5 ft) near logs, stumps, or boulders in quiet backwater locations or open areas of lakes and reservoirs (Aho, et. al, 1986).

Small fishes, such as shiners, juvenile sunfish, and small suckers serve as the food base for larger, piscivorous species. In general, these species typically have high fecundity rates and will utilize a variety of habitat types for spawning, cover, and resting. These species are typically found within or in the vicinity of aquatic vegetation or other cover. When inundated, the shallow areas may be frequented by these species for forage and cover.

Pool Elevations

During the construction of Monticello Reservoir and the Fairfield Development in 1974, crest gates were added to Parr Shoals Dam, allowing for a full operating range of 256 ft to 266 ft at Parr Reservoir. Monticello Reservoir was constructed to allow for a full operating range of 420.5 ft to 425 ft.

SCE&G submitted surface area and capacity curves as part of the Final Environmental Impact Statement for Parr Hydroelectric Project, conducted in March 1974, after the crest gates were added to Parr Shoals Dam. In Monticello Reservoir, a change in elevation from 425 feet to 420.5 feet will reduce the surface area of the reservoir from 6,800 acres to 6,467 acres (95% of full pool surface area), resulting in a difference of 333 acres of shoreline exposed. The exposed shoreline is generally included in a narrow band that extends around the reservoir. A change in elevation on Parr Reservoir from 266 ft to 256 ft will reduce the surface area of the reservoir from 4,369 acres to 1,375 acres (31.5% of the full pool surface area), resulting in a difference of 2,994 acres of exposed lake bottom. Prior to the construction of the crest gates and reservoir expansion, the approximately 3,000 acres was not inundated or available as aquatic habitat in Parr Reservoir.

3.0 STUDY OBJECTIVES

Monticello Reservoir Study Objectives

The objective of this study with regards to Monticello Reservoir is two-fold. First, SCE&G will provide a qualitative assessment of the potential effects of operational reservoir fluctuations on aquatic habitat within the reservoir. As noted in Section 2.0, areas of shoreline are exposed during impoundment fluctuations, but the type and quality of those areas are not currently documented. This study will provide information to characterize habitats within areas exposed during lake-level fluctuations, including the collection of reservoir elevations at all study sites. Second, this study will identify potential fish habitat enhancements which could be considered as part of the Protection, Mitigation and Enhancements (PM&E) measures.

Parr Reservoir Study Objectives

Study objectives with regards to Parr Reservoir include providing a qualitative and quantitative assessment of the potential effects of operational reservoir fluctuations on aquatic habitat and navigation within the reservoir. This study will provide information to characterize habitats within areas exposed during lake-level fluctuations as well as identify areas with potential navigation issues caused by fluctuations. Data collected will characterize the degree to which reservoir fluctuations affect navigation in the reservoir and identify portions of the reservoir which are potentially influenced in relation to dewatering of aquatic habitat and constricted channel.

4.0 GEOGRAPHIC AND TEMPORAL SCOPE

The study will focus on the littoral zones of Parr and Monticello Reservoirs between maximum normal pool and minimum normal pool that are dewatered by reservoir fluctuations. Several transects will be established at representative locations along Parr and Monticello Reservoirs, where information such as slope and elevation will be gathered. Members of the Fisheries TWC will select these transect locations prior to the study being performed, which will be no later than the summer of 2015. The study will commence after transect locations are selected.

After fluctuation data is collected and analyzed, the TWC will meet to discuss potential PM&E measures that could be considered for each reservoir.

5.0 METHODOLOGY

The study area will include both Parr and Monticello reservoirs. A maximum of four Priority Areas will be identified in Parr Reservoir by the Fisheries TWC members. Potential Priority Areas in Parr Reservoir have been identified and are depicted in Figure 5-1 and Figure 5-2. These Priority Areas will be locations within the reservoir that best depict a variety of existing aquatic habitat types. Within each Priority Area, 3 to 5 transects will be identified across the wetted area. At each transect, elevations will be collected at full pool via GPS (GeoExplorer 6000 paired with an external Zephyr antenna or equivalent model) or survey methods, as well as at 1 foot increments as the reservoir level is lowered during a fluctuation cycle. Surveys will be performed during a low inflow and high energy demand period (possibly August/September) so that as much of the full operating range of 10 ft as possible, from 266 ft to 256 ft can be observed. From this information an estimate of how much reservoir area is dewatered at each 1 foot contour will be documented and compared to the existing Reservoir Area Curve for the Project. At or near the minimum normal pool elevation (256 ft), slope and habitat type will also be photographed. Prior to the field study, locations that may present potential navigation issues during low fluctuations in Parr Reservoir will be identified (or included as a Priority Area). While aquatic habitat information is being collected in Parr Reservoir, field workers will also examine these areas during a fluctuation cycle. Any areas that appear to have navigation concerns will be documented and photographed.

FIGURE 5-1 POTENTIAL PRIORITY AREAS IN UPPER PORTION OF PARR RESERVOIR

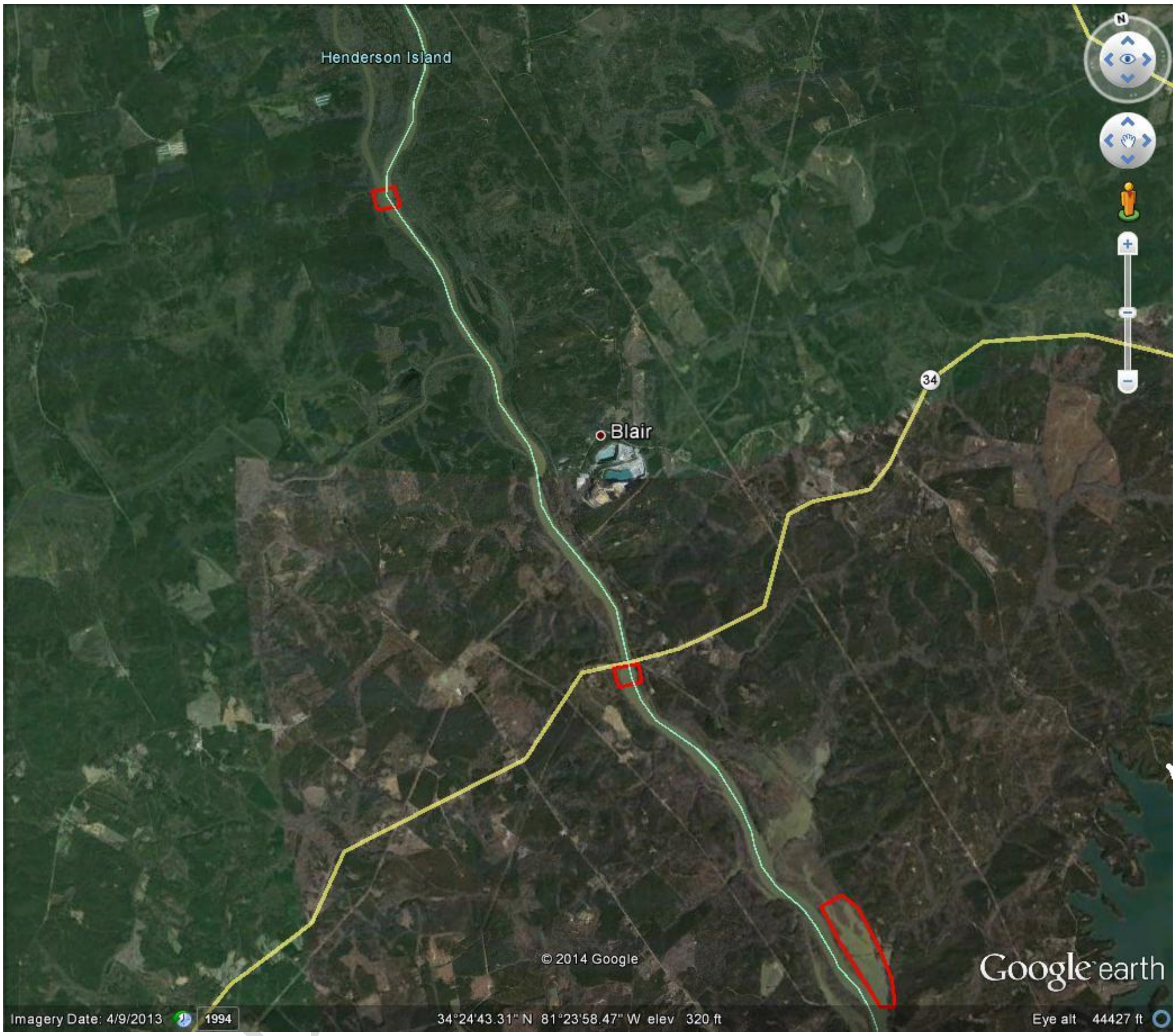
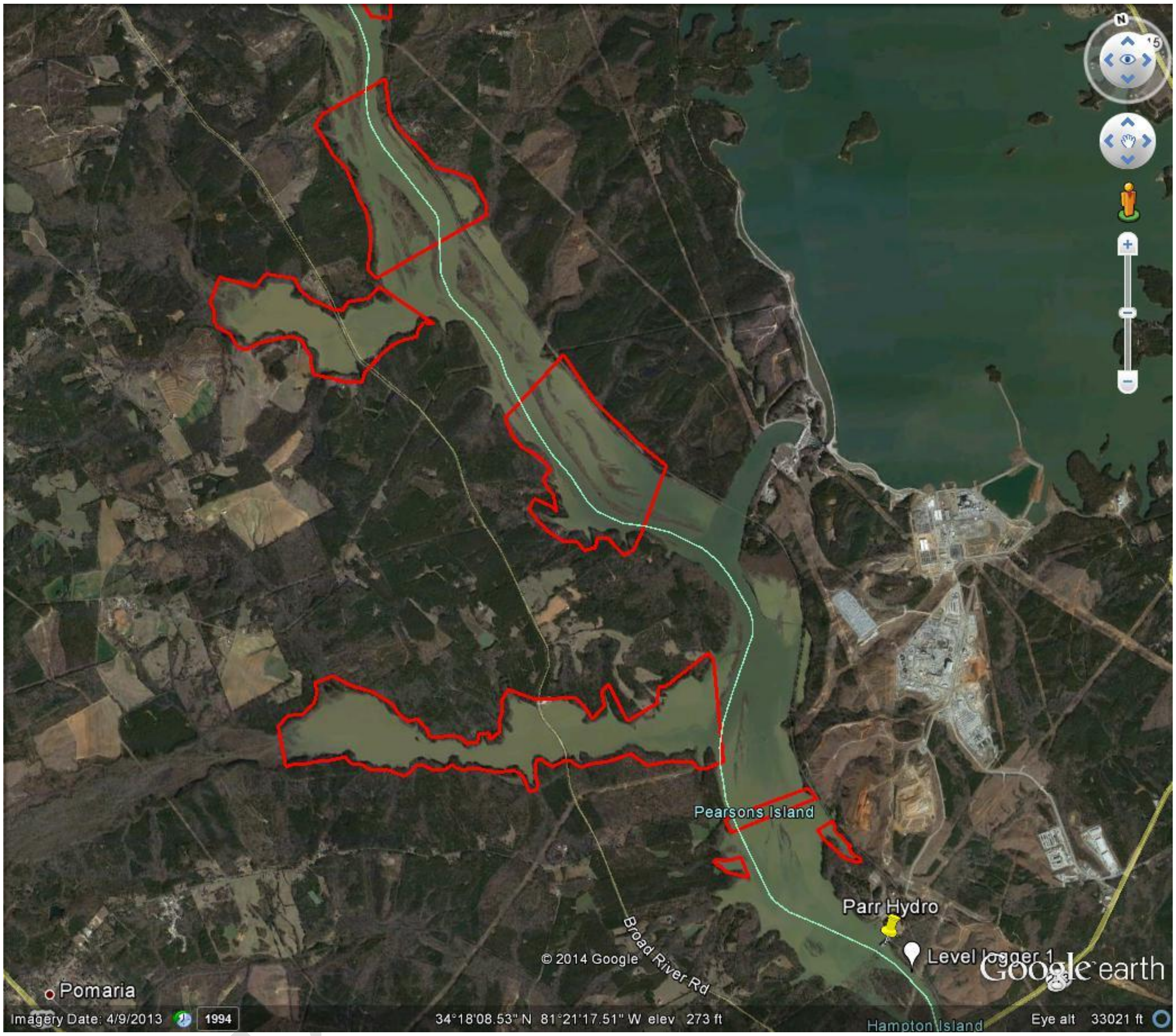


FIGURE 5-2 POTENTIAL PRIORITY AREAS IN LOWER PORTION OF PARR RESERVOIR



In Monticello Reservoir, from two to six Priority Areas will be identified that represent potential critical aquatic habitat areas (see Figure 5-3). At each of these locations, data will be collected to characterize the general slope (measured at 1 ft increments) and habitat type (photographed at each 1 ft increment) of the Priority Area for the 425 ft to 420.5 ft fluctuation band. Data will be collected to characterize the general slope and habitat of the Priority Area.

The collected data will be consolidated into a report for the Fisheries TWC review and comment. This report will be used as a basis for the Fisheries TWC to identify potential PM&E measures that could be implemented at each reservoir.

FIGURE 5-3 POTENTIAL PRIORITY AREAS IN MONTICELLO RESERVOIR

6.0 SCHEDULE

Selection of Priority Areas will be completed no later than July of 2015. Field collections will be completed no later than the fall of 2015. After field data collection have been summarized in a report and distributed for review, the Fisheries TWC will meet to discuss PM&E measures that are appropriate for each reservoir. A final report summarizing the study findings and potential PM&E measures that could be considered as part of the Final License Application will be issued in or around July 2016. Study methodology, timing and duration may be adjusted based on weather and consultation with resource agencies and interested stakeholders.

7.0 USE OF STUDY RESULTS

Study results will be used as an information resource during discussion of relicensing issues and developing potential Protection, Mitigation and Enhancement measures with the South Carolina Department of Natural Resources, U.S. Fish and Wildlife Service (USFWS), Fisheries TWC, and other relicensing stakeholders.

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Exhibit E-5 Fisheries Resources

Parr and Monticello Reservoir Fluctuation Study Report

PARR AND MONTICELLO RESERVOIR FLUCTUATION STUDY

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RESERVOIR FLUCTUATIONS STUDY

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During issue scoping meetings, the Fisheries TWC identified the need for a Reservoir Fluctuation Study on the Parr and Monticello Reservoirs. The operating regime for the Project consists of a lowering and a refilling of the Project's two reservoirs on a daily basis. Parr Reservoir is currently permitted by the FERC license to fluctuate up to 10 feet and Monticello Reservoir can fluctuate up to 4.5 feet. However, the amount that the Project reservoirs fluctuate will vary dependent on load demands and system needs. The magnitude of daily fluctuations also varies seasonally in both impoundments, with the largest average daily fluctuations generally occurring in June, July, and August in both reservoirs (see Table 1-1 and Table 1-2).

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TABLE 1-2 MONTICELLO RESERVOIR MONTHLY AVERAGE ELEVATIONS: 2005-2013

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During February through April, when many fish species are spawning in shallow water habitat, average daily fluctuations range from 2.9-4.2 feet in Parr Reservoir and from 1.6-2.4 feet in Monticello Reservoir (TWC meeting presentation 12-19-13). Resource agencies and stakeholders expressed concerns that these daily and seasonal fluctuations may be affecting aquatic habitat along the shorelines of the reservoirs and fish spawning and recruitment.

2.0 STUDY OBJECTIVES

2.1 PARR RESERVOIR STUDY OBJECTIVES

Study objectives with regards to Parr Reservoir include providing a qualitative and quantitative assessment of the potential effects of operational reservoir fluctuations on aquatic habitat and navigation within the reservoir. This study provides information to characterize habitat types that are exposed during lake-level fluctuations as well as identify areas with potential navigation issues caused by fluctuations. Data collected will characterize the degree to which reservoir fluctuations affect navigation in the reservoir and identify portions of the reservoir which are potentially influenced through dewatering of aquatic habitat and/or constricted channel.

2.2 MONTICELLO RESERVOIR STUDY OBJECTIVES

The objective of this study with regards to Monticello Reservoir is two-fold. First, SCE&G will provide a qualitative assessment of the potential effects of operational reservoir fluctuations on aquatic habitat within the reservoir. Areas of shoreline are exposed during impoundment fluctuations, but the type and quality of those areas are not currently documented. This study provides information on areas of the reservoir identified by the TWC that are eligible for habitat enhancements that will promote or enhance fish spawning and recruitment.

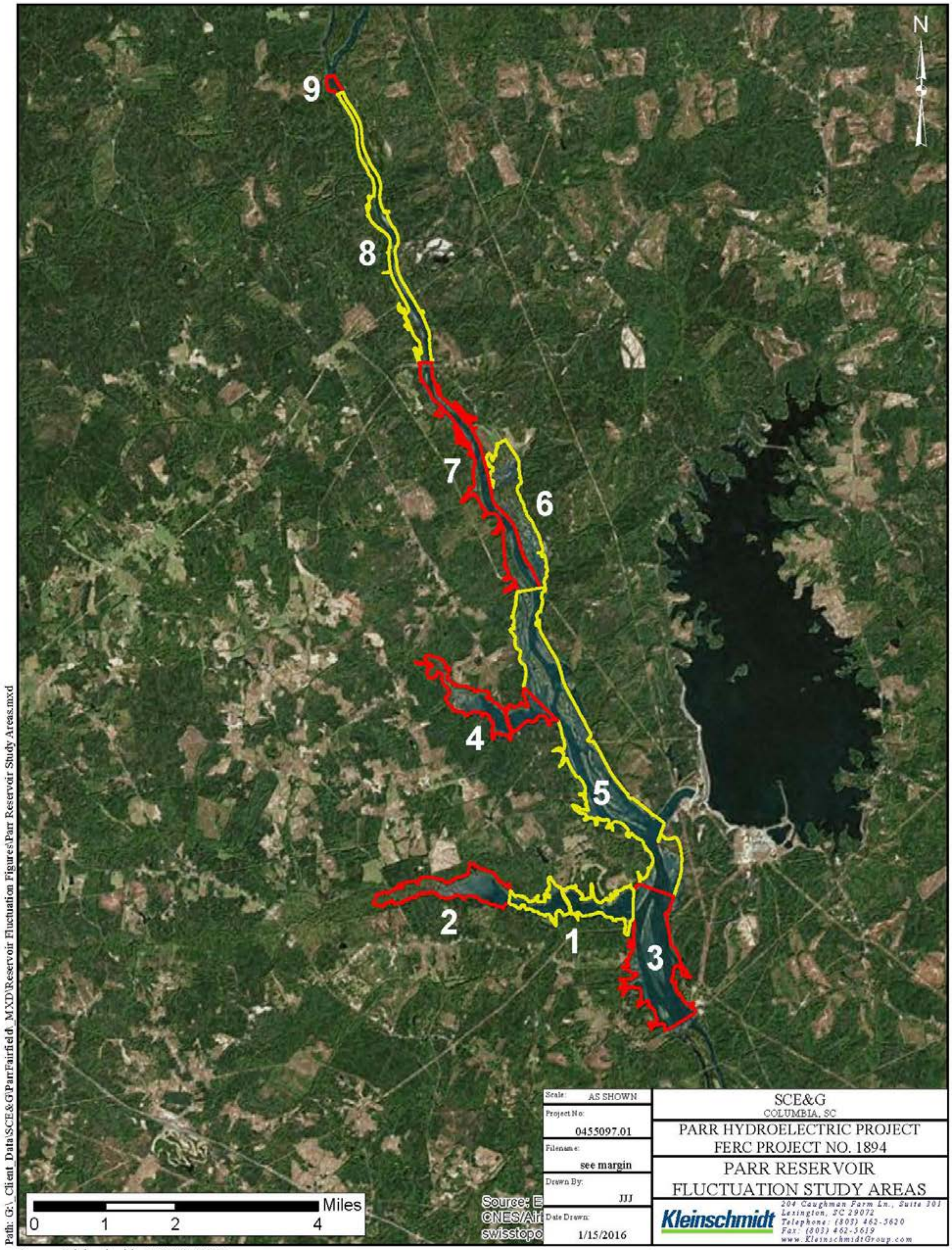
3.0 METHODS AND MATERIALS

The study area includes both Parr and Monticello Reservoirs. TWC members performed field observations of the reservoirs during 2015 to assess the variety of existing aquatic habitat types. In addition to the TWC observations, digital imagery of the reservoirs was collected during a drawdown period (9.9 foot down from full pool on Parr and 2.25 foot down from full pool on Monticello) so that substrate types could be observed. SCE&G used photogrammetry to convert the digital imagery to a Digital Elevation Model (DEM) for both reservoirs at 2 foot contours (Orbis 2015).

3.1 PARR RESERVOIR FLUCTUATION

The Parr Reservoir DEM covered the shoreline from elevation 266' msl down to 256.1' msl. Initially, Parr Reservoir was separated into 9 Study Areas based on reservoir characteristics and TWC input (Figure 3-1). Using GIS, a grid system was then applied to each Study Area and approximately 10 percent subsample of each Study Area was selected by random sample. Based on the digital imagery and personal observation/photographs collected during the drawdown, the subsampled shoreline area substrates were classified as mud/silt, sand, or gravel/cobble. Areas of structure (trees, stumps, stream channels and submerged vegetation) were also identified.

After classifications were completed, 2 foot contours for the entire Study Area were established using GIS and photogrammetry. The total acreage of the subsample and the entire Study Area was also determined. The substrate and structure type was summed for each 2 foot contour within the subsample area. The subsample breakdowns of substrate by 2 foot contour were then converted to percent composition based on the total area of the subsample within each 2 foot contour. The subsample percentages were then multiplied by the area within each 2 foot contour for the entire Study Area to determine the breakdown of substrate acreage for each 2 foot contour for each Study Area.

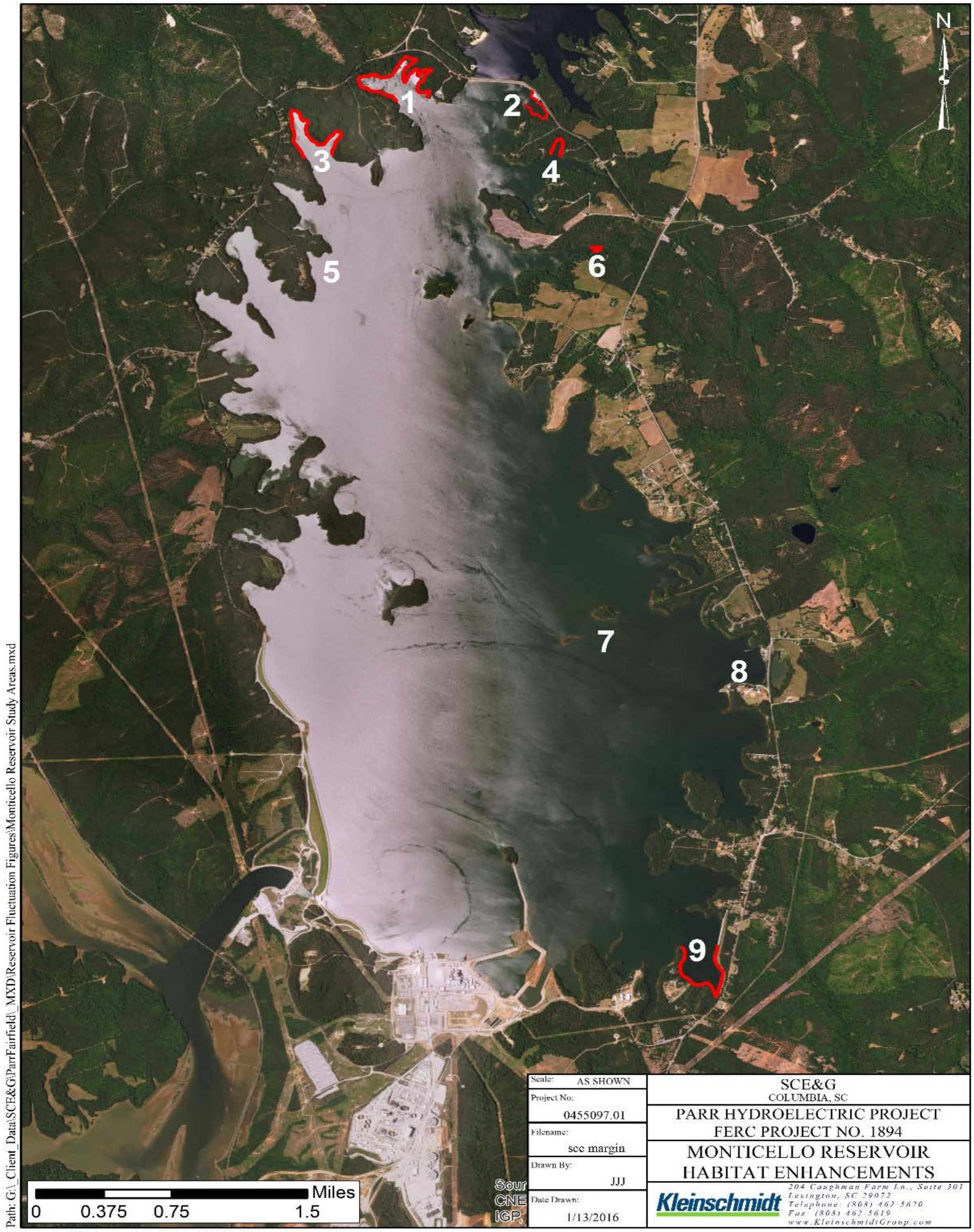


Source: Kleinschmidt, SCE&G, ESRI

FIGURE 3-1 PARR RESERVOIR STUDY AREA SECTIONS

3.2 MONTICELLO RESERVOIR FLUCTUATION

On Monticello Reservoir, SCE&G also collected digital imagery during a partial drawdown (425’ msl to 422.75’ msl) and used it to create a DEM that could be viewed and assessed using GIS. SCE&G and TWC members reviewed the DEM and digital imagery information during the September 29, 2015 TWC meeting to identify areas to consider for potential habitat enhancement measures. The TWC also identified the types of enhancement measures (spawning, fry protection, and adult fish structure) that could be incorporated (Figure 3-2). Nine enhancement areas were identified on the reservoir based on the digital imagery and TWC recommendations. At each of the nine enhancement locations, GIS was used to calculate the amount of shoreline area available (for spawning and fry protection) within the identified area. These measurements will be used to help identify the amount (linear area enhanced or number of enhancements) of habitat enhancement structures that could be installed.



Source: Kleinschmidt, Orbis, SCE&G

FIGURE 3-2 MONTICELLO SHORELINE HABITAT ENHANCEMENT AREAS IDENTIFIED BY TWC

4.0 RESULTS

4.1 PARR RESERVOIR

Parr Reservoir results are provided below in tabular format. Substrate and structure acreage estimates are provided for each of the Study Areas on Parr Reservoir. Results are separated by both habitat and substrate types along with the associated elevation range. A 95% confidence interval (CI) was also calculated for each estimate to demonstrate the GIS accuracy for each estimate. In some cases total acreage by elevation does not equal the sum of the substrate or structure breakdowns, because there are slight errors in using GIS. These variances were not significant. The area at 256’ was also provided to show how much of the reservoir was still wetted. Note that the reservoir drawdown level was 256.1’, yet DEM labeled some areas that had shallow depressions on mud flats as 256’. This created an anomaly when GIS analysis counted some areas below the 256’ elevation as “dewatered” (Figure 4-1). This GIS artifact appeared in Areas 2, 5 and 6 but were not a significant number or amount of area. Figures for each Parr Study Area are included in Appendix A.

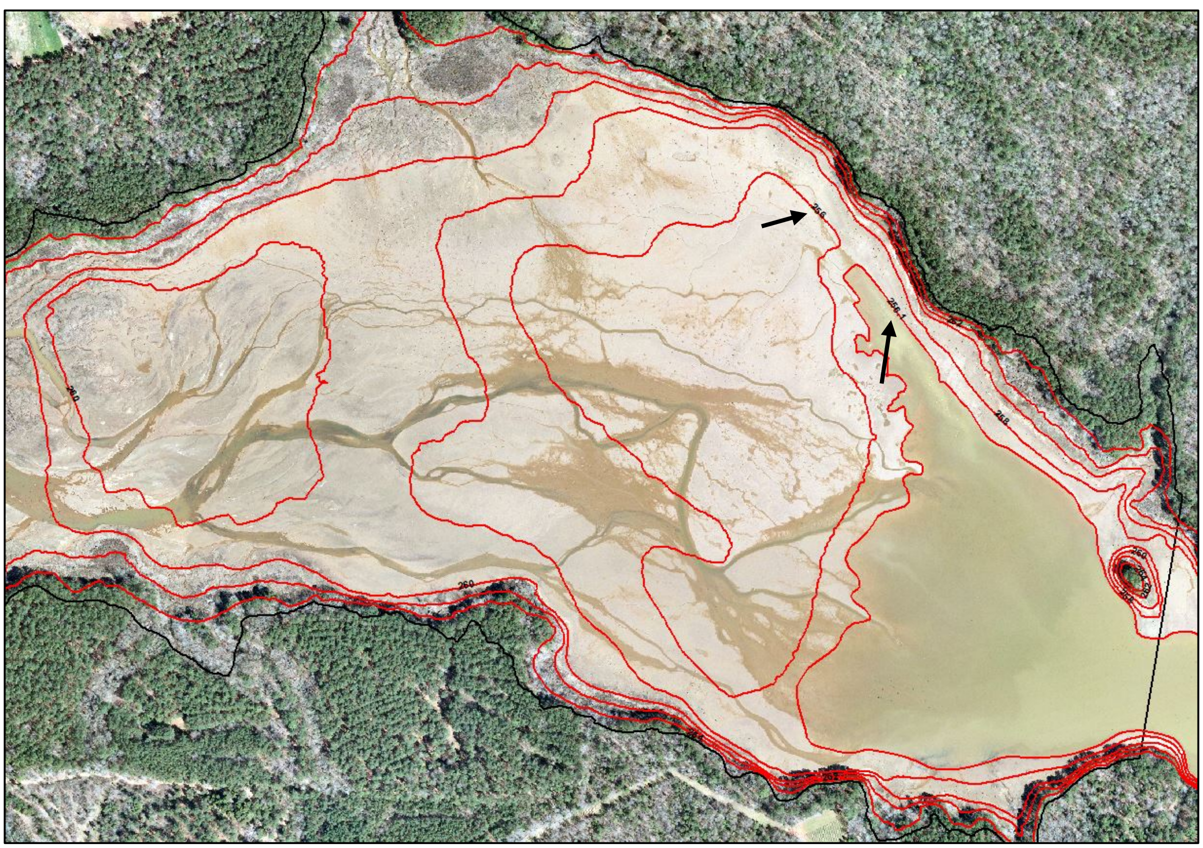


FIGURE 4-1 PARR RESERVOIR - EXAMPLE OF ELEVATION 256 ANOMALY

4.1.1 Parr Study Area 1

Study Area 1 is located in Cannons Creek near the mainstem of the reservoir. The study area is primarily made up of silt and sand substrates with stumps representing the primary structure. Elevations 256-258’ and 258-260’ contain the largest portions of the study area that are periodically exposed by reservoir fluctuations. This elevation band also contains the most structure used by typical warmwater species present within the Reservoir (SCANA 2016). Substrate composition shifts from silt at 256-260’ to sand at 260-264’. The elevation band from 264-266’ is dominated by terrestrial plants with unknown substrates due to tree cover.

TABLE 4-1 SUBSTRATE AND STRUCTURE COMPOSITION OF EXPOSED SHORELINES IN STUDY AREA 1 OF PARR RESERVOIR

SS1 EXTRAPOLATED		SUBSTRATE									
		SAND		SILT		GRAVEL/COBBLE		UNKNOWN		UNEXPOSED	
Elev Range	Acreage	Acreage	95% CI	Acreage	95% CI	Acreage	95% CI	Acreage	95% CI	Acreage	95% CI
264-266	19.60	0.00	0.00	0.00	0.00	1.11	0.12	18.40	0.26	0.00	0.00
262-264	19.19	9.62	0.40	0.00	0.00	0.80	0.07	8.77	0.10	0.00	0.00
260-262	15.97	13.63	0.08	1.51	0.04	0.83	0.07	0.00	0.00	0.00	0.00
258-260	23.09	2.82	0.08	19.59	0.26	0.61	0.06	0.00	0.00	0.00	0.00
256-258	25.38	2.54	0.33	22.08	0.24	0.76	0.08	0.00	0.00	0.00	0.00
< 256	223.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	223.03	2.18

SS1 EXTRAPOLATED		STRUCTURE							
		TREES		SUBMERGED VEGETATION		STUMPS		STREAM CHANNELS	
Elev Range	Acreage	Acreage	95% CI	Acreage	95% CI	Acreage	95% CI	Acreage	95% CI
264-266	19.60	17.63	0.29	0.00	0.00	0.00	0.00	0.00	0.00
262-264	19.19	5.70	0.14	0.13	0.00	5.37	0.80	0.00	0.00
260-262	15.97	1.06	0.50	3.07	0.27	2.08	0.13	0.00	0.00
258-260	23.09	0.02	0.00	0.06	0.00	9.42	0.39	0.00	0.00
256-258	25.38	0.01	0.00	0.00	0.00	11.65	0.24	0.00	0.00
< 256	223.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

4.1.2 PARR STUDY AREA 2

Study Area 2 is located in the upper portion of Cannons Creek and offers more backwater rather than mainstem habitat characteristics. The study area is dominated by silt and sand substrates with stumps and aquatic vegetation representing the primary structure. The study area as a whole displays significant dewatering during reservoir fluctuation, exposing creek channels in the upper portion of the study area. Substrate composition shifts from silt at 256-260' to sand at 260-264'. Elevation 264-266' is dominated by terrestrial plants with unknown substrates due to tree cover and contains the most area exposed by fluctuations in the reservoir. Note: There were a few spots below the 256' elevation line that showed up as "dewatered" despite the reservoir height being at 256', which is an artifact of the GIS analysis.

TABLE 4-2 SUBSTRATE AND STRUCTURE COMPOSITION OF EXPOSED SHORELINES IN STUDY AREA 2 OF PARR RESERVOIR

SS2 EXTRAPOLATED		**SUBSTRATE**									
		SAND		**SILT**		**GRAVEL/COBBLE**		**UNKNOWN**		**UNEXPOSED**	
Elev Range	Acreage	Acreage	95% CI	Acreage	95% CI	Acreage	95% CI	Acreage	95% CI	Acreage	95% CI
264-266	114.65	13.40	0.89	0.00	0.00	0.00	0.00	100.86	5.03	0.39	0.00
262-264	45.81	34.63	0.63	0.00	0.00	0.00	0.00	9.58	0.48	1.60	0.36
260-262	49.69	33.06	0.62	12.70	0.72	0.00	0.00	0.00	0.00	3.93	0.20
258-260	34.68	4.07	0.27	29.08	1.01	0.00	0.00	0.00	0.00	1.52	0.92
256-258	35.48	0.00	0.00	31.37	1.00	0.00	0.00	0.00	0.00	4.10	0.35
< 256	55.90	0.00	0.00	5.35	3.41	0.00	0.00	0.00	0.00	50.52	3.86

SS2 EXTRAPOLATED		**STRUCTURE**							
		TREES		**SUBMERGED VEGETATION**		**STUMPS**		**STREAM CHANNELS**	
Elev Range	Acreage	Acreage	95% CI	Acreage	95% CI	Acreage	95% CI	Acreage	95% CI
264-266	114.65	54.20	1.55	60.09	7.03	0.00	0.00	0.00	0.00
262-264	45.81	6.49	0.62	35.34	0.79	0.15	0.03	0.00	0.00
260-262	49.69	0.00	0.00	28.96	0.83	0.06	0.04	1.46	0.78
258-260	34.68	0.00	0.00	2.67	1.75	15.71	2.63	0.00	0.00
256-258	35.48	0.00	0.00	0.00	0.00	14.91	2.04	2.37	0.81
< 256	55.90	0.00	0.00	0.00	0.00	0.00	0.00	0.43	0.00

4.1.3 PARR STUDY AREA 3

Study Area 3 is the downstream most study area along the mainstem reservoir adjacent to the dam. The study area is dominated by silt and sand substrates with stumps and aquatic vegetation representing the primary structure. Substrate composition shifts from silt at 256-260’ to sand at 260-264’. The upper two feet affected by fluctuations is dominated by terrestrial plants with unknown substrates due to tree cover. Elevation 258-260’ contains the most area exposed by fluctuations in the reservoir. Note: This study area also contains some small areas that showed up as dewatered below elevation 256’.

TABLE 4-3 SUBSTRATE AND STRUCTURE COMPOSITION OF EXPOSED SHORELINES IN STUDY AREA 3 OF PARR RESERVOIR

SS3 EXTRAPOLATED		SUBSTRATE									
		SAND		SILT		GRAVEL/COBBLE		UNKNOWN		UNEXPOSED	
Elev Range	Acreage	Acreage	95% CI	Acreage	95% CI	Acreage	95% CI	Acreage	95% CI	Acreage	95% CI
264-266	15.33	0.00	0.00	0.00	0.00	0.00	0.00	15.33	9.81	0.00	0.00
262-264	22.29	22.17	0.50	0.09	0.00	0.03	0.00	0.00	0.00	0.00	0.00
260-262	31.80	25.36	0.14	6.41	0.06	0.00	0.00	0.00	0.00	0.00	0.00
258-260	159.41	6.07	0.18	152.95	1.11	0.00	0.00	0.00	0.00	0.40	0.00
256-258	66.95	1.67	0.22	68.16	1.04	0.00	0.00	0.00	0.00	0.00	0.00
< 256	405.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	399.36	2.26

SS3 EXTRAPOLATED		STRUCTURE							
		TREES		SUBMERGED VEGETATION		STUMPS		STREAM CHANNELS	
Elev Range	Acreage	Acreage	95% CI	Acreage	95% CI	Acreage	95% CI	Acreage	95% CI
264-266	15.33	14.74	0.00	0.00	0.00	0.00	0.00	0.00	0.00
262-264	22.29	0.63	0.00	21.27	0.50	0.66	0.00	0.00	0.00
260-262	31.80	0.00	0.00	17.35	0.36	0.33	0.03	0.00	0.00
258-260	159.41	0.00	0.00	0.00	0.00	17.37	4.07	0.00	0.00
256-258	66.95	0.00	0.00	0.00	0.00	9.27	0.23	0.00	0.00
< 256	405.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

4.1.4 PARR STUDY AREA 4

Study Area 4 is the located in Hellers Creek off the mainstem of the reservoir. The study area is dominated by silt and sand substrates with stumps and aquatic vegetation representing the primary structure. Substrate composition shifts from silt at 256-260’ to sand at 260-264’. The upper two feet (264-266’) of the fluctuation zone is dominated by terrestrial plants with unknown substrates due to tree cover. Elevation 256-258’ contains the most area exposed by fluctuations in reservoir elevation.

TABLE 4-4 SUBSTRATE AND STRUCTURE COMPOSITION OF EXPOSED SHORELINES IN STUDY AREA 4 OF PARR RESERVOIR

SS4 EXTRAPOLATED		**SUBSTRATE**									
		SAND		**SILT**		**GRAVEL/COBBLE**		**UNKNOWN**		**UNEXPOSED**	
Elev Range	Acreage	Acreage	95% CI	Acreage	95% CI	Acreage	95% CI	Acreage	95% CI	Acreage	95% CI
264-266	57.85	7.96	0.00	0.00	0.00	8.42	1.84	41.47	9.40	0.00	0.00
262-264	36.54	34.73	1.27	0.00	0.00	0.76	0.15	1.05	0.62	0.00	0.00
260-262	33.72	24.69	0.99	1.07	0.47	0.79	0.14	0.00	0.00	7.06	0.53
258-260	32.77	3.69	0.42	28.07	1.03	1.01	0.20	0.00	0.00	0.00	0.00
256-258	89.40	0.85	0.11	88.03	1.49	0.52	0.04	0.00	0.00	0.00	0.00
< 256	105.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	105.66	3.02

SS4 EXTRAPOLATED		**STRUCTURE**							
		TREES		**SUBMERGED VEGETATION**		**STUMPS**		**STREAM CHANNELS**	
Elev Range	Acreage	Acreage	95% CI	Acreage	95% CI	Acreage	95% CI	Acreage	95% CI
264-266	57.85	49.44	3.71	0.00	0.00	0.00	0.00	0.00	0.00
262-264	36.54	1.05	0.62	31.79	1.32	2.94	0.00	0.00	0.00
260-262	33.72	0.00	0.00	18.19	5.58	0.00	0.00	0.00	0.00
258-260	32.77	0.00	0.00	0.00	0.00	2.26	1.50	0.00	0.00
256-258	89.40	0.00	0.00	0.00	0.00	17.81	0.29	0.00	0.00
< 256	105.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

4.1.5 PARR STUDY AREA 5

Study Area 5 is the located along the mainstem of the reservoir. The study area is dominated by silt and sand substrates with stumps and aquatic vegetation representing the primary structure. Substrate composition shifts from silt at 256-260’ to sand at 260-264’. The upper two feet of the fluctuation zone (264-266’) is dominated by terrestrial plants with unknown substrates due to tree cover. The study area becomes more riverine as water levels drop with the channel becoming more defined. Elevation 258-260’ contains the most area exposed by fluctuations in the reservoir. Note: This study area also contains some small areas that showed up as dewatered below elevation 256’.

TABLE 4-5 SUBSTRATE AND STRUCTURE COMPOSITION OF EXPOSED SHORELINES IN STUDY AREA 5 OF PARR RESERVOIR

SS5 EXTRAPOLATED		**SUBSTRATE**									
		SAND		**SILT**		**GRAVEL/COBBLE**		**UNKNOWN**		**UNEXPOSED**	
Elev Range	Acreage	Acreage	95% CI	Acreage	95% CI	Acreage	95% CI	Acreage	95% CI	Acreage	95% CI
264-266	106.88	69.77	2.02	0.00	0.00	0.00	0.00	37.11	1.58	0.00	0.00
262-264	159.03	158.64	0.16	0.00	0.00	0.00	0.00	0.39	0.00	0.00	0.00
260-262	118.77	66.86	0.08	51.89	0.14	0.00	0.00	0.00	0.00	0.00	0.00
258-260	265.78	6.79	0.22	258.99	0.62	0.00	0.00	0.00	0.00	0.00	0.00
256-258	185.72	3.57	2.13	182.15	0.88	0.00	0.00	0.00	0.00	0.00	0.00
< 256	506.27	0.00	0.00	60.91	3.46	0.00	0.00	0.00	0.00	445.36	6.15

SS5 EXTRAPOLATED		**STRUCTURE**							
		TREES		**SUBMERGED VEGETATION**		**STUMPS**		**STREAM CHANNELS**	
Elev Range	Acreage	Acreage	95% CI	Acreage	95% CI	Acreage	95% CI	Acreage	95% CI
264-266	106.88	73.75	1.55	32.61	1.71	0.00	0.00	0.00	0.00
262-264	159.03	2.06	0.21	153.05	0.19	0.46	0.00	0.00	0.00
260-262	118.77	0.35	0.00	24.39	0.17	0.00	0.00	0.00	0.00
258-260	265.78	0.00	0.00	0.00	0.00	62.52	4.40	0.00	0.00
256-258	185.72	0.00	0.00	0.00	0.00	23.35	0.83	0.00	0.00
< 256	506.27	0.00	0.00	0.00	0.00	18.98	0.00	0.00	0.00

4.1.6 PARR STUDY AREA 6

Study Area 6 is a backwater area located off the mainstem of the reservoir near the Broad River WMA. The study area is dominated by silt and sand substrates with stumps and aquatic vegetation representing the primary structure. Substrate composition shifts from silt at 256-262' to sand at 262-266'. The area is dominated by aquatic vegetation throughout the study area, with stumps most common below elevation 262'. Elevation 264-266' contains the most area exposed by fluctuations in reservoir elevation. Note: This study area also contains some small areas that showed up as dewatered below elevation 256'.

TABLE 4-6 SUBSTRATE AND STRUCTURE COMPOSITION OF EXPOSED SHORELINES IN STUDY AREA 6 OF PARR RESERVOIR

SS6 EXTRAPOLATED		**SUBSTRATE**									
		SAND		**SILT**		**GRAVEL/COBBLE**		**UNKNOWN**		**UNEXPOSED**	
Elev Range	Acreage	Acreage	95% CI	Acreage	95% CI	Acreage	95% CI	Acreage	95% CI	Acreage	95% CI
264-266	101.31	101.27	0.99	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00
262-264	100.98	100.98	0.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
260-262	89.20	32.52	0.26	56.66	0.35	0.00	0.00	0.00	0.00	0.00	0.00
258-260	53.50	0.07	0.00	53.43	1.01	0.00	0.00	0.00	0.00	0.00	0.00
256-258	14.60	0.00	0.00	14.60	1.05	0.00	0.00	0.00	0.00	0.00	0.00
< 256	12.35	0.00	0.00	0.42	0.14	0.00	0.00	0.00	0.00	11.93	0.67

SS6 EXTRAPOLATED		**STRUCTURE**							
		TREES		**SUBMERGED VEGETATION**		**STUMPS**		**STREAM CHANNELS**	
Elev Range	Acreage	Acreage	95% CI	Acreage	95% CI	Acreage	95% CI	Acreage	95% CI
264-266	101.31	90.09	1.27	7.84	2.46	0.00	0.00	0.00	0.00
262-264	100.98	11.14	1.20	67.97	0.80	0.00	0.00	0.00	0.00
260-262	89.20	0.00	0.00	20.08	1.07	18.63	1.13	0.51	0.05
258-260	53.50	0.00	0.00	0.00	0.00	6.85	1.27	4.78	1.20
256-258	14.60	0.00	0.00	0.00	0.00	9.81	1.72	0.00	0.00
< 256	12.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

4.1.7 PARR STUDY AREA 7

Study Area 7 is located along the mainstem of the reservoir adjacent to Study Area 6. The area is long and narrow with a well-defined channel with sparse sandbars and backwater areas. The study area is dominated by silt and sand substrates with aquatic and riparian vegetation representing the primary structure. Substrate composition shifts from silt at 256-262’ to sand at 262-266’. Elevation 264-266’ contains the most area exposed by fluctuations in reservoir elevation.

TABLE 4-7 SUBSTRATE AND STRUCTURE COMPOSITION OF EXPOSED SHORELINES IN STUDY AREA 7 OF PARR RESERVOIR

SS7 EXTRAPOLATED		SUBSTRATE									
		SAND		SILT		GRAVEL/COBBLE		UNKNOWN		UNEXPOSED	
Elev Range	Acreage	Acreage	95% CI	Acreage	95% CI	Acreage	95% CI	Acreage	95% CI	Acreage	95% CI
264-266	52.98	37.84	1.42	0.00	0.00	0.00	0.00	15.14	0.32	0.00	0.00
262-264	36.54	33.85	0.83	0.51	0.14	0.00	0.00	2.17	0.13	0.00	0.00
260-262	46.39	6.97	0.11	38.97	1.65	0.00	0.00	0.44	0.14	0.00	0.00
258-260	27.04	15.78	2.95	10.78	0.13	0.00	0.00	0.44	0.10	0.05	0.01
256-258	21.88	6.66	0.69	15.05	0.23	0.00	0.00	0.14	0.00	0.03	0.00
< 256	223.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	223.95	1.98

SS7 EXTRAPOLATED		STRUCTURE							
		TREES		SUBMERGED VEGETATION		STUMPS		STREAM CHANNELS	
Elev Range	Acreage	Acreage	95% CI	Acreage	95% CI	Acreage	95% CI	Acreage	95% CI
264-266	52.98	29.01	1.13	8.54	0.00	1.76	0.00	0.00	0.00
262-264	36.54	2.72	0.12	20.29	0.00	0.00	0.00	0.00	0.00
260-262	46.39	0.00	0.00	0.00	0.00	6.31	0.37	4.51	0.45
258-260	27.04	0.00	0.00	0.00	0.00	4.13	0.06	3.09	0.79
256-258	21.88	0.00	0.00	0.00	0.00	1.74	0.16	0.00	0.00
< 256	223.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

4.1.8 PARR STUDY AREA 8

Study Area 8 is located along the mainstem in the upper portion of the reservoir. The area is long and narrow with a well-defined channel and steep banks. The study area is dominated by silt and sand substrates with riparian vegetation and channels representing the primary structure. Substrate composition shifts from silt at 258-260’ to sand at 260-266’. Elevation 262-264’ contains the most area exposed by fluctuations in the reservoir.

TABLE 4-8 SUBSTRATE AND STRUCTURE COMPOSITION OF EXPOSED SHORELINES IN STUDY AREA 8 OF PARR RESERVOIR

SS8 EXTRAPOLATED		SUBSTRATE									
		SAND		SILT		GRAVEL/COBBLE		UNKNOWN		UNEXPOSED	
Elev Range	Acreage	Acreage	95% CI	Acreage	95% CI	Acreage	95% CI	Acreage	95% CI	Acreage	95% CI
264-266	23.87	15.74	1.17	0.00	0.00	0.00	0.00	8.13	0.09	0.00	0.00
262-264	152.60	5.23	0.62	3.47	0.07	0.00	0.00	1.14	0.06	142.73	1.56
260-262	79.86	3.32	1.58	13.68	0.78	0.00	0.00	0.00	0.00	62.85	3.13
258-260	12.89	0.00	0.00	12.89	8.93	0.00	0.00	0.00	0.00	0.00	0.00
256-258	0.77	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
< 256	0.11	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

SS8 EXTRAPOLATED		STRUCTURE							
		TREES		SUBMERGED VEGETATION		STUMPS		STREAM CHANNELS	
Elev Range	Acreage	Acreage	95% CI	Acreage	95% CI	Acreage	95% CI	Acreage	95% CI
264-266	23.87	23.11	0.28	0.00	0.00	0.00	0.00	0.00	0.00
262-264	152.60	0.15	0.10	0.00	0.00	0.08	0.00	3.58	0.00
260-262	79.86	0.00	0.00	0.00	0.00	1.56	0.31	3.95	0.00
258-260	12.89	0.00	0.00	0.00	0.00	0.00	0.00	12.89	0.00
256-258	0.77	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
< 256	0.11	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

4.1.9 PARR STUDY AREA 9

No substrate and structure data could be collected in Study Area 9 due to the riverine nature of the study area. This Study Area did not exhibit any measurable habitat dewatering resulting from reservoir fluctuations at the flow experienced on the day of data collections. The area does contain ledges that offer significant riverine habitat but none of these were exposed even at the lowest observed reservoir elevations of 256.1’ msl at the dam.

4.1.10 TOTAL PARR RESERVOIR AREAS

The total amount of shoreline exposed at each two foot drawdown is shown in Table 4-9. The estimated acreage exposed was calculated by subtracting unexposed area estimates from the total area within each contour interval.

TABLE 4-9 TOTAL AREA OF SHORELINES EXPOSED IN ALL STUDY AREAS OF PARR RESERVOIR COMBINED

ELEVATION	ESTIMATED ACREAGE EXPOSED	ESTIMATED TOTAL CUMULATIVE ACREAGE EXPOSED
264-266	492.08	492.08
262-264	428.63	920.71
260-262	391.54	1312.25
258-260	607.20	1919.44
256-258	436.05	2355.49

4.1.11 PARR RESERVOIR NAVIGATION

Navigation restrictions were noted during the TWC field observations at elevation 256.1 msl. Navigation in the mainstem of the reservoir did not appear to be restricted as a definite channel was observed throughout the reservoir. During the observations, a navigation channel was most restricted in the mouth of Heller’s and Cannon’s creeks. Heller’s Creek had both sediments and stumps that reduced or prevented boat traffic at the lowest level of drawdown. Cannon’s Creek was restricted mostly by the presence of stumps. However, a navigation channel was navigable between the stumps from the mouth upstream to the Cannon’s Creek boat access (Mealing pers. com. 2015).

4.2 MONTICELLO RESERVOIR

During the September 29, 2015 Fisheries TWC meeting, critical habitat areas on Monticello Reservoir were identified to be analyzed for potential enhancement measures. Because the reservoir experiences several feet of fluctuation each day and it is not a natural stream bank, the shoreline diversity is very limited. There is a general lack of structure and stable substrates in shallow areas that would be used by typical warmwater species present in the reservoir. TWC discussions identified three types of aquatic enhancements that would be beneficial primarily to the Centrarchid (and secondarily to the Ictalurid) populations in the reservoir. These enhancements included: shallow water spawning areas, fry rearing structures to be positioned near the identified spawning areas, and deep water structures to attract adult fishes and enhance recreational fishing. The TWC noted that any enhancements installed should be located below elevation 420' msl to ensure that they would not be exposed during reservoir fluctuations or serve as a navigation hazard.

TWC discussions indicated that spawning area enhancements should be located in cove areas with stable sloped banks, which include Areas 1, 2, 3, 4, 6, and 9 (Table 4-10). Table 4-10 also included the total length of shoreline for each Area to give a relative understanding of the amount of proposed spawning enhancements. In Areas where shoreline spawning enhancements were proposed, fry rearing structures were also proposed to help protect swim up fry as they migrate from the spawning area enhancement.

Deep water structures were identified for Areas 1, 3, 4, 5, 7, 8, and 9. These structures were positioned in open cove areas, cove mouth areas, or in open water areas adjacent to islands in Monticello Reservoir. The proposed habitat enhancements are also included within the table and illustrated in Figures 1-9 in Appendix B.

A preliminary list of costs for the various habitat enhancement structures (not including labor for installation) is provided in Appendix C (Mossback 2015). These prices are based on the Mossback company designs and price list available at http://www.mossbackrack.com/. These structures were selected as a basis for costs because of the product durability and presence and use in southeastern reservoirs. Initial contacts with Mossback have indicated the company's ability to work as a contractor for installation and design of habitat enhancements for specific reservoir applications. Unit costs for spawning areas is not as definitive at this point and will require additional discussions with the TWC on final length and location, design, and type of product used to build and maintain them.

TABLE 4-10 POTENTIAL MONTICELLO HABITAT ENHANCEMENTS

MONTICELLO RESERVOIR CRITICAL HABITAT AREAS		POTENTIAL HABITAT ENHANCEMENTS			
Area Number	Shoreline Length (ft)	Spawning Habitat (ft)	Percent of Shoreline (%)	Fry Rearing	Deepwater Attractor
1	8947	450	5.0	3	3
2	2422	100	4.1	1	0
3	5966	225	3.8	2	2
4	1434	150	10.5	2	1
5	deep water	0	0	0	2
6	629	50	7.9	1	0
7	deep water	0	0	0	3
8	deep water	0	0	0	2
9	4936	150	3.0	0*	1
TOTALS	**24334**	**1125**		**9**	**14**

*Fry habitat was not proposed for Area 9 due to the extensive amount of rip-rap areas adjacent to the proposed spawning enhancement.

5.0 DISCUSSION

The Parr Reservoir results will be reviewed and discussed with the TWC[1]. The study results will provide a basis for the TWC to identify the magnitude of impact associated with reservoir fluctuations and develop potential alternatives to reduce the impacts, as well as aid in the identification of priority areas for potential PM&E measures that could be considered as part of the Settlement Agreement.

The Monticello Reservoir results will also be presented to the TWC for review and discussion. The proposed habitat enhancements should provide a basis for discussion and recommendation of the types and amounts of habitat enhancements that could be proposed for the Settlement Agreement. The proposed enhancements should provide benefits to various life stages of Centrarchids (spawning and fry rearing) within Monticello Reservoir. The deep-water structures should provide habitat for several types of adult fish and enhance fishing opportunities in the reservoir. While Centrarchids are the primary focus of the listed aquatic habitat enhancements, the stable structures may provide additional benefits to other species of fish and aquatic biota (mussels and macroinvertebrates).

[1] A Fisheries TWC meeting was held on March 3, 2016 to discuss this report. Meeting notes are included in Appendix D.

6.0 REFERENCES

Orbis. 2015. Contractor for collection of Photogrammetry data and conversion to a Digital Elevation Model for Parr and Monticello Reservoirs, March 2015.

Kleinschmidt. 2013. *Baseline Fisheries Resources Report: Parr Hydroelectric Project*. Prepared for SCE&G by Kleinschmidt Associates, Lexington, SC. November 2013.

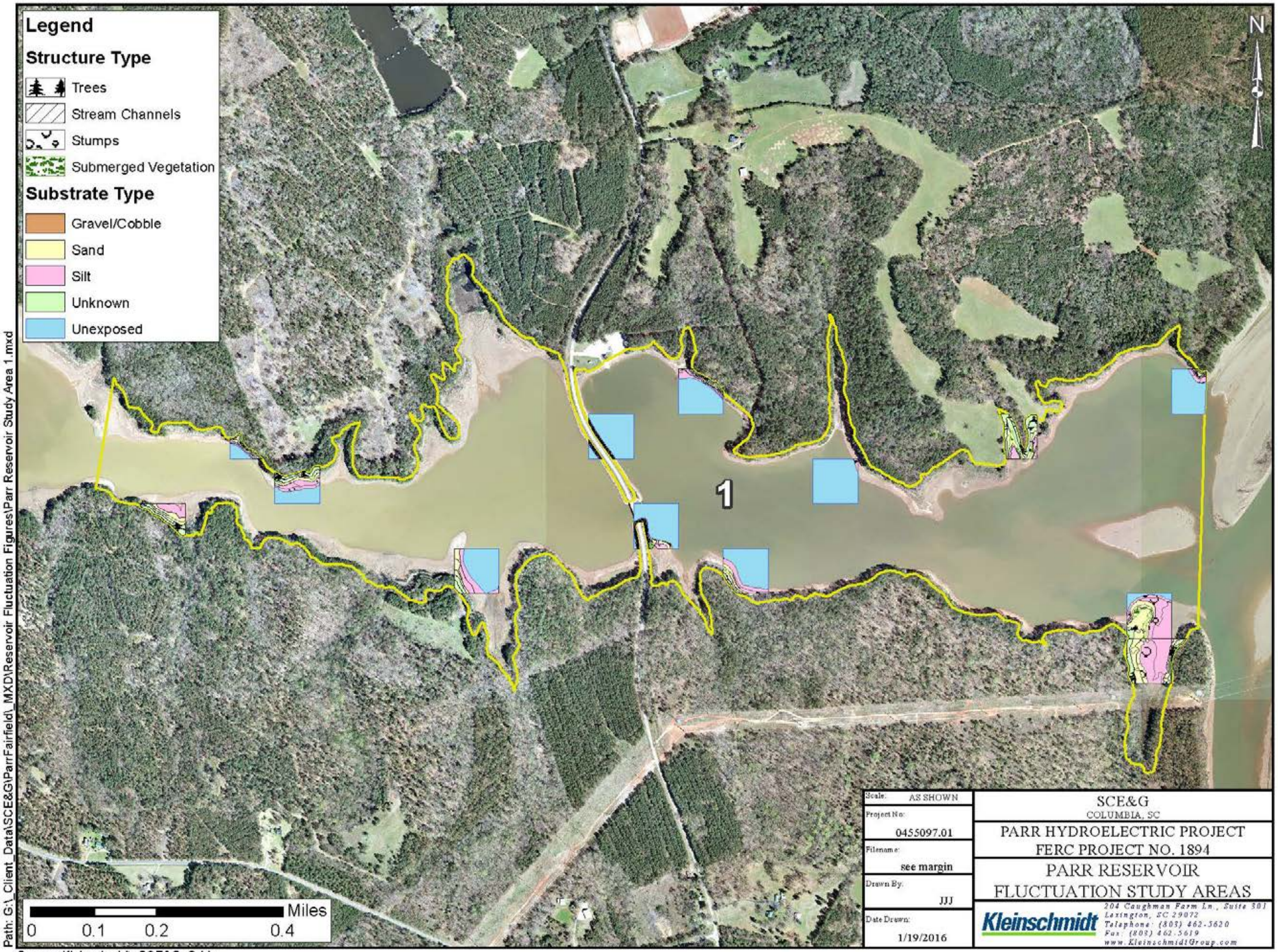
Mossback Fish Habitat. www.mossbackrack.com. Web. January 2015.

Mealing, H. (December 2015). Personal Communication. Parr Reservoir Fisheries TWC Site Visit, March 2015.

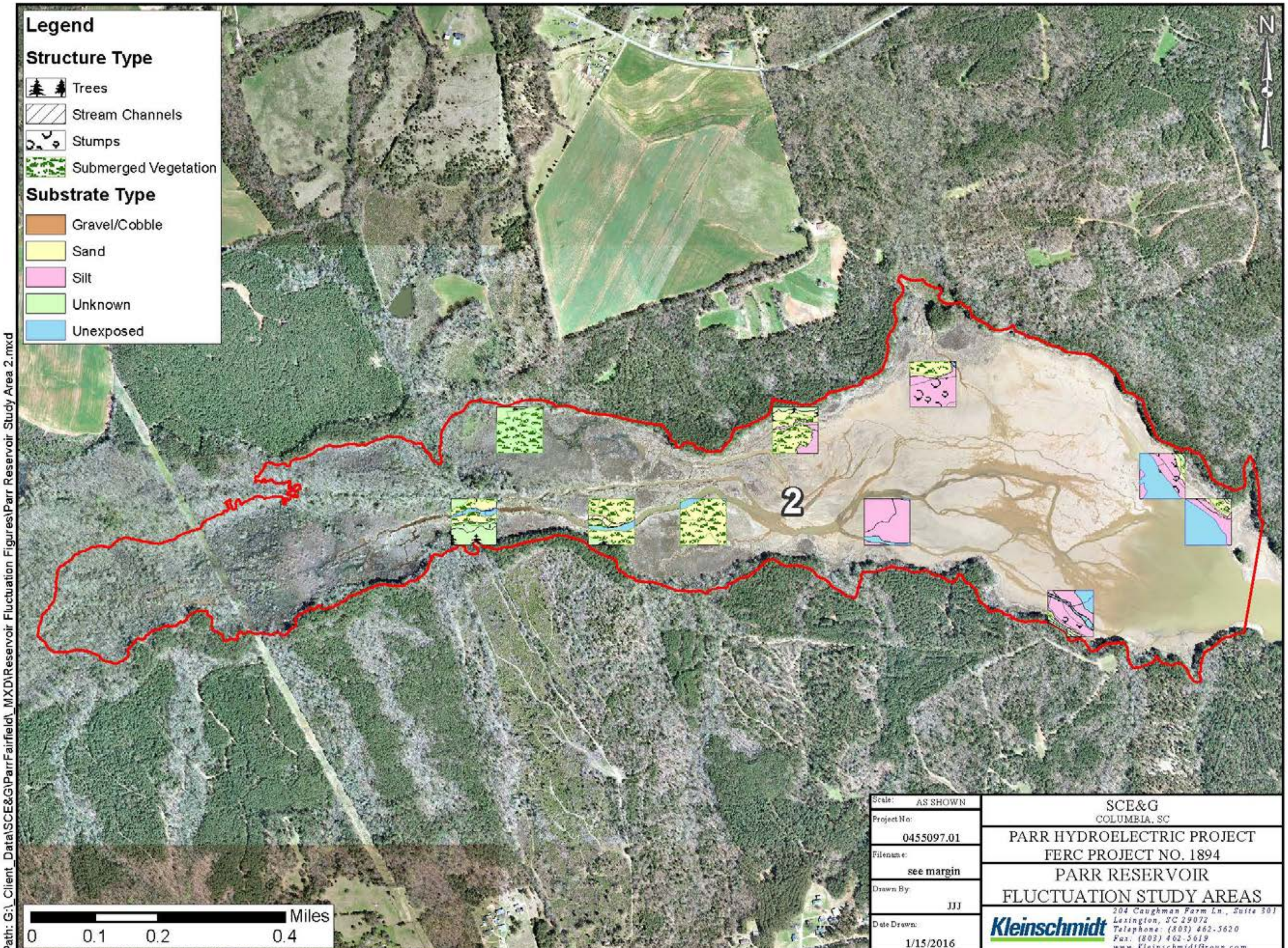
SCANA Services, Inc. 2016. Fish Community Assessment of Parr Reservoir 2015. Summary of fish collections in Parr Reservoir from 2012-2015.

APPENDIX A

PARR RESERVOIR STUDY AREAS



Source: Kleinschmidt, SCE&G, Orbis



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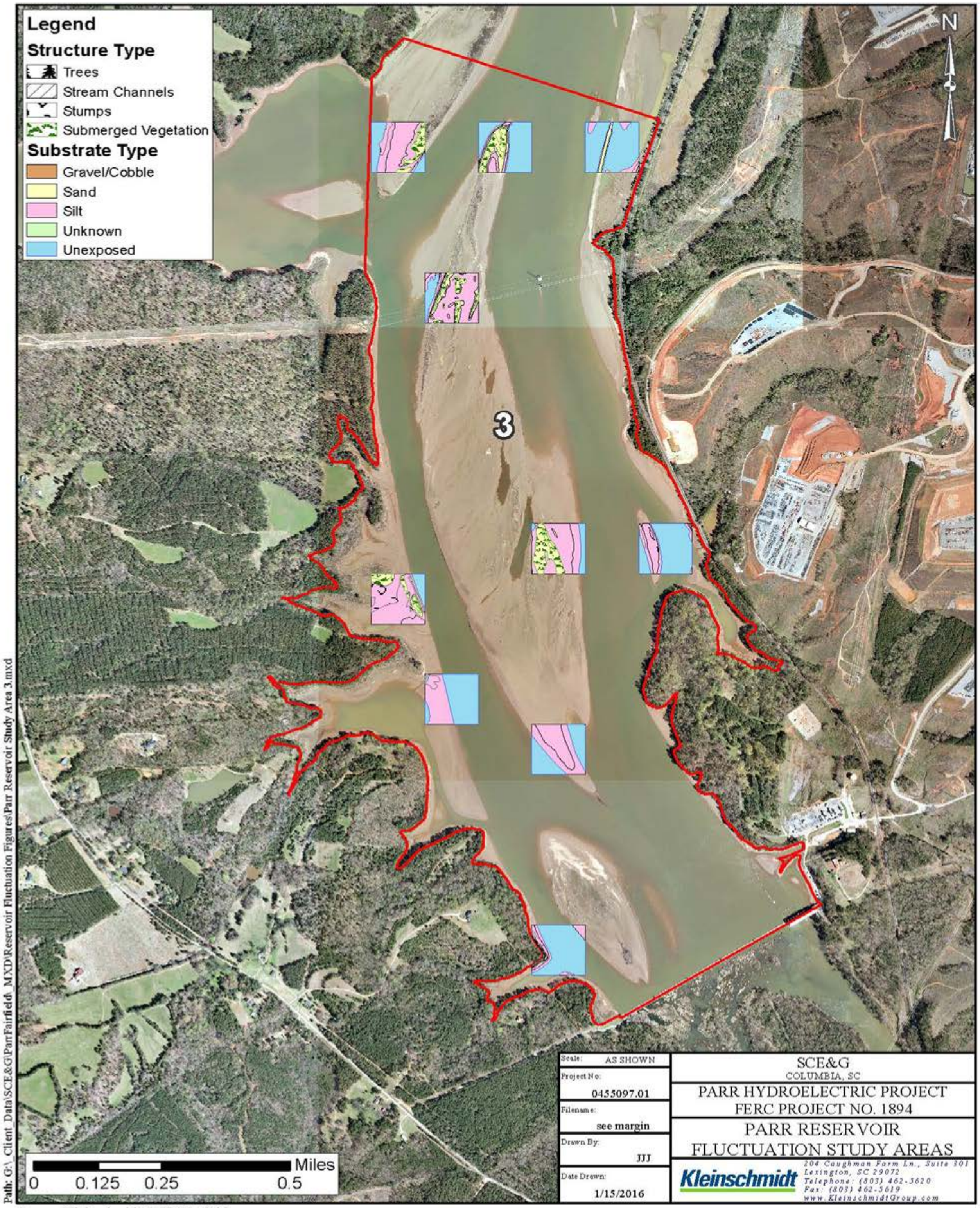
Source: Kleinschmidt, SCE&G, Orbis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Structure Type
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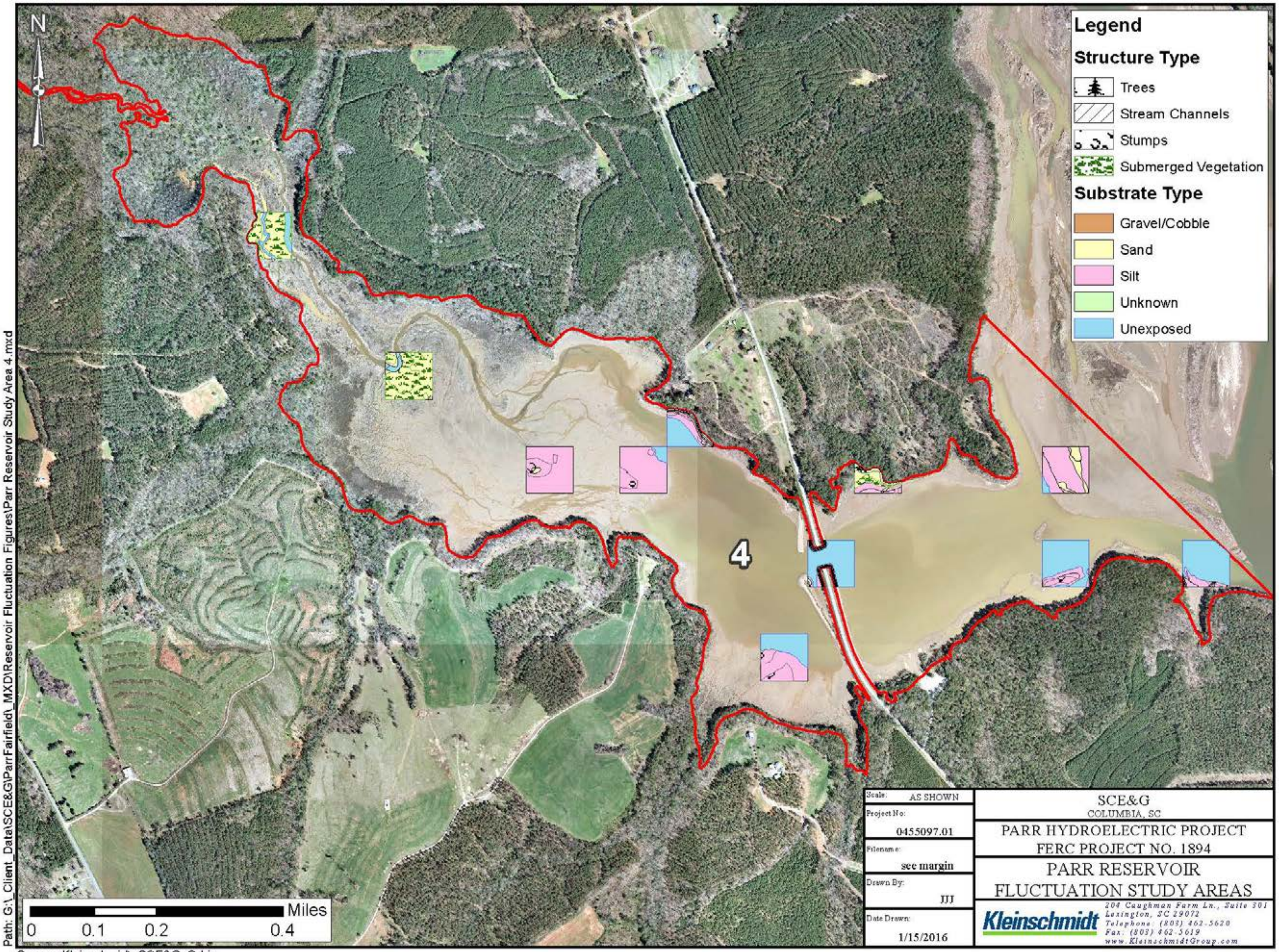
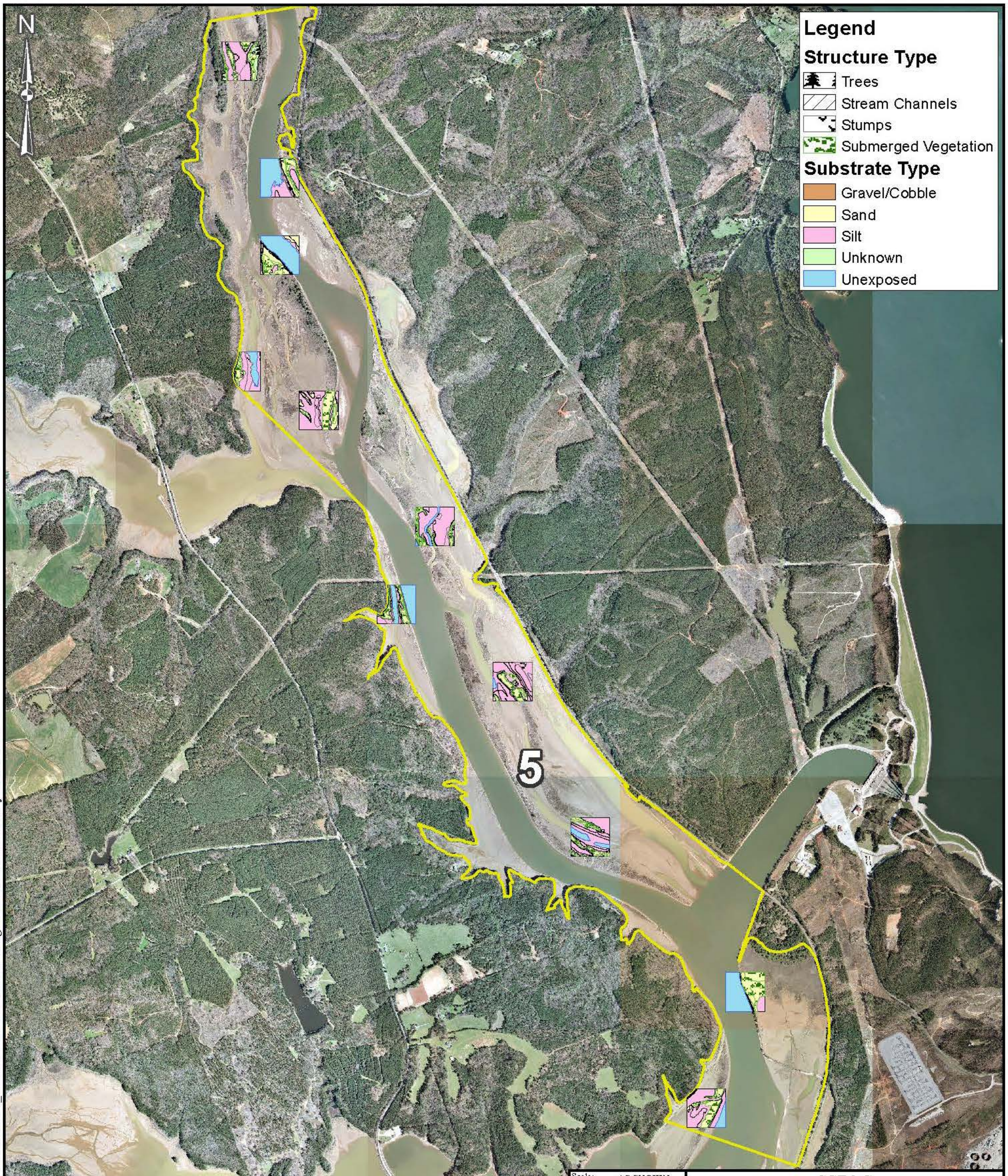
Stream Channels
Stumps
Submerged Vegetation
Substrate Type
Gravel/Cobble
Sand
Silt
Unknown
Unexposed
N
3
Miles
0 0.125 0.25 0.5
Scale: AS SHOWN
Project No: 0455097.01
Filename: see margin
Drawn By: JJJ
Date Drawn: 1/15/2016
SCE&G
COLUMBIA, SC
PARR HYDROELECTRIC PROJECT
FERC PROJECT NO. 1894
PARR RESERVOIR
FLUCTUATION STUDY AREAS
Kleinschmidt
204 Caughman Farm Ln., Suite 301
Lexington, SC 29072
Telephone: (803) 462-5620
Fax: (803) 462-5619
www.KleinschmidtGroup.com
Path: G:_Client_Data\SCE&G\ParrFairfield_MXD\Reservoir Fluctuation Figures\Parr Reservoir Study Area 3.mxd



Source: Kleinschmidt, SCE&G, Orbis



Scale: AS SHOWN	SCE&G COLUMBIA, SC
Project No: 0455097.01	PARR HYDROELECTRIC PROJECT FERC PROJECT NO. 1894
Filename: see margin	PARR RESERVOIR FLUCTUATION STUDY AREAS
Drawn By: JJJ	Kleinschmidt 204 Caughman Farm Ln., Suite 301 Lexington, SC 29072 Telephone: (803) 462-5620 Fax: (803) 462-5619 www.KleinschmidtGroup.com
Date Drawn: 1/15/2016	

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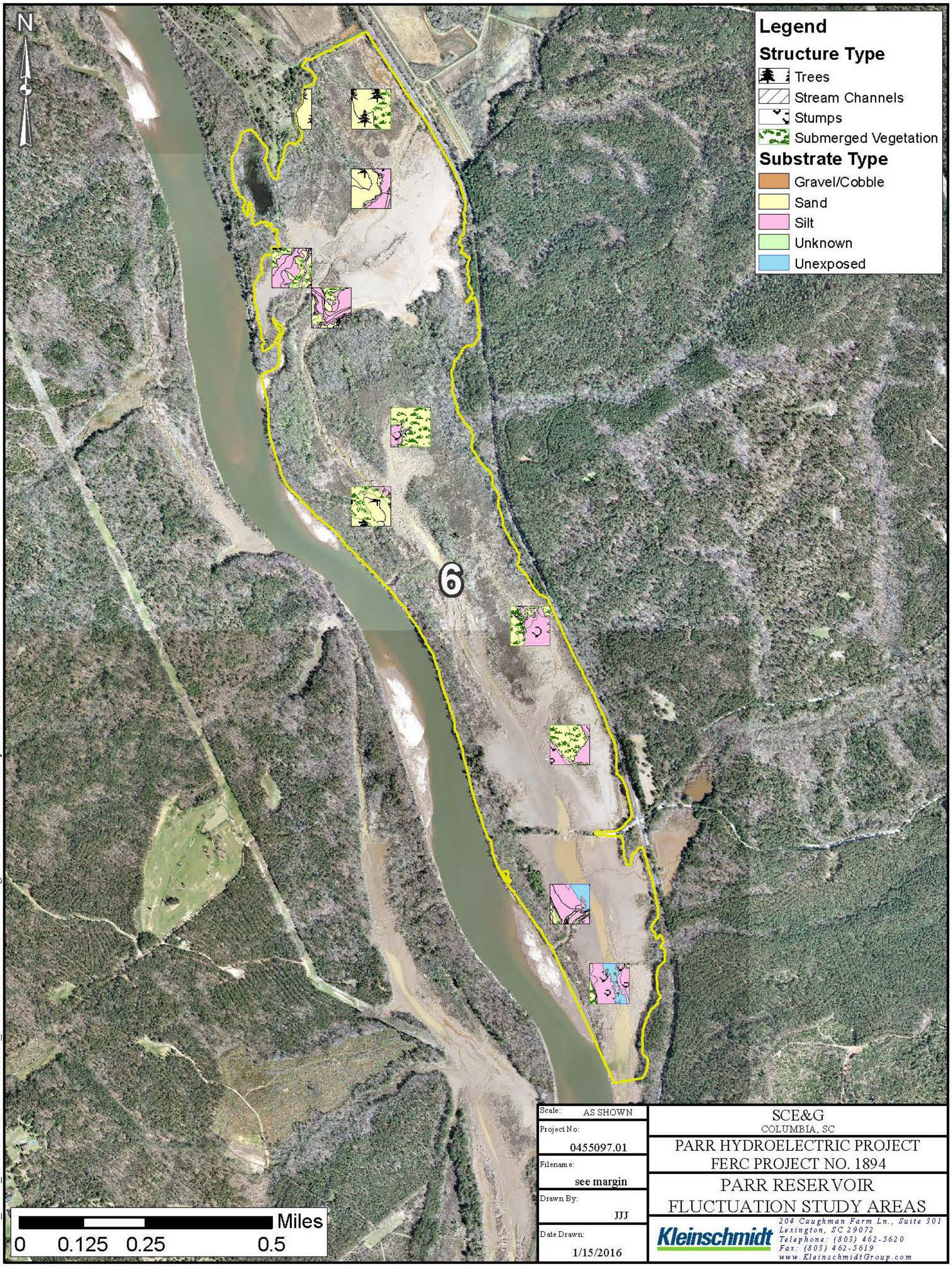
Source: Kleinschmidt, SCE&G, Orbis



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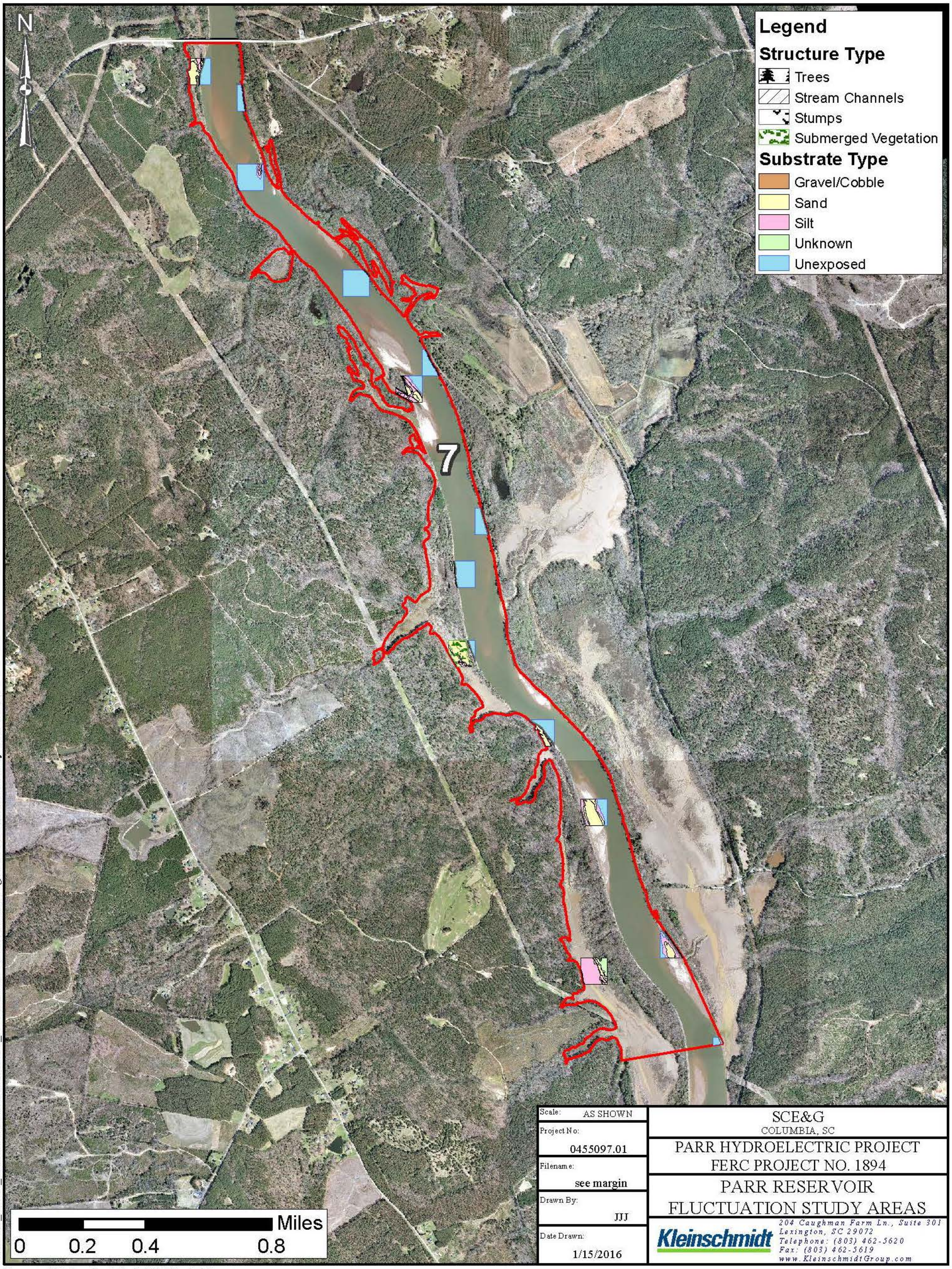

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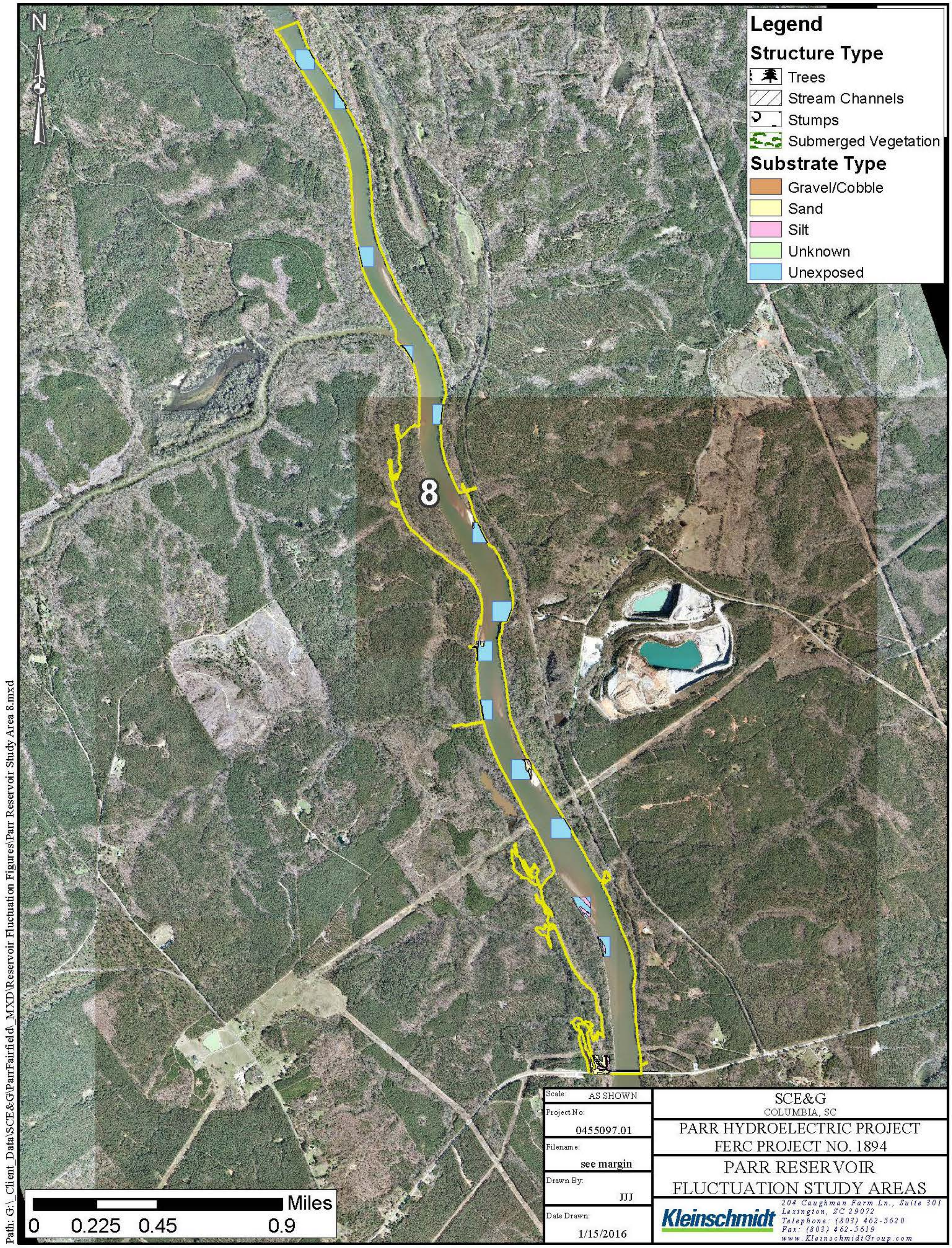

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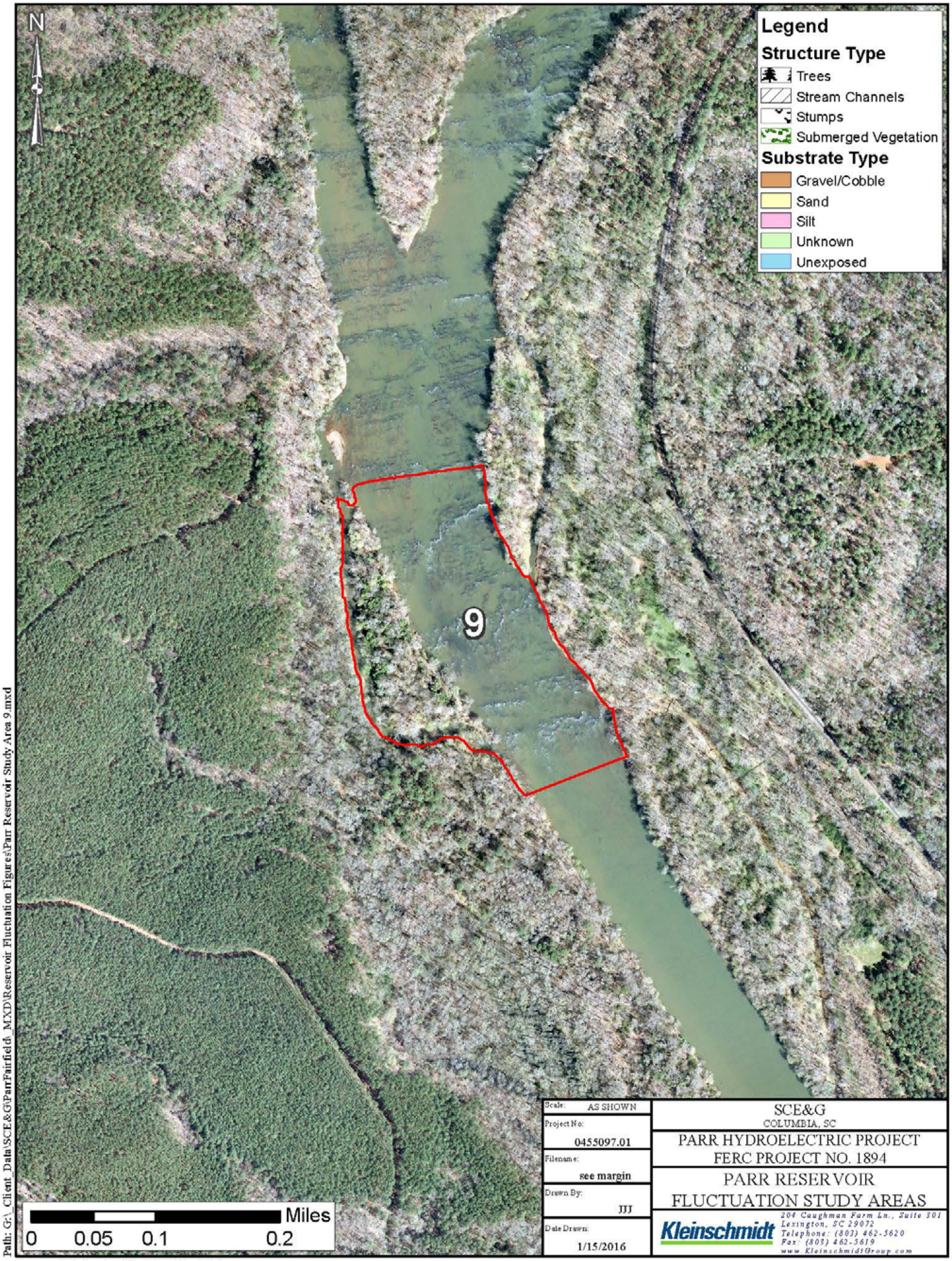

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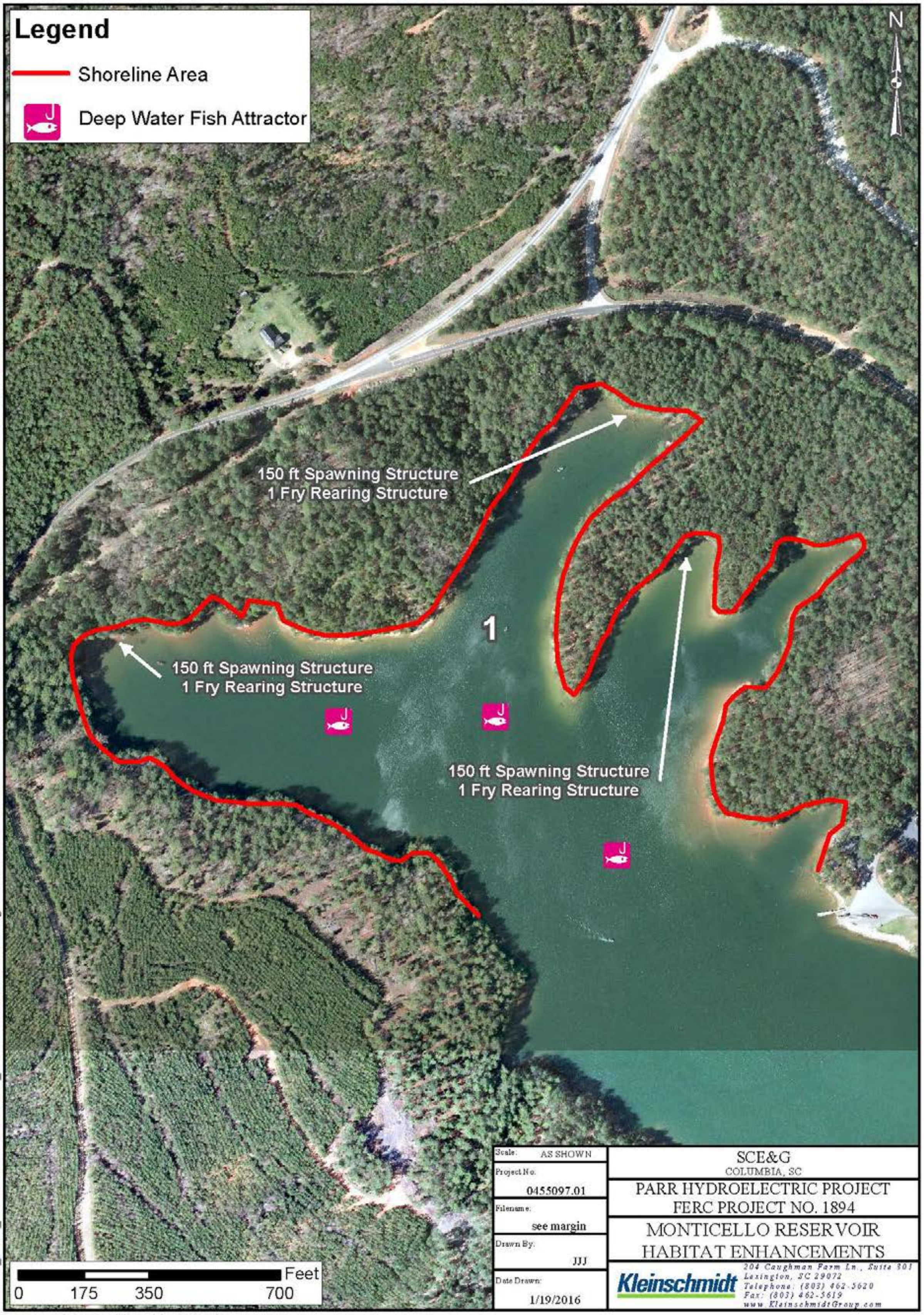
Source: Kleinschmidt, SCE&G, Orbis

APPENDIX B

MONTICELLO RESERVOIR STUDY AREA HABITAT ENCHANTMENTS



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Source: Kleinschmidt, Orbis, SCE&G

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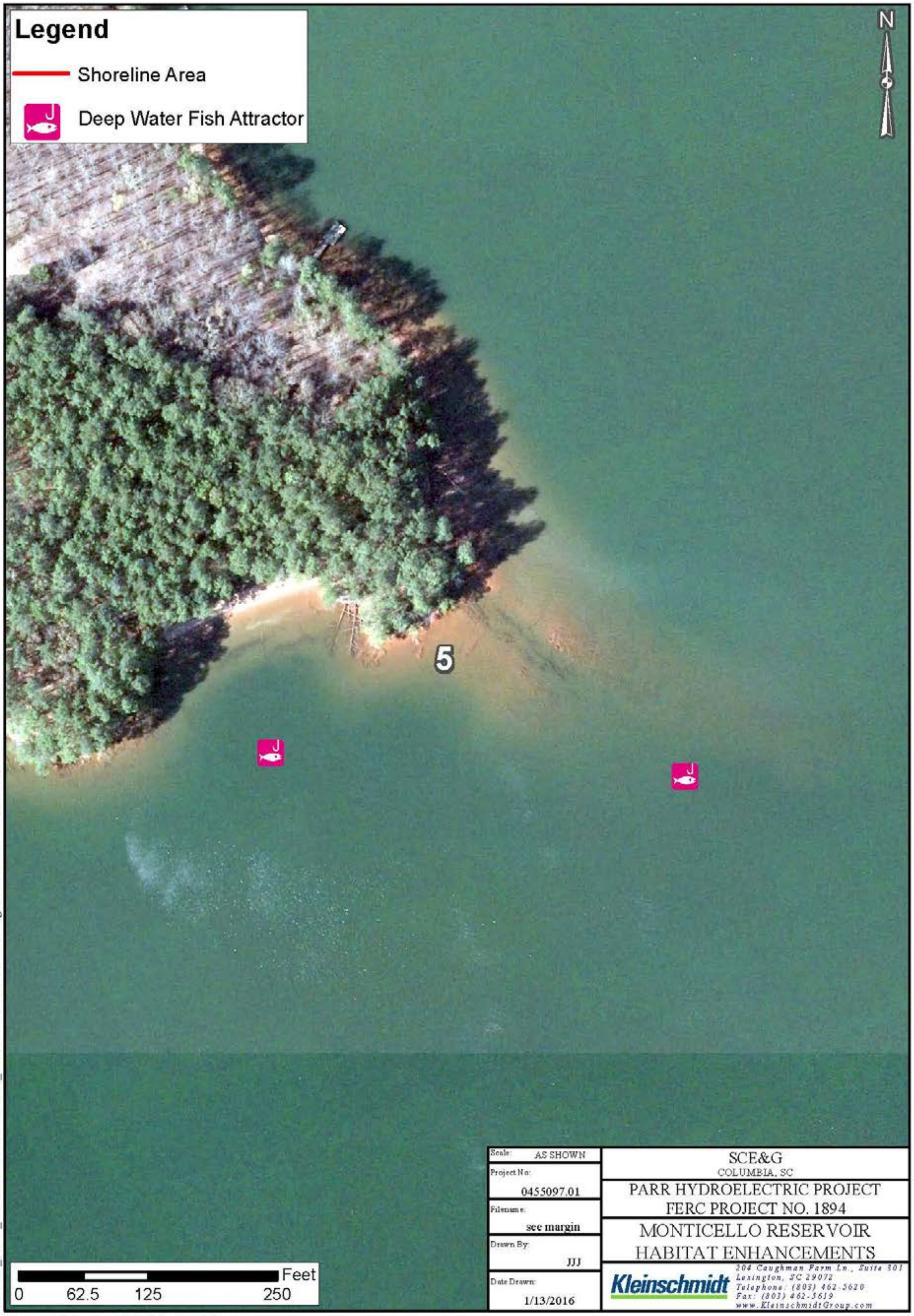

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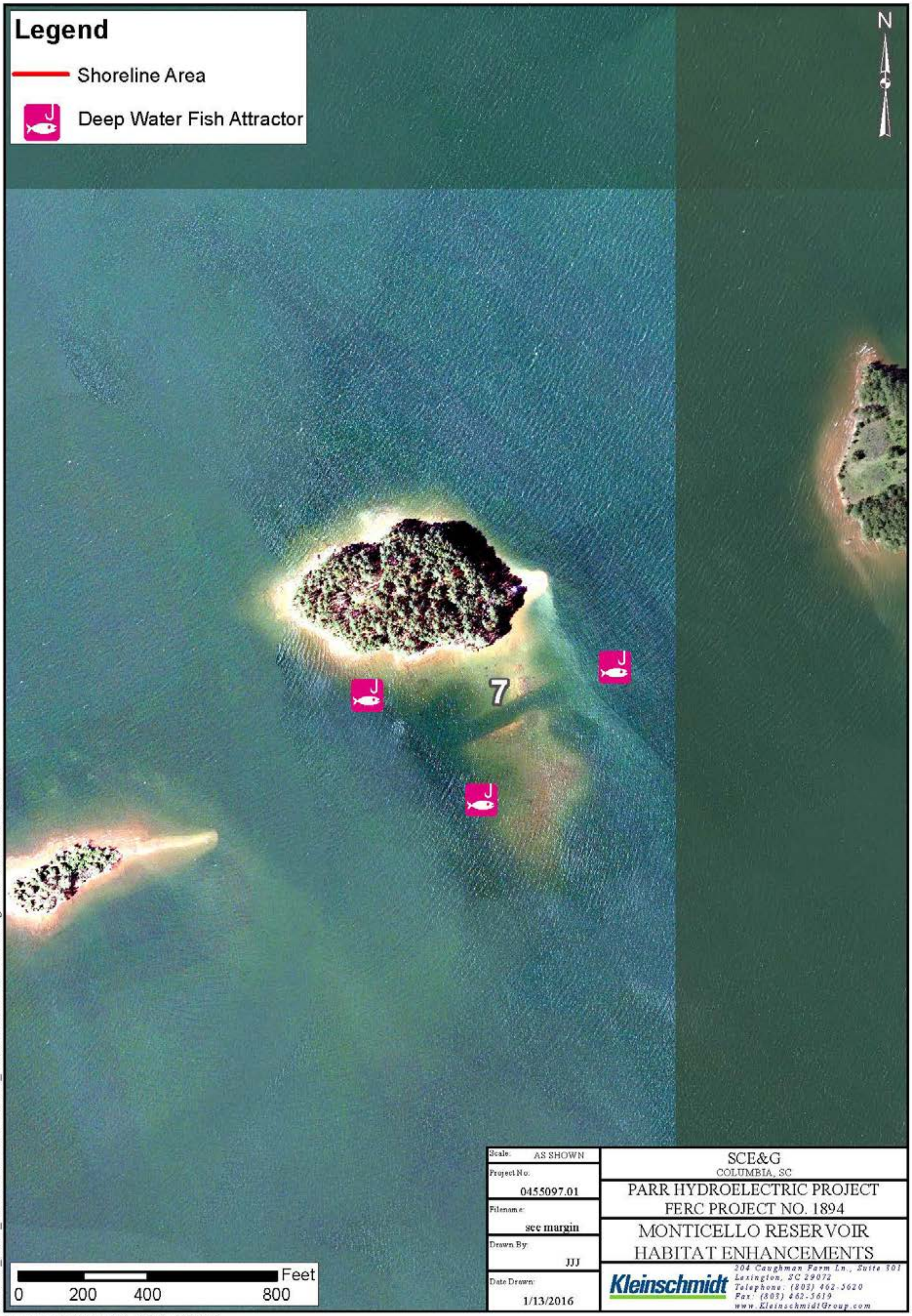

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Source: Kleinschmidt, Orbis, SCE&G

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Source: Kleinschmidt, Orbis, SCE&G

Source: Kleinschmidt, Orbis, SCE&G

APPENDIX C

MOSSBACK FISH HABITAT STRUCTURE COSTS

TABLE 4-1 MOSSBACK FISH HABITAT STRUCTURE COSTS

MOSSBACK FISH ATTRACTOR KITS	
Juvenile Structure	Cost
Fry Cage	$499.95
Safe Haven 5-Post	$224.95
Safe Haven 9-Post	$529.95
Adult Structure	Cost
MB1 Trophy Tree	$324.95
MB2 Trophy Tree	$599.95
Reef Kit	$499.95
Mega Reef Kit	$1,129.95

APPENDIX D

FISHERIES TWC MEETING NOTES
MARCH 3, 2016

MEETING NOTES

SOUTH CAROLINA ELECTRIC & GAS COMPANY
Fisheries TWC Meeting

March 3, 2016

Final KMK 03-07-16

ATTENDEES:

Bill Argentieri (SCE&G)
Ray Ammarell (SCE&G)
Randy Mahan (SCE&G)
Brandon Stutts (SCANA)
Caleb Gaston (SCANA)
Tom McCoy (USFWS) via conf. call
Fritz Rohde (NOAA) via conf. call
Dick Christie (SCDNR)
Bill Marshall (SCDNR)
Alex Pellett (SCDNR) via conf. call
Henry Mealing (Kleinschmidt)
Kelly Kirven (Kleinschmidt)
Jordan Johnson (Kleinschmidt)

These notes serve as a summary of the major points presented during the meeting and are not intended to be a transcript or analysis of the meeting.

Henry opened the meeting with introductions and told the group the purpose of the meeting was to review the Reservoir Fluctuation Report and identify any Protection, Mitigation and Enhancement (PM&E) measures that might be associated with fluctuation of Parr and Monticello reservoirs.

Parr Reservoir

Henry explained the methodology included in the study, where Parr Reservoir was divided into nine segments and 10% of each segment was analyzed to determine how much and what type of habitat was dewatered at each 2 foot increments from 266 down to 256.1 msl.

TWC members had expressed concern over the fluctuation of Parr Reservoir, and so the group tried to identify ways to improve habitat and navigation in the reservoir.

Bill M. asked for ways that navigation could be improved when the reservoir was low. Henry said that at Heller's Creek, stumps could be removed, however this would also remove important fish habitat. Bill M. suggested that only some stumps be removed, to allow for better navigation, but to still provide some fish habitat. Henry said that improving access from Heller's Landing could be considered as a PM&E measure.

Dick said another idea would be to limit fluctuations on both Parr and Monticello reservoirs during spring fish spawning. He understands that this is a difficult issue to address and that this could be something that is done only when conditions allow. Bill A. asked if it's more important to keep the habitat wetted or dry and Dick said that it's more important for the reservoir level to remain stable. Ideally, both reservoirs would be full and stable during spawning, however if the reservoir can't be full, then they should be stable, so fish nests aren't left dry when the water level drops. Bill A. and

Ray said they would talk with operators to see if this is possible. It would also depend on how much water is coming from upstream, although in the spring, generally there is excess water, which may make it easier to hold the reservoir at a steady level.

Henry said that Ron Ahle (SCDNR) had mentioned in a previous TWC meeting that it would be nice to stabilize one of the side channels as a small impoundment in Parr Reservoir, similar to the Recreation Lake at Monticello Reservoir, as a PM&E measure. The group discussed the possibility of this and how the US Army Corps of Engineers (USACE) might handle it. The group looked at maps of Parr and identified a small side channel area as the potential site for an impoundment. Brandon said it would likely be difficult to obtain a permit, plus mitigation would need to be done to account for the loss of wetlands or streams. The railroad would also need to be contacted to see how this would possibly affect their operations, since the railroad tracks run close to the area in question. Caleb also mentioned that duck hunters would need to be considered, since this proposed area for the impoundment is a heavily used location for duck hunting. Navigation into and out of this area could become an issue.

The group also listed the following items for consideration regarding the impoundment:

- build a berm or gate around the 262' or 260' mark, approximately 125 feet long
- the impoundment would need to be somewhat small, so it wouldn't affect storage in Parr (how many acre feet would this take away from operations)
- build a temporary structure that could be installed only during the spring (March, April, May), so sediment doesn't build up, hunting isn't affected, and water doesn't get stagnant
- potentially build a boat ramp that allows for access inside the impoundment (could be considered a recreation enhancement as well)

Tom was concerned about how this structure may cause navigation issues and possible sediment issues for fish and mussels when removed each year. He indicated that a permanent structure, such as a rice trunk, may be the best option. The group decided that this option needs to be discussed further, both internally for SCE&G and externally with the USACE.

Henry said the take-home message regarding Parr Reservoir fluctuations is that SCE&G doesn't bring the pond level up to 266' very often, as evidenced by the amount of vegetation growing in the upper contours. Below elevation 260', substrate is mainly sand and silt with large numbers of stumps. There is a large amount of natural structure occurring lower in the reservoir along the shorelines, while the upstream sections of the reservoir are more riverine.

Monticello Reservoir

One of the goals identified by the TWC in the Study Plan was to focus on identifying PM&E measures in this reservoir to enhance spawning/recruitment/and fishing to mitigate for fluctuations. Prior to the meeting, Dick prepared and distributed a document outlining potential enhancements for Monticello Reservoir, from SCDNR's perspective. This document is attached to the end of these notes.

Bill A. asked how SCE&G will show compliance with some of the enhancements that Dick proposed. Dick said that license articles could be worded to require consultation with agencies. Implementation of enhancements can be documented and agencies would send in letters of confirmation that work was completed. He is not concerned with performing creel surveys or other studies to prove that enhancements are improving fish recruitment in the reservoir. He believes that the enhancements he is proposing have already been proven in many studies in other reservoirs to increase fish production. The installation of these enhancements should be considered successful compliance with the license article.

SCE&G said they are concerned about some of the proposed enhancements, including the amount of gravel needed and possible re-contouring of shorelines. Dick said these are just examples of some things that can be done, but SCDNR would be willing to negotiate on these items. He said that ideally, SCE&G would install all of the agreed upon enhancements versus just providing the funding for work to be done. However, SCDNR may be able to provide some assistance during installation, in the way of boats or technicians.

The group discussed the different ideas that Dick presented and agreed that a PM&E measure could address installing three different types of fish habitat: spawning, nursery, and deep water, which agrees with the report. Some of the attractors could be purchased from Mossback, or a similar company, and some could be built by SCE&G. Brandon and Caleb brought an example of a deep water attractor to the meeting that they built using scrap parts. A photo is included below.

PHOTO 1 DEEP WATER FISH ATTRACTOR BUILT BY SCE&G

The TWC and report initially identified “9 enhancement areas” on Monticello. The group discussed these and other areas of the reservoir and identified approximately 20 areas around the lake where spawning, nursery, and/or deep water fish attractors could be installed. Some of the 20 areas included all three components, while others included only one or two. The group agreed to the following specifics for each habitat type:

- Spawning – areas will be approximately 1000ft x 10ft, and will include up to 200 spawning disks or gravel beds – spawning disks will be installed in groups of 3-5
- Nursery – areas will be paired with spawning sites above and will include approximately 15 nursery/fry structures, such as the fry cage built by Mossback or handmade stake beds or bamboo structures built by SCE&G.
- Deep water – each deep water site will be approximately 1500 square feet, with approximately 15 structures scattered around a central buoy. Structures can be constructed by SCE&G or purchased from Mossback.

SCE&G and Kleinschmidt will put together a PM&E proposal that addresses site location, cost estimation, and installation schedule. This will be brought back to the TWC for review and discussion. The group discussed several different schedules for the term of the new license, including installing enhancements in two sessions several years apart, or installing one or two sites per year for 15 years. The group also discussed prioritizing sites and installing in phases during the first 30 years of the license. Everyone agreed that at least one pause in the timeline is necessary for a check and adjust on the process.

Kleinschmidt will order a few fish attractors from Mossback to use for testing. The TWC will plan to meet at the reservoir later in the spring to field verify the sites identified and possibly install a few fish attractors to determine level of difficulty. Dick noted that Robert Stroud (SCDNR) should be involved, since he is the SCDNR representative assigned to Monticello Reservoir. Scott Collins (SCE&G) will also be consulted to ensure that the sites identified are not located in areas where docks can be permitted.

The meeting adjourned. Action items from this meeting are listed below.

ACTION ITEMS:

- SCE&G will discuss internally the option of building a berm at the site on Parr Reservoir identified in the meeting. Depending on the outcome of this discussion, they, potentially along with SCDNR, will talk with USACE about permitting this action.
- SCE&G and Kleinschmidt will put together a PM&E proposal detailing the next steps for installing fish habitat enhancement in Monticello Reservoir – types, places, timeline.
- Kleinschmidt will order some fish attractors from Mossback for testing.
- The TWC will meet later in the spring to visit the Monticello Reservoir sites identified in the meeting for fish habitat enhancement.

Aquatic habitat enhancement in Monticello Reservoir

Monticello Reservoir is a 6,800 acre impoundment associated with the Parr Shoals Hydroelectric Project (project). This project is a pump-back project that utilizes the Fairfield Pumped Storage Facility to generate electricity and refill the lake. The project has the capacity to transfer up to 29,000 acre-feet of water between Parr Shoals reservoir and Lake Monticello, and for the period 2005-2013, average daily fluctuations in Lake Monticello were 2.35 feet. However, the authorized daily operational range is 4.5 feet, which could result in a minimum reservoir level (MRL) of 420.5 feet and should be considered in the placement of any fish habitat.

When the project is operated at the minimum reservoir levels, the surface acreage is reduced from 6,800 acres to 6,467 acres, which results in the dewatering of about 333 acres or (14.5 million sq. feet) This shoreline, which is exposed on a daily basis, is generally devoid of aquatic or terrestrial vegetation, woody debris, or other structure that could provide habitat for aquatic organisms. Much of this shoreline is a silt/clay hardpan material.

To mitigate project effects on littoral habitat, the fisheries technical working committee (TWC) is developing a proposal to supplement aquatic habitat in Monticello Reservoir. The TWC recommended 1) enhancements should provide habitat for spawning, nursery area and deep water cover; 2) they should be installed in close proximity to facilitate movements from one habitat type to another; and 3) ideal spawning habitat would be located in the backs of coves protected from the wind.

Draft DNR Proposal: DNR recommends a robust fisheries enhancement program be implemented over the term of the new license. If the new license is issued for a term of 30-years, we recommend enhancement of a minimum of 15 coves on Lake Monticello. In the event a License is issued for more than 30 years, an additional 5 coves should be enhanced for each additional 10-year period. Enhancement efforts should focus on the creation of spawning, nursery and deep water cover or attraction habitats. In keeping with proposed language in the General Permit (GP) for Lake Monticello, *inshore enhancements* would include spawning and nursery habitats, and be placed in shallow water areas along shorelines and within coves, in a minimum depth of 3 feet below MRL (with the exception of felled or hinged trees). Ideal areas for inshore structures exist in areas with little to no human habitation, docks, piers or boat landings. *Open water enhancements* would be located in deep water areas away from shorelines, in water depths where the tops of the structures would be a minimum of 6 (?) feet below MRL and would not interfere with navigation. Ideal areas for open water structures exist where the absence of aquatic vegetation, submerged woody debris, or topographical depressions may provide natural fish habitat.

Spawning habitat – Cove selection is important and should be conducted in coordination with the resource agencies. Selected coves would be enhanced with structure that provides substrate suitable for spawning and cover to attract spawning fish and to provide protection for fry. Area covered (square feet) is probably more important than height (cubic feet) for spawning habitat. Spawning habitat should cover an area ranging from about 0.25 to 1 acre in each cove, which would result in a total reservoir enhancement of between 3.75 and 15 acres. Each area would be from 1000 – 2000 linear feet in length and 10-20 feet wide, depending on topography, and these areas would be located primarily in the backs of coves.

Enhancement materials could include, but are not limited to:

- gravel beds 3-4 inches in depth with aggregate ranging in size from pea gravel to crusher run (or native stone equivalent);
- spawning benches created by utilizing a 4 to 6 foot piece of log sawed lengthwise in half and attached to cinder blocks on each end; and
- spawning discs such as the Honey Hole spawning disc. Honey Hole recommends installing up to 24 discs per acre in groups of 3 to 8. We are thinking that a minimum of 200 discs/1000 linear feet of shoreline may be adequate if used alone, fewer if other spawning habitats are also used.

A combination of these various habitat types is recommended. Rock jetties less than 2 feet high and or stump fields and felled trees should be placed near the spawning habitat to provide cover for all life stages and to stabilize gravel. During periods of low water levels, exposed lake bottoms may be re-contoured to excavate a shallow depression in which to hold gravel for spawning beds. All of the structures utilized to provide spawning habitat would be generally located in water depths of 3 – 6 feet below MRL and marked with appropriate signage and/or noted with downloadable GPS data.

Nursery habitat – for each cove, several shallow water structures should be established to serve as nursery habitat. These structures should be designed to provide cover for fry and juveniles and substrate for periphyton, and would be placed near the spawning areas and in depths of water ranging from 6 -10 feet at MRL. The goal would be to establish a minimum of 2-3 "nursery areas" associated with each spawning area, each consisting of a minimum of 12 habitat units (8 feet by 8 feet) spread over an 800 -1000 square foot area. Some vertical profile is important (2-4 feet tall) for this habitat type, as is the need for numerous small interstitial spaces that exclude fish larger than 6 inches. Enhancement areas would be marked with appropriate signage and/or noted with downloadable GPS data.

Enhancement materials for nursery habitat could include:

- rock jetties 3-4 feet tall;
- stump fields;
- a combination of rock jetties and stump fields;
- concrete or corrugated culverts no greater than 24 inches in diameter;
- homemade pvc attractors;

- commercial artificial structures such as the Mossback safehaven or 9-post safehaven structures; and
- low-profile horizontal bamboo bream nursery mats.

Open water habitat - open water habitat enhancement (fish attractors) will be established at suitable locations, and would generally be located in the proximity of the spawning/nursery area enhancements but could also be located in other areas as determined by the TWC. The purpose of these areas is to enhance structure and habitat to provide cover, feeding areas and attraction for larger fish, and they would be placed in water depths between 12 and 20 feet at MRL. Vertical profile is very important for attraction habitat. The goal would be to establish at least one attractor per cove, and each attractor should cover at least 2,000 square feet (1/10 of a surface acre) and provide vertical profile (50% of water depth). All open water enhancement areas would be marked with "Coast Guard" yellow fish attractor buoys.

Enhancement materials for open water attractors could include:

- homemade PVC;
- small and large diameter corrugated and/or concrete pipe;
- concrete products or clean construction debris;
- bamboo, recycled coniferous trees and other large woody debris with concrete block anchors;
- commercially available products such as the larger Mossback safehaven structures.

Staging areas - Designated staging areas will need to be developed at Lake Monticello. These could be at existing lake access areas, or could be in areas previously used by SCDNR for Canada Geese restoration activities. Best Management Practices will be incorporated throughout the use of these areas as temporary staging for loading of materials. The proposed materials may be transported by boat or barge to a site from the designated staging areas and placed. Because of the high fluctuations in water levels, it will be necessary to use heavy materials to insure they remain where they are deployed. A mini-excavator and a skid-loader (or similar equipment) will be needed to load and off-load the material to and from the barge.

Excavation may be required in order for habitat barges to reach staging areas for load of material. Excavation is limited to the minimum necessary for access to temporary staging areas, and excavated material must be properly disposed of on an upland site. All disposed material shall be properly stabilized or contained so as to preclude entry into any surface waters, wetlands, streams or any other waters of the United States, or public property. The disposed material shall not affect cultural or historic resources or threatened or endangered species. All disposal sites must be authorized by the lake manager.

Material outlined above (ex. large rock, logs, gravel) may be used to form a temporary ramp or nosing area to load material onto boat or barge from the staging area. Stabilization of the shoreline using a rock loading ramp will prevent gouging and shoreline erosion during construction. Temporary matting may also be used where applicable. When appropriate the materials in the loading/nosing areas will be removed, though some residual material may be left in place as bank stabilization and/or habitat enhancement (i.e. gravel beds) where applicable.

Approach – SCE&G would ultimately be responsible for conducting this work. DNR will consult with SCE&G to identify the specific areas for enhancement, to develop cove-specific descriptions of the enhancement activities, and to provide other guidance as needed for the selection of enhancement materials and deployment. We recommend that the project be phased over the term of the new license by the establishment of 10-year work periods. Annual meetings would be held to discuss the progress and accomplishments of the program and to conduct planning and coordination for annual activities. A 10-year meeting would be conducted in the last year of the work period to discuss and formulate the next 10-year work plan.

Exhibit E-5 Fisheries Resources

Monticello Fisheries Habitat Enhancement Plan

MONTICELLO RESERVOIR FISHERIES HABITAT ENHANCEMENT PLAN

PARR HYDROELECTRIC PROJECT

FERC NO. 1894

Prepared for:

South Carolina Electric & Gas Company
Cayce, South Carolina

Prepared by:

Kleinschmidt

Lexington, South Carolina
www.KleinschmidtGroup.com

October 2017

MONTICELLO RESERVOIR
FISHERIES HABITAT ENHANCEMENT PLAN

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FERC NO. 1894

SOUTH CAROLINA ELECTRIC & GAS COMPANY

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PARR HYDROELECTRIC PROJECT
FERC NO. 1894

SOUTH CAROLINA ELECTRIC & GAS COMPANY

1.0 INTRODUCTION

South Carolina Electric & Gas Company (SCE&G) is the Licensee of the Parr Hydroelectric Project (FERC No. 1894) (Project). The Project consists of the Parr Shoals Development and the Fairfield Pumped Storage Development. Both developments are located along the Broad River in Fairfield and Newberry Counties, South Carolina.

The Project is currently involved in a relicensing process which involves cooperation between SCE&G, as licensee, and a variety of stakeholders including state and federal resource agencies, state and local government, non-governmental organizations (NGOs), and interested individuals. SCE&G established several Technical Working Committees (TWCs) comprised of interested stakeholders with the objective of identifying Project-related resource issues and impacts.

During issue scoping meetings, the Fisheries TWC identified the need for a Reservoir Fluctuation Study on the Parr and Monticello Reservoirs. The operating regime for the Project consists of a lowering and a refilling of the Project's two reservoirs on a daily basis. Monticello Reservoir is currently permitted to fluctuate up to 4.5 feet. However, the amount that the Project reservoirs fluctuate will vary dependent on load demands and system needs. The magnitude of daily fluctuations also varies seasonally in both impoundments, with the largest average daily fluctuations generally occurring in June, July, and August in both reservoirs (Table 1-1).

TABLE 1-1 MONTICELLO RESERVOIR MONTHLY AVERAGE ELEVATIONS: 2005-2013

MONTHLY AVERAGE RES. ELEV.			
	MAX	MIN	RANGE
Jan	423.92	422.32	1.60
Feb	423.93	422.45	1.49
Mar	423.82	422.18	1.66
Apr	424.08	421.88	2.22
May	424.42	421.64	2.80
June	424.74	421.42	3.33
Jul	424.69	421.38	3.29
Aug	424.71	421.31	3.40
Sep	424.53	421.45	3.06
Oct	424.02	421.83	2.18
Nov	423.61	422.00	1.61
Dec	423.86	422.28	1.58
AVERAGE	**424.19**	**421.84**	**2.35**

During February through April, when many fish species are spawning in shallow water habitat, average daily fluctuations range from 1.6-2.4 feet in Monticello Reservoir (TWC Meeting presentation 12-19-13). Resource agencies and stakeholders expressed concerns that these daily and seasonal fluctuations may be affecting aquatic habitat along the shorelines of the reservoirs and fish spawning and recruitment.

2.0 METHODS

This study report was developed as a result of the Monticello Reservoir Fluctuation Study to assess the effects of fluctuations on reservoir habitat. The bases for this study can be found in the following documents: Fisheries TWC Meeting notes from April 2014, September 2015, March 2016, and May 2016, the Revised Reservoir Fluctuation Study Plan, and the Parr and Monticello Reservoir Fluctuation Study. The April 2014 TWC meeting identified the study objectives relative to each reservoir. It was decided that Monticello would be assessed qualitatively to identify areas that could be candidates for habitat enhancement. The September 2015 meeting identified potential habitat enhancement areas and the types of enhancements that would be explored: spawning, nursery, and deep-water. The subsequent March 2016 meeting involved discussions of the findings of the Reservoir Fluctuation Study and refining of the habitat enhancements for Monticello Reservoir. The group further refined the types of structures that could be used for each enhancement and the amount of enhancement that could be provided to an identified area. The final TWC meeting in May 2016 involved a site visit to Monticello Reservoir to confirm the potential enhancement sites and the exact location and amount of enhancements that could be installed at a given site.

3.0 RESULTS

The TWC proposed potential fish habitat enhancements to be placed throughout Monticello Reservoir to mitigate for reservoir fluctuation impacts on current shoreline areas. Habitat enhancement structures would be installed to enhance spawning, nursery, and deep-water habitats available within Monticello Reservoir. The habitat enhancement structures would serve two purposes within the reservoir. First, the structures could provide enhanced fish production within the reservoir. Second, they would concentrate fish as an enhancement for recreational fishermen (Wagner 2016). Maps of the proposed locations within Monticello Reservoir for fish habitat enhancement are included in Appendix A. Descriptions for each proposed enhancement and total PM&E installation costs are presented in the following sections.

3.1 SPAWNING HABITAT ENHANCEMENTS

The proposed spawning habitat enhancements could be made by the installation of “spawning bed” structures. These structures would consist of commercially available three-foot diameter plastic pools (of varying color based upon vendor) (Figure 3-1) filled with 3-4 inches (in.) of pea gravel/sand. While the commercially available plastic pools were used for purposes of estimating costs and materials, the TWC suggested that other more permanent spawning structure materials may be considered. There were eight spawning areas identified by the TWC and spawning beds could be installed in each area identified for spawning habitat enhancement. The structures would be constructed on a pontoon style work boat and lowered into place via a three-point attachment rope system and winch. The enhancement locations would be located in areas that are approximately 5 to 6 feet deep when the reservoir is at full pool, leaving the spawning beds 0.5 to 1.5 feet underwater at the lowest reservoir elevation.

FIGURE 3-1 COMMERCIALLY AVAILABLE 3-FOOT DIAMETER PLASTIC POOL
(Color may vary based upon vendor selected.)

Timing of Installation

Due to TWC concerns over the resilience of the proposed spawning structures, these habitat enhancements will be installed and evaluated in a stepwise approach. The proposed number of spawning structures to be installed during the new license is 360. Based on TWC recommendations, SCE&G will install 15 spawning beds in each of the 8 coves identified for spawning habitat enhancement (Appendix A) within the first three years of the new license. The SCDNR may request to vary the spawning structure material, substrate material, and/or substrate depth to evaluate fish preferences. SCE&G and SCDNR will develop a matrix to test the effects of these variables. The installed spawning beds will be inspected by SCE&G (underwater camera observation) after two spawning seasons for condition and evidence of use by fish. SCE&G will report observations to SCDNR and consult on the installation of up to 240 (30 structures per 8 locations) additional spawning beds to be installed over the following two years.

3.2 NURSERY HABITAT ENHANCEMENTS

Nursery habitat enhancements could be made by the installation of Mossback Safe-Haven structures. The safe-haven structures are made up of three 50 inches tall PVC posts, 72 50 inches long composite limbs, a three-post base, and a three-hole shade top (Mossback 2016) (Figure 3-2). The nursery structures would be constructed on a pontoon style work boat, weighted with a concrete cinder block, and lowered into position via rope. The structures would be installed at a depth sufficient to leave approximately four feet of water above the top of the structure at the lowest reservoir elevation. Three safe-haven structures would be installed at each point marked by the TWC for nursery habitat enhancement (Appendix A). A total 111 nursery structures would be installed based on TWC recommendations.

FIGURE 3-2 MOSSBACK SAFE-HAVEN KIT

During the Fisheries TWC meeting on September 1, 2016, the SCDNR stated that they would like to investigate periodic “shoreline tree felling” in various areas around the reservoir as an aquatic habitat enhancement. Shoreline trees (including hardwood, pine or cedar trees) would be felled into the lake and cabled to the shoreline to insure they do not become a navigation hazard. SCE&G agreed to coordinate with the SCDNR on their efforts to introduce this aquatic habitat during the new license.

Timing of Installation

Within the first five years of the new license, SCE&G will install three Mossback Safe-Haven (or equivalent) structures for nursery habitat enhancements at each location identified in the Appendix A for a total of 111 structures. These nursery habitat enhancements will require no additional monitoring after installation.

3.3 DEEP-WATER HABITAT ENHANCEMENT

Deep-water habitat enhancements would be made by the installation of Mossback Trophy Tree and Trophy Tree XL structures. As an alternative, structures constructed by SCE&G could be used in place of the Mossback structures (TWC meeting March 2016). The Mossback Trophy Tree structure is made up of three 50 in. tall PVC posts, 36 50 in. long composite limbs, a three-post base, and a three-hole shade top (Mossback 2016) (Figure 3-3). The Mossback Trophy Tree XL structure is approximately eight feet tall and made up of six 50 in. tall PVC posts, with 72 50 in. long composite limbs, a three-post base, and a three-hole shade top (Mossback 2016) (Figure 3-4). The deep-water structures would be constructed on a pontoon style work boat, weighted with a concrete cinder block, and lowered into position via rope. The structures would be installed at a depth sufficient to leave 10-15 feet of water above the top of the structure at the lowest reservoir elevation. The TWC recommended that 15 deep-water enhancement structures would be installed at each location marked for enhancement (Appendix A). The structures would be positioned in a five by three grid around the enhancement area. If Mossback structures are used, the four corners of the grid would be Trophy Tree XL units with the regular Trophy Trees making up the final 11 units within the enhancement area. Each of these areas would be marked with a floating buoy for reference.

Timing of Installation

Within the first five years of the new license, SCE&G will install deep-water habitat enhancements and buoy markers at 13 sites identified by the TWC and presented in Appendix A. Each of these enhancements will consist of 11 Mossback Trophy Tree (or equivalent) structures (143 total) and 4 Mossback Trophy Tree XL (or equivalent) structures (52 total) for a total of 195 structures. These deep-water habitat enhancements will require no additional monitoring after installation.

FIGURE 3-3 MOSSBACK TROPHY TREE KIT

FIGURE 3-4 MOSSBACK TROPHY TREE XL KIT

3.4 INSTALLATION COSTS

Habitat enhancement implementation costs were evaluated to include the costs to purchase the enhancement structure materials and estimated installation costs. Cost evaluations were made using several assumptions. Those assumptions include:

- One work day is 20 man-hours (two people working 10 hours);
- the labor rate used is $50/hour;
- installation of spawning beds would be 15 units/day;
- nursery habitat structures would be installed at a rate of 10 units/day; and
- deep-water habitat structures would be installed at a rate of 10 units/day.

Costs were evaluated for each individual enhancement structure and then grouped by enhancement type. Total costs for each habitat enhancement type are presented in the sections below. All estimates are based on 2016 prices for materials and labor. More detailed tables and information is presented in Appendix B.

3.4.1 SPAWNING BED MATERIAL COSTS

The cost of the materials for an individual spawning bed are approximately $16 for the plastic pool, $10.50 for the pea gravel/sand, and $2 for the rope. Using these assumptions, we used a value of $28.50 for the materials for each spawning bed. Installation costs were based on the previous stated assumptions. Total estimated cost including materials and installation for 360 spawning structures is $34,260 (Table 3-1). This estimate does not include the cost of alternate spawning bed materials or the spawning structure evaluation and consultation with the SCDNR during the license.

TABLE 3-1 SPAWNING HABITAT ENHANCEMENT COSTS

SPAWNING HABITAT ENHANCEMENT	
Structure Costs	$10,260.00
Labor Costs	$24,000.00
TOTAL COSTS	**$34,260.00**

3.4.2 NURSERY HABITAT ENHANCEMENTS

The cost for materials for an individual Mossback Safe-Haven unit is $209.99. This includes a discount for bulk orders. Installation costs were based on the previous stated assumptions. Total estimated cost for installation of 111 Safe-Haven structures is $34,409.89 (Table 3-2).

TABLE 3-2 NURSERY HABITAT ENHANCEMENT COSTS

NURSERY HABITAT ENHANCEMENT	
Structure Costs	$23,308.89
Labor Costs	$11,100.00
TOTAL COSTS	**$34,408.89**

3.4.3 DEEP-WATER HABITAT ENHANCEMENTS

The cost for materials for an individual Mossback Trophy Tree is $179 and for an individual Trophy Tree XL is $359. This includes a discount for bulk orders. Installation costs were based on the previous stated assumptions. Total estimated cost for materials and installation is $66,365.00. We did not include the price option for SCE&G to construct deep-water structures from recycled materials, but installation costs should be similar. This includes installation of one buoy ($200) per site. We did not include a cost for periodic replacement of the buoys during the new license.

TABLE 3-3 DEEP-WATER HABITAT ENHANCEMENT COSTS

NURSERY HABITAT ENHANCEMENT	
Structure Costs	$46,865.00
Labor Costs	$19,500.00
TOTAL COSTS	**$66,365.00**

4.0 DISCUSSION

The TWC recommended aquatic habitat enhancements for Monticello Reservoir that should enhance fish production and recreational fishing on the reservoir. The total costs of implementing these habitat enhancements (based on 2016 costs) is approximately $135,000 (Appendix B). These enhancements were proposed to offset the impacts of daily reservoir fluctuations and should create spawning and nursery habitat for juvenile fish that is not impacted by the maximum fluctuations. The placement of deep-water enhancements should also improve recreational fishing on the reservoir. Finally, implementation of this enhancement program should help to offset potential entrainment issues related to the operation of the Fairfield Development. Habitat structures have been located further up the lake away from the turbine intakes. Therefore, fish production and survival should be increased in the upper portions of the lake and these fish would be much less susceptible to entrainment by project operations.

5.0 PROTECTION MITIGATION AND ENHANCEMENT MEASURES

SCE&G proposes to provide these fish habitat enhancements on Monticello Reservoir as a Protection, Mitigation, and Enhancement (PME) measure for the renewal of the Parr Hydroelectric Project License.

Installation of both Nursery and Deepwater habitat enhancements are fairly straightforward.

- Within the first five years of the new license, SCE&G will install three Mossback Safe-Haven (or equivalent) structures for nursery habitat enhancements at each location identified in Appendix A of this report - for a total of 111 structures. These nursery habitat enhancements will not be monitored.
- Within the first five years of the new license, SCE&G will install deep-water habitat enhancements and buoy markers at 13 sites identified in Appendix A of this report. Each of these enhancements will consist of 11 Mossback Trophy Tree (or equivalent) structures (143 total) and 4 Mossback Trophy Tree XL (or equivalent) structures (52 total) for a total of 195 structures. These deep-water habitat enhancements will not be monitored.

Installation of the spawning structures will be performed in an adaptive management approach. TWC members expressed concern that the plastic pools might not be resilient or be used by target fish species. Therefore, SCE&G will install these habitat enhancements in a stepwise approach. Within the first three years of the new license, SCE&G will install 15 spawning beds as described in this report in each of the 8 coves (120 structures total) identified for spawning habitat enhancement as depicted in Appendix A of this report. The SCDNR noted during TWC discussions that they may request an alternate spawning bed material and that a variety of spawning substrate materials (pea gravel/sand) of various sizes and/or depth of substrates within the spawning structure may be evaluated on these initial installations. SCE&G and SCDNR will consult to develop a test matrix to evaluate the effects of these and other variables on the preference of fish to use the structure for spawning. The installed spawning beds will be inspected by SCE&G (possibly by underwater camera) after two spawning seasons for the condition of the structure and evidence of use for fish spawning. SCE&G will report observations to SCDNR and consult on the installation of up to 240 (30 structures per 8 locations) additional spawning beds to be installed over the following two years after completion of consultation. All installed structures will be fitted with labels that include owner information. Signage will be installed at each public boat ramp informing the public that a habitat enhancement program is underway and not to disturb the structures if they encounter them.

6.0 REFERENCES

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Mossback Fish Habitat. www.mossbackrack.com. Web. January 2016.

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APPENDIX A

MONTICELLO RESERVOIR FISH HABITAT ENHANCEMENT AREAS

Scale: AS SHOWN	SCE&G COLUMBIA, SC
Project No: 0455097.01	PARR HYDROELECTRIC PROJECT FERC PROJECT NO. 1894
Filename: see margin	MONTICELLO RESERVOIR HABITAT ENHANCEMENTS
Drawn By: JJJ	
Date Drawn: 10/7/2016	Kleinschmidt 204 Caughman Farm Ln., Suite 301 Lexington, SC 29072 Telephone: (803) 462-5620 Fax: (803) 462-5619 www.KleinschmidtGroup.com

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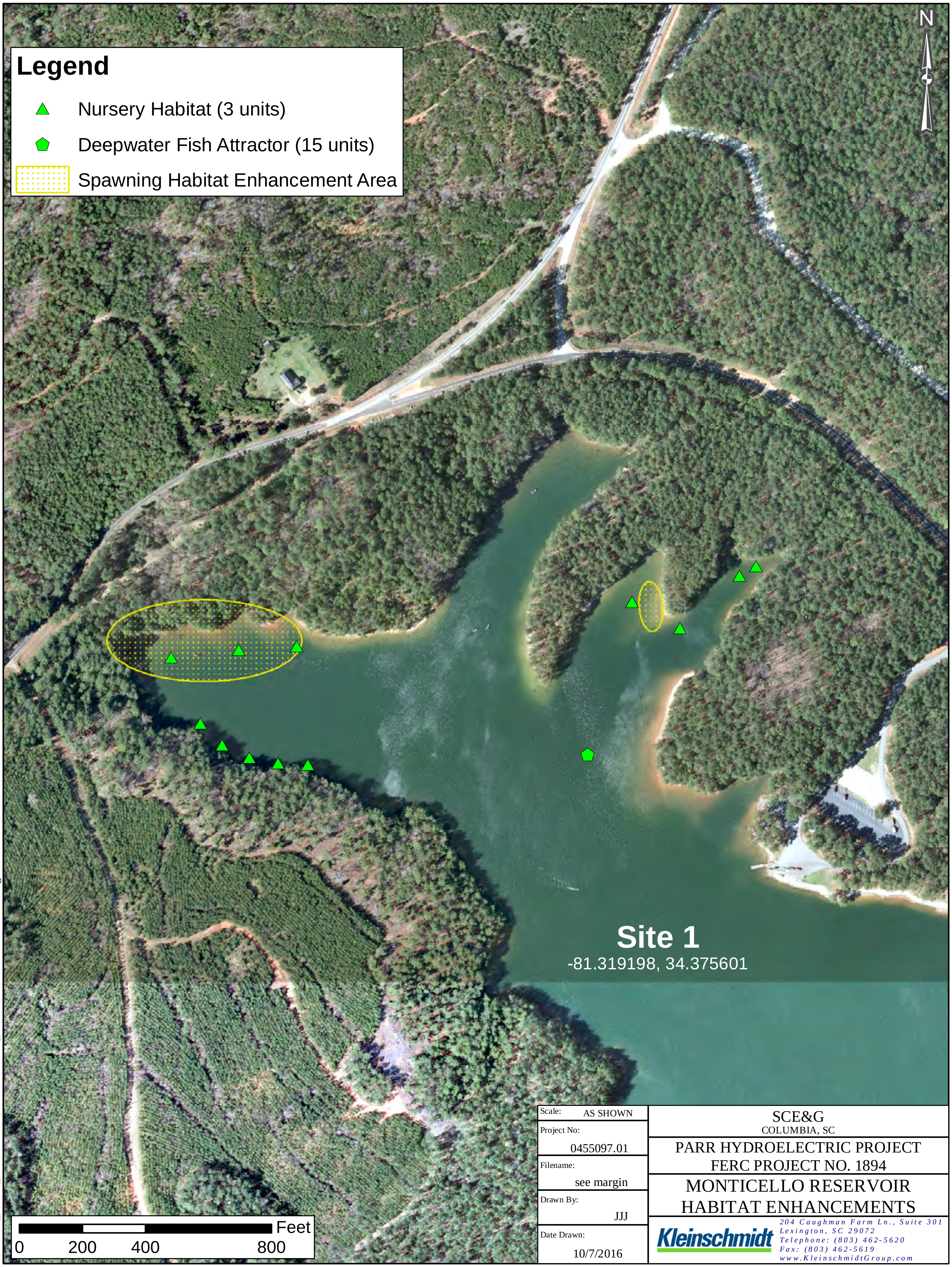
Source: Kleinschmidt, Orbis, SCE&G



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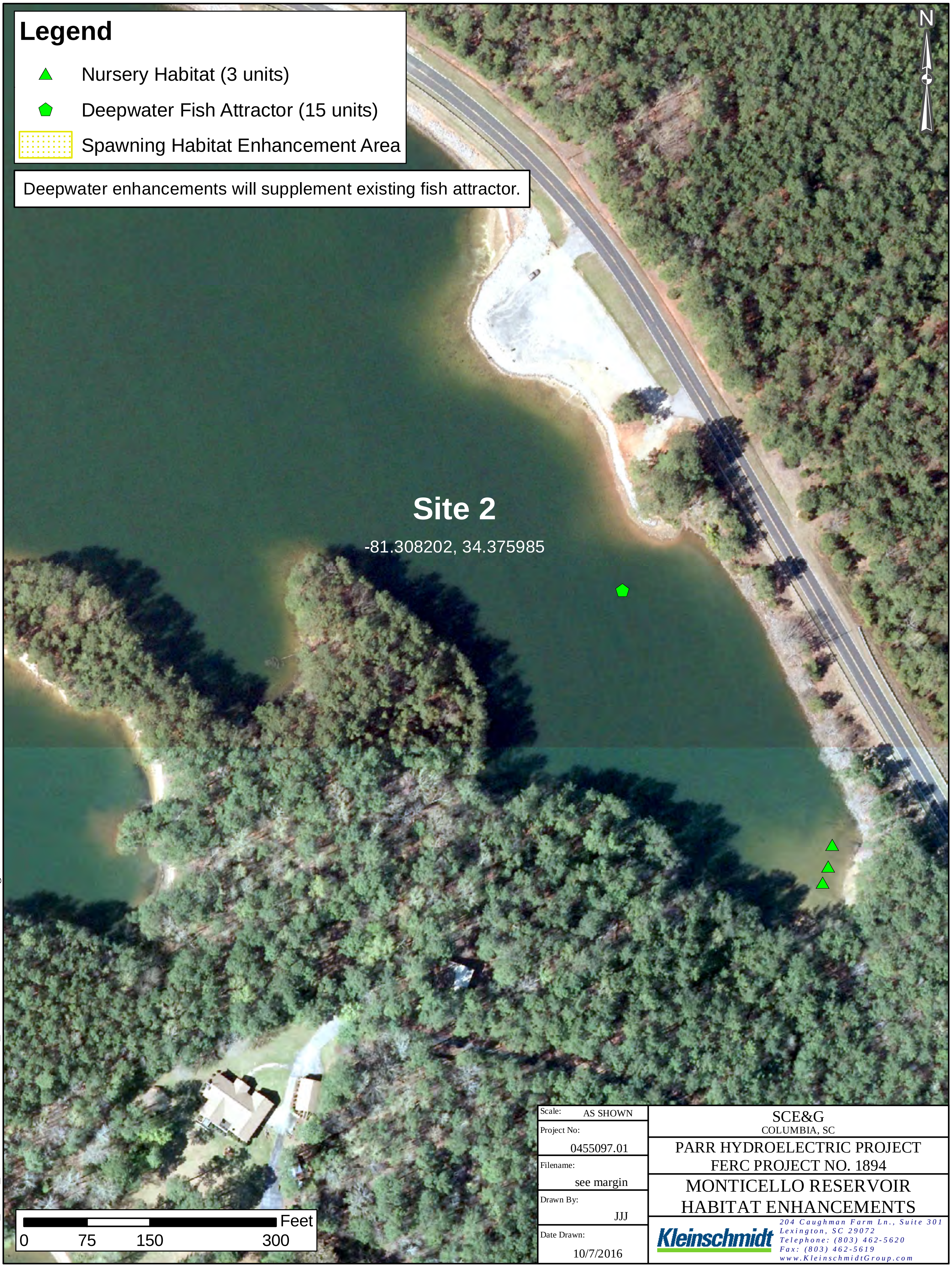

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Source: Kleinschmidt, Orbis, SCE&G

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Source: Kleinschmidt, Orbis, SCE&G

Path: G:_Client_Data\SCE&G\ParrFairfield_MXD\Reservoir Fluctuation Figures\Monticello Area 4 Enhancements.mxd

Scale: AS SHOWN	SCE&G COLUMBIA, SC
Project No: 0455097.01	PARR HYDROELECTRIC PROJECT FERC PROJECT NO. 1894
Filename: see margin	MONTICELLO RESERVOIR HABITAT ENHANCEMENTS
Drawn By: JJJ	Kleinschmidt
Date Drawn: 10/7/2016	204 Caughman Farm Ln., Suite 301 Lexington, SC 29072 Telephone: (803) 462-5620 Fax: (803) 462-5619 www.KleinschmidtGroup.com

Source: Kleinschmidt, Orbis, SCE&G

Scale: AS SHOWN	SCE&G COLUMBIA, SC
Project No: 0455097.01	PARR HYDROELECTRIC PROJECT FERC PROJECT NO. 1894
Filename: see margin	MONTICELLO RESERVOIR HABITAT ENHANCEMENTS
Drawn By: JJJ	Kleinschmidt
Date Drawn: 10/7/2016	204 Caughman Farm Ln., Suite 301 Lexington, SC 29072 Telephone: (803) 462-5620 Fax: (803) 462-5619 www.KleinschmidtGroup.com

Source: Kleinschmidt, Orbis, SCE&G

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Project No: 0455097.01	PARR HYDROELECTRIC PROJECT FERC PROJECT NO. 1894
Filename: see margin	MONTICELLO RESERVOIR HABITAT ENHANCEMENTS
Drawn By: JJJ	
Date Drawn: 10/7/2016	Kleinschmidt 204 Caughman Farm Ln., Suite 301 Lexington, SC 29072 Telephone: (803) 462-5620 Fax: (803) 462-5619 www.KleinschmidtGroup.com

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Source: Kleinschmidt, Orbis, SCE&G

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Source: Kleinschmidt, Orbis, SCE&G

Scale: AS SHOWN	SCE&G COLUMBIA, SC	
Project No: 0455097.01	PARR HYDROELECTRIC PROJECT FERC PROJECT NO. 1894	
Filename: see margin	MONTICELLO RESERVOIR HABITAT ENHANCEMENTS	
Drawn By: JJJ	Kleinschmidt	204 Caughman Farm Ln., Suite 301 Lexington, SC 29072 Telephone: (803) 462-5620 Fax: (803) 462-5619 www.KleinschmidtGroup.com
Date Drawn: 10/7/2016		

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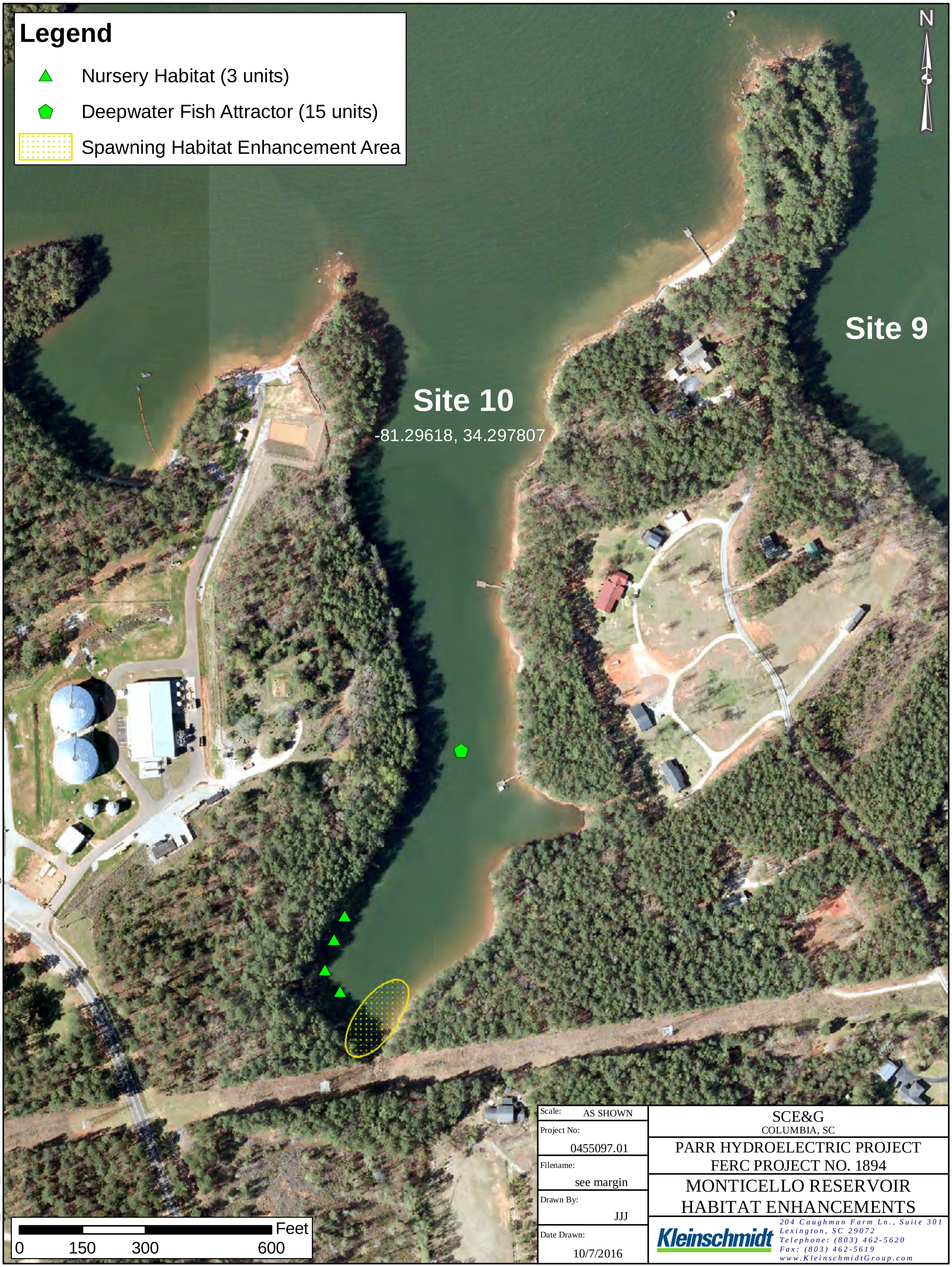

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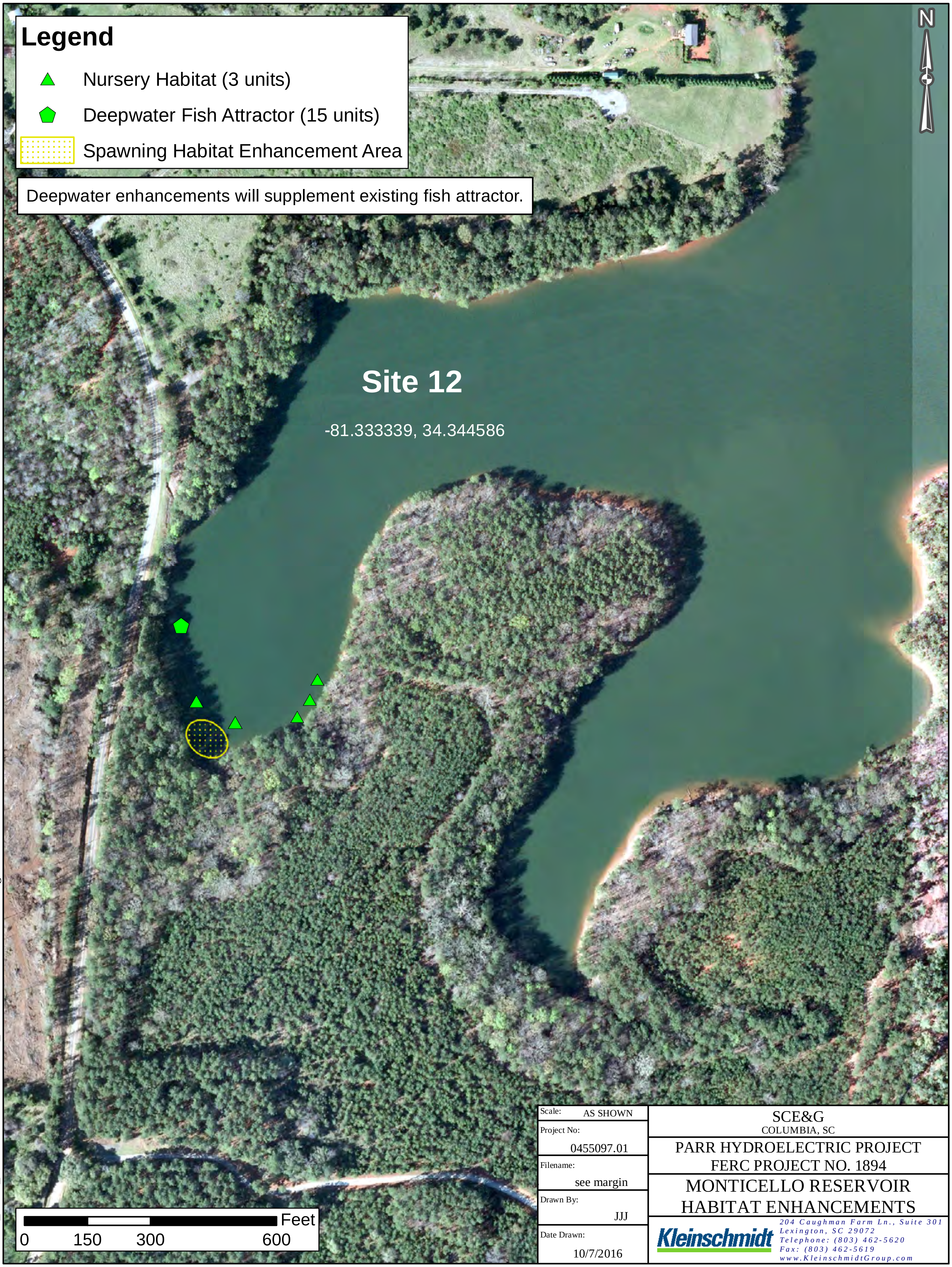

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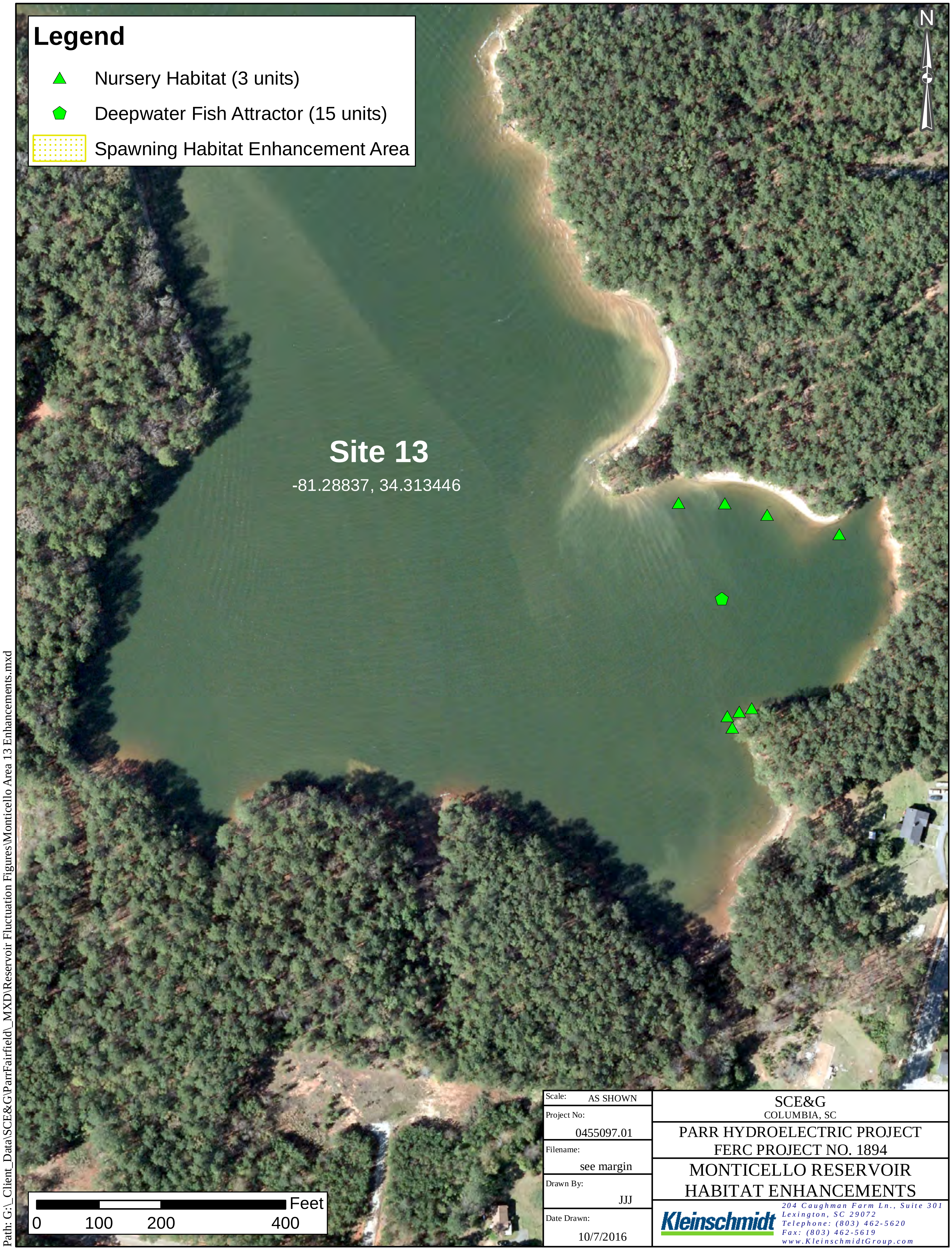

Source: Kleinschmidt, Orbis, SCE&G

APPENDIX B

MONTICELLO RESERVOIR FISH HABITAT ESTIMATED ENHANCEMENT COSTS

Monticello Reservoir Fish Habitat Enhancements Costs for Materials and for Installation

June 30, 2016

Enhancement Structure	Enhancement Locations	Structures per Enhancement Area	Total Structures	Costs per Structure	Total Structure Costs
Spawning Bed	8	15	360	$28.50	$10,260.00
Safe Haven	37	3	111	$209.99	$23,308.89
Trophy Tree	13	11	143	$179.00	$25,597.00
Trophy Tree XL	13	4	52	$359.00	$18,668.00
Buoy Markers	13	1	13	$200.00	$2,600.00
Total					$80,433.89

Note that these prices are valid for 2016 only and do not include a CPI for future costs.

Labor Costs	Hours/day	$/hr	$/day
Person 1	10	$50	$500
Person 2	10	$50	$500
Total	20	$50	$1,000

Installation Assumptions

Day = **20** man-hours

10 nursery structures/day

10 deep-water structures/day

15 spawning structures per day

Enhancement Type	Total Structure Costs	Install Speed (structure/day)	Install Days	Labor Costs ($/day)	Total Labor Costs	**Total PM&E Costs**
Spawning Enhancement	$10,260.00	15	24.0	$1,000	$24,000.00	$34,260.00
Nursery Enhancement	$23,308.89	10	11.1	$1,000	$11,100.00	$34,408.89
Deep-water Enhancement	$46,865.00	10	19.5	$1,000	$19,500.00	$66,365.00
Total	$80,433.89				$54,600.00	**$135,033.89**

Exhibit E-5 Fisheries Resources

Instream Flow Study Plan

INSTREAM FLOW STUDY PLAN

PARR HYDROELECTRIC PROJECT
(FERC NO. 1894)

Prepared for:

South Carolina Electric & Gas Co.
Cayce, South Carolina

Prepared by:

Kleinschmidt

Lexington, South Carolina
www.KleinschmidtUSA.com

May 2014

INSTREAM FLOW STUDY PLAN

PARR HYDROELECTRIC PROJECT
(FERC NO. 1894)

Prepared for:

South Carolina Electric & Gas Co.
Cayce, South Carolina

Prepared by:

Kleinschmidt

Lexington, South Carolina
www.KleinschmidtUSA.com

May 2014

INSTREAM FLOW STUDY PLAN

PARR HYDROELECTRIC PROJECT
(FERC NO. 1894)

SOUTH CAROLINA ELECTRIC & GAS CO.
COLUMBIA, SOUTH CAROLINA

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PARR HYDROELECTRIC PROJECT
(FERC NO. 1894)

SOUTH CAROLINA ELECTRIC & GAS CO.
COLUMBIA, SOUTH CAROLINA

1.0 INTRODUCTION

The Parr Hydroelectric Project (FERC No. 1894) (Project) is a 525 megawatt (MW) licensed hydroelectric facility located on the Broad River in Newberry and Fairfield counties of South Carolina, and is owned and operated by South Carolina Electric & Gas (SCE&G). The Project consists of the Parr Shoals Development and the Fairfield Pumped Storage Development. Both developments are located along the Broad River in Fairfield and Newberry Counties, South Carolina (Figure 1).

The Parr Shoals Development forms Parr Reservoir along the Broad River. The Development consists of a 37-foot-high, 200-foot-long concrete gravity spillway dam with a powerhouse housing generating units with a combined licensed capacity of 14.9 MW. Parr Shoals operates in a modified run-of-river mode and normally operates to continuously pass Broad River flow. The 13-mile-long Parr Reservoir has a surface area of 4,400 acres at full pool and serves as the lower reservoir for pumped-storage operations.

The Fairfield Pumped Storage Development is located directly off of the Broad River and forms the 6,800-acre upper reservoir, Monticello Reservoir, with four earthen dams. As noted, Parr Reservoir serves as the lower reservoir for pumped storage operations. The Fairfield Development has a licensed capacity of 511.2 MW and is primarily used for peaking operations, reserve generation, and power usage.

In anticipation of the Project relicensing process, SCE&G met with a number of state and federal resource agencies and interested stakeholders to begin scoping environmental issues as they pertain to project operation. As a result, the United States Fish and Wildlife Service (USFWS), South Carolina Department of Natural Resources (SCDNR), National Marine Fisheries Service (NMFS), and several Non-governmental Organizations (NGO’s) requested studies to determine the potential impact of Project operation on fishery resources and aquatic habitat, including an Instream Flow Incremental Methodology Study (IFIM) for the Broad River downstream of the Project. SCE&G formed a Technical Working Committee (TWC) composed of representatives from each interested party that consults to provide input and guidance for the study design and execution.

1.1 EXISTING OPERATIONS

As previously noted Parr Shoals Development operates in a modified run-of-river mode and normally continuously operates to pass Broad River flow. Current minimum flow license articles require that 1,000 cubic feet-per-second (cfs), or average daily natural inflow to Parr Reservoir[1], whichever is less, be provided downstream of Parr Shoals Dam from March through May. During the remainder of the year, 800 cfs daily average flows and 150 cfs minimum flows, or natural inflow minus evaporation, whichever is less, are required downstream of the Parr Shoals Dam.

1.2 SUMMARY OF TWC CONCERNS

In general, the TWC is interested in exploring the protection of instream habitat in the Broad River below the Project (see Appendix A for a detailed summary of discussions) by evaluating existing and potential flow releases. The TWC has identified the following issues that this study will:

- assist in identifying minimum flows that are protective of aquatic habitat;
- provide data that can be used to evaluate minimum flows necessary for safe navigation; and
- provide data that can be used to evaluate the flow necessary to facilitate volitional upstream fish passage.

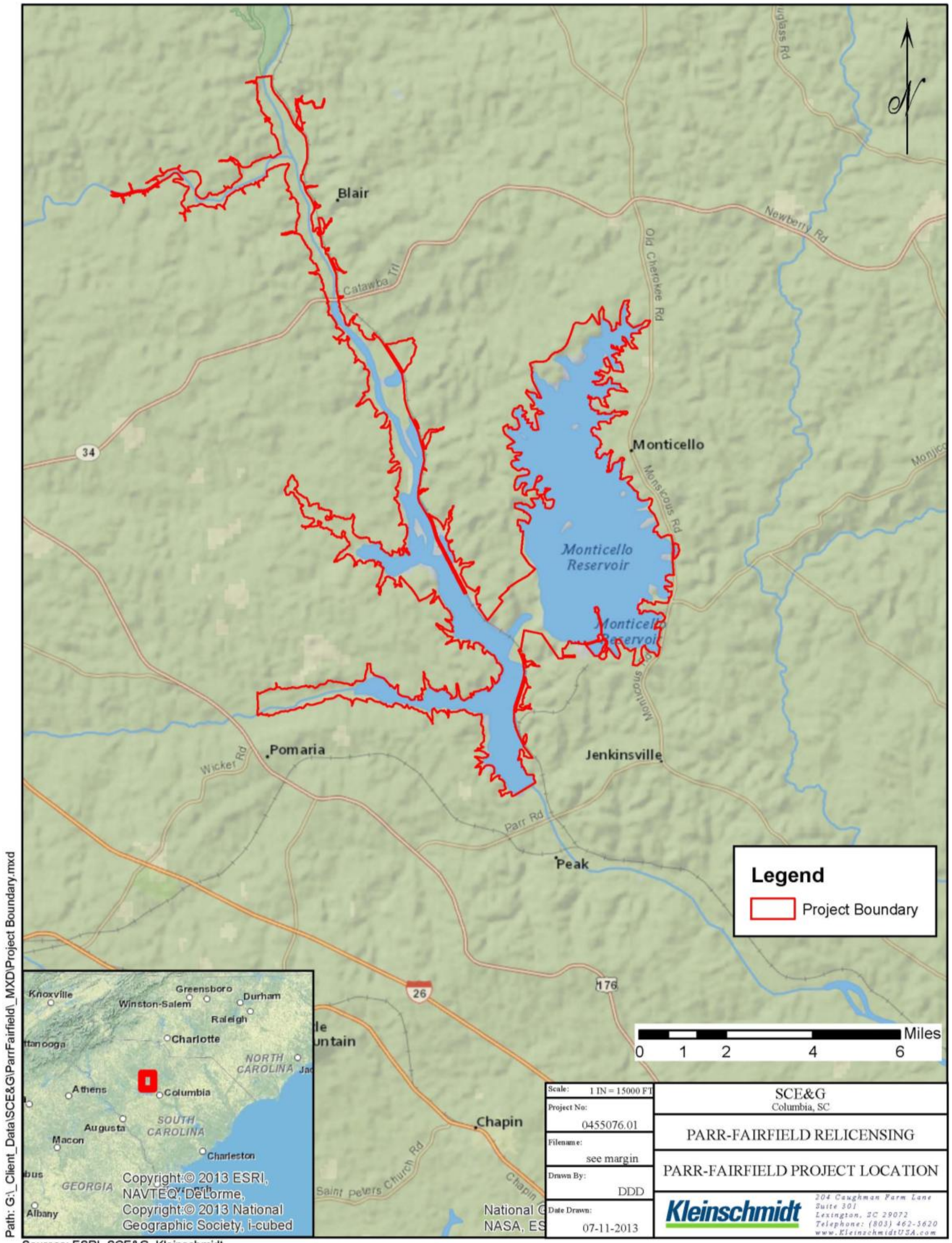
1.3 PURPOSE OF THIS STUDY

The scope of this study is to provide data quantifying the effects of flows on aquatic habitat suitability in the Broad River for the aquatic community and its managed fish resources, including diadromous and resident fish species, and aquatic invertebrates and to assist the TWC in identifying flow targets that support habitat requirements for a balanced aquatic community.

1 Evaporative loss from Parr and Monticello Reservoirs is subtracted from average daily natural inflow to determine flows downstream of Parr Dam.

These data will then be used in conjunction with hydrologic, operational and other models to evaluate the costs and benefits of providing alternate flows to the Broad River.

FIGURE 1 PROJECT LOCATION MAP



Sources: ESRI, SCE&G, Kleinschmidt

2.0 DESCRIPTION OF STUDY AREA

The Broad River rises on the east slope of the Appalachian Mountains, and flows southeasterly across the Piedmont geomorphic province to its confluence at the fall line with the lower Saluda River in Columbia, South Carolina (SCDHEC, 2007), where the combined flows form the Congaree River. Below the Parr Shoals Dam, the river is free flowing for approximately 26 miles through generally low gradient[2] riverine geomorphology until just below Boatrights Island. Below Boatrights Island, the Broad is influenced by backwatering from the Columbia Hydroelectric Project, which is located approximately two miles above the confluence with the lower Saluda River. The drainage area at the Parr Project is 4,750 square miles. A real time stream flow gage exists at USGS 02161000 (*Broad River at Alston, SC*), which is located approximately 1.5 miles below the Parr dam.

2.1 UPSTREAM AND DOWNSTREAM BOUNDARIES

The TWC identified the segment of the Broad River between the Parr Shoals Dam and the downstream end of the Bookman Island complex as the study area (Figure 3 and Figure 4). Flow in this reach is primarily influenced by releases from the Parr Shoals Dam and powerhouse. There are no significant flow contributions from tributaries within the study reach[3].

2.2 HABITAT AND GEOMORPHOLOGY

The Broad River flows southeasterly through a river corridor that is predominantly rural, and in general the river banks and riparian zones are forested. Overall the river is relatively straight for much of the reach, with moderate levels of sinuosity. The upper segment of the study area is dominated by well-defined banks (*i.e.* with discernible and consistent crests and toes) and relatively low-gradient pools, runs and glides, periodically segmented by short riffles. The lower segment also contains pools, glides and runs, but exhibits higher gradient bedrock drops and more pronounced riffles, and features ledge and boulder substrates which reflect down cutting through the piedmont terrace. There are a several islands with pronounced side channels and/or braids such as Haltiwanger, Bookman and Huffman islands.

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[2] Reach is punctuated by short, higher gradient reaches (3-4%), near Haltiwanger and Bookman islands, but generally gradient is 1% or less.

[3] Because Little River, as well as other more minor tributaries, are ungaged, a desktop exercise using pro-rated discharge data from adjacent and/or similarly sized basins may be necessary to ensure that tributary flows during a normal water year do not exceed 10% of the total flow of the Broad River.

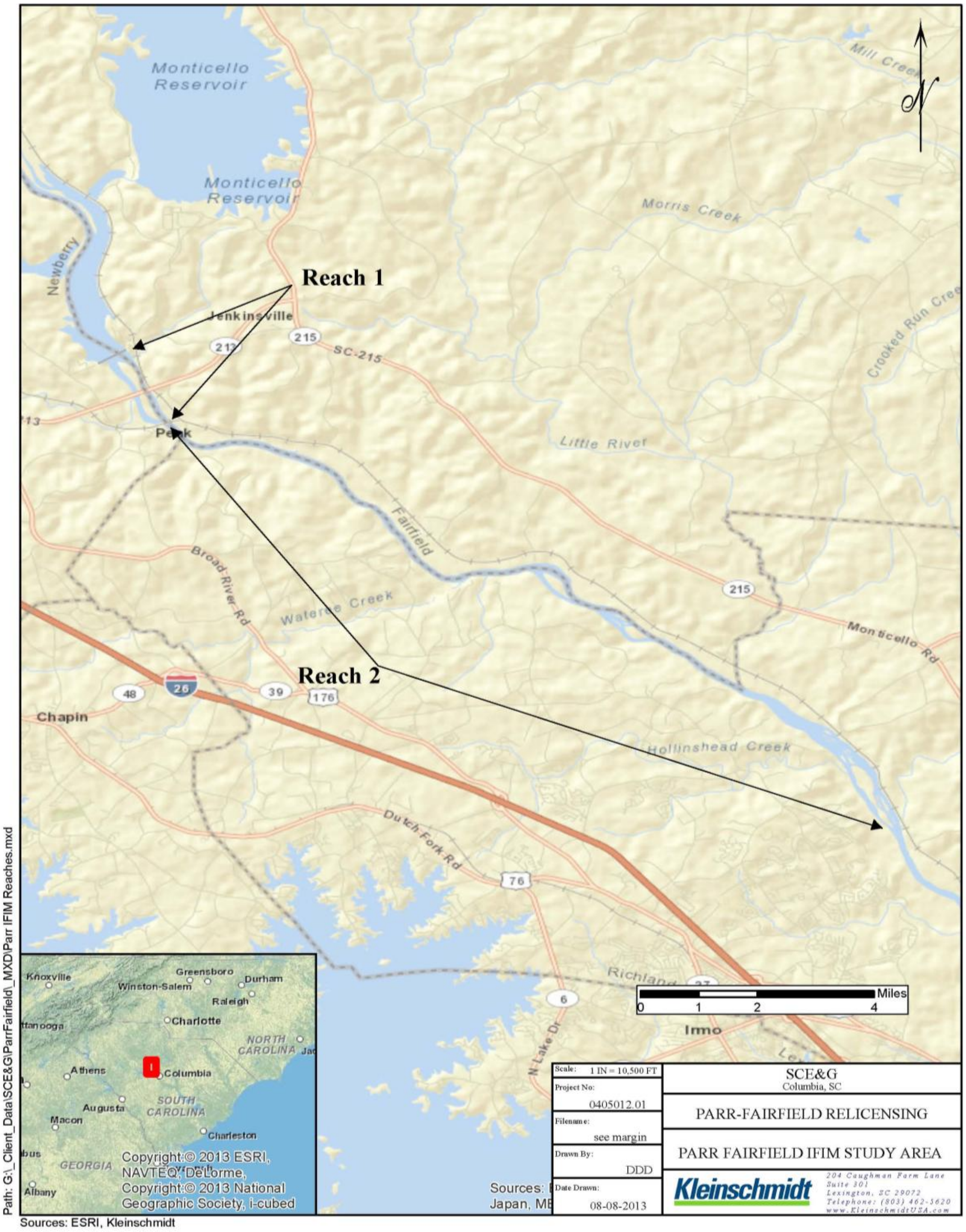
2.3 FISHERY, FISH MANAGEMENT OBJECTIVES, AND SEASONAL HABITAT USES

The varied instream features within the study area support a diverse community of warm water fish species and provide seasonal spawning and nursery habitat for anadromous American shad and striped bass. In addition, smallmouth bass, other centrarchids and catfish provide a sport fishery. Robust redhorse are rare migratory suckers present in the study area. Collaborative restoration efforts are underway to protect this fish and the USFWS describes it as an At-Risk-Species (ARS)[4]. Features within the study reach may also provide suitable conditions for Robust redhorse spawning and rearing (Appendix B). The Broad River spiny crayfish (*Cambarus spicatus*) is another ARS and has been documented from bank habitats of the Little River, a tributary that empties into the Broad River study area.

Anadromous fish restoration priorities for the Santee Basin focus on restoring runs of anadromous fish primarily up the Congaree and Broad rivers. The Santee Cooper Basin Diadromous Fish Passage Restoration Plan reports that the Broad River and its tributaries are the most promising sub-basin for diadromous fish restoration (USFWS et al., 2001).

[4] At-Risk-Species are species that the USFWS has been petitioned to list and for which a positive 90-day finding has been issued (listing may be warranted), yet no Federal protections currently exist.

FIGURE 2 PARR FAIRFIELD INSTREAM FLOW STUDY AREA



Sources: ESRI, Kleinschmidt

3.0 PROPOSED METHODS

3.1 FIELD RECONNAISSANCE AND HABITAT MAPPING

The TWC concluded that an IFIM study would be appropriate to develop an understanding of key habitat-flow relationships in the Broad River, and elected to use a Physical Habitat Simulation (PHABSIM) model to quantify these relationships. The model will be used to quantify flows that meet habitat requirements of target species and life stages, based on output representing selected diadromous and resident fish. In addition, empirical data and/or a flow demonstration approach may be required to document flows that provide adequate fish passage at limiting bedrock ledges, such as those above Haltiwanger Island and near Huffman Island.

Consistent with IFIM protocol, a TWC comprised of agency, NGO and licensee biologists was formed for the purpose of making technical decisions regarding input parameters and review of study output. Specifically, that team designated or will designate:

1. boundaries of the study area,
2. locations of specific study sites,
3. locations of study site cell boundaries and/or transects,
4. Habitat Suitability Index (HSI) criteria, and
5. calibration flows and range of flows to be assessed.

The TWC members may also participate in field and analytical activities as feasible.

Mesohabitat Classification

Initially, a field survey will be conducted to quantify and map the distribution of mesohabitats in the Broad River study area. On June 18-19, 2013, the TWC conducted a reconnaissance survey of the study area (See notes in Appendix A). On July 31, 2013 the TWC discussed and finalized functional definitions of mesohabitat classes, as follows:

Riffle	Shallow, with moderate velocity, turbulent, high gradient, moderate to large substrates (cobble/gravel). Typically > 1% gradient.
Glide	Moderately shallow, well-defined non-turbulent laminar flow, transition from low to moderate velocity, lacking a definite thalweg, typically flat stream geometry, typically finer substrates, transitional from pool.
Run	Moderately deep, well-defined non-turbulent laminar flow, range from low to moderate velocity, well-defined thalweg, typically concave stream geometry, varying substrates, gently downstream slope (<1%).
Pool	Deep, low to no velocity, well-defined hydraulic control at outlet.
Rapid/Shoal	Shallow, with moderate to high velocity, turbulent, with chutes and eddies, high gradient, large substrates or bedrock. Typically >2% gradient.
Backwater	Varying depth, no or minimal velocity, off the primary channel flow.

Mesohabitat mapping will include a review of aerial photographs followed by ground verification. A field crew will field-delineate the relative quantity and spatial distribution of each mesohabitat type in the study area. Delineation will occur during a period of relatively low-to-moderate flow so that breaks in mesohabitat, substrate, object cover and hydraulics representative of approximate base flow conditions can be readily observed. Study team members are encouraged to participate in delineation to the extent feasible. The upstream and downstream boundary of each mesohabitat within the study area will be classified and geo-referenced in the field, and the information transferred to a Geographic Information System

(GIS) format. GIS will then be used to provide both a visual map and quantitative tabular information on the abundance of mesohabitat types in the study area.

Selection of Reaches, Study Sites and Transects

The TWC consulted in May 2013 to define study reaches and select potentially applicable mesohabitat study sites within each reach (Appendix A). The TWC then selected specific study sites and cell/transects within each study reach during the reconnaissance visit in June 2013 (Appendix A).

Within each study reach, the TWC identified study sites that represent typical and/or critical mesohabitats, and selected upstream and downstream cell boundaries within each study site based on localized observable shifts in stream width, cover, substrate, and hydraulics. The area between each upstream – downstream cell boundary is considered reasonably homogenous, and thus the field crew will subsequently locate a representative transect within each longitudinal cell.

Reach One, as defined by the TWC, extends from the Parr Shoals Dam downstream to the Palmetto Trail trestle (Figure 3), just below where the tailrace and bypass channels converge below Hampton Island. This reach contains five study sties (1 through 5) (Figure 3). Although PHABSIM will be the primary analytical tool used to describe habitat suitability, the TWC made two study site-specific exceptions. Study site 1 is partially composed of bedrock pools where a PHABSIM model is not applicable. These pools will be delineated so that each pool's volume can be estimated and the amount of flow necessary to maintain suitable water quality can be calculated, as well as the minimum flow necessary to maintain fish passage through the most limiting inter-pool channel constriction. Study site 4 will be assessed by employing a wetted perimeter transect, as described in the site selection notes (Appendix A).

Reach Two extends from the trestle downstream through the Bookman Island complex, and contains an additional five study sites (6 through 10) (Figure 4). The TWC noted that study site 7 is likely the most limiting for navigation and upstream fish passage due to the large bedrock ledge, and therefore will be assessed using the deKozlowski (1988) and Bulak and Jobsis (1989) criteria. The TWC also agreed that the Bookman Island complex (study site 10) could not be effectively modeled with PHABSIM due to the complex of channels, braids and islands, but will instead be assessed using a two-dimensional (2-D) modeling approach. The 2-D model defines an overall upstream and downstream model boundary of the study site but relies on a finite elements model rather than on the transect/cell boundary approached used in one-dimensional (1-D) PHABSIM modeling. The TWC also determined that habitat suitability in study site 9 (Huffman Island) would be evaluated via an empirical flow demonstration following development and review of results from study site 10.

During preliminary relicensing meetings, TWC members also requested information characterizing spawning habitat for robust redhorse (*Moxostoma robustum*) within the study area. It was subsequently determined that potential spawning sites would be field delineated concurrent with the mesohabitat assessment and other early field work to determine their proximity to the established IFIM study sites discussed above. The purpose of this effort was to determine if potential spawning sites fall within reasonable proximity to established IFIM study sites such that spawning habitat could be evaluated as part of the PHABSIM and 2-D modeling effort. Field reconnaissance for potential spawning sites was conducted by biologists from SCNDR, SCANA Environmental Services, and Kleinschmidt in October 2013 and February 2014, results of which are summarized in the attached memorandum (Appendix B).

FIGURE 3 AERIAL VIEW OF REACH ONE STUDY SITES

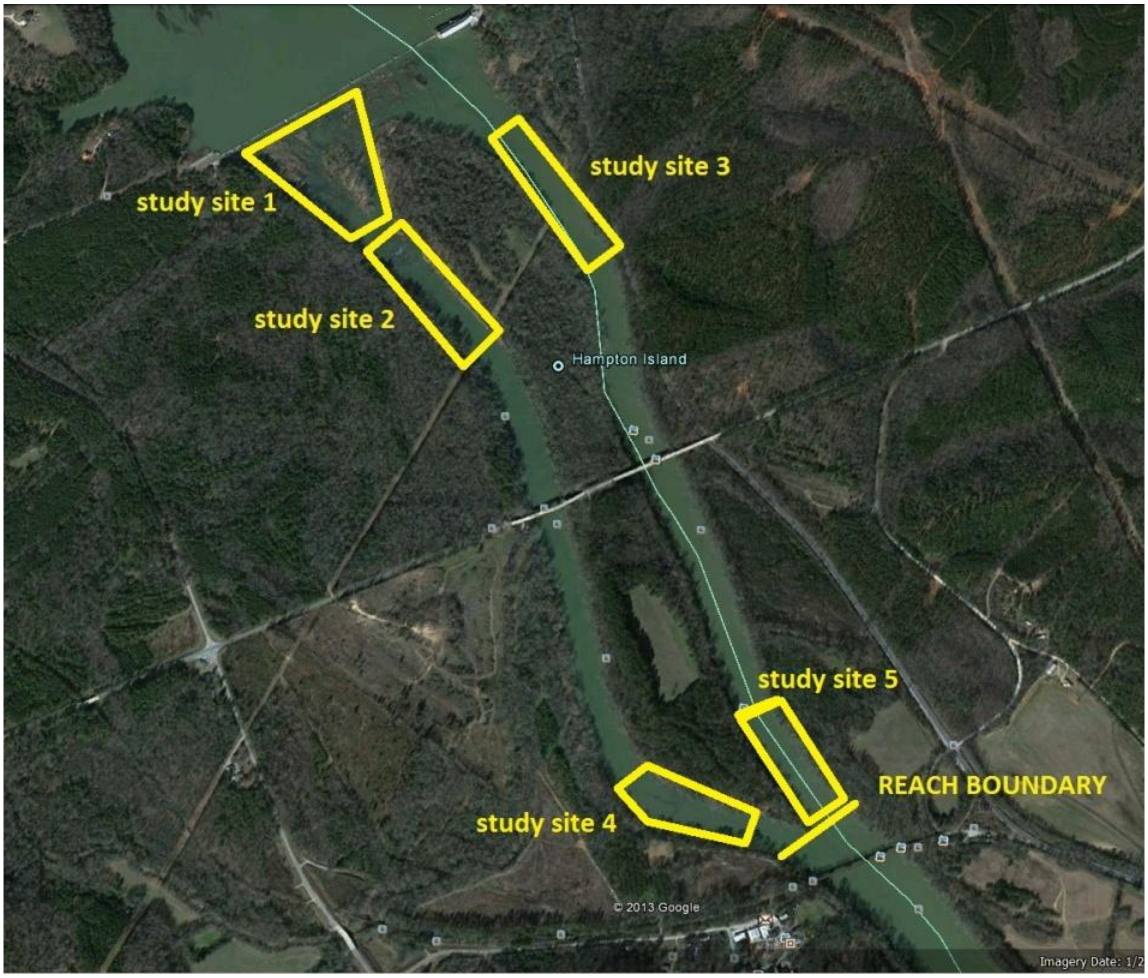
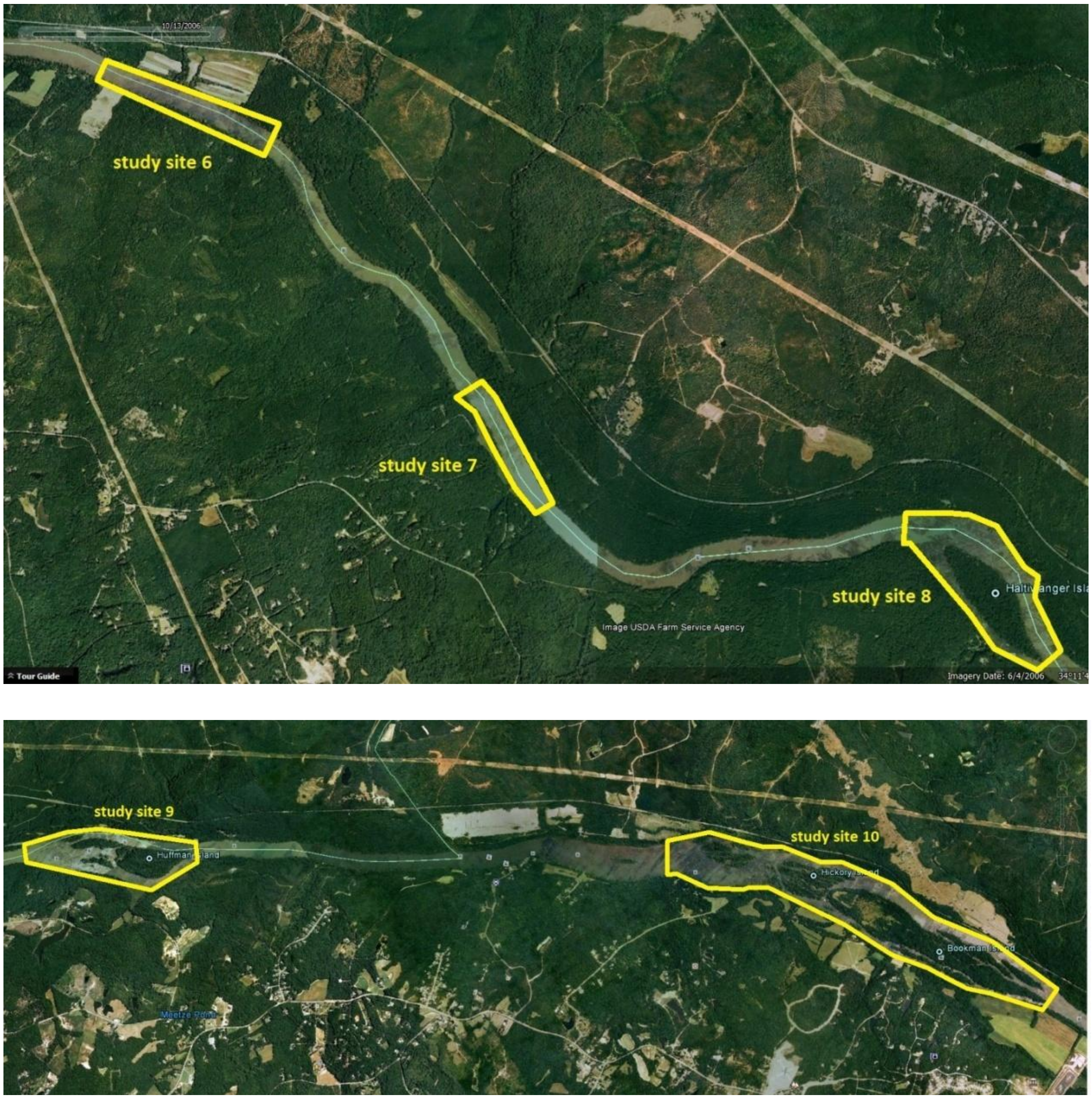


FIGURE 4 AERIAL VIEW OF REACH TWO STUDY SITES



3.2 FIELD DATA COLLECTION

3.2.1 PHABSIM STUDY SITES

General Approach

The second phase will entail the determination of habitat-discharge relationships for selected species, lifestages, and guilds as discussed by the TWC in July 2013 (Appendix A). Standard PHABSIM data collection and flow modeling procedures of the IFIM methodology (Bovee, 1982, Bovee, *et al*. 1998) will be used to evaluate habitat suitability in all 1-D reaches, and a 2-D model such as River 2-D or the equivalent will be employed to quantify habitat suitability in the Bookman Island complex (study site 10). As previously noted, empirical flow measurements will be obtained to evaluate zone-of-passage hydraulics at a limiting river channel sites, and also to evaluate habitat suitability in the Huffman Island vicinity (study site 9) following a review of flow recommendations related to the 2-D model conducted at Bookman Island (study site 10). The TWC also requested a wetted perimeter transect in Reach One at study site 4 below Hampton Island.

Modeling will be based on hydraulic data developed from cross-sectional depth, velocity, and substrate measurements using PHABSIM for Windows (V 2) (Milhouse, *et al.*, 1989), distributed by the USGS Fort Collins (CO) Science Center. River 2-D modeling will follow procedures described by Steffler and Blackburn (2002).

Flow Range to Be Modeled

Based on TWC consultation (See Appendix A), SCE&G anticipates that habitat-discharge relationships would be developed for flows ranging from 200 cfs to approximately 20,000 cfs, and that the modeling effort would focus on both selected mesohabitat types and the limiting fish passage and navigation channels selected by the TWC.

Suitability Index Criteria[5]

The TWC is presently gathering and considering specific Habitat Suitability Index (HSI) rating curves for use in this study. Based on TWC consultation, SCE&G proposes the use of HSI curves adopted primarily from prior studies, including the Saluda and Pee Dee instream flow studies. Provisional HSI curves were proposed and discussed on July 31, 2013 (Appendix A); however, collaboration on additional curve refinement is likely to occur, for example, with striped bass and smallmouth bass. In addition, appropriate cover and substrate coding for the Broad River spiny crayfish will be developed in consultation with the USFWS. Provisional curves, and related TWC discussion notes are contained in Appendix B. Additional species and life stages of interest for which stand-alone curves are unavailable or potentially inapplicable, have been classified by the TWC into habitat guild classes (*i.e*. deep slow, shallow slow, shallow fast, deep fast) and representative HSI curves for each guild selected by the team in consultation.

[5] This section will likely need modification assuming that HSI curves are finalized before submittal of the Pre-Application Document.

Data Collection (PHABSIM 1-D model)

The location of each transect will be field blazed with flagging or other appropriate means and documented using Global Position System (GPS) technology. Each study site and cell will be mapped sufficiently to quantify the area represented by each transect. The transect headpin and tailpin ends will be located at or above the top-of-bank elevation, and secured by steel rebar or other similar means. Transect orientation will be such that each headpin will be positioned on river right (looking downstream) and tailpins consequently located river left. A measuring tape accurate to 0.1 ft will be secured at each transect to enable repeat field measurements to occur at specific stream loci[6]. Stream bed and water elevations tied to a local datum will be surveyed to the nearest 0.1 ft using standard optical surveying instrumentation and methods.

Depth, velocity, cover and substrate data will be gathered at intervals (verticals) along each transect. Each vertical will be located to the nearest 0.1 ft wherever an observed shift in depth or substrate/cover[7] occurs. Between 20 and 99 verticals per transect will be established as necessary to define cross-sectional habitat. Verticals will be arranged so that no more than 10% of the river discharge passes between any pair, thus enhancing hydraulic model calibration. At least one staff gage will be located per study site, and will be monitored at the beginning and end of each set of hydraulic measurements to confirm stable flow during measurements. If flow is found to be insufficiently stable[8], the related data will be discarded and re-measured once stable flow is established.

Mean column velocity will be measured to the nearest 0.1 ft/second with either a calibrated electronic velocity meter mounted on a top-setting wading rod, or alternatively an Acoustic-Doppler Current Profiler (ADCP) transducer. In water less than 2.5 ft depth, measurements will be made at 0.6 of total depth (measured from the water surface); at greater depths, paired measurements will be made at 0.2 and 0.8 of total depth and averaged.

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[6] Supplemental transects may be located as needed to record water surface and bed elevation data at hydraulic controls to establish backwatering parameters necessary for hydraulic modeling.

[7] Cover that is clustered and in close proximity to the transect (such as woody debris important to Broad River spiny crayfish) will be documented.

[8] "Stable water conditions" refers to absence of a pronounced upward or downward trend in staff gage height during the course of a set of hydraulic measurements. It should be noted, however, that previous IFIM experience by Kleinschmidt on other large rivers suggests that minor variations in staff gage height of up approximately 0.5 inch may occur, due to wind pitch and wave action. Under most such circumstances a hydraulic engineer will be consulted to evaluate whether measurements are acceptable or not for modeling purposes.

Each calibration flow will be provided by scheduled releases from the Project via unit operation and/or spillage. Turbine rating curves, USGS gaging, and study-site field gaging will be collectively used to estimate each calibration flow release. The hydraulic model will be built from measurements gathered at a *minimum* of three calibration flows to facilitate extrapolation of hydraulic data across the range of interest. To accomplish calibration, a full set of depth, velocity and water surface elevation (WSEL) data will be gathered at the intermediate flow, and WSEL will be measured at each transect for the low and high calibration flows. At transects with complex hydraulics such as braided channels or riffles, and/or sites with unusual backwatering or eddy effects, supplemental velocity data may be gathered at the low calibration flow to enhance model accuracy. This will be determined in the field on a case-by-case basis.

Each calibration flow should ideally be separated by about an order of magnitude to provide a suitable stage-discharge curve for the hydraulic model. At a minimum, SCE&G anticipates utilizing calibration flows of approximately: 400, 2000 and 10,000 cfs, as determined in consultation with the TWC (See July 31, 2013 meeting notes, Appendix A). Depending on calibration quality, this should allow the PHABSIM model to theoretically project Weighted Usable Area (WUA) for a flow range from 200 to approximately 20,000 cfs. The need for additional calibration flow data may vary by transect and will be evaluated on a case-by-case basis.

Data Collection (2-D Model)

As previously noted, the TWC deemed that a 2-D hydraulic model is most appropriate for capturing the hydraulics and habitat suitability of the Bookman Island complex (study site 10) due to the complex channel characteristics. For the 2-D model, two calibration flows will be employed. The exact flows required are not critical but should represent hydraulic conditions including both "typical" low and "intermediate" discharge through the study reach. Inflow will be estimated by means of gaging and/or an ADCP unit. The two calibration flows will be collected under approximately steady flow conditions, as safety and hydrologic conditions allow. The calibration flow data allows the modeler to evaluate the flow directionality and magnitude under different flow conditions through the study area. Additionally, at least three water level loggers will be deployed within the study reach to assist with model calibration. In general, specific locations will include one logger in the "upper" portion of the study reach, upstream of the islands, one logger in the right main channel, and a third logger in the left main channel.

A two dimensional substrate map will be developed based on data collected during the field effort. Substrate and cover will be categorized based on codes specified within the HSI curves in Appendix B. The 2-D model will be developed using a combination of terrain (Light Detection and Ranging (LIDAR) and/or Digital Elevation Model, depending on availability) and bathymetric bed elevation survey data[9]. This will include a WSEL survey, and flow gaging at the inlet and/or outlet of the study site boundaries.

Data Collection (ledge pools below dam in study site 1)

Pool volumes will be field surveyed to create a 3-D bathymetric map to estimate pool volume. Bed elevations will be gathered and spatially located using submeter accuracy GPS to create a bathymetric profile. The volumetric turnover rate at various inflows will then be calculated, and temperature and dissolved oxygen will be empirically measured at different inflows to assess the extent to which water quality will support aquatic life. The most limiting zone of passage point among pools will be identified and a cross sectional survey will be completed, after which a stage-discharge curve will be developed to estimate the minimum flow required to facilitate volitional fish movements through the restriction.

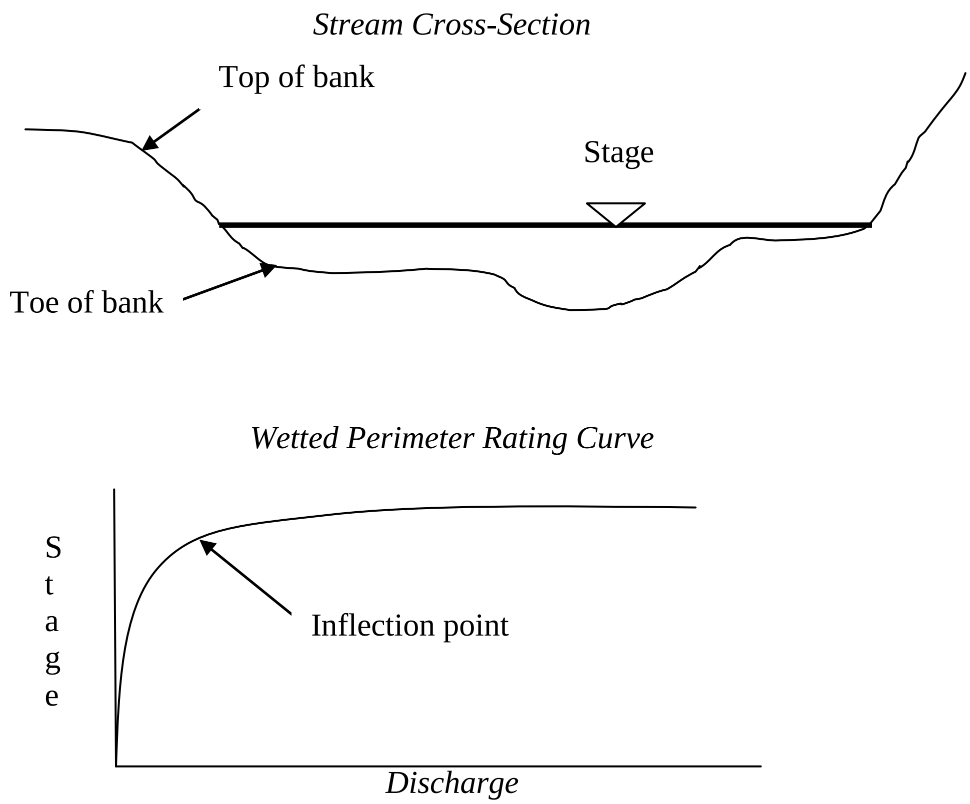
Data Collection (wetted perimeter at study site 4; backwater at lower West Channel)

Although originally established to assess the stage/discharge relationship associated with backwater effects of generation releases, efforts will be made to position this transect at the location most limiting to fish passage and one-way navigation. The transect end points at study site 4 will be field blazed with flagging or other appropriate means and documented with sub-meter GPS. The transect headpin and tailpin ends will be located at or above the top-of-bank elevation, and secured by steel rebar or other similar means. A measuring tape accurate to 0.1 ft will be secured at the transect to enable repeat field measurements to occur at specific stream locations. If necessary, streambed and water elevations tied to a local datum will be surveyed to the nearest 0.1 ft using standard optical surveying instrumentation and methods. A sufficient number of verticals will be established along the transect to accurately depict cross-sectional channel geometry. Water elevation at three flows spanning the range of releases associated with the PHABSIM data collection will be recorded through both survey and staff gaging, so that a

[9] As noted in the Rocky Shoals Spider Lily (RSSL) Study Plan, elevations of the existing RSSL colonies may also be documented concurrent with the bathymetric bed elevation survey, if deemed feasible during execution of the IFIM study.

stage-discharge relationship can be established. These data will then be used to establish a wetted perimeter rating curve, as example of which is shown in Figure 5.

FIGURE 5 SCHEMATIC DIAGRAM OF WETTED PERIMETER CROSS-SECTION, WATER ELEVATION AND CORRESPONDING RATING CURVE



Hydraulic Modeling

Hydraulic modeling and quality assurance/quality control techniques will be in accordance with standard practice for PHABSIM and River 2-D. Hydraulic modeling will be accomplished by correlating each surveyed WSEL with discharge to develop a stage-discharge relationship for each transect. Once this relationship is established, the model then adjusts velocities obtained at calibration flows to each flow increment of interest for which a defined water stage has been calculated. The model is then calibrated by comparing simulated hydraulics to empirical measurements taken at the calibration flows. Detailed steps are summarized below:

Field data collected at transects (e.g. cross section surveys, WSELs, velocities, discharge and slope measurements) will be entered into a computer database compatible with PHABSIM software. All field calculations of discharge and data entry will be proofed and cross-checked for accuracy. The field data include measurements at three calibration flows, and are used to simulate depth, velocity, substrate and cover conditions at discharges other than the calibration flows. Discharges and WSELs are determined for all calibration flows. Bed profiles, substrate and cover used in the model are derived from surveys made during low flows. Velocity calibration in the PHABSIM model typically relies on velocities measured during mid-range flows, although velocity measurements are sometimes made in the field for low flows at features such as riffles where velocities are very irregular across the cross section.

Transects within a common study site and mesohabitat type will be linked hydraulically (*i.e.* within the same datum) with adjacent contiguous transects or with downstream hydraulic controls that create backwater conditions. Stand alone transects, however, will be independently modeled. Simulation of water surface elevations at each transect will be accomplished using one of three methods within PHABSIM: IFG4, MANSQ or WSP. Often, all three models are run with the best stage-discharge relationship determined for each cross-section. The specific model used at a given transect depends on site characteristics, including gradient and backwatering from downstream hydraulic controls. IFG4 uses a log-log fit to determine a stage-discharge curve for the three calibration flows. MANSQ determines the stage-discharge relationship using the Manning's equation for stream flow, while WSP uses hydraulically-linked cross-sections in a backwater model to determine the relationship. WSP is similar to backwater models such as the U.S. Army Corps of Engineers' HEC-RAS program.

Velocity calibrations for each transect are performed using routines within the IFG4 model, usually at the mid-range flow. Where a low flow velocity set is also available, two models may be prepared, one to cover low flows and the other to represent mid-range to high flows. The range of simulated flows represented by each calibration set is determined by the hydraulic engineer based on the model's performance at the calibration flows and trends in hydraulic parameters such as water surface elevation and velocity. PHABSIM output for each simulated flow, such as Velocity Adjustment Factors (VAFs), are plotted as smooth curves with aberrations in these curves indicative of range boundaries for a given calibration flow. Typically, these fall toward extreme low or high flows in high gradient channels, at which point one of the other three calibration sets will be used to continue the model out to the extremes. The hydraulic engineer will review all hydraulic output and determine and document the acceptable range of simulated flows. This range usually extends from slightly below the low calibration flow to slightly higher than the high calibration flow. All hydraulic model output is reviewed by a second hydraulic engineer before being used in habitat modeling.

Habitat Suitability

Once the hydraulic model is calibrated, estimates of habitat suitability at each flow increment of interest will be generated by combining the HSI and hydraulic model data using the HABTAE and supporting programs within PHABSIM. These ultimately produce output known as Weighted Usable Area (WUA) for each transect at each flow increment. WUA is an index of habitat suitability based on units of square ft of optimal habitat available per 1,000 ft of represented stream length. WUA output for all transects in a given mesohabitat type are then weighted according to actual linear distance each transect represents within the mesohabitat, as mapped in the field, to provide a mesohabitat habitat-flow curve. All mesohabitat WUA within a given study reach is then weighted and summed for each flow increment to provide a net WUA estimate for the entire study reach.

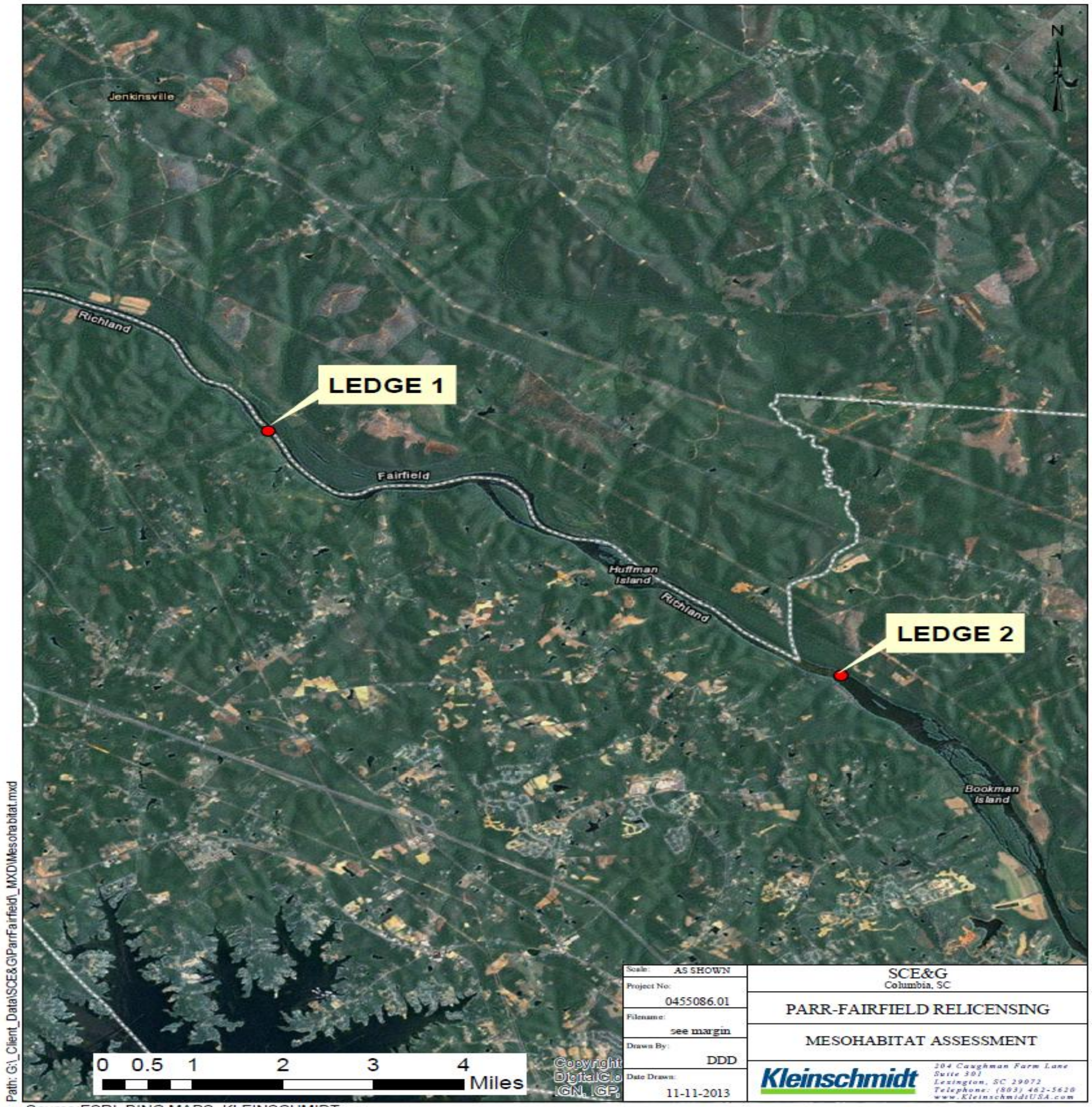
3.2.2 FISH PASSAGE AND NAVIGATION STUDY SITE(S)

During the IFIM field effort, data will also be collected to identify critical flows necessary to facilitate volitional upstream fish passage through limiting shoals areas, as well as one-way, downstream navigation through these sites. In preparation for this effort, the study area was examined during periods of low wadable flow when channel geometry and probable zone of passage routes were readily observed[10]. Two sites were selected that the TWC believes represent critical passage routes (Figure 6). The first is the bedrock ledge located approximately 2.4 mi upstream of Haltiwanger Island at Study Site 7 (81°15’46.507”W, 34°12’49.999”N). The passage point is on river left (looking upstream) and is approximately 45 ft wide (Figure 7), with an approximate change in elevation of 1.5 ft. The second is a ledge located approximately 1.3 mi upstream of Hickory Island and approximately 0.5 mi downstream of the mouth of Little River (81°10’15.941”W, 34°10’18.154”N). The passage point is also on river left (looking upstream) and is approximately 60 ft wide (Figure 8), with an estimated change in elevation of 1.5-2.0 ft.

[10] Field examinations were during the June 2013 agency field reconnaissance and during November 2013 as part of efforts to quantify mesohabitats occurring in the study area.

The field crew will obtain bed bathymetry, water elevation and velocity measurements at each calibration flow. These data will then be displayed graphically and in tabular format to develop a stage-discharge relationship that identifies flows that promote hydraulics that can provide suitable fish passage. Criteria for fish passage are presented in Bulak and Jobsis (1989). Recommendations for flows sufficient to support recreational navigation are described in the SC State Water Plan (SCDNR 2004) and deKozlowski (1988). According to those documents, instream flows in Piedmont streams should be sufficient to 1) provide one-way downstream passage of a 14 foot jon-boat without a motor through rocky shoals; and 2) provide two-way navigation in runs and pools with a 14 foot jon-boat with an outboard motor. Methodology and reporting requirements are described in greater detail in the *Parr Hydroelectric Project Downstream Navigational Flow Assessment Study Plan.*

FIGURE 6 FISH PASSAGE AND NAVIGATION PASSAGE STUDY SITES



Source:ESRI, BING MAPS, KLEINSCHMIDT

FIGURE 7 AERIAL VIEW OF BEDROCK LEDGE AT STUDY SITE 7.

FIGURE 8 AERIAL VIEW OF BEDROCK LEDGE ABOVE HICKORY ISLAND.

4.0 REPORTING

Phase 1 Report

A draft report will be prepared for TWC review and comment, documenting methods and results as encountered in the field and during modeling. This report will focus on analysis of the WUA /flow relationship at all study sites. Supporting hydraulic data will be presented in graphic and tabular form, along with an analysis of trends in the data, and documentation of study team consultation. Appendices will also include cross-sectional survey data and reference photographs of study sites. The report will be finalized and provided to the TWC following receipt of input from the study team.

Phase 2 Report - Dual Flow Analysis

During the second phase, a Dual Flow analysis will be performed following TWC review and approval of the Phase 1 report. The TWC will then consult to define the scope and parameters of the analysis. The purpose of this analysis will be to evaluate the effect on habitat suitability of various combinations of generation flows and base flows.

The assumption behind Dual Flow analysis for non-mobile organisms (e.g. macroinvertebrates, fish egg nests, *etc*) is that a specific patch of stream bed (represented by a modeled habitat cell) is only suitable as long as the hydraulic conditions remain suitable throughout the range of flows ("effectively-available habitat"). Habitat suitability is calculated by comparing the WUA of each 1-D or 2-D cell at each of two flows (a given base *vs.* generation flow pair). In the analysis, the lower of the two paired WUA values is considered to be the effectively available level of suitability for that cell. For example, if the habitat suitability value for a cell is zero at either the low *or* high flow, it is assumed to have zero effectively available habitat. The resulting WUA is then summed across all cells, to establish a composite WUA value for each flow pair of interest. For mobile lifestages, the same overall process is followed but the WUA comparison occurs at the study site scale rather than at the cell scale.

The TWC will consult to define bioperiods (seasons), and to select applicable base flow/peak flow couplets for analysis, subsets of habitat suitability criteria, and study site(s) at which to conduct the analysis. The report will provide both tabular and graphic data showing the ranges of WUA for each selected lifestage at each flow pair of interest, and a discussion of trends in the data.

5.0 CONSULTATION

This study relies upon periodic input from TWC members so that upon receipt of the final report, the TWC may provide flow recommendations to be used in other analyses such as assessing project operation issues, lake level management, and overall flow regime evaluation (see section 1.3). The TWC has thus far developed this study plan, conducted a reconnaissance of the study area, selected study reach boundaries, cell boundaries, developed provisional HSC, reviewed mesohabitat mapping of the study area, and met several times to confirm and/or refine aspects of the study plan.

SCE&G is responsible for conducting the study and analyses in accordance with this plan; during the course of the study, SCE&G will continue to consult with, and update the TWC regarding study progress, and seek input as necessary. This will include further development of HSC, advising TWC members of field data collection schedules, and modeling status prior to development of the Phase 1 Report. Following development of a draft Phase 1 Report, the TWC will conduct a workshop to review the WUA and flow relationships which are the foundation of flow recommendations and further Dual Flow analyses. The TWC will also select provisional base flow targets from the model output that can be used to conduct the empirical flow demonstration at Huffman Island (Study Site 9), and to verify modeling efficacy at other sites of interest, including zone of passage and navigability sites.

The final aspect of the study will be for the TWC to identify specific inputs for the Dual Flow analysis (described in Section 4), and to review and discuss the results of that analysis prior to developing preliminary habitat based recommendations for use in evaluating relicensing alternatives. Upon completion of the study and resulting consultation, minimum flow recommendations developed by the TWC will be provided to the Fish, Wildlife and Water Quality Resource Conservation Group (RCG) for consideration in development of the relicensing Protection, Mitigation and Enhancement (PM&E) Measures.

6.0 SCHEDULE

TASK	**COMPLETION DATE**[1]
Finalize target species/guilds	December 2013
Finalize HSI curves to be used	December 2013
Mesohabitat characterization; select transect locations	Winter 2014
Collect transect data	3rd Quarter 2015
Complete modeling	1st Quarter 2016
Issue draft Phase 1 report	2rd Quarter 2016
Conduct empirical flow demonstration	2nd Quarter 2016
Develop Dual Flow analysis	3rd Quarter 2016
TWC review and analysis of Dual Flow results	3rd Quarter 2016
Issue final report	4th Quarter2016
Provide Flow Recommendations to RCG	4th Quarter 2016

[1] Schedule is tentative and is intended as a general guide.

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APPENDIX A
TECHNICAL WORKING COMMITTEE MEETING NOTES

MEETING NOTES

SOUTH CAROLINA ELECTRIC & GAS COMPANY
Instream Flows TWC Meeting

May 7, 2013

Final KDM 05-31-13

ATTENDEES:

Bill Marshall (SCDNR)
Ron Ahle (SCDNR)
Gerrit Jobsis (American Rivers)
Shane Boring (Kleinschmidt)
Alan Stuart (Kleinschmidt)
Kelly Miller (Kleinschmidt)
Bill Stangler (Congaree Riverkeeper)
Ray Ammarell (SCE&G)
Vivianne Vejdani (SCDNR)
Bill Argentieri (SCE&G)
Milton Quattlebaum (SCANA)
Steve Summer (SCANA)
Randy Mahan (SCANA)
Dick Christie (SCDNR)
Tom McCoy (USFWS) via conference call
Prescott Brownell (NOAA)
Kerry Castle (SCDNR)

These notes serve to be a summary of the major points presented during the meeting and are not intended to be a transcript or analysis of the meeting.

Alan opens the meeting by briefly going over the agenda, then gives the group an overview of the float trip taken on March 19th and 20th. During this review, the group looks at the Project Area on a map, which sparks a discussion on the habitat just below the Parr Dam.

Ron explains how he is concerned about the separation in the habitat along the first mile of the Broad River, just below the Parr Dam. He says this is a highly utilized area of the river by fish species, and the side of the river along the west bank can grow stagnate during periods of low flow. Shane asks if a critical habitat study should be performed in this area. Ron says there are several critical habitats that need to be studied before the rest of the river is characterized. Prescott and Ron both mention they would like to have a habitat map made for as far down river as possible. Ron says that a habitat map should at least be made for the area immediately below the Parr Dam.

Gerrit tells the group he would also like to look at access along the river, since there are several areas that aren't accessible. Prescott mentions that he is interested in studying the tributaries along the river. Ron mentions that there is a good amount of data already available on the tributaries, collected by the DNR Stream Team.

Alan refers the group to a study on the Broad River, completed by Jason Bettinger (referred to throughout these notes as the Bettinger Study), as a possible starting point for the Parr Project's Mesohabitat Assessment and Instream Flow Study. The group notes that the Parr Project area was not included in this study, as the area in the Bettinger Study begins at Neal Shoals and extends upstream. However, the methodology used in the paper might still be utilized by the group.

After discussion on various needs for the Mesohabitat Assessment and Instream Flow Study, Gerrit focuses the group back on the agenda by beginning to list the goals and objectives for the study. Through much discussion the group agrees on four goals with corresponding objectives, as well as additional studies that need to be completed. These goals, objectives, and studies and included as an attachment at the end of these notes.

Steve and Ron then discuss the habitat issues at the west bank area. Ron says he believes that the decrease in DO and increase in temperature along the west bank area is related to the operating of the Fairfield Pumped Storage Project. Steve asks Bill if he has a copy of some aerial photos that were taken prior to Project construction since the west bank features are the result of natural topography, of which Bill answers he is not sure. Steve says he will try to find the photos, since they might show how river flow was distributed between the east and west bank area before the Project was built. Steve says that the issue will be getting water into that west channel during low flow situations. Gerrit says that Duke Energy is building a separate dam to help control flows at one of its projects. He believes the group needs to focus first on deciding what the flow needs for the area are, by seeing the area during higher flow situations. This will allow the group to evaluate how flows might be manipulated to create an even distribution over the area during low flow situations. Steve adds that LIDAR information will also be helpful, and that baseline data on temperature and DO in the west bank area will be needed to feed into the module. Ron mentions that spring through fall data needs to be collected, since he hasn't studied the area except during the summer. Kerry asks if turbidity will need to be examined along with the temperature and DO. The group considers this but decides that turbidity data is not necessary.

While looking at a photo of the dam, the group notes that there is a bit of leakage, which could be beneficial to the seemingly flow deprived west bank area. Ron agrees, but points out that during the summer, any benefits of the slight leakage at the dam may be diminished by the time they reach the central rocky location in the west channel.

The group then focuses their attention towards defining the geographic scope of the Mesohabitat Assessment and Instream Flow Study. The next hydro on the Broad River, downstream of the Parr Fairfield Project, is the Columbia Hydro Project. The upper reach of the PBL for the Columbia Hydro is noted as being at a Rocky Shoals Spider Lily population located just above the upper tip of Boatright Island. The group discusses whether or not this should mark the end of the scope for the Mesohabitat Assessment. It is decided that the scope for the Mesohabitat Assessment will stretch from Parr Dam downstream to the lower end of Bookman Island. Bill S. points out that there is a tributary on the lower end of Bookman Island, named Big Cedar Creek, and the scope should include this as well.

After deciding the scope, the group begins discussion on which definitions to use for the various mesohabitats. Two slightly varying sets of definitions are considered, including one used during the Saluda Hydro Relicensing Project, and one used in the Bettinger Study. Alan points out that using the definitions from the Bettinger study will be good for consistency, however, the group seems to prefer the definitions used during the Saluda Relicensing. Shane points out that there are several other commonly accepted definitions for the various mesohabitats and so the group decides to consider these options also. This issue is left undecided for now.

The group agrees to stay with the methodology that was used in the Bettinger Study. The group then discusses what the ideal flow would be when conducting the study. Ron says that lower flows make it easier to delineate the habitats, while Shane says the flow should be near the mean annual flow when mapping. Ron suggests a flow that is below 2,000 cfs would be best for conducting the study, and everyone agrees.

The focus then turns to identifying target and driver species for the various Habitat Use Guilds. Ron offers his personal list of fish species he has observed in the Broad River to be used as a starting point. The group decides on a list of driver species including:

- Smallmouth Bass
- American Shad
- Brassy Jumprock
- Whitefin Shiner
- Robust Redhorse
- Santee Chub
- Striped Bass
- Piedmont Darter
- Snail Bullhead
- Redbreast Sunfish
- Channel Catfish

Although the list is longer than is customary, Alan says that it can be included in the study plan with a caveat that says some of these species will later be grouped into guilds. Alan makes the point that the species which have HSI curves need to be identified, and suggests that Shane and Brandon Kulik work together on this task. Shane and Brandon will also recommend surrogates for the group to consider that can be used for the species that do not have HSI curves and work on guild classifications.

The group then focuses on establishing general transect locations for the study. Dick mentions that in the Bettinger Study a majority of the river was categorized as being glides, pools and shoals, and that these will be areas to look for when deciding on transect locations. Ron specifies that he would like at least one transect to be established right below the Parr Dam, in the area he has identified as a critical habitat. The group launches into a heavy discussion on where the transects should go and how many are needed. Eventually everyone agrees to four general areas for the study to implement the IFIM technique. These include an area immediately below Parr Dam, upstream of Haltiwanger Island, along the Coleman property, and at Haltiwanger Island. Additionally, two other sites were identified for studying wetted perimeter/staged discharge relationships, at Huffman Island and Bookman Island. These locations are included in Figure 1. With these sites agreed upon, the group decides to schedule a field trip to identify the specific locations for transects. Group members interested in participating in this trip are Ron Ahle, Shane Boring, Gerrit Jobsis, Bill Stangler, Bill Marshall, Alan Stuart, Vivianne Vejdani, Milton Quattlebaum, Tom McCoy, Prescott Brownell, Steve Summer, Ray Ammarell and/or Bill Argentieri.

To close the meeting, the group discusses scheduling, keeping in mind that the final study plan needs to be developed by early 2014 to be included in the PAD, which is due late 2014/early 2015. The actual IFIM study will be started during the summer of 2015. The group plans to meet again during the July-August timeframe to discuss the draft study plan and HSI curves. With this, the meeting adjourns. Action items stemming from this meeting are listed below, along with an attachment that includes all decisions made during the meeting.

ACTION ITEMS:

- Shane Boring will contact Brandon Kulik to work together on identifying relevant HSI curves and surrogates for the study. Shane will also ask Brandon to make guild recommendations.

- Shane Boring will research other options for mesohabitat definitions to be used in the study.

- Kelly will schedule the “Transect Identification Recon Trip” with the interested parties for June 18th and 19th.

- Kelly will schedule a follow-up meeting/conference call during the July-August timeframe for the discussion of HSI curves and study plan development.

Goals and Objectives of Mesohabitat Assessment and Instream Flow Study

Goal 1: Characterize the flow/habitat relationships for aquatic species present in the lower Broad River below Parr Dam

- Objective A: Classify and quantify/map (characterize/define) Mesohabitats occurring within study area
- Objective B: Establish target species/guilds
- Objective C: Identify study methodology (recommended IFIM)
- Objective D: Identify tributaries and study areas (reaches) on the lower Broad River of interest for the study

Goal 2: Determine effects of Parr and FFPS operations on flows of the lower Broad River below Parr Dam

- Objective A: Identify operational ranges/constraints of two facilities
- Objective B: Evaluate effects of Project operations on Parr Dam releases at various inflow ranges into Project

Goal 3: Develop recommendations for Parr Hydro Project operations to enhance flows for aquatic resources in the Congaree River (this does not include a transect study)

- Objective A: Influence on diadromous fish (includes striped bass, sturgeon)
- Objective B: Influence on other resident aquatic species (including RT&E)
- Objective C: Influence on Congaree National Park
- Objective D: Consideration of Saluda operations consistent with goals of the Santee Basin Accord

Goal 4: Develop flow recommendations for lower Broad River below Parr Dam

- Objective A: Evaluate baseline habitat
- Objective B: Evaluate high and low flows
- Objective C: Seasonal and inter-annual variations of flow recommendations
- Objective D: Evaluate low flow protocol recommendations

Additional studies:
Temperature and DO in the west channel below Parr Dam (three monitoring locations)
Recreation flows – operation of Parr
Navigation flows – operation of Parr
Water Quality – operation of Parr

Define Geographic scopes of Mesohabitat Assessment and Instream Flow Study / Discuss Mesohabitat Assessment (including methodologies)

Geographic Boundary - Parr Dam to downstream end (lower extent) of Bookman Island, just below the confluence of Big Cedar Creek

Methodologies –
Mesohabitat unit definitions for visual assessment. (NOTE: May be modified by use of Saluda descriptions)

Habitat	Type Description
Riffle	Relatively shallow (<0.5m), swift flowing section of river where water surface is broken.
Glide	Relatively shallow (<1m); with visible flow but mostly laminar in nature; minimal observable turbulence; relatively featureless bottom.
Run	Deep (>1m), swift flowing sections with turbulent flow; surface generally not broken.
Pool	Deep (>1m) slow moving sections.
Shoals	Shoal area; which may contain a variety of habitat complexes.

Use same methods Jason Bettinger used for his study in the upper Broad River, such as GPS for start and end of each classification.

Mesohabitat study should be conducted below 2,000 CFS

Define Species of Interest for Instream Flow Study

Summary of Habitat Use Guilds

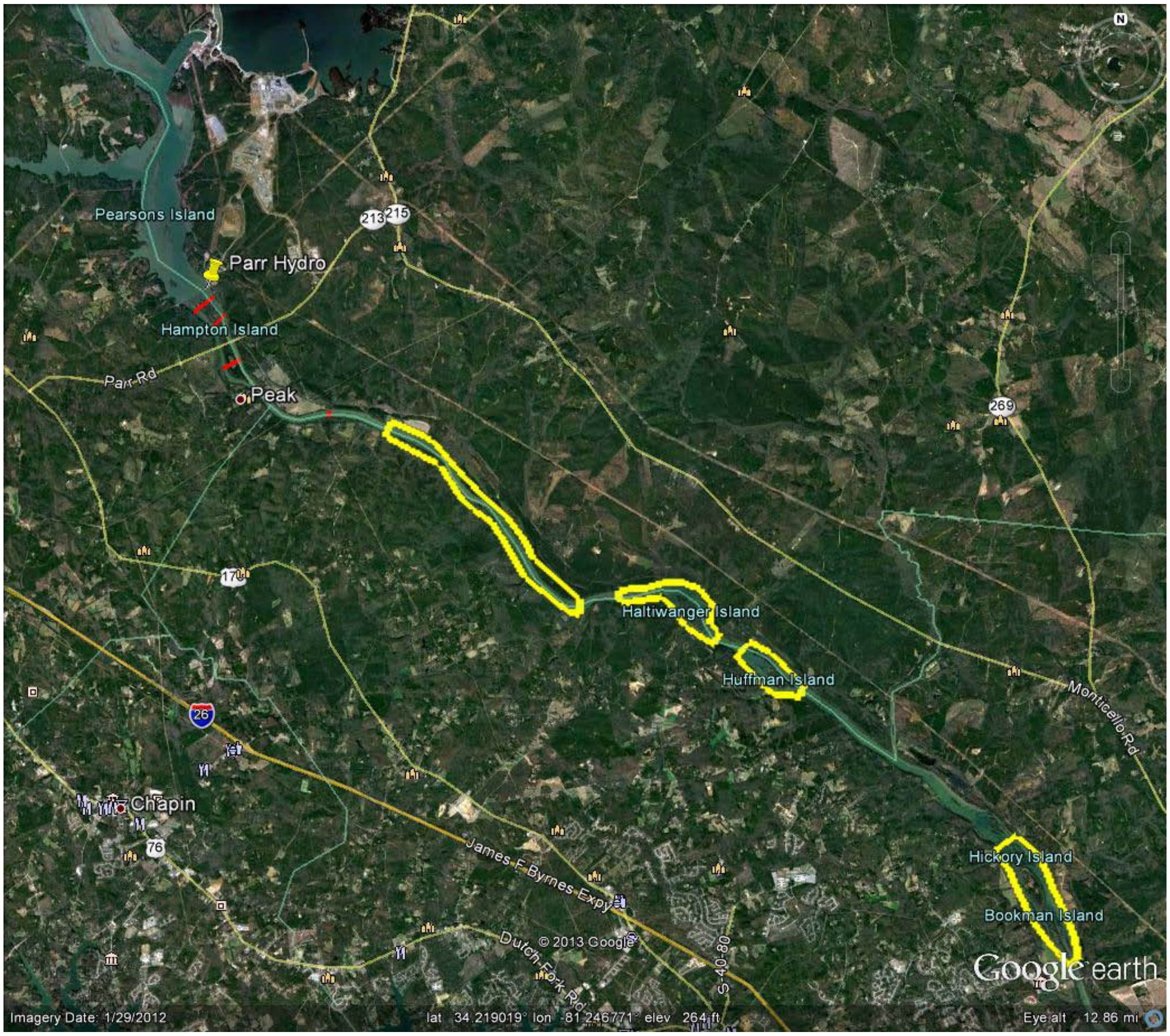
Driver Species:
American shad
Brassy jumprock
Channel catfish
Piedmont darter
Redbreast sunfish
Robust Redhorse
Santee chub
Small mouth bass
Snail bullhead
Striped bass
Whitefin shiner

Discuss Methodology (including HSI curves, number and location of transects, areas of specific interests)

Look for HSI curves that exist for driver species and make recommendations for surrogates and guilds

Methodology (number and location of transects, areas of specific interests): IFIM above Huffman Island, wetted perimeter for Huffman and Bookman islands.

Figure 1 **General Transect Locations**



PARR-FAIRFIELD PROJECT

Instream Flow Study

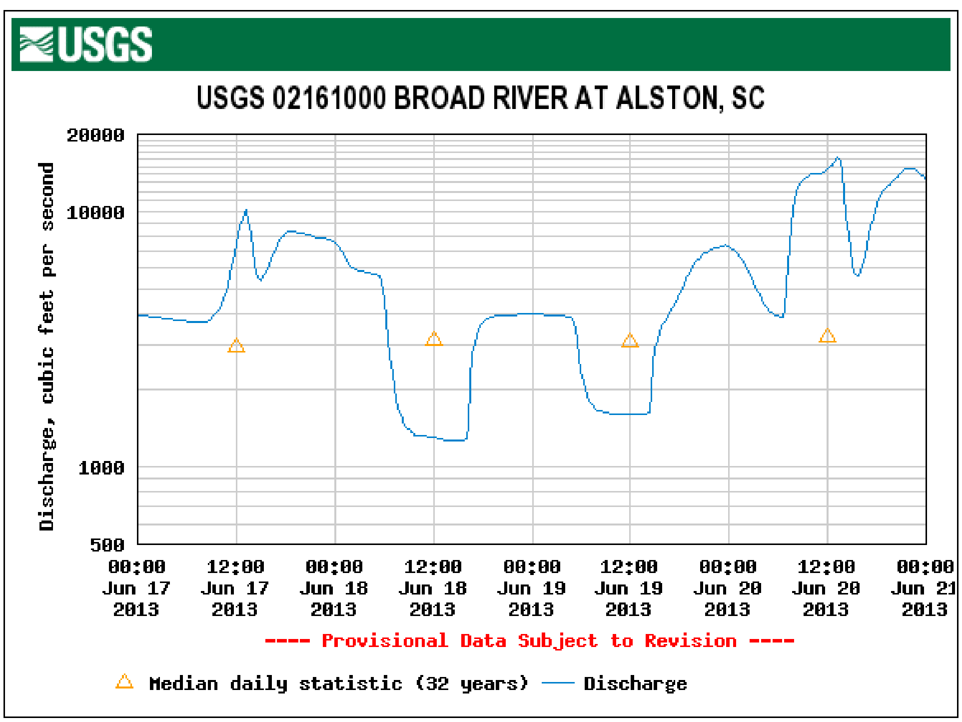
Study site and transect selection field visit summary

DATE: June 18-19, 2013

ATTENDEES:

Ron Ahl	S.C. Dept of Natural Resources (SCDNR)
Bill Marshall	SCDNR
Gerrit J¨bsis	American Rivers
Bill Stangler	Congaree Riverkeeper
Bill Argenteri	SC Electric & Gas (SCE&G)
Milton Quattlebaum	SCE&G
Alan Stuart	Kleinschmidt Associates (KA)
Shane Boring	KA
Brandon Kulik	KA

The goal of this meeting was to collaboratively select study reaches, study sites, transect cell boundaries and discuss data collection and modeling approaches for an IFIM Study of the Broad River, consistent with TWC objectives set at the May 7, 2013 TWC meeting. At that meeting, key river reaches for modeling and analysis were identified. During the site visit, participant hiked, waded and boated these reaches. During each day of the site visit, SCE&G managed discharge downstream from the Parr-Fairfield dam in the range of approximately 1,300-1,700 cfs so that the TWC could view mesohabitat and channel features.



The following notes reflect in-field study scoping decisions:

The study area was divided into two study reaches:

Reach 1 – from the dam to the confluence of the tailwater and bypass reach (near the downstream tip of Hampton Island (near the Palmetto Trail trestle crossing) and

Reach 2 - from the trestle downstream through Bookman Island complex.

Reach 1 – from dam to downstream end of Hampton Island

Study Site 1 – immediately below the western end of the dam, habitat is dominated by pools formed by perched bedrock ledge that primarily receive incidental flow during high flows or periodic spillage under existing operation. It was observed that there was little to no flow in this area on the day of site visits. The TWC agreed that the primary habitat issue was volitional passage of fish among pools, and adequate water circulation to maintain suitable temperature and dissolved oxygen (DO) for fish occupying pools, and that this site could not be effectively modeled using Physical Habitat Simulation (PHABSIM. Effort will focus on quantifying the turnover rate that maintains temperature and DO in pools) and adequate zone of passage at the most limiting channel constriction.

Photo 1. Ledge/pool area below dam in study site 1

Study Site 2 – Site viewed from Highway 213 bridge. Site located just to the west of the island, below site 1 on "bypass reach" side. The TWC agreed to 2 transects above power line in run/glide habitat to capture different substrate /cover conditions: one within boulder field, and a second in a more open channel between the boulder field and power line. The TWC concurred that this site could potentially be modeled with PHABSIM, and that the areas downstream from the power line within the study reach were backwatered, and composed of ephemeral fines that migrate.

Photo 2. Run/glide mesohabitat in study site 2 (in distance near transmission tower) looking upstream from highway bridge; ephemeral sand deposits are in foreground

Study Site 3 – Located on tailrace side of Hampton Island. The TWC delineated cell boundaries for this site and gathered GPS waypoints to mark upstream and downstream cell boundaries. Site consists of Run → Glide→ Riffle complex, and group agreed on one PHABSIM transect in each. Run begins at gravel bar approximately 100 yds downstream of powerhouse (GPS pt #77), transitions to glide (GPS pt "Glide3") and transitions to riffle bedrock ledge (GPS pt #77). Bottom of riffle needs to be determined from aerial or determined in field at time of transect set-up. Run transect selected at location of large sycamore near aforementioned gravel bar (flagged). Ron Stated that this is potentially a very important robust redhorse habitat site, and also important for quillback carpsucker, American shad, and represents complex habitat not represented elsewhere.

Study Site 4 - Just upstream of Palmetto Trail trestle at the lower end of channel on west side of Hampton Island. Group observed Native American weir and small shoal near lower end. Ron noted this as important habitat, noting that it is highly influenced by backwatering from powerhouse flows. The TWC decided that a stage/discharge transect would best fit for this area rather than a PHABSIM model, with the objective of evaluating response at different side channel and powerhouse flows

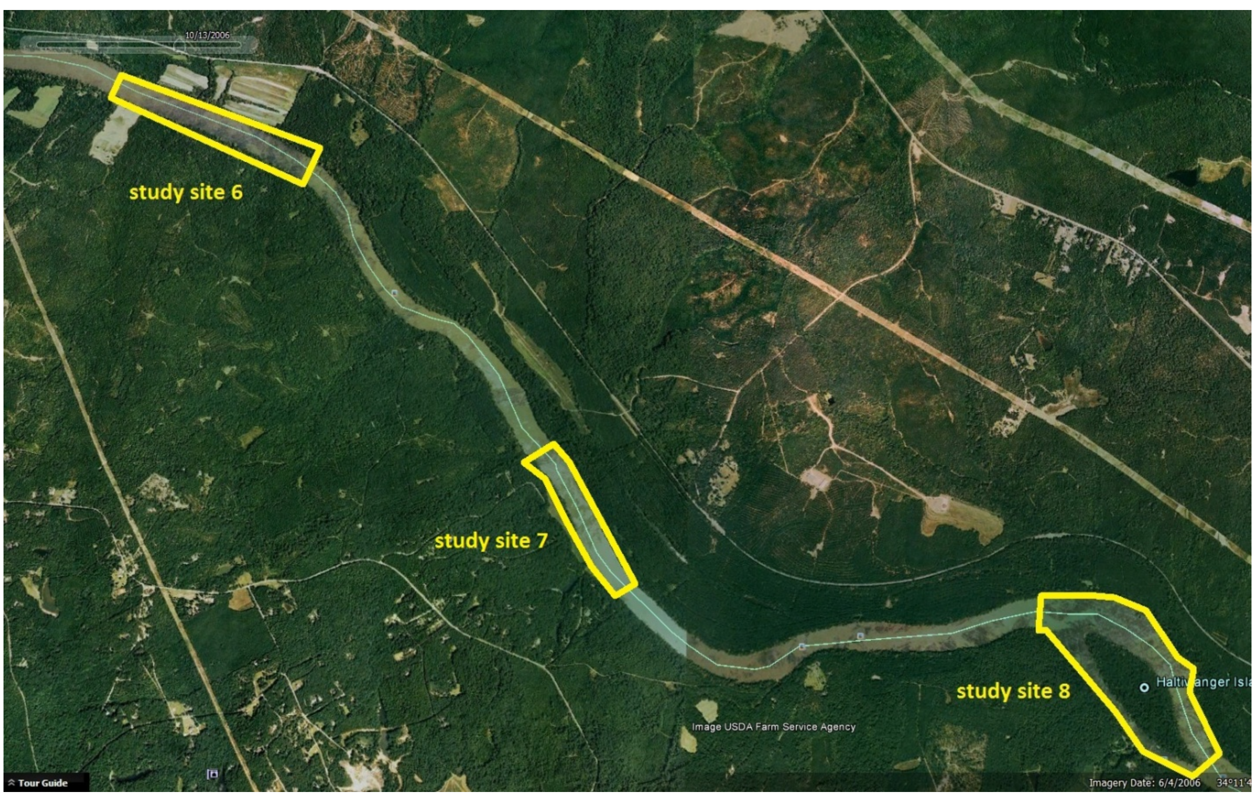
Photo 3. Run/riffle mesohabitat in study site 4, looking upstream from trestle

Study Site 5 – Just upstream of Palmetto Trail trestle on the downstream end of powerhouse side of Hampton Island. The TWC agreed to focus on 1 of the 2 shoals occurring in this area, with at least one riffle and one run transect for PHABSIM modeling.

Photo 4. Shoal mesohabitat in study site 5, looking upstream from trestle

<u>Reach 2 – from end of Reach 1 downstream through Huffman Islands</u>

The TWC then boarded canoes to traverse the next segment downstream to Haltiwanger Island. Brandon Kulik did not accompany the group on this segment due to a schedule conflict.



Study Site 6 – Large "main-channel riffle" approximately 2 miles downstream of Palmetto Trail trestle. Large field on river left, study site ends at large shed at downstream edge of field. Uppermost cell boundary at the head of riffle (GPS pt #79). Downstream end of study area delineated by GPS pt # 80. Numerous rocky areas spread across river, very different than shoal above RR bridge. Gerrit noted this area was too variable to capture with just one transect; potentially needs to 2-3. It was noted that most rocks covered at observed flow (approx 1400cfs), but many shallow areas with rocks just under surface.

Study Site 7 – "Big Ledge" (near George Addy Rd.) that Ron noted as being very unique to the River (GPS pt # 81). Consisted of Glide → Shoal → Pool complex. The TWC agreed that 2-3 PHABSIM transects likely needed, with one each in glide and riffle mesohabitats, and potentially one in the pool. The TWC was undecided on how and whether to include the pool in a PHABSIM model, or how best to document it. The TWC noted that site is likely the most limiting for navigation and upstream fish passage, and therefore should also be assessed for navigation and fish passage due to the large bedrock ledge (See DeKozlowski 1986 for methodology).

Study Site 8 – The TWC concluded the first day of site work at the Haltiwanger Island complex. The TWC noted very diverse habitat above island; river right and river left channels are at this flow (approx 1,400 cfs). The majority of water appeared to be flowing down left channel. The TWC agreed that one PHBSIM transect above island was needed and at least one for river right and river left channels adjacent to island. The group also noted that it would be important to determine how flow partitioned between channels at different flows.

Study Site 9 – The TWC boated upstream to the Chapel Shoals/Huffman Island Complex on June 19. Gerrit Jobsis was unable to participate due to a schedule conflict. Bill Argenteri joined the group.

Huffman Island divides the flow between two channels.

The TWC concluded that a wetted perimeter analysis was not suitable for this site, and initially considered this as a potential study area for River 2D modeling, with data collection occurring at the shoals at the downstream end of Huffman Island and Chapel Shoals at the upper end, with less intense data collection along the two connecting channels. The group also considered simplifying modeling by using the shoal spanning the whole channel immediately downstream from the island as a surrogate study site. However, after viewing the larger, more complex river channel located a short distance downstream at Bookman Island (see discussion of study site 10), it was concluded that a thorough modeling effort at Bookman Island would adequately account for flows at the Chapel Shoals/Huffman Island site. The TWC agreed that once potential flow targets are determined based on the Bookman Island model, a flow demonstration of such flows will be conducted at Huffman Island as necessary to empirically document habitat suitability in the Huffman Island study site.

Study Site 10 – Bookman Island complex. This complex is comprised of numerous small and large islands, main and side channels, and complex bed bathymetry. The TWC agreed that, due to the size and complexity, neither a wetted perimeter nor 1-D PHABSIM model would be sufficient, but that a 2D model of this would be the most conclusive way to quantitatively evaluate habitat suitability. The group agreed that a 2D data collection effort would be conducted throughout the reach from the upstream tip of Hickory Shoal downstream to where the channels converge below Bookman Island.

MEETING NOTES

SOUTH CAROLINA ELECTRIC & GAS COMPANY
Instream Flows TWC Meeting

July 31, 2013

Final KDM 08-20-13

ATTENDEES:

Bill Marshall (SCDNR)
Ron Ahle (SCDNR)
Gerrit Jobsis (American Rivers)
Shane Boring (Kleinschmidt)
Alan Stuart (Kleinschmidt)
Kelly Miller (Kleinschmidt)
Bill Stangler (Congaree Riverkeeper)
Vivianne Vejdani (SCDNR)
Frank Henning (Congaree National Park)
Chad Altman (SCDHEC)
Bill Argentieri (SCE&G)
Milton Quattlebaum (SCANA) via conf. call
Steve Summer (SCANA)
Brandon Kulik (Kleinschmidt) via conf. call
Dick Christie (SCDNR)
Tom McCoy (USFWS)
Byron Hamstead (USFWS)
Rusty Wenerick (SCDHEC)
Fritz Rohde (NOAA)

These notes serve to be a summary of the major points presented during the meeting and are not intended to be a transcript or analysis of the meeting.

After introductions, Alan opens the meeting by reviewing the agenda. He then turns the meeting over to Brandon and Shane to give an overview of the IFIM recon trip that was held June 18th and 19th. Brandon reviews the notes from the trip, which were provided to the group via email on July 10th, giving a description of each of the ten study sites. Study site 7 was noted by Ron to be a very unique stretch of the river and a very important study area. He said this area has a defined drop with an obvious glide that is highly utilized by fish. Ron says this area of the river is unique because of the size of the drop, but it is also quite representative of the river overall, due to the types of habitats it provides. The group agreed that Site 7 should be evaluated using the DNR's navigation criteria and that other sites should also be considered.

Brandon and Ron then discussed the pool that was located at study site 7 and whether this area was going to be included in the study. Brandon says while pools don't really influence flow decision-making, this area should be documented. Frank H asked if the pool areas need to be studied from a sediment standpoint, to determine if there is enough flow to flush sediment out of the pool, and prevent sediment trapping. Ron and Shane both agree that this shouldn't be an issue, as there is plenty of flow to keep the sediment moving. Ron says the pools will be mapped during the mesohabitat study, and agrees with Brandon that transects aren't needed here.

Brandon then describes how a 2D model works, which is a possible option for study site 9. 2D modeling uses a honeycomb type of data gathering, which fit together to form a picture. This gives a different view of a site versus a straight transect. The group decided that a 2D model should be used at study site 10, at Bookman Island. Gerrit asks how the analysis for the 2D modeling will be conducted, with the flows being at the selected levels. Brandon says that field data will be collected at Bookman and then used to see what flow range makes the most sense for modeling. Alan asks if the entire Bookman Island complex will be used for modeling at Huffman Island, or will just a piece of the complex be used. Brandon says the entire Bookman Island complex will be used. He adds that the two island complexes will not be mathematically linked, but instead an empirical examination will be used to determine similarities between the two (i.e., a field verification, similar to what was done for the Saluda Project) of flow recommendations, to ensure that recommendations developed are based on work at Bookman are applicable to Huffman Island.

Gerrit mentions the importance of determining how the channels at Bookman are linked, and how some of the smaller channels may be isolated during periods of lower flow. Brandon assures Gerrit that the 2D modeling will include the small cross-channels around the islands, so that these areas may be studied as well. Gerrit says he wants to make sure the study plan captures not only the analysis using HSI curves, but also how various flows affect these small channels. He would like to have a site visit to examine Huffman and Bookman Islands during several different flows to ground truth 2D modeling results.

With this, Alan notes that there seems to be concurrence within the group on the study approach, and asks Brandon if he has enough information to develop a study plan. Brandon says he does and will begin developing a study plan to bring back to the group for review.

The group then begins discussing the HSI curves that Brandon sent to the group to review. Brandon proposes that we use the Hightower curves for the American shad. Alan mentions that these curves are the ones sent to the group by Prescott Brownell a month earlier.

Ron then questions some of the guild classifications for the various fish species. He disagrees with some of the guild assignments and Alan and Dick suggest we work through the information until everyone can agree. The group discusses the difference between shallow versus deep and fast versus slow. The group also discusses the addition of other species at various life stages to the list. Ron suggests listing all life stages for the smallmouth bass in the study plan. Ron disagrees with the curve that corresponds to the smallmouth bass spawning, saying that spawning tends to decrease in waters deeper than approximately 4.5 feet. Brandon agrees, recommending the curve be changed to a stair step, with spawning increasing after reaching a depth of approximately 0.5 feet. Shane agrees to do some research on smallmouth bass spawning and work with Brandon to develop a modified curve for this species for discussion within the TWC.

The group discussed brassy jumprock curves and the need to change the guild for adults to Deep Fast and the guild for juveniles to Shallow Fast.

Gerrit recommends that striped bass spawning lifestage be included in the study. Ron agrees. The group discussed applicable curves from the Pee Dee IFIM study and Crance. Gerrit recommended that we bring in DNR striped bass expert Dr. Jim Bulak to help determine/develop appropriate curves.

The group discussed the importance of adding snail bullhead juvenile lifestage to the study and the need to review bullhead and catfish lifestage curves.

Gerrit and Ron ask for clarification regarding the channel index scale. Brandon explains the scale where 0 corresponds to detritus, 1 to fines, 2 to small gravel, 3 to large gravel, 4 to small cobble, 5 to large cobble, 6 to small boulder, 7 to large boulder, 8 to smooth bedrock, and 9 to irregular bedrock. Shane adds that a table from Wentworth will be included in the study plan that describes these substrates. Gerrit observes that the curves use different channel indices and recommends that all curves use the same channel index.

The group then focuses on modifying the guilds and habitat suitability criteria that Brandon provided. These modifications are included at the end of these notes. Gerrit mentions that the original studies should be referenced in the study plan and not just the broader study in which they were last used, such as the Pee Dee River IFIM.

The group discusses the range of operational flows that modeled as part of the IFIM study, as well as what calibration flows would be needed to model that range. Alan mentions that a range of 250 cfs to 2100 cfs was modeled during the IFIM study for the Saluda Relicensing Project. Brandon suggests putting some level loggers out in the river ahead of the study. Gerrit suggests that a dual flow analysis should be evaluated, to determine Project effects. The group decides on the following calibration flows to allow for modeling of the full range of operational flows: low flow of 400 cfs, with a medium flow of 2000 cfs and a high flow of 10,000 cfs.

After lunch, the group discusses the mesohabitat definitions that Shane provided. Tom says he likes the measurements that are included in the Bettinger definitions and the extra details that are included in the Catawba Wateree definitions. He would like to combine these two with the Saluda definitions. Ron says he doesn't want hard lines to be set for each definition with regards to depth as depths change depending on river flow. He would like to see the depths to be used as guides, but not exact measurements. Brandon suggests adding general depths and flows to the definitions for each habitat. Brandon points out that many of these habitats have already been identified on the river by the group during the IFIM recon trip. The group just needs to agree on the wording for each definition. The group discusses the differences between a glide versus a run, deciding that the slope upstream or downstream is a determining factor. The group works to modify the Saluda definitions and these modifications are included at the end of these notes.

SCE&G and Kleinschmidt personnel will begin to develop the study plans for the IFIM study and Mesohabitat Assessment and will have a draft ready for TWC review and approval by the beginning of October. The group plans to meet or have a conference call before the mesohabitat assessment is started. Any action items stemming from this meeting are included below.

ACTION ITEMS:

- Shane will research the smallmouth bass spawning and will work with Brandon develop a new HSI curve for review within the TWC.
- Shane will refine the mesohabitat definitions and distribute to the group for approval.

DRAFT MEMORANDUM

TO: Parr-Fairfield Hydro: Instream Flow/Aquatic Habitat TWC

FROM: Brandon Kulik

DATE: July 9, 2013

RE: **PROPOSED HABITAT SUITABILITY CRITERIA**

On May 7, 2013, the Instream Flow/Aquatic Habitat Technical Working Committee (TWC) agreed upon species and lifestages for which habitat suitability should be evaluated on the Broad River below the Parr-Fairfield Project as a part of AN IFIM study (Table 1)..

Table 1: Evaluation species elected by the TWC

- Smallmouth Bass
- American Shad
- Brassy Jumprock
- Whitefin Shiner
- Robust Redhorse
- Santee Chub
- Striped Bass
- Piedmont Darter
- Snail Bullhead
- Redbreast Sunfish
- Channel Catfish

The purpose of this memo is to recommend potential Habitat Suitability Criteria (HSC) for use in this study that are applicable to the above species. Smallmouth bass and redbreast sunfish criteria were sourced from the Saluda study, as the TWC has already vetted these curves. Although the Saluda study had employed TWC-approved American shad HSC, these criteria have recently been refined, based on the research of Joe Hightower in North Carolina (Hightower, *et. al*, 2012) and provided to us by NOAA Fisheries. We propose that the TWC consider using these updated criteria.

The remaining species do not have well developed, individual HSC. However, the Pee Dee IFIM study addressed habitat suitability for these species by classifying each of them into applicable guilds. This information was provided to the Saluda IFIM TWC during study scoping (Gerrit Jobsis, October 16, 2006). Based this information (Table 2), we classified the remaining Parr-Fairfield evaluation species and lifestages into proposed guild categories (Table 3)

Attachment A displays the coordinates for the resulting HSC proposed for use, based on the source material identified in Table 3.

Kleinschmidt

Table 2. Guild classification for individual species and lifestages, from Pee Dee River IFIM study (2004)

Species and Habitat Guild Assignment Table for the Pee Dee River Instream Flow Study. Revision 2 - July 9, 2004.

Scientific Name	Common Name	Habitat Types and Guilds[1, 2, 3]			
		Shallow Slow	Shallow Fast	Deep Slow	Deep Fast
Petromyzontidae	**Lampreys**				
Petromyzon marinus	sea lamprey		A		
Acipenseridae	**Sturgeons**				
Acipenser oxyrinchus	Atlantic sturgeon				S
Acipenser brevirostrum	shortnose sturgeon				S
Lepisostedidae	**Gars**				
Lepisosteus osseus	longnose gar	A, J		A, J, S	
Amidae	**Bowfin**				
Amia calva	bowfin			A, S	
Anguillidae	**Freshwater eels**				
Anguilla rotstrata	American eel	J		A, J	J
Clupeidae	**Herrings**				
Dorosoma cepidanum	gizzard shad	A, J		A, J, S	
Dorosoma petenense	threadfin shad	A, J		A, J, S	
Alosa mediocris	hickory shad			J, S	
Alosa sapidissima	American shad			J	J, S
Alosa aestivalis	blueback herring			J, S	
Cyprinidae	**Carps and Minnows**				
Cyprinus carpio	common carp	J, S		A, J, S	
Notemigonus crysoleucas	golden shiner	A, J, S		A, J, S	
Hybognathus regius	Eastern silvery minnow	J, S		A, J, S	
Nocomis leptocephalus	bluehead chub		A, S		
Cyprinella analostana	satinfin shiner	A, J, S		A, J, S	
Cyprinella nivea	whitefin shiner	A, J	S	A	
Cyprinella pyrrhomelas	fieryblack shiner	A, J	S	A	
Notropis altipinnis	highfin shiner	J, S		A	
Notropis amoenus	comely shiner	A, J	S	A, J	
Notropis hudsonius	spottail shiner	A, J	S	A, J	
Notropis petersoni	coastal shiner	A, J	S	A	
Notropis scepticus	sandbar shiner	A, J	S	A	
Catostomidae	**Suckers**				
Catostomus commersoni	white sucker	J	S	A, J	A
Minytrema melanops	spotted sucker	J	S	A	
Scartomyzon spp.	brassy jumprock	J	S	A	A
Moxostoma macrolepidotum	shorthead redhorse	J	S	A	A[4]
Moxostoma anisurum	silver redhorse	J	S	A, J	
Moxostoma robustum	robust redhorse		S	A, J	
Moxostoma sp.	Carolina redhorse		S	A, J	
Carpiodes cyprinus	quillback		S	A	S
Erimyzon oblongus	creek chubsucker	S?		A, J, S?	
Carpiodes velifer	highfin carpsucker		S	A	S
Ictiobus bubalus	smallmouth buffalo	J	A	A, S	A
Ictiobus cyprinellus	bigmouth buffalo			A	

Table 2.
Continued

Scientific Name	Common Name	Habitat Types and Guilds[1,2,3] Shallow Slow	Shallow Fast	Deep Slow	Deep Fast
Ictaluridae	**Bullhead catfishes**				
Ictalurus punctatus	channel catfish			A, J	J
Ictalurus furcatus	blue catfish			A, S	A
Ameiurus catus	white catfish			A	A, J
Ameiurus brunneus	snail bullhead			A	
Ameiurus nebulosus	brown bullhead			A	
Ameiurus platycephalus	flat bullhead			A	
Pylodictus olivaris	flathead catfish	J		A, J, S	
Esocidae	**Pikes**				
Esox americanus americanu	redfin pickerel			A, J, S	
Esox niger	chain pickerel			A, J, S	
Umbridae	**Mudminnows**				
Umbra pygmaea	Eastern mudminnow			A, J, S	
Poeciliidae	**Livebearers**				
Gambusia holbrooki	Eastern mosquitofish			A, J, S	
Aphredoderidae	**Pirate perches**				
Aphredoderus saynus	pirate perch			A	
Atherinidae	**Silversides**				
Labidesthes sicculus	brook silverside			A	
Percichthyidae	**Temperate basses**				
Morone americana	white perch	J	S	A, J	S
Morone chrysops	white bass	J	S	A, J	S
Morone saxatilis	striped bass				A, S
Centrarchidae	**Sunfishes**				
Lepomis auritus	redbreast sunfish	J, S		A, J, S	
Lepomis cyanellus	green sunfish			A, J, S	
Lepomis gibbosus	pumpkinseed	J, S		A, J, S	
Lepomis macrochirus	bluegill	J, S		A, J, S	
Lepomis microlophus	redear sunfish			A, J, S	
Lepomis punctatus	spotted sunfish			A, J, S	
Micropterus salmoides	largemouth bass	J, S		A, J, S	
Pomoxis nigromaculatus	black crappie			A, J, S	
Percidae	**Perches**				
Etheostoma olmstedi	tessellated darter	A, J	S	A	
Percina crassus	Piedmont darter		A, S		
Perca flavescens	yellow perch			A, J, S	

[1]Habitat types based on predominant habitat types present in the Pee Dee River derived from the aerial videography study.

[2]Life stages: A = adult, J = juvenile, including young-of-year, and S = spawning.

[3]Classification of species and life stages into habitat types based on Becker (1983), Hamilton and Nelson (1984), Aadland et al. (1991), Jenkins and Burkhead (1994), Rhode et al. (1994), Leonard and Dilts (2003), and Progress Energy (2003).

[4]Foraging adults based on Jenkins and Berkhead (1994).

Table 3. Proposed HSC source data for Parr-Fairfield IFIM study

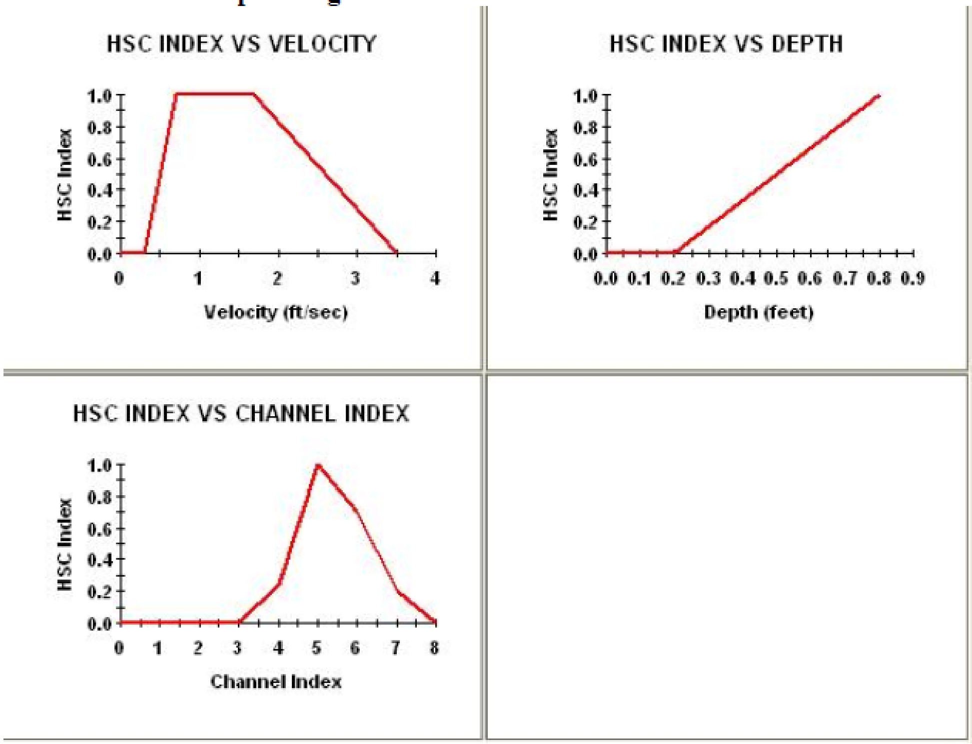
species criteria	lifestage	source	guild
Smallmouth Bass	All (spawning, fry, juvenile &adult)	Saluda	N/A
American Shad	spawning	Hightower, *et al.*, 2012	N/A
Brassy Jumprock	adult	Pee Dee River IFIM	deep ~~slow~~fast
Brassy Jumprock	juvenile	Pee Dee River IFIM	shallow ~~slow~~fast
Brassy Jumprock	spawning	Pee Dee River IFIM	shallow fast
Whitefin Shiner	adult	Pee Dee River IFIM	shallow slow; deep slow
Whitefin Shiner	juvenile	Pee Dee River IFIM	shallow slow
Whitefin Shiner	spawning	Pee Dee River IFIM	shallow fast
Robust Redhorse	adult	Pee Dee River IFIM	~~deep slow~~Stand alone species (Bud Freeman HSI)
Robust Redhorse	juvenile	Pee Dee River IFIM	Stand alone species ~~deep slow~~
Robust Redhorse	spawning	Pee Dee River IFIM	Stand alone species ~~shallow fast~~
Santee Chub	adult	Pee Dee River IFIM	shallow fast
Striped Bass	Adult	Pee Dee River IFIM	Deep slow, deep fast
Striped Bass	Spawning		N/A (Crance, Bulak)
Piedmont Darter	adult	Pee Dee River IFIM	shallow fast
Piedmont Darter	spawning	Pee Dee River IFIM	shallow fast
Snail Bullhead	Adult	Pee Dee River IFIM	deep slow
Snail Bullhead	Juvenile		shallow fast
Redbreast Sunfish	Adult	Saluda	N/A or deep slow?
Redbreast Sunfish	Spawning		Shallow slow?
Channel Catfish	adult	Pee Dee River IFIM	deep slow
Channel Catfish	juvenile	Pee Dee River IFIM	deep slow; deep fast

LITERATURE CITED

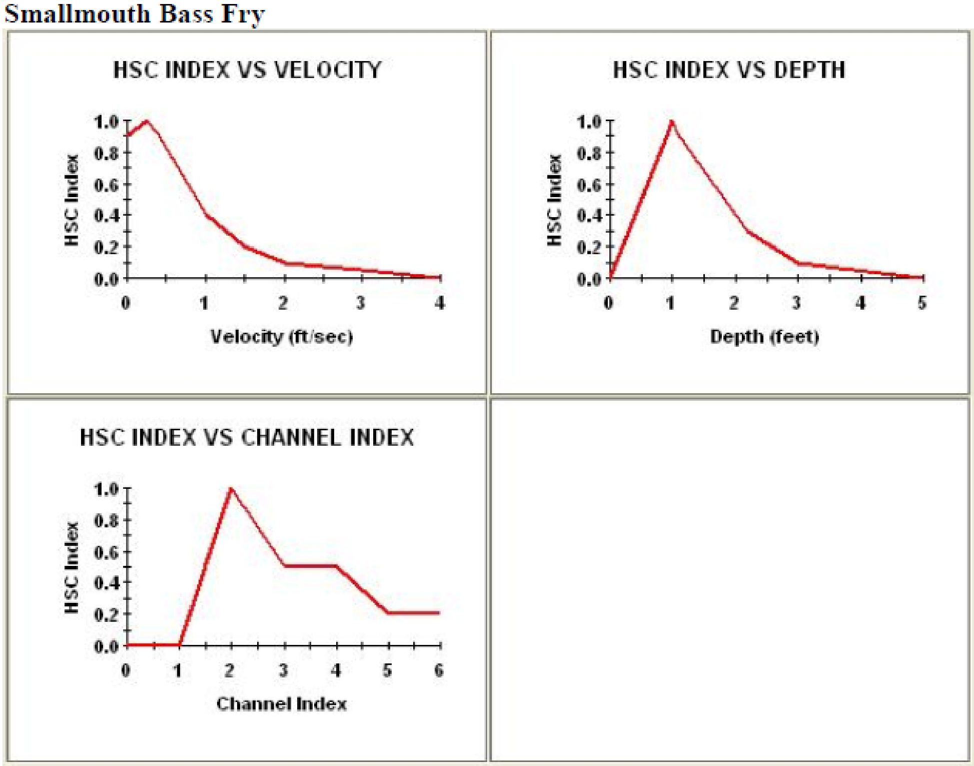
Hightower JE, Harris JE, Raabe JK, Brownell P, Drew CA. 2012. A Bayesian spawning habitat suitability model for American shad in southeastern United States rivers. Journal of Fish and Wildlife Management 3(2):184–198; e1944-687X. doi: 10.3996/082011-JFWM-047

Attachment A
Habitat Suitability Criteria

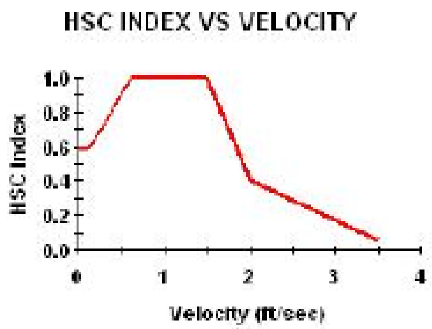
Smallmouth Bass Spawning

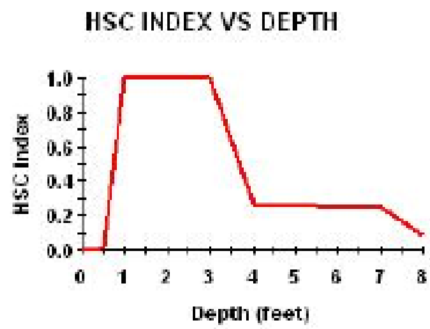


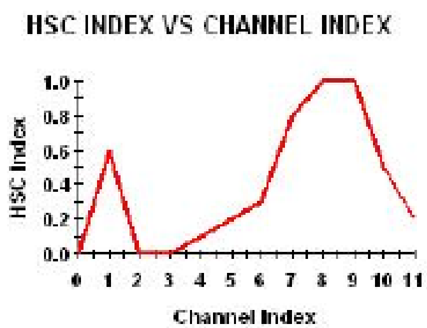
Smallmouth Bass Fry



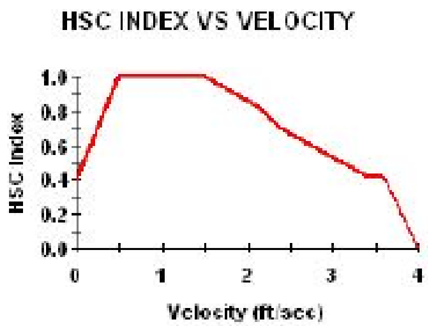
Smallmouth Bass Juvenile

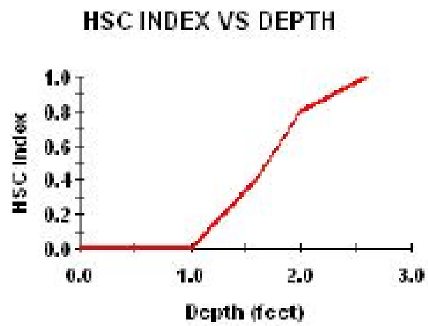


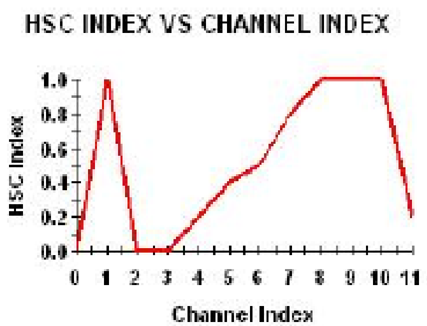




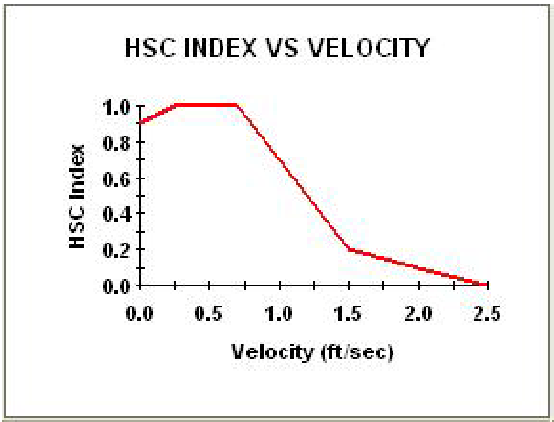
Smallmouth Bass Adult

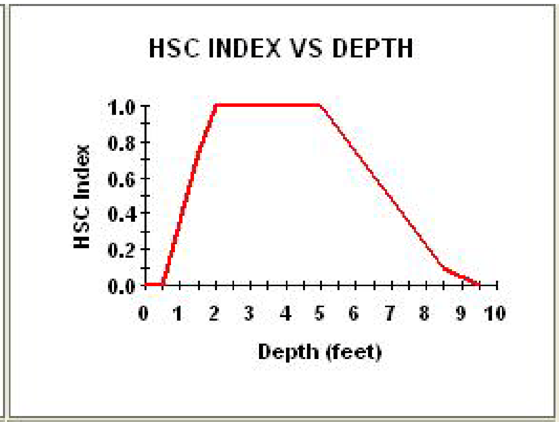


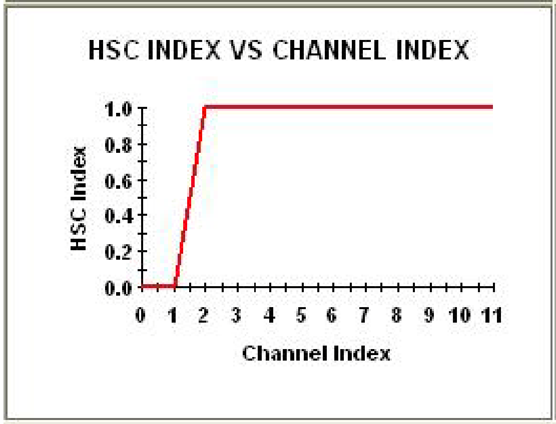




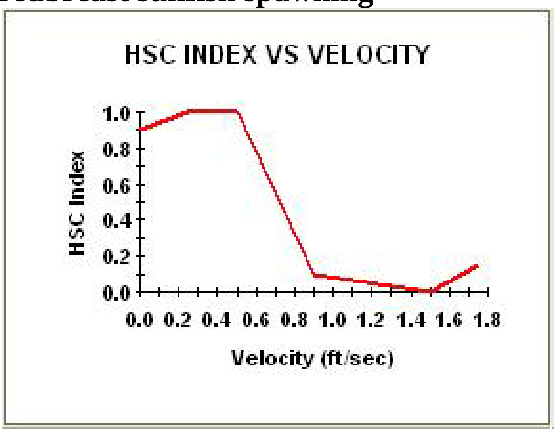
redbreast sunfish adult

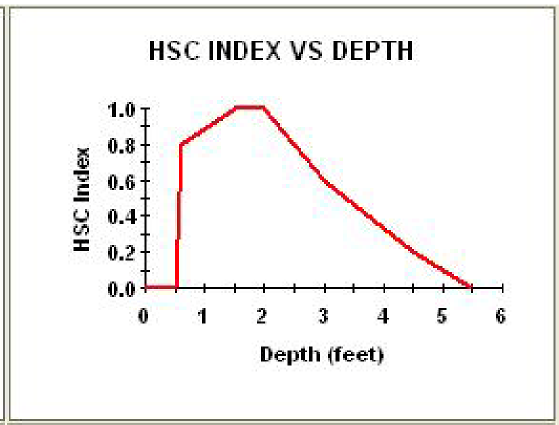


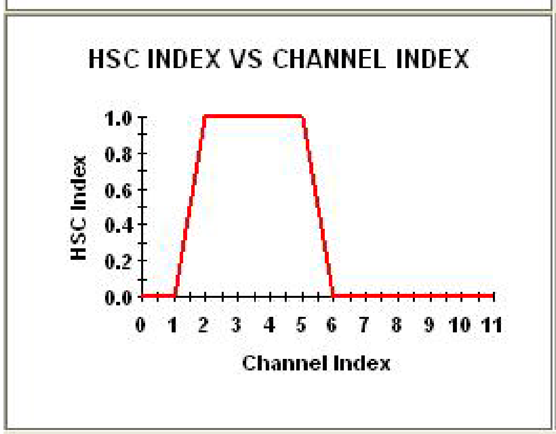




redbreast sunfish spawning







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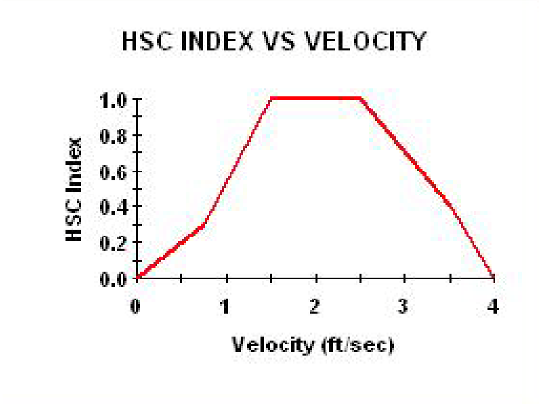
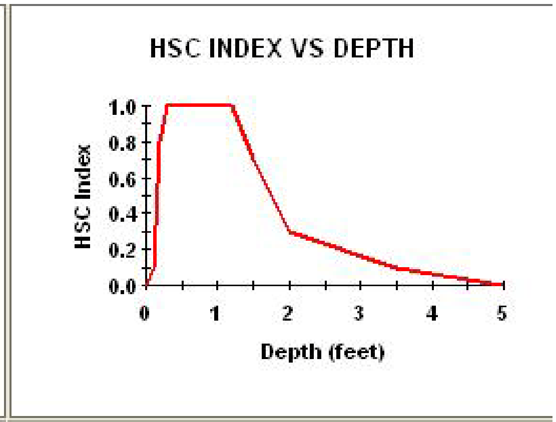
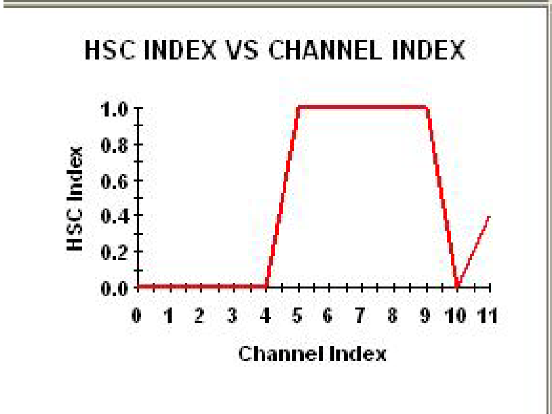
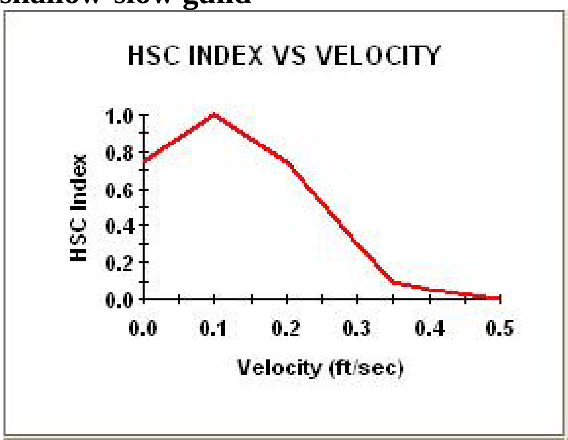
shallow-fast guild

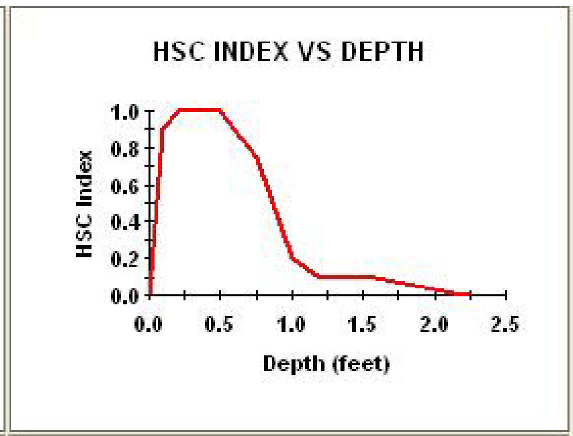


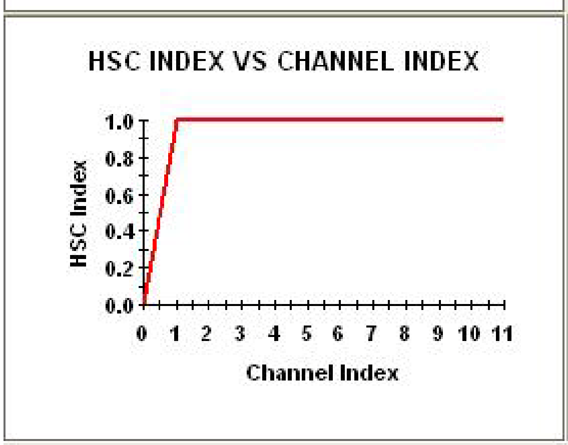




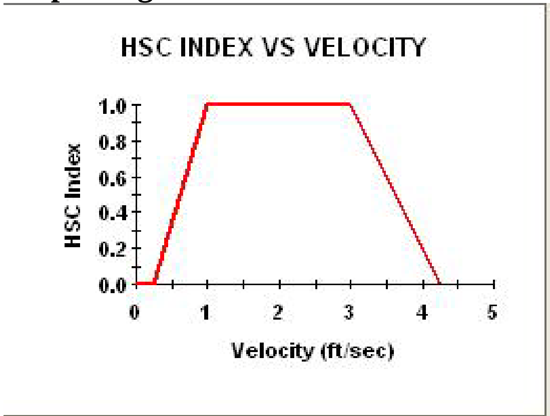
shallow-slow guild

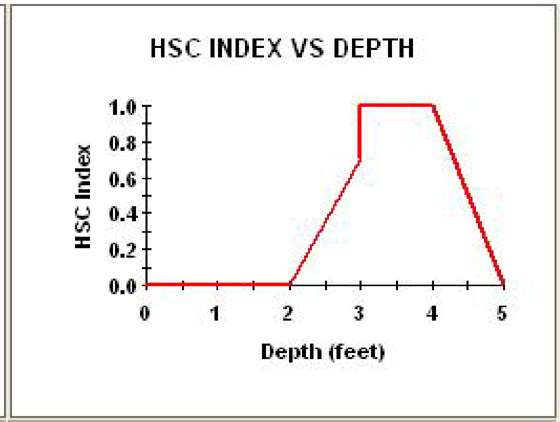


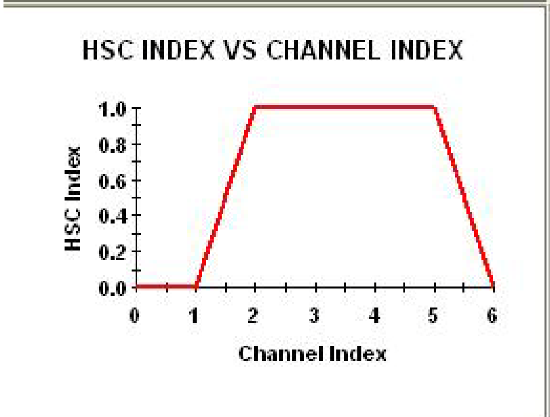




Deep-fast guild

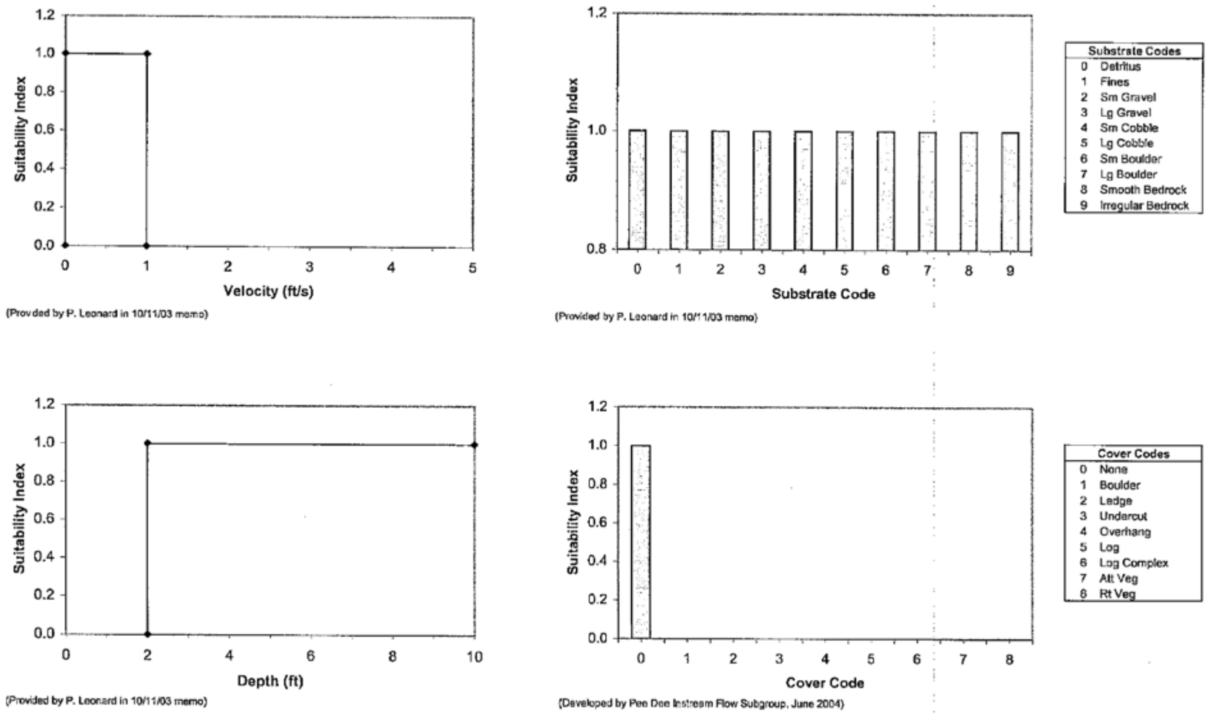






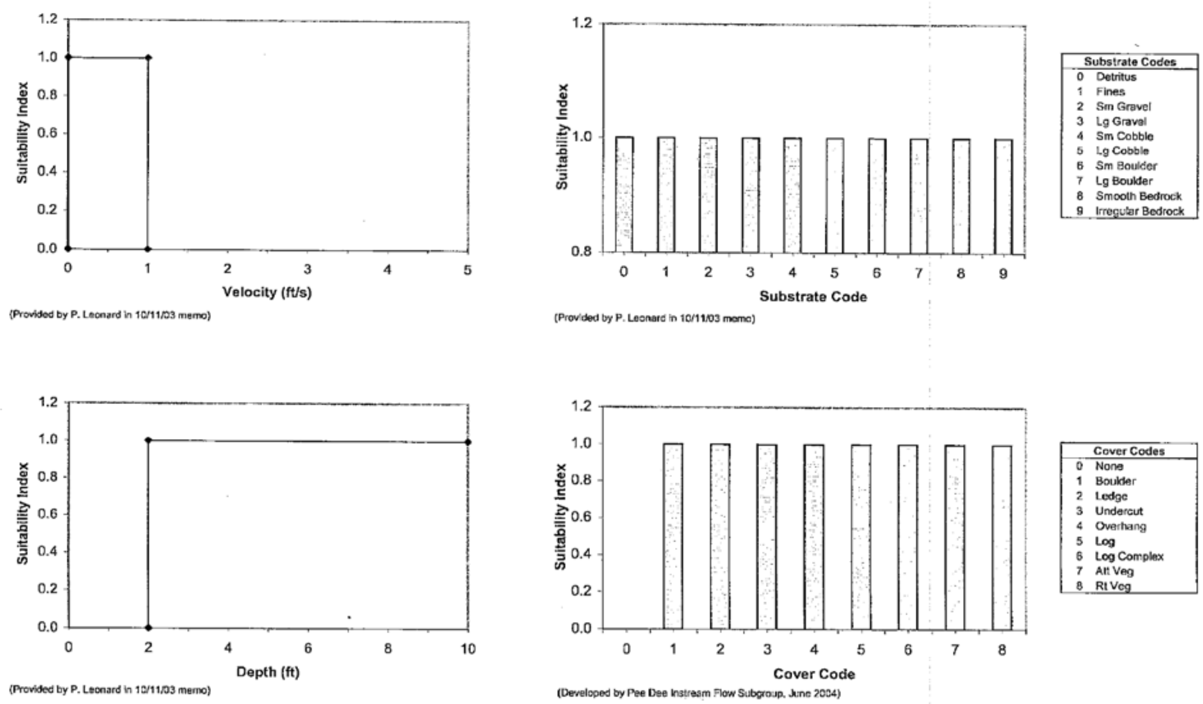
Deep Slow Guild, No Cover

Generic guild habitat suitability



Deep Slow Guild, Cover

Generic guild habitat suitability



AMERICAN SHAD spawning (*Hightower, et al., 2012*).

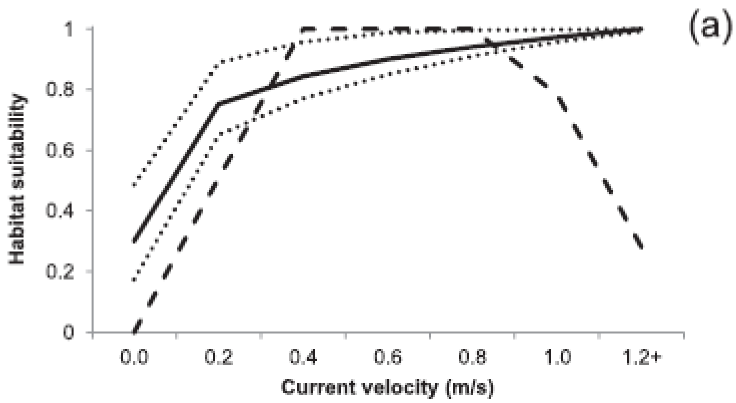


Figure 5. (**a**) Estimated American shad *Alosa sapidissima* spawning-habitat suitability for current velocity (median, with dotted lines indicating 95% CI) in southeastern U.S. rivers, based on a resource selection function fitted to (**b**) data on habitat use vs. availability, by 0.2-m/s velocity bin. The dashed line shows the suitability curve developed by Stier and Crance (1985).

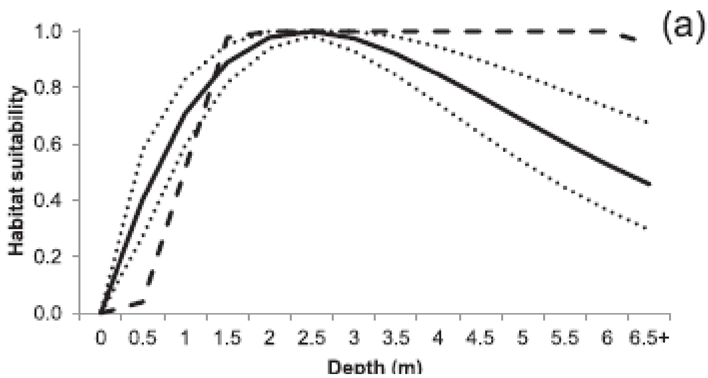


Figure 6. (**a**) Estimated American shad *Alosa sapidissima* spawning-habitat suitability for water depth in m (median, with dotted lines indicating 95% CI) in southeastern U.S. rivers, based on a resource selection function fitted to (**b**) data on habitat use vs. availability, by 0.5-m depth bin. The dashed line shows the suitability curve developed by Stier and Crance (1985).

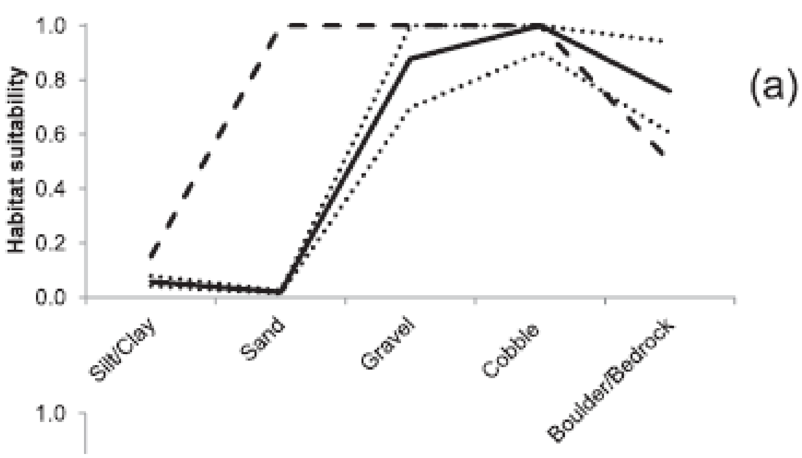


Figure 7. (**a**) Estimated American shad *Alosa sapidissima* spawning-habitat suitability for substrate (median, with dotted lines indicating 95% CI) in southeastern U.S. rivers, based on a resource selection function fitted to (**b** and **c**) data on habitat use vs. availability, by substrate category. The dashed line shows the suitability curve developed by Stier and Crance (1985), using averages for combined categories (silt/clay, boulder/bedrock).

Mesohabitiat Classifications

Bettinger et al 2003

Habitat Type	Description
Riffle	Riffle Relatively shallow (<0.5m), swift flowing section of river where water surface is broken.
Glide	Relatively shallow (<1m); with visible flow but mostly laminar in nature; minimal observable turbulence; relatively featureless bottom
Run	Deep (>1m), swift flowing sections with turbulent flow; surface generally not broken
Pool	Deep (>1m) slow moving sections.
Shoals	Shoal area; which may contain a variety of habitat complexes.

Saluda Hydro IFIM Study

Habitat Type	Description
Riffle	Shallow, with moderate velocity, turbulent, high gradient, moderate to large substrates (cobble/gravel). Typically > 1% gradient.
Glide	Moderately shallow, well-defined non-turbulent laminar flow, transition from low to moderate velocity, lacking a definite ~~well-defined~~ thalweg, typically flat stream geometry, typically finer substrates, transitional from pool.
Run	Moderately deep ~~to deep~~, well-defined non-turbulent laminar flow, range from low to moderate velocity, well-defined thalweg, typically concave stream geometry, varying substrates, gently downstream slope (<1%).
Pool	Deep, low to no velocity, well-defined hydraulic control at outlet.
Rapid/Shoal	Shallow, with moderate to high velocity, turbulent, with chutes and eddies, high gradient, large substrates or bedrock. Typically >2% gradient.
Backwater	Varying depth, no or minimal velocity, off the primary channel flow ~~long backwatered reaches.~~

Kleinschmidt

Catawba Wateree

Habitat Type	Description
Glide	Depending on the strength of the shoal and the bed profile directly upstream of the control, a glide or a pool will be created. A glide is generally defined by slower velocities and a relatively uniform bed profile, but a rough bed profile is not uncommon. Glides will either progress into a more concave bed profile just upstream of the shoal (creating a pool), or maintain their uniform hydraulic and bed features until direct contact with the shoal. Substrates can be large or small but, except at very high flows, do not create turbulence. Due to the slower velocities and increased depths, finer substrates will typically begin to settle in glides.
Run	Immediately downstream of the shoal, there is typically a transition area prior to the water entering the next pool or glide. This unit consists of relatively fast moving, turbulent water and a gradually descending bed profile. When mapping habitat in higher discharges (deeper flow), these areas can be visually identified by an upwelling of water just on the downstream edge of the shoal. This “roiling” effect is created by the sudden drop in water off of the shoal due to the lack of any backwater effect. Substrate composition varies from fine sediments to cobble and boulders. As the water begins to collect and back up further downstream, velocities slow, depths increase, and the transition into a glide or pool occurs.
Pool	If the bed profile upstream of the shoal is more concave or possesses significant undulations, a pool will be formed. Pools are visually represented by the slowest velocities of the four main habitat types and the most extreme depths. Steep banks and narrow channels relative to the rest of the reach can often be associated with pools. The stronger or more defined the downstream control (shoal), the more defined the pool. Substrate composition in pools generally consists of a layer (thick or thin) of finer substrates over boulder or bedrock.
Shoal	Shoals are relatively shallow, submerged ridges that occur with a consistent frequency down the longitudinal profile of the river. Shoals act as downstream controls to pools and glides and create the hydraulic conditions necessary to form runs immediately downstream. Substrate composition in shoals is typically bedrock, boulders, and coarse substrates. The “strength” of each hydraulic control dictates the magnitude to which it influences the upstream habitat types. Each shoal will create a unique situation upstream in which pools, glides or both may be identified.

AFS Aquatic Habitat Assessment Methods (Bain and Stevenson, 1999)

Habitat Type (macrohabitats)	Description
Glide	Nonturbulent, low-moderate velocity; gravel, cobble, sand substrate; slop 0-1%. Wide channel lacking a definite thalweg; usually at the transition between a pool and riffle; no major flow obstructions; lacks features associated with pools; moderately shallow (10-30 cm)
Run	Nonturbulent, swift velocities; gravel, cobble, boulder substrate; low slope. Occurs over a defined thalweg flat plane with a uniform channel form; no major flow obstructions; moderately shallow; deeper than riffles.
Pool	Formed from lateral construction of channel or sharp drop in water surface profile. Features: bend in channel, large-scale obstructions (e.g. boulder, log). Concave in shape; direction of flow varies widely; depth greater than riffle or runs.
Riffle	Moderate turbulence; little to no whitewater; high turbulence at points of channel construction. Moderate velocity (20-50 cm/s). Gravel, pebble, cobble substrates (totally or partially submerged). Slope <4%. Channel profile usually straight to convex.
Rapid	Considerable turbulence and whitewater. High velocity (>50 cm/s). Course, exposed, cobble, gravel substrate. Slope of 4-7%. Steps and pocket pools common; planar longitudinal profile.

SOUTH CAROLINA ELECTRIC & GAS COMPANY
Instream Flows TWC Meeting

March 5, 2014

Final KDM 04-8-14

ATTENDEES:

Bill Marshall (SCDNR)	Bill Argentieri (SCE&G)
Ron Ahle (SCDNR)	Milton Quattlebaum (SCANA)
Gerrit Jobsis (American Rivers)	Steve Summer (SCANA)
Shane Boring (Kleinschmidt)	Brandon Kulik (Kleinschmidt) via conf. call
Henry Mealing (Kleinschmidt)	Dick Christie (SCDNR)
Kelly Miller (Kleinschmidt)	Randy Mahan (SCANA)
Bill Stangler (Congaree Riverkeeper)	Byron Hamstead (USFWS)
Vivianne Vejdani (SCDNR)	Fritz Rhode (NOAA) via conf. call

These notes serve to be a summary of the major points presented during the meeting and are not intended to be a transcript or analysis of the meeting.

Henry opened the meeting with introductions and then Shane lead the group in a review of the Mesohabitat Assessment Report. Shane explained the intent of the study and reviewed the results, including an overview of the maps. Ron asked to see an individual breakdown of maps 2a, 2b and 2c and Shane said he will provide these maps to the group.

Bill M. asked if we learned anything new from the study. Shane said that the most restricted point on the river for fish passage and boat navigation was identified. This area is right above the Bookman Shoals complex. This area is identified in the IFIM Study Plan as an area that needs further study. Shane said they also did a survey for Robust Redhorse spawning areas during the mesohabitat study. Two areas were identified including a location right downstream of Parr Shoals Dam and another location upstream of Bookman Shoals. Shane said that Scott Lamprecht agreed that these spots seemed ideal for Robust Redhorse spawning. Milton said he also went out on the river with Scott and they identified another area near the Bookman Shoals complex and Hickory Island. A spot near Haltiwanger Island was also identified. Shane will develop a memo summarizing all of this information on Robust Redhorse spawning sites and will distribute this memo to the group. He will also append the memo to the final IFIM report. Shane will edit the IFIM Study Plan so it mentions that the Robust Redhorse memo will be appended to the final IFIM report.

Shane also said that during the mesohabitat assessment they learned that Bookman Island is very complex with lot of cross channels, braiding and varying elevations. He said that at least seven channels had been identified in the area. Fritz added that seams of bedrock add complexity because they act as weirs, moving the water in different directions depending on flow. He said it is good that 2D modeling will be performed in this area during the IFIM study. Byron asked if the 2D modeling will include the two Robust Redhorse sites identified in the Bookman Island complex and Shane said yes. Shane added that the upstream site at Haltiwanger Island will be studied using PHABSIM along with the site right below Parr Shoals Dam at Hampton Island. Ron said that the area just downstream of the Parr Shoals Dam is good for Robust Redhorse because there seems to be a dike formed by the rock with a gravel bed, covered by deep water. Ron said suckers are often found in this area.

Ron said that the Broad River downstream of Parr Shoals Dam is very complex, and that the maps included in the Mesohabitat Assessment Report are generalized. But he believes they are fairly accurate and that the proportions of the various mesohabitat types found in the river are accurate. Shane agreed and said that sometimes while looking at a cross section of the river, one side of the river may have a run and the other side may have a backwater pool. Shane said this was hard to convey in the maps, but that overall the map delineations and the report are very accurate.

Byron asked if areas of constriction throughout the river have been mapped out. Shane said GPS points have been taken and can be provided to the group, but cross sections detailing depth and other information has not been mapped out yet and will be completed as part of the IFIM study. Shane showed the group, using Bing maps, two areas in the river where fish passage and navigation may be possible. These areas will be studied in more detail during the IFIM study.

The group began reviewing the IFIM Study Plan and Shane mentioned that the Mesohabitat Assessment Report will be added as an appendix to the final IFIM Report. Byron wanted to know how the information collected in the IFIM study would be used for determining suitable crayfish habitat. Will the amount and type of cover available at various depths be examined? Henry said this will not be done using PHABSIM, but this information can be collected as part of the general description of the study area. Gerrit asked if when determining cover types, isn't it typical to not only look at the transect, but upstream as well? Brandon said yes because at the upstream/ downstream cell boundary level, the area is reasonably homogenous but within the cross section localized substrate variations can be like a mosaic, so it is typical to look upstream and downstream a reasonable distance to characterize the substrates assigned to a particular vertical. Brandon said that in regards to crayfish, the group can establish what the important cover types are for a particular species beforehand so that the field crews know what to look for during data collection. Byron said he will do some additional research to identify the preferred covers for the spiny crayfish. He is interested in determining how much cover is available and how much is exposed at varying water levels. Henry said that this may be possible with rocky substrates since they are fairly permanent, but that the abundance and distribution of woody debris can change from year to year so only general qualitative observations can be made. Henry said that if large woody debris is located at a PHABSIM transect, it will be surveyed in depth, otherwise just general descriptions of what is located upstream and downstream will be recorded to characterize conditions and where it is located relative to water levels. Brandon said that photos and possibly videos will also be taken to document the substrate and cover types in the area. If Byron develops a specific list of the type of substrate and cover that is important for crayfish, including a description of the types of woody debris preferred (approximate size and position in the water column), it will make it easier to document these during the study. Brandon said they can look at what is exposed during low flows and also record how high flows mobilize these substrates. Ron said that in his experience the large woody debris found in the central portion of the river is usually located in areas of accumulating sand and is typically transient and moving. All other woody debris tends to be found along the shorelines. Byron said that the wetted perimeter study will provide a lot of information on the woody debris found throughout the river. He will determine what the specific habitat requirements are for the spiny crayfish, an at risk species which is currently under candidate review, and provide these to the group prior to the IFIM study.

In section 3.2.2 of the IFIM Study Plan, Shane added in a description of the downstream ledge which may be a possible navigation site.

Bill S. asked why the river directionality is positioned looking upstream. Shane said that it just depends on how the biologist is trained. The group agrees to change all direction references to looking downstream.

Prior to the meeting, Gerrit submitted a comment regarding the inclusion of a Dual Flow analysis (DFA) into the IFIM Study Plan. Brandon explained to the group what a DFA is and his description is attached to the end of these notes. He said the goal of a DFA is to assess Project generating flows and how various operating scenarios affect habitat suitability. Base flow and generating flow couplets of interest are identified, along with selection of key species and lifestages. Effectively available habitat for a particular study site is calculated at pair of stream flows. A comparison of the amount of units of WUA available at the base flow versus the units of WUA at the generating flow is completed. DFA only records WUA corresponding to the lower of the two paired values regardless of whether the lower WUA occurs at the low or high flow. The assumption is that the lower WUA value represents the level of suitability persisting under both conditions For example, if the habitat value is zero at the low or high flow, then the value for that pairing is zero. Shane said this can be done as a desktop exercise and doesn’t require any extra field effort however a basic PHABSIM analysis must be completed and reviewed first since this step establishes the quantification basis.

Gerrit said DFA can also be done to mitigate the effects of peak flows by changing the base flow. He said you can iteratively move the base flow up or peak flow down to mitigate and lessen the affect on habitat to assess different operating scenarios. The idea is that if the higher the habitat suitability is a majority of the time, then the episodes of lower habitat suitability are less stressful to the aquatic species . Bill A. asked if base flows would be changed during certain times of the day or seasonally. Gerrit said this is a seasonal change. Brandon said spatially peaking effects attenuate going downstream so that the effect is most pronounced nearest the tailrace. The group would have to decide if the analysis should focus on the upstream reaches of the river or the downstream reaches.

The group decided that the study plan needs to include information on process steps regarding the DFA. The TWC will review initial WUA output and then meet to determine the DFA scope. No additional field work will be needed. Shane will add a few paragraphs to the IFIM Study Plan describing the DFA process. Kelly will send these paragraphs out to the TWC for review and comment.

Other additions to the IFIM Study Plan include mentioning the Robust Redhorse memo, adding in crayfish habitat suitability information (provided by Byron) and adding wording on the identification of substrates for crayfish during the IFIM study. Ron mentioned he would like to see a more specific schedule for when the IFIM study will take place because he would like to help. He would like to see the schedule already included in the IFIM Study Plan expanded to include more specifics. He would also like to see qualifiers added in to account for bad weather or flows that might inhibit data collection.   All of these changes will be made to the study plan in track changes and sent out to the TWC for review and approval.

Dick asked the group if they want to specify the goals of the analyses in the study plan. For example, SCDNR's recommendation is to identify a minimum flow that would provide 80 percent of maximum WUA. The group decided to add a list or table outlining the process of the study, which will include an expanded section on TWC consultation.

Gerrit asked if there will be demonstration flows scheduled following the results of the IFIM study regarding navigation and fish passage. Bill A. said that there can be demonstration flows and Shane will add this into the process schedule.

Dick mentioned the navigation component of the IFIM Study Plan and said that it was not consistent with the Navigational Flows Study Plan, which is discussed in the Recreation TWC. The Navigational Flows Study Plan needs to be changed to include a description of the two-way navigation requirement. This study will still only focus on one way navigation, but a description of two-way navigation needs to be included. This study plan will be re-circulated to the Recreation TWC for approval and then finalized.

Shane then gave the group an overview of the 2014 field season efforts for the IFIM study. Level loggers will be deployed in late March or early April in 12 different locations from the Parr Shoals Dam to the Columbia Dam pool, near the rowing facility. Level logger data is being collected to examine travel time for flows and to develop stage discharge relationships. Additionally, 2-D data collection will be completed in the Bookman Shoals area (Study Site 10), which includes latitude, longitude and elevation data for the entire two mile study area. At Study Site 1, a terrain model for quantifying pools and fish passage will be created. Cross sectional profiles including bed elevations and water surface elevations will also be collected at Study Site 4. Bill S. asked how many points will be examined at Study Site 10. Shane said he isn't sure yet, but it will be a good idea to look at existing LiDAR data and DEM data to make sure they establish an adequate number of points. This should give clarity to the density of points needed for the model. Densities could be as tight at every three meters. Shane said that the TWC is welcome to help with these efforts this year as well. Emails will be sent to the group to notify them as soon as possible when the work will be done.

The IFIM Study Plan will be updated to reflect the items discussed at the meeting and sent back out to the TWC for approval. Action items stemming from this meeting are listed below.

ACTION ITEMS:

- Byron will identify the preferred habitat substrates for the spiny crayfish and provide this information to the group for use during the IFIM study.

- Shane will change the language in the IFIM Study Plan to reflect a "looking downstream" perspective.

- Shane will add in a section describing the process steps of the IFIM study with an expanded section on TWC consultation. He will also expand the schedule to include more specific dates and times which will include demonstration flows if possible. He will also add qualifiers to account for bad weather or flows that might inhibit data collection.

- Shane will add in a section to the IFIM Study Plan discussing Dual Flow Analysis. He will also add in a few sentences discussing the information collection on Robust Redhorse spawning areas. Additionally, once Byron provides the information regarding preferred spiny crayfish habitat substrates, Shane will include this in the IFIM Study Plan.

- Kleinschmidt will update the Navigational Flows Study Plan with information on two-way navigation and redistribute to the Recreation TWC.

DUAL FLOW ANALYSIS

- The basic WUA/flow relationship is the foundation
- Base flow/generating flow couplets of interest are identified
- Key species/lifestages (or guilds) are strategically selected
- Effectively available habitat for a study site[1] is calculated at pairs of stream flows: (base) non-peaking and a (generation) peaking flow.
- Dual Flow analysis only records WUA corresponding to the lower (*"effectively available"*) of the two paired values. If the habitat value is zero at either the low or high flow, then the value for that pairing is zero.
-

Example:

basic WUA/flow relationship (*example from Chippewa River, WI*):

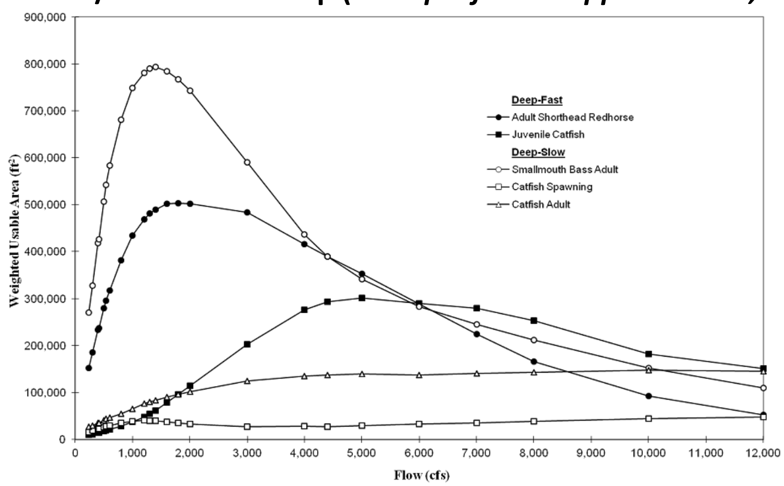
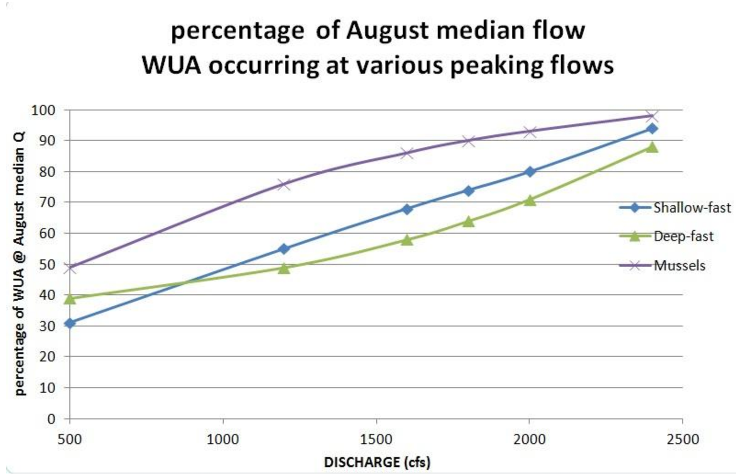


Figure 4. Habitat-discharge relations for fishes in Deep-Fast and Deep-Slow habitat guilds within the Cornell Project instream flow study area.

Effective Habitat WUA of generation vs. base flow condition plotted



[1] For non-mobile life stages such as macroinvertebrates or nest spawning, calculations can optionally be performed at the cell level using the "HABEF" routine in PHABSIM

APPENDIX B

ROBUST REDHORSE SPAWNING HABITAT MEMORANDUM

MEMORANDUM

TO: Parr/Fairfield Hydro Relicensing Fisheries and Instream Flow TWC

FROM: Shane Boring and Milton Quattlebaum

DATE: April 29, 2014

RE: Robust Redhorse Spawning Areas

An assessment of spawning habitat for robust redhorse (*Moxostoma robustum*) was requested by stakeholders during the study scoping phase of relicensing. Stakeholders agreed that a qualitative assessment of the Instream Flow Incremental Methodology (IFIM) study reach downstream of Parr Shoals Dam would be conducted concurrently with the mesohabitat assessment and other field efforts during the fall of 2013 and winter of 2014. This memorandum summarizes the assessment results.

Methods

The reach of the Broad River extending from Parr Shoals through the Bookman Island complex was observed by biologists (Milton Quattlebaum (SCANA), Ron Ahle (South Carolina Department of Natural Resources), and Shane Boring (Kleinschmidt Associates)) in October and November 2013 during the mesohabitat assessment conducted in support of the proposed IFIM Study. A follow up visit was made by Quattlebaum and Scott Lamprecht (South Carolina Department of Natural Resources) in February 2014. During the assessment, the group utilized published habitat suitability criteria to identify areas along the river reach they believed were potential robust redhorse (RRH) spawning sites. According to Freeman and Freeman (2001), RRH spawning habitat is characterized as being mid-channel gravel bars dominated by medium to coarse gravel with less that 30% sand and minimal fine particles. Spawning sites are also characterized as containing gravel small enough to be moved for egg deposition, but large enough to offer interstitial space for the eggs. Water depths are typically between 1 and 3.6 feet, with an average water column velocity of 0.85 to 2.20 ft/s. Sites encountered during the assessment that appeared to display these characteristics were noted on the field datasheets, their locations were documented with Global Positioning System (GPS), and in some instances, the sites were photographed.

Results

Four potential RRH spawning sites were examined during the assessment. The upstream-most site is located in the tailrace of the Parr development powerhouse within IFIM Study Site 3 (Figure 1). Fisheries Technical Working Committee (TWC) members have noted that RRH activity is well documented at that site, including observed potential spawning behavior. Three new sites were located during the assessment: one just upstream of Haltiwanger Island and two in the Bookman Shoals complex (IFIM Study Site 10) in the vicinity of Hickory Island (Figure 2). Results of PHABSIM and 2-D modeling conducted as part of the IFIM study will develop weighted usable area (WUA) estimates of spawning habitat under various flow scenarios, which will be taken into consideration by the TWC in developing a downstream flow recommendation that is best for multiple species, including RRH spawning.

FIGURES

FIGURE 1 POTENTIAL ROBUST REDHORSE SPAWNING AREA DOWNSTREAM OF PARR DAM

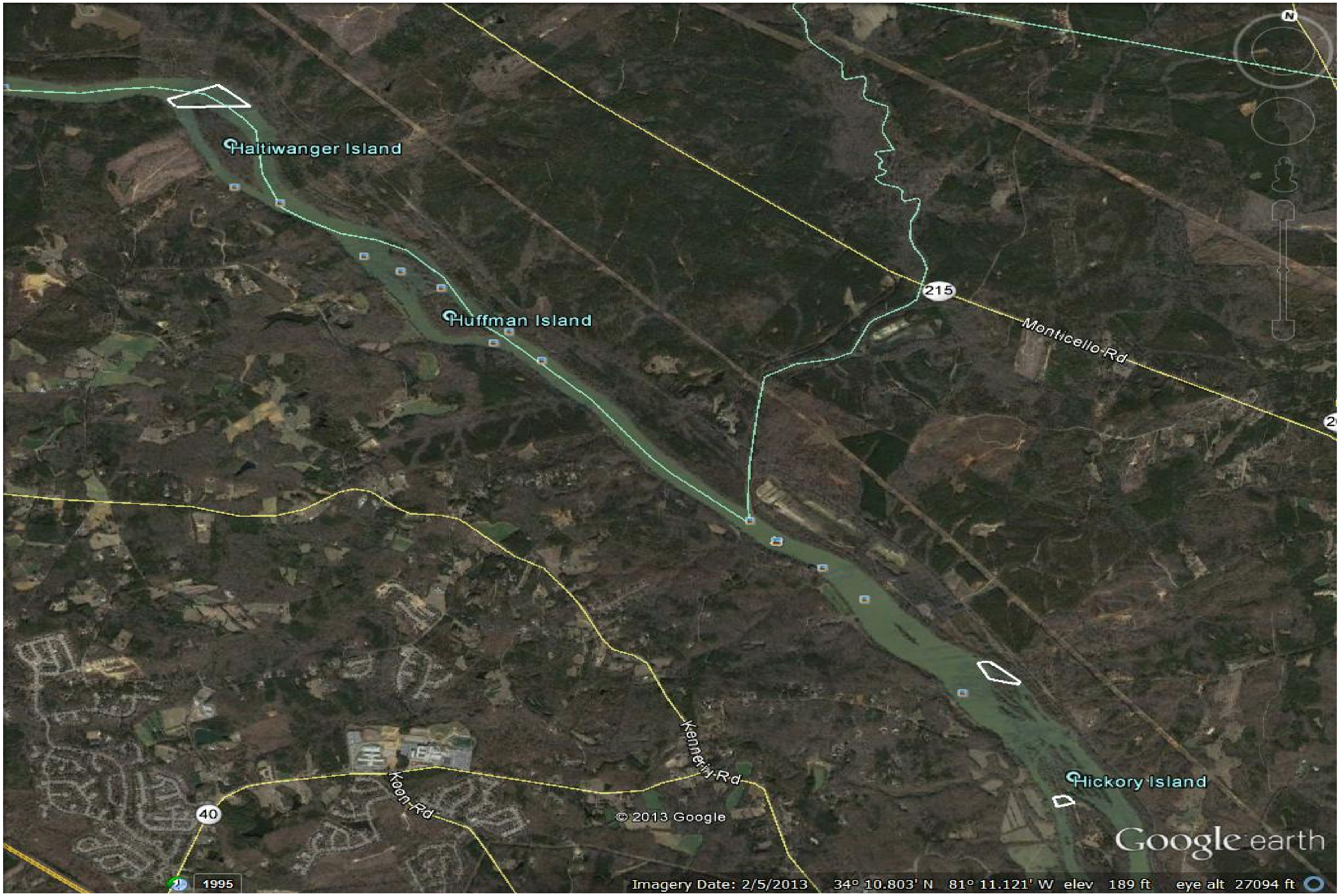


FIGURE 2 POTENTIAL ROBUST REDHORSE SPAWNING SITE AT HALTIWANGER ISLAND AND IN BOOKMAN SHOALS COMPLEX

APPENDIX C

PROVISIONAL HABITAT SUITABILITY CURVES FOR TARGET SPECIES/GUILDS

DRAFT MEMORANDUM

TO: Parr-Fairfield Hydro: Instream Flow/Aquatic Habitat TWC

FROM: Brandon Kulik

DATE: July 9, 2013

RE: **PROPOSED HABITAT SUITABILITY CRITERIA**

On May 7, 2013, the Instream Flow/Aquatic Habitat Technical Working Committee (TWC) agreed upon species and lifestages for which habitat suitability should be evaluated on the Broad River below the Parr-Fairfield Project as a part of AN IFIM study (Table 1).

TABLE 1 EVALUATION SPECIES ELECTED BY THE TWC

- Smallmouth Bass
- American Shad
- Brassy Jumprock
- Whitefin Shiner
- Robust Redhorse
- Santee Chub
- Striped Bass
- Piedmont Darter
- Snail Bullhead
- Redbreast Sunfish
- Channel Catfish

The purpose of this memo is to recommend potential Habitat Suitability Criteria (HSC) for use in this study that are applicable to the above species. Smallmouth bass and redbreast sunfish criteria were sourced from the Saluda study, as the TWC has already vetted these curves. Although the Saluda study had employed TWC-approved American shad HSC, these criteria have recently been refined, based on the research of Joe Hightower in North Carolina (Hightower, *et. al*, 2012) and provided to us by NOAA Fisheries. We propose that the TWC consider using these updated criteria.

The remaining species do not have well developed, individual HSC. However, the Pee Dee IFIM study addressed habitat suitability for these species by classifying each of them into applicable guilds. This information was provided to the Saluda IFIM TWC during study scoping (Gerrit Jobsis, October 16, 2006). Based this information (Table 2), we classified the remaining Parr-Fairfield evaluation species and lifestages into proposed guild categories (Table 3) Attachment A displays the coordinates for the resulting HSC proposed for use, based on the source material identified in Table 3.

TABLE 2 GUILD CLASSIFICATION FOR INDIVIDUAL SPECIES AND LIFESTAGES, FROM PEE DEE RIVER IFIM STUDY (2004)

Species and Habitat Guild Assignment Table for the Pee Dee River Instream Flow Study. Revision 2 - July 9, 2004.

Scientific Name	Common Name	Habitat Types and Guilds[1, 2, 3] Shallow Slow	Shallow Fast	Deep Slow	Deep Fast
Petromyzontidae	**Lampreys**				
Petromyzon marinus	sea lamprey		A		
Acipenseridae	**Sturgeons**				
Acipenser oxyrinchus	Atlantic sturgeon				S
Acipenser brevirostrum	shortnose sturgeon				S
Lepisostedidae	**Gars**				
Lepisosteus osseus	longnose gar	A, J		A, J, S	
Amidae	**Bowfin**				
Amia calva	bowfin			A, S	
Anguillidae	**Freshwater eels**				
Anguilla rotstrata	American eel	J		A, J	J
Clupeidae	**Herrings**				
Dorosoma cepidanum	gizzard shad	A, J		A, J, S	
Dorosoma petenense	threadfin shad	A, J		A, J, S	
Alosa mediocris	hickory shad			J, S	
Alosa sapidissima	American shad			J	J, S
Alosa aestivalis	blueback herring			J, S	
Cyprinidae	**Carps and Minnows**				
Cyprinus carpio	common carp	J, S		A, J, S	
Notemigonus crysoleucas	golden shiner	A, J, S		A, J, S	
Hybognathus regius	Eastern silvery minnow	J, S		A, J, S	
Nocomis leptocephalus	bluehead chub		A, S		
Cyprinella analostana	satinfin shiner	A, J, S		A, J, S	
Cyprinella nivea	whitefin shiner	A, J	S	A	
Cyprinella pyrrhomelas	fieryblack shiner	A, J	S	A	
Notropis altipinnis	highfin shiner	J, S		A	
Notropis amoenus	comely shiner	A, J	S	A, J	
Notropis hudsonius	spottail shiner	A, J	S	A, J	
Notropis petersoni	coastal shiner	A, J	S	A	
Notropis scepticus	sandbar shiner	A, J	S	A	
Catostomidae	**Suckers**				
Catostomus commersoni	white sucker	J	S	A, J	A
Minytrema melanops	spotted sucker	J	S	A	
Scartomyzon spp.	brassy jumprock	J	S	A	A
Moxostoma macrolepidotum	shorthead redhorse	J	S	A	A[4]
Moxostoma anisurum	silver redhorse	J	S	A, J	
Moxostoma robustum	robust redhorse		S	A, J	
Moxostoma sp.	Carolina redhorse		S	A, J	
Carpiodes cyprinus	quillback		S	A	S
Erimyzon oblongus	creek chubsucker	S?		A, J, S?	
Carpiodes velifer	highfin carpsucker		S	A	S
Ictiobus bubalus	smallmouth buffalo	J	A	A, S	A
Ictiobus cyprinellus	bigmouth buffalo			A	

TABLE 2 *CONTINUED*

Scientific Name	Common Name	Habitat Types and Guilds[1, 2, 3] Shallow Slow	Shallow Fast	Deep Slow	Deep Fast
Ictaluridae	**Bullhead catfishes**				
Ictalurus punctatus	channel catfish			A, J	J
Ictalurus furcatus	blue catfish			A, S	A
Ameiurus catus	white catfish			A	A, J
Ameiurus brunneus	snail bullhead			A	
Ameiurus nebulosus	brown bullhead			A	
Ameiurus platycephalus	flat bullhead			A	
Pylodictus olivaris	flathead catfish	J		A, J, S	
Esocidae	**Pikes**				
Esox americanus americanu	redfin pickerel			A, J, S	
Esox niger	chain pickerel			A, J, S	
Umbridae	**Mudminnows**				
Umbra pygmaea	Eastern mudminnow			A, J, S	
Poeciliidae	**Livebearers**				
Gambusia holbrooki	Eastern mosquitofish			A, J, S	
Aphredoderidae	**Pirate perches**				
Aphredoderus saynus	pirate perch			A	
Atherinidae	**Silversides**				
Labidesthes sicculus	brook silverside			A	
Percichthyidae	**Temperate basses**				
Morone americana	white perch	J	S	A, J	S
Morone chrysops	white bass	J	S	A, J	S
Morone saxatilis	striped bass				A, S
Centrarchidae	**Sunfishes**				
Lepomis auritus	redbreast sunfish	J, S		A, J, S	
Lepomis cyanellus	green sunfish			A, J, S	
Lepomis gibbosus	pumpkinseed	J, S		A, J, S	
Lepomis macrochirus	bluegill	J, S		A, J, S	
Lepomis microlophus	redear sunfish			A, J, S	
Lepomis punctatus	spotted sunfish			A, J, S	
Micropterus salmoides	largemouth bass	J, S		A, J, S	
Pomoxis nigromaculatus	black crappie			A, J, S	
Percidae	**Perches**				
Etheostoma olmstedi	tessellated darter	A, J	S	A	
Percina crassus	Piedmont darter		A, S		
Perca flavescens	yellow perch			A, J, S	

[1]Habitat types based on predominant habitat types present in the Pee Dee River derived from the aerial videography study.

[2]Life stages: A = adult, J = juvenile, including young-of-year, and S = spawning.

[3]Classification of species and life stages into habitat types based on Becker (1983), Hamilton and Nelson (1984), Aadland et al. (1991), Jenkins and Burkhead (1994), Rhode et al. (1994), Leonard and Dilts (2003), and Progress Energy (2003).

[4]Foraging adults based on Jenkins and Berkhead (1994).

TABLE 3 PROPOSED HSC SOURCE DATA FOR PARR-FAIRFIELD IFIM STUDY

SPECIES CRITERIA	LIFESTAGE	SOURCE	GUILD
Smallmouth Bass	all	Saluda	N/A
American Shad	spawning	Hightower, *et al.*, 2012	N/A
Brassy Jumprock	adult	Pee Dee River IFIM	deep slow
Brassy Jumprock	juvenile	Pee Dee River IFIM	shallow slow
Brassy Jumprock	spawning	Pee Dee River IFIM	shallow fast
Whitefin Shiner	adult	Pee Dee River IFIM	shallow slow; deep slow
Whitefin Shiner	juvenile	Pee Dee River IFIM	shallow slow
Whitefin Shiner	spawning	Pee Dee River IFIM	shallow fast
Robust Redhorse	adult	Pee Dee River IFIM	deep slow
Robust Redhorse	juvenile	Pee Dee River IFIM	deep slow
Robust Redhorse	spawning	Pee Dee River IFIM	shallow fast
Santee Chub	adult	Pee Dee River IFIM	shallow fast
Striped Bass	adult	Pee Dee River IFIM	deep fast
Piedmont Darter	adult	Pee Dee River IFIM	shallow fast
Piedmont Darter	spawning	Pee Dee River IFIM	shallow fast
Snail Bullhead	adult	Pee Dee River IFIM	deep slow
Redbreast Sunfish	adult	Saluda	N/A
Channel Catfish	adult	Pee Dee River IFIM	deep slow
Channel Catfish	juvenile	Pee Dee River IFIM	deep slow; deep fast

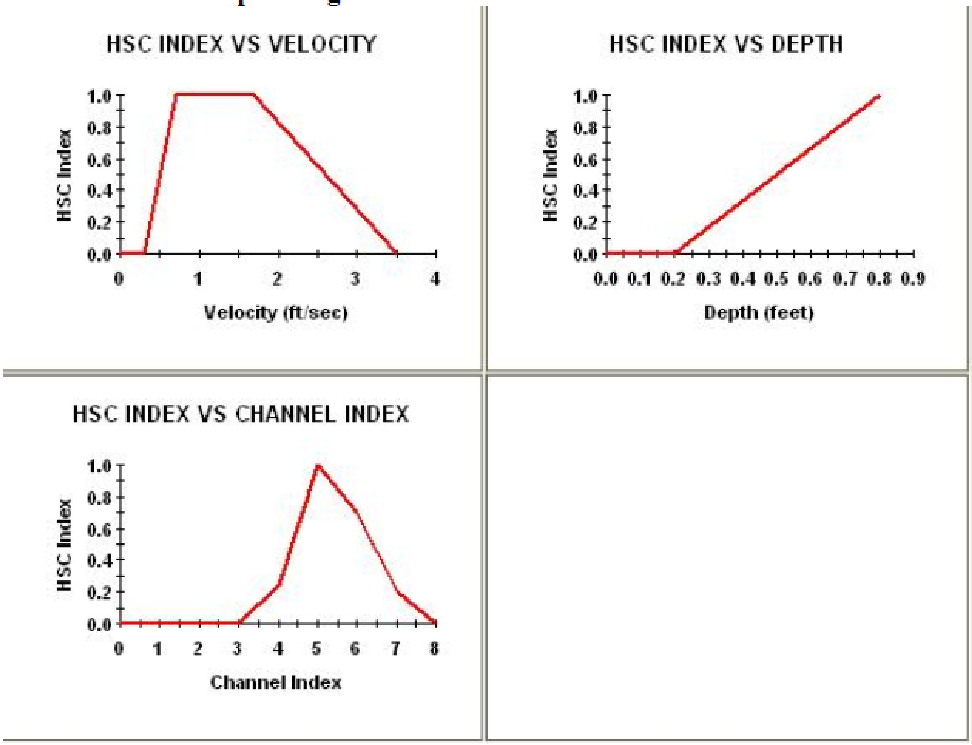
LITERATURE CITED

Hightower JE, Harris JE, Raabe JK, Brownell P, Drew CA. 2012. A Bayesian spawning habitat suitability model for American shad in southeastern United States rivers. Journal of Fish and Wildlife Management 3(2):184–198; e1944-687X. doi: 10.3996/082011-JFWM-047

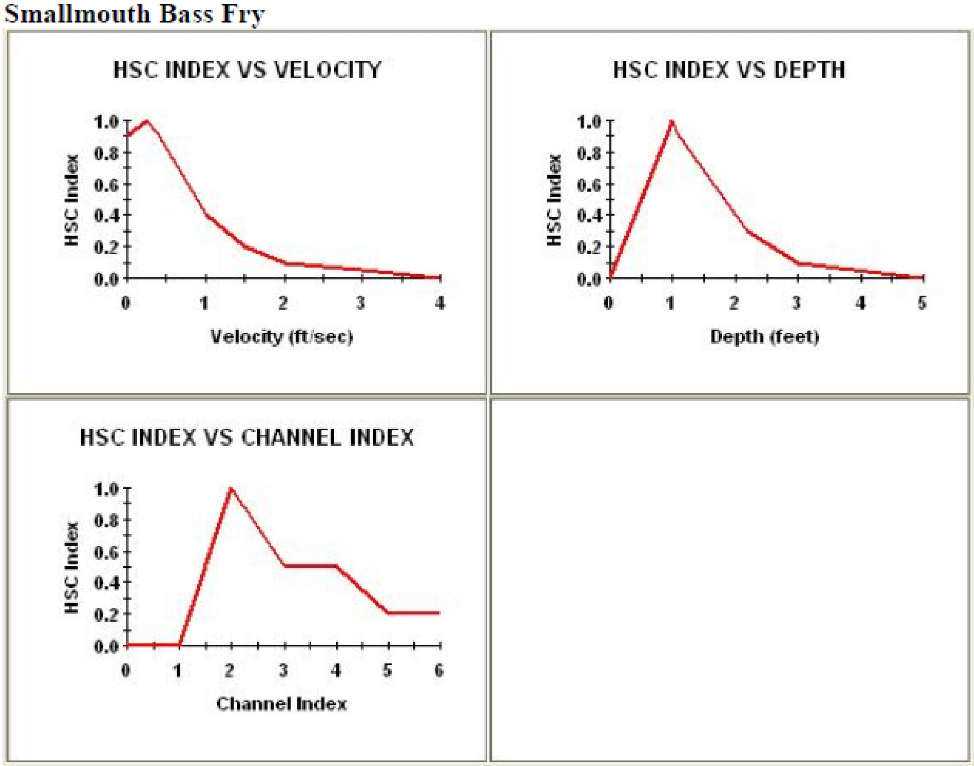
ATTACHMENT A

HABITAT SUITABILITY CRITERIA

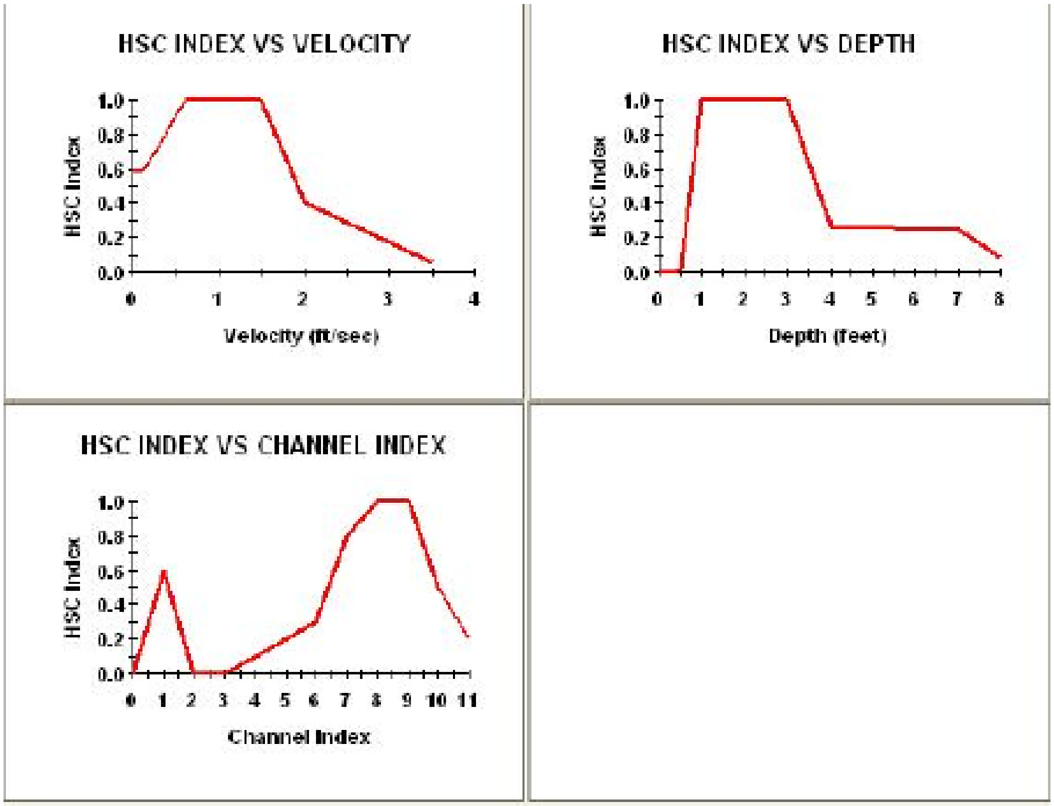
Smallmouth Bass Spawning



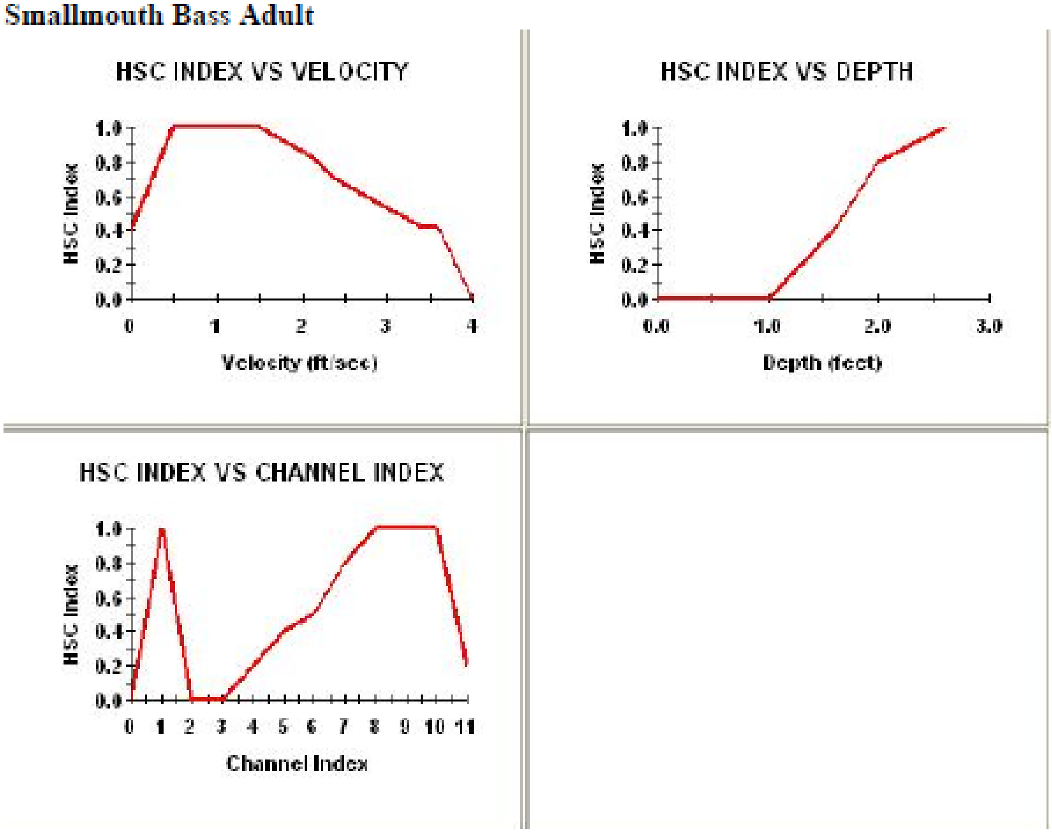
Smallmouth Bass Fry



Smallmouth Bass Juvenile

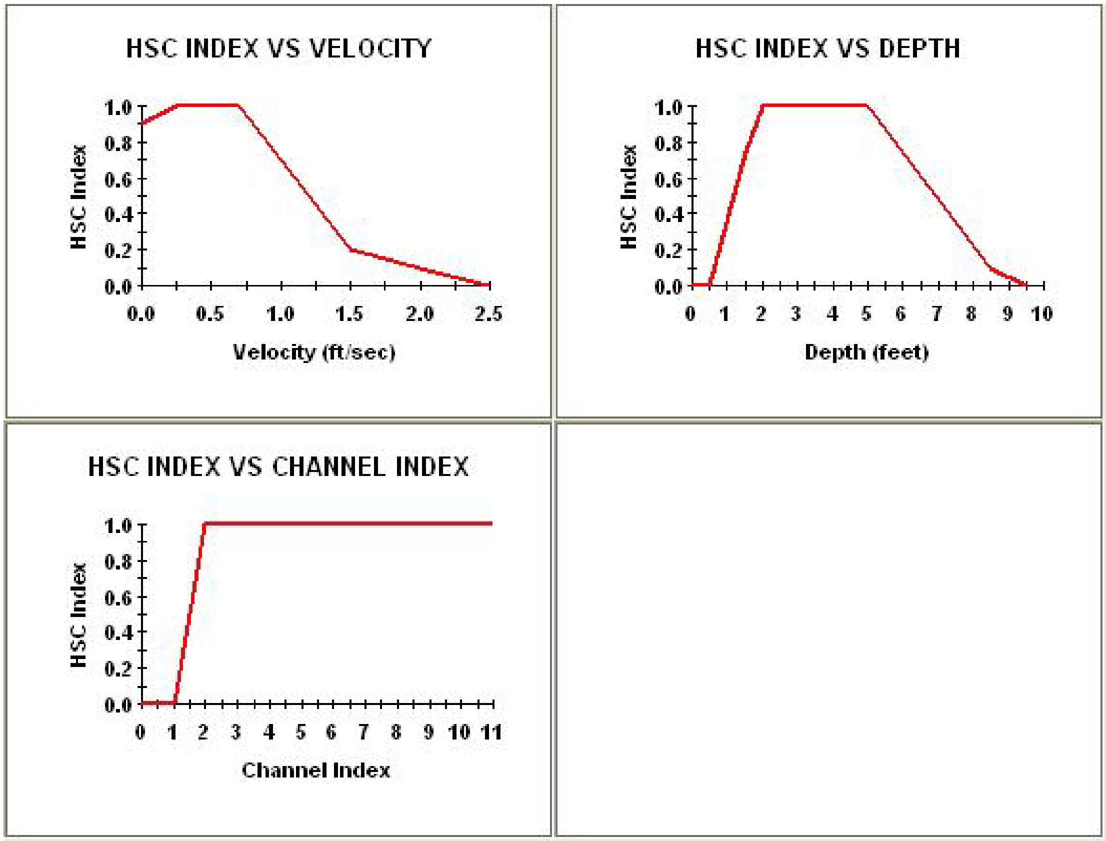


Smallmouth Bass Adult

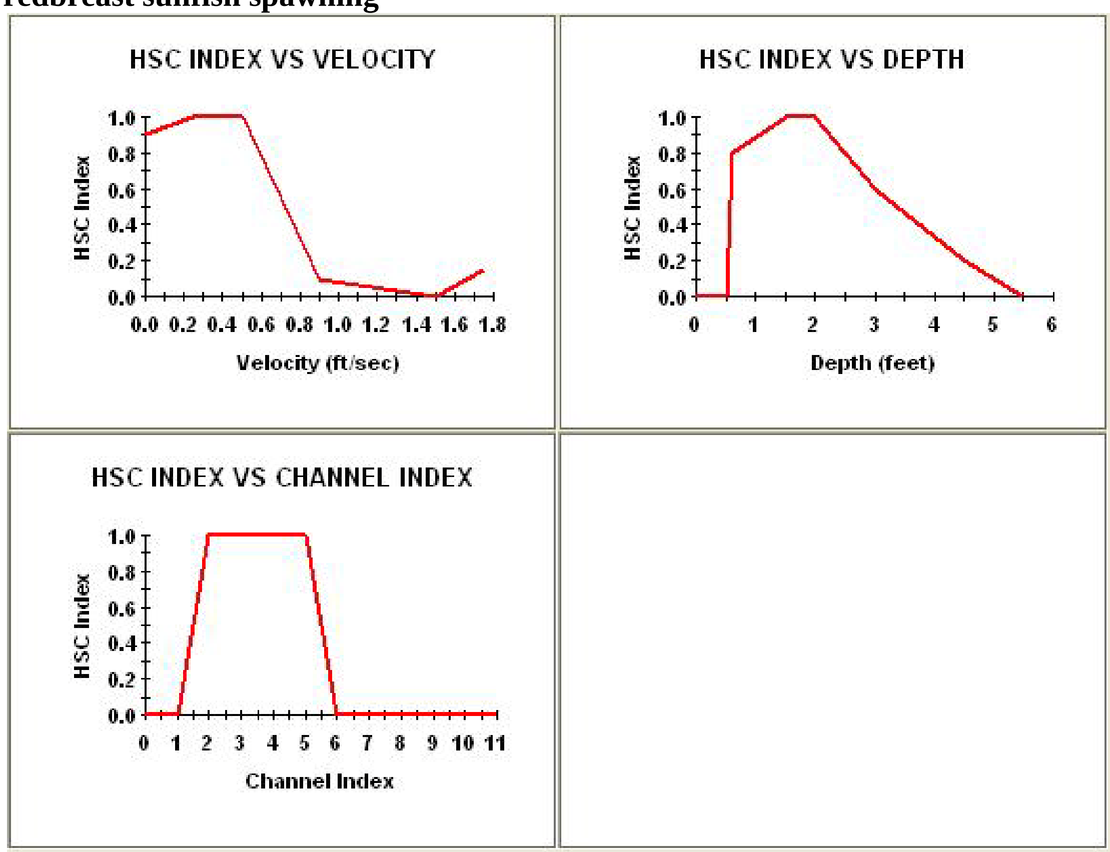


Kleinschmidt

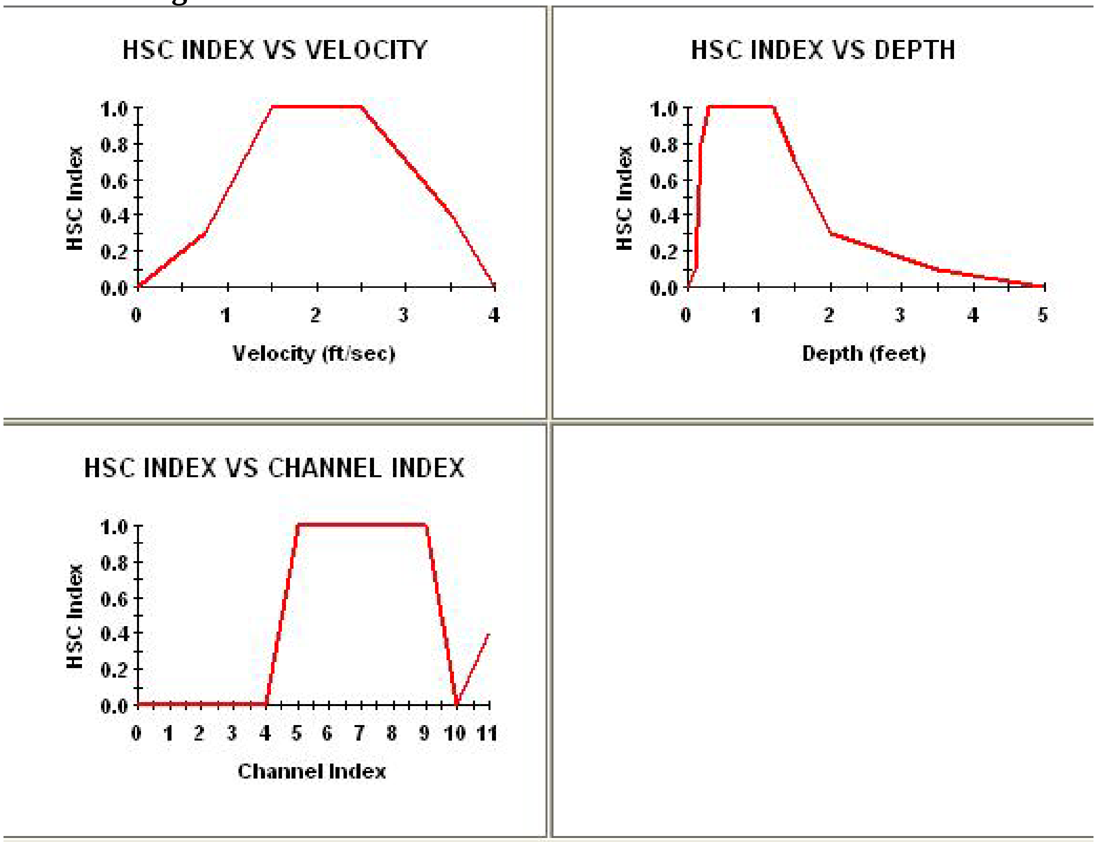
redbreast sunfish adult



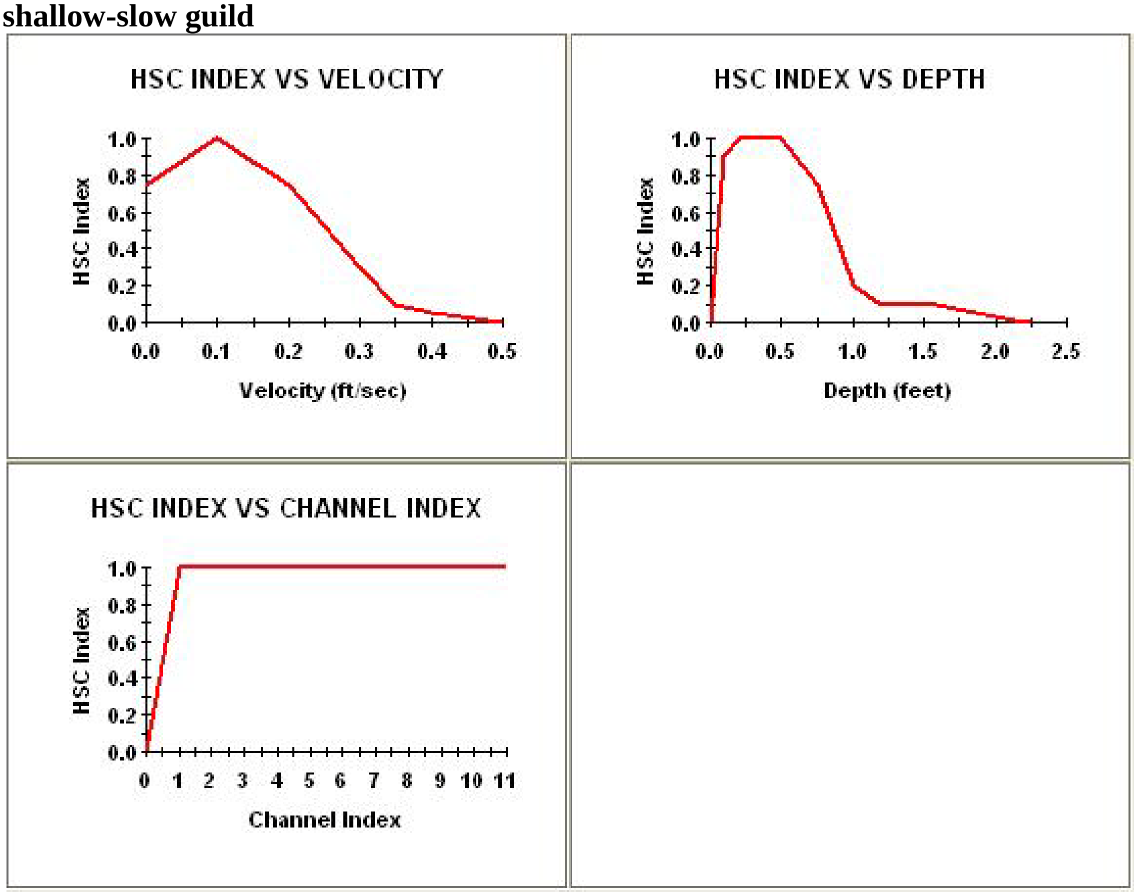
redbreast sunfish spawning



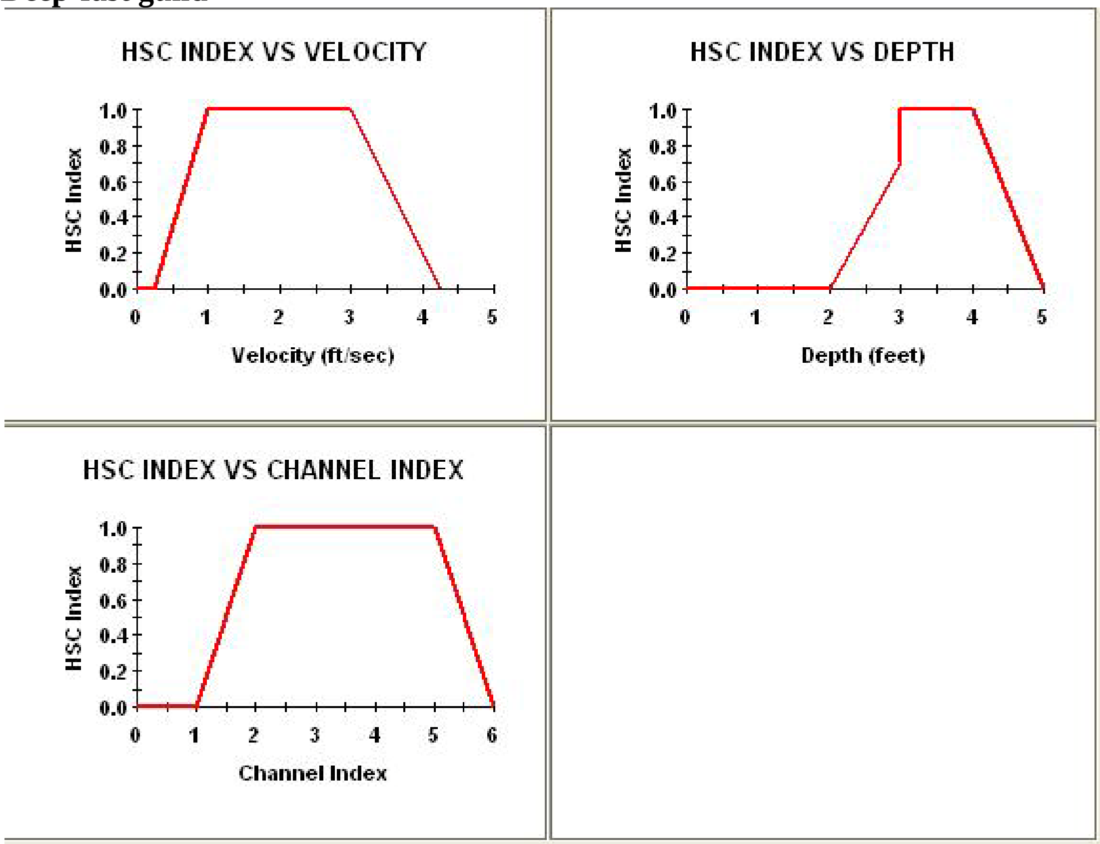
shallow-fast guild



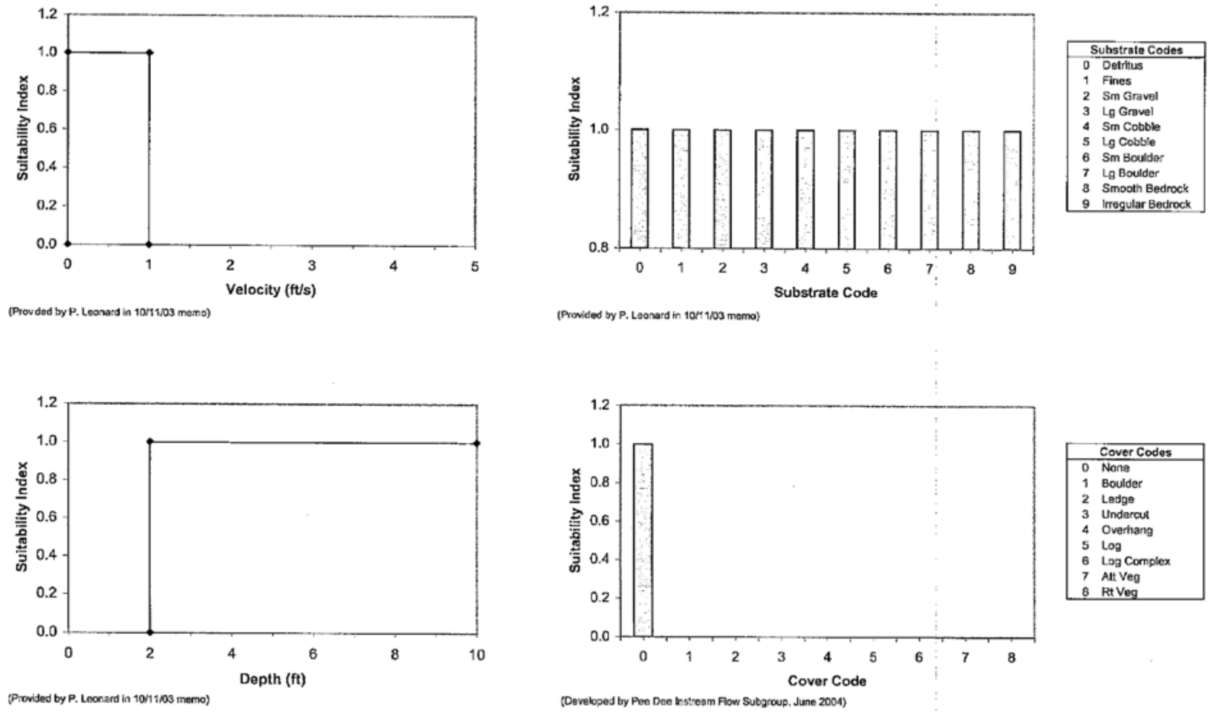
shallow-slow guild



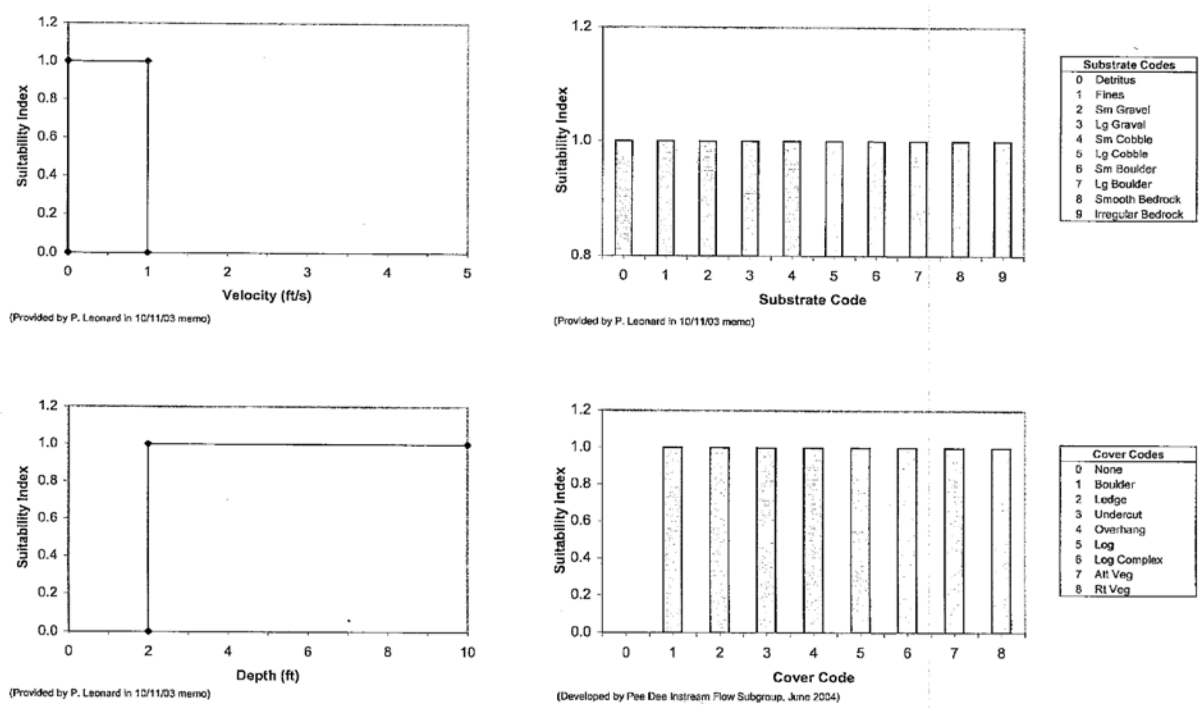
Deep-fast guild



Deep Slow Guild, No Cover
Generic guild habitat suitability



Deep Slow Guild, Cover
Generic guild habitat suitability



American Shad Spawning (*Hightower, et al., 2012)*.

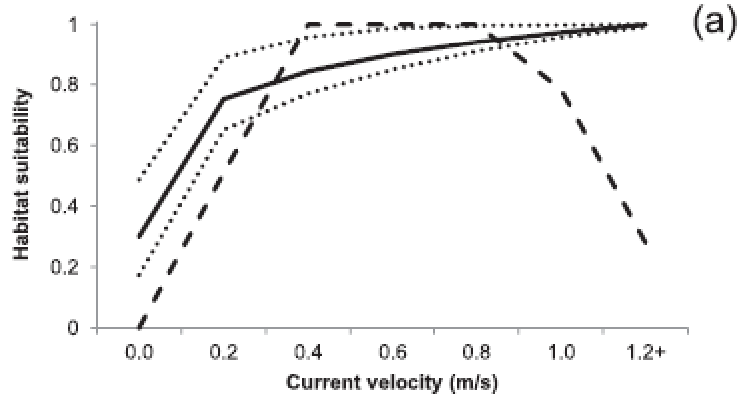


Figure 5. (**a**) Estimated American shad *Alosa sapidissima* spawning-habitat suitability for current velocity (median, with dotted lines indicating 95% CI) in southeastern U.S. rivers, based on a resource selection function fitted to (**b**) data on habitat use vs. availability, by 0.2-m/s velocity bin. The dashed line shows the suitability curve developed by Stier and Crance (1985).

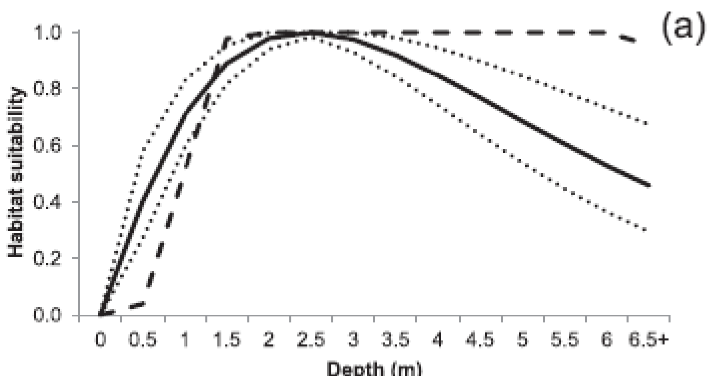


Figure 6. (**a**) Estimated American shad *Alosa sapidissima* spawning-habitat suitability for water depth in m (median, with dotted lines indicating 95% CI) in southeastern U.S. rivers, based on a resource selection function fitted to (**b**) data on habitat use vs. availability, by 0.5-m depth bin. The dashed line shows the suitability curve developed by Stier and Crance (1985).

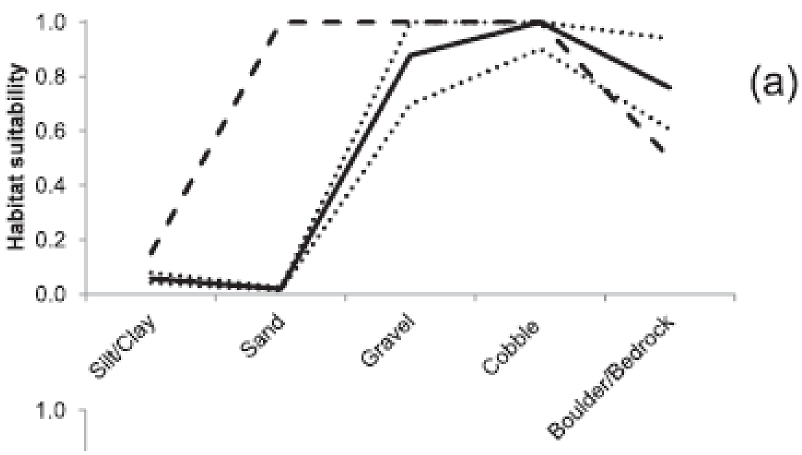


Figure 7. (**a**) Estimated American shad *Alosa sapidissima* spawning-habitat suitability for substrate (median, with dotted lines indicating 95% CI) in southeastern U.S. rivers, based on a resource selection function fitted to (**b** and **c**) data on habitat use vs. availability, by substrate category. The dashed line shows the suitability curve developed by Stier and Crance (1985), using averages for combined categories (silt/clay, boulder/bedrock).

MEMORANDUM

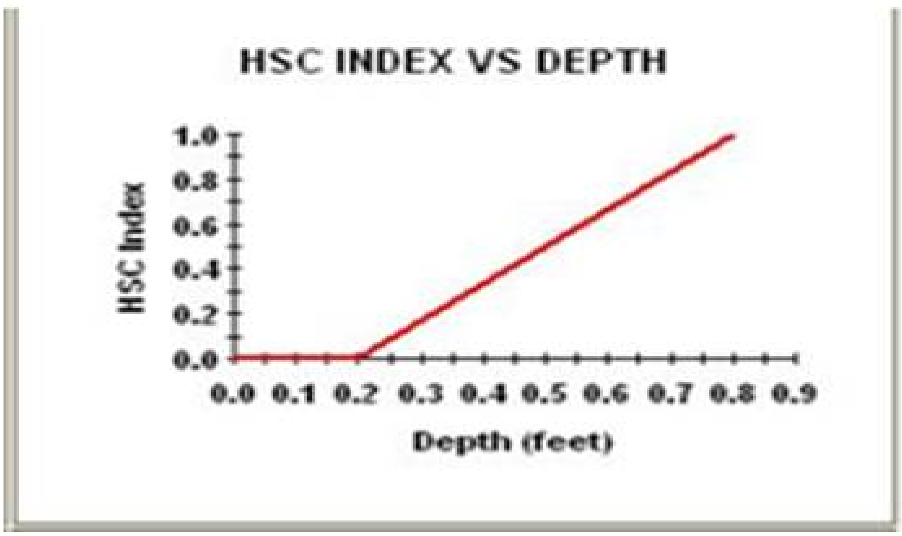
TO: Parr-Fairfield Hydro: Instream Flow/Aquatic Habitat TWC

FROM: Shane Boring

DATE: October 10, 2013

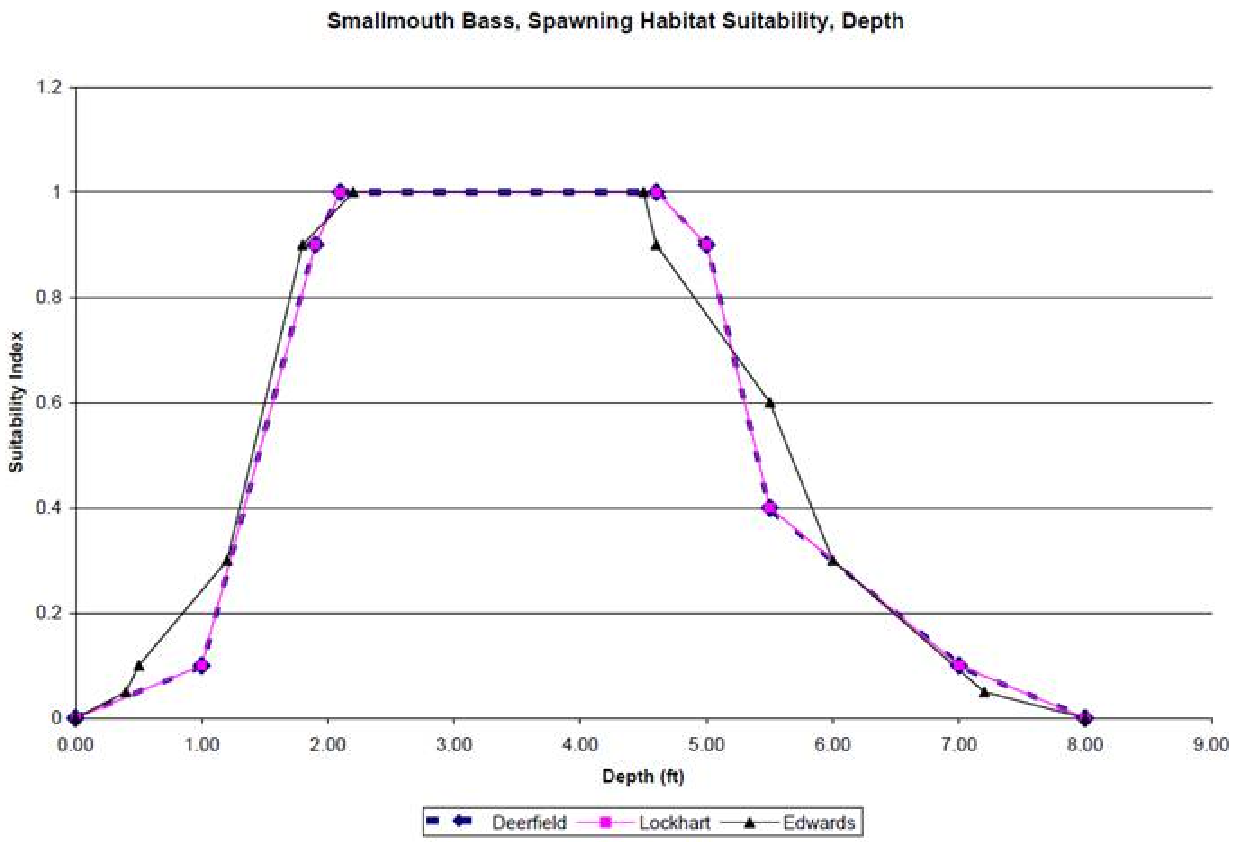
RE: **DEPTH HABITAT SUITABILITY FOR SMALLMOUTH BASS**

At the July 31, 2013, meeting of the Fisheries Technical Working Committee (TWC), Kleinschmidt presented a memo containing provisional Habitat Suitability Criteria (HSC) for target species (Memo from Brandon Kulik, dated July 9, 2013). The following curve for smallmouth bass spawning HSC index versus depth prompted some discussion, as many of the group stated that it was not reflective of their understanding of smallmouth spawning depth requirements:



There was agreement among the group that a more suitable curve would likely be a “stairstep” with habitat suitability picking up around 0.5 ft, peaking at around 2 ft and beginning to decline around 4.5 ft (the group developed a rough sketch of the curve during the meeting).

Kleinschmidt was subsequently tasked with identifying a curve more reflective of the groups understanding of SMB requirements. To that end, we recommend that the following smallmouth bass depth HSC curve developed for the Deerfield River, MA (NEP, 1990), and later used for the Lockhart Hydro instream flow study (Figure 2), be adopted in lieu of the curve cited in the original memorandum. The Lockhart/Deerfield curve appears to be a slight modification of the more general Edwards Blue Book criteria and is consistent with the TWC’s understanding of smallmouth bass depth requirements for spawning.



Kleinschmidt

Exhibit E-5 Fisheries Resources

Parr/Fairfield Hydro Relicensing Instream Flow
TWC Mesohabitat Assessment Memo

MEMORANDUM

TO: Parr/Fairfield Hydro Relicensing Instream Flow TWC

FROM: Shane Boring

DATE: January 8, 2014

RE: Mesohabitat Assessment

A mesohabitat assessment of the Broad River downstream of Parr Shoals Dam was completed by biologists from Kleinschmidt (Shane Boring), SCANA (Milton Quattlebaum) and the South Carolina Department of Natural Resources (Ron Ahle) during October and November of 2013. The assessment was conducted in support of the ongoing Parr/Fairfield Hydroelectric Project relicensing effort, and more specifically, in preparation for the upcoming Instream Flow Incremental Methodology (IFIM) and other studies. The purpose of the assessment was to classify and determine the quantity and spatial distribution of different mesohabitat types within the study area previously outlined by the Instream Flow Technical Working Committee (TWC) (Figure 1). These data will be used to weight the Weighted Usable Area (WUA) output from individual representative transects and study sites according to the relative abundance and distribution of the mesohabitat types throughout the study area.

"Mesohabitats" are generalized habitat types that are commonly used to describe stream habitat (i.e. riffle, run, pool). Acceptable mesohabitat definitions were determined in consultation with the Instream Flow TWC (See July 30, 2013 meeting notes), and include the following:

RIFFLE	Shallow, with moderate velocity, turbulent, high gradient, moderate to large substrates (cobble/gravel). Typically > 1% gradient.
GLIDE	Moderately shallow, well-defined non-turbulent laminar flow, transition from low to moderate velocity, lacking a definite thalweg, typically flat stream geometry, typically finer substrates, transitional from pool.
RUN	Moderately deep, well-defined non-turbulent laminar flow, range from low to moderate velocity, well-defined thalweg, typically concave stream geometry, varying substrates, gently downstream slope (<1%).
POOL	Deep, low to no velocity, well-defined hydraulic control at outlet.
RAPID/SHOAL	Shallow, with moderate to high velocity, turbulent, with chutes and eddies, high gradient, large substrates or bedrock. Typically >2% gradient.
BACKWATER	Varying depth, no or minimal velocity, off the primary channel flow.

ASSESSMENT METHODS

For purposes of the mesohabitat assessment, the approximately 18 mile-long study area was broken into the two reaches agreed upon during the June 2013 field reconnaissance: Reach One – extending from the Parr Shoals dam downstream to the Palmetto Trail trestle crossing and Reach Two – extending from the trestle to the downstream end of Bookman Island (Figure 1). The study area was traversed by canoe/kayak or on foot at flows ranging from approximately 1,000 to 2,200[1] cubic feet per second (cfs), and mesohabitats occurring in each reach were classified into one of the six categories described above.

Upstream and downstream boundaries of each mesohabitat segment were documented using a Garmin 60cs Global Position System (GPS). Although not included in this report, field observations regarding dominant substrate, overall cover quality[2], and approximate channel width were recorded should this information be needed at a later date (e.g., during IFIM modeling efforts). Reference photos for each mesohabitat type were also taken at selected locations. GPS data were incorporated into a Geographic Information System (ArcGIS) and area polygons constructed and calculated for each mesohabitat segment (Figure 2).

RESULTS

Area and proportion of mesohabitats occurring in each reach are illustrated below in Figures 2-6 and summarized in Table 1. Reach One is dominated by run habitats, with an abundance of shoal habitat associated primarily with the bedrock outcroppings at the base of the Parr Shoals Dam (Table 1; Figure 3). Reach Two, which is depicted as Reaches 2a, 2b and 2c for illustration purposes (Figures 4-6), is dominated by pool habitats, with the remainder primarily consisting of nearly equal proportions of shoals, riffle and run habitats (Table 1). No significant backwaters were observed during the survey.

Table 1. Proportions of Mesohabitats Occurring Downstream of Parr Shoals Dam

	Glide	Pool	Riffle	Shoal	Run
Reach One	**4%**	**18%**	**0%**	**31%**	**47%**
Reach Two	**6%**	**28%**	**21%**	**25%**	**20%**

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[1] Small portions of Reach One were also observed at approximately 4000 cfs during wrap-up of field work in late-November 2013.
[2] Refers to the relative density of object cover such as boulders, logs, etc.

FIGURES

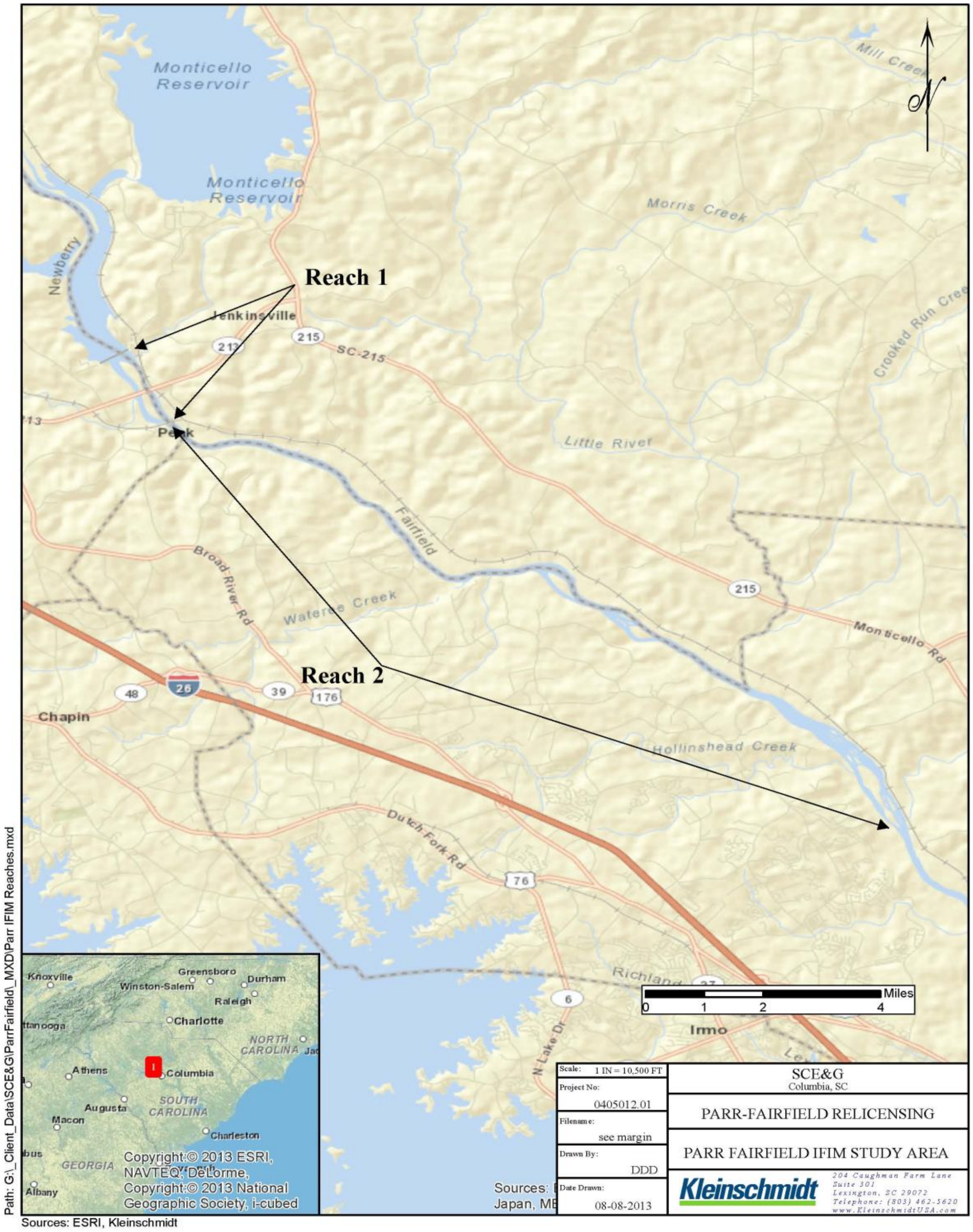


FIGURE 1 PARR-FAIRFIELD PROJECT, BROAD RIVER INSTREAM FLOW STUDY. IFIM STUDY REACHES

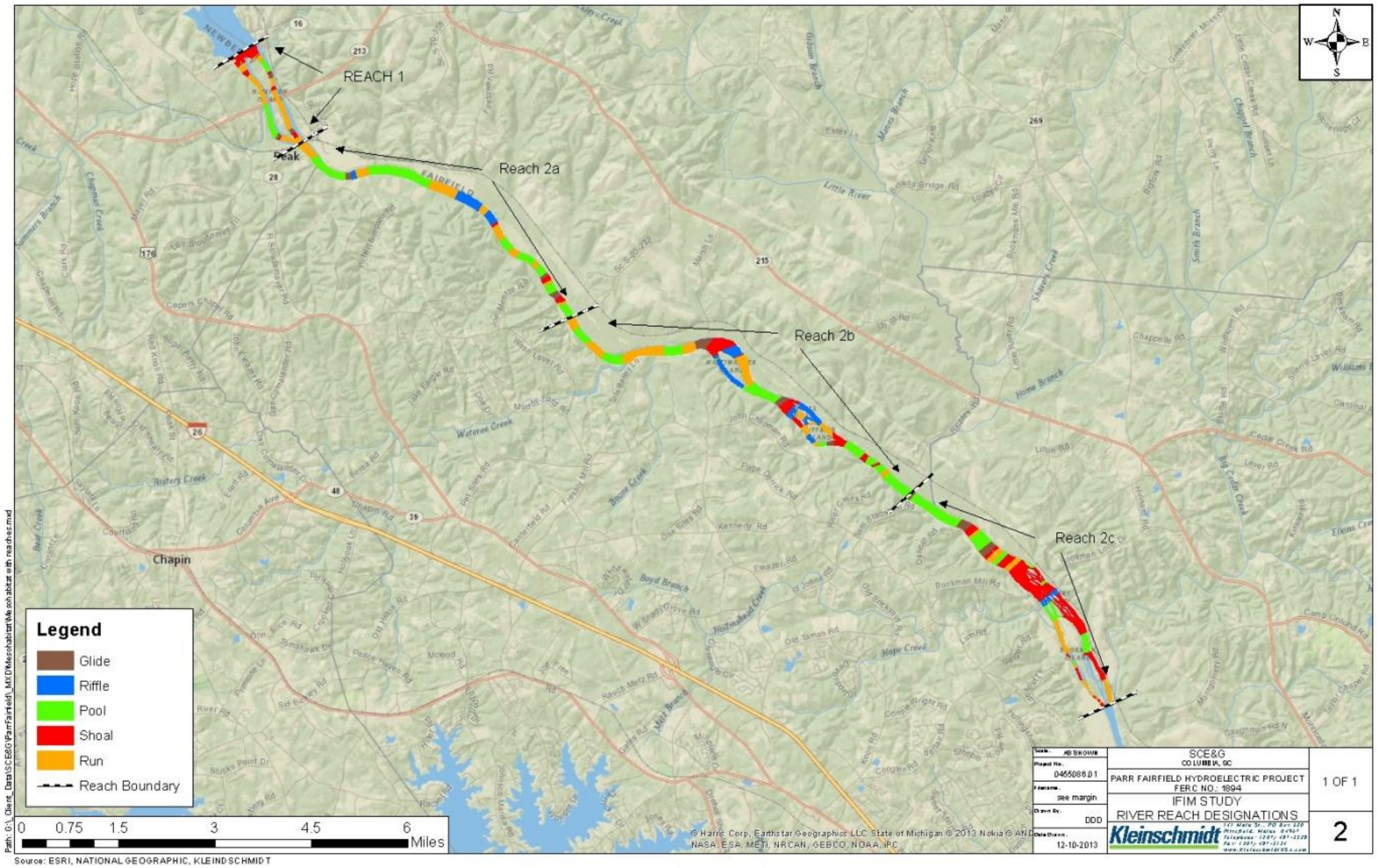


FIGURE 2 IFIM STUDY RIVER REACH DESIGNATIONS

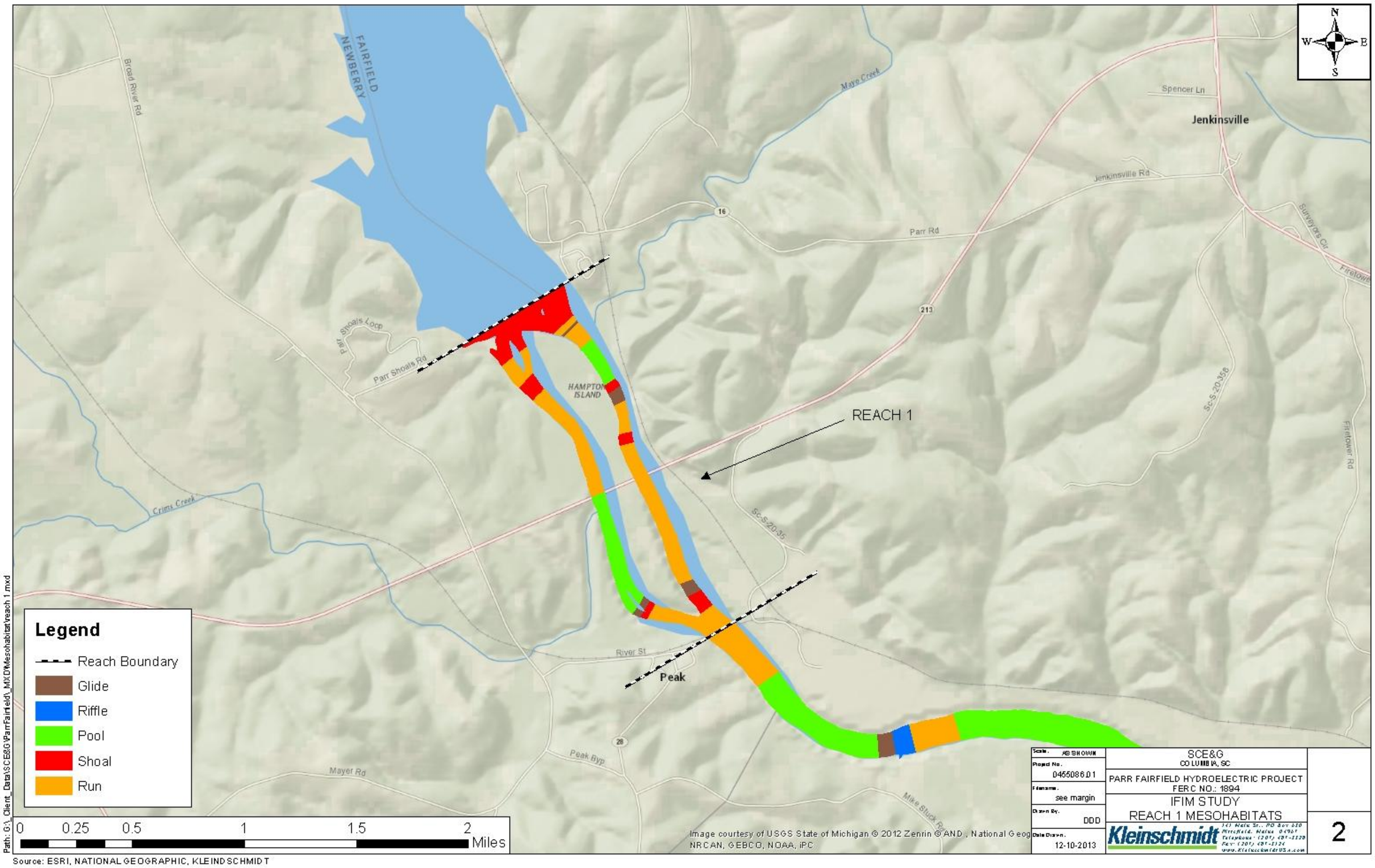
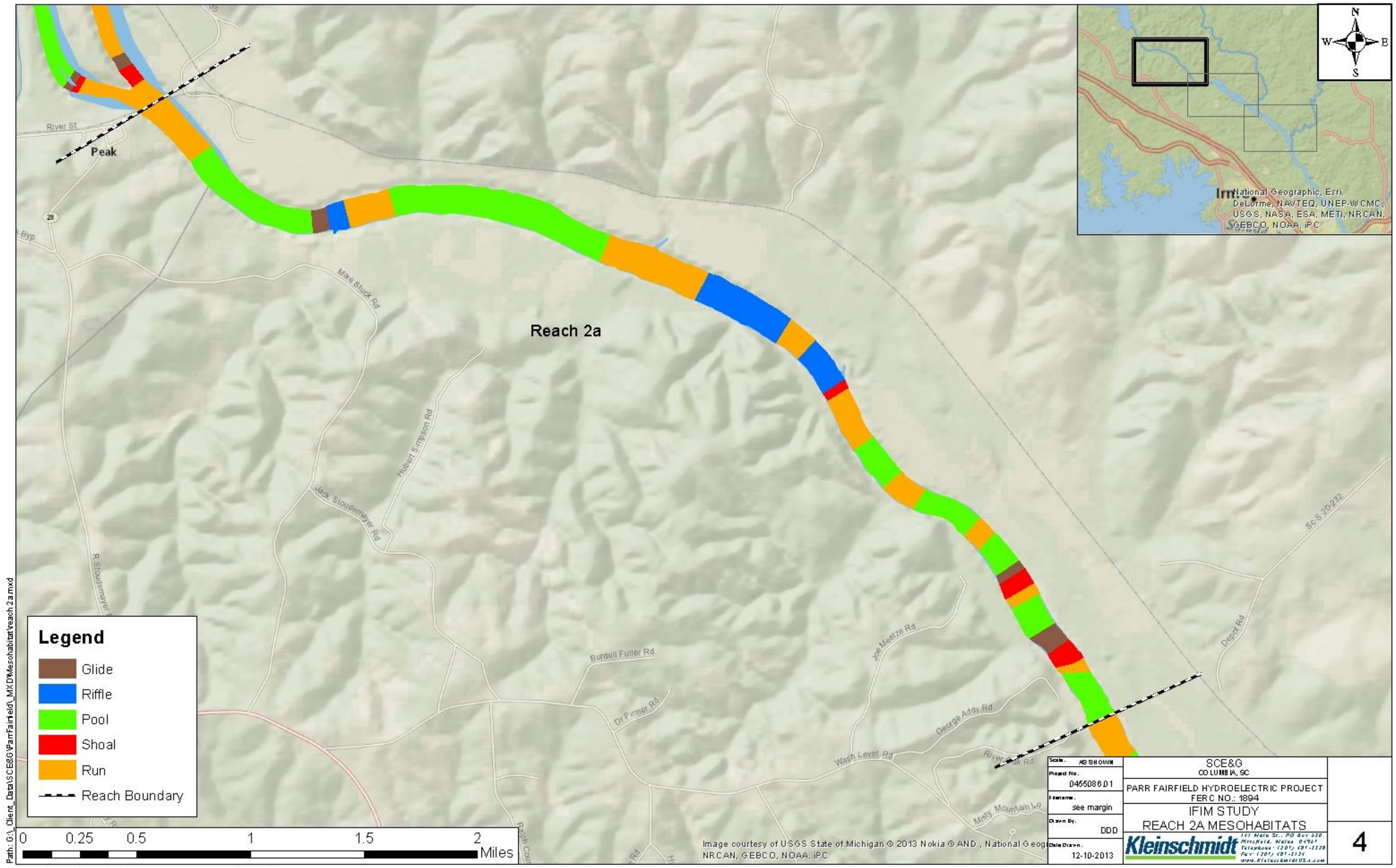


FIGURE 3 IFIM STUDY REACH 1 MESOHABITATS



Source: ESRI, NATIONAL GEOGRAPHIC, KLEINDSCHMIDT

FIGURE 4 IFIM REACH 2A MESOHABITATS

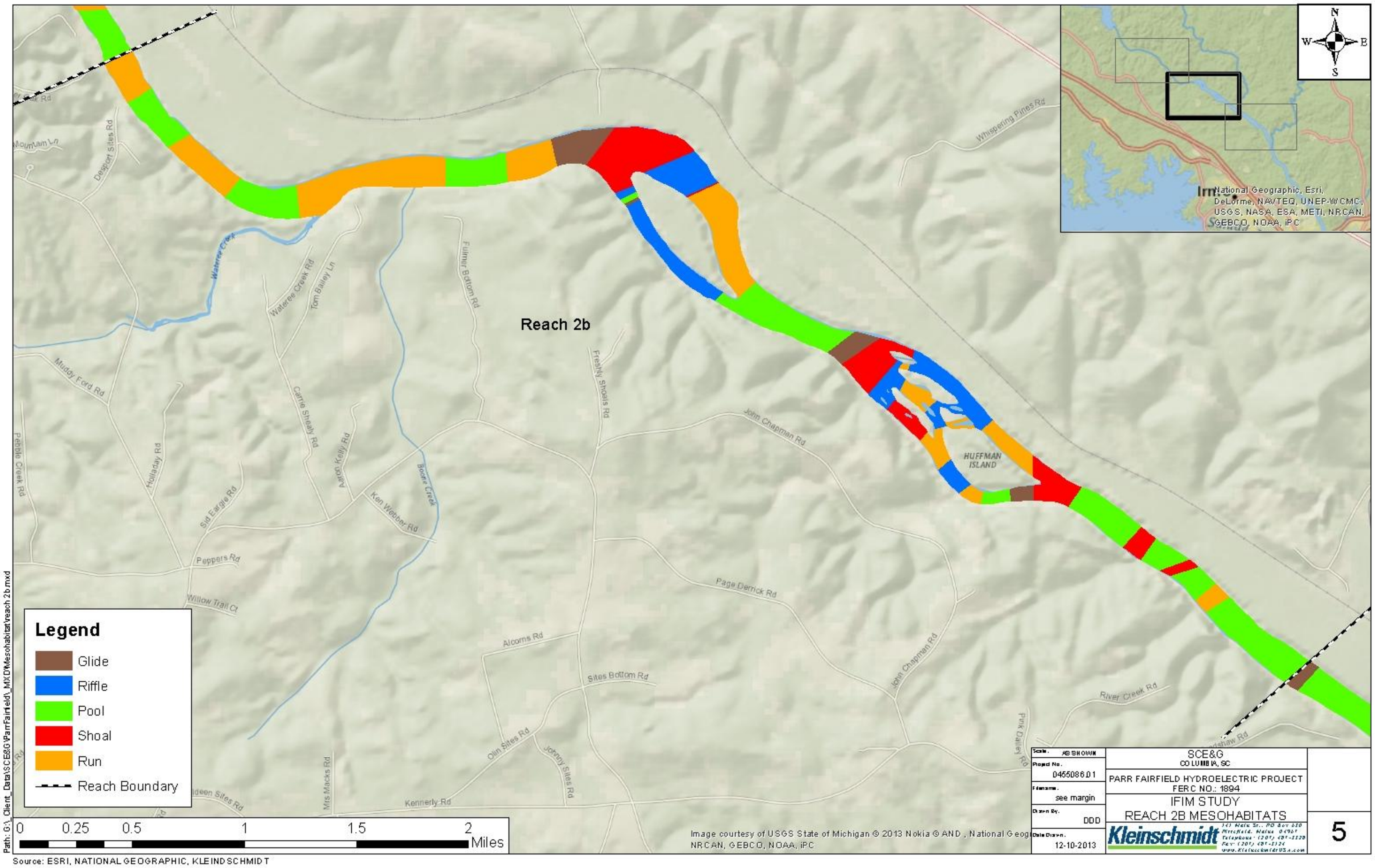


FIGURE 5　　IFIM STUDY REACH 2B MESOHABITATS

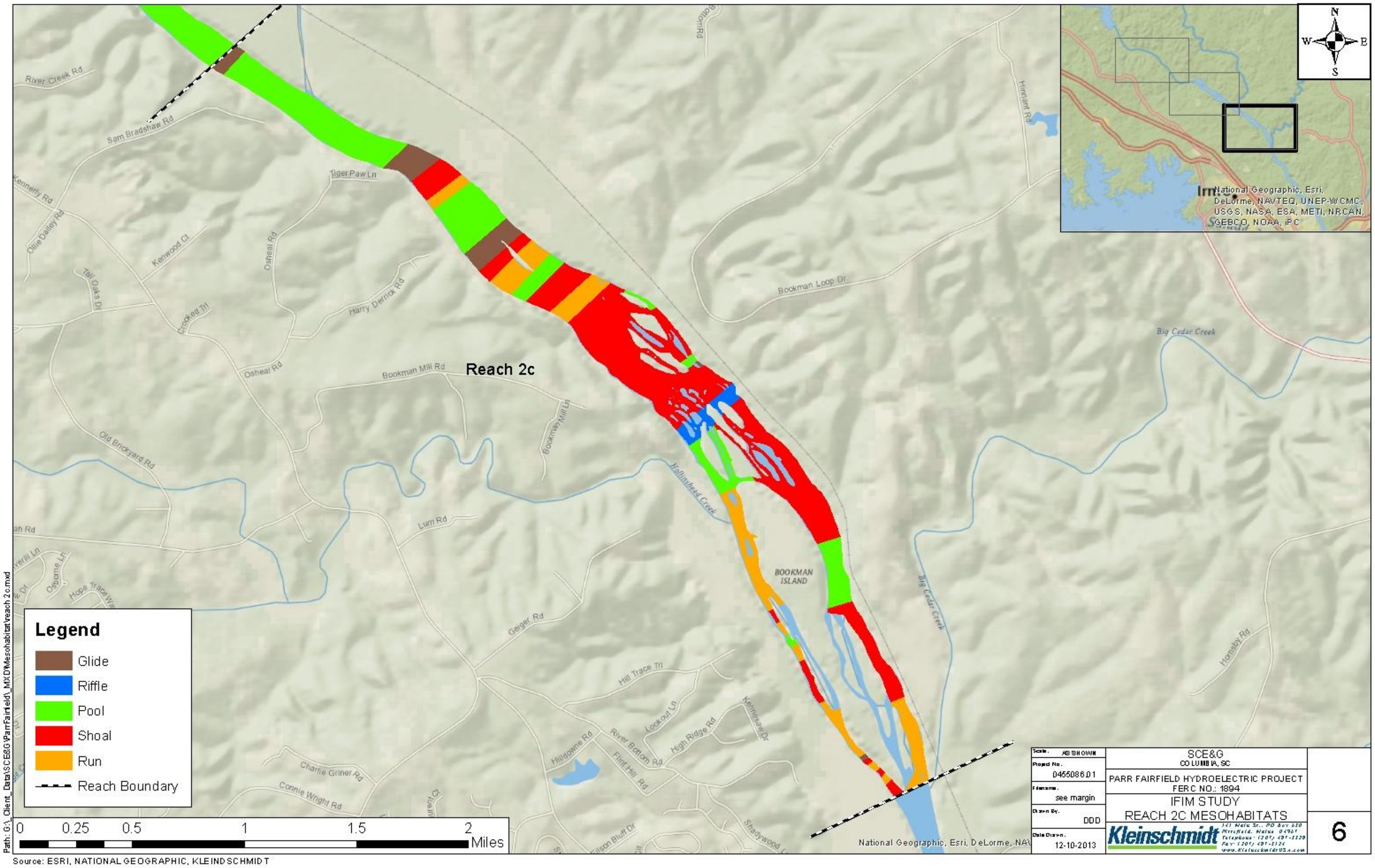


FIGURE 6 IFIM STUDY REACH 2C MESOHABITATS

Exhibit E-5 Fisheries Resources

Parr/Fairfield Hydro Relicensing Fisheries and Instream Flow TWC Robust Redhorse Spawning Area Assessment

MEMORANDUM

TO: Parr/Fairfield Hydro Relicensing Fisheries and Instream Flow TWC

FROM: Shane Boring and Milton Quattlebaum

DATE: April 29, 2014

RE: Robust Redhorse Spawning Areas

An assessment of spawning habitat for robust redhorse (*Moxostoma robustum*) was requested by stakeholders during the study scoping phase of relicensing. Stakeholders agreed that a qualitative assessment of the Instream Flow Incremental Methodology (IFIM) study reach downstream of Parr Shoals Dam would be conducted concurrently with the mesohabitat assessment and other field efforts during the fall of 2013 and winter of 2014. This memorandum summarizes the assessment results.

Methods

The reach of the Broad River extending from Parr Shoals through the Bookman Island complex was observed by biologists (Milton Quattlebaum (SCANA), Ron Ahle (South Carolina Department of Natural Resources), and Shane Boring (Kleinschmidt Associates)) in October and November 2013 during the mesohabitat assessment conducted in support of the proposed IFIM Study. A follow up visit was made by Quattlebaum and Scott Lamprecht (South Carolina Department of Natural Resources) in February 2014. During the assessment, the group utilized published habitat suitability criteria to identify areas along the river reach they believed were potential robust redhorse (RRH) spawning sites. According to Freeman and Freeman (2001), RRH spawning habitat is characterized as being mid-channel gravel bars dominated by medium to coarse gravel with less that 30% sand and minimal fine particles. Spawning sites are also characterized as containing gravel small enough to be moved for egg deposition, but large enough to offer interstitial space for the eggs. Water depths are typically between 1 and 3.6 feet, with an average water column velocity of 0.85 to 2.20 ft/s. Sites encountered during the assessment that appeared to display these characteristics were noted on the field datasheets, their locations were documented with Global Positioning System (GPS), and in some instances, the sites were photographed.

Results

Four potential RRH spawning sites were examined during the assessment. The upstream-most site is located in the tailrace of the Parr development powerhouse within IFIM Study Site 3 (Figure 1). Fisheries Technical Working Committee (TWC) members have noted that RRH activity is well documented at that site, including observed potential spawning behavior. Three new sites were located during the assessment: one just upstream of Haltiwanger Island and two in the Bookman Shoals complex (IFIM Study Site 10) in the vicinity of Hickory Island (Figure 2). Results of PHABSIM and 2-D modeling conducted as part of the IFIM study will develop weighted usable area (WUA) estimates of spawning habitat under various flow scenarios, which will be taken into consideration by the TWC in developing a downstream flow recommendation that is best for multiple species, including RRH spawning.

FIGURES

FIGURE 1 POTENTIAL ROBUST REDHORSE SPAWNING AREA DOWNSTREAM OF PARR DAM

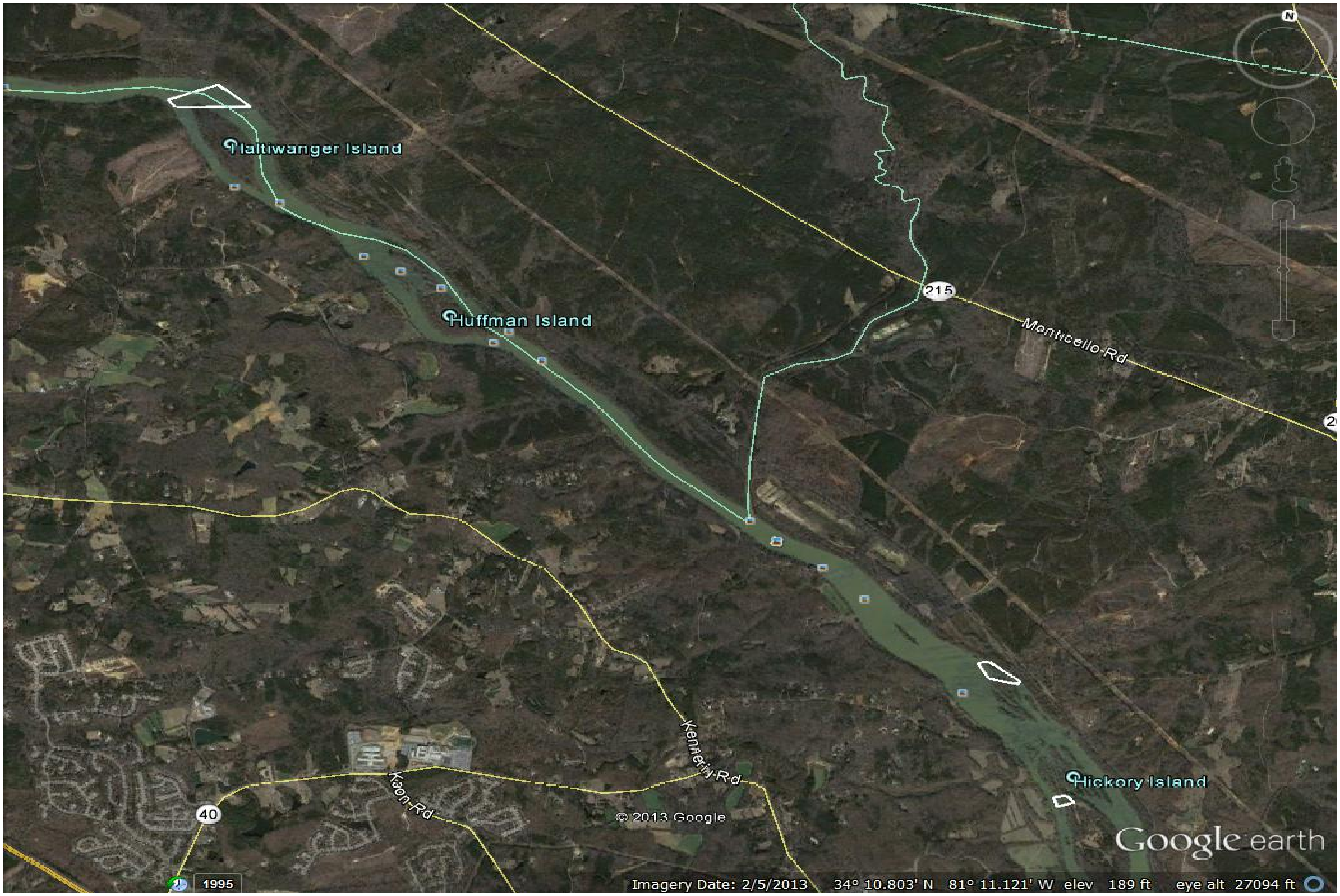


FIGURE 2 POTENTIAL ROBUST REDHORSE SPAWNING SITE AT HALTIWANGER ISLAND AND IN BOOKMAN SHOALS COMPLEX

Exhibit E-5 Fisheries Resources

Instream Flow Study Report

Instream Flow Study Report

Parr Hydroelectric Project

(FERC No. 1894)

Prepared for:

South Carolina Electric & Gas Co.
Cayce, South Carolina

Prepared by:

Kleinschmidt

Lexington, South Carolina
www.KleinschmidtGroup.com

October 2016

INSTREAM FLOW STUDY REPORT

PARR HYDROELECTRIC PROJECT

(FERC NO. 1894)

Prepared for:

South Carolina Electric & Gas Co.
Cayce, South Carolina

Prepared by:

Kleinschmidt

Lexington, South Carolina
www.KleinschmidtGroup.com

October 2016

INSTREAM FLOW STUDY REPORT

PARR HYDROELECTRIC PROJECT
(FERC NO. 1894)

SOUTH CAROLINA ELECTRIC & GAS CO.

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PARR HYDROELECTRIC PROJECT
(FERC NO. 1894)

SOUTH CAROLINA ELECTRIC & GAS CO.

1.0 INTRODUCTION

The Parr Hydroelectric Project (FERC No. 1894) (Project) is a 526.08 megawatt (MW) licensed hydroelectric facility and is owned and operated by South Carolina Electric & Gas (SCE&G). The Project consists of the Parr Shoals Development and the Fairfield Pumped Storage Development. Both developments are located along the Broad River in Fairfield and Newberry Counties, South Carolina (Figure 1-1).

The Parr Shoals Development forms Parr Reservoir along the Broad River. The Development consists of a 37-foot-high, 200-foot-long concrete gravity spillway dam with a powerhouse housing generating units with a combined licensed capacity of 14.88 MW. Parr Shoals operates in a modified run-of-river mode and normally operates to continuously pass Broad River flow. The 13-mile-long Parr Reservoir has a surface area of 4,400 acres at full pool and serves as the lower reservoir for pumped-storage operations. The Fairfield Pumped Storage Development is located directly off of the Broad River and forms the 6,800-acre upper reservoir, Monticello Reservoir, with four earthen dams. As noted, Parr Reservoir serves as the lower reservoir for pumped storage operations. The Fairfield Development has a licensed capacity of 511.2 MW and is primarily used for peaking operations, reserve generation, and non-peak energy storage.

In anticipation of the Project relicensing process, SCE&G met with a number of state and federal resource agencies and interested stakeholders to begin scoping environmental issues as they pertain to project operations. As a result, the United States Fish and Wildlife Service (USFWS), South Carolina Department of Natural Resources (SCDNR), and several Non-governmental Organizations (NGO’s) requested studies to determine the potential impact of Project operation on fishery resources and aquatic habitat, including an Instream Flow Incremental Methodology Study (IFIM) for the Broad River downstream of the Project. SCE&G formed a Technical

Working Committee (TWC) composed of representatives from each interested party that consult to provide input and guidance for the study design and execution.

The IFIM is a nationally recognized method used to solve competing instream water uses involving aquatic habitat. It was developed by the Instream Flow and Aquatic Systems Group of the U.S. Fish and Wildlife Service (now a branch of the USGS). The IFIM is a tool that provides decision-makers with information showing the degree of habitat available in a defined river reach, across a range of flows (Bovee 1982). It does this by developing a quantitative estimate of habitat area at selected discharges, from site-specific measurements of stream morphology, cover, substrate, depth, velocity and discharge gathered in reaches along the river. These physical measurements are then rated for habitat suitability, based on objective habitat use data developed for the aquatic species and life stages of concern.

The IFIM does not compute a single “answer”, but instead estimates degrees of suitability under existing and alternative flow scenarios. In this application, it may be used to estimate the extent that various project water management proposals may affect aquatic habitat in particular stream reaches. IFIM results must be evaluated in the context of watershed hydrology and the strategic needs of other competing uses, which in this case include, but are not necessarily limited to Parr Reservoir lake levels, water quality, fisheries, boating, and hydroelectric power generation.

The scope of this study is to provide data quantifying the effects of flows on aquatic habitat suitability in the Broad River for the aquatic community and its managed fish resources, including diadromous and resident fish species, and to assist the TWC in identifying flow targets that support habitat requirements for a balanced aquatic community. These data are used in conjunction with hydrologic, operational and other models to evaluate the costs and benefits of providing alternate flows to the Broad River. This IFIM study was scoped and directed by a study team that included representatives from the TWC. The study was conducted by SCE&G under the supervision of the TWC.

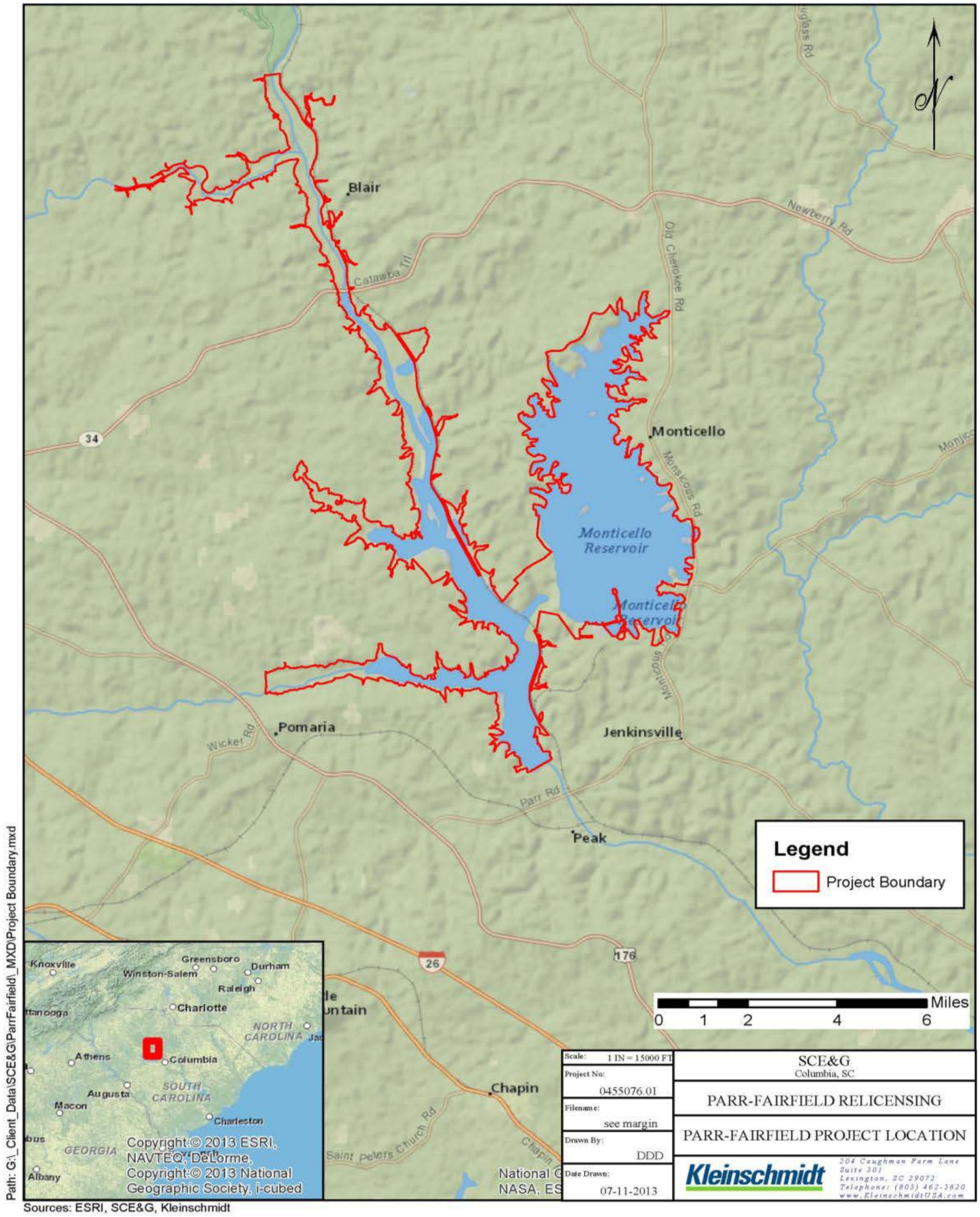


FIGURE 1-1 PROJECT LOCATION MAP

2.0 DESCRIPTION OF THE STUDY AREA

The Broad River rises on the east slope of the Appalachian Mountains, and flows southeasterly across the Piedmont geomorphic province to its confluence at the fall line with the lower Saluda River in Columbia, South Carolina, where the combined flows form the Congaree River. Below the Parr Shoals Dam, the river is free flowing for approximately 26 miles through generally low gradient riverine geomorphology until just below Boatright Island. Below Boatright Island, the Broad River is influenced by backwatering from the Columbia Hydroelectric Project, which is located approximately two miles above the confluence with the lower Saluda River. The drainage area at the Parr Project is 4,750 square miles. A real time stream flow gage exists at USGS 02161000 (*Broad River at Alston, SC*), which is located approximately 1.5 miles below the Parr Shoals Dam.

2.1 UPSTREAM AND DOWNSTREAM BOUNDARIES

The TWC identified the segment of the Broad River between the Parr Shoals Dam and the downstream end of the Bookman Island complex as the study area (Figure 2-1). Flow in this reach is primarily influenced by releases from the Parr Shoals dam and powerhouse. There are no significant flow contributions from tributaries within the study reach.

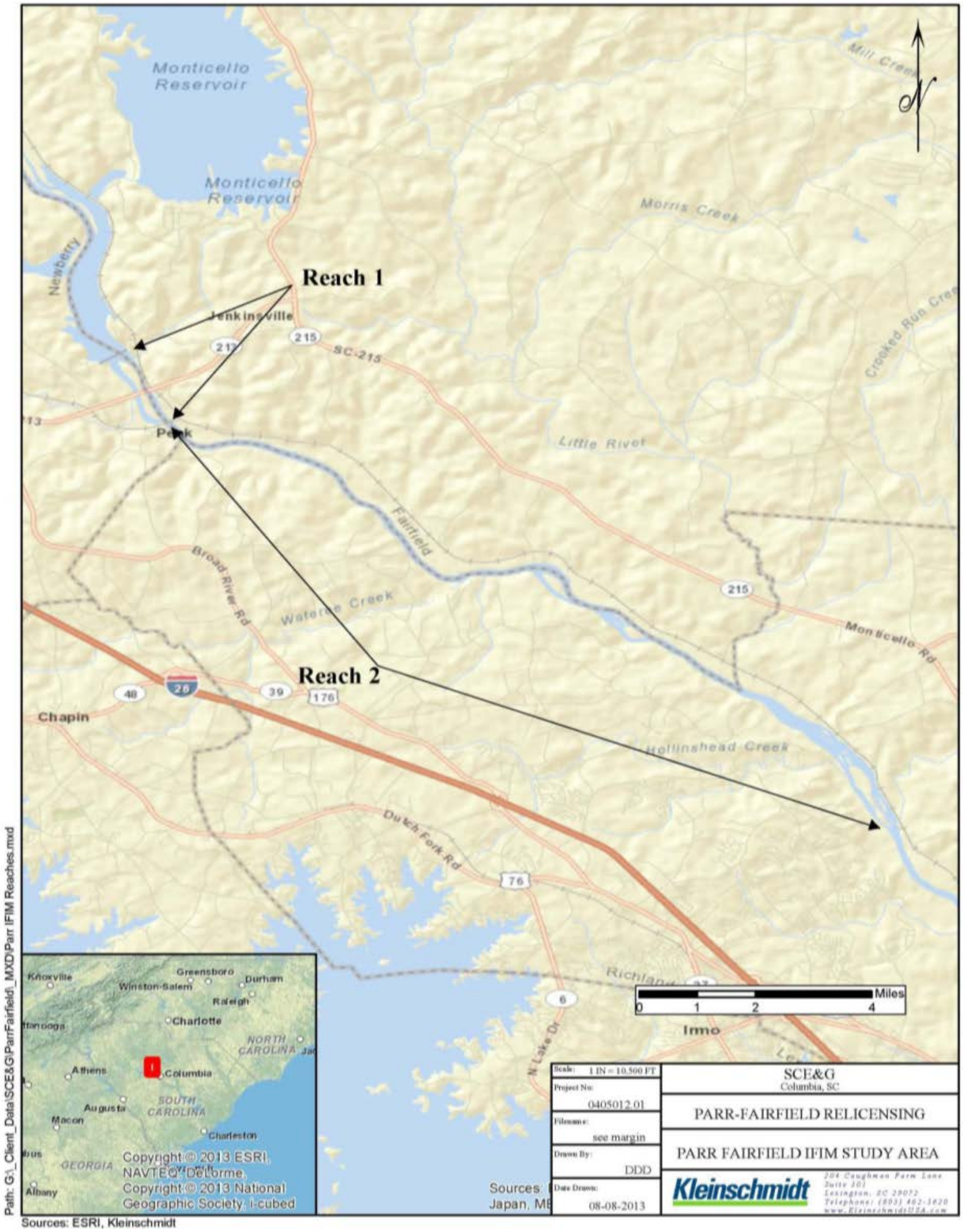


FIGURE 2-1 PARR FAIRFIELD INSTREAM FLOW STUDY AREA

2.2 HABITAT AND GEOMORPHOLOGY

The Broad River flows southeasterly through a river corridor that is predominantly rural, and in general the river banks and riparian zones are forested. Overall the river is relatively straight for much of the reach, with moderate levels of sinuosity. The upper segment of the study area (Reach One) is dominated by well-defined banks (i.e. with discernible and consistent crests and toes) and relatively low-gradient pools, runs and glides, periodically segmented by short riffles. The lower segment (Reach Two) also contains pools, glides and runs, but exhibits higher gradient bedrock drops and more pronounced riffles, and features ledge and boulder substrates which reflect down cutting through the piedmont terrace. There are several islands with pronounced side channels and/or braids such as Haltiwanger, Bookman and Huffman islands.

2.3 FISHERY MANAGEMENT

The varied instream features within the study area support a diverse community of warm water fish species and provide seasonal spawning and nursery habitat for anadromous American shad and striped bass. In addition, smallmouth bass, other centrarchids and catfish provide a sport fishery. Robust redhorse is a rare migratory sucker species present in the study area. Collaborative restoration efforts are underway to protect this fish, and the USFWS describes it as an At-Risk-Species (ARS). Features within the study reach may also provide suitable conditions for robust redhorse spawning and rearing (See Robust Redhorse Spawning Memo in Appendix A).

2.4 HYDROLOGY

The total contributing drainage area for the Parr Shoals development is 4,750 square miles, and the drainage area for the Fairfield Development is 15 square miles. Flows are recorded downstream of Parr Shoals dam at the USGS gage at Alston (USGS gage 02161000). This gage has a continuous period of record dating back to 1981. The monthly mean, minimum and maximum flows for the Project are presented below in Table 2-1. Annual flow-duration curves for the Project are contained in Appendix A of the Pre-Application Document (PAD).

TABLE 2-1 MONTHLY MEAN, MAXIMUM AND MINIMUM DATA FOR THE USGS GAGE AT ALSTON (02161000), FOR WATER YEARS 1981-2013, BY WATER YEAR (WY) (IN CUBIC FEET PER SECOND)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
MEAN	3,565	4,016	5,650	7,252	7,877	9,023	6,606	5,033	3,791	3,198	3,475	2,760
MAX	17,360	14,500	14,190	17,790	16,960	21,560	18,040	14,830	8,909	12,440	10,210	14,740
(WY)	(1991)	(1993)	(2010)	(1993)	(1990)	(1993)	(2003)	(2003)	(2003)	(2013)	(1995)	(2004)
MIN	638	725	1,251	2,106	1,985	3,170	2,821	1,783	763	600	546	624
(WY)	(2008)	(2008)	(2008)	(2011)	(2009)	(2006)	(2012)	(2001)	(2008)	(2008)	(2002)	(2007)

3.0 METHODS

Aquatic habitat suitability at most sites was evaluated using standard field procedures and Physical Habitat Simulation (PHABSIM) modeling techniques of the Instream Flow Incremental Methodology (IFIM), developed by the National Ecology Research Center of the National Biological Survey (Bovee, 1982; Bovee, et al. 1998; Milhouse et al. 1989). The IFIM quantifies habitat values of alternative stream flows using pre-determined habitat suitability index (HSI) criteria for selected species based on stream hydraulics models of study reaches. HSI criteria are based on flow-related depth, velocity, substrate, and cover preferences of targeted lifestages of the evaluation species.

General procedures involve collecting hydraulic data (e.g. bed profile, depth, velocity, and water surface elevation at a series of known calibration flows) and habitat data (i.e. substrate and relevant cover characteristics) at a series of loci (“verticals”) along representative cross-sectional transects. Paired verticals along a transect define the lateral boundaries of a series of "cells". Each cell area is assumed to be homogeneous with respect to depth, velocity, substrate, and cover. The length of stream represented by each transect is determined by field mapping. Hydraulic modeling predicts changes in depth and velocity in each cell as discharge varies. The area of each cell is then weighted relative to HSI criteria for each evaluation species life stage to compute habitat suitability. Total habitat suitability at each flow is calculated by summing weighted habitat area at all transect cells. Weighted Usable Area (WUA) is the standard unit of habitat calculated in standard IFIM computations: one unit of WUA is equal to one square foot of “optimum” habitat suitability as defined by the habitat suitability criteria.

Locations where PHABSIM methodologies were not used include a braided reach where two-dimensional (2-D) modeling was employed (Sites 9 and 10), a backwater area affected by Project operations (Site 4) where wetted perimeter modeling was employed, and a site consisting of perched bedrock pools (Site 1) where calculation of pool volume turnover was conducted for purposes of addressing water quality concerns. These methodologies are discussed in greater detail below.

3.1 SCOPING

The study was collaboratively designed by members of the TWC, including biologists from USFWS, SCDNR and American Rivers. The TWC provided technical input to the consultant, and determined study area boundaries, evaluation lifestages, HSI criteria, modeling approach, and study site locations within each reach. These parameters were based on site reconnaissance and first-hand knowledge of habitat in the Broad River (Appendix B – TWC Scoping).

The TWC conducted a float trip in June 2013 to select study reaches study sites and in some cases transects, and data collection and modeling approaches. Based on this site visit, the study area was segmented into two independent reaches (Figure 2-1). Reach One extends from Parr Shoals Dam to the downstream end of Hampton Island, near the Palmetto Trail crossing, and includes five study sites selected by the TWC (Figure 3-1). The TWC determined that PHABSIM would be the primary tool to assess aquatic habitat suitability in Reach One, with the exception of Study Sites 1 and 4. Study Site 1 consisted primarily of perched bedrock pools located at the base of the dam. The TWC requested bathymetric mapping for purposes of determining pool volumes to support determination of flows necessary to maintain acceptable water quality. Study Site 4 was located in the west channel near the downstream terminus of Hampton Island and was deemed not suitable for PHABSIM modeling due to backwatering from the project tailrace. Study Site 4 was subsequently assessed through a wetted perimeter analysis.

Reach Two extended from the Palmetto Trail trestle crossing at the base of Hampton Island to Boatright Island and included five additional study sites (Figure 3-1). PHABSIM was again the primary mean of assessing habitat suitability, with two exceptions. A 2-D modeling approach was deemed appropriate at Study Site 10 due to the braided and complex nature of the Bookman Island complex. Finally, the TWC determined that habitat at Study Site 9 (Huffman Island) was similar to habitat occurring at Study Site 10; therefore the former could be addressed through a simple flow demonstration to confirm transferability of 2-D modeling results from Study Site 10.

Each study site was chosen by the TWC to represent a specific type of representative and/or biologically strategic habitat within the subject reach. PHABSIM transects were placed within each study site (Figures 3-2 and 3-3) as necessary to portray channel configuration, slope, hydraulics and/or substrate and cover of specific mesohabitat types of interest (Table 3-1). The total length of stream represented by each study site within each reach was determined by mesohabitat mapping. Mesohabitat boundaries were delineated in the field by demarking the upstream boundary of each contiguous mesohabitat type with a handheld GPS unit. Boundaries were identified by visual inspection and soundings obtained from a small boat traversing the study area at a low flow (approximately 800 cfs). Additional detail regarding the mesohabitat assessment result are included in Appendix C.

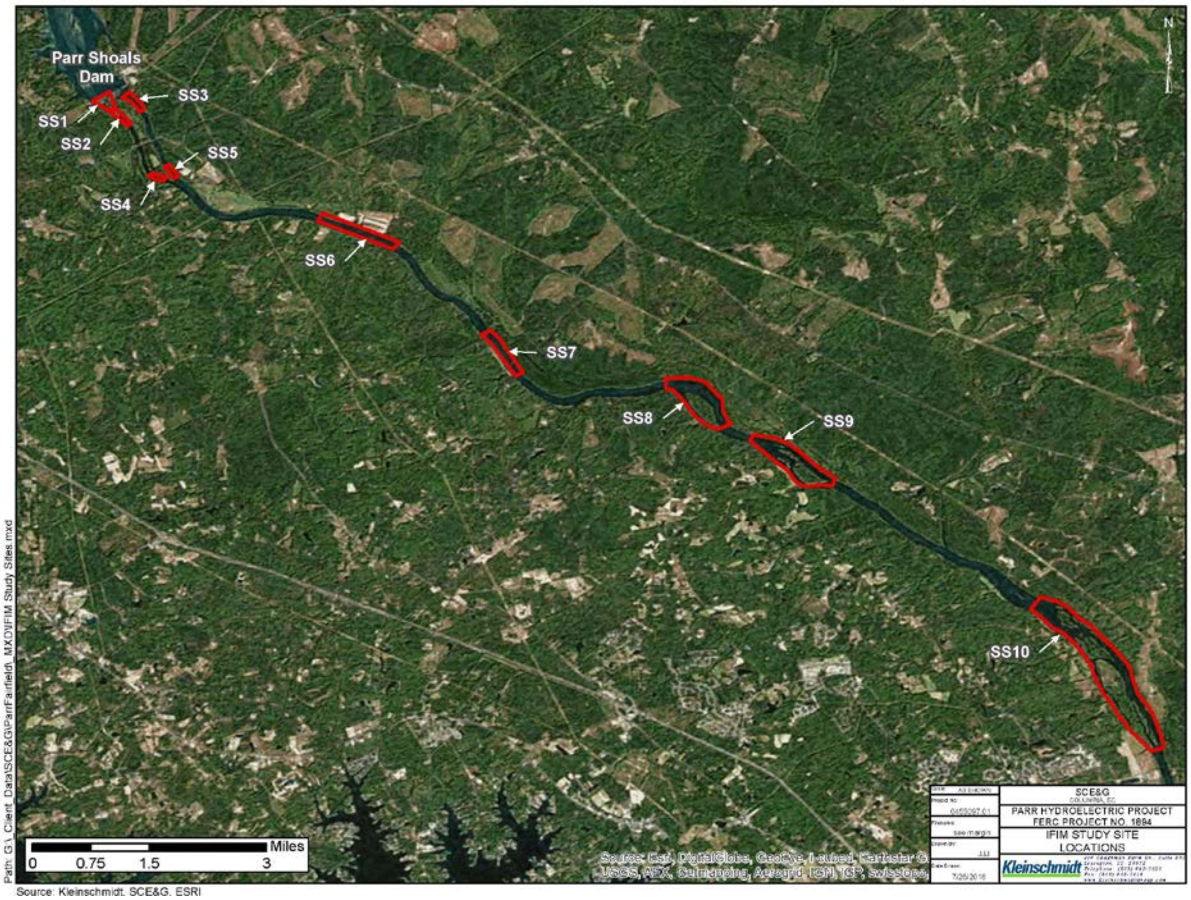
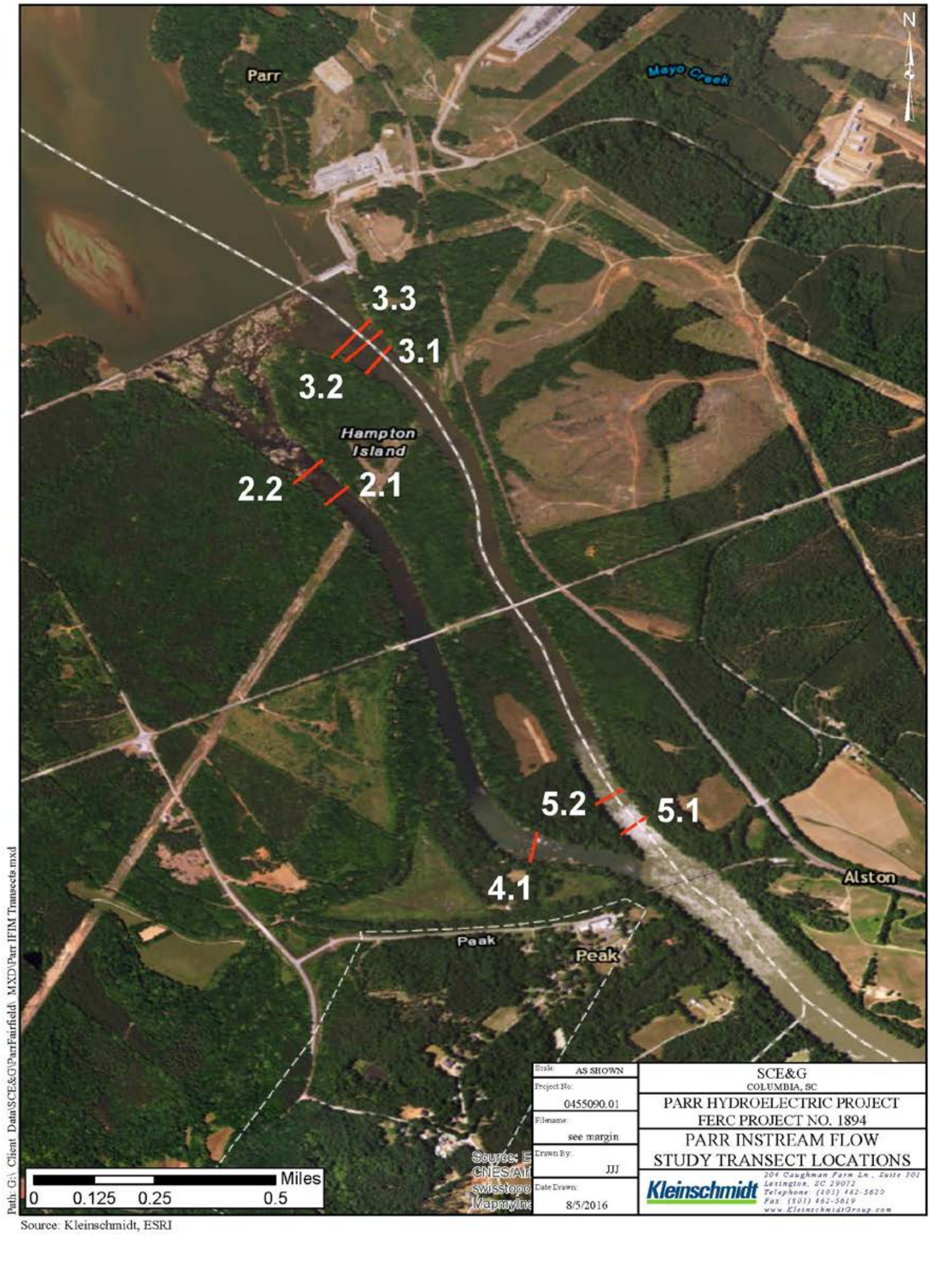
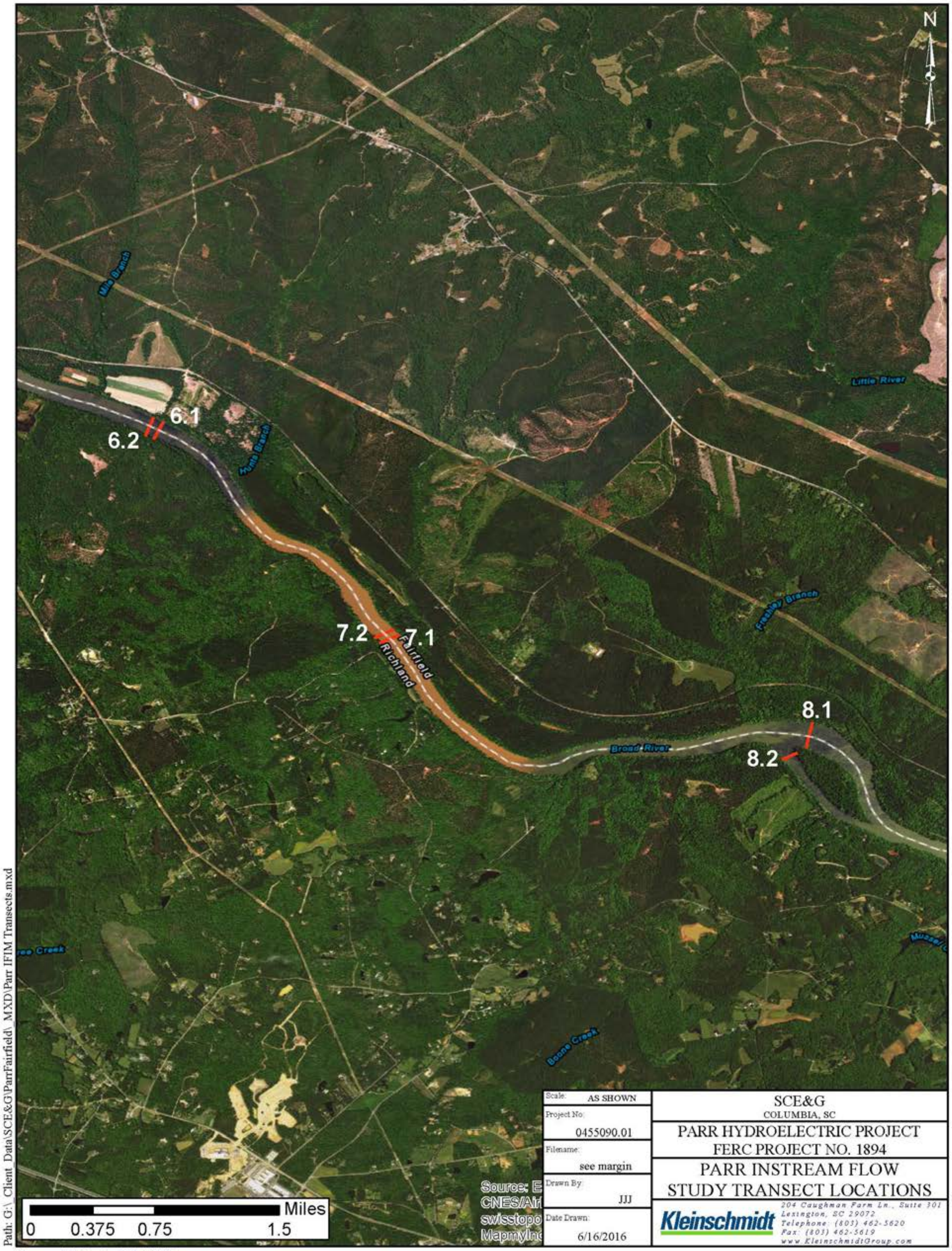


FIGURE 3-1 PARR HYDRO PROJECT – IFIM STUDY SITES



Source: Kleinschmidt, ESRI

FIGURE 3-2 PARR HYDRO PROJECT - REACH ONE HABITAT TRANSECTS



Source: Kleinschmidt. ESRI

FIGURE 3-3 PARR HYDRO PROJECT - REACH TWO HABITAT TRANSECTS

TABLE 3-1 PARR HYDRO IFIM STUDY - SUMMARY OF STUDY SITES AND TRANSECTS

STUDY SITE	TRANSECT ID	MESOHABITAT
2	2.2	Glide
	2.1	Run
3	3.3	Run
	3.2	Glide
	3.1	Riffle
4	4.1	backwater
5	5.2	Run
	5.1	Riffle
6	6.2	Glide
	6.1	Riffle
7	7.2	Glide
	7.1	Riffle
8	8.2	Riffle
	8.1	Riffle

In addition to habitat study sites, the TWC also identified two areas during scoping that were potentially restrictive to the upstream passage of fish. These areas were identified in the Study Plan as "Ledge 1" and "Ledge 2" (Figure 3-4). Ledge 1 consists of a bedrock ledge located at a lat/long of 34°12’49.999”N, 81°15’46.507”W, approximately 2.4 miles upstream of Haltiwanger Island. Ledge 1 is located directly downstream and serves as the hydraulic control for IFIM Study Site 7. The study plan originally identified a primary passage point for Ledge 1 on river left (looking upstream); however, a secondary passage point, located near mid-channel, was also noted during execution of the field effort. Ledge 2 consists of a bedrock ledge located at a lat/long of 34°10’18.154”N, 81°10’15.941”W, 1.3 miles upstream of Hickory Island and approximately 0.5 miles downstream of the mouth of Little River. Field investigations identified the primary navigational passage point on river left (looking upstream).

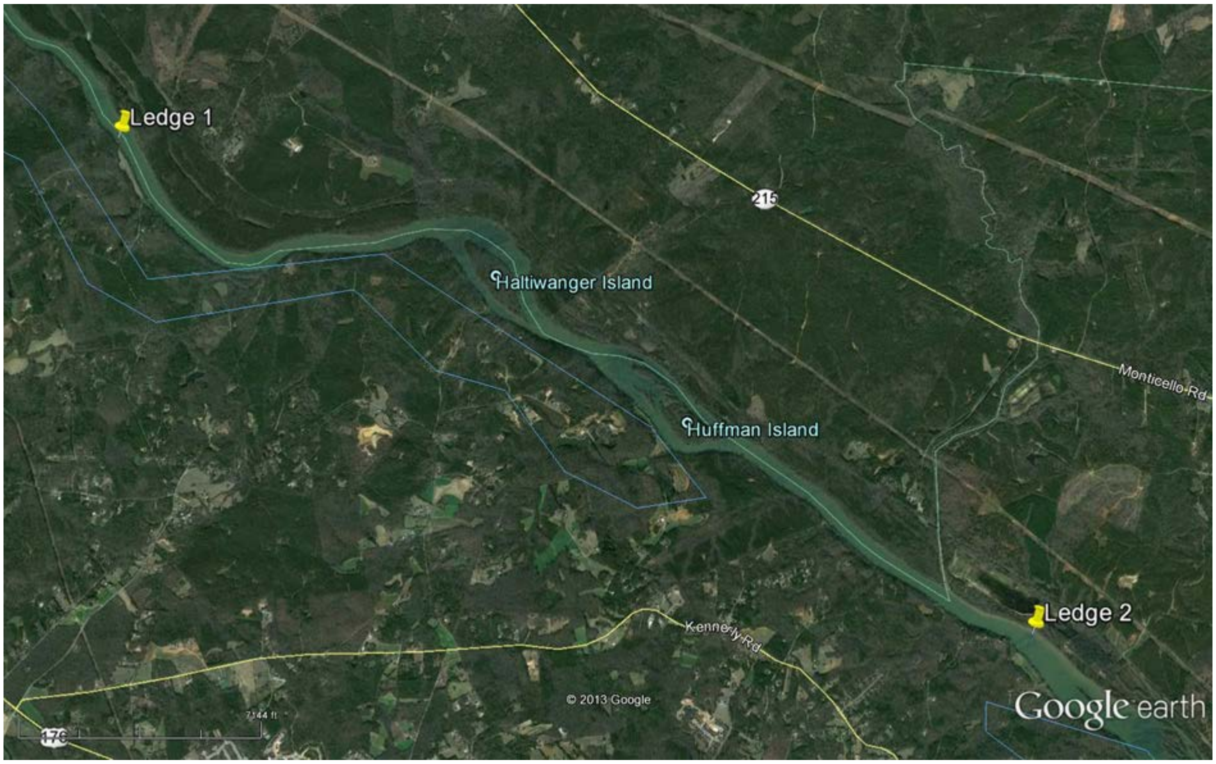


FIGURE 3-4 ZONE-OF-PASSAGE SITES IDENTIFIED BY THE TWC

3.1.1 EVALUATION LIFESTAGES

Each species and lifestage was quantitatively rated using HSI criteria, in which parameters of depth, velocity, and substrate were independently assigned rating values based on research, literature, observations, and/or professional judgment (Bovee, 1982; Bovee et al., 1998). The TWC originally identified 11 target species for evaluation during the IFIM study (Table 3-2). Consultation with the TWC resulted in many of these species being combined into guilds based on similar habitat requirements, with smallmouth bass (spawning, fry, juveniles and adults), redbreast sunfish (spawning and adults), and American shad (spawning) remaining as stand-alone species (Table 3-2).

HSI curves used in this study are included in Appendix D and were adopted primarily from the Lower Saluda River IFIM Study (Kleinschmidt 2008). One exception was smallmouth bass spawning depth, for which the TWC identified a HSI curve developed for the Deerfield River, MA as being more appropriate. Similarly, the TWC elected to utilize curves recently developed by Hightower et al. (2012) to quantify spawning habitat for American shad.

TABLE 3-2 TARGET SPECIES HABITAT USE GUILDS AND HSI CRITERIA SOURCE

	LIFESTAGE	SOURCE	GUILD
smallmouth bass	spawning (depth)	Deerfield River, MA	N/A
smallmouth bass	spawning (velocity and substrate)	Saluda	N/A
smallmouth bass	fry	Saluda	N/A
smallmouth bass	juvenile	Saluda	N/A
smallmouth bass	adult	Saluda	N/A
American shad	spawning	Hightower et al. 2012	N/A
brassy jumprock	adult	Saluda	deep fast/shallow fast
brassy jumprock	juvenile	Saluda	shallow fast
brassy jumprock	spawning	Saluda	shallow fast
whitefin shiner	adult	Saluda	shallow slow; deep slow
whitefin shiner	juvenile	Saluda	shallow slow
whitefin shiner	spawning	Saluda	shallow fast
robust redhorse	adult	Saluda	deep fast/shallow fast
robust redhorse	juvenile	Saluda	shallow fast
robust redhorse	spawning	Saluda	shallow fast
Santee chub	adult	Saluda	shallow fast
striped bass	adult	Saluda	deep fast
piedmont darter	adult	Saluda	shallow fast
piedmont darter	spawning	Saluda	shallow fast
snail bullhead	adult	Saluda	deep slow
redbreast sunfish	adult	Saluda	N/A
redbreast sunfish	spawning	Saluda	N/A
channel catfish	adult	Saluda	deep slow
channel catfish	juvenile	Saluda	deep slow; deep fast

3.2 PHABSIM 1-D MODELING SITES

Field Methods

The location of each transect was field blazed with flagging and paint and documented using Global Position System (GPS) technology. The transect headpin and tailpin ends were located at or above the top-of-bank elevation, and were secured by steel rebar. Each headpin was positioned on river right (looking downstream) and tailpins were located on river left. A measuring tape or kevlar line was secured at each transect to enable repeat field measurements to occur at specific stream loci. Stream bed and water elevations tied to a local datum were surveyed to the nearest 0.1 ft using standard optical surveying instrumentation and methods.

Depth, velocity, cover and substrate data were gathered at intervals (verticals) along each transect. Each vertical was located to the nearest 0.1 ft wherever an observed shift in depth or substrate/cover occurred. Verticals were arranged so that no more than 10% of the river discharge passed between any pair, enhancing hydraulic model calibration. A staff gage was set and monitored at the beginning and end of each set of hydraulic measurements to confirm stable flow during measurements.

Mean column velocity was measured to the nearest 0.1 ft/second with either a calibrated electronic velocity meter mounted on a top-setting wading rod or an Acoustic-Doppler Current Profiler (ADCP) transducer. In water less than 2.5 ft depth, measurements were made at 0.6 of total depth (measured from the water surface); at greater depths, paired measurements were made at 0.2 and 0.8 of total depth, and averaged.

Discharge through the study area is regulated by Parr Shoals Dam and therefore field work was coordinated with pre-arranged releases from the Project. Hydraulic data were collected at three calibration discharges according to study objectives (approximately 400; 2,000 and 6,000 cfs), to facilitate modeling in a range from approximately 200 cfs up to 15,000 cfs. One exception to this was Study Site Two, which is located in the West Channel below the dam and is not subject to powerhouse flows. At this site, calibration flows of approximately 46, 395 and 1,880 cfs were released into the West Channel via the spillway crest gates to allow modeling from 20 cfs up to 2,000 cfs.

Because the stage-discharge relationship is rarely linear, a minimum of three calibration flows is required to define the shape of stage-discharge curve for the flow range of interest. PHABSIM hydraulic models, as a rule of thumb, may extrapolate to as low as 40% of the lowest flow and up to 250% of the highest flow under ideal conditions. Therefore a low calibration flow of 400 cfs was selected to adequately provide data to model down to approximately 200 cfs and a high calibration flow of 6,000 cfs was selected to enable model extrapolation up to 15,000 cfs. The choice of middle calibration flow was made to be at least twice as high as the low flow in order to capture a set of hydraulic conditions significantly different than the low flow, and also approximately an order of magnitude lower than the high calibration flow.

Hydraulic Modeling

Hydraulic modeling and quality assurance/quality control techniques were conducted in accordance with standard practices for PHABSIM. Hydraulic modeling was accomplished by correlating each surveyed WSEL with discharge to develop a stage-discharge relationship for each transect. The model then adjusted velocities obtained at calibration flows to each flow increment of interest for which a defined water stage had been calculated. The model was then calibrated by comparing simulated hydraulics to empirical measurements taken at the calibration flows. Detailed steps are summarized below.

Field data collected at transects (e.g. cross section surveys, WSELs, velocities, discharge and slope measurements) were entered into a computer database compatible with PHABSIM software. All field calculations of discharge and data entry were proofed and cross-checked for accuracy. The field data included measurements at all three calibration flows, and were used to simulate depth, velocity, substrate, and cover conditions at discharges other than the calibration flows. Discharges and WSELs were determined for all calibration flows. Bed profiles, substrate, and cover used in the model were derived from surveys made during low flows. Velocity calibration in the PHABSIM model typically relies on velocities measured during mid-range flows, although velocity measurements are sometimes made in the field for low flows at features such as riffles where velocities are irregular across the cross section.

Transects within a common study site and mesohabitat type were linked hydraulically (*i.e.* within the same datum) with adjacent contiguous transects and/or with downstream hydraulic controls that create backwater conditions. Stand-alone transects were independently modeled. Simulation of water surface elevations at each transect was accomplished using one of three models within the PHABSIM analysis: IFG4, MANSQ or WSP. Often, all three models are run with the best stage-discharge relationship determined for each cross-section. The specific model used at a given transect depends on site characteristics, including gradient and backwatering from downstream hydraulic controls. IFG4 uses a log-log fit to determine a stage-discharge curve for the three calibration flows. MANSQ determines the stage-discharge relationship using the Manning's equation for stream flow, while WSP uses hydraulically-linked cross-sections in a backwater model to determine the relationship. WSP is similar to backwater models such as the U.S. Army Corps of Engineers' HEC-RAS program.

Velocity calibrations for each transect were performed using routines within the IFG4 model. The range of simulated flows represented by each calibration set is determined by the hydraulic engineer based on the model's performance at the calibration flows and trends in hydraulic parameters such as water surface elevation and velocity. PHABSIM output for each simulated flow, such as Velocity Adjustment Factors (VAFs), were plotted as smooth curves, with aberrations in these curves indicative of range boundaries for a given calibration flow. Typically, these fall toward extreme low or high flows in high gradient channels, at which point one of the other three calibration sets is used to continue the model out to the extremes. The hydraulic engineer reviewed all hydraulic output and determined and documented the acceptable range of simulated flows. This range usually extended from slightly below the low calibration flow to slightly higher than the high calibration flow.

3.3 DATA COLLECTION (2-D MODEL)

The TWC recommended that a 2-D hydraulic model as most appropriate for capturing the hydraulics and habitat suitability of the Bookman Island complex (Study Site 10) due to the complex channel characteristics. This process included the following steps:

- Raw data (terrain, velocity, depth and substrate) gathering and processing
- 2-D model development and calibration

- WUA computations

The preliminary data processing included the acquisition of remote-sensed terrain data, and merging this data with other bathymetric and topographic data. Aerial surveying was conducted at a flow of approximately 500 cfs, which provided comprehensive coverage of the study site. The end-product was a georeferenced bedfile, which is, in general terms, an xyz datafile with points that comprise the topology of the model domain (Figure 3-5).

FIGURE 3-5 SUBSECTION OF MODEL DOMAIN BEDFILE - (EACH PIXEL IS A DATAPOINT WITHIN THE 2D MODEL)

Depth, velocity, WSEL, and substrate information were collected throughout the reach during two different periods of controlled flows of 1,000 and 2,000 cfs. There were three water level loggers deployed within the study reach to provide additional model calibration data. These level loggers were deployed in the upper, middle, and lower sections of the study reach.

A two dimensional substrate map (Figure 3-6) was developed based on data collected during the field effort. Substrate and cover were categorized based on codes specified within the HSI curves.

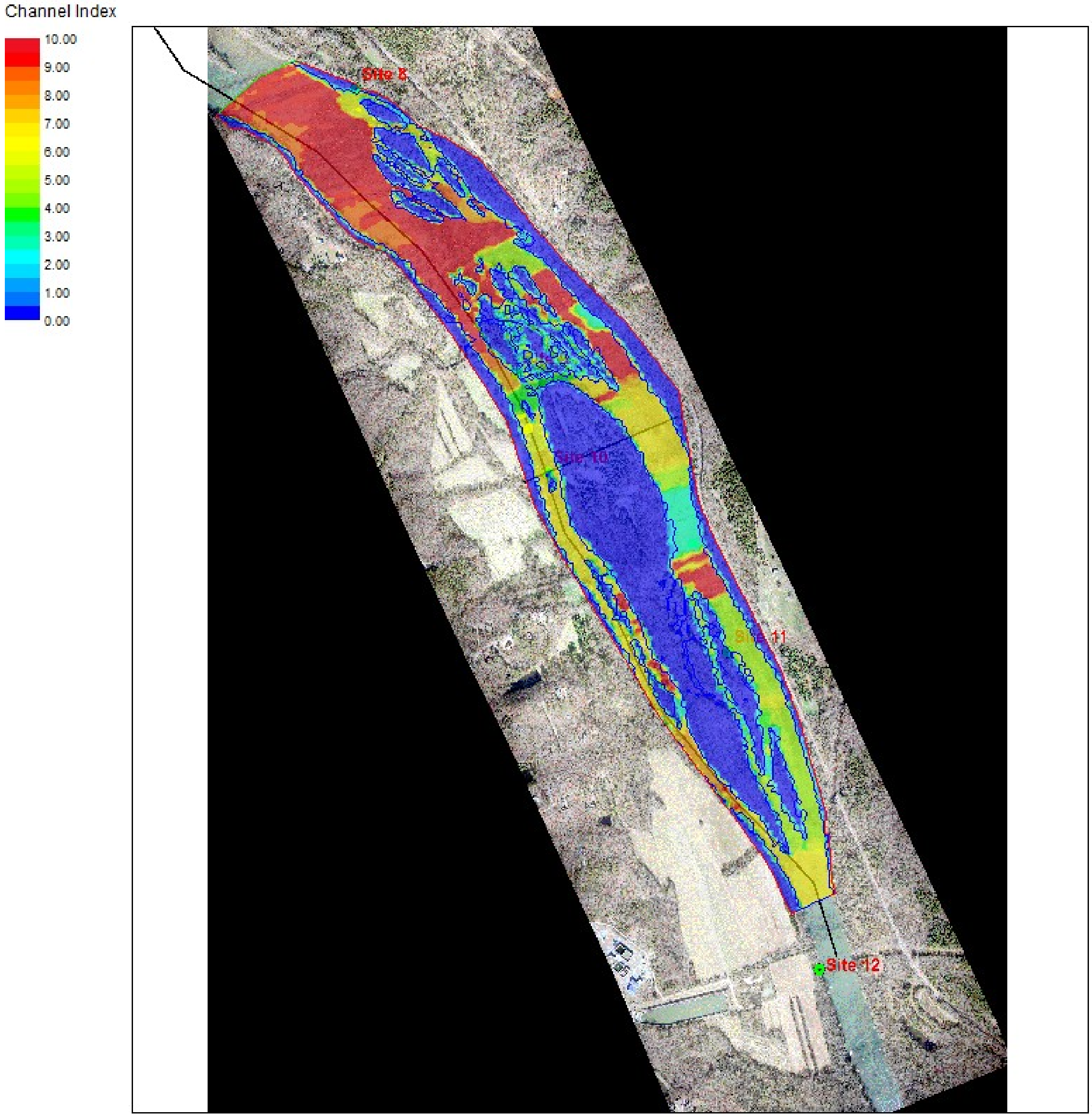


FIGURE 3-6 CHANNEL INDEX (SUBSTRATE) MAP - STUDY SITE 10

The 2-D modeling was performed with River2D (Steffler and Blackburn 2002), which is a public domain software package developed as a cooperative effort between the University of Alberta, Fisheries and Oceans – Canada, and the USGS. The River2D suite includes subroutines for bed editing, mesh development and editing, depth-averaged hydrodynamic modeling, and computation of WUA. Subsequent to the bedfile development, the model mesh was developed and edited in conjunction with the model calibration. The mesh editing and calibration, in brief, involved inspecting the flow pathways within the model domain. The majority of this effort was directed at refining the mesh in locations where the base data did not accurately shape the flow pathways (Figure 3-7).

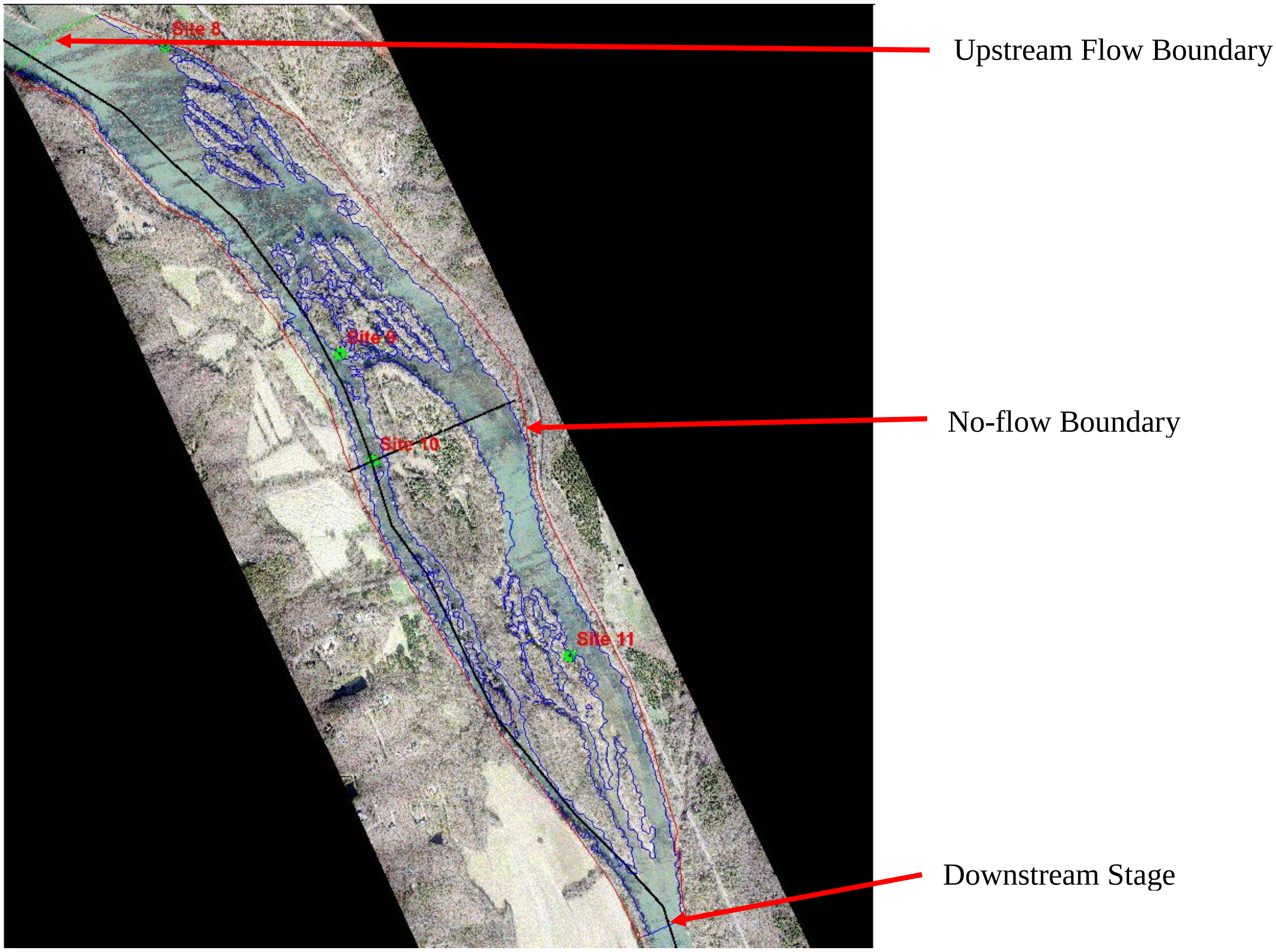


FIGURE 3-7 FLOW PATHWAY MAP - STUDY SITE 10

The WUA calculations were performed within the River2D model suite, using the same data that were used to simulate the flow. The HSI curves for depth, velocity and substrate were incorporated into the modeling data. The WUA calculations were performed using the simulated velocity and depth, and a lookup of the substrate. The WUA value was computed as the summation of the product of the HSI values times the area for all mesh cells.

3.4 DATA COLLECTION (LEDGE POOLS BELOW DAM IN STUDY SITE 1)

Bedrock pools occurring in the upper West Channel directly downstream of Parr Shoals Dam were surveyed using a Sontek M-9 ADCP unit to provide bathymetric data for the area.

Supplemental depth data was collected manually in each of the primary pools at full pool leakage flow (approximately 50 cfs) during a site visit conducted in May 2016. These representative depths were then used in combination with Geographic Information System (GIS)-based surface area calculation to determine pool volumes at low flow conditions when water quality issues are likely to occur.

3.5 DATA COLLECTION (WETTED PERIMETER AT STUDY SITE 4; BACKWATER AT LOWER WEST CHANNEL)

The transect end points at Study Site 4 were field blazed with flagging and paint and documented with sub-meter GPS. The transect headpin and tailpin ends were located above the top-of-bank elevation, and secured by steel rebar. A Kevlar line was secured at the transect to enable repeat field measurements at specific stream locations. Streambed and water elevations tied to a local datum were surveyed to the nearest 0.1 ft using standard optical surveying instrumentation and methods. Approximately 30 verticals were established along the transect to accurately depict cross-sectional channel geometry. Water elevation at three flows spanning the range of releases associated with the PHABSIM data collection was recorded through both survey and staff gaging, so that a stage-discharge relationship could be established. These data were then used to establish a wetted perimeter rating curve.

4.0 RESULTS

Calibration flow data were primarily collected in April, June and July of 2015, with additional low flow data in support of the 2-D modeling at Study Site 10 collected in April of 2016. Results are presented below for each study site, beginning upstream.

4.1 STUDY SITE 1 (BEDROCK POOLS IN UPPER WEST CHANNEL)

Bathymetric mapping in Study Site 1 indicated five primary pools in the upstream portion of the West Channel (Figure 4-1). The estimates of pool volume range in size from 0.2 to 4.9 acre-ft (Table 4-1). Additional testing is scheduled at this site for August 2016, during which pulses of varying magnitudes will be released to the West Channel via the spillway crest gates. The releases will be monitored to determine the extent which adequate turnover is achieved to reach the desired water quality conditions.

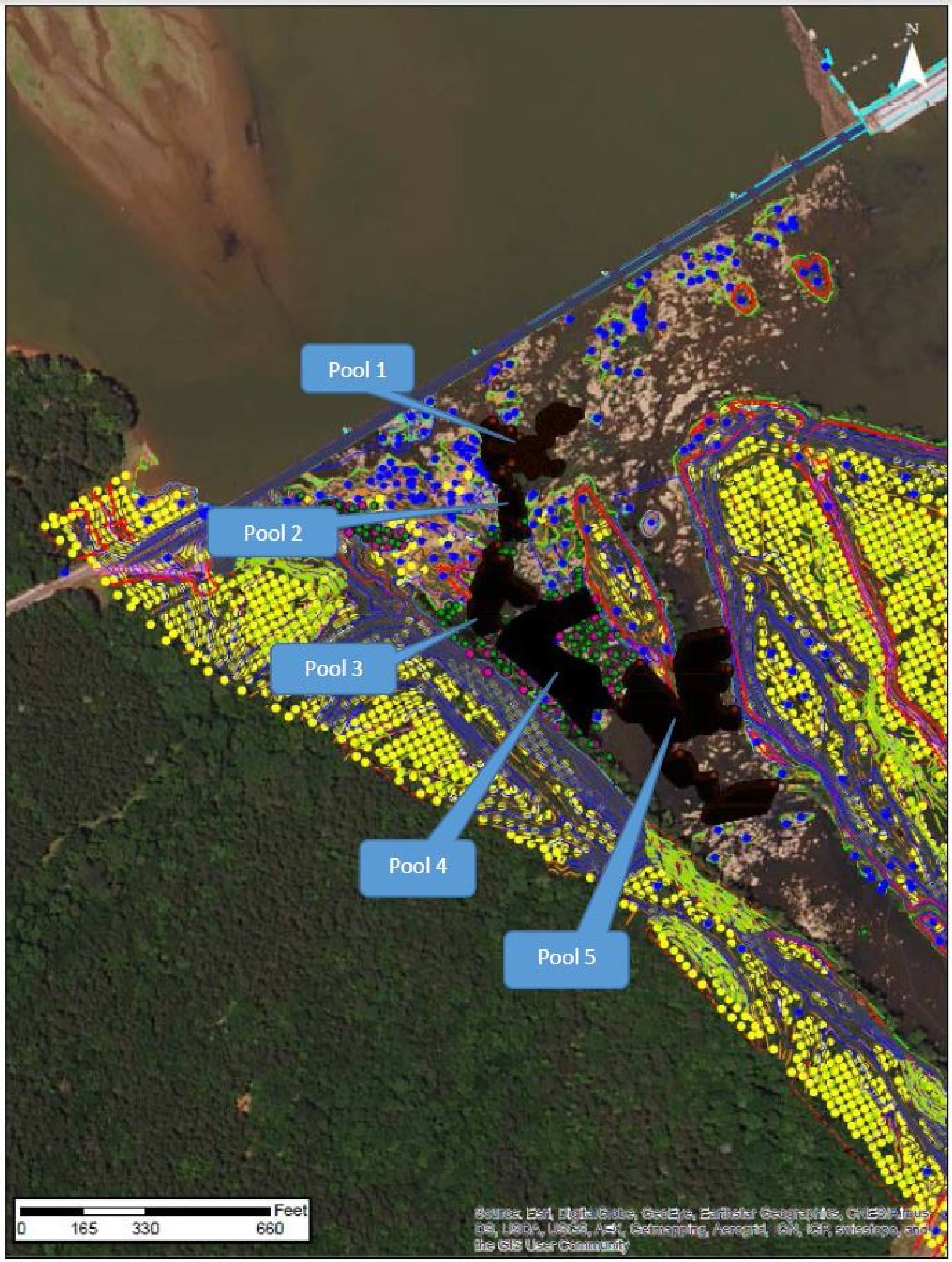


FIGURE 4-1 PRIMARY POOLS IN UPPER WEST CHANNEL BELOW PARR SHOALS DAM (IFIM STUDY SITE 1)

TABLE 4-1 ESTIMATED VOLUME OF FIVE MAJOR POOLS IN THE UPSTREAM PORTION OF THE WEST CHANNEL

POOL #	AREA (SQ FT)	DEPTH AT 50 CFS (FT)	POOL VOLUME (CUBIC FT)	POOL VOLUME (ACRE FT)
1	29,394	3.1	91,121	2.1
2	3,760	2.3	8,648	0.2
3	39,255	1.5	58,882	1.4
4	35,952	3.1	75,499	1.7
5	119,771	1.8	215,588	4.9
TOTAL				**10.3**

4.2 STUDY SITE 2 (RIFFLE AND RUN COMPLEX LOCATED IN WEST CHANNEL)

This site is comprised of two linked transects spanning a boulder-dominated riffle and run complex located in the West Channel below the project dam. Data from this site suggest that WUA for several key lifestages, namely adult redbreast sunfish, smallmouth bass juveniles and the deep-slow and shallow-fast guilds, peaks in the range of 250 to approximately 500 cfs (Figure 4-2) (Table 4-2). American shad spawning and smallmouth bass adults experience maximum WUA at approximately 1,000 cfs, but this is at the detriment of many other lifestages. Finally, several lifestages, including smallmouth bass fry, redbreast sunfish spawning and the shallow-slow guild, appear velocity limited at this site, with WUA values falling as flow increases from the base flow.

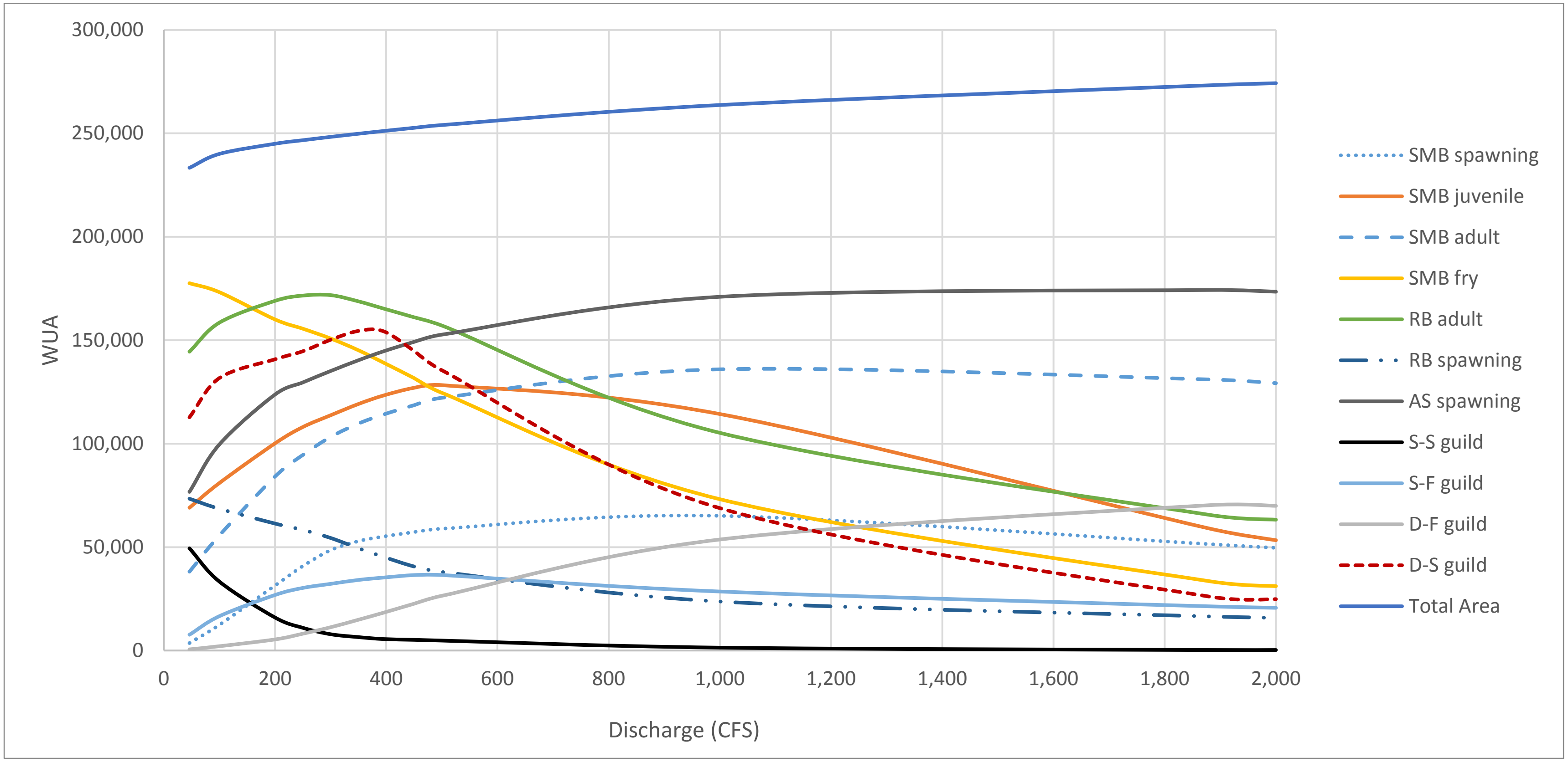


FIGURE 4-2 STUDY SITE 2 HABITAT SUITABILITY

TABLE 4-2 STUDY SITE 2 HABITAT SUITABILITY[1]

Discharge	SMB spawning		SMB juvenile		SMB adult		SMB fry		RB adult		RB spawning		AS spawning		S-S guild		S-F guild		D-F guild		D-S guild	
46	3,593	6%	69,023	54%	38,107	28%	177,587	100%	144,465	84%	73,381	100%	76,695	44%	49,409	100%	7,628	21%	552	1%	112,750	73%
100	12,447	19%	81,000	63%	55,695	41%	173,223	98%	158,542	92%	68,520	93%	99,675	57%	33,296	67%	16,616	46%	2,083	3%	131,748	85%
200	31,419	48%	100,168	78%	84,144	62%	160,052	90%	169,059	98%	61,376	84%	123,780	71%	15,941	32%	26,854	74%	5,358	8%	140,813	91%
250	40,828	63%	108,057	84%	94,555	70%	155,581	88%	171,592	100%	58,300	79%	129,619	75%	10,971	22%	30,255	83%	8,136	12%	144,693	94%
300	48,503	74%	113,747	89%	103,268	76%	150,849	85%	171,812	100%	54,404	74%	135,135	78%	7,869	16%	32,231	88%	11,255	16%	150,234	97%
350	52,879	81%	119,193	93%	109,727	81%	145,157	82%	168,805	98%	49,425	67%	140,343	81%	6,473	13%	34,118	93%	14,886	21%	154,505	100%
395	55,112	85%	123,293	96%	114,102	84%	139,183	78%	165,331	96%	45,290	62%	144,651	83%	5,539	11%	35,270	97%	18,281	26%	154,341	100%
450	57,259	88%	127,005	99%	118,596	87%	131,707	74%	161,105	94%	40,626	55%	149,215	86%	5,166	10%	36,469	100%	22,624	32%	144,867	94%
500	58,896	90%	128,312	100%	122,177	90%	124,582	70%	157,107	91%	37,982	52%	152,723	88%	4,803	10%	36,497	100%	26,461	38%	135,481	88%
600	60,139	92%	125,515	98%	124,932	92%	114,295	64%	146,731	85%	35,123	48%	156,382	90%	4,120	8%	34,903	96%	31,904	45%	122,150	79%
700	61,382	94%	122,718	96%	127,688	94%	104,008	59%	136,356	79%	32,265	44%	160,040	92%	3,437	7%	33,308	91%	37,347	53%	108,818	70%
800	62,626	96%	119,921	93%	130,443	96%	93,721	53%	125,980	73%	29,406	40%	163,699	94%	2,754	6%	31,713	87%	42,790	61%	95,487	62%
900	63,869	98%	117,124	91%	133,199	98%	83,434	47%	115,604	67%	26,547	36%	167,357	96%	2,071	4%	30,119	83%	48,233	69%	82,155	53%
1,000	65,112	100%	114,327	89%	135,955	100%	73,148	41%	105,229	61%	23,689	32%	171,016	99%	1,388	3%	28,524	78%	53,676	76%	68,823	45%
1,100	63,563	98%	108,227	84%	135,285	100%	68,944	39%	101,032	59%	22,900	31%	171,261	99%	1,274	3%	27,736	76%	55,303	79%	64,424	42%
1,200	62,014	95%	102,126	80%	134,615	99%	64,741	36%	96,834	56%	22,111	30%	171,507	99%	1,160	2%	26,948	74%	56,930	81%	60,025	39%
1,300	60,465	93%	96,025	75%	133,944	99%	60,537	34%	92,637	54%	21,322	29%	171,752	99%	1,045	2%	26,160	72%	58,556	83%	55,626	36%
1,400	58,916	90%	89,925	70%	133,274	98%	56,333	32%	88,440	51%	20,533	28%	171,998	99%	931	2%	25,371	70%	60,183	86%	51,227	33%
1,600	57,367	88%	83,824	65%	132,604	98%	52,130	29%	84,243	49%	19,745	27%	172,243	99%	817	2%	24,583	67%	61,810	88%	46,828	30%
1,880	51,434	79%	58,992	46%	131,051	96%	33,514	19%	65,590	38%	16,478	22%	174,298	100%	252	1%	21,364	59%	70,253	100%	26,080	17%
2,000	49,621	76%	53,321	42%	129,254	95%	31,112	18%	63,256	37%	15,800	22%	173,471	100%	245	0%	20,643	57%	69,943	100%	24,833	16%
100%	65,112		128,312		135,955		177,587		171,812		73,381		174,298		49,409		36,497		70,253		154,505	
75%	48,834		96,234		101,966		133,190		128,859		55,036		130,724		37,057		27,373		52,690		115,879	

[1] Shading indicates WUA value that are equal or exceed 75% of maximum WUA for that species/lifestage at that study site.

4.3 STUDY SITE 3 (RUN-GLIDE-RIFFLE COMPLEX DIRECTLY DOWNSTREAM OF PARR POWERHOUSE)

This site consists of three linked transects spanning a cobble and gravel dominated run-glide-riffle complex located directly downstream of the Parr Shoals powerhouse. This site has been noted as an important site for freshwater mussels and as a potential robust redhorse spawning site. WUA results show that several lifestages, including redbreast sunfish adult and smallmouth bass juveniles, have peak habitat suitability at flows ranging from 400 to approximately 900 cfs (Figure 4-3) (Table 4-3). The shallow-fast guild, which includes robust redhorse spawning, also peaks in this range. Finally, habitat suitability for smallmouth bass adults, smallmouth bass spawning and American shad spawning follow similar patterns to one another, peaking at approximately 1,500 to 2,000 cfs. Smallmouth bass fry and the shallow-slow guild appear to be velocity limited at this site, with WUA values falling as flow increases from the base flow. Both deep-slow and shallow-slow guilds have limited habitat suitability at this under all flow increments.

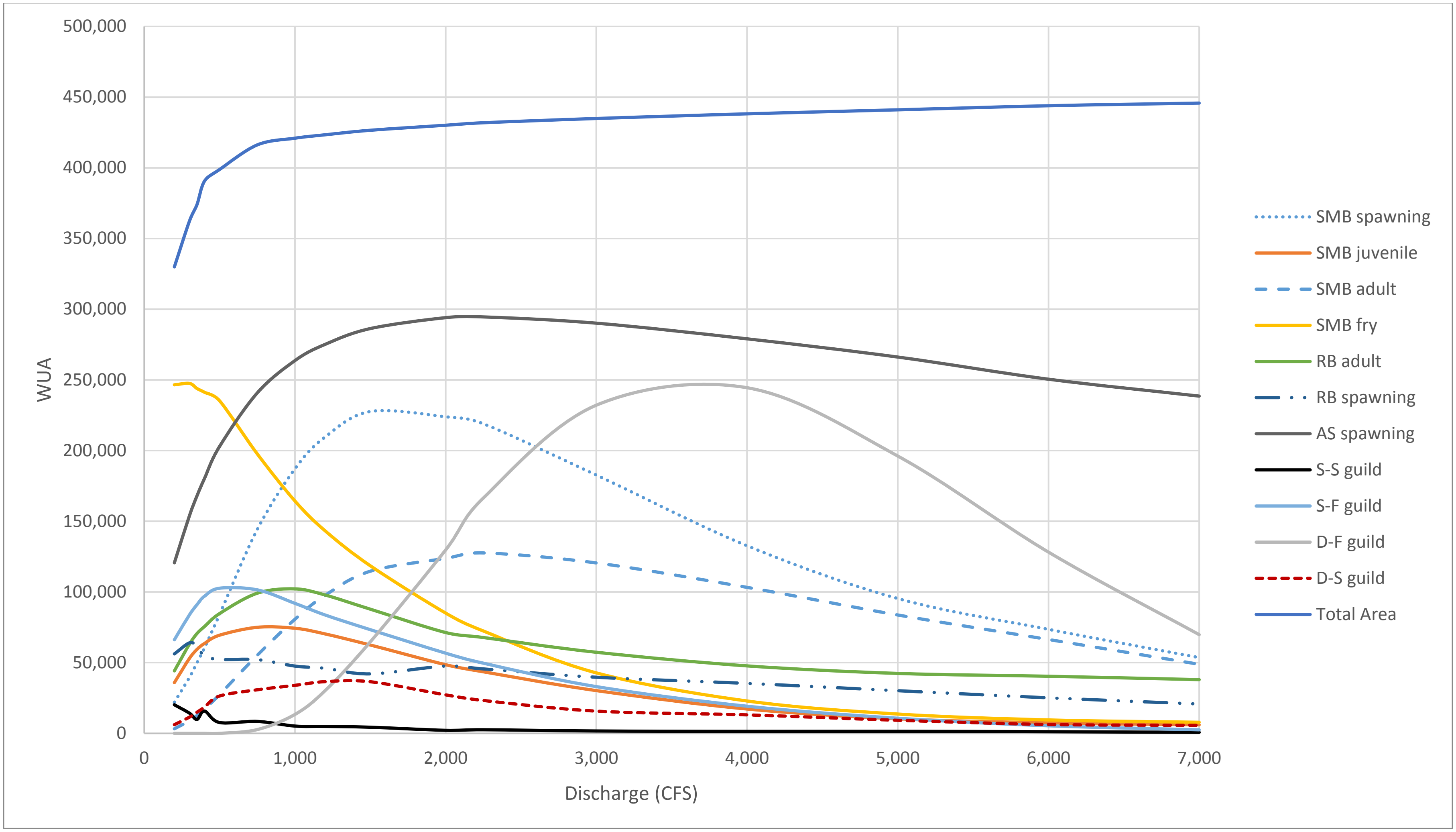


FIGURE 4-3 STUDY SITE 3 HABITAT SUITABILITY

TABLE 4-3 STUDY SITE 3 HABITAT SUITABILITY

Discharge	SMB spawning		SMB juvenile		SMB adult		SMB fry		RB adult		RB spawning		AS spawning		S-S guild		S-F guild		D-F guild		D-S guild	
200	22,010	10%	35,895	48%	3,245	3%	246,534	100%	44,190	43%	56,194	88%	120,632	41%	20,227	100%	66,201	64%	0	0%	6,155	17%
300	39,568	17%	53,023	71%	8,842	7%	247,519	100%	63,111	62%	64,009	100%	153,920	52%	14,301	71%	83,824	82%	0	0%	11,464	31%
350	49,956	22%	59,398	79%	12,657	10%	243,919	99%	70,590	69%	61,535	96%	167,976	57%	9,857	49%	91,012	89%	0	0%	14,970	41%
400	60,444	27%	63,598	85%	17,079	13%	241,241	97%	75,583	74%	54,781	86%	180,321	61%	15,779	78%	97,020	94%	0	0%	18,557	51%
500	84,153	37%	69,445	93%	27,450	22%	235,249	95%	84,730	83%	52,279	82%	202,960	69%	7,678	38%	102,671	100%	18	0%	26,424	72%
600	108,176	48%	71,675	96%	38,563	30%	220,223	89%	90,492	89%	52,231	82%	218,096	74%	7,989	39%	102,207	100%	1,084	0%	28,182	77%
750	144,211	63%	75,020	100%	55,233	43%	197,685	80%	99,135	97%	52,159	81%	240,800	82%	8,456	42%	101,510	99%	2,683	1%	30,820	84%
900	169,961	75%	74,625	99%	70,526	55%	177,690	72%	100,972	99%	49,417	77%	254,511	86%	6,481	32%	95,779	93%	9,107	4%	32,714	89%
1,000	187,128	82%	74,361	99%	80,722	63%	164,360	66%	102,196	100%	47,588	74%	263,652	90%	5,165	26%	91,959	90%	13,389	5%	33,976	93%
1,100	198,374	87%	72,351	96%	89,180	70%	153,828	62%	100,034	98%	46,805	73%	269,389	91%	5,037	25%	87,850	86%	21,793	9%	35,273	96%
1,200	209,621	92%	70,340	94%	97,638	77%	143,295	58%	97,872	96%	46,021	72%	275,126	93%	4,908	24%	83,741	82%	30,196	12%	36,570	100%
1,300	215,631	95%	67,729	90%	103,323	81%	135,051	55%	94,529	92%	44,706	70%	278,857	95%	4,721	23%	80,277	78%	41,700	17%	36,553	100%
1,400	221,641	97%	65,117	87%	109,007	85%	126,806	51%	91,187	89%	43,392	68%	282,587	96%	4,534	22%	76,813	75%	53,205	22%	36,537	100%
1,500	227,651	100%	62,505	83%	114,691	90%	118,562	48%	87,845	86%	42,077	66%	286,317	97%	4,346	21%	73,349	71%	64,709	26%	36,520	100%
1,600	226,903	100%	59,717	80%	116,507	91%	111,868	45%	84,541	83%	43,188	67%	287,860	98%	3,909	19%	70,025	68%	77,711	32%	34,663	95%
2,000	223,911	98%	48,562	65%	123,771	97%	85,089	34%	71,328	70%	47,632	74%	294,034	100%	2,162	11%	56,730	55%	129,719	53%	27,237	74%
2,250	218,971	96%	43,563	58%	127,623	100%	72,426	29%	67,802	66%	45,587	71%	294,550	100%	2,559	13%	49,660	48%	166,430	68%	23,277	64%
2,400	211,716	93%	40,901	55%	126,207	99%	66,497	27%	65,714	64%	44,409	69%	293,666	100%	2,384	12%	46,342	45%	179,569	73%	21,766	60%
2,600	206,879	91%	39,126	52%	125,263	98%	62,544	25%	64,322	63%	43,624	68%	293,076	99%	2,268	11%	44,130	43%	188,329	77%	20,759	57%
3,000	182,696	80%	30,254	40%	120,543	94%	42,781	17%	57,363	56%	39,697	62%	290,129	98%	1,686	8%	33,070	32%	232,128	95%	15,725	43%
3,500	157,697	69%	23,741	32%	111,904	88%	32,844	13%	52,545	51%	37,521	59%	284,590	97%	1,563	8%	26,136	25%	238,302	97%	14,404	39%
4,000	132,698	58%	17,228	23%	103,264	81%	22,907	9%	47,726	47%	35,346	55%	279,051	95%	1,440	7%	19,202	19%	244,475	100%	13,084	36%
4,500	114,045	50%	13,765	18%	93,499	73%	18,286	7%	45,068	44%	32,764	51%	272,609	93%	1,462	7%	14,954	15%	220,313	90%	11,167	31%
5,000	95,391	42%	10,302	14%	83,733	66%	13,665	6%	42,410	41%	30,183	47%	266,167	90%	1,483	7%	10,706	10%	196,150	80%	9,249	25%
6,000	73,583	32%	7,408	10%	66,396	52%	9,506	4%	40,400	40%	25,129	39%	250,501	85%	1,184	6%	5,364	5%	128,195	52%	6,275	17%
7,000	53,598	24%	6,030	8%	48,860	38%	7,856	3%	38,010	37%	20,758	32%	238,542	81%	721	4%	2,515	2%	69,829	29%	5,693	16%
100%	227,651		75,020		127,623		247,519		102,196		64,009		294,550		20,227		102,671		244,475		36,570	
75%	170,738		56,265		95,717		185,639		76,647		48,007		220,913		15,171		77,004		183,356		27,428	

4.4 Study Site 4 (West Channel Wetted Perimeter Transect)

A bed profile depicting the wetted perimeter transect at Study Site 4 is provided in Figure 4-4. A rating curve depicting the wetted width – flow relationship for Study Site 4 is provided is Figure 4-5.

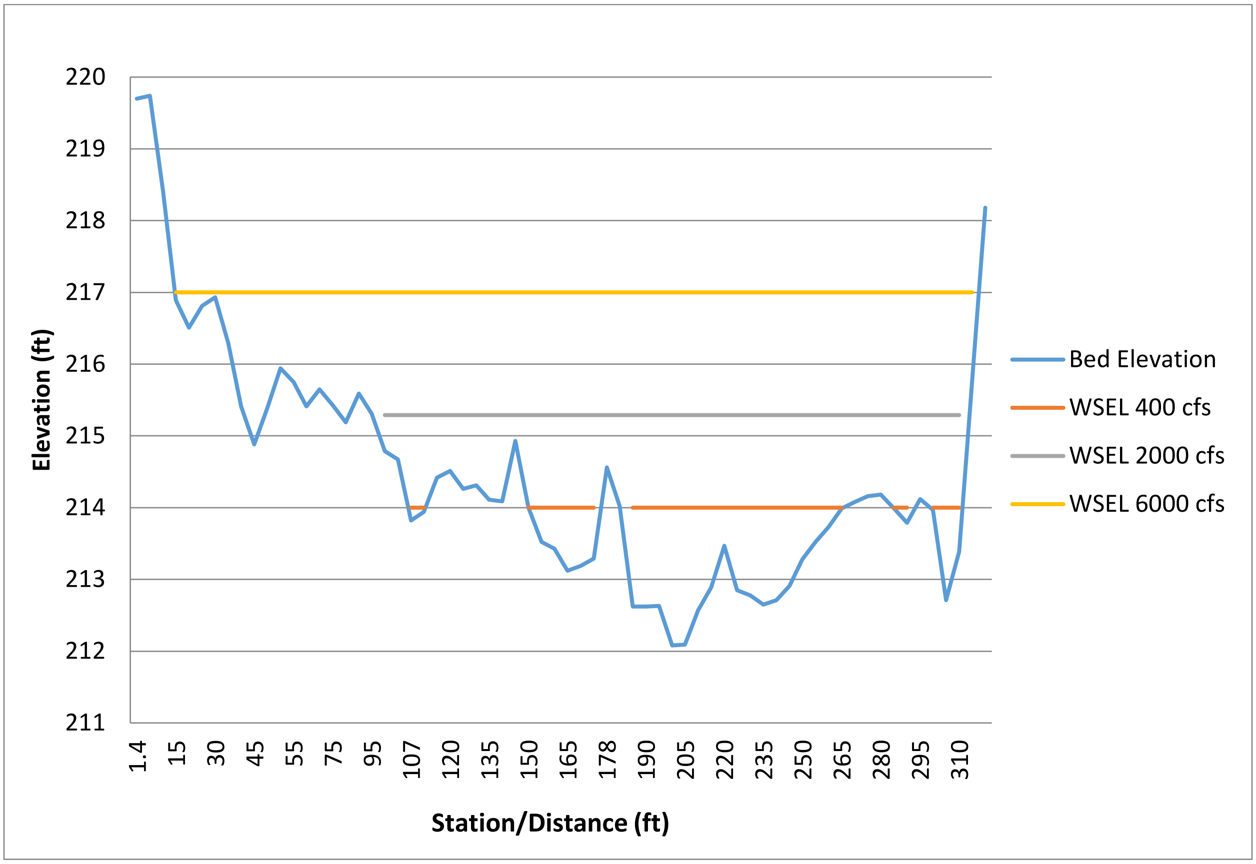


Figure 4-4 Bed Profile at Study Site 4 Showing Water Surface Elevation at IFIM Calibration Flows

FIGURE 4-5 WETTED WIDTH RATING CURVE FOR STUDY SITE 4

4.5 STUDY SITE 5 (LEDGE-CONTROLLED RIFFLE IN LOWER EAST CHANNEL)

This site consists of two linked transects located at a ledge-controlled glide-riffle located downstream of the Parr Shoals powerhouse just upstream of the downstream terminus of Hampton Island. All of the lifestages and guilds modeled at this site experienced peak WUA in the range of 500 to approximately 1000 cfs (Figure 4-6) (Table 4-4). This site provides relatively limited suitability for a number of lifestages, including shallow-fast guild, deep-fast guild, smallmouth bass fry, and redbreast sunfish spawning.

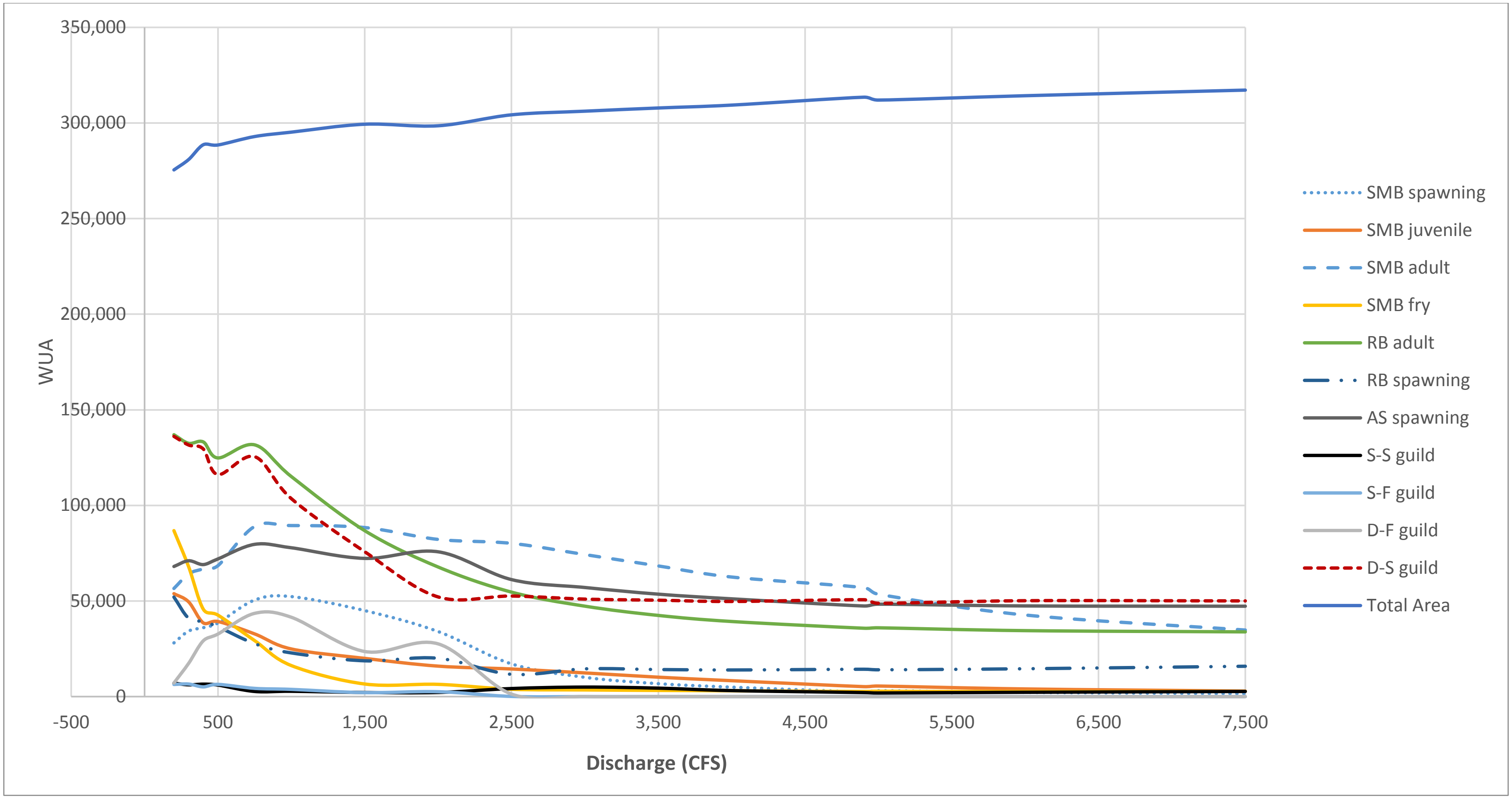


FIGURE 4-6 STUDY SITE 5 HABITAT SUITABILITY

TABLE 4-4 STUDY SITE 5 HABITAT SUITABILITY

Discharge	SMB spawn		SMB juvenile		SMB adult		SMB fry		RB adult		RB spawning		AS spawning		S-S guild		S-F guild		D-F guild		D-S guild	
200	28,083	54%	53,848	100%	56,543	63%	86,800	100%	136,977	100%	52,055	100%	68,051	85%	7,018	100%	6,342	96%	7,119	16%	136,092	100%
300	34,276	66%	49,561	92%	64,142	72%	67,987	78%	132,491	97%	40,997	79%	71,047	89%	6,160	88%	6,572	100%	17,363	40%	131,583	97%
400	36,049	69%	38,556	72%	66,756	75%	45,721	53%	133,190	97%	39,197	75%	69,047	87%	6,514	93%	5,081	77%	29,183	67%	129,485	95%
500	38,478	74%	39,271	73%	68,494	77%	42,613	49%	124,819	91%	36,520	70%	72,001	90%	6,032	86%	6,393	97%	32,730	75%	116,099	85%
600	43,284	83%	36,677	68%	76,693	86%	37,280	43%	127,556	93%	32,985	63%	75,054	94%	4,695	67%	5,556	85%	37,055	85%	119,861	88%
750	50,493	97%	32,787	61%	88,993	99%	29,282	34%	131,661	96%	27,682	53%	79,632	100%	2,689	38%	4,302	65%	43,541	100%	125,505	92%
900	51,580	99%	28,062	52%	89,268	100%	21,450	25%	121,716	89%	24,781	48%	78,559	99%	2,743	39%	3,989	61%	42,314	97%	112,328	83%
1,000	52,305	100%	24,913	46%	89,452	100%	16,229	19%	115,085	84%	22,847	44%	77,843	98%	2,779	40%	3,780	58%	41,495	95%	103,544	76%
1,150	50,107	96%	23,438	44%	89,140	100%	13,336	15%	106,593	78%	21,608	42%	76,174	96%	2,590	37%	3,268	50%	36,121	83%	95,210	70%
1,350	47,177	90%	21,472	40%	88,725	99%	9,478	11%	95,271	70%	19,956	38%	73,949	93%	2,338	33%	2,586	39%	28,956	67%	84,098	62%
1,500	44,979	86%	19,998	37%	88,413	99%	6,584	8%	86,780	63%	18,717	36%	72,279	91%	2,149	31%	2,075	32%	23,583	54%	75,763	56%
1,650	41,695	80%	18,779	35%	86,552	97%	6,532	8%	81,081	59%	19,116	37%	73,316	92%	2,150	31%	2,219	34%	24,783	57%	68,674	50%
1,850	37,318	71%	17,155	32%	84,070	94%	6,462	7%	73,483	54%	19,647	38%	74,697	94%	2,152	31%	2,411	37%	26,384	61%	59,221	44%
2,000	34,035	65%	15,936	30%	82,209	92%	6,410	7%	67,785	49%	20,045	39%	75,734	95%	2,153	31%	2,555	39%	27,585	63%	52,131	38%
2,500	17,113	33%	14,441	27%	80,148	90%	3,840	4%	54,643	40%	11,662	22%	61,197	77%	4,216	60%	91	1%	1,333	3%	52,594	39%
3,000	10,080	19%	12,385	23%	74,277	83%	3,483	4%	47,300	35%	14,517	28%	57,062	72%	4,976	71%	0	0%	0	0%	50,984	37%
3,500	6,759	13%	10,156	19%	68,334	76%	3,235	4%	42,455	31%	14,154	27%	53,573	67%	4,421	63%	0	0%	0	0%	50,415	37%
4,000	4,938	9%	8,315	15%	62,530	70%	3,046	4%	39,279	29%	13,929	27%	51,134	64%	3,144	45%	0	0%	0	0%	49,753	37%
4,900	2,439	5%	5,211	10%	56,984	64%	2,667	3%	35,760	26%	14,309	27%	47,393	60%	2,098	30%	0	0%	0	0%	50,663	37%
5,000	3,049	6%	5,526	10%	53,526	60%	2,802	3%	35,985	26%	14,020	27%	48,334	61%	1,890	27%	0	0%	0	0%	48,825	36%
6,000	2,213	4%	4,004	7%	42,668	48%	2,604	3%	34,497	25%	14,561	28%	47,419	60%	2,263	32%	0	0%	0	0%	50,155	37%
7,500	1,615	3%	2,883	5%	34,807	39%	2,755	3%	33,855	25%	15,873	30%	47,275	59%	2,690	38%	0	0%	0	0%	50,047	37%
100%	52,305		53,848		89,452		86,800		136,977		52,055		79,632		7,018		6,572		43,541		136,092	
75%	39,229		40,386		67,089		65,100		102,733		39,041		59,724		5,264		4,929		32,656		102,069	

4.6 STUDY SITE 6 (LARGE MAIN CHANNEL RIFFLE)

This site is comprised of two linked transects located in gravel and cobble-dominated riffle complex located approximately 3.5 miles downstream of Parr Shoals Dam. Habitat suitability for the majority of target lifestages and guilds peaks at approximately 1,500 to 1,900 cfs at this site. Smallmouth bass spawning and adult lifestages, as well as the deep fast guild, peaked at approximately 3500 cfs (Figure 4-7) (Table 4-5).

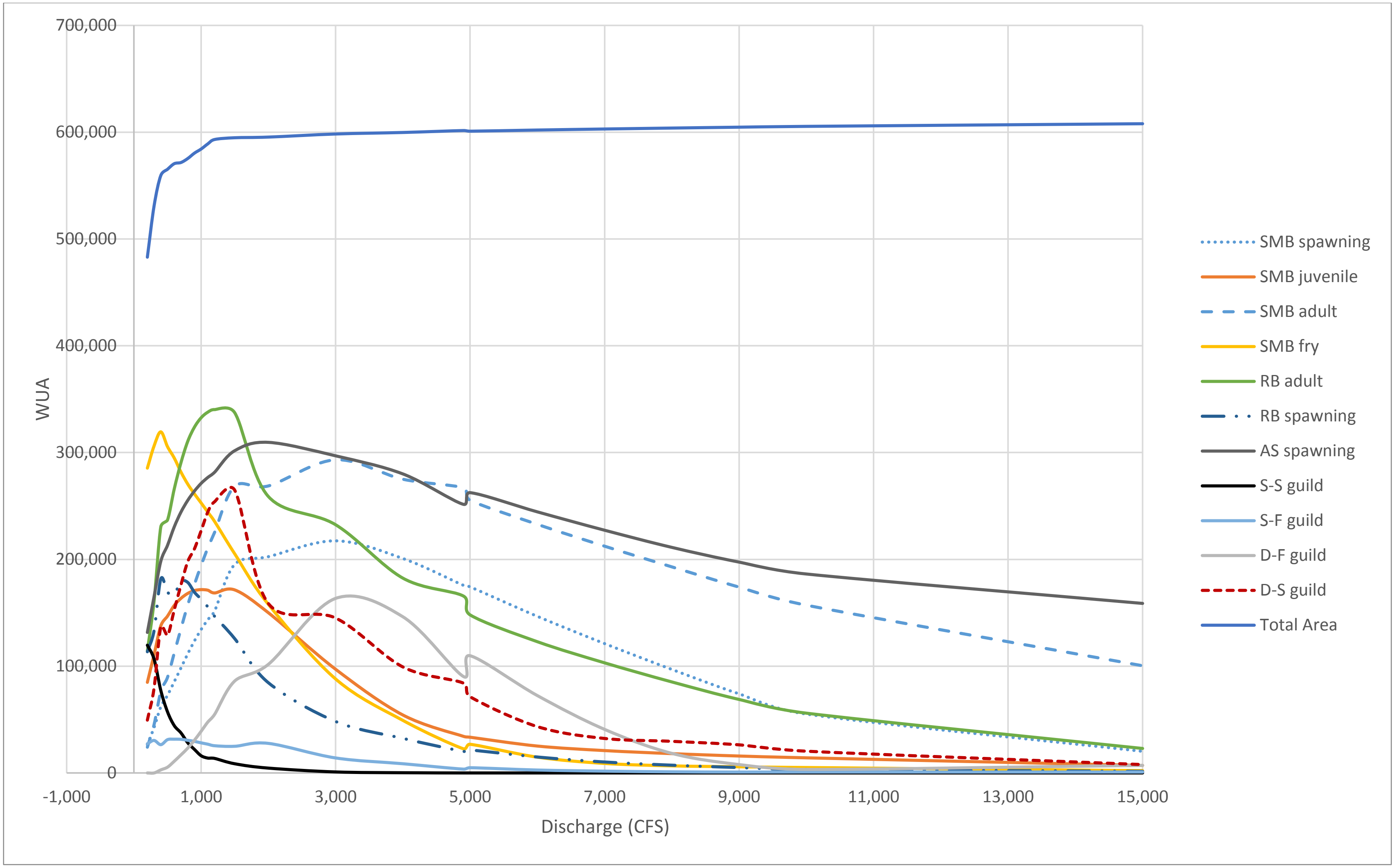


FIGURE 4-7 STUDY SITE 6 HABITAT SUITABILITY

TABLE 4-5 STUDY SITE 6 HABITAT SUITABILITY

Discharge	SMB spawning		SMB juvenile		SMB adult		SMB fry		RB adult		RB spawning		AS spawning		S-S guild		S-F guild		D-F guild		D-S guild	
200	26,585	12%	84,857	49%	24,118	8%	285,437	89%	114,115	34%	113,475	62%	131,577	43%	119,617	100%	27,340	86%	0	0%	49,474	19%
300	42,637	20%	110,798	65%	45,260	15%	306,222	96%	160,968	47%	133,234	73%	165,137	53%	106,635	89%	30,427	96%	0	0%	79,497	30%
400	61,906	28%	137,727	80%	76,247	26%	319,394	100%	230,410	68%	181,637	100%	198,199	64%	77,266	65%	26,471	84%	2,864	2%	136,779	52%
500	72,730	33%	146,876	86%	89,526	31%	305,488	96%	236,882	70%	169,259	93%	213,162	69%	57,169	48%	31,181	99%	5,417	3%	128,920	49%
600	85,471	39%	156,886	91%	112,313	38%	294,903	92%	265,947	78%	167,381	92%	230,434	74%	44,331	37%	31,617	100%	10,954	7%	152,720	58%
700	98,310	45%	163,508	95%	135,068	46%	281,734	88%	290,581	85%	179,292	99%	244,294	79%	37,514	31%	31,491	100%	16,941	10%	176,107	67%
800	111,494	51%	168,086	98%	157,142	54%	270,554	85%	310,409	91%	178,462	98%	255,182	82%	28,297	24%	30,600	97%	23,183	14%	197,806	75%
900	123,595	57%	170,807	100%	176,480	60%	261,320	82%	323,790	95%	169,242	93%	263,953	85%	22,044	18%	29,573	94%	30,634	19%	209,830	79%
1,000	134,345	62%	171,663	100%	194,370	66%	252,831	79%	332,639	98%	162,699	90%	271,192	88%	16,105	13%	28,176	89%	39,037	24%	226,852	86%
1,100	143,613	66%	171,112	100%	210,820	72%	244,155	76%	337,882	99%	155,421	86%	276,775	89%	13,912	12%	26,919	85%	47,747	29%	244,469	92%
1,200	151,615	70%	168,556	98%	225,268	77%	235,503	74%	340,255	100%	146,664	81%	281,595	91%	13,618	11%	25,488	81%	54,830	34%	253,984	96%
1,500	195,308	90%	171,373	100%	268,572	92%	205,111	64%	337,243	99%	125,677	69%	301,792	97%	8,596	7%	24,979	79%	86,147	53%	264,661	100%
2,000	202,531	93%	150,005	87%	268,770	92%	157,825	49%	258,831	76%	84,461	47%	309,582	100%	4,538	4%	27,685	88%	101,722	62%	158,617	60%
3,000	217,358	100%	97,067	57%	293,225	100%	87,967	28%	232,410	68%	48,187	27%	296,949	96%	942	1%	14,045	44%	163,477	100%	145,056	55%
4,000	200,810	92%	54,266	32%	275,050	94%	49,201	15%	182,416	54%	32,379	18%	280,009	90%	204	0%	8,629	27%	146,235	89%	99,247	37%
4,900	175,703	81%	34,291	20%	266,943	91%	22,600	7%	165,653	49%	20,187	11%	251,537	81%	0	0%	3,575	11%	90,326	55%	84,097	32%
5,000	174,226	80%	33,445	19%	255,326	87%	26,829	8%	147,997	43%	21,491	12%	262,462	85%	0	0%	4,891	15%	109,750	67%	71,327	27%
6,000	146,633	67%	25,185	15%	232,790	79%	14,774	5%	122,888	36%	14,915	8%	244,481	79%	0	0%	2,732	9%	72,430	44%	43,378	16%
7,000	121,113	56%	20,946	12%	212,332	72%	8,898	3%	103,098	30%	10,256	6%	227,281	73%	0	0%	1,687	5%	40,786	25%	32,282	12%
8,000	96,921	45%	18,087	11%	192,959	66%	6,637	2%	85,223	25%	7,271	4%	211,218	68%	0	0%	1,055	3%	18,319	11%	29,607	11%
9,000	74,082	34%	15,851	9%	174,016	59%	5,770	2%	68,824	20%	5,035	3%	197,430	64%	0	0%	836	3%	7,838	5%	26,329	10%
10,000	55,106	25%	14,153	8%	157,095	54%	5,083	2%	55,986	16%	3,257	2%	186,297	60%	0	0%	883	3%	3,321	2%	20,375	8%
15,000	20,244	9%	7,050	4%	100,384	34%	2,152	1%	22,933	7%	1,460	1%	158,756	51%	0	0%	863	3%	7,059	4%	7,834	3%
100%	217,358		171,663		293,225		319,394		340,255		181,637		309,582		119,617		31,617		163,477		264,661	
75%	163,019		128,747		219,919		239,546		255,191		136,228		232,186		89,713		23,713		130,782		198,495	

4.7 STUDY SITE 7 (PIZZA OVEN SITE)

This site is comprised of two linked transects located in a ledge-controlled riffle-glide complex located approximately 5.4 miles downstream of Parr Shoals Dam. Habitat suitability for the majority of target lifestages and guilds peaked at approximately 700 to 1,000 cfs at this site (Figure 4-8) (Table 4-6). American shad spawning reached an inflexion point at around 1,500 cfs and remained steady through the remainder of the flow range modeled. A much broader range of suitability was indicated for smallmouth bass adult, with a relatively broad peak occurring between approximately 500 and 4000 cfs. Habitat for the shallow-fast guild rose moderately as the flow departed from base flow, peaking at around 2000 cfs.

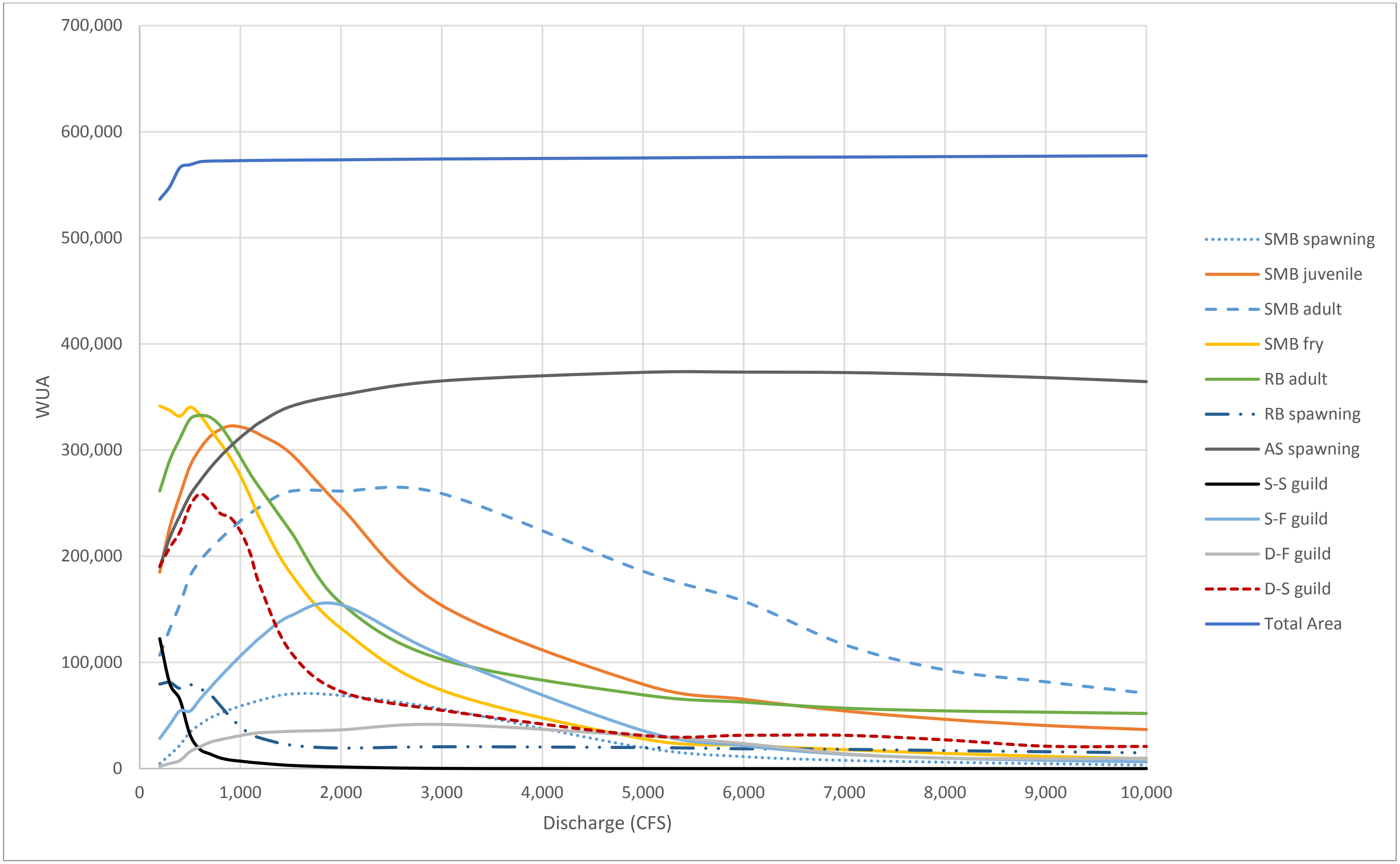


FIGURE 4-8 STUDY SITE 7 HABITAT SUITABILITY

TABLE 4-6 STUDY SITE 7 HABITAT SUITABILITY

Discharge	SMB spawning		SMB juvenile		SMB adult		SMB fry		RB adult		RB spawning		AS spawning		S-S guild		S-F guild		D-F guild		D-S guild	
200	4,778	7%	185,059	57%	106,819	41%	341,484	100%	261,525	79%	79,634	98%	190,039	51%	122,349	100%	28,370	18%	2,170	5%	190,546	74%
300	12,942	18%	227,495	70%	131,731	50%	337,537	99%	290,739	87%	81,168	100%	217,716	58%	79,969	65%	41,312	27%	4,747	11%	208,321	81%
400	22,121	31%	257,381	80%	154,708	59%	331,938	97%	310,815	93%	75,471	93%	238,470	64%	64,989	53%	54,353	35%	7,648	18%	222,996	86%
500	34,302	49%	284,854	88%	181,096	69%	340,459	100%	329,123	99%	79,053	97%	257,465	69%	31,947	26%	54,073	35%	15,931	38%	247,404	96%
600	41,500	59%	301,292	93%	195,795	75%	333,109	98%	332,707	100%	75,154	93%	270,953	73%	18,056	15%	65,422	42%	20,536	49%	258,756	100%
700	47,678	68%	312,857	97%	206,639	79%	319,872	94%	330,990	99%	69,883	86%	283,123	76%	13,759	11%	76,079	49%	24,832	60%	251,728	97%
800	51,975	74%	319,568	99%	216,098	83%	306,876	90%	323,038	97%	59,448	73%	293,809	79%	10,047	8%	86,486	56%	27,215	65%	240,446	93%
900	55,638	79%	322,798	100%	225,065	86%	293,088	86%	309,500	93%	48,517	60%	303,336	81%	8,054	7%	96,392	62%	29,135	70%	236,609	91%
1,000	58,836	84%	321,939	100%	233,257	89%	275,941	81%	293,562	88%	39,499	49%	311,927	84%	7,023	6%	106,071	69%	31,049	75%	223,683	86%
1,100	61,701	88%	319,118	99%	240,484	92%	255,893	75%	277,494	83%	32,494	40%	319,565	86%	5,963	5%	115,004	75%	32,678	79%	202,451	78%
1,200	64,396	92%	314,315	97%	246,780	94%	234,437	69%	263,507	79%	28,756	35%	326,457	87%	5,119	4%	123,672	80%	33,791	81%	171,054	66%
1,500	70,354	100%	296,828	92%	261,265	100%	183,945	54%	223,513	67%	22,186	27%	341,146	91%	3,001	2%	143,933	93%	35,123	84%	109,837	42%
2,000	68,846	98%	246,315	76%	261,421	100%	132,089	39%	155,888	47%	19,335	24%	351,931	94%	1,539	1%	154,310	100%	36,462	88%	72,651	28%
3,000	56,303	80%	153,774	48%	259,133	99%	73,814	22%	102,887	31%	20,563	25%	365,229	98%	154	0%	106,998	69%	41,599	100%	54,884	21%
5,000	19,731	28%	79,456	25%	185,911	71%	28,076	8%	69,454	21%	19,786	24%	373,297	100%	0	0%	35,689	23%	30,924	74%	31,185	12%
6,000	11,261	16%	65,346	20%	157,747	60%	21,965	6%	62,599	19%	18,668	23%	373,525	100%	0	0%	21,625	14%	23,526	57%	31,344	12%
7,000	7,733	11%	54,310	17%	116,788	45%	17,849	5%	56,946	17%	18,123	22%	373,111	100%	0	0%	13,469	9%	13,985	34%	31,344	12%
8,000	6,028	9%	46,404	14%	92,940	36%	14,344	4%	54,355	16%	16,964	21%	371,234	99%	0	0%	9,784	6%	9,834	24%	27,074	10%
9,000	4,534	6%	40,600	13%	81,702	31%	11,438	3%	53,145	16%	15,861	20%	368,321	99%	0	0%	7,763	5%	9,207	22%	21,086	8%
10,000	3,312	5%	36,778	11%	70,898	27%	9,418	3%	51,921	16%	14,828	18%	364,584	98%	0	0%	6,388	4%	9,782	24%	20,862	8%
100%	70,354		322,798		261,421		341,484		332,707		81,168		373,525		122,349		154,310		41,599		258,756	
75%	52,765		242,098		196,066		256,113		249,530		60,876		280,144		91,762		115,733		31,199		194,067	

4.8 STUDY SITE 8 (HALTIWANGER ISLAND)

Study Site 8 consists of a pair of adjacent transects located near the upstream end of Haltiwanger Island, with one transect (8.1) located on the east side of the island and the second (8.2) on the west. Transect 8.1 is predominantly a riffle with a deeper run/thalweg along the east shore. Transect 8.2 is located in a steep riffle habitat and represents the smaller of the two channels. Hydraulic analyses indicate a 68:32 flow split between the east channel (Transect 8.2) and west channel (Transect 8.1), respectively, at the 400 cfs calibration flow; a 73:27 split at 2000 cfs; and 78:22 split at 6000 cfs. Habitat suitability at Transects 8.1 and 8.2 are combined below on Figures 4-9. Habitat suitability for the majority of target lifestages and guilds peaks at approximately 1,000 to 1,500 cfs at this site (Figure 4-9) (Table 4-7). American shad spawning reached an inflexion point at around 4,000 cfs and remained optimal throughout the remainder of the flow range. Adult smallmouth bass display a broad suitability, peaking at approximately 3,000 cfs and gradually decreasing with increased flow.

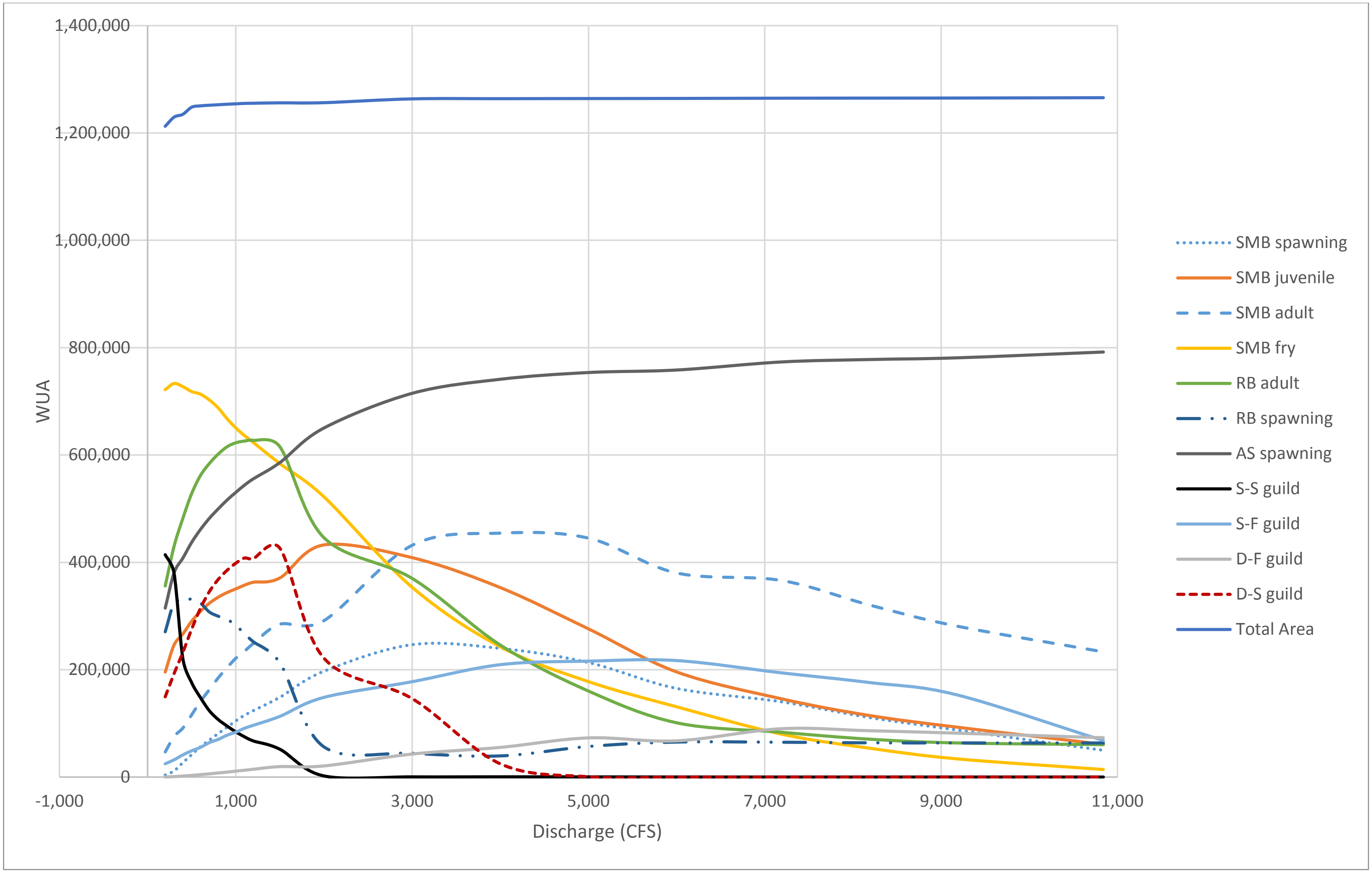


FIGURE 4-9 STUDY SITE 8 HABITAT SUITABILITY

TABLE 4-7 STUDY SITE 8 HABITAT SUITABILITY

Discharge	SMB spawning		SMB juvenile		SMB adult		SMB fry		RB adult		RB spawning		AS spawning		S-S guild		S-F guild		D-F guild		D-S guild	
200	3,720	2%	195,659	45%	46,839	10%	721,773	98%	356,086	57%	270,665	82%	314,815	40%	414,242	100%	24,760	11%	166	0%	149,560	35%
300	11,454	5%	245,974	57%	75,439	17%	733,279	100%	429,842	69%	324,069	98%	380,288	48%	379,840	92%	32,086	15%	840	1%	192,595	45%
400	26,831	11%	266,697	62%	91,273	20%	727,425	99%	482,042	77%	329,175	99%	407,905	52%	220,601	53%	41,293	19%	1,875	2%	232,315	54%
500	41,634	17%	290,381	67%	115,972	26%	718,183	98%	528,262	84%	331,371	100%	437,285	55%	175,901	42%	48,963	23%	3,065	3%	275,507	65%
600	56,489	23%	308,680	71%	141,045	31%	713,354	97%	561,905	90%	324,021	98%	461,329	58%	147,922	36%	55,300	25%	4,562	5%	314,469	74%
700	68,856	28%	323,788	75%	162,671	36%	702,619	96%	584,088	93%	307,575	93%	481,975	61%	123,687	30%	64,177	30%	5,953	7%	345,334	81%
800	80,862	33%	335,029	77%	184,653	41%	688,045	94%	601,579	96%	299,726	90%	499,479	63%	107,299	26%	70,081	32%	7,639	8%	367,988	86%
900	92,719	38%	343,683	79%	203,627	45%	667,906	91%	615,229	98%	293,642	89%	515,893	65%	95,238	23%	77,859	36%	9,176	10%	384,954	90%
1,000	104,570	42%	350,523	81%	221,233	49%	650,628	89%	622,795	99%	283,118	85%	530,301	67%	84,249	20%	83,585	39%	11,013	12%	398,347	93%
1,100	115,183	47%	357,569	83%	234,509	52%	636,083	87%	626,048	100%	266,684	80%	543,988	69%	74,911	18%	90,937	42%	12,743	14%	408,175	96%
1,200	123,807	50%	362,965	84%	248,852	55%	623,217	85%	627,310	100%	251,980	76%	555,727	70%	67,242	16%	96,478	44%	14,539	16%	407,006	95%
1,500	148,669	60%	370,903	86%	284,722	63%	584,023	80%	615,528	98%	212,865	64%	585,840	74%	51,834	13%	113,087	52%	19,458	22%	426,396	100%
1,750	172,905	70%	401,724	93%	288,049	63%	553,105	75%	530,790	85%	134,574	41%	618,084	78%	26,971	7%	130,762	60%	20,089	22%	323,960	76%
2,000	197,141	80%	432,546	100%	291,377	64%	522,187	71%	446,052	71%	56,283	17%	650,328	82%	2,109	1%	148,437	68%	20,719	23%	221,524	52%
2,500	221,910	90%	420,686	97%	361,574	80%	437,908	60%	408,119	65%	50,305	15%	682,629	86%	1,205	0%	163,054	75%	31,787	35%	183,913	43%
3,000	246,679	100%	408,827	95%	431,772	95%	353,629	48%	370,186	59%	44,326	13%	714,931	90%	301	0%	177,672	82%	42,856	48%	146,301	34%
3,500	243,189	99%	380,938	88%	443,135	97%	298,212	41%	308,111	49%	41,869	13%	728,038	92%	371	0%	193,536	89%	49,060	55%	85,503	20%
4,000	239,700	97%	353,049	82%	454,498	100%	242,795	33%	246,036	39%	39,412	12%	741,146	94%	441	0%	209,400	96%	55,265	61%	24,704	6%
4,500	226,543	92%	314,586	73%	449,830	99%	210,318	29%	203,154	32%	48,211	15%	747,432	94%	354	0%	212,696	98%	64,126	71%	12,632	3%
5,000	213,386	87%	276,123	64%	445,163	98%	177,842	24%	160,272	26%	57,011	17%	753,718	95%	267	0%	215,992	100%	72,986	81%	561	0%
6,000	165,147	67%	195,876	45%	380,246	84%	130,922	18%	101,113	16%	65,215	20%	758,374	96%	105	0%	217,047	100%	67,462	75%	0	0%
7,180	140,433	57%	146,134	34%	366,469	81%	80,343	11%	83,555	13%	64,896	20%	773,326	98%	0	0%	194,347	90%	89,994	100%	0	0%
8,180	111,113	45%	114,875	27%	320,858	71%	53,984	7%	70,642	11%	63,805	19%	777,900	98%	0	0%	176,258	81%	86,345	96%	0	0%
9,170	87,961	36%	93,164	22%	281,520	62%	34,044	5%	63,590	10%	63,553	19%	781,042	99%	0	0%	153,515	71%	81,857	91%	0	0%
10,840	49,805	20%	60,943	14%	233,230	51%	14,076	2%	60,365	10%	63,484	19%	791,919	100%	0	0%	68,001	31%	73,303	81%	0	0%
100%	246,679		432,546		454,498		733,279		627,310		331,371		791,919		414,242		217,047		89,994		426,396	
75%	185,009		324,409		340,873		549,960		470,482		248,528		593,939		310,681		162,785		67,496		319,797	

4.9 STUDY SITE 9 (HUFFMAN ISLAND)

This site is to be evaluated through the proposed flow demonstration only and will be described after the TWC field observations.

4.10 STUDY SITE 10 (BOOKMAN ISLAND COMPLEX)

Habitat suitability for velocity-intolerant lifestages such as shallow slow, and smallmouth bass fry peaked at 200 cfs and declined rapidly at higher flows due to increases in velocity (Figure 4-10). Redbreast sunfish spawning also declined at rising flows but at a gradual rate, inflecting downward at approximately 2,000 cfs. Smallmouth bass spawning and juvenile lifestages, adult redbreast sunfish, shallow-fast, and the deep fast guild, generally achieve the greatest suitability in a range between approximately 700 – 3,000 cfs before slowly declining in suitability at higher flows. Smallmouth bass adult exhibit a sharp peak of suitability at 3,000 cfs, but are generally in a plateau of relatively high suitability between 2,000-10,000 cfs. American shad spawning habitat suitability reaches an inflection point at approximately 1,200 cfs, gradually rises to an absolute peak at 4,000 cfs then gently declines at higher flows (Figure 4-10) (Table 4-8).

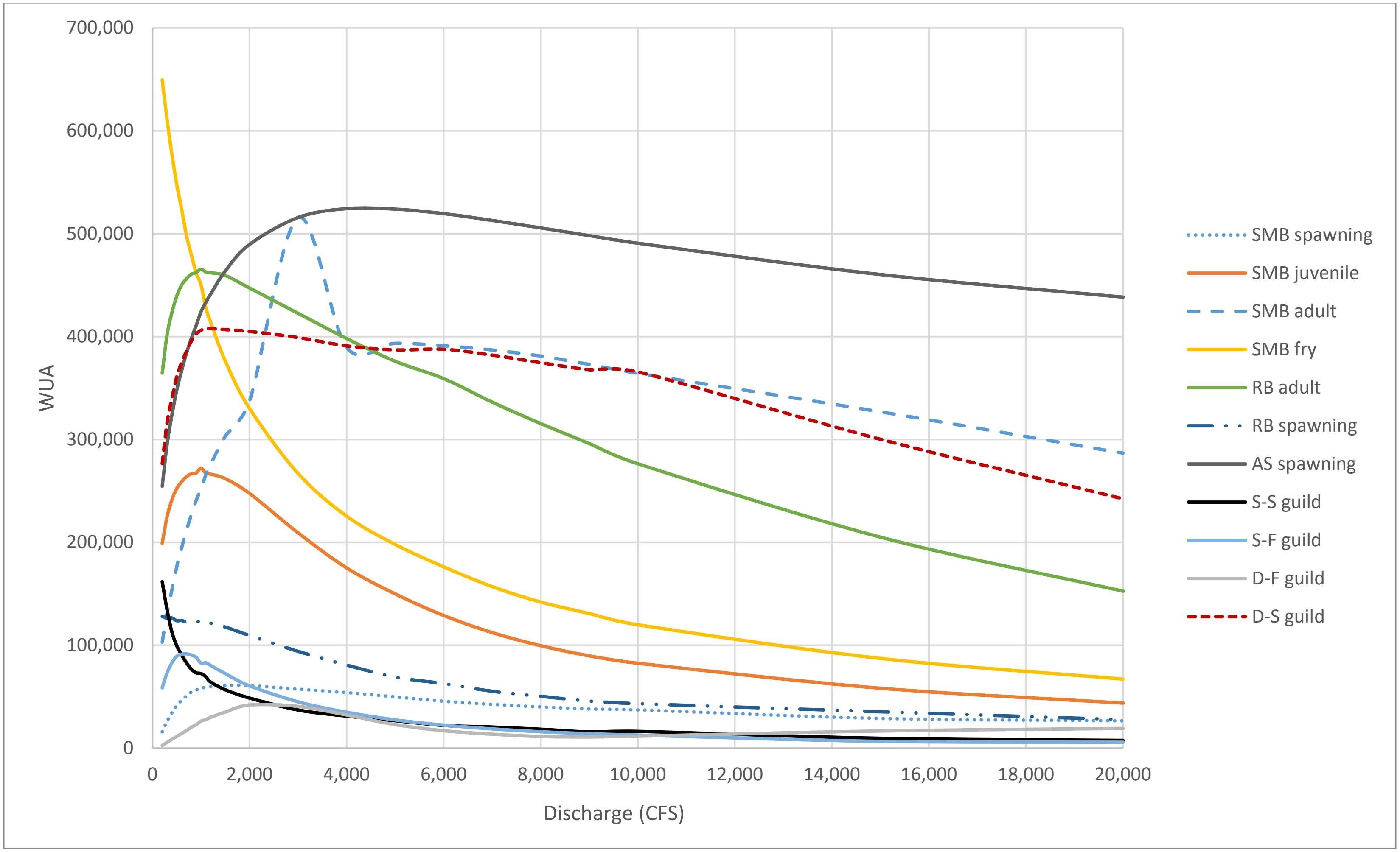


Figure 4-10 Study Site 10 Habitat Suitability

TABLE 4-8 STUDY SITE 10 HABITAT SUITABILITY

Discharge	SMB spawning		SMB juvenile		SMB adult		SMB fry		RB adult		RB spawning		AS spawning		S-S guild		S-F guild		D-F guild		D-S guild	
200	15,928	26%	199,145	73%	102,985	20%	649,442	100%	364,539	78%	128,007	100%	254,591	49%	161,819	100%	58,679	64%	2,612	6%	276,504	68%
300	26,186	43%	225,022	83%	131,339	25%	611,007	94%	401,820	86%	126,720	99%	295,234	56%	134,449	83%	73,244	80%	5,633	13%	316,376	78%
400	34,282	56%	241,384	89%	153,838	30%	577,108	89%	423,349	91%	126,515	99%	323,861	62%	112,886	70%	82,985	91%	8,648	21%	340,069	83%
500	41,427	68%	252,537	93%	176,506	34%	547,736	84%	439,415	94%	123,901	97%	348,047	66%	99,508	61%	89,424	98%	11,441	27%	361,310	89%
600	46,541	76%	258,908	95%	194,749	38%	523,940	81%	450,035	97%	124,147	97%	366,965	70%	90,537	56%	91,205	100%	14,193	34%	374,690	92%
700	50,821	83%	263,908	97%	211,866	41%	498,166	77%	456,214	98%	122,416	96%	383,823	73%	82,987	51%	91,627	100%	17,128	41%	385,859	95%
800	54,551	89%	266,671	98%	226,999	44%	479,577	74%	460,611	99%	122,401	96%	398,192	76%	76,764	47%	90,558	99%	20,359	48%	395,625	97%
900	56,569	93%	267,506	98%	240,853	47%	461,675	71%	462,315	99%	122,196	95%	410,855	78%	73,243	45%	88,219	96%	22,786	54%	402,553	99%
1,000	58,310	96%	272,046	100%	252,029	49%	450,274	69%	465,506	100%	124,383	97%	424,207	81%	72,492	45%	82,685	90%	26,305	63%	406,112	100%
1,100	59,200	97%	267,211	98%	265,624	52%	427,936	66%	462,794	99%	122,957	96%	433,210	83%	69,395	43%	83,046	91%	27,813	66%	407,510	100%
1,200	59,811	98%	266,324	98%	275,994	54%	413,859	64%	462,037	99%	121,360	95%	441,486	84%	64,222	40%	80,362	88%	29,999	71%	407,904	100%
1,500	61,016	100%	261,923	96%	303,244	59%	376,252	58%	459,447	99%	117,753	92%	463,727	88%	56,794	35%	72,480	79%	35,081	84%	406,762	100%
1,750	60,939	100%	254,760	94%	320,287	62%	353,185	54%	453,329	97%	113,632	89%	476,669	91%	52,762	33%	66,538	73%	38,541	92%	405,882	100%
2,000	60,862	100%	247,598	91%	337,330	65%	330,119	51%	447,210	96%	109,511	86%	489,611	93%	48,730	30%	60,597	66%	42,000	100%	405,001	99%
2,500	59,135	97%	228,452	84%	426,528	83%	298,556	46%	434,926	93%	101,818	80%	502,668	96%	42,923	27%	52,835	58%	41,335	98%	402,054	99%
3,000	57,409	94%	209,306	77%	515,726	100%	266,992	41%	422,641	91%	94,124	74%	515,726	98%	37,115	23%	45,073	49%	40,670	97%	399,108	98%
3,500	55,722	91%	192,263	71%	452,623	88%	246,280	38%	410,404	88%	87,456	68%	520,046	99%	34,156	21%	40,010	44%	36,471	87%	395,051	97%
4,000	54,035	89%	175,220	64%	389,520	76%	225,568	35%	398,166	86%	80,787	63%	524,367	100%	31,196	19%	34,947	38%	32,272	77%	390,995	96%
4,500	51,951	85%	162,609	60%	391,503	76%	211,806	33%	387,110	83%	74,935	59%	524,136	100%	28,958	18%	31,245	34%	27,596	66%	389,029	95%
5,000	49,866	82%	149,997	55%	393,487	76%	198,045	30%	376,055	81%	69,083	54%	523,905	100%	26,720	17%	27,544	30%	22,921	55%	387,064	95%
6,000	45,643	75%	129,004	47%	391,164	76%	176,282	27%	359,215	77%	62,778	49%	519,506	99%	22,182	14%	22,432	24%	16,984	40%	387,711	95%
7,000	42,583	70%	112,357	41%	387,016	75%	157,062	24%	336,321	72%	55,331	43%	512,876	98%	20,562	13%	18,775	20%	13,608	32%	382,017	94%
8,000	40,152	66%	99,624	37%	381,099	74%	142,052	22%	315,493	68%	50,430	39%	505,625	96%	18,433	11%	16,008	17%	11,391	27%	374,653	92%
9,000	38,147	63%	89,761	33%	372,981	72%	130,865	20%	296,073	64%	45,753	36%	498,147	95%	15,818	10%	14,138	15%	10,965	26%	367,839	90%
10,000	37,224	61%	82,577	30%	364,316	71%	119,961	18%	276,451	59%	43,285	34%	490,768	94%	16,374	10%	12,723	14%	11,698	28%	365,756	90%
15,000	28,938	47%	58,283	21%	326,924	63%	87,254	13%	205,152	44%	35,439	28%	460,335	88%	9,615	6%	6,631	7%	16,741	40%	300,232	74%
20,000	26,610	44%	43,863	16%	286,761	56%	67,153	10%	152,602	33%	27,737	22%	438,390	84%	7,585	5%	5,804	6%	19,210	46%	242,391	59%
100%	61,016	100%	272,046	100%	515,726	100%	649,442	100%	465,506	100%	128,007	100%	524,367	100%	161,819	100%	91,627	100%	42,000	100%	407,904	100%
75%	45,762		204,035		386,795		487,082		349,129		96,006		393,275		121,364		68,720		31,500		305,928	

4.11 FISH PASSAGE LEDGES

SCDNR zone-of-passage criteria state that instream flow should be sufficient to provide a minimum 10 ft-wide passage point with a minimum depth of 1.5 ft. At Ledge 1 (IFIM Study Site 7). This criterion is met by a flow of 500 cfs, with the minimum 1.5 ft depth provided over a cross-sectional distance of approximately 85 ft at the primary passage point identified in the study plan (Figure 4-11). The secondary passage point at Ledge 1, which was identified during the field efforts, provides an additional passage point approximately 44 ft in width that also meets the minimum 1.5 ft depth criteria at 500 cfs (Figure 4-12). These results suggest that fish passage is not a limiting factor at this location for flows as low as 500 cfs.

At Ledge 2, field data demonstrate that the fish passage criterion is met at flows as lows as 700 cfs, with the minimum 1.5 ft depth provided over a cross-sectional distance of approximately 27 ft (Figure 4-13). These results indicate that Ledge 2, located just upstream of the Bookman Shoals complex, is the more limiting of the two study sites from both the navigational and fish passage perspectives.

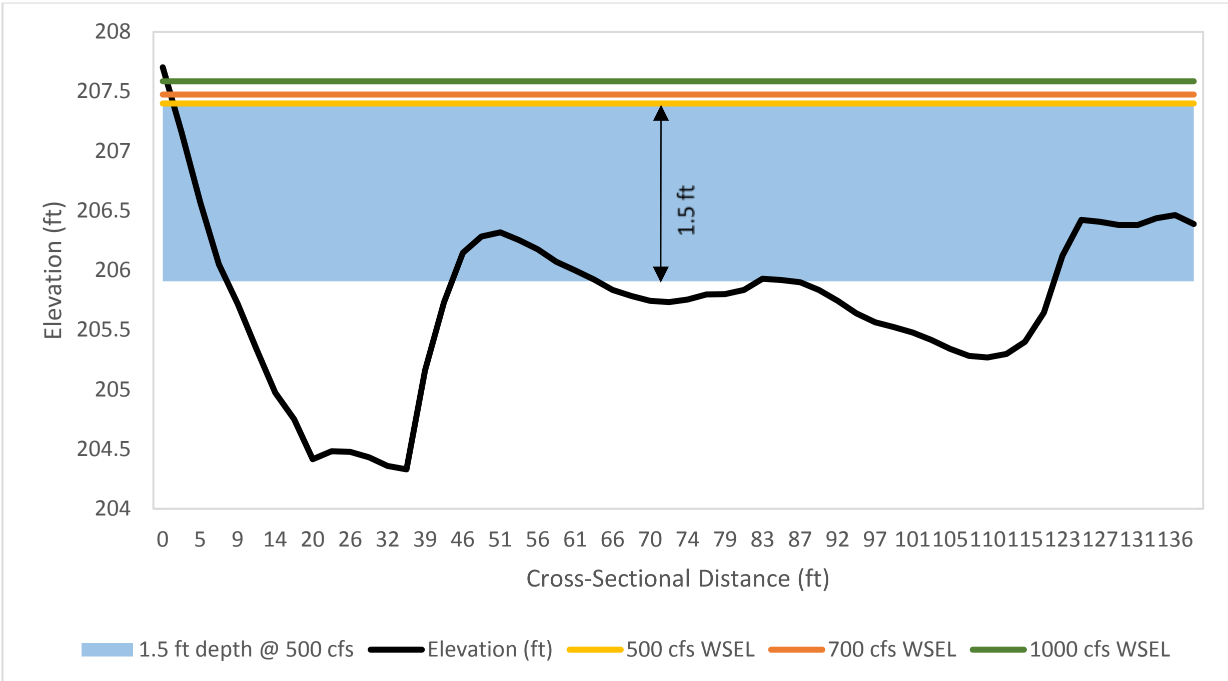


FIGURE 4-11 BED PROFILE AND WATER SURFACE ELEVATIONS AT THE RIVER LEFT PASSAGE POINT AT LEDGE 1 (UPSTREAM VIEW)

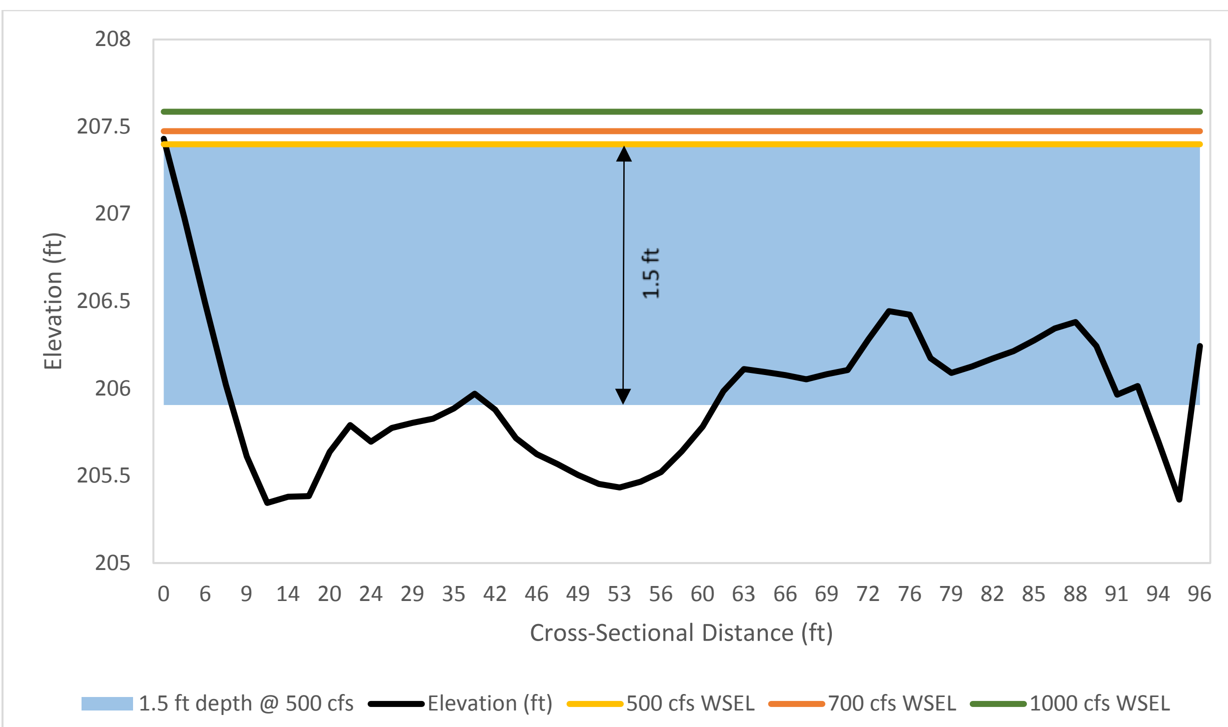


FIGURE 4-12 BED PROFILE AND WATER SURFACE ELEVATIONS AT THE MID-CHANNEL PASSAGE POINT AT LEDGE 1 (UPSTREAM VIEW)

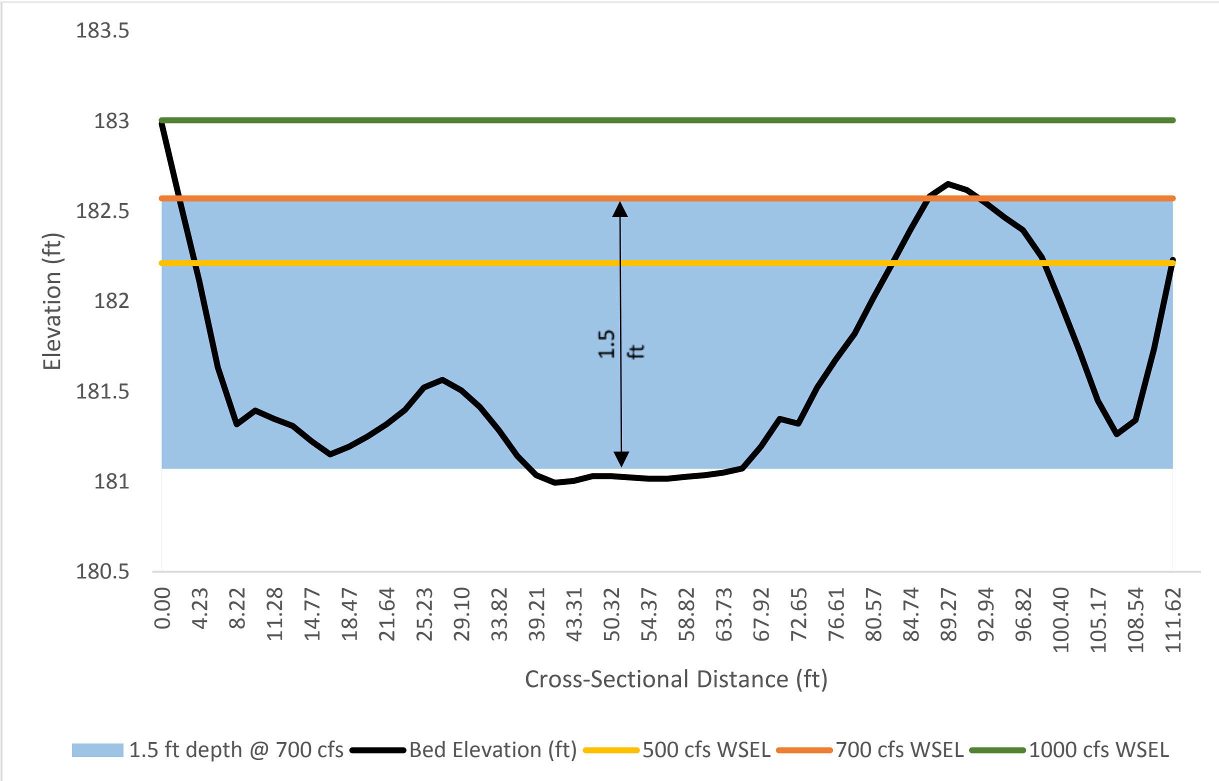


FIGURE 4-13 LEDGE 2 BED PROFILE SHOWING NAVIGATION PASSAGE AREA AT 700 CFS (UPSTREAM VIEW)

5.0 DISCUSSION

According to MESC (2001) “the basic WUA versus discharge relationships obtained in PHABSIM represent only instantaneous variation of physical habitat with flow and should not be interpreted in the absence of one or more alternative flow regimes for a particular study site”. The purpose of this discussion is to recommend how these data may help determine suitable instream flow ranges for accommodating both aquatic habitat objectives and other instream uses. These data can then be integrated into additional analyses such as time series, and/or further dissection of results.

5.1 PRIORITIZATION OF SPECIES AND LIFESTAGES

In multiple species/lifestage assessments, WUA curves among target species and lifestages frequently peak and decline inharmoniously. Examples of such conflicting curves can be observed in this study. This makes it difficult to form recommendations that satisfy all biological goals (MESC 2001). A number of balancing techniques are commonly employed to resolve this type of issue; there is no single “right” or “wrong” approach. Most involve prioritizing particular species and lifestages either through time or space, or under different management priorities. Some possibilities include:

- delete species/lifestages that are not sensitive to habitat/flow changes;
- delete species/lifestages with redundant flow-WUA relationships;
- combine species in a post-modeling guilding such as cumulative multispecies curve;
- parse species and lifestages into monthly or seasonal time units that correspond to applicable seasonal habitat functions (e.g. spawning criteria are applied during March-May, etc., YOY criteria are applied June- October, etc.); and
- limiting lifestage. For species for which multiple lifestages are modeled, such as smallmouth bass, a particular lifestage may be determined to be the population bottleneck for recruitment to catchable sized fish. Giving habitat priority to the limiting or critical lifestage may relieve some conflicts and support the management for the species.

5.2 PRIORITIZATION AND BALANCING OF RIVER REACHES AND MESOHABITATS

The PHABSIM data contained in this report quantify the raw relationship between flow and aquatic habitat suitability in specific reaches of the Broad River, and are indices that can be applied to estimate the extent to which the existing project operation and alternatives may affect aquatic habitat suitability. Analysis of these data should be made in the context of watershed hydrology and the strategic needs of management of upstream reservoir fluctuations, water quality, recreation, and hydroelectric power generation. These data should be used in conjunction with specific hydrologic, operational and other models to evaluate the costs and benefits of providing alternate flows to the lower Broad River.

The study area is comprised of two independent study reaches, each with distinct geomorphic characteristics. Different mesohabitat types were modeled within each reach. WUA – flow relationships vary within each reach due to differences in hydraulics, stream slope and geometry, and in some cases because different guild criteria are applicable. The TWC will need to consider techniques for balancing and/or prioritizing these reaches.

Representative Habitat − WUA is an index calculated in units per 1,000 ft of similar stream reach. For reaches and mesohabitats shared by all species/lifestages, WUA results within each study site are commonly weighted and summed according to relative contributing reach length of each modeled mesohabitat type throughout the study area. The weighting information can be quantified directly from existing mesohabitat mapping measurements.

Critical Habitat − A particular reach, mesohabitat type or study site that may be a minority of the study area, but which is strategic because it is where a critical lifestage function (such as spawning) occurs is prioritized during the time of year it is required. Conversely, a reach, mesohabitat type or study site can be deleted from the analysis if no applicable species/lifestage-specific habitat function occurs there during a given time frame.

6.0 CONCLUSIONS

This IFIM study report will serve as the basis for TWC discussions regarding selection of a minimum flow for the Parr Project. The data contained in this report covers the life stages and transect areas that were identified as important by the TWC. After discussion and selection of a minimum flow(s), the TWC will schedule a field observation to observe the flow(s) at selected transect sites. These observations and recommendations from the TWC will be recorded and included in the creation of a protection, mitigation, or enhancement (PME) that will be evaluated as part of the Parr Project Operations Model. That Model will determine if the recommended flow(s) can be maintained in the new license without significant impact to the future project operations of the Parr and Fairfield Developments.

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APPENDIX A

ROBUST REDHORSE SPAWNING MEMORANDUM

MEMORANDUM

TO: Parr/Fairfield Hydro Relicensing Fisheries and Instream Flow TWC

FROM: Shane Boring and Milton Quattlebaum

DATE: April 29, 2014

RE: Robust Redhorse Spawning Areas

An assessment of spawning habitat for robust redhorse (*Moxostoma robustum*) was requested by stakeholders during the study scoping phase of relicensing. Stakeholders agreed that a qualitative assessment of the Instream Flow Incremental Methodology (IFIM) study reach downstream of Parr Shoals Dam would be conducted concurrently with the mesohabitat assessment and other field efforts during the fall of 2013 and winter of 2014. This memorandum summarizes the assessment results.

<u>Methods</u>
The reach of the Broad River extending from Parr Shoals through the Bookman Island complex was observed by biologists (Milton Quattlebaum (SCANA), Ron Ahle (South Carolina Department of Natural Resources), and Shane Boring (Kleinschmidt Associates)) in October and November 2013 during the mesohabitat assessment conducted in support of the proposed IFIM Study. A follow up visit was made by Quattlebaum and Scott Lamprecht (South Carolina Department of Natural Resources) in February 2014. During the assessment, the group utilized published habitat suitability criteria to identify areas along the river reach they believed were potential robust redhorse (RRH) spawning sites. According to Freeman and Freeman (2001), RRH spawning habitat is characterized as being mid-channel gravel bars dominated by medium to coarse gravel with less that 30% sand and minimal fine particles. Spawning sites are also characterized as containing gravel small enough to be moved for egg deposition, but large enough to offer interstitial space for the eggs. Water depths are typically between 1 and 3.6 feet, with an average water column velocity of 0.85 to 2.20 ft/s. Sites encountered during the assessment that appeared to display these characteristics were noted on the field datasheets, their locations were documented with Global Positioning System (GPS), and in some instances, the sites were photographed.

<u>Results</u>
Four potential RRH spawning sites were examined during the assessment. The upstream-most site is located in the tailrace of the Parr development powerhouse within IFIM Study Site 3 (Figure 1). Fisheries Technical Working Committee (TWC) members have noted that RRH activity is well documented at that site, including observed potential spawning behavior. Three new sites were located during the assessment: one just upstream of Haltiwanger Island and two in the Bookman Shoals complex (IFIM Study Site 10) in the vicinity of Hickory Island (Figure 2). Results of PHABSIM and 2-D modeling conducted as part of the IFIM study will develop weighted usable area (WUA) estimates of spawning habitat under various flow scenarios, which will be taken into consideration by the TWC in developing a downstream flow recommendation that is best for multiple species, including RRH spawning.

FIGURES

FIGURE 1 POTENTIAL ROBUST REDHORSE SPAWNING AREA DOWNSTREAM OF PARR DAM

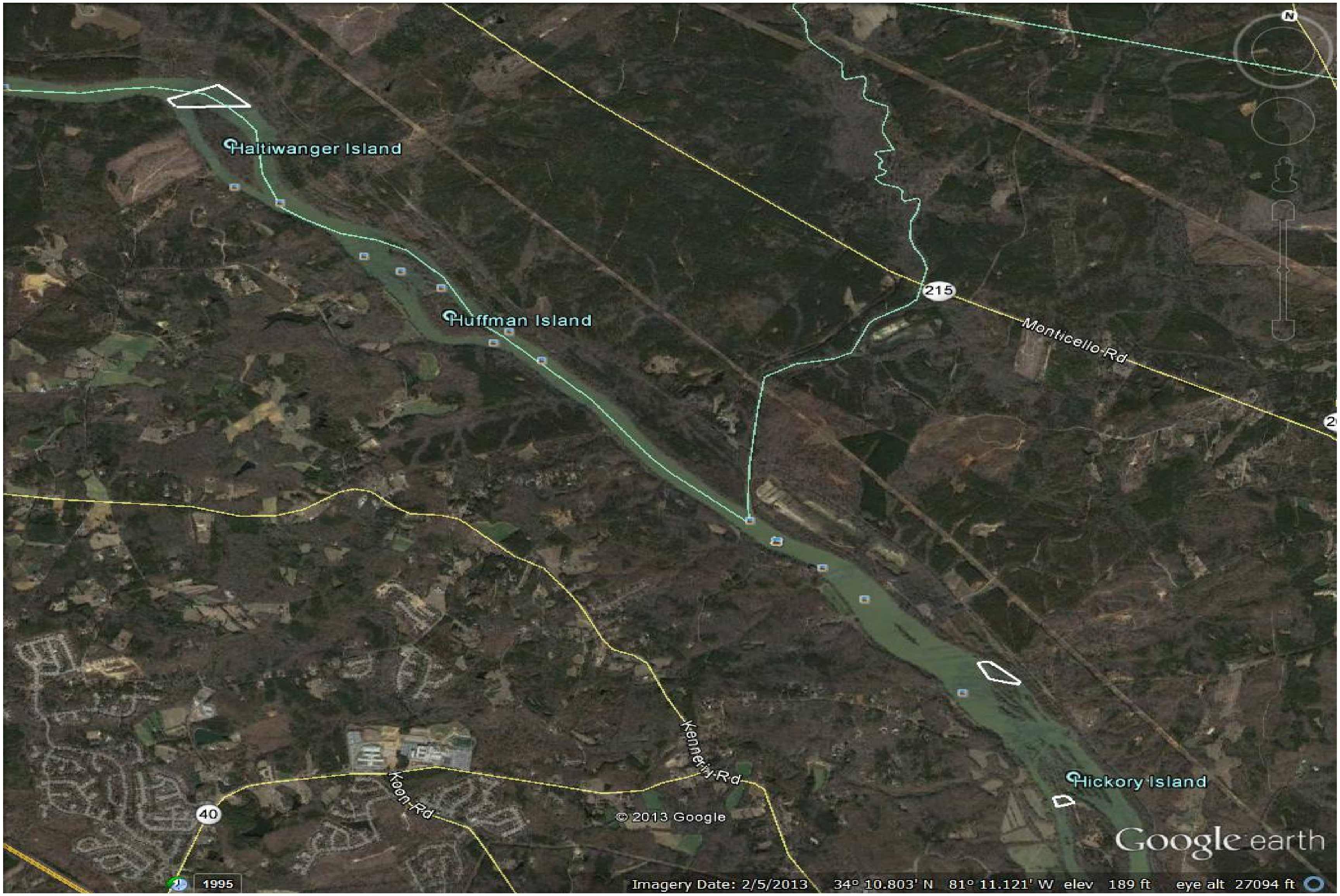


FIGURE 2 **POTENTIAL ROBUST REDHORSE SPAWNING SITE AT HALTIWANGER ISLAND AND IN BOOKMAN SHOALS COMPLEX**

APPENDIX B

TWC SCOPING

MEETING NOTES

SOUTH CAROLINA ELECTRIC & GAS COMPANY
Instream Flows TWC Meeting

May 7, 2013

Final KDM 05-31-13

ATTENDEES:

Bill Marshall (SCDNR)
Ron Ahle (SCDNR)
Gerrit Jobsis (American Rivers)
Shane Boring (Kleinschmidt)
Alan Stuart (Kleinschmidt)
Kelly Miller (Kleinschmidt)
Bill Stangler (Congaree Riverkeeper)
Ray Ammarell (SCE&G)
Vivianne Vejdani (SCDNR)
Bill Argentieri (SCE&G)
Milton Quattlebaum (SCANA)
Steve Summer (SCANA)
Randy Mahan (SCANA)
Dick Christie (SCDNR)
Tom McCoy (USFWS) via conference call
Prescott Brownell (NOAA)
Kerry Castle (SCDNR)

These notes serve to be a summary of the major points presented during the meeting and are not intended to be a transcript or analysis of the meeting.

Alan opens the meeting by briefly going over the agenda, then gives the group an overview of the float trip taken on March 19th and 20th. During this review, the group looks at the Project Area on a map, which sparks a discussion on the habitat just below the Parr Dam.

Ron explains how he is concerned about the separation in the habitat along the first mile of the Broad River, just below the Parr Dam. He says this is a highly utilized area of the river by fish species, and the side of the river along the west bank can grow stagnate during periods of low flow. Shane asks if a critical habitat study should be performed in this area. Ron says there are several critical habitats that need to be studied before the rest of the river is characterized. Prescott and Ron both mention they would like to have a habitat map made for as far down river as possible. Ron says that a habitat map should at least be made for the area immediately below the Parr Dam.

Gerrit tells the group he would also like to look at access along the river, since there are several areas that aren't accessible. Prescott mentions that he is interested in studying the tributaries along the river. Ron mentions that there is a good amount of data already available on the tributaries, collected by the DNR Stream Team.

Alan refers the group to a study on the Broad River, completed by Jason Bettinger (referred to throughout these notes as the Bettinger Study), as a possible starting point for the Parr Project's Mesohabitat Assessment and Instream Flow Study. The group notes that the Parr Project area was not included in this study, as the area in the Bettinger Study begins at Neal Shoals and extends upstream. However, the methodology used in the paper might still be utilized by the group.

After discussion on various needs for the Mesohabitat Assessment and Instream Flow Study, Gerrit focuses the group back on the agenda by beginning to list the goals and objectives for the study. Through much discussion the group agrees on four goals with corresponding objectives, as well as additional studies that need to be completed. These goals, objectives, and studies and included as an attachment at the end of these notes.

Steve and Ron then discuss the habitat issues at the west bank area. Ron says he believes that the decrease in DO and increase in temperature along the west bank area is related to the operating of the Fairfield Pumped Storage Project. Steve asks Bill if he has a copy of some aerial photos that were taken prior to Project construction since the west bank features are the result of natural topography, of which Bill answers he is not sure. Steve says he will try to find the photos, since they might show how river flow was distributed between the east and west bank area before the Project was built. Steve says that the issue will be getting water into that west channel during low flow situations. Gerrit says that Duke Energy is building a separate dam to help control flows at one of its projects. He believes the group needs to focus first on deciding what the flow needs for the area are, by seeing the area during higher flow situations. This will allow the group to evaluate how flows might be manipulated to create an even distribution over the area during low flow situations. Steve adds that LIDAR information will also be helpful, and that baseline data on temperature and DO in the west bank area will be needed to feed into the module. Ron mentions that spring through fall data needs to be collected, since he hasn't studied the area except during the summer. Kerry asks if turbidity will need to be examined along with the temperature and DO. The group considers this but decides that turbidity data is not necessary.

While looking at a photo of the dam, the group notes that there is a bit of leakage, which could be beneficial to the seemingly flow deprived west bank area. Ron agrees, but points out that during the summer, any benefits of the slight leakage at the dam may be diminished by the time they reach the central rocky location in the west channel.

The group then focuses their attention towards defining the geographic scope of the Mesohabitat Assessment and Instream Flow Study. The next hydro on the Broad River, downstream of the Parr Fairfield Project, is the Columbia Hydro Project. The upper reach of the PBL for the Columbia Hydro is noted as being at a Rocky Shoals Spider Lily population located just above the upper tip of Boatright Island. The group discusses whether or not this should mark the end of the scope for the Mesohabitat Assessment. It is decided that the scope for the Mesohabitat Assessment will stretch from Parr Dam downstream to the lower end of Bookman Island. Bill S. points out that there is a tributary on the lower end of Bookman Island, named Big Cedar Creek, and the scope should include this as well.

After deciding the scope, the group begins discussion on which definitions to use for the various mesohabitats. Two slightly varying sets of definitions are considered, including one used during the Saluda Hydro Relicensing Project, and one used in the Bettinger Study. Alan points out that using the definitions from the Bettinger study will be good for consistency, however, the group seems to prefer the definitions used during the Saluda Relicensing. Shane points out that there are several other commonly accepted definitions for the various mesohabitats and so the group decides to consider these options also. This issue is left undecided for now.

The group agrees to stay with the methodology that was used in the Bettinger Study. The group then discusses what the ideal flow would be when conducting the study. Ron says that lower flows make it easier to delineate the habitats, while Shane says the flow should be near the mean annual flow when mapping. Ron suggests a flow that is below 2,000 cfs would be best for conducting the study, and everyone agrees.

The focus then turns to identifying target and driver species for the various Habitat Use Guilds. Ron offers his personal list of fish species he has observed in the Broad River to be used as a starting point. The group decides on a list of driver species including:

- Smallmouth Bass
- American Shad
- Brassy Jumprock
- Whitefin Shiner
- Robust Redhorse
- Santee Chub
- Striped Bass
- Piedmont Darter
- Snail Bullhead
- Redbreast Sunfish
- Channel Catfish

Although the list is longer than is customary, Alan says that it can be included in the study plan with a caveat that says some of these species will later be grouped into guilds. Alan makes the point that the species which have HSI curves need to be identified, and suggests that Shane and Brandon Kulik work together on this task. Shane and Brandon will also recommend surrogates for the group to consider that can be used for the species that do not have HSI curves and work on guild classifications.

The group then focuses on establishing general transect locations for the study. Dick mentions that in the Bettinger Study a majority of the river was categorized as being glides, pools and shoals, and that these will be areas to look for when deciding on transect locations. Ron specifies that he would like at least one transect to be established right below the Parr Dam, in the area he has identified as a critical habitat. The group launches into a heavy discussion on where the transects should go and how many are needed. Eventually everyone agrees to four general areas for the study to implement the IFIM technique. These include an area immediately below Parr Dam, upstream of Haltiwanger Island, along the Coleman property, and at Haltiwanger Island. Additionally, two other sites were identified for studying wetted perimeter/staged discharge relationships, at Huffman Island and Bookman Island. These locations are included in Figure 1. With these sites agreed upon, the group decides to schedule a field trip to identify the specific locations for transects. Group members interested in participating in this trip are Ron Ahle, Shane Boring, Gerrit Jobsis, Bill Stangler, Bill Marshall, Alan Stuart, Vivianne Vejdani, Milton Quattlebaum, Tom McCoy, Prescott Brownell, Steve Summer, Ray Ammarell and/or Bill Argentieri.

To close the meeting, the group discusses scheduling, keeping in mind that the final study plan needs to be developed by early 2014 to be included in the PAD, which is due late 2014/early 2015. The actual IFIM study will be started during the summer of 2015. The group plans to meet again during the July-August timeframe to discuss the draft study plan and HSI curves. With this, the meeting adjourns. Action items stemming from this meeting are listed below, along with an attachment that includes all decisions made during the meeting.

ACTION ITEMS:

- Shane Boring will contact Brandon Kulik to work together on identifying relevant HSI curves and surrogates for the study. Shane will also ask Brandon to make guild recommendations.

- Shane Boring will research other options for mesohabitat definitions to be used in the study.

- Kelly will schedule the "Transect Identification Recon Trip" with the interested parties for June 18th and 19th.

- Kelly will schedule a follow-up meeting/conference call during the July-August timeframe for the discussion of HSI curves and study plan development.

Goals and Objectives of Mesohabitat Assessment and Instream Flow Study

Goal 1: Characterize the flow/habitat relationships for aquatic species present in the lower Broad River below Parr Dam

- Objective A: Classify and quantify/map (characterize/define) Mesohabitats occurring within study area
- Objective B: Establish target species/guilds
- Objective C: Identify study methodology (recommended IFIM)
- Objective D: Identify tributaries and study areas (reaches) on the lower Broad River of interest for the study

Goal 2: Determine effects of Parr and FFPS operations on flows of the lower Broad River below Parr Dam

- Objective A: Identify operational ranges/constraints of two facilities
- Objective B: Evaluate effects of Project operations on Parr Dam releases at various inflow ranges into Project

Goal 3: Develop recommendations for Parr Hydro Project operations to enhance flows for aquatic resources in the Congaree River (this does not include a transect study)

- Objective A: Influence on diadromous fish (includes striped bass, sturgeon)
- Objective B: Influence on other resident aquatic species (including RT&E)
- Objective C: Influence on Congaree National Park
- Objective D: Consideration of Saluda operations consistent with goals of the Santee Basin Accord

Goal 4: Develop flow recommendations for lower Broad River below Parr Dam

- Objective A: Evaluate baseline habitat
- Objective B: Evaluate high and low flows
- Objective C: Seasonal and inter-annual variations of flow recommendations
- Objective D: Evaluate low flow protocol recommendations

Additional studies:
Temperature and DO in the west channel below Parr Dam (three monitoring locations)
Recreation flows – operation of Parr
Navigation flows – operation of Parr
Water Quality – operation of Parr

Define Geographic scopes of Mesohabitat Assessment and Instream Flow Study / Discuss Mesohabitat Assessment (including methodologies)

Geographic Boundary - Parr Dam to downstream end (lower extent) of Bookman Island, just below the confluence of Big Cedar Creek

Methodologies –
Mesohabitat unit definitions for visual assessment. (NOTE: May be modified by use of Saluda descriptions)

Habitat	Type Description
Riffle	Relatively shallow (<0.5m), swift flowing section of river where water surface is broken.
Glide	Relatively shallow (<1m); with visible flow but mostly laminar in nature; minimal observable turbulence; relatively featureless bottom.
Run	Deep (>1m), swift flowing sections with turbulent flow; surface generally not broken.
Pool	Deep (>1m) slow moving sections.
Shoals	Shoal area; which may contain a variety of habitat complexes.

Use same methods Jason Bettinger used for his study in the upper Broad River, such as GPS for start and end of each classification.

Mesohabitat study should be conducted below 2,000 CFS

Kleinschmidt

Define Species of Interest for Instream Flow Study

Summary of Habitat Use Guilds

Driver Species:
American shad
Brassy jumprock
Channel catfish
Piedmont darter
Redbreast sunfish
Robust Redhorse
Santee chub
Small mouth bass
Snail bullhead
Striped bass
Whitefin shiner

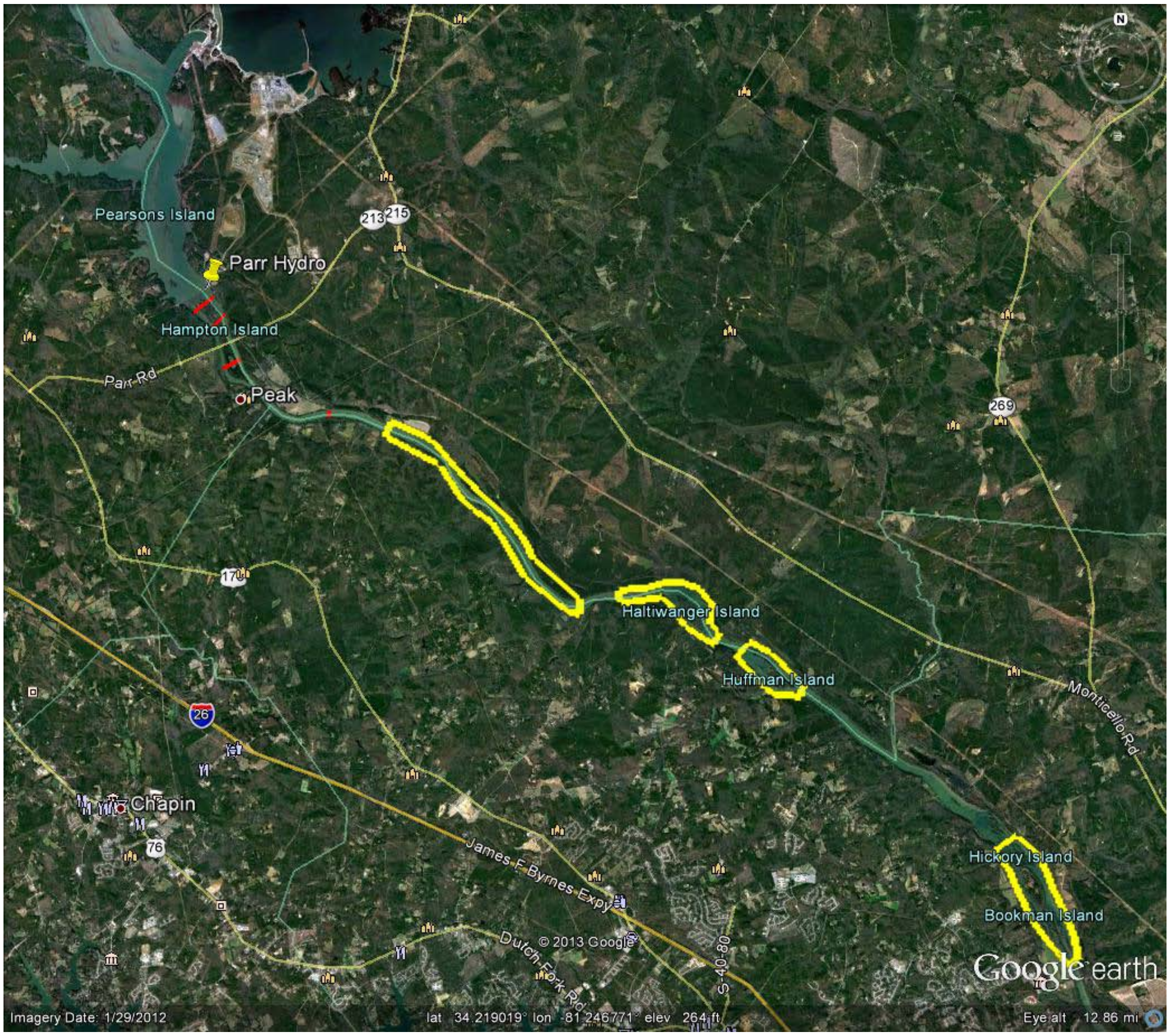
Discuss Methodology (including HSI curves, number and location of transects, areas of specific interests)

Look for HSI curves that exist for driver species and make recommendations for surrogates and guilds

Methodology (number and location of transects, areas of specific interests): IFIM above Huffman Island, wetted perimeter for Huffman and Bookman islands.

Kleinschmidt

Figure 1 **General Transect Locations**



Kleinschmidt

MEETING NOTES

SOUTH CAROLINA ELECTRIC & GAS COMPANY
Instream Flows TWC Meeting

March 5, 2014

Final KDM 04-8-14

ATTENDEES:

Bill Marshall (SCDNR)
Ron Ahle (SCDNR)
Gerrit Jobsis (American Rivers)
Shane Boring (Kleinschmidt)
Henry Mealing (Kleinschmidt)
Kelly Miller (Kleinschmidt)
Bill Stangler (Congaree Riverkeeper)
Vivianne Vejdani (SCDNR)
Bill Argentieri (SCE&G)
Milton Quattlebaum (SCANA)
Steve Summer (SCANA)
Brandon Kulik (Kleinschmidt) via conf. call
Dick Christie (SCDNR)
Randy Mahan (SCANA)
Byron Hamstead (USFWS)
Fritz Rhode (NOAA) via conf. call

These notes serve to be a summary of the major points presented during the meeting and are not intended to be a transcript or analysis of the meeting.

Henry opened the meeting with introductions and then Shane lead the group in a review of the Mesohabitat Assessment Report. Shane explained the intent of the study and reviewed the results, including an overview of the maps. Ron asked to see an individual breakdown of maps 2a, 2b and 2c and Shane said he will provide these maps to the group.

Bill M. asked if we learned anything new from the study. Shane said that the most restricted point on the river for fish passage and boat navigation was identified. This area is right above the Bookman Shoals complex. This area is identified in the IFIM Study Plan as an area that needs further study. Shane said they also did a survey for Robust Redhorse spawning areas during the mesohabitat study. Two areas were identified including a location right downstream of Parr Shoals Dam and another location upstream of Bookman Shoals. Shane said that Scott Lamprecht agreed that these spots seemed ideal for Robust Redhorse spawning. Milton said he also went out on the river with Scott and they identified another area near the Bookman Shoals complex and Hickory Island. A spot near Haltiwanger Island was also identified. Shane will develop a memo summarizing all of this information on Robust Redhorse spawning sites and will distribute this memo to the group. He will also append the memo to the final IFIM report. Shane will edit the IFIM Study Plan so it mentions that the Robust Redhorse memo will be appended to the final IFIM report.

Shane also said that during the mesohabitat assessment they learned that Bookman Island is very complex with lot of cross channels, braiding and varying elevations. He said that at least seven channels had been identified in the area. Fritz added that seams of bedrock add complexity because they act as weirs, moving the water in different directions depending on flow. He said it is good that 2D modeling will be performed in this area during the IFIM study. Byron asked if the 2D modeling will include the two Robust Redhorse sites identified in the Bookman Island complex and Shane said yes. Shane added that the upstream site at Haltiwanger Island will be studied using PHABSIM along with the site right below Parr Shoals Dam at Hampton Island. Ron said that the area just downstream of the Parr Shoals Dam is good for Robust Redhorse because there seems to be a dike formed by the rock with a gravel bed, covered by deep water. Ron said suckers are often found in this area.

Ron said that the Broad River downstream of Parr Shoals Dam is very complex, and that the maps included in the Mesohabitat Assessment Report are generalized. But he believes they are fairly accurate and that the proportions of the various mesohabitat types found in the river are accurate. Shane agreed and said that sometimes while looking at a cross section of the river, one side of the river may have a run and the other side may have a backwater pool. Shane said this was hard to convey in the maps, but that overall the map delineations and the report are very accurate.

Byron asked if areas of constriction throughout the river have been mapped out. Shane said GPS points have been taken and can be provided to the group, but cross sections detailing depth and other information has not been mapped out yet and will be completed as part of the IFIM study. Shane showed the group, using Bing maps, two areas in the river where fish passage and navigation may be possible. These areas will be studied in more detail during the IFIM study.

The group began reviewing the IFIM Study Plan and Shane mentioned that the Mesohabitat Assessment Report will be added as an appendix to the final IFIM Report. Byron wanted to know how the information collected in the IFIM study would be used for determining suitable crayfish habitat. Will the amount and type of cover available at various depths be examined? Henry said this will not be done using PHABSIM, but this information can be collected as part of the general description of the study area. Gerrit asked if when determining cover types, isn't it typical to not only look at the transect, but upstream as well? Brandon said yes because at the upstream/ downstream cell boundary level, the area is reasonably homogenous but within the cross section localized substrate variations can be like a mosaic, so it is typical to look upstream and downstream a reasonable distance to characterize the substrates assigned to a particular vertical. Brandon said that in regards to crayfish, the group can establish what the important cover types are for a particular species beforehand so that the field crews know what to look for during data collection. Byron said he will do some additional research to identify the preferred covers for the spiny crayfish. He is interested in determining how much cover is available and how much is exposed at varying water levels. Henry said that this may be possible with rocky substrates since they are fairly permanent, but that the abundance and distribution of woody debris can change from year to year so only general qualitative observations can be made. Henry said that if large woody debris is located at a PHABSIM transect, it will be surveyed in depth, otherwise just general descriptions of what is located upstream and downstream will be recorded to characterize conditions and where it is located relative to water levels. Brandon said that photos and possibly videos will also be taken to document the substrate and cover types in the area. If Byron develops a specific list of the type of substrate and cover that is important for crayfish, including a description of the types of woody debris preferred (approximate size and position in the water column), it will make it easier to document these during the study. Brandon said they can look at what is exposed during low flows and also record how high flows mobilize these substrates. Ron said that in his experience the large woody debris found in the central portion of the river is usually located in areas of accumulating sand and is typically transient and moving. All other woody debris tends to be found along the shorelines. Byron said that the wetted perimeter study will provide a lot of information on the woody debris found throughout the river. He will determine what the specific habitat requirements are for the spiny crayfish, an at risk species which is currently under candidate review, and provide these to the group prior to the IFIM study.

In section 3.2.2 of the IFIM Study Plan, Shane added in a description of the downstream ledge which may be a possible navigation site.

Bill S. asked why the river directionality is positioned looking upstream. Shane said that it just depends on how the biologist is trained. The group agrees to change all direction references to looking downstream.

Prior to the meeting, Gerrit submitted a comment regarding the inclusion of a Dual Flow analysis (DFA) into the IFIM Study Plan. Brandon explained to the group what a DFA is and his description is attached to the end of these notes. He said the goal of a DFA is to assess Project generating flows and how various operating scenarios affect habitat suitability. Base flow and generating flow couplets of interest are identified, along with selection of key species and lifestages. Effectively available habitat for a particular study site is calculated at pair of stream flows. A comparison of the amount of units of WUA available at the base flow versus the units of WUA at the generating flow is completed. DFA only records WUA corresponding to the lower of the two paired values regardless of whether the lower WUA occurs at the low or high flow. The assumption is that the lower WUA value represents the level of suitability persisting under both conditions For example, if the habitat value is zero at the low or high flow, then the value for that pairing is zero. Shane said this can be done as a desktop exercise and doesn't require any extra field effort however a basic PHABSIM analysis must be completed and reviewed first since this step establishes the quantification basis.

Gerrit said DFA can also be done to mitigate the effects of peak flows by changing the base flow. He said you can iteratively move the base flow up or peak flow down to mitigate and lessen the affect on habitat to assess different operating scenarios. The idea is that if the higher the habitat suitability is a majority of the time, then the episodes of lower habitat suitability are less stressful to the aquatic species . Bill A. asked if base flows would be changed during certain times of the day or seasonally. Gerrit said this is a seasonal change. Brandon said spatially peaking effects attenuate going downstream so that the effect is most pronounced nearest the tailrace. The group would have to decide if the analysis should focus on the upstream reaches of the river or the downstream reaches.

The group decided that the study plan needs to include information on process steps regarding the DFA. The TWC will review initial WUA output and then meet to determine the DFA scope. No additional field work will be needed. Shane will add a few paragraphs to the IFIM Study Plan describing the DFA process. Kelly will send these paragraphs out to the TWC for review and comment.

Other additions to the IFIM Study Plan include mentioning the Robust Redhorse memo, adding in crayfish habitat suitability information (provided by Byron) and adding wording on the identification of substrates for crayfish during the IFIM study. Ron mentioned he would like to see a more specific schedule for when the IFIM study will take place because he would like to help. He would like to see the schedule already included in the IFIM Study Plan expanded to include more specifics. He would also like to see qualifiers added in to account for bad weather or flows that might inhibit data collection.   All of these changes will be made to the study plan in track changes and sent out to the TWC for review and approval.

Dick asked the group if they want to specify the goals of the analyses in the study plan. For example, SCDNR's recommendation is to identify a minimum flow that would provide 80 percent of maximum WUA. The group decided to add a list or table outlining the process of the study, which will include an expanded section on TWC consultation.

Gerrit asked if there will be demonstration flows scheduled following the results of the IFIM study regarding navigation and fish passage. Bill A. said that there can be demonstration flows and Shane will add this into the process schedule.

Dick mentioned the navigation component of the IFIM Study Plan and said that it was not consistent with the Navigational Flows Study Plan, which is discussed in the Recreation TWC. The Navigational Flows Study Plan needs to be changed to include a description of the two-way navigation requirement. This study will still only focus on one way navigation, but a description of two-way navigation needs to be included. This study plan will be re-circulated to the Recreation TWC for approval and then finalized.

Shane then gave the group an overview of the 2014 field season efforts for the IFIM study. Level loggers will be deployed in late March or early April in 12 different locations from the Parr Shoals Dam to the Columbia Dam pool, near the rowing facility. Level logger data is being collected to examine travel time for flows and to develop stage discharge relationships. Additionally, 2-D data collection will be completed in the Bookman Shoals area (Study Site 10), which includes latitude, longitude and elevation data for the entire two mile study area. At Study Site 1, a terrain model for quantifying pools and fish passage will be created. Cross sectional profiles including bed elevations and water surface elevations will also be collected at Study Site 4. Bill S. asked how many points will be examined at Study Site 10. Shane said he isn't sure yet, but it will be a good idea to look at existing LiDAR data and DEM data to make sure they establish an adequate number of points. This should give clarity to the density of points needed for the model. Densities could be as tight at every three meters. Shane said that the TWC is welcome to help with these efforts this year as well. Emails will be sent to the group to notify them as soon as possible when the work will be done.

The IFIM Study Plan will be updated to reflect the items discussed at the meeting and sent back out to the TWC for approval. Action items stemming from this meeting are listed below.

ACTION ITEMS:

- Byron will identify the preferred habitat substrates for the spiny crayfish and provide this information to the group for use during the IFIM study.

- Shane will change the language in the IFIM Study Plan to reflect a "looking downstream" perspective.

- Shane will add in a section describing the process steps of the IFIM study with an expanded section on TWC consultation. He will also expand the schedule to include more specific dates and times which will include demonstration flows if possible. He will also add qualifiers to account for bad weather or flows that might inhibit data collection.

- Shane will add in a section to the IFIM Study Plan discussing Dual Flow Analysis. He will also add in a few sentences discussing the information collection on Robust Redhorse spawning areas. Additionally, once Byron provides the information regarding preferred spiny crayfish habitat substrates, Shane will include this in the IFIM Study Plan.

- Kleinschmidt will update the Navigational Flows Study Plan with information on two-way navigation and redistribute to the Recreation TWC.

DUAL FLOW ANALYSIS

- The basic WUA/flow relationship is the foundation
- Base flow/generating flow couplets of interest are identified
- Key species/lifestages (or guilds) are strategically selected
- Effectively available habitat for a study site[1] is calculated at pairs of stream flows: (base) non-peaking and a (generation) peaking flow.
- Dual Flow analysis only records WUA corresponding to the lower (*"effectively available"*) of the two paired values. If the habitat value is zero at either the low or high flow, then the value for that pairing is zero.
-

Example:

basic WUA/flow relationship (*example from Chippewa River, WI*):

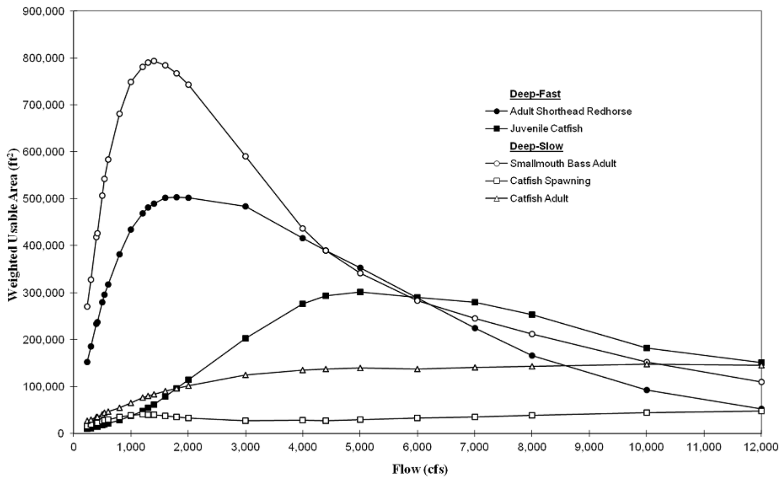
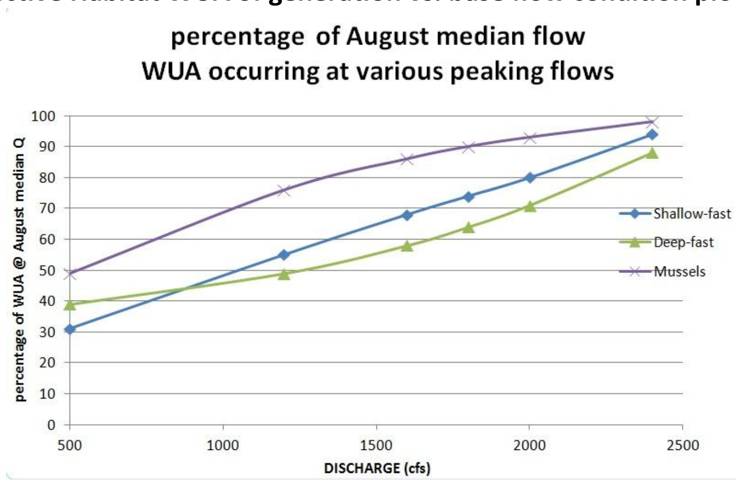


Figure 4. Habitat-discharge relations for fishes in Deep-Fast and Deep-Slow habitat guilds within the Cornell Project instream flow study area.

Effective Habitat WUA of generation vs. base flow condition plotted



[1] For non-mobile life stages such as macroinvertebrates or nest spawning, calculations can optionally be performed at the cell level using the "HABEF" routine in PHABSIM

MEETING NOTES

SOUTH CAROLINA ELECTRIC & GAS COMPANY
Instream Flows TWC Meeting

September 27, 2016

Final KMK 10-26-16

ATTENDEES:

Bill Argentieri (SCE&G)	Bill Marshall (SCDNR)
Ray Ammarell (SCE&G)	Dick Christie (SCDNR)
Caleb Gaston (SCANA)	Ron Ahle (SCDNR)
Mike Mosley (SCANA)	Tom McCoy (USFWS)
Brandon Stutts (SCANA)	Gerrit Jobsis (American Rivers)
Randy Mahan (SCANA)	Bill Stangler (Congaree Riverkeeper)
Shane Boring (Kleinschmidt)	Alex Pellet (SCDNR) via conf. call
Henry Mealing (Kleinschmidt)	Fritz Rhode (NOAA) via conf. call
Jordan Johnson (Kleinschmidt)	Brandon Kulik (Kleinschmidt) via conf. call

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These notes are a summary of the major points presented during the meeting and are not intended to be a transcript or analysis of the meeting.

Henry opened the meeting with introductions and a brief overview of the agenda and meeting goals. The goal of the meeting was to review the Parr Downstream Flow IFIM Study results, seek agreement on the results, and begin discussions of the potential minimum flow range that should be considered. The group was given handouts of the Wetted Usable Area (WUA) results from PHABSIM and 2D model runs to review.

Shane noted that, with the exception of Study Site 2 (west channel), the WUA tables had been revised to include the additional flow increments requested by SCDNR. Shane reminded all attendees that the goal of the IFIM study is to balance hydropower operations and aquatic habitat. He recommended that the group initially focus on putting boundaries around a flow range for minimum flow discussions. Ron commented that the group should carefully consider the study results before considering what is practical in relation to project operations. Caleb commented that the group should always keep project limitations in consideration when discussing the results as to not discuss flows/scenarios that aren't possible. Gerrit stated that he was expecting a habitat duration and/or dual flow analyses but did not see these items in the report. Shane said that the group should discuss and approve the raw WUA vs flow relationships contained in the PHABSIM model runs prior to discussions about next steps, which then could include the habitat duration and/or dual flow analyses. Gerrit noted that habitat duration is a very important aspect in making a minimum flow recommendation. Gerrit also provided the group with a brief explanation, noting that habitat duration allows the WUA data to be analyzed based on how often different flows occur at the Project. Brandon K. commented that the group should discuss and specify timeframes addressed in any duration analysis; annual/monthly vs. seasonal vs. periods of low flow. Shane added that due to the large of WUA output for the various species and lifestages, the group also needs to discuss “driver” species or study sites as to narrow down the dataset for any additional analysis.

Shane opened a PowerPoint presentation outlining the IFIM study. Reach 1 of the study is located from Parr Dam to the downstream end of Hampton Island. Reach 2 of the study is located from the downstream end of Hampton Island to the downstream end of the Bookman Island complex. These study reaches are primarily influenced by the Project with little inflow from tributaries. The only tributary of note is Little River, located just upstream of Bookman Island. Shane gave a brief overview of each study site, including their locations and characteristics. Shane made a special note of study site 9, located at Huffman Island, as it was originally slated for 2-D modeling. He explained that the TWC decided 2-D modelling of study site 10 (Bookman Island) would be sufficient and any flow recommendations would be verified by a site visit to study site 9.

Shane moved on to explain how the east and west channels below the dam, separated by Hampton Island, were analyzed. The west channel had its own calibration flows and was analyzed separately from the rest of the reach. The east channel, which encompasses all flow passed through the powerhouse, followed the 400, 2000, 6000 cfs calibration flows conveyed throughout the rest of the study area. Shane also gave a brief overview of the fish passage analysis completed as part of the IFIM study. Shane wrapped up his overview of the study by providing a table illustrating the target species, lifestage, Habitat Suitability Curve (HSC) sources, and guilds assigned during study scoping. He noted that recent comments from SCDNR were incorporated into the table. Brassy jumprock and robust redhorse were changed to the “deep fast; shallow fast” guild. Shane also explained one change made to HSC source data for smallmouth bass included data from a study in Deerfield River in MA.

Shane moved discussions over to the study results for each study site.

West Channel (*study sites 1,2 and 4*). The group started with discussions of site 1 in the upper West Channel. Shane explained the elevation data used to analyze pool volumes in study site 1; including DEM data collected by Glenn Associates, ADCP data collected by Watercube, and point elevations collected by Kleinschmidt and Glenn Associates. Henry also provided a brief discussion of methods and data collected during the 2016 West Channel Water Quality. He explained how those data will be used in ongoing discussions of conditions at Study Site 1. Shane wrapped up the West Channel IFIM results with a review of study site 4. He explained that the site was a “wetted perimeter” transect that is backwatered somewhat buy flow from the east channel, and showed the group the results of the analysis.

Shane then moved the group into discussions of the east channel and Reach 2 study sites.

East Channel

Study Site 3 is located immediately downstream of the Parr powerhouse. Shane noted the site has higher velocities and therefore the “slow” guilds and species returned poor results. Ron noted that the WUA table for study site 3 contained multiple flows that had 100% of available habitat. Shane explained that this was simply rounding by Microsoft Excel and that edits would be made to the tables. The group briefly discussed why the site was given the moniker “sucker city”. Ron explained that this is a result of observations made during electrofishing efforts in the area for robust redhorse spawning grounds.

Study Site 5. Shane gave a brief overview of the results, explaining that this site was deeper. Gerrit asked if it is known how water partitions into the east and west channels. Henry said that most of the flows from the powerhouse move down the east channel and that water released through the spillway gates moves to both channels (especially dependent upon which gates are releasing). The 2016 West Channel Water Quality Study should provide additional understanding of this relationship. Study site 6 results showed that optimal WUA ranges between 1,000-1,500 cfs for most of the species/guilds. Shane explained that the small "bumps" seen in the WUA curves at 5,000 cfs are artifacts of the hydraulic model. The group noted a few errors in the WUA tables that will be corrected. Dick noted that he would like to review the report again with any edits resulting from the meeting. Henry replied that the report and WUA tables would be redistributed to the group for review.

Downstream study sites

Shane returned discussions to **study site 6** by asking Ron to give a brief review of why the site was chosen for analysis. Ron commented that the site is a slate belt run with deeper pockets that is very important to the smallmouth bass fishery as it offers some of the best smallmouth bass fishing habitat in the river. He noted that the site also provides cover and habitat for juveniles in the shallower areas. Shane added that this site represents a situation where smallmouth bass could be a "driver" species when evaluating a minimum flow.

Study site 7 WUA peaks around 600-1,200 cfs. Shane also briefly mentioned that this site contained two passage points that were analyzed for fish and navigational passage.

Study site 8 (Haltiwanger Island) peak WUA values occur between 500-1,500 cfs. Shane explained that there was one transect located in each channel around the island; each one was independently modeled. Shane pointed out "fluctuations" in the WUA curves, explaining that this resulted from combining the PHABSIM results for each transect into one graph for analysis. He mentioned that higher flows were likely needed to provide the most habitat at this site. This is a result of the very wide and shallow nature of the western channel. **Study site 8** was the final site analyzed using PHABSIM. Gerrit commented that this site could be good for assessing seasonal and interannual flows, explaining that the project lends itself to providing more water during high flow years. Henry commented that while this is true, SCE&G will need an "or inflow" component with any minimum flow recommendation. Ray A. added that this should already be happening as Parr does not store any water. High flow years should be reflected in the flow record. Ron commented that if seasonal flows might be considered for a minimum flow recommendation, the group needs to be sure and consider all the different species if spawning seasons will be used.

Study site 10 (the Bookman Island complex). Shane explained that it was modeled with the program River2D due to the complexity of the reach including multiple channel bifurcations and patches of habitat. He explained that elevations throughout the reach were collected using a combination of methods. Elevation data were first collected during a flyover of the area using georeferenced aerial photogrammetry methods during low flows (400-600 cfs) in December 2014. These data were supplemented with additional field data collections with survey grade GPS. These elevation data were the basis for the River2D analysis. Shane broke down the WUA results, noting that the peaks tend to be around 1,000 cfs, with smallmouth bass peaking around 3,000 cfs.

Gerrit asked the group how the study sites should be weighted based on the varying analysis methods (1D/PHABSIM vs. River2D). Shane and Brandon K. explained that results could be weighted according to river linear length or they could not be weighted at all (these are the representative reach vs. critical habitat approaches). Shane added that results presented for each study site are standardized at WUA per 1,000 linear feet of stream, so study sites can be compared regardless of their length differences. The group noted that the WUA results could be also be weighted utilizing the results of the Mesohabitat mapping assessment, if the representative reach approach is chosen.

Zone of Passage

Shane reminded the group of the fish passage portion of the IFIM analysis. He gave the group an overview of the results noting the flows required to meet the passage criteria. The ledge at study site 7 meets fish passage criteria at 500 cfs. The ledge upstream of Bookman Island meets the criteria at 700 cfs. Shane summarized that most sites experience optimum WUA between 800 and 1,200 cfs.

Discussion of further analysis

Shane explained to the group that he would like to take the results presented to the group and discuss driver species and sites individually. Gerrit asked if the sites could be prioritized by suitability for species. He explained that he would like to see WUA comparisons by species across multiple sites, in addition to WUA comparisons by site across multiple species. Ray displayed flow duration curves (FDC) to the group that were developed utilizing a prorated inflow dataset used by the Project Operations Model. The group reviewed monthly flow duration curves, noting the 90% and 50% exceedance flows. Henry explained that he wanted the group to see these in response to Gerrit's comment about analyzing the WUA data in light of what flows are available in the river. The group broke for lunch, planning to have a workshop session in the afternoon to narrow down driver species and flow ranges to be addressed in any further analysis.

Workshop session

The group opened up the "workshop" session after lunch by constructing a calendar with the flows from the FDC review (Appendix A). They added bio-periods to the calendar based on species/guilds of importance. During the "workshop" session, Gerrit offered up a suggestion for how to analyze the WUA data by species rather than study site. He created an example table using the American Shad WUA from each study site (Appendix A). The group approved of Gerrit's suggestions, and created similar tables for adult smallmouth bass and robust redhorse/deep-fast guild. The tables allowed the group to rank/prioritize the study sites based on the available WUA.

After the workshop session, the group returned to the tables for discussion. Henry and Shane asked the group if there were priority species or study sites that the group is considering. Ron and Gerrit identified American shad, robust redhorse, and adult smallmouth bass as priority species. Ron added that smallmouth bass continues to be an important fishery for the SCDNR. Ron also pointed out that while study site 3 offers unique habitat for suckers not found in other parts of the river, it shouldn't take precedence over downstream study sites when evaluating for minimum flow. Since it is close to the powerhouse, conditions there remain relatively stable no matter the flow.

Henry provided a recap of what the TWC discussed in the meeting. He noted that the WUA tables will be presented by species rather than by study site. He noted that the group will need to continue to narrow the flow ranges discussed in order to start establishing minimum flow recommendations. He also noted that SCE&G would like to have 3 or less seasonal minimum flows in a year.

Seasonal Flow Targets
Caleb G. asked the group if they could identify periods of time where they would like to see certain minimum flows (i.e. bio-periods). He noted that this doesn't require a particular flow recommendation, just a general description such as low, medium, and high. The group referred back to the calendar produced during the "workshop" session. The group considered the exceedance flows provided by the inflow flow duration curves and the time periods identified that are of importance to the various species and guilds. They identified a period of "high" minimum flows starting February 15th and extending until May 15th or 30th depending on river conditions. The minimum flow would then drop back to a "medium" flow through June 30th. The "low" minimum flow period would extend until November 30th and then returning to "medium" flows until the following February 15th. The flow periods are illustrated in the attached tables. Henry asked the group if they could identify potential flows they would like to apply to the "low, medium, and high" flow periods. After clearly explaining that additional information (i.e. habitat duration) and analysis (i.e. dual flow) were needed before final recommendations could be made, Gerrit recommended for discussion purposes 2,500 cfs for the "high" period, 1,800 for the "medium" period, and 1,200 for the "low" period. SCE&G identified 2,000 cfs for the "high" flow, 1,300 cfs for the "medium" flow, and 700 cfs for the "low" flow period. Henry encouraged the other stakeholders and agencies to provide specific flows as this issue is resolved.

Habitat Duration
The group turned discussions back to the habitat duration analysis. Gerrit reiterated that applying the flow duration data to the WUA data would allow the group to make a flow recommendation that best benefits aquatic habitat. He noted that the analysis will also provide the group with more information to identify time periods that should be grouped into the low, medium, and high minimum flow periods. Brandon commented that completing the flow duration analysis can be accomplished utilizing existing data presented during the meeting.

Ray and Bill A. reiterated to the group that it's important to consider plant operations when recommending minimum flows. Ray explained that SCE&G currently calculates minimum flow as inflow minus evaporative loss. He added that current maximum evaporative loss is 118 cfs; however, this will increase to 180 cfs when the new nuclear units begin operating. SCE&G needs enough room between inflows and minimum flow requirement to account for these variables. SCE&G will review how inflows are currently calculated to ensure they are not overestimating. They will also review their compliance records to identify times where they struggled with maintaining minimum flows and see if the suggested flow ranges fit with their capabilities.

Brandon K. asked the group if there were species or guilds currently being analyzed that can be removed from future analyses. Ron recommended that the shallow-slow guild be removed. Gerrit added that the group most discussed robust redhorse, American shad, smallmouth bass, and the deep-fast guild during the "workshop" discussions.

Dual Flow analysis
Bill A. asked the group if the dual flow analysis still needed to be considered. Shane asked if, with the emphasis put on the habitat duration analysis, the dual flow analysis was still the best tool. Henry noted that the findings from the Downstream Flow Fluctuation Group could replace the dual flow analysis. He added that the TWC could incorporate the IFIM data into recommendations to SCE&G on an operational band for them to try and stay between while operating the project. He

noted that this could be included in an adaptive management plan and would provide a way for SCE&G to evaluate how they are managing downstream fluctuation flows while benefitting aquatic habitat. Gerrit replied that he is willing to suspend a dual flow analysis until after the results of the habitat duration analysis is presented. He explained that the dual flow analysis may provide a means of quantifying the effects of large spill events and offers a way to mitigate later.

The group discussed an operational band for Parr. Gerrit and Henry explained that there would be a target release for the project with an upper and lower band. There wouldn't be any penalty for operating below or above the target flow, as long as the project operated within the band. This could provide a means to mitigate instances where there are peaks and valleys created within the hydrograph by Project operations. Henry reiterated that this would be a means for the group to evaluate the success of SCE&G's operational changes to address project influenced flow fluctuations. Henry also reminded the group that they should consider low inflow protocols as part of their recommendations. Gerrit added that an operational band is about providing a buffer for project operations. He provided an example to the group. The minimum flow could be 1,200 cfs, if inflow were at or above 1,500 cfs. If inflows drop below 1,500 cfs, the minimum flow could, for example, drop to 1,000 cfs to allow for operational needs. Gerrit added that an operational band would allow for flexibility during low inflow periods, while also providing an opportunity for flows to be higher than a prescribed minimum flow requirement when there were higher inflows.

Gerrit asked if the group was still considering stabilization flows during spawning periods. Bill replied that it is still being considered, and will be addressed in the next Downstream Flow Fluctuations TWC meeting in October.

The meeting adjourned. Action items from this meeting are listed below.

ACTION ITEMS:

- Kleinschmidt - prepare meeting notes
- Kleinschmidt - increase detail of higher range of flows for Study Site 2
- Kleinschmidt - edit errors identified in the WUA table percentages
- Kleinschmidt - edit WUA tables and curves. Data by species/guild rather than study site.
- SCE&G - review how inflow is calculated by the operators, ensure not overestimating
- SCE&G - review compliance records to establish times where maintaining minimum flows were an issue. See if the TWC's suggested flow ranges match up with capabilities.
- Kleinschmidt - remove Shallow-Slow guild from list for further analyses
- All TWC Members - provide recommendations for upper and lower operational limits based on WUA tables
- Kleinschmidt - prioritize transects based on mesohabitat data
- Kleinschmidt - develop habitat duration curves

Workshop Attachments

American Shad			
Transect	**75% WUA Flows (cfs)**	**WUA Units**	**Rank**
SS3	750-7,000	238k-294k	5
SS5	200-2,500	61k-79k	6
SS6	700-6,000	244k-309k	4
SS7	700-10,000	283k-373k	3
SS8	1,750-10,840	618k-791k	1
SS10	800-20,000	398k-524k	2

Deep Fast/Robust Redhorse			
Transect	**75% WUA Flows (cfs)**	**WUA Units**	**Rank**
SS3	2,600-5,000	188k-244k	1
SS5	500-1,150	32-43k	4.5
SS6	3,000-4,000	146-163	2
SS7	1,200-3,000	34-42	5
SS8	5,000-10,800	67-90	3
SS10	1,500-4,000	32-42	5

Smallmouth Bass Adult			
Transect	**75% WUA Flows (cfs)**	**WUA Units**	**Rank**
SS3	1,200-4,500	96-128	5
SS5	400-3,500	67-89	6
SS6	1,200-6,000	220-293	3
SS7	600-3,000	196-261	4
SS8	2,500-7,180	341-455	2
SS10	2,500-7,000	387-516	1

	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
90% Exceedance	2,435	2,571	3,365	2,978	2,036	1,368	1,045	771	865	1,083	1,235	1,979
50% Exceedance	5,000		6,000	5,000	3,750	3,000	2,500	2,250	2,160	2,300	3,000	4,400
		D/F	AMS	AMS	AMS juv (shallow, fast)							
				RRH	RRH							
				SMB (spawn)	SMB (spawn fry)	SMB (juv/fry)						
					RBS (spawning)	RBS (spawn/fry)	RBS (fry/juv)					
				Striped Bass	Striped Bass							

FLOW	2/15	5/15 or 31	6/30	11/30
Medium	High Flow Stakeholder -2,500 SCEG-2,000	Medium Flow Stakeholder -1,800 SCEG-1,300	Low Flow Agency-1,200 SCEG-700	

MEETING NOTES

SOUTH CAROLINA ELECTRIC & GAS COMPANY
Instream Flows TWC Meeting

January 24, 2017

Final KMK 2-16-17

ATTENDEES:

Bill Argentieri (SCE&G)
Ray Ammarell (SCE&G)
Caleb Gaston (SCANA)
Brandon Stutts (SCANA)
Tom McCoy (USFWS)
Melanie Olds (USFWS)
Dick Christie (SCDNR)
Bill Marshall (SCDNR)
Ron Ahle (SCDNR)
Alex Pellett (SCDNR)
Gerrit Jobsis (American Rivers)
Bill Stangler (Congaree Riverkeeper)
Henry Mealing (Kleinschmidt)
Brandon Kulik (Kleinschmidt) via conf. call
Bret Hoffman (Kleinschmidt)
Jason Moak (Kleinschmidt)
Jordan Johnson (Kleinschmidt)
Kelly Kirven (Kleinschmidt)

These notes serve as a summary of the major points presented during the meeting and are not intended to be a transcript or analysis of the meeting.

Henry opened the meeting with introductions and distributed a memo entitled "Parr IFIM Study – Habitat Duration Analysis and Misc. Action Items" dated January 23, 2017. This memo was an update of the "Habitat Duration" memo distributed in December 2016. Henry then began a PowerPoint presentation, which is attached to the end of these notes along with the January 23rd memo. The goals of the meeting included selecting values for minimum flows, selecting seasonal date ranges for low, mid, and high minimum flows, discussing potential observation dates and discussing methods and transects for observation. Regarding the timing for the observation flows, Henry suggested that there will likely be three separate outings to view the flows; one in early spring, one in May, and one in August. Henry then reviewed the action items from the previous meeting. The corrected WUA tables from the IFIM report are included in Attachment A of the memo, the new figures and tables of WUA by target species and life-stage are in Attachment B of the memo, and the Habitat Duration Analysis is in Attachment C of the memo. The WUA data weighted by mesohabitat is presented in the body of the memo.

Henry then turned the presentation over to Bret, who discussed the Habitat Duration Analysis. He explained that seasonal hydrologic availability was compared to WUA and to the seasonal minimum flow ranges that were proposed at the previous TWC meeting (held on September 27, 2016). Bret explained that there was an inflection point in the prorated data around 3,900 cfs, which resulted in overestimation of inflows below this point and underestimation of inflows above it. Because of this, he used non-prorated data to complete the habitat duration analysis. Also, in order to tailor the effort during this analysis, he focused on select months, species/life stages and study sites that were noted as having the greatest interest or importance. Bret said the exceedance percentages, which are in Table 2 of the memo, display how often the low, transitional, and high flows are exceeded. For example, a flow of 1,800 cfs in June is available 74 percent of the time and not available 26 percent of the time. Henry added that this Project is not a storage reservoir, so outflows are totally dependent on inflow. SCE&G is not able to hold back excess water in the spring for release in the summer. Ray said that since SCE&G will try to avoid dropping gates as part of a parallel effort to dampen downstream flow fluctuations, this will drive water through the powerhouse more consistently.

Gerrit began discussing a potential Low Inflow Protocol (LIP). He said that, for example, if Flow A is the minimum flow and inflow decreases to a certain point, then Flow B will become the minimum flow. If inflow decreases to within 200 cfs of the minimum flow, then the minimum flow can be reduced and act as a buffer. Gerrit asked how SCE&G currently operates when they are at inflow now. Ray said when they are at inflow, they release inflow minus evaporation. He said he finds that losses are greater in the system as a whole than what is calculated for inflow, so they can still operate Fairfield, just a little less each day. Monticello Reservoir starts dropping each day during a drought or period of low flows, so the maximum amount you can release is constantly decreasing. He said in extreme periods of low flows, which may have more impact on Parr Hydro in the future due to the two new nuclear units at V.C. Summer, Fairfield operations are limited. When a storm comes and flows increase, SCE&G attempts to make up losses in the reservoir that occurred over the low flow period until Monticello is restored to full pool. The group agreed that this recovery mechanism for Monticello Reservoir should be incorporated into the LIP.

Henry said that he wants to ensure SCE&G has some flexibility in their operations so that they can meet their minimum flows and consistently stay within compliance. He also noted that a change in philosophy on how the Project is run, including removing downstream pulses and no longer operating with a daily average minimum flow, will affect the new minimum flows in a positive way.

The group refocused on the presentation and Jordan began explaining the representative reach analysis and methods for weighting WUA. He explained that this analysis focuses on Reach 2 of the IFIM study because this reach is hydraulically linked unlike Reach 1, which is split into east and west channels by Hampton Island and because Reach 2 includes critical study sites that were identified by the TWC. He then explained that the total linear feet for each mesohabitat type within Reach 2 was measured using ArcGIS. Study sites 6, 7, and 8 were assessed separately from Bookman Island because they contained different types of habitat and were modeled using different methods. The two areas were weighted based on their individual linear lengths and then the weighted values were summed to provide WUA for the entire Reach 2. Graphs were reviewed that compare WUA availability by species for low flows, high flows and transitional flows.

One conclusion from the analysis that Henry noted is that a low flow of 700 cfs provides 79-120 percent of the suitability of a flow of 1,200 cfs. Ron noted that the 700 cfs flow only reach 120 percent suitability when small mouth bass fry are included. He said that the fry stage lasts for a very short period of time and shouldn't be taken into account for low flows.

The stakeholders held a breakout session to review and discuss the data presented in the memo.

After lunch, the group reconvened. Gerrit acted as the spokesperson for the stakeholder group and explained what they had discussed and the recommendation they were proposing. He said that there were two important things they looked at regarding their flow recommendations. First, they identified certain species that were most affected by flows. Second, they identified Study Site 3 as being important since whatever flows are released in that area, a portion will be diverted to the west channel. They also identified Bookman Shoals and Haltiwanger Island as important areas. Gerrit said they also looked at the exceedance flows and took into account how often certain flows would be available in the river. They identified a flow duration exceedance (not a WUA score) of 75-80 percent as acceptable.

Gerrit said the minimum flows that the stakeholders are recommending are as follows:

- Low Flows – June 1-November 30 – base flow of 1,200 cfs – drivers are adult smallmouth bass habitat, Study Site 3 (West Channel)

- Transitional Flows – January, May, December – base flow of 2,250 cfs – drivers are adult smallmouth bass habitat, robust redhorse spawning (deep fast guild), Study Site 3

- High Flows – February, March, April – base flow of 3,000 cfs – drivers are robust redhorse spawning, American shad spawning, Study Site 3

Gerrit added that they also discussed having a step down mechanism built into the LIP. They identified 200 cfs as a reasonable buffer flow. For example, during the minimum flow period when inflow reaches 1,400 cfs, the minimum flow released from the Project will drop from 1,200 cfs to 1,000 cfs. Then, when inflow drops below 1,000 cfs, outflow will equal inflow. The same consideration will apply to transitional and high flows. When inflow is 3,200 cfs, the minimum flow will drop to 2,800 cfs (for high flow periods) and when inflow is 2,450 cfs, the minimum flow will drop to 2,050 cfs (for transitional flow periods). Stakeholders also agree to include a recovery period to allow Monticello Reservoir to recover to full pool after periods of low flows.

Ray said that these proposed minimum flows are higher than what the stakeholders proposed at the previous meeting. He said that including June in the low flow period and removing it from the transitional period seems reasonable. He said that a base flow of 1,200 cfs will be difficult to accomplish in August. SCE&G already struggles to meet the current minimum flow in August, which is a daily average of 800 cfs. Ron asked what years of data were included in the monthly exceedance percentages shown in Table 2 of the memo. Henry said that those numbers were developed using 35 years of data. Ron said that if the exceedance percentages were calculated using only the last 10 years or so, they may drop down. Kleinschmidt will redo the table using only data from the last 15 years, to possibly give a clearer image of recent flows.

Ray said that the suggested low flows are concerning and will be difficult to comply with since the Project doesn't have a storage reservoir. Ray asked if the stakeholders are okay with subtracting evaporation from inflow. Gerrit said yes. Ray said that an instantaneous minimum flow of 1,200 cfs versus a daily average of 800 cfs will be difficult and inflow may be what's passed very often, since summer flows are often below 1,200 cfs. Bill A. asked if they are open to having these numbers be daily averages. Gerrit said no, these numbers are instantaneous minimums.

Bill A. asked how long flows should be low before they step down to a lower minimum flow per the LIP. Gerrit said one 15 minute reading shouldn't cause an issue, but when the whole river drops down to a new level, then the LIP should be initiated.

Bill S. said that they had to consider moving flows to the west channel and how this would affect the east channel in Study Site 3. Caleb asked how much flow do stakeholders envision being diverted to the west channel. Bill S. said around 200 cfs. Henry said he was surprised by the proposed minimum flows and he thought they would move closer to the 20/30/40 % numbers identified in the state recommendations for minimum flows.

Ron said they didn't separate spawning and adult habitats for robust redhorse. Henry asked if the deep/fast guild was a driver in the proposed flows. Gerrit said that adults were a driver and they are in the deep/fast guild. He said that American shad and robust redhorse were drivers during high flows and the west channel was a driver for all flows. Henry reminded the group that the robust redhorse spawn in shallow fast habitats. After the meeting KA reviewed the record and robust redhorse juvenile and fry stages were originally placed in the deep slow guild based on studies on the Pee Dee River, which had been omitted in previous meetings. The deep fast habitat is likely linked only with adult habitat and not linked to spawning and recruitment.

Gerrit said he doesn't envision many long periods where only the minimum flow is passed. He thinks the outcome will be better if SCE&G doesn't focus on what the minimum flow is as much as they focus on better flow management. He said he doesn't want to close the book on coming up with something creative that addresses American Rivers' interest, which is having flows mimic natural river flows.

Henry asked if all transects and all species were considered. Ron said that with all of the transects put together, they will get 66 percent of the smallmouth bass habitat at 1,200 cfs. By ensuring water is there for smallmouth bass, they won't be taking anything away from other species. The stakeholders agree that smallmouth bass is an especially important species for recreation.

Henry noted that the higher the minimum flows, the more chances SCE&G could have deviations because the Project will be in the "or inflow" mode of operation. Henry said SCE&G has agreed to do several operational changes during the new license including diverting water to the west channel, stop or minimize downstream fluctuation flows, and implement new minimum flows. Henry asked if the stakeholders would consider allowing for a minimum flow adaptive management plan to test the new minimum flows over several years and see how easy or difficult it is to comply with the other operational changes being proposed. They can show progress each year on how they are meeting this goal and even submit reports to FERC. Gerrit said this is a reasonable request and might be possible.

Melanie asked if a gliding minimum flow could be set up, using a percentage of inflow from the previous day minus evaporation. The group agrees this is a good idea and Henry said we will explore this idea further. Henry said that something similar to this was agreed to at an Entergy Project on the Ouachita River and one of the Coosa Developments in Alabama. They use percentages of inflow to adjust outflows on a frequent basis.

Bill A. noted that based on this new set of flows proposed by the stakeholders, observation flow dates would not be scheduled at this time since the stakeholder flows had increased from their previous proposal.

Following this discussion, the meeting adjourned. Action items from the meeting are listed below.

ACTION ITEMS:

- Kleinschmidt will put together meeting notes and distribute to the group.
- Kleinschmidt will recalculate the exceedance percentages on Table 2 of the memo, using only data from the last 15 years.
- SCE&G will discuss the new proposed minimum flows with management and they will work with Kleinschmidt to come up with other possible options.
- Kleinschmidt and SCE&G will review the TWC recommendation and perform additional hydrologic and biological analysis for minimum flows more in line with the proposal from the last meeting.

APPENDIX C

MESOHABITAT ASSESSMENT MEMORANDUM

MEMORANDUM

TO: Parr/Fairfield Hydro Relicensing Instream Flow TWC

FROM: Shane Boring

DATE: January 8, 2014

RE: Mesohabitat Assessment

A mesohabitat assessment of the Broad River downstream of Parr Shoals Dam was completed by biologists from Kleinschmidt (Shane Boring), SCANA (Milton Quattlebaum) and the South Carolina Department of Natural Resources (Ron Ahle) during October and November of 2013. The assessment was conducted in support of the ongoing Parr/Fairfield Hydroelectric Project relicensing effort, and more specifically, in preparation for the upcoming Instream Flow Incremental Methodology (IFIM) and other studies. The purpose of the assessment was to classify and determine the quantity and spatial distribution of different mesohabitat types within the study area previously outlined by the Instream Flow Technical Working Committee (TWC) (Figure 1). These data will be used to weight the Weighted Usable Area (WUA) output from individual representative transects and study sites according to the relative abundance and distribution of the mesohabitat types throughout the study area.

"Mesohabitats" are generalized habitat types that are commonly used to describe stream habitat (i.e. riffle, run, pool). Acceptable mesohabitat definitions were determined in consultation with the Instream Flow TWC (See July 30, 2013 meeting notes), and include the following:

RIFFLE	Shallow, with moderate velocity, turbulent, high gradient, moderate to large substrates (cobble/gravel). Typically > 1% gradient.
GLIDE	Moderately shallow, well-defined non-turbulent laminar flow, transition from low to moderate velocity, lacking a definite thalweg, typically flat stream geometry, typically finer substrates, transitional from pool.
RUN	Moderately deep, well-defined non-turbulent laminar flow, range from low to moderate velocity, well-defined thalweg, typically concave stream geometry, varying substrates, gently downstream slope (<1%).
POOL	Deep, low to no velocity, well-defined hydraulic control at outlet.
RAPID/SHOAL	Shallow, with moderate to high velocity, turbulent, with chutes and eddies, high gradient, large substrates or bedrock. Typically >2% gradient.
BACKWATER	Varying depth, no or minimal velocity, off the primary channel flow.

ASSESSMENT METHODS

For purposes of the mesohabitat assessment, the approximately 18 mile-long study area was broken into the two reaches agreed upon during the June 2013 field reconnaissance: Reach One – extending from the Parr Shoals dam downstream to the Palmetto Trail trestle crossing and Reach Two – extending from the trestle to the downstream end of Bookman Island (Figure 1). The study area was traversed by canoe/kayak or on foot at flows ranging from approximately 1,000 to 2,200[1] cubic feet per second (cfs), and mesohabitats occurring in each reach were classified into one of the six categories described above.

Upstream and downstream boundaries of each mesohabitat segment were documented using a Garmin 60cs Global Position System (GPS). Although not included in this report, field observations regarding dominant substrate, overall cover quality[2], and approximate channel width were recorded should this information be needed at a later date (e.g., during IFIM modeling efforts). Reference photos for each mesohabitat type were also taken at selected locations. GPS data were incorporated into a Geographic Information System (ArcGIS) and area polygons constructed and calculated for each mesohabitat segment (Figure 2).

RESULTS

Area and proportion of mesohabitats occurring in each reach are illustrated below in Figures 2-6 and summarized in Table 1. Reach One is dominated by run habitats, with an abundance of shoal habitat associated primarily with the bedrock outcroppings at the base of the Parr Shoals Dam (Table 1; Figure 3). Reach Two, which is depicted as Reaches 2a, 2b and 2c for illustration purposes (Figures 4-6), is dominated by pool habitats, with the remainder primarily consisting of nearly equal proportions of shoals, riffle and run habitats (Table 1). No significant backwaters were observed during the survey.

Table 1. Proportions of Mesohabitats Occurring Downstream of Parr Shoals Dam

	Glide	Pool	Riffle	Shoal	Run
Reach One	**4%**	**18%**	**0%**	**31%**	**47%**
Reach Two	**6%**	**28%**	**21%**	**25%**	**20%**

J:\455\086\Docs\001-Parr FF Mesohab Memo Report.docx

[1] Small portions of Reach One were also observed at approximately 4000 cfs during wrap-up of field work in late-November 2013.
[2] Refers to the relative density of object cover such as boulders, logs, etc.

FIGURES

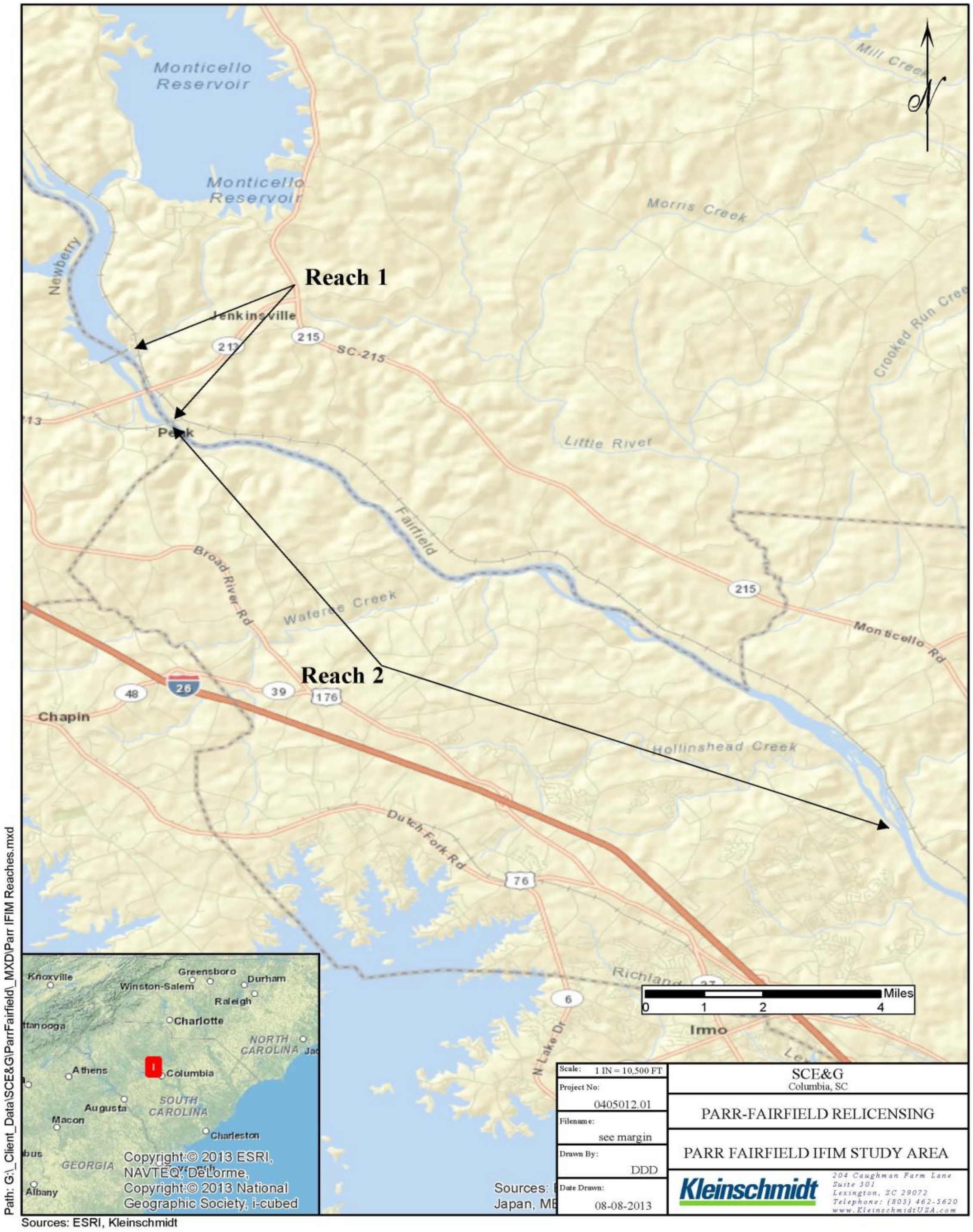


FIGURE 1 PARR-FAIRFIELD PROJECT, BROAD RIVER INSTREAM FLOW STUDY. IFIM STUDY REACHES

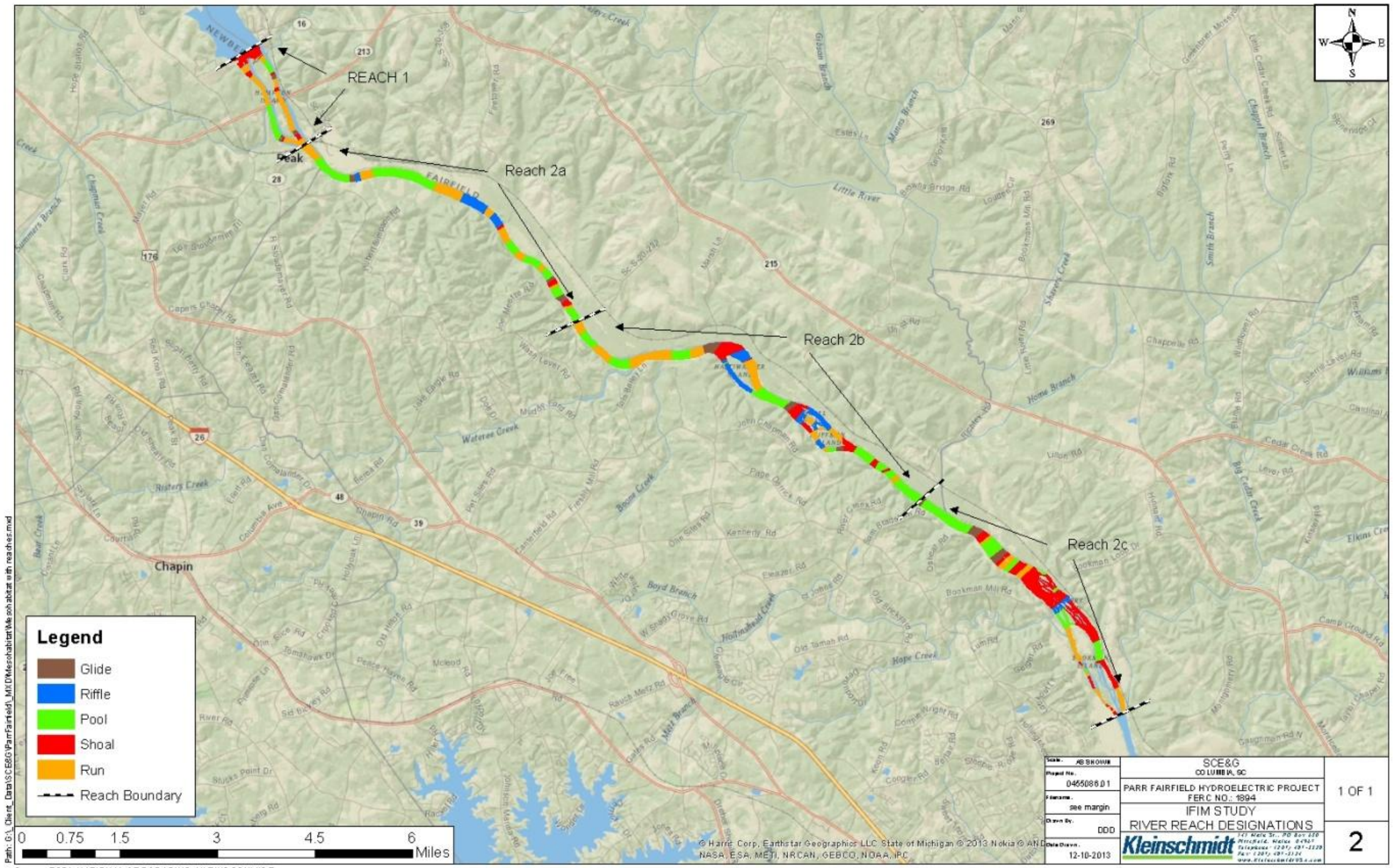


FIGURE 2 IFIM STUDY RIVER REACH DESIGNATIONS

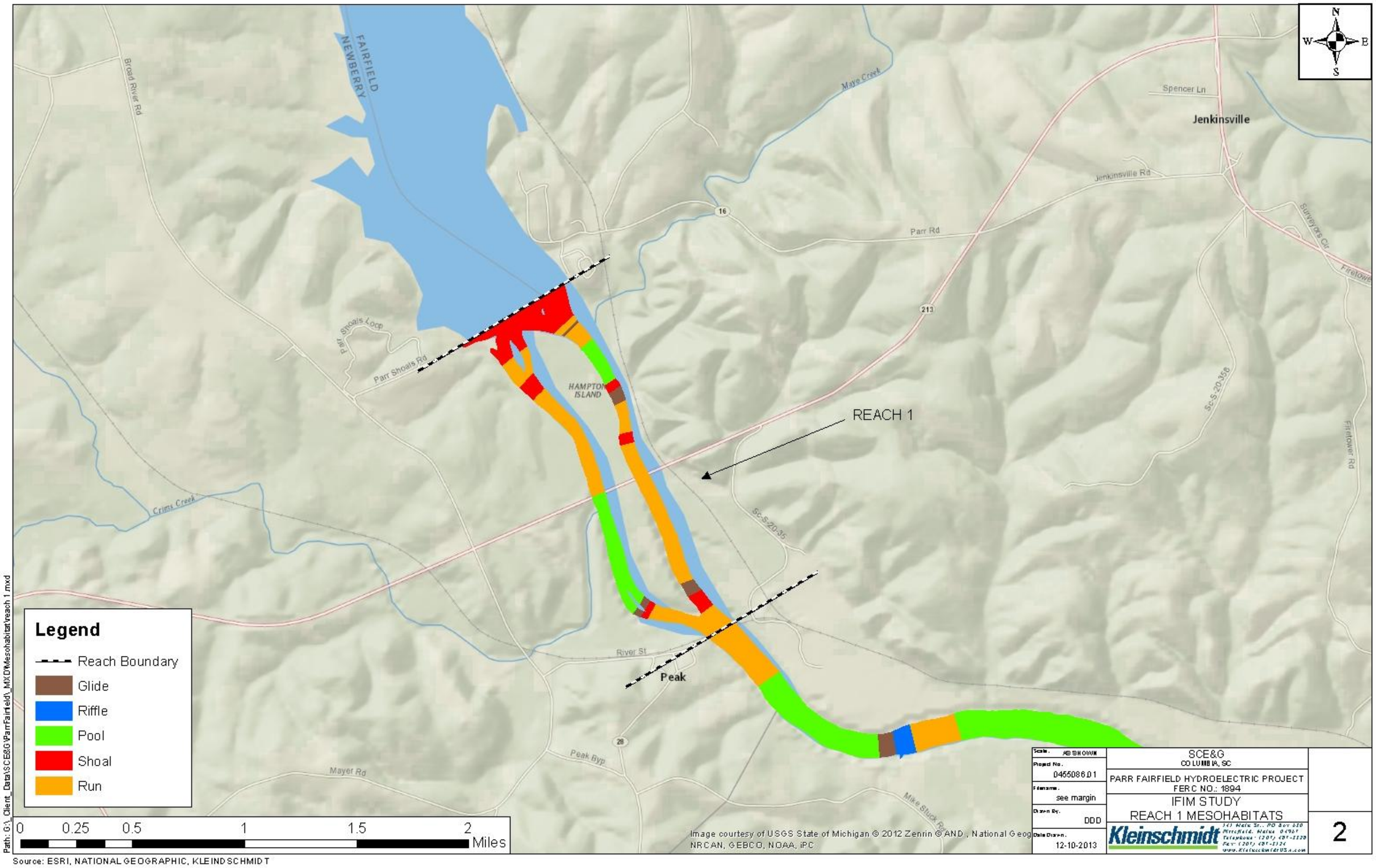


FIGURE 3 IFIM STUDY REACH 1 MESOHABITATS

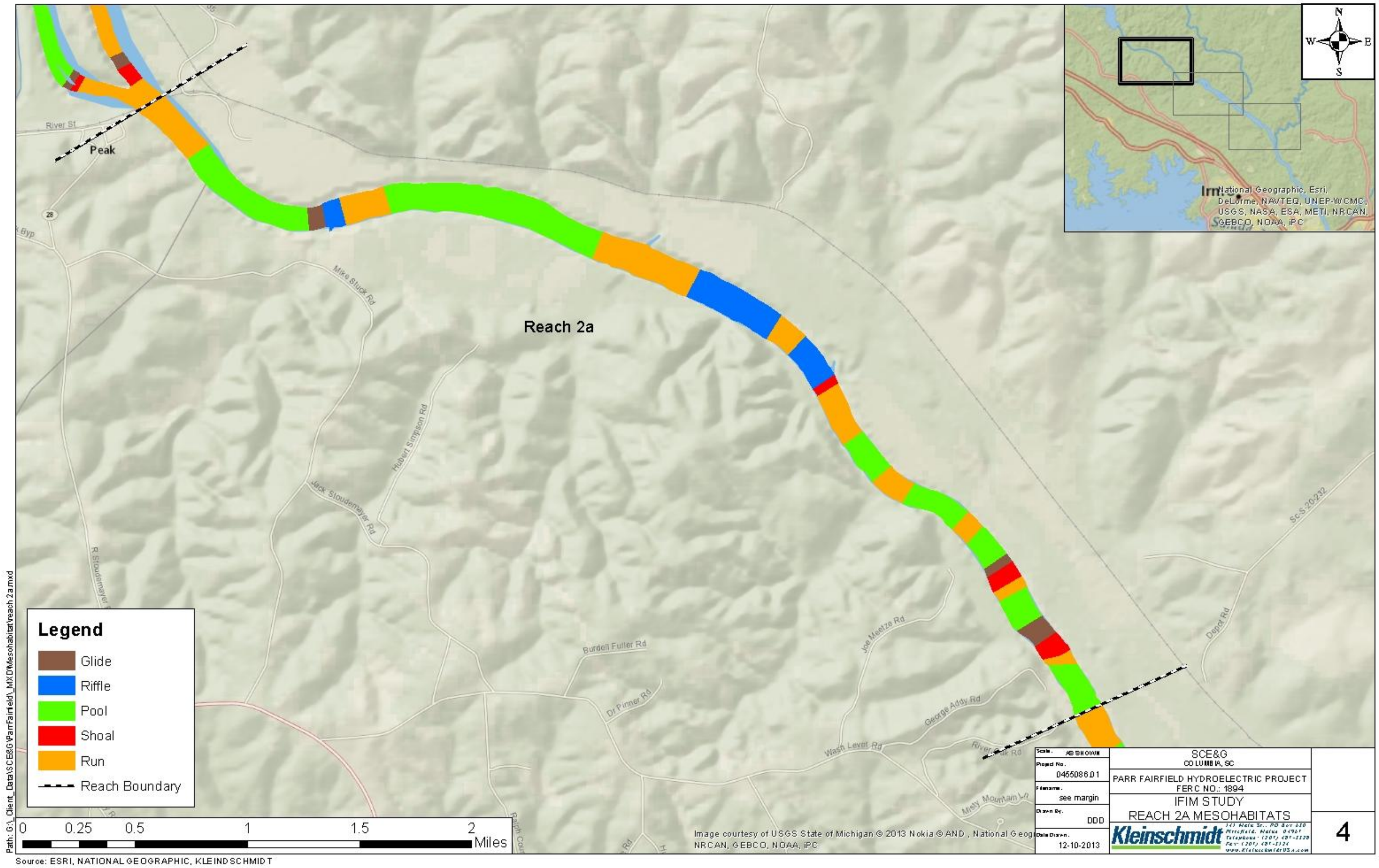
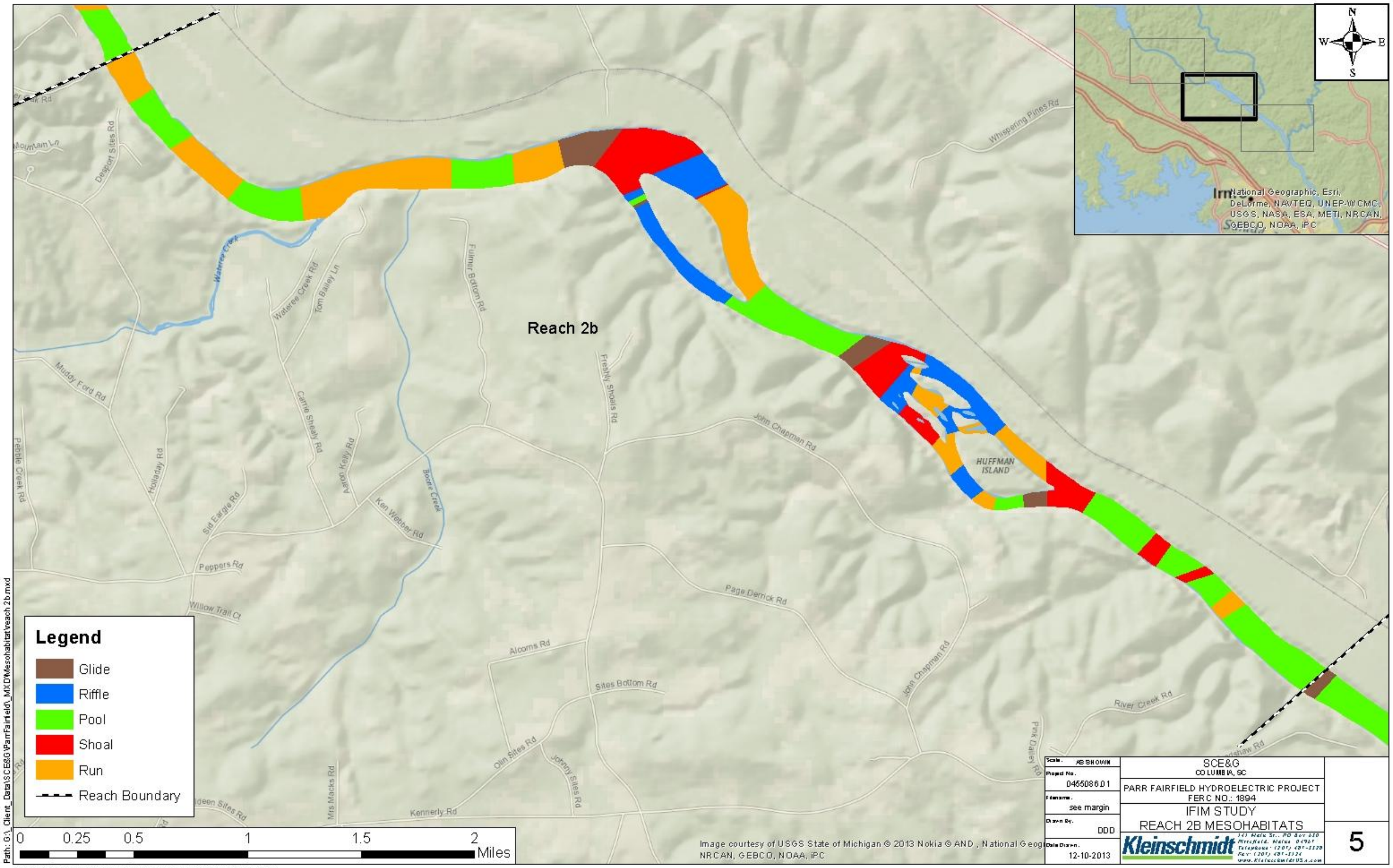


FIGURE 4 IFIM REACH 2A MESOHABITATS



Source: ESRI, NATIONAL GEOGRAPHIC, KLEINDSCHMIDT

FIGURE 5 IFIM STUDY REACH 2B MESOHABITATS

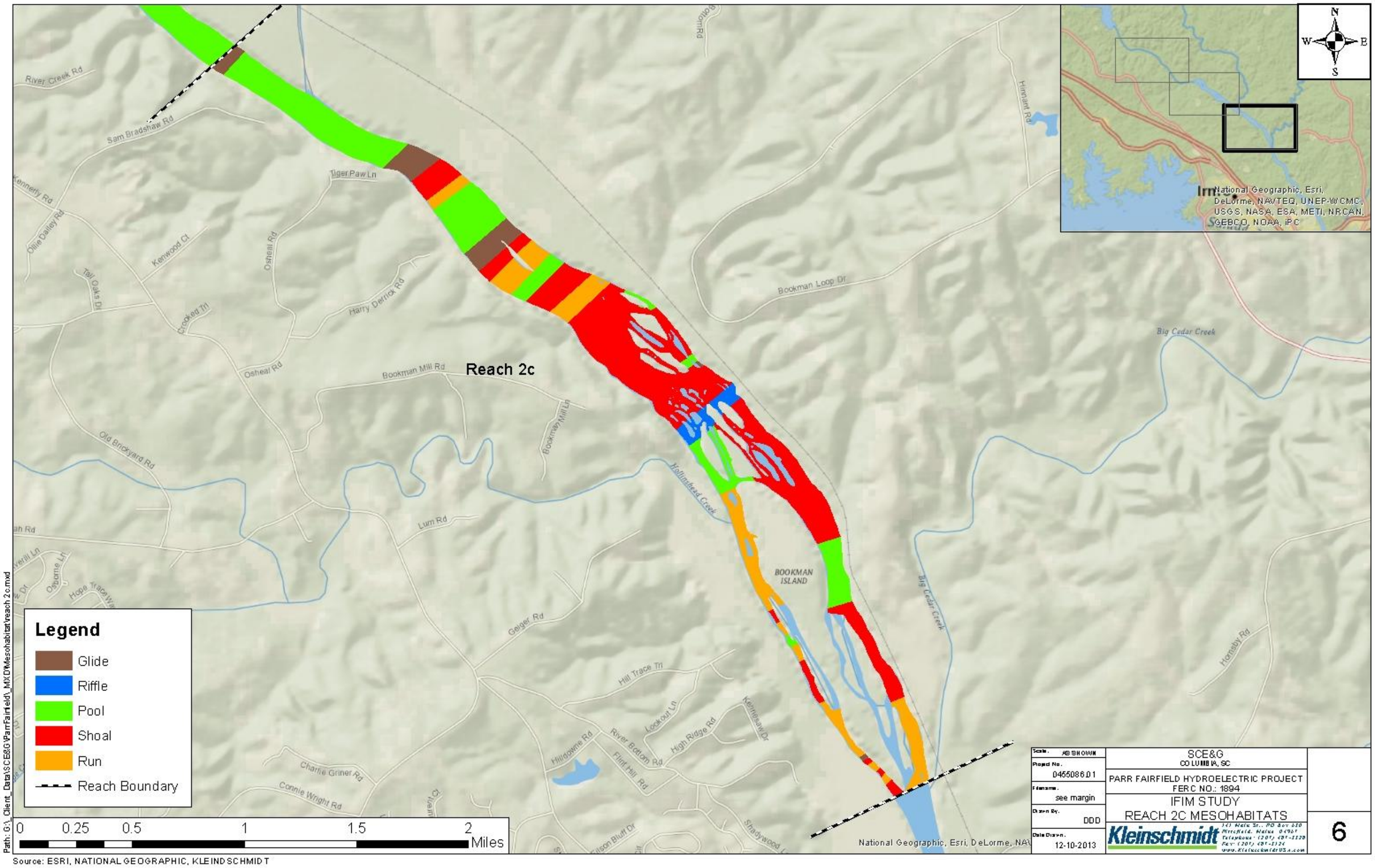
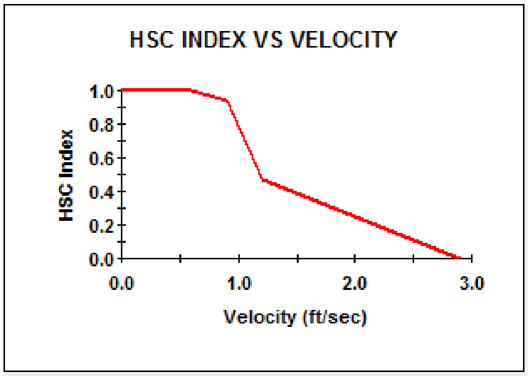


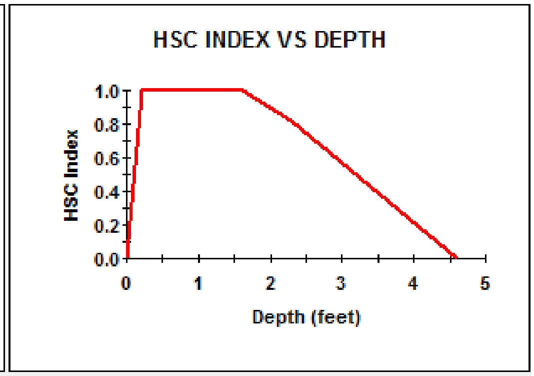
FIGURE 6 IFIM STUDY REACH 2C MESOHABITATS

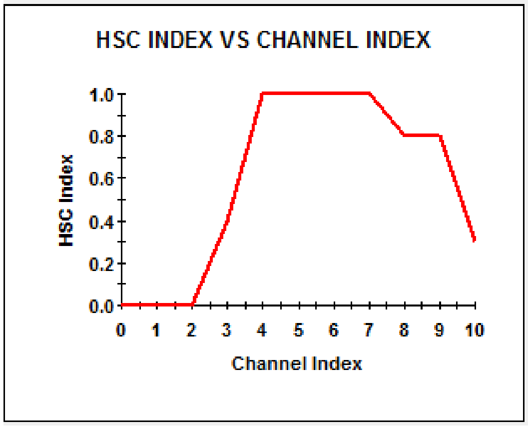
APPENDIX D

HABITAT SUITABILITY INDEX (HSI) CURVES

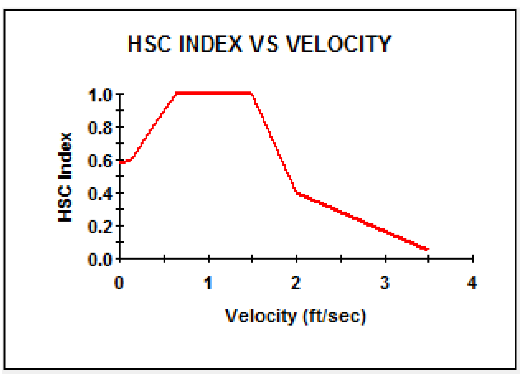
Smallmouth bass Fry

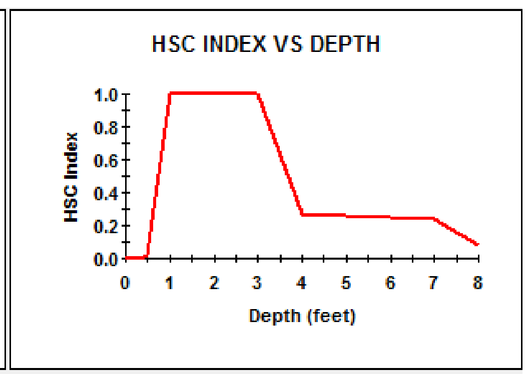


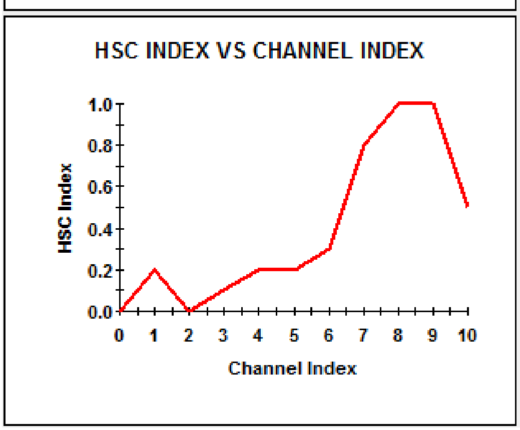




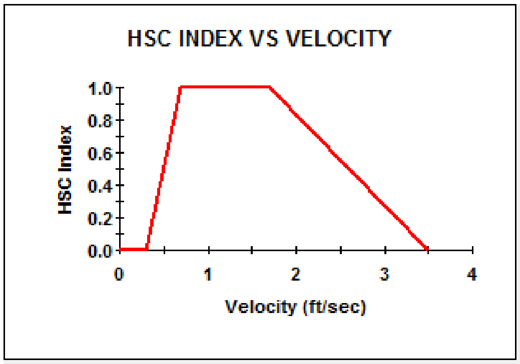
Smallmouth bass Juvenile

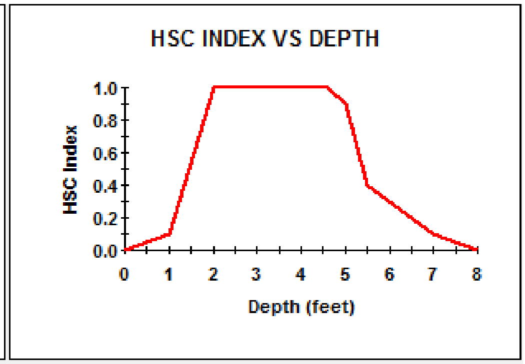


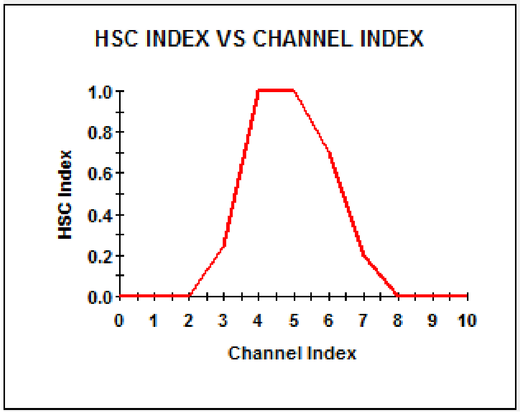




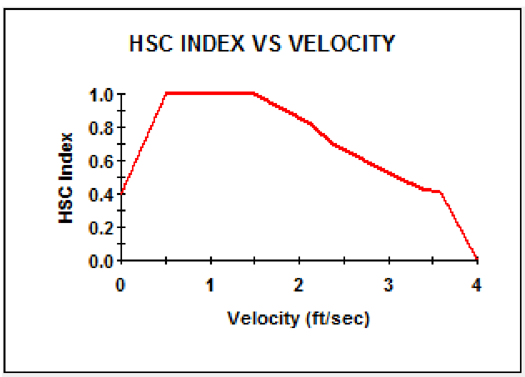
Smallmouth bass Spawning

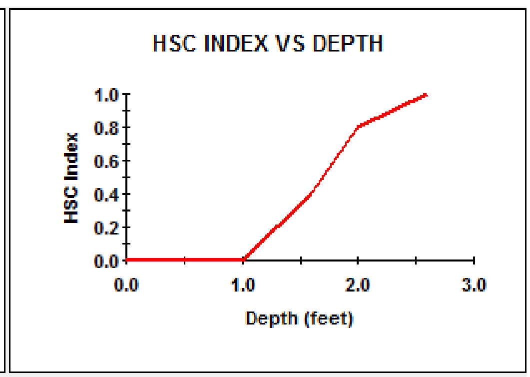


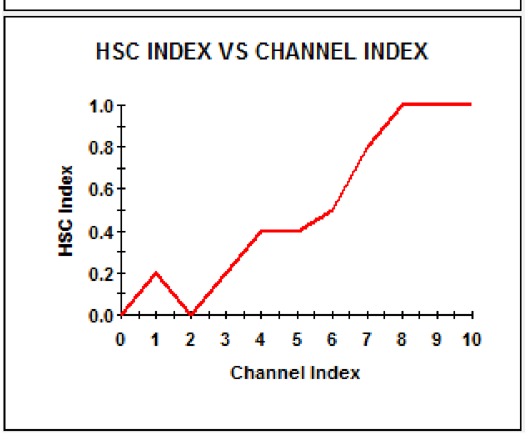




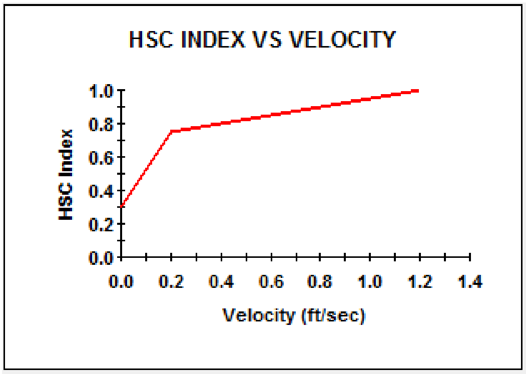
Smallmouth bass adult

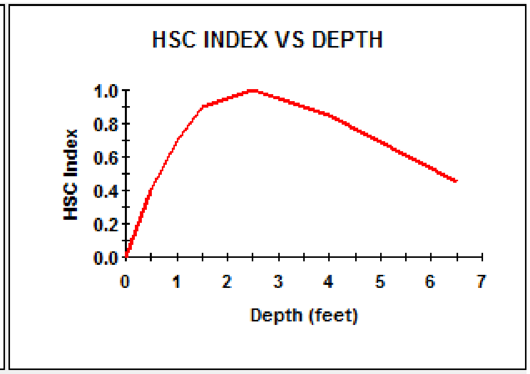


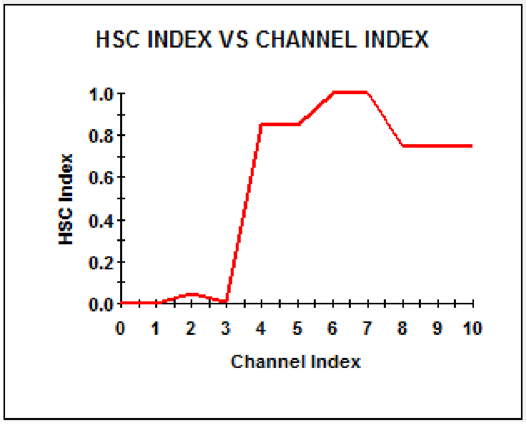




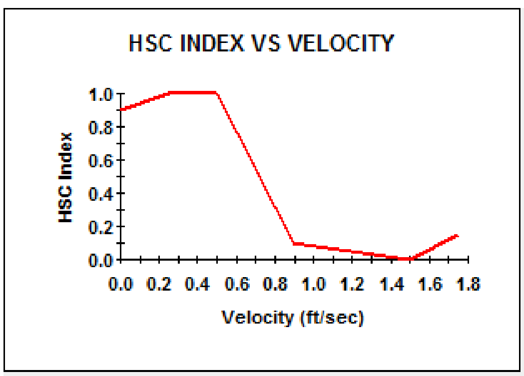
American Shad Spawning

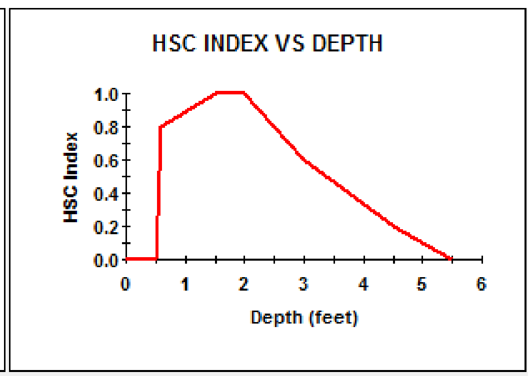


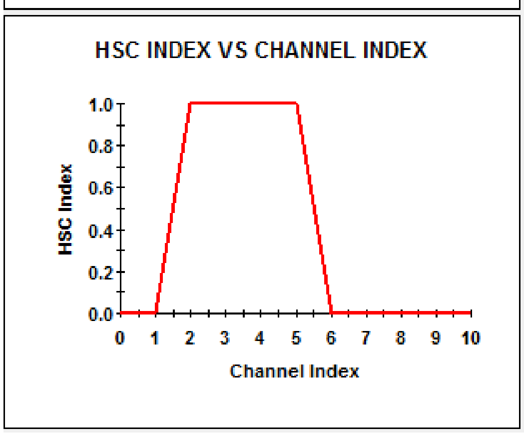




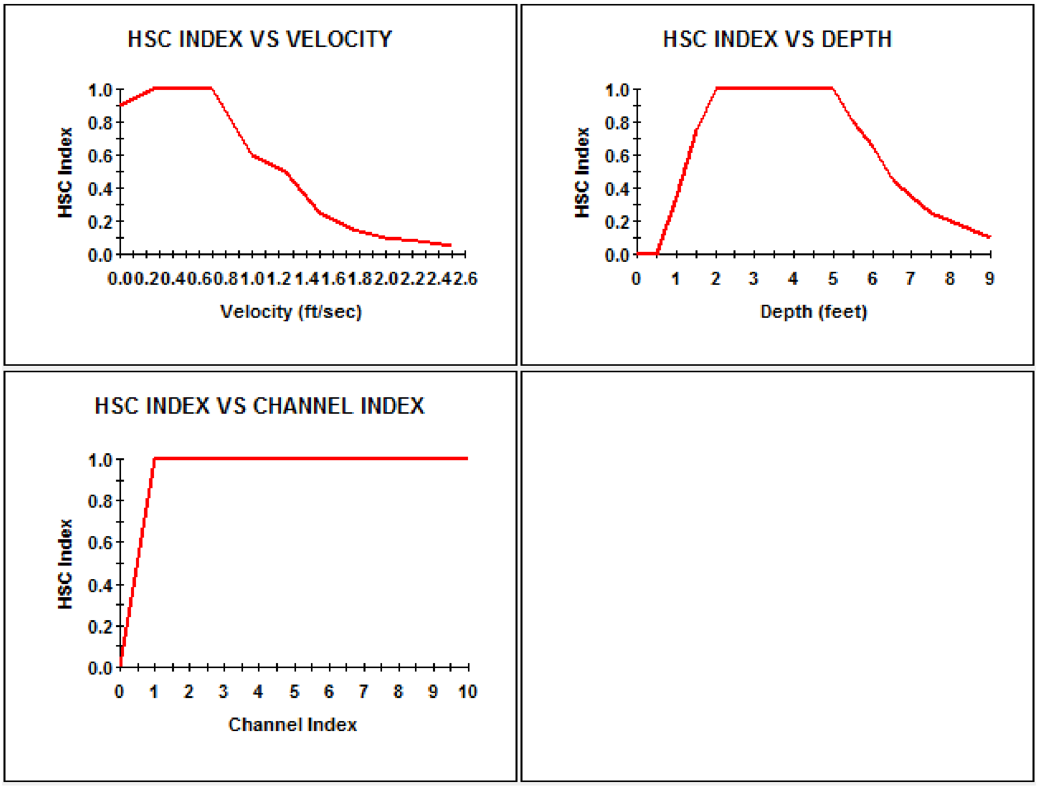
Redbreast Sunfish Spawning



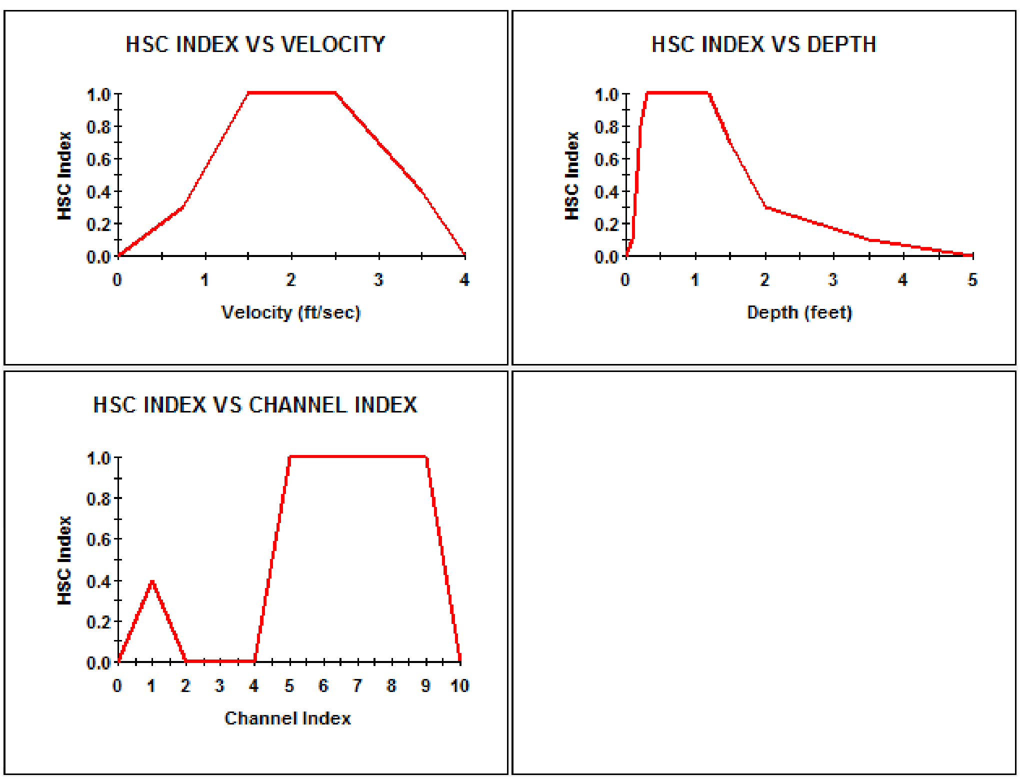




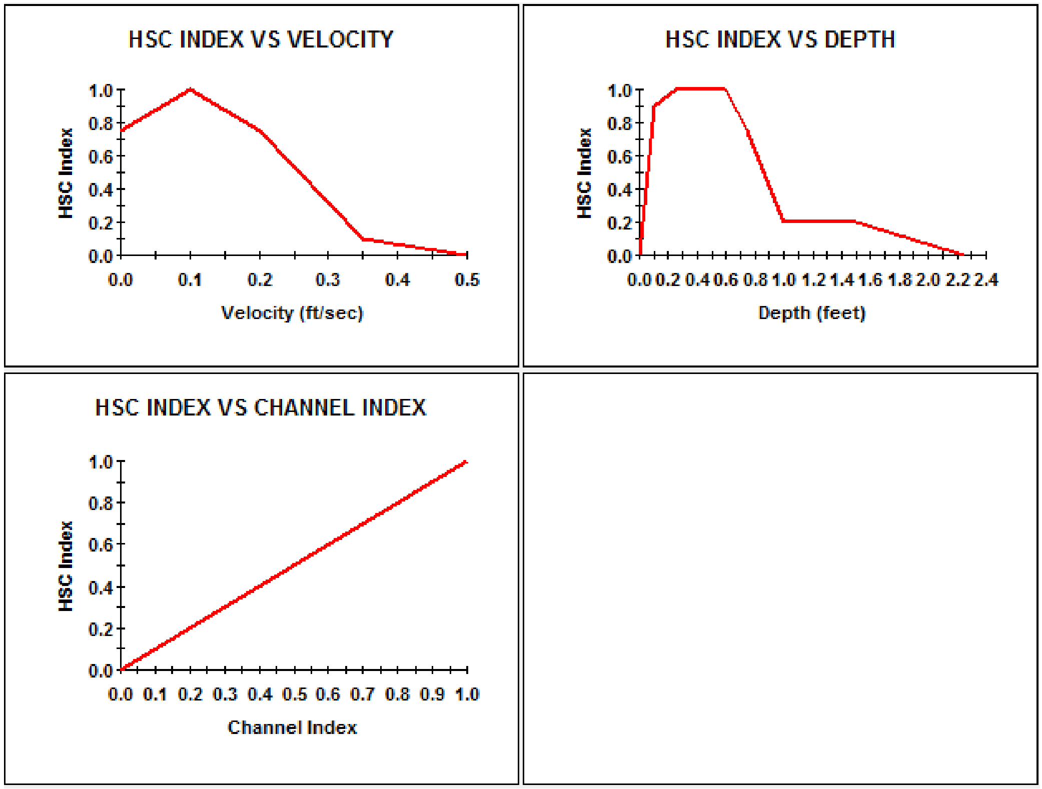
Redbreast sunfish Adult



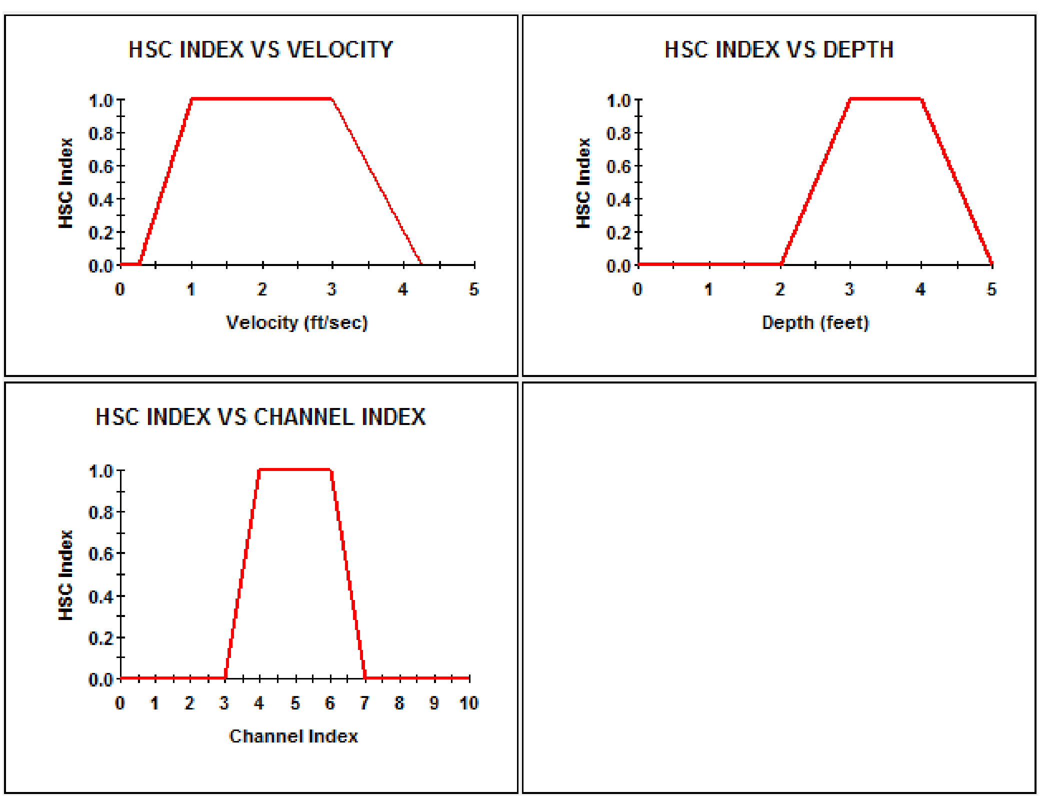
Shallow Fast



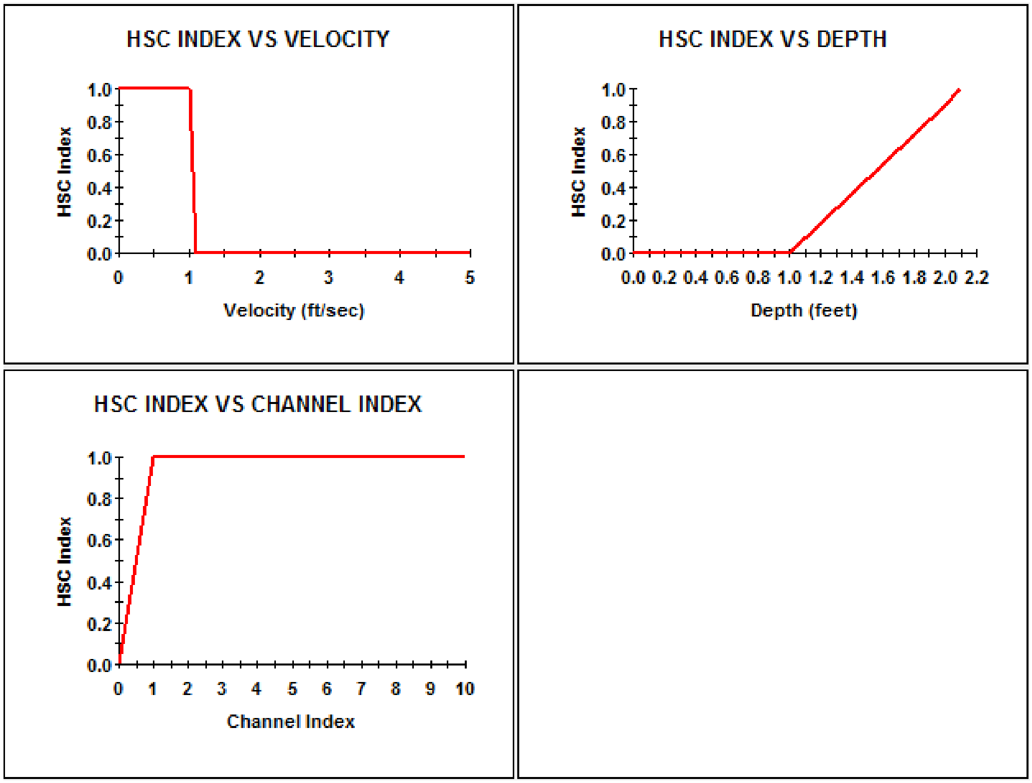
Shallow Slow



Deep Fast



Deep Slow



HSC INDEX VS VELOCITY
HSC Index
1.0
0.8
0.6
0.4
0.2
0.0
0
1
2
3
4
5
Velocity (ft/sec)
HSC INDEX VS DEPTH
HSC Index
1.0
0.8
0.6
0.4
0.2
0.0
0.0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2
Depth (feet)
HSC INDEX VS CHANNEL INDEX
HSC Index
1.0
0.8
0.6
0.4
0.2
0.0
0 1 2 3 4 5 6 7 8 9 10
Channel Index

APPENDIX E

SITE PHOTOGRAPHS

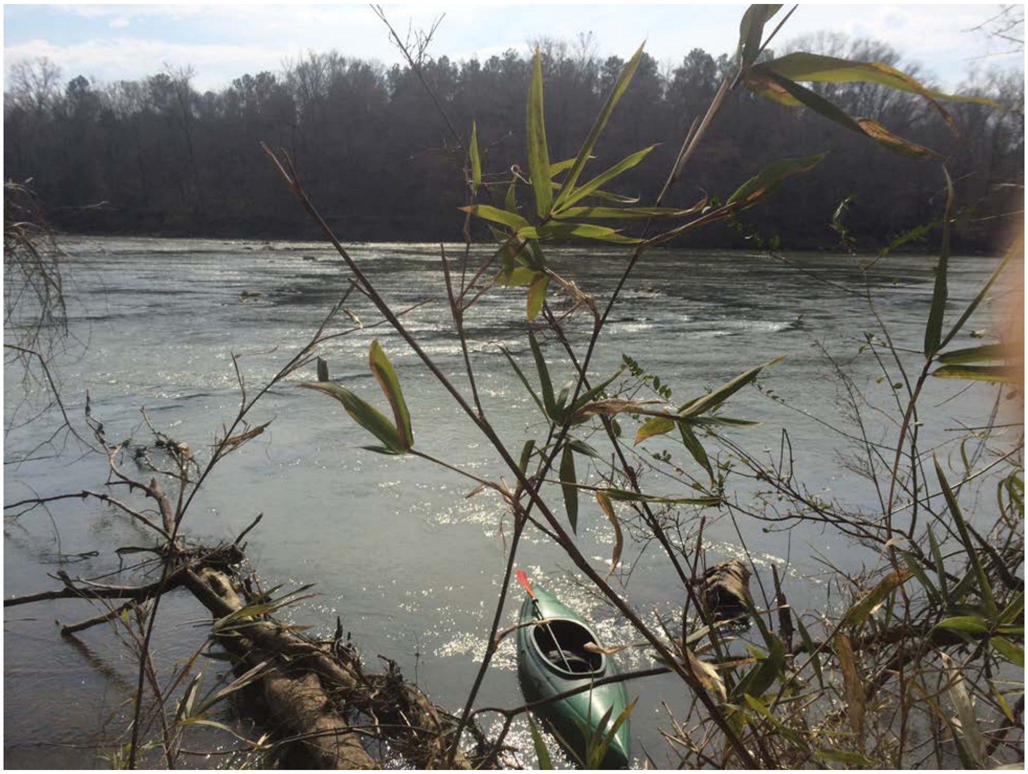
Site 1

Site 2

Site 3

Site 4

Site 5



Site 6

Site 7

Site 8

Site 9

Site 10

Exhibit E-5 Fisheries Resources

Minimum Flow Adaptive Management Plan

ADAPTIVE MANAGEMENT PLAN

MINIMUM FLOWS DOWNSTREAM OF PARR SHOALS DAM

SOUTH CAROLINA ELECTRIC & GAS COMPANY

FERC NO. 1894

Prepared by:

South Carolina Electric & Gas Company

June 2018

ADAPTIVE MANAGEMENT PLAN
FOR THE
MINIMUM FLOWS DOWNSTREAM OF PARR SHOALS DAM

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DEFINITIONS OF TERMS, ACRONYMS, AND ABBREVIATIONS

AMP	Adaptive Management Plan
AR	American Rivers
CFR	Code of Federal Regulations
cfs	cubic feet per second
Commission	Federal Energy Regulatory Commission
Compliance Limit	The instantaneous minimum flow required by FERC to be released from the Project.
CRK	Congaree Riverkeeper
CRSA	Comprehensive Relicensing Settlement Agreement
DLA	Draft License Application
FERC	Federal Energy Regulatory Commission
FLA	Final License Application
ft	foot
IFIM	Instream Flow Incremental Methodology
IFTWC	Instream Flow Technical Working Committee
installed capacity	the nameplate megawatt rating of a generator or group of generators
interested parties	individuals and entities that have an interest in a proceeding
kW	Kilowatt
kWh	kilowatt-hour
Licensee	South Carolina Electric & Gas Company
Licensing/Relicensing	the process of acquiring an original FERC license for a new proposed hydropower project; or, the process of acquiring a new FERC license for an existing hydropower project after the previous license has expired.
Low inflow protocol	An agreement between a licensee and stakeholders that provides instructions to the licensee on how to manage flows during low inflow periods.
Minimum Flow	A continuous flow, measured in CFS that is required to be released from the Project dam during specified periods of time.
Msl	mean sea level
MW	megawatt
MWh	megawatt-hour
Net inflow	The previous day's daily average inflow as calculated using the sum of the three upstream USGS gages (USGS 02156500, Broad River near Carlisle, SC; USGS 02160105, Tyger River near Delta, SC; and USGS 02160700, Enoree River at Whitmire, SC) minus evaporation from the reservoirs.
NGO	non-governmental organization

NMFS	National Marine Fisheries Services, also known as NOAA Fisheries
NOAA	National Oceanic and Atmospheric Administration, including NMFS
normal operating capacity	The maximum MW output of a generator or group of generators under normal maximum head and flow conditions
PM&E	protection, mitigation and enhancement measures
Project	Parr Hydroelectric Project (FERC No. 1894)
Project Area	Zone of potential, reasonably direct project effects within the FERC Project Boundary.
Project Boundary	The boundary line defined in the license issued by FERC that surrounds areas needed for Project purposes.
Review Committee	A group, including SCE&G and stakeholders, formed to direct the implementation of the Minimum Flow AMP. Members of the Review Committee must be signatories to the Comprehensive Relicensing Settlement Agreement.
RTWC	Recreation Technical Working Committee
SCDHEC	South Carolina Department of Health and Environmental Control
SCDNR	South Carolina Department of Natural Resources
SCE&G	South Carolina Electric & Gas Company
SHPO	State Historic Preservation Officer
Tailrace	Channel through which water is discharged from the turbines
Target Flow	The instantaneous minimum flow recommended by the IFTWC to be released from the Project.
TLP	Traditional Licensing Process
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service, an agency of the DOI
USGS	U.S. Geological Survey
WQC	Water Quality Certification, issued under Section 401 of the Federal Clean Water Act
WUA	Weighted Usable Area

ADAPTIVE MANAGEMENT PLAN
FOR THE
MINIMUM FLOWS DOWNSTREAM OF PARR SHOALS DAM

1.0 INTRODUCTION

South Carolina Electric & Gas Company (SCE&G) must file an application for a new license for its Parr Hydroelectric Project (Project) (FERC No. 1894) (Project) with the Federal Energy Regulatory Commission (FERC) by June 2018. The relicensing process is a multi-year cooperative effort between SCE&G and stakeholders, including state and federal resource agencies, non-governmental organizations and concerned citizens, to address operational, recreational and ecological concerns associated with Project operations. During the relicensing process, the potential impact of Project operation minimum flows on fishery resources, aquatic habitat, and fish/navigation passage was identified as an issue to address.

SCE&G formed the Instream Flow Technical Working Committee (IFTWC) and the Recreation Technical Working Committee (RTWC) to develop an Instream Flow Incremental Methodology (IFIM) Study and a Downstream Navigational Flow Assessment, respectively, to address the minimum flow issue. The IFTWC includes representatives from SCE&G, South Carolina Department of Natural Resources (SCDNR), South Carolina Department of Health and Environmental Control (SCDHEC), U.S. Fish and Wildlife Service (USFWS), National Ocean and Atmospheric Administration (NOAA), American Rivers, and Congaree Riverkeeper. The RTWC includes representatives from SCE&G, SCDNR, SCDHEC, NOAA, American Rivers, Congaree Riverkeeper, and other interested individuals.

During the TWC meetings, a framework for a Minimum Flow Adaptive Management Plan (AMP) was developed to address minimum flows to be released downstream of the Project during the new license term. This AMP describes the minimum flow issue and SCE&G's proposed actions to maintain minimum flows that will support fishery resources, aquatic habitat, and navigation passage downstream of the Project. These actions will be implemented during the new Project license.

1.1 PROJECT DESCRIPTION

The Project includes the 14.88-megawatt (MW) Parr Shoals Development (Parr Development) and the 511.2-MW Fairfield Pumped Storage Development (Fairfield Development) located in Fairfield and Newberry counties, South Carolina. Parr Reservoir is a 4,400-acre impoundment formed by the Parr Shoals Dam on the Broad River and serves as the lower reservoir for the Fairfield Development. Monticello Reservoir is a 6,800-acre impoundment formed by a series of four earthen dams and serves as the upper reservoir for the Fairfield Development. The existing Project license was issued by FERC on August 28, 1974 for a period of 46 years, terminating on June 30, 2020. SCE&G intends to file for a new license with FERC on or before May 31, 2018.

2.0 MINIMUM FLOW AMP REVIEW COMMITTEE

2.1 COMMITTEE MEMBERS

A Review Committee will be formed to direct the implementation of the AMP. Members of the Review Committee must be signatories to the Comprehensive Relicensing Settlement Agreement (CRSA) with the exception of NOAA Fisheries, USFWS, US Forest Service, South Carolina State Historic Preservation Office, SCDHEC and SCDNR.

SCE&G will serve as chairperson of the Review Committee, and be responsible for organizing meetings and distributing documents to committee members. Each entity will have the opportunity to select a representative to the Review Committee from within their organization.

The Review Committee will ultimately work to guide the decision making processes specified in the Minimum Flow AMP. The Review Committee will not make decisions that conflict with state or federal law. The Review Committee’s responsibilities may include, but are not limited to:

- Providing overall guidance for the AMP process;
- Evaluating other study (i.e., existing) information or information which becomes available during the time period of evaluations and would be applicable to the AMP;
- Reviewing and considering long term impacts of operational modifications on the Project and Project economics when evaluating the feasibility of implementing modifications;

- Reviewing the Minimum Flow Annual Report which documents the prior year's AMP activities which SCE&G will file with FERC, making it publicly available; and
- Advising on modifications to the AMP to be presented to FERC and advising if any amendment action is necessary during the license.

2.2 BUDGET/RESOURCES

The responsibility for implementing this AMP will rest primarily with SCE&G, as licensee for the Project. SCE&G will also rely on other resources outside of its establishment including, but not limited to, the following:

- federal, state and local grants
- donated services (federal and state agency involvement)
- equipment (purchases and loaners)
- expertise (governmental, non-governmental, private)

2.3 COMMITTEE MEETINGS

The Review Committee is tentatively scheduled to consult once per year via an in-person meeting or conference call. The frequency of meetings may be adjusted based on need. The tentative schedule is provided in Section 6.0 of this plan. Minutes from each meeting, as well as any pertinent materials discussed in the meetings will be filed with FERC as an appendix to the annual report of AMP activities, as described in Section 7.0.

3.0 GOALS AND OBJECTIVES

The overall goal of this AMP is to provide a minimum flow from the Project that considers fishery resources, aquatic habitat, and fish/navigation passage needs. This AMP provides the guidance for releasing minimum flows from the Project that consider these downstream resources. The methods that will be employed under this AMP to achieve this goal and objective are described in Section 5.0.

4.0 INSTREAM FLOW STUDIES

4.1 IFIM STUDY AND IFTWC DISCUSSIONS

SCE&G conducted an IFIM study during 2014-2016 in the Broad River from the Parr Shoals Dam to the downstream end of the Bookman Island complex (Figure 4-1) (Kleinschmidt 2016b). The IFIM study results provided quantitative estimates of habitat area at selected discharges, based on site-specific measurements of stream morphology, cover, substrate, depth, velocity and discharge gathered at transects within predetermined river reaches. These physical measurements were rated for habitat suitability based on habitat use data developed for eleven key aquatic species (and various life stages) and quantified as Weighted Usable Areas (WUA) over a range of flow releases from Parr Shoals Dam (Kleinschmidt 2016b and Meeting Notes Appendix A).

The IFTWC had multiple meetings from September 2016 through July 2017 to discuss the results of the IFIM study and to develop a recommendation for a minimum flow at the Project (Meeting Notes - Appendix A). The IFTWC conducted a float trip in October 2017 to observe target minimum flow(s) at select study sites. During the field observations, the IFTWC concurred with the minimum flow recommendations for the Project.

The IFTWC established three minimum flow periods and a series of minimum flow targets for each period (Section 5.0). The recommendation includes a “Target Flow” and a “Compliance Limit”. Because the Project is not a storage project and outflows should be related to inflow to the Project, the Target Flow is a minimum flow based on habitat data from the IFIM study results and the Compliance Limit is based on inflow exceedance values and the need for an operation margin. Target Flow and Compliance Limit will be evaluated as part of this AMP, which is anticipated to last for the first 5 years of the new license. The Review Committee will evaluate annually how well SCE&G met the Target Flow and the Compliance Limit in relation to inflows to the Project. It is SCE&G’s goal to improve the instream habitat downstream of Parr Shoals Dam and minimize the number of non-compliance events during the license. The IFTWC also agreed to an “operation margin” that would allow operations during low flow periods to be conducted without the need for a complicated low inflow protocol.

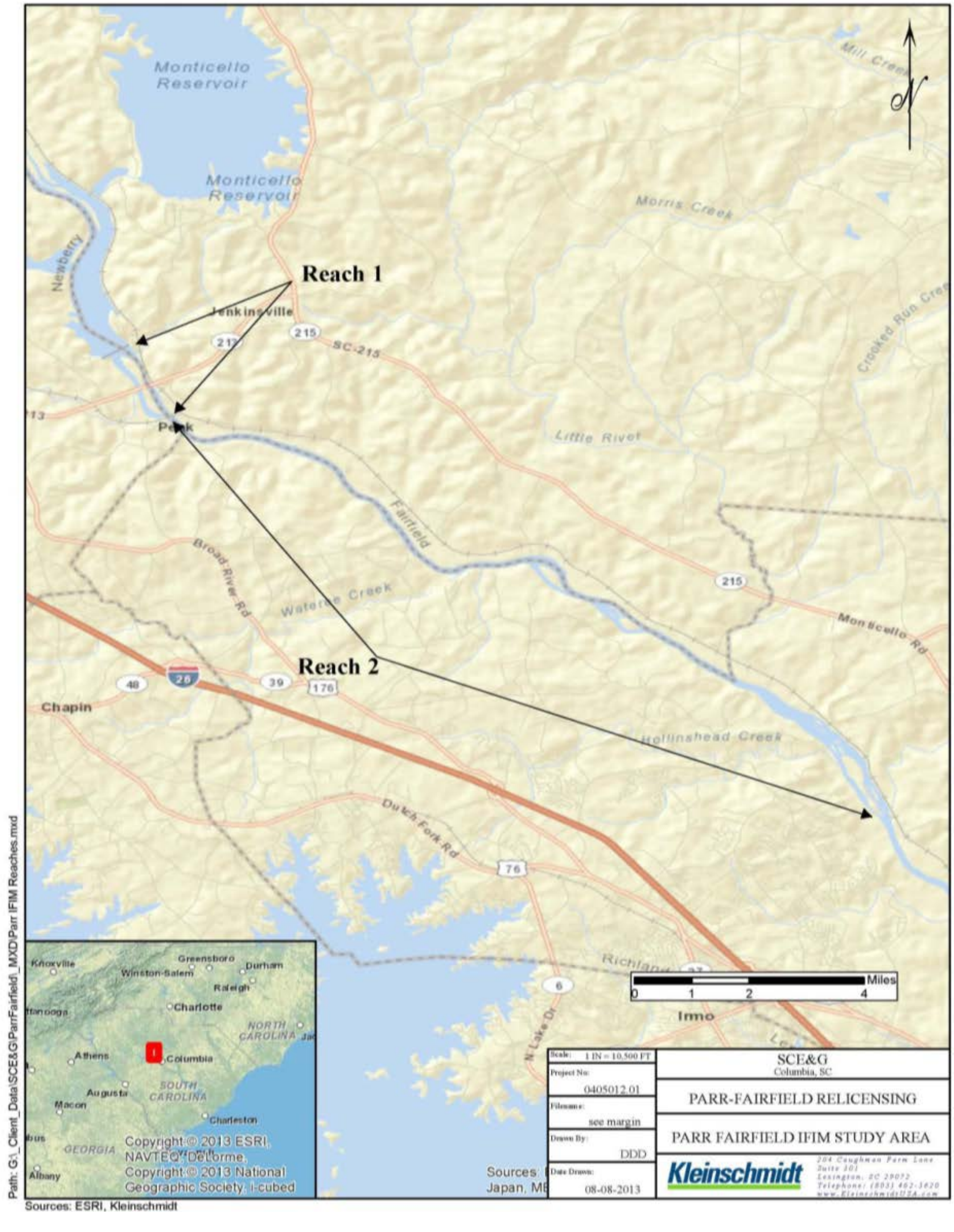

FIGURE 4-1 IFIM STUDY AREA

4.2 DOWNSTREAM NAVIGATIONAL FLOW ASSESSMENT

The Downstream Navigational Flow Assessment was conducted to ensure that the minimum flow recommendation developed during relicensing would consider the flow needed for one-way navigation in the Broad River. The recommendation for one-way navigation is defined as a "minimum depth of one foot across a channel 10 feet wide or across 10 percent of the total stream width, whichever is greater. Minimum depth does not need to occur across a continuous 10 percent of the stream width, but each point of passage must be at least 10 feet wide." One-way navigation recommendations are based on the passage of a 14 foot Jon-boat without a motor in the downstream direction only (SCWRC, 1988).

The navigational analyses evaluated constrictions on the Broad River downstream of the Parr Dam at two areas identified by the Recreation TWC. These areas were identified as "Ledge 1" and "Ledge 2" (Figure 4-2). Ledge 1 (Figure 4-3) consists of a bedrock ledge located approximately 2.4 miles upstream of Haltiwanger Island. Ledge 2 (Figure 4-4) consists of a bedrock ledge located 1.3 miles upstream of Hickory Island and approximately 0.5 miles downstream of the mouth of Little River.

Results of the assessment indicated that a flow of 500 cfs meets the passage recommendation at Ledge 1 with approximately 205 ft of cross-sectional passage provided collectively by two notches. A flow of 1,000 cfs meets the passage recommendation at Ledge 2. The navigation report noted that flows of 700 cfs provide the ‘1-foot’ passage criteria through a notch at Ledge 2 that is 66 ft wide. Although this flow does not meet the exact navigation recommendation of providing navigation across 10 percent of the total stream width, it does provide a passage point that should be sufficient for one-way passage of a 14 ft Jon-boat, canoes, and kayaks. These results were considered along with the results of the IFIM Study in developing a minimum flow recommendation for the new license.

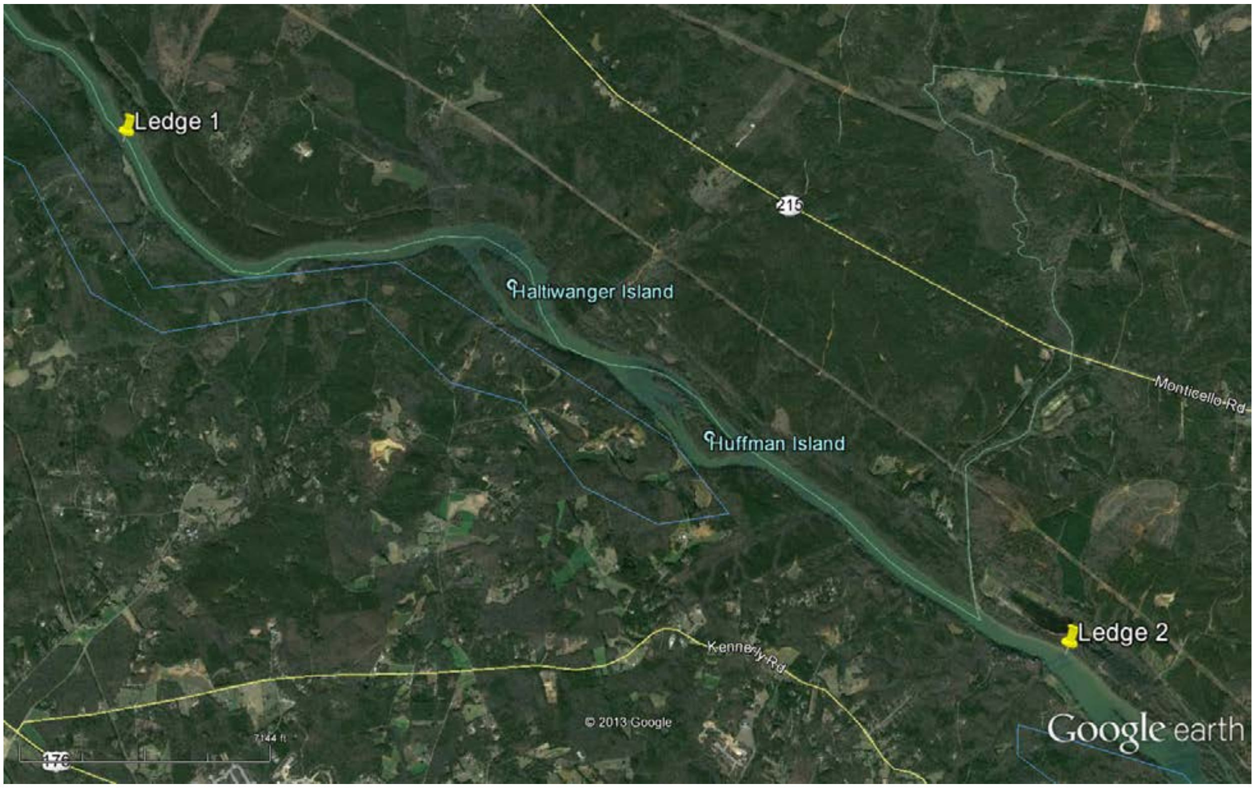

FIGURE 4-2 POINTS OF NAVIGATIONAL CONSTRICTION

FIGURE 4-3 LEDGE 1

FIGURE 4-4 LEDGE 2

5.0 MINIMUM FLOW RECOMMENDATION

The IFTWC identified several measures to implement and monitor the recommended minimum flow regime in the new operating license through the AMP. These measures are described in detail in the sections below. The timing and magnitude of the IFTWC's recommended "continuous" flows are as follows.

5.1 TARGET FLOW

A Target Flow is defined as the instantaneous minimum flow recommended by the IFTWC to be released from the Project. The Target Flow value will vary seasonally and will have "operation margin" based on inflow. During this AMP, the Review Committee will evaluate the annual flow record at the Alston gage (USGS 02161000 Broad River at Alston, SC) for meeting the Target Flow.

5.2 COMPLIANCE LIMIT

A Compliance Limit is defined as the instantaneous minimum flow required by FERC to be released from the Project. The Compliance Limit value will vary based on net inflow, but will generally be 100 to 200 cfs lower than the Target Flow. For compliance purposes, "operation margin" will allow SCE&G to discharge less than the Target Flow for up to six hours per day (with a maximum of three consecutive hours) so that flows are between the target and compliance flow without triggering a non-compliance event. This variance will be used to adjust the balance of storage between the reservoirs, and to allow for variation in flow due to equipment or human factors. When net inflow falls to 600 cfs or less, the Compliance Limit flow would be computed as net inflow minus a 50 cfs buffer. If flow releases drop below the Compliance Limit, or if flows drop below the Target Flow for longer than 6 hours a day and/or longer than 3 consecutive hours, SCE&G will notify the Review Committee within ten days and will include the deviation and reason for that deviation in the annual report to FERC.

A goal of the AMP is to reduce the number of hours per day and the number of consecutive hours of flows between the target and compliance flow values, to the extent that a reduction is shown to be possible based on operational experience during the term of the AMP.

5.3 Calculation of Net Inflow and Target Flows

Net inflow is defined as the previous day's daily average inflow as calculated using the sum of the three upstream USGS gages[1] minus evaporation from the reservoirs. Evaporation for the Parr and Monticello reservoirs is based on standard accepted evaporation methodology. Monthly evaporation values for each reservoir, calculation of those values, and citations for the methodology used are provided in Appendix B.

The previous day's daily average inflow would be based on midnight to midnight of the previous day, and the new Target Flow would be implemented from noon of the current day to noon of the next day. When the previous day's net inflow is below the prescribed Target Flow but above the Compliance Limit, the new target flow would be computed as the net inflow. The Compliance Limit would fluctuate based on how low the net inflow is below the prescribed Target Flow as shown in Section 5.4 below.

When net inflow falls to 600 cfs or less, the new Compliance Limit flow would be computed as net inflow minus a 50 cfs buffer. This step will allow an operation margin for SCE&G to recover up to 50 cfs for up to six hours during each day (with a maximum of three consecutive hours) during low flow periods. This provision will take the place of a low inflow protocol for the project.

5.4 Minimum Flow Recommendation

Table 5-1 describes the specifics of a Minimum Flow Recommendation for the Project. This recommendation identifies Target Flows and Compliance Limits in relation to net inflows into the Project.

1 (USGS 02156500, Broad River near Carlisle, SC; USGS 02160105, Tyger River near Delta, SC; and USGS 02160700, Enoree River at Whitmire, SC)

TABLE 5-1 PARR MINIMUM FLOW RECOMMENDATION

	Net Inflow (cfs)	Minimum Target Outflow (cfs)	Compliance Outflow (cfs)
High Flow Period Feb 1 – April 30	> 2300	2300	2100
	≤ 2300 and > 2200	net inflow	2100
	≤ 2200 and ≥ 600	net inflow	(net inflow minus 100 cfs) or 550 cfs whichever is greater
	< 600	net inflow	net inflow minus 50 cfs
Transitional Flow Periods Dec 1 – Jan 31; May 1 – May 31	>1500	1500	1300
	≤ 1500 and > 1400	net inflow	1300
	≤ 1400 and ≥ 600	net inflow	(net inflow minus 100 cfs) or 550 cfs whichever is greater
	< 600	net inflow	net inflow minus 50 cfs
Low Flow Period June 1 – Nov 30	> 1000	1000	900
	≤ 1000 and ≥ 600	net inflow	(net inflow minus 100 cfs) or 550 cfs whichever is greater
	< 600	net inflow	net inflow minus 50 cfs

6.0 SCHEDULE

The AMP schedule is described in the table below in relation to the issuance of the license by FERC.

TABLE 6-1 AMP IMPLEMENTATION SCHEDULE

Period	Item
Within 90 days of license issuance	Submit Updated Minimum Flow AMP to FERC
Within 120 days of license issuance	Form Review Committee and review Minimum Flow AMP
Year 1 of new license	• Implementation of Minimum Flow • Review Committee annual meeting February of following year • File Annual Report with FERC – April 30th after Review Committee meeting
Year 2 of new license	• Implementation of any AMP-Minimum Flow changes • Review Committee annual meeting February of following year • File Annual Report with FERC – April 30th after Review Committee meeting

Year 3 of new license	• Implementation of any AMP-Minimum Flow changes • Review Committee annual meeting February of following year • File Annual Report with FERC – April 30th after Review Committee meeting
Year 4 of new license	• Implementation of any AMP-Minimum Flow changes • Review Committee annual meeting February of following year • File Annual Report with FERC – April 30th after Review Committee meeting
Year 5 of new license	• Implementation of any AMP-Minimum Flow changes • Review Committee annual meeting February of following year • Develop recommendation for completion or continuation of AMP • File Annual Report and Final AMP Recommendations with FERC – April 30th after Review Committee meeting

7.0 COMPLIANCE

Compliance will be based on following the schedule in Section 6.0 and the submission of an annual AMP report to FERC. The annual report will contain a summary of all AMP activities and data, including an assessment of the extent to which goals and objectives were achieved. The report will be made available to appropriate entities for review and comment at least 30 days prior to being submitted to FERC. All comments on the report, pertinent correspondence, and Review Committee meeting minutes will be appended to the annual report.

At the end of the 5-year AMP period, the Review Committee will provide final recommendations to FERC on extension or completion of the AMP. If the AMP is completed, then final compliance criteria will be proposed by the Review Committee for use during the remainder of the license.

8.0 REFERENCES

Kleinschmidt Associates. 2016a. Downstream Navigational Flow Assessment. September 2016.

Kleinschmidt Associates. 2016b. Instream Flow Study Report. October 2016.

South Carolina Water Resources Commission (SCWRC). 1988. Instream Flow Study Phase II: Determination of Minimum Flow Standards to Protect Instream Uses in Priority Stream Segments: A Report to the South Carolina General Assembly. Available Online [URL]: http://scwaterlaw.sc.gov/Instream%20Flow%20Study%20ph2.pdf. Accessed August 2013.

APPENDIX A

SUMMARY OF CONSULTATION

Appendix A

The Instream Flow TWC, a sub-section of the Water Quality, Fish and Wildlife RCG, convened often throughout the relicensing process to discuss the development of the Minimum Flows AMP. A list of meeting dates pertinent to the development of this AMP is included below. The complete consultation record for the development of this AMP, including notes from the meetings listed below, can be found in Appendix A of the Final License Application's Exhibit E.

- Instream Flow TWC Meeting – March 5, 2014
- Instream Flow TWC Meeting – September 27, 2016
- Instream Flow TWC Meeting – January 24, 2017
- Joint[1] RCG Meeting – March 28, 2017
- Joint RCG Meeting – July 13, 2017

[1] A Joint RCG Meeting refers to a meeting where all RCGs are present, including the Water Quality, Fish and Wildlife RCG, the Lake and Land Management and Recreation RCG, and the Operations RCG.

Appendix B

Evaporation Methodology

Estimated Evaporation from Parr and Monticello Reservoirs

Evaporation, Central SC			Reservoir Evaporation Loss Estimates in CFS					
	Avg. Monthly FWS Evap. (in).	Evap. Rate (CFS/1000 ac.)	Monticello Evap. Rate (CFS)	VCS Increased Evap. Rate (CFS)	Parr Evap. Rate, (CFS)	**Total Evap. Rate Incl. VCS (CFS)**	**Total Evap. Rate Not Incl. VCS (CFS)**	**Total Evaporation (ac-ft)**
January	1.29	1.75	12	20	8	**40**	**20**	**2,462**
February	1.82	2.74	19	21	12	**51**	**31**	**2,845**
March	3.19	4.33	29	21	19	**70**	**48**	**4,282**
April	4.50	6.31	43	23	28	**93**	**71**	**5,553**
May	5.24	7.10	48	24	31	**103**	**79**	**6,356**
June	5.53	7.75	53	25	34	**112**	**87**	**6,656**
July	5.77	7.82	53	26	34	**113**	**88**	**6,953**
August	5.00	6.78	46	25	30	**101**	**76**	**6,231**
September	4.03	5.64	38	24	25	**88**	**63**	**5,207**
October	3.08	4.18	28	23	18	**70**	**47**	**4,276**
November	2.00	2.80	19	21	12	**53**	**31**	**3,127**
December	1.37	1.85	13	20	8	**41**	**21**	**2,523**
Whole Year	**42.8**	**4.92**	**33**	**23**	**22**	**78**	**55**	**56,473**
May-October	**28.7**	**6.54**	**45**	**24**	**29**	**98**	**73**	**35,680**
	(Sum)	(Average)	(Average)	(Average)	(Average)	(Average)	(Average)	(Sum)

Source: Pan Evaporation Records for the South Carolina Area, John C. Purvis, South Carolina State Climatology Office
FWS values were computed as 75 percent of pan evaporation values.
This factor was estimated from a discussion in NOAA Technical Report NWS 33, Evaporation Atlas for the 48 Contiguous States.

Reservoir evaporation loss estimates are based on surface areas of 6,800 acres for Monticello and 4,400 acres for Parr.

The conversion from evaporation in inches to evaporation rate in CFS per thousand acres is:

(inches) x (1 ft/12 in) x (1 month/31 [or 30 or 28] days) x (43,560 SF/acre) x (1 day/86,400 sec) x (1,000 acres/thousand acres)

Increased evaporation from V.C. Summer Station is estimated using information provided by VCS, and is based on average ambient temperature for each month.

Exhibit E-5 Fisheries Resources

Downstream Flow Fluctuations Memo

December 16, 2015

Parr Hydroelectric Project – FERC No. 1894
Downstream Flow Fluctuations – Memorandum

TO:	Parr/Fairfield Relicensing Water Quality, Fish and Wildlife Resource Conservation Group (RCG)
FROM:	Kelly Miller and Henry Mealing – Kleinschmidt Associates
DATE:	December 16, 2015
RE:	Downstream Flow Fluctuations – Initial Analysis

As part of the comments received on the Preliminary Application Document (PAD), several agencies requested additional information on the periodic flow fluctuations from the Parr Hydroelectric Project (Project). At the August 26, 2015 relicensing meeting, stakeholders presented concerns that flow fluctuations from the Project could impact the spawning of several species of fish in the Broad River downstream of the Project and extending downstream to where Highway 601 crosses the Congaree River. The target species identified in the meeting were shortnose sturgeon, American shad, striped bass, and robust redhorse. Target spawning months include January through May (RCG Meeting Notes 08-26-2015).

As the initial step in addressing these concerns, flow records for 2010-2015 were collected from USGS for the following gage locations: Carlisle (2156500), Tyger (2160105), Enoree (2160700), Alston (2161000), Saluda downstream of Lake Murray (2169000), and the Congaree River (2169500). Flows were compared from January through May on an annual basis, and were prorated based on drainage areas. All flow data will be provided on a CD upon request by RCG members.

Methods

Hourly inflows to the Project were prorated using data from the Carlisle, Tyger, and Enoree gages, which represent the contributing drainage area of the Parr Reservoir. A regional coefficient and exponent, which were determined by regression analysis as part of the Parr operations model inflow dataset development[1], were applied to the ratios for accuracy. These flows were graphically compared with the Project outflow data (from the Alston gage), and an offset applied to account for flow travel time; a shift of 9 hours was visually determined to best fit the datasets, based on inflow events exceeding 40,000 cfs, which are outside of the Project impact. The comparison of these datasets gave a depiction of the frequency and magnitude of how Project operations affect downstream flow. Shifts in streamflow greater than 2,000, 3,000, 5,000 and 10,000 cfs (on an hourly basis) were identified.

Flow records from Carlisle, Tyger and Enoree gages were summed and prorated to the drainage area of the Broad River, approximated by subtracting the drainage area of the Saluda gage from

[1] Kleinschmidt, "Inflow Dataset Development: Statistical Methodology," May 2014.

that of the Congaree gage. This dataset was added to flow records from the Saluda gage, then compared with the Congaree gage data. This provided an hourly estimate of downstream flows without the influence of the Parr Project operations. Flow records from the Alston gage were also prorated and added to flow records from the Saluda gage, and then compared with the Congaree gage data. This allowed for the observation of flow attenuation downstream, or the persistence of a peak wave down to the upper portion of the Congaree River. It also showed how the Saluda Hydro Project influenced flows in the Congaree River. Flows prorated down to the Congaree area were prorated using direct area only, as no regional coefficient or exponent has been determined for this additional drainage area. As with the inflow comparison with the Alston data, the upstream datasets were offset to account for flow travel time (18 hours for the three gages upstream of the Project, and 7 hours to the Alston data).

Discussion

Inflow, which was calculated by adding flows from the Carlisle, Tyger and Enoree gages, was compared to outflow, represented by the Alston gage flows (Appendix A - Figures 1 through 6).

Shifts in streamflow greater than 2,000, 3,000, 5,000, and 10,000 cfs on an hourly basis were identified for the entire period of study (January-May, 2010-2015). Because this evaluation accounts for hourly differences, the percent of time the difference occurs is provided, rather than the number of flow variance events. The average percent of time these variances occur is provided, not the number of flow variance events in any given month or year (which independently could last longer than one hour). The results of these magnitudes and frequency of occurrence are shown in Table 1 below. The frequency and magnitude of flow shifts varied with hydraulic year and operation demands.

Flow Variance	% of Occurrence
2000	20.0%
3000	11.5%
5000	4.7%
10000	0.9%

Table 1 – Project-Induced Flow Variance Magnitude and Frequency

Prorated flow datasets from Carlisle, Tyger and Enoree gages combined with flows records from Saluda, which represents Congaree River inflows without the influence of the Project operation, were graphically compared to flows as recorded by the Congaree River gage (Appendix A - Figures 7 through 12).

Finally, prorated Alston flows added to the flow records from Saluda to compare flows upstream of the Congaree River, which takes into account effects of the Parr Project operations were graphically compared to flows as recorded by the Congaree River gage (Appendix A - Figures 13 through 18).

Figures 19 through 24 in Appendix A depict flow releases from Alston with and without the addition of Saluda flow contributions. This demonstrates that some of the spikes in flow downstream at Congaree are attributed to contributions from the Saluda River, and not the Parr Project.

Next Steps

The RCG should review this information and provide their input to move to the next steps.

1. Does it look like there may be a potential impact on downstream fish spawning? If so, please provide reasons for that assumption.

2. Provide any potential RCG requests that may move towards diminishing the flow impact?

Based on RCG input, SCE&G will go to their Operations Group and determine if the suggested changes are feasible. If the RCG can provide timely input, SCE&G may be able to perform a few one-day tests at the Project to see if the operation changes can be implemented and whether they 1) diminish the peak; 2) cause inconsistencies with safety at the plant, or 3) increase the chances of upstream flooding issues.

APPENDIX A

FLOW DATA

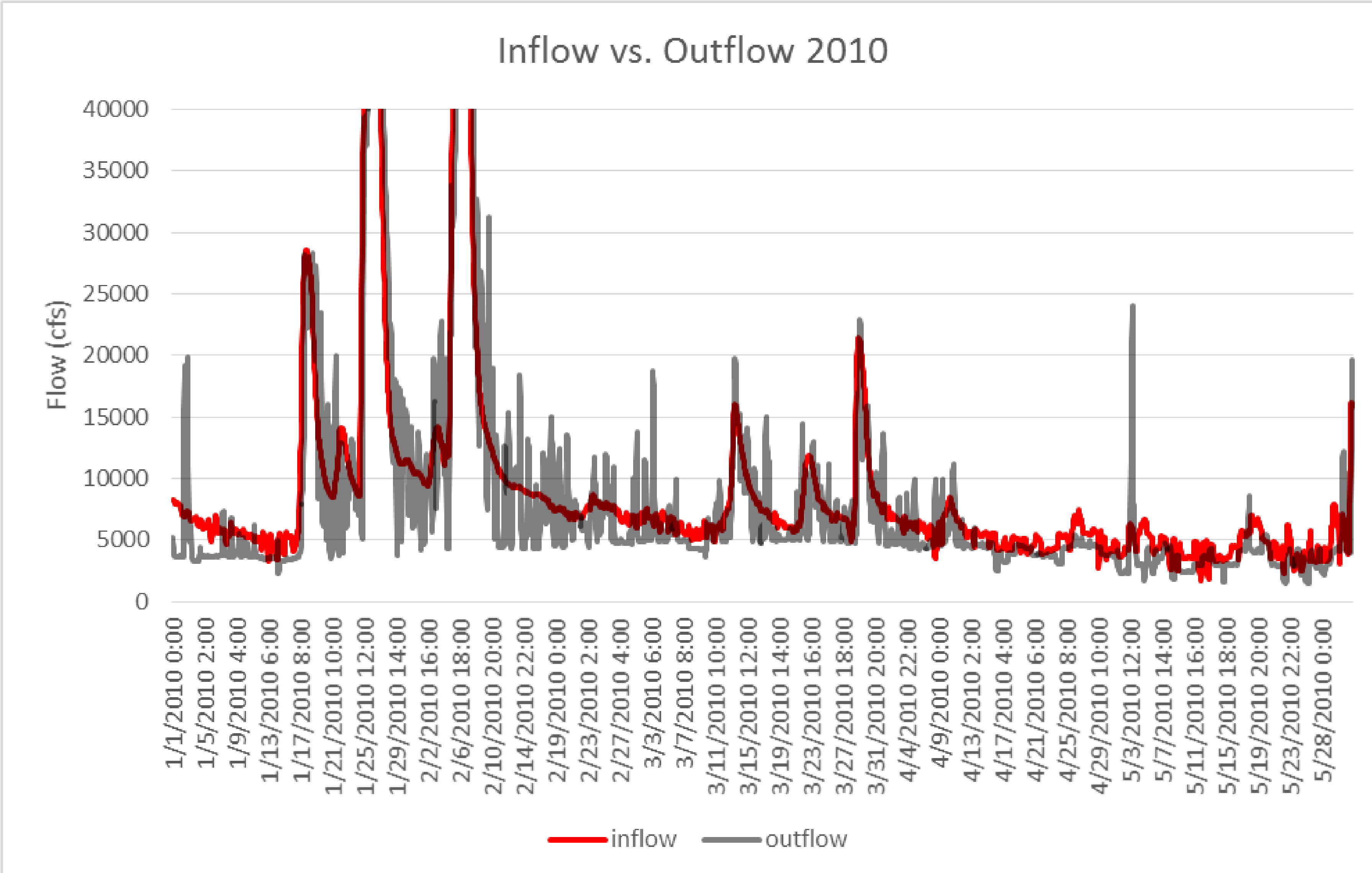

Figure 1 2010 Parr Project Inflow (Carlisle, Enoree, Tyger Gages) vs. Outflow (Alston Gage)

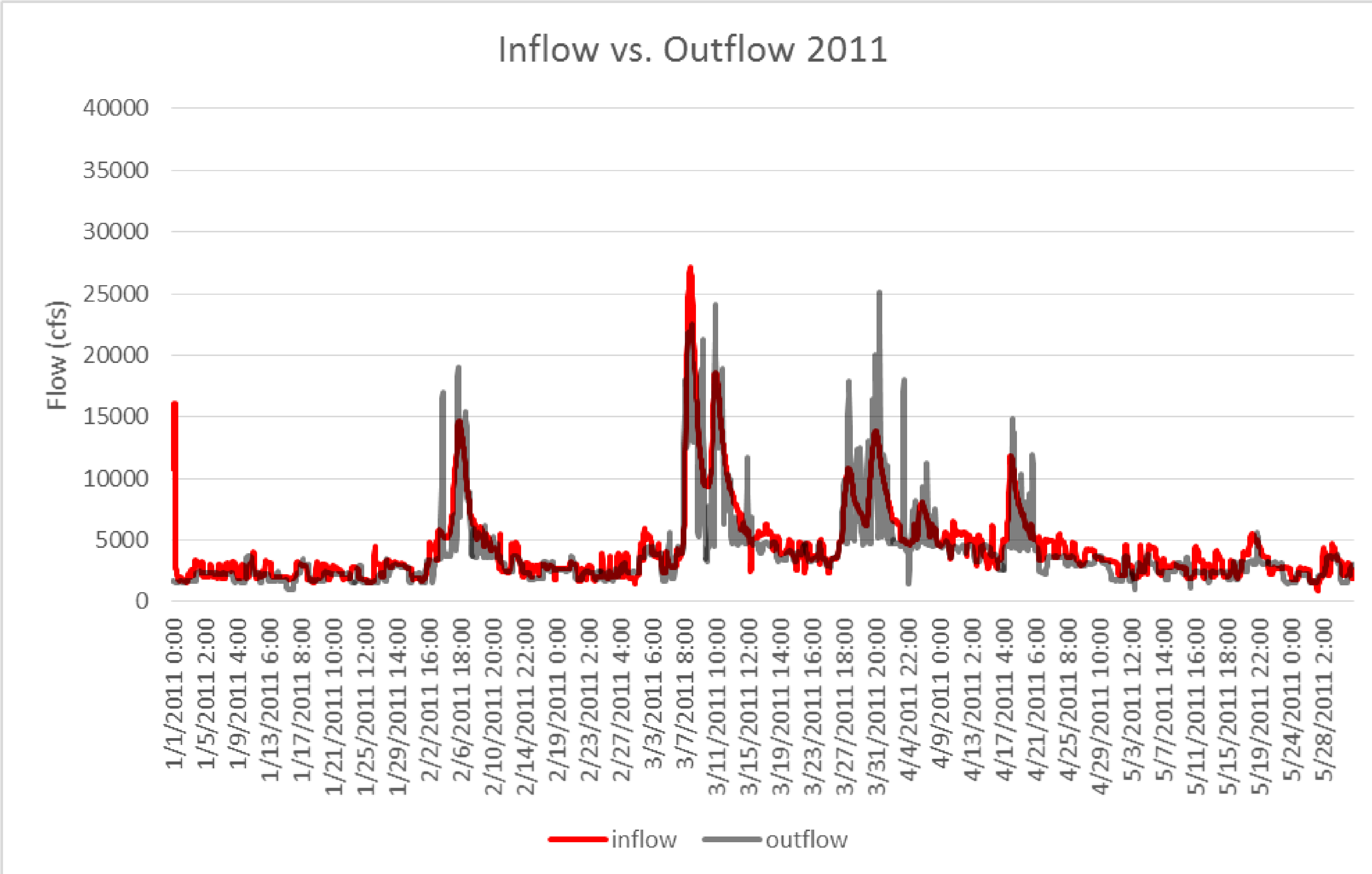

FIGURE 2 2011 PARR PROJECT INFLOW (CARLISLE, ENOREE, TYGER GAGES) VS. OUTFLOW (ALSTON GAGE)

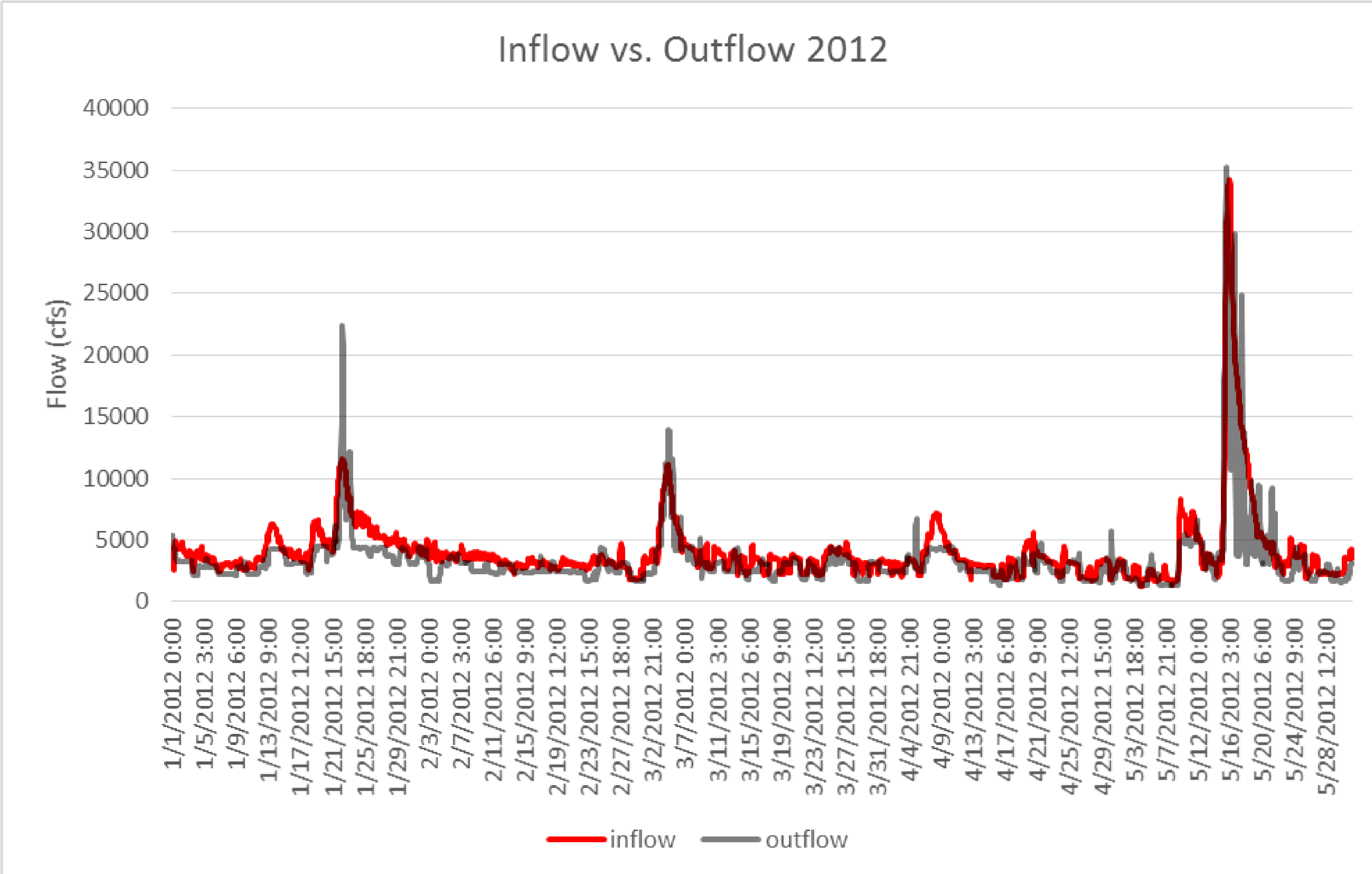

FIGURE 3 2012 PARR PROJECT INFLOW (CARLISLE, ENOREE, TYGER GAGES) VS. OUTFLOW (ALSTON GAGE)

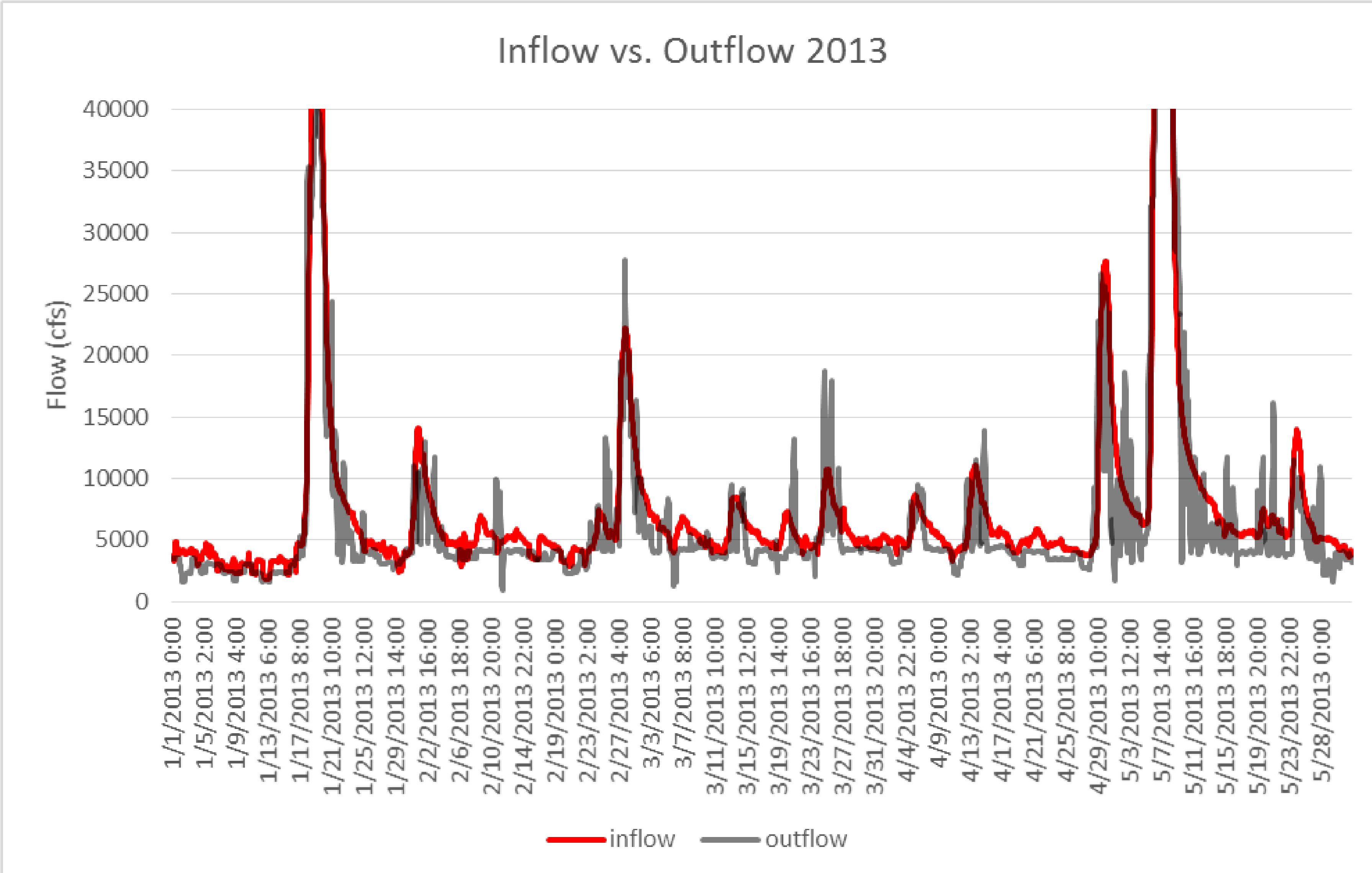

FIGURE 4 **2013 PARR PROJECT INFLOW (CARLISLE, ENOREE, TYGER GAGES) VS. OUTFLOW (ALSTON GAGE)**

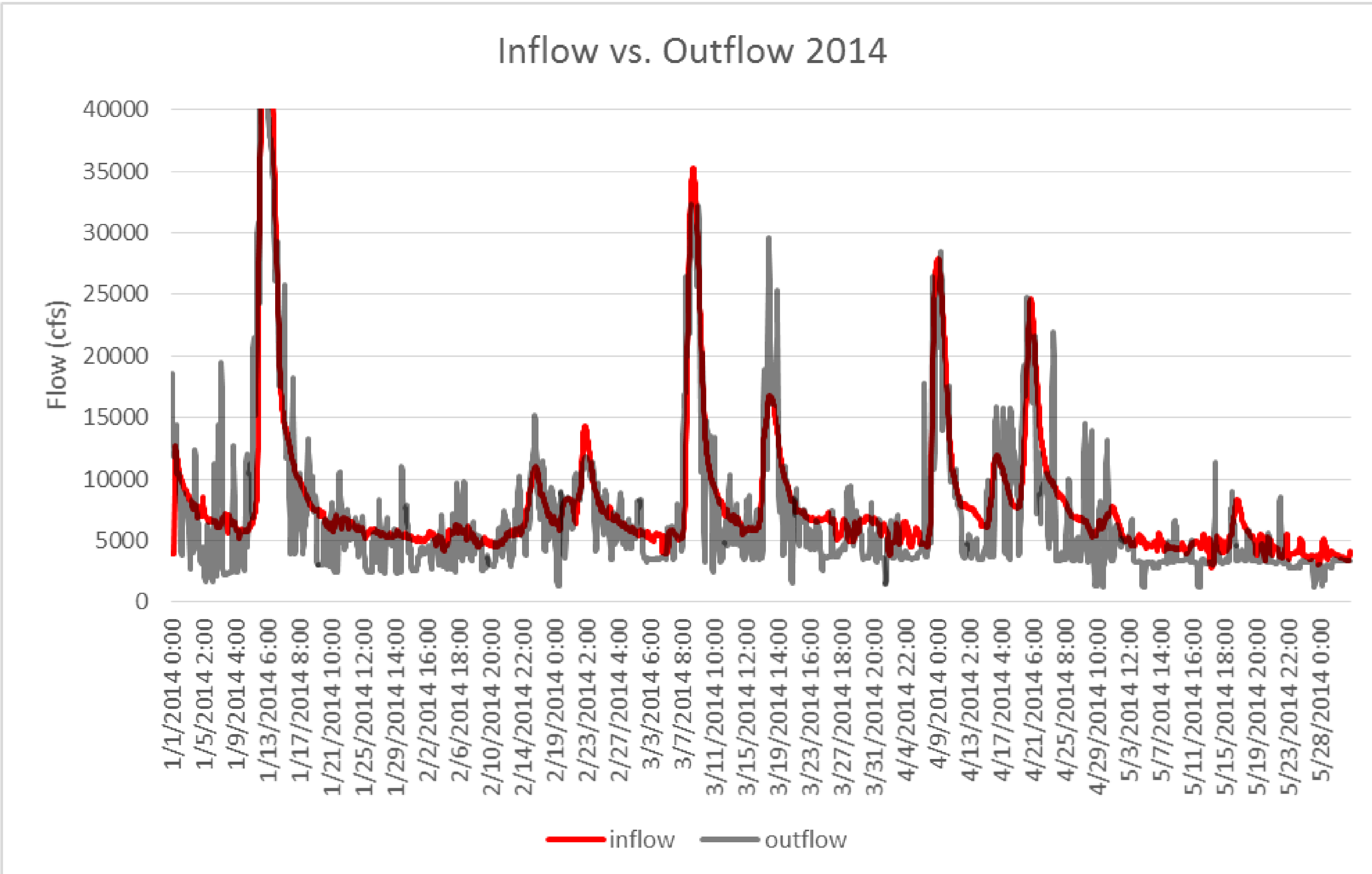

FIGURE 5 **2014 PARR PROJECT INFLOW (CARLISLE, ENOREE, TYGER GAGES) VS. OUTFLOW (ALSTON GAGE)**

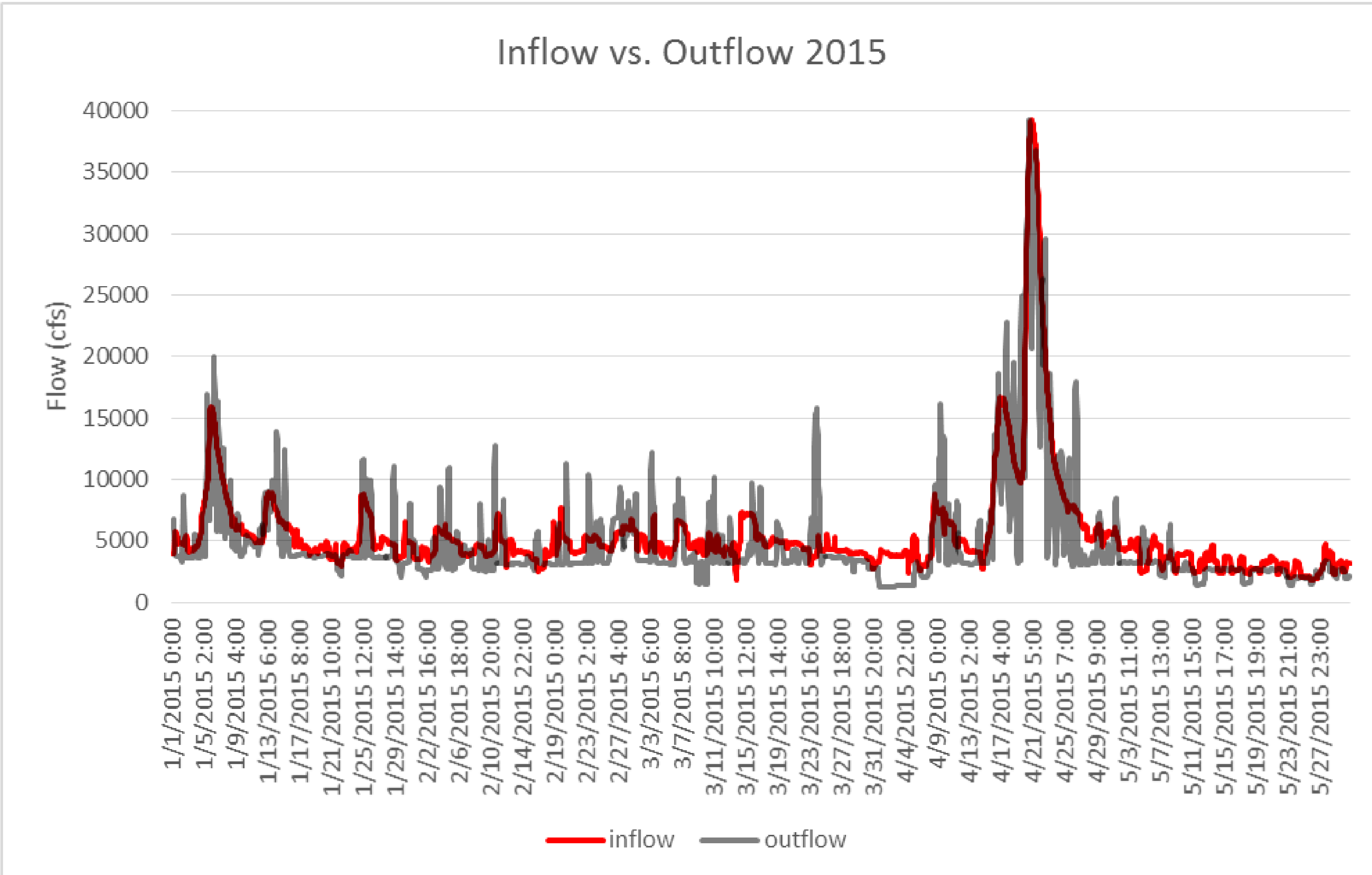

FIGURE 6 2015 PARR PROJECT INFLOW (CARLISLE, ENOREE, TYGER GAGES) VS. OUTFLOW (ALSTON GAGE)

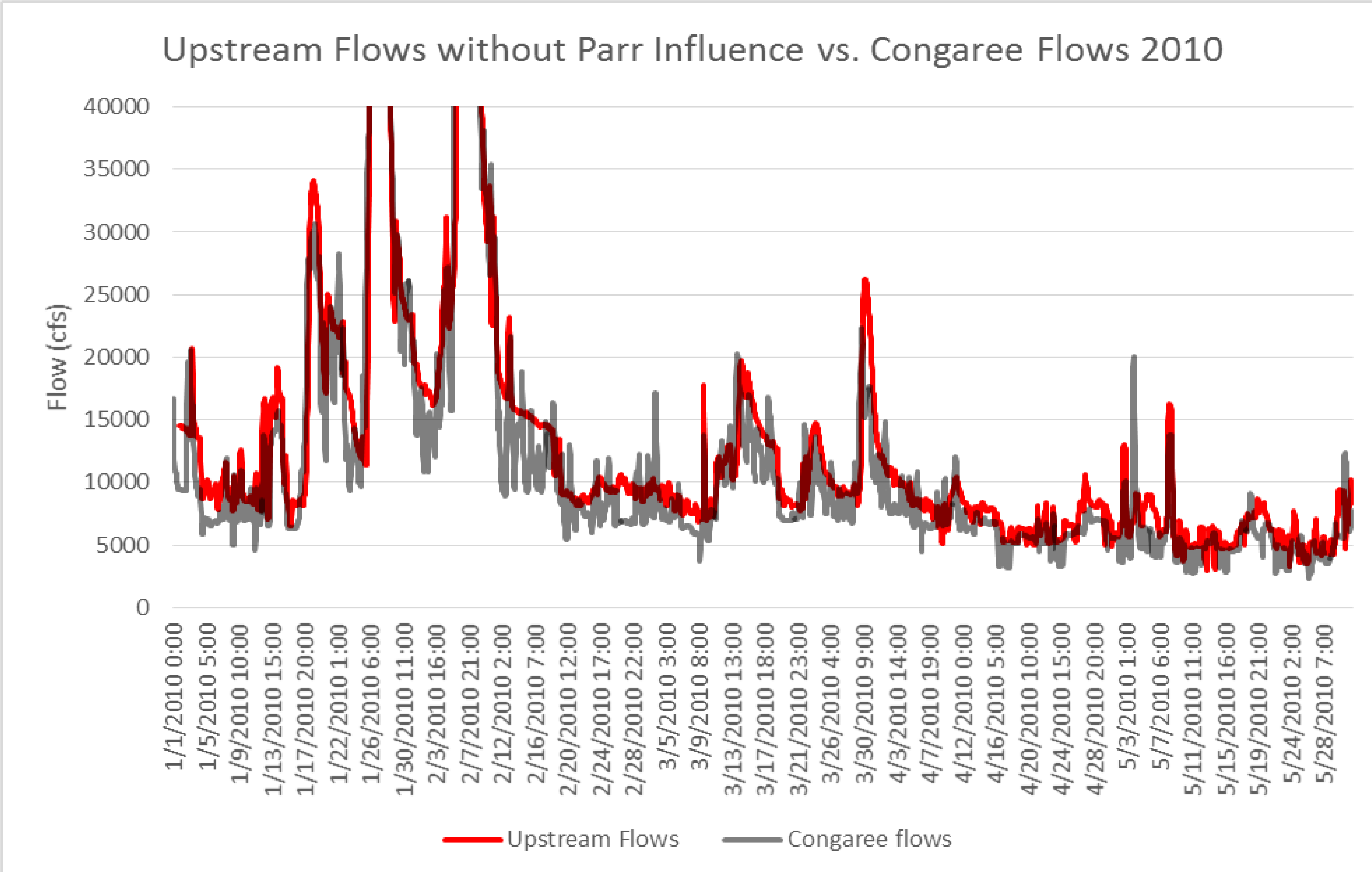

FIGURE 7 **2010 UPSTREAM FLOWS (CARLISLE, ENOREE, TYGER, SALUDA GAGES) VS. CONGAREE FLOWS (CONGAREE RIVER GAGE)**

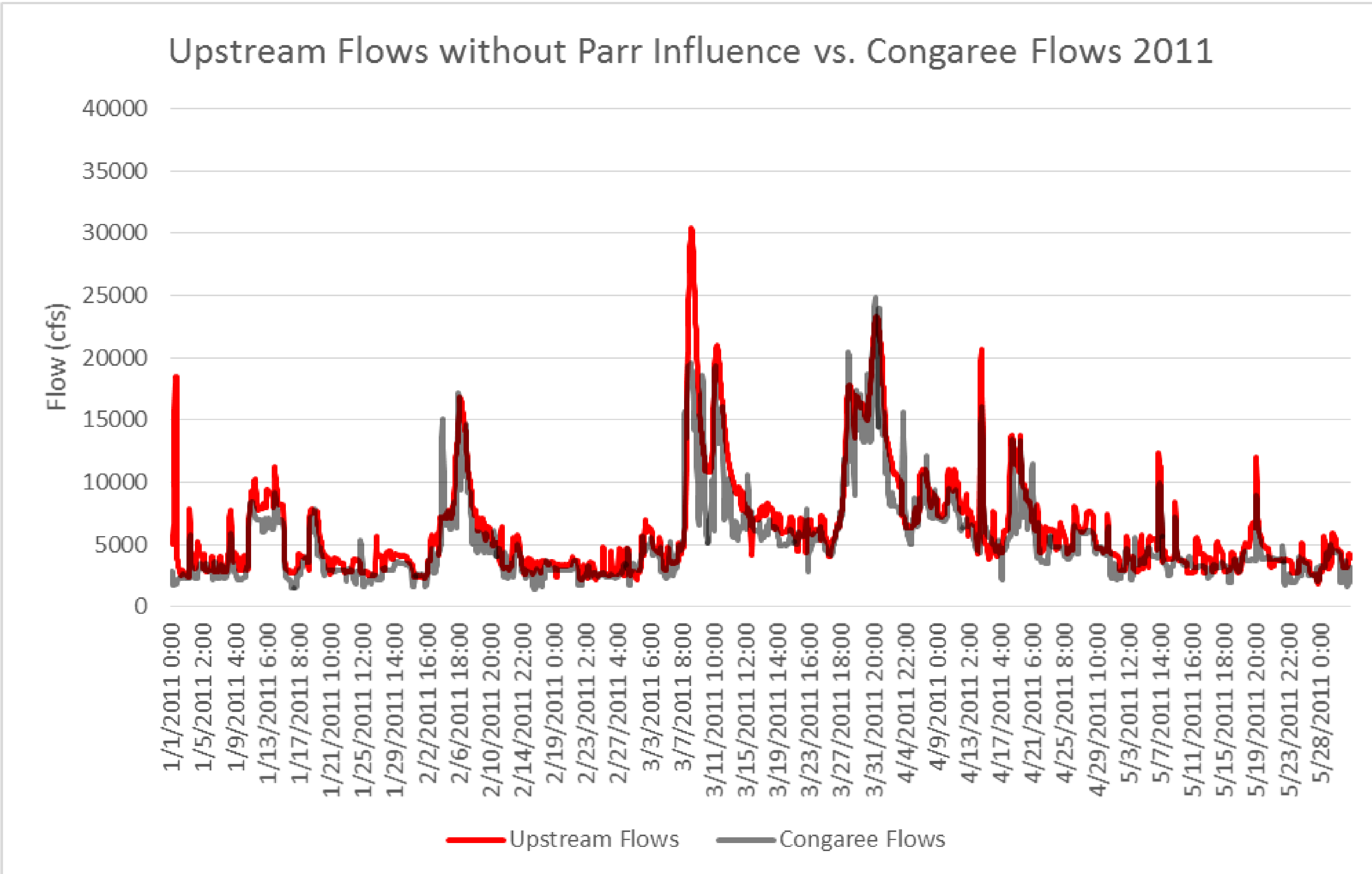

FIGURE 8 **2011 UPSTREAM FLOWS (CARLISLE, ENOREE, TYGER, SALUDA GAGES) VS. CONGAREE FLOWS (CONGAREE RIVER GAGE)**

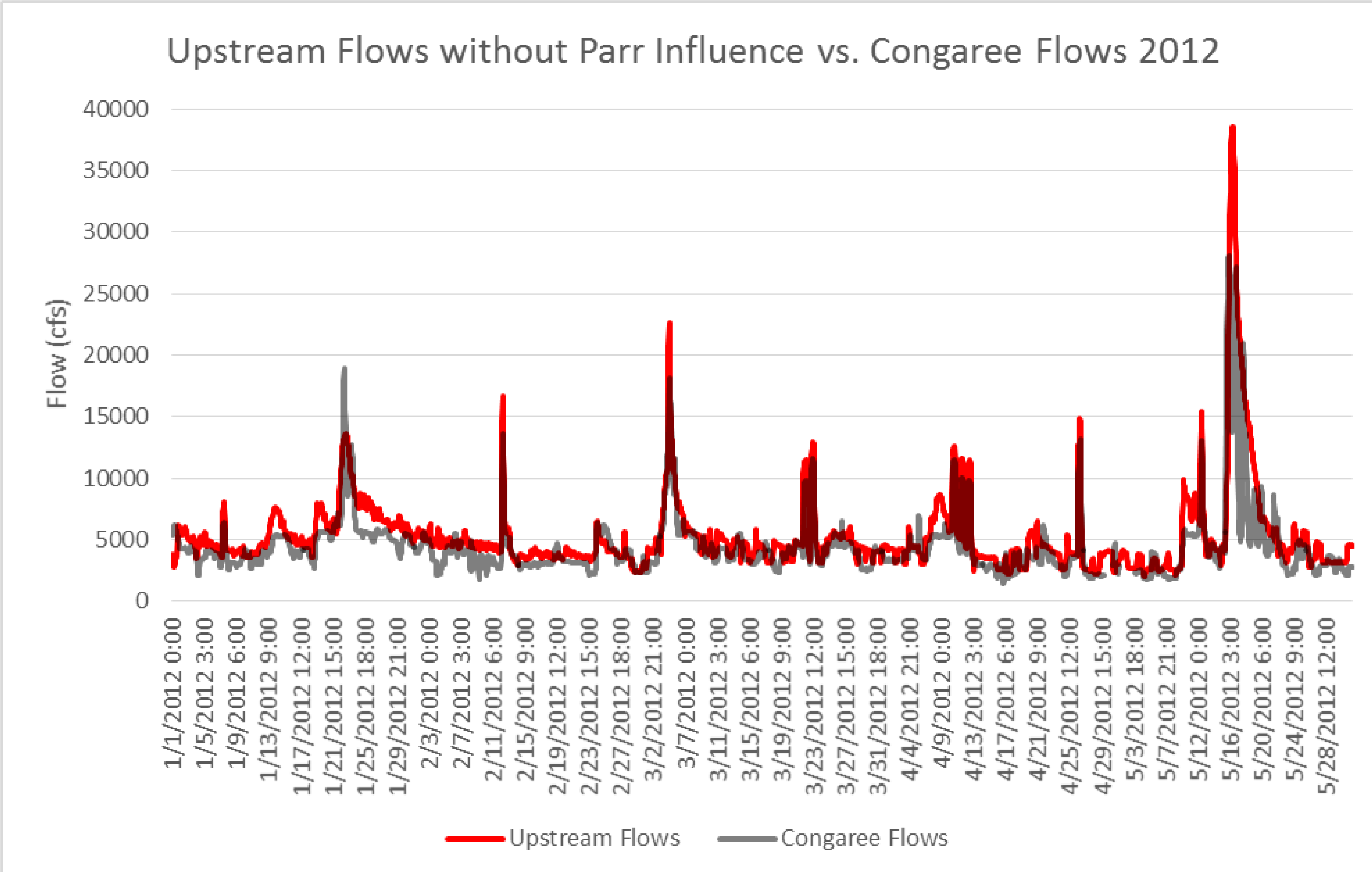

FIGURE 9 **2012 UPSTREAM FLOWS (CARLISLE, ENOREE, TYGER, SALUDA GAGES) VS. CONGAREE FLOWS (CONGAREE RIVER GAGE)**

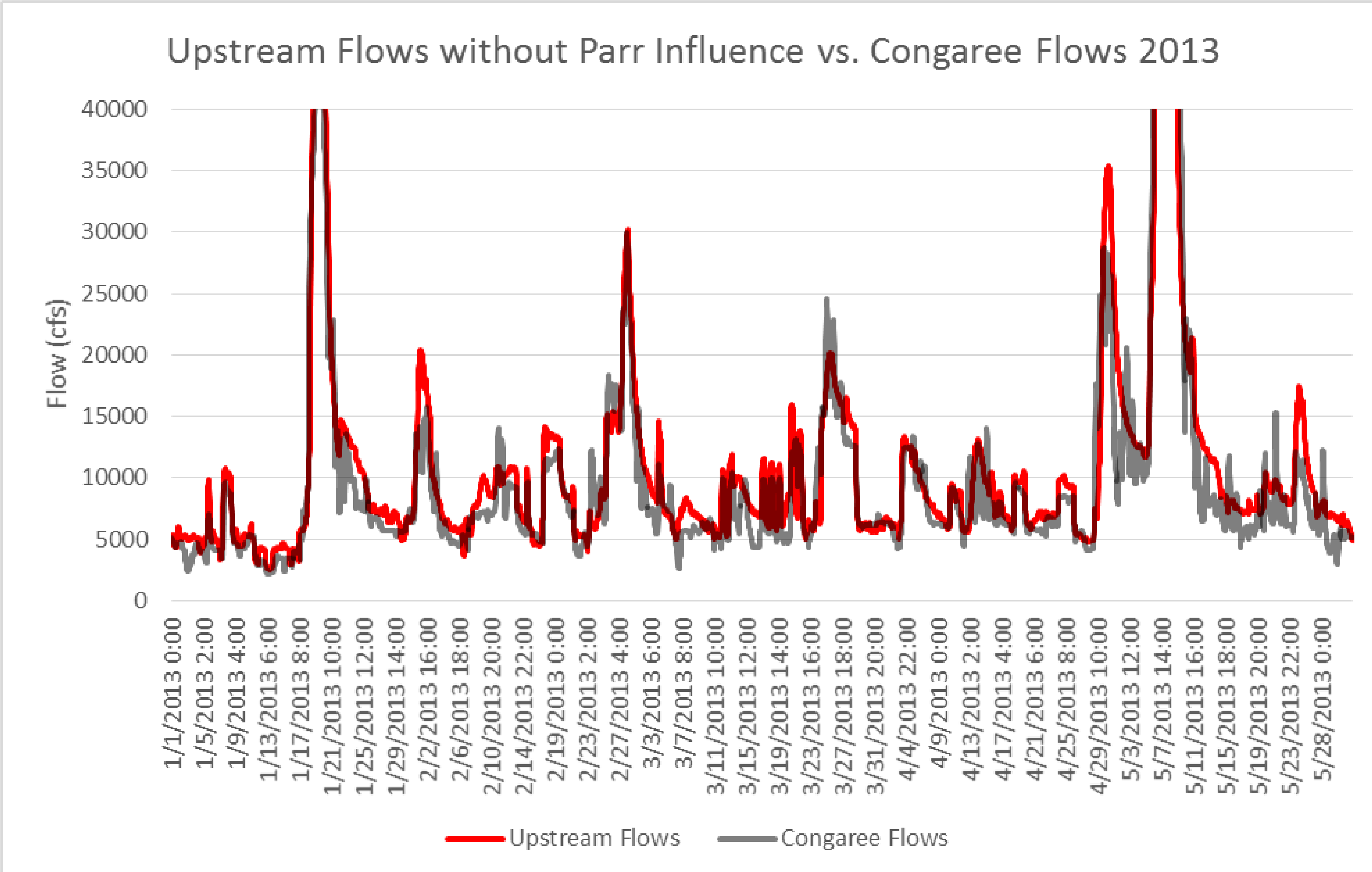

FIGURE 10 2013 UPSTREAM FLOWS (CARLISLE, ENOREE, TYGER, SALUDA GAGES) VS. CONGAREE FLOWS (CONGAREE RIVER GAGE)

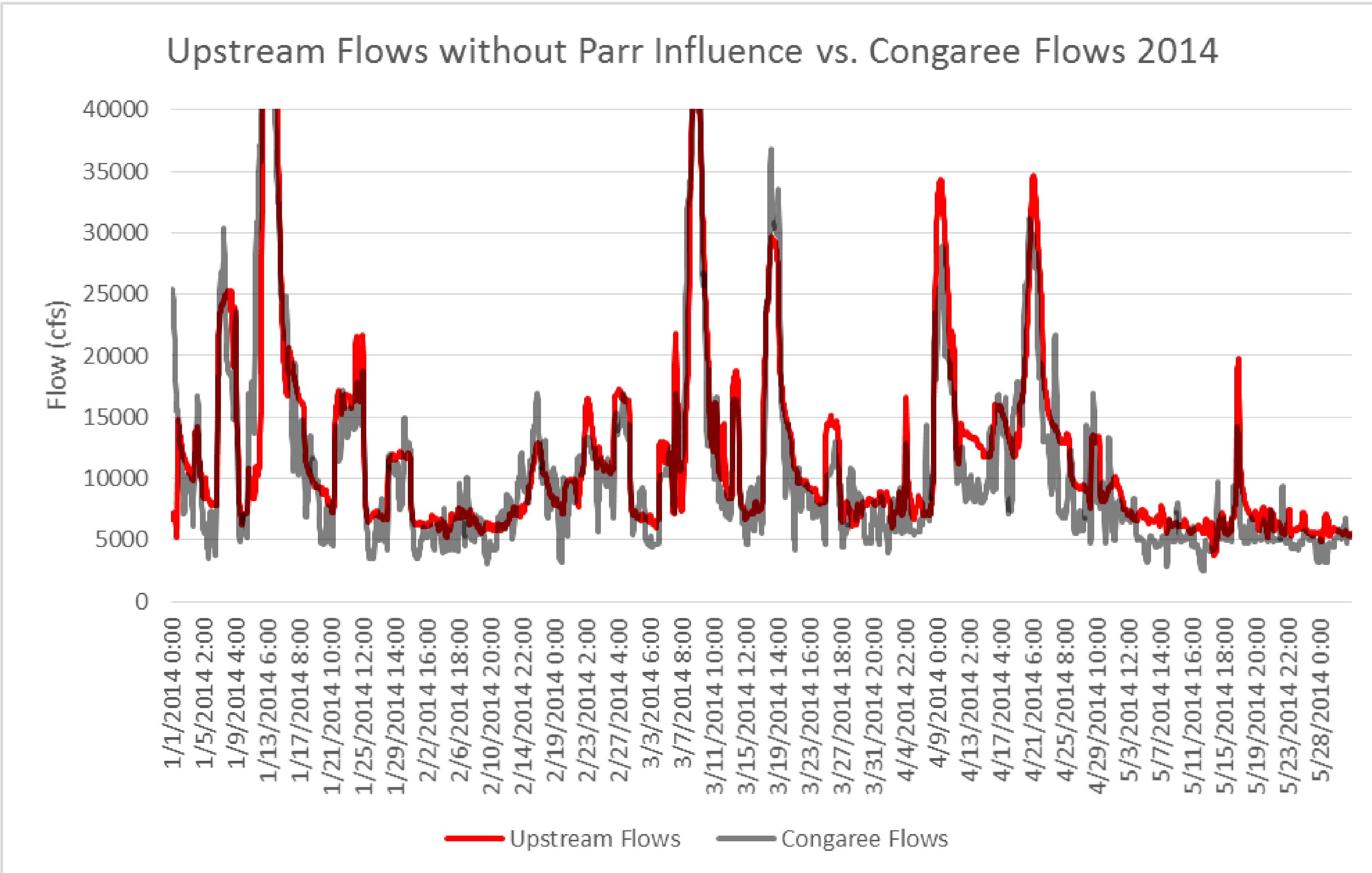

Figure 11 **2014 Upstream Flows (Carlisle, Enoree, Tyger, Saluda Gages) vs. Congaree Flows (Congaree River Gage)**

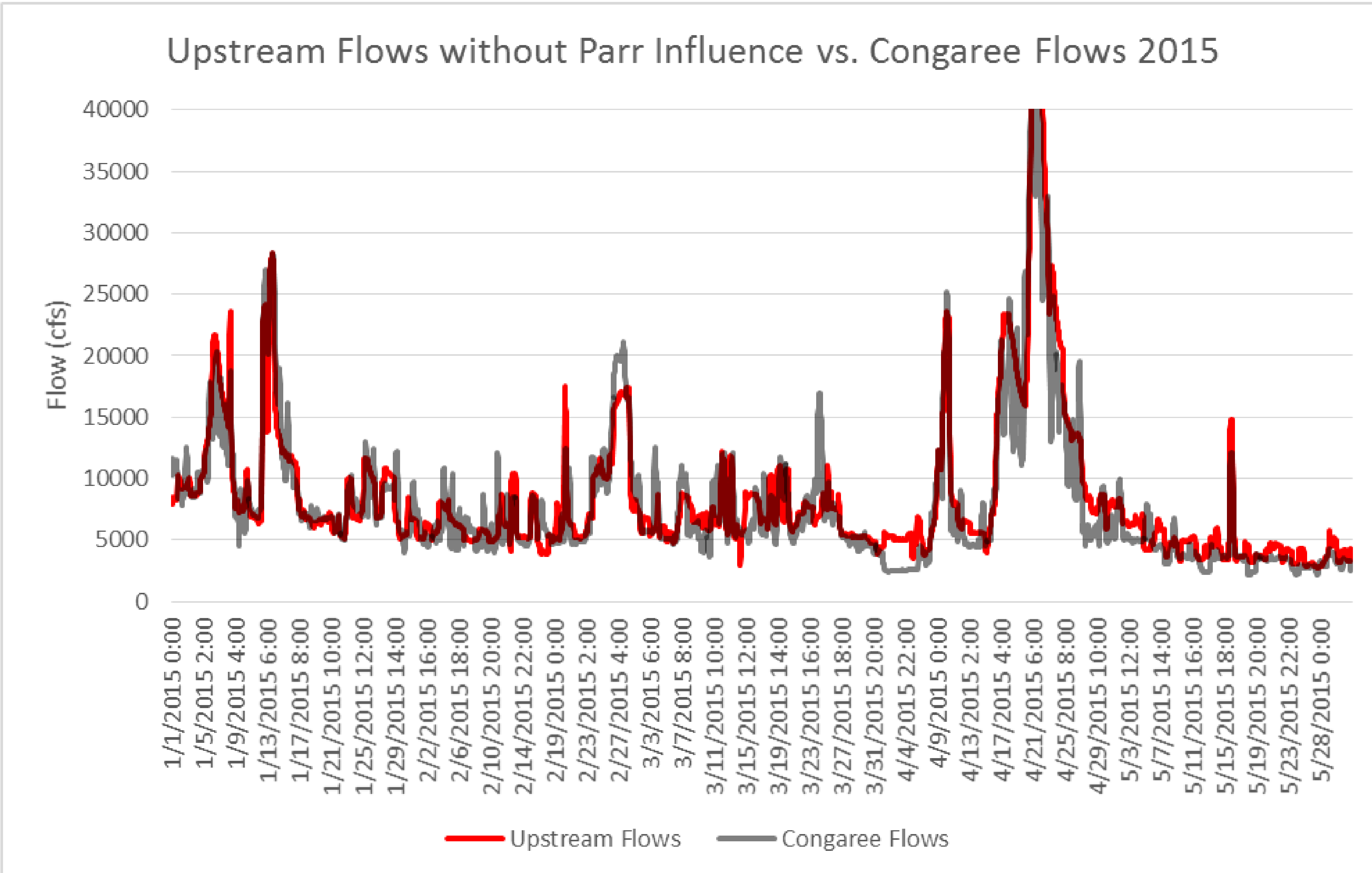

FIGURE 12 **2015 UPSTREAM FLOWS (CARLISLE, ENOREE, TYGER, SALUDA GAGES) VS. CONGAREE FLOWS (CONGAREE RIVER GAGE)**

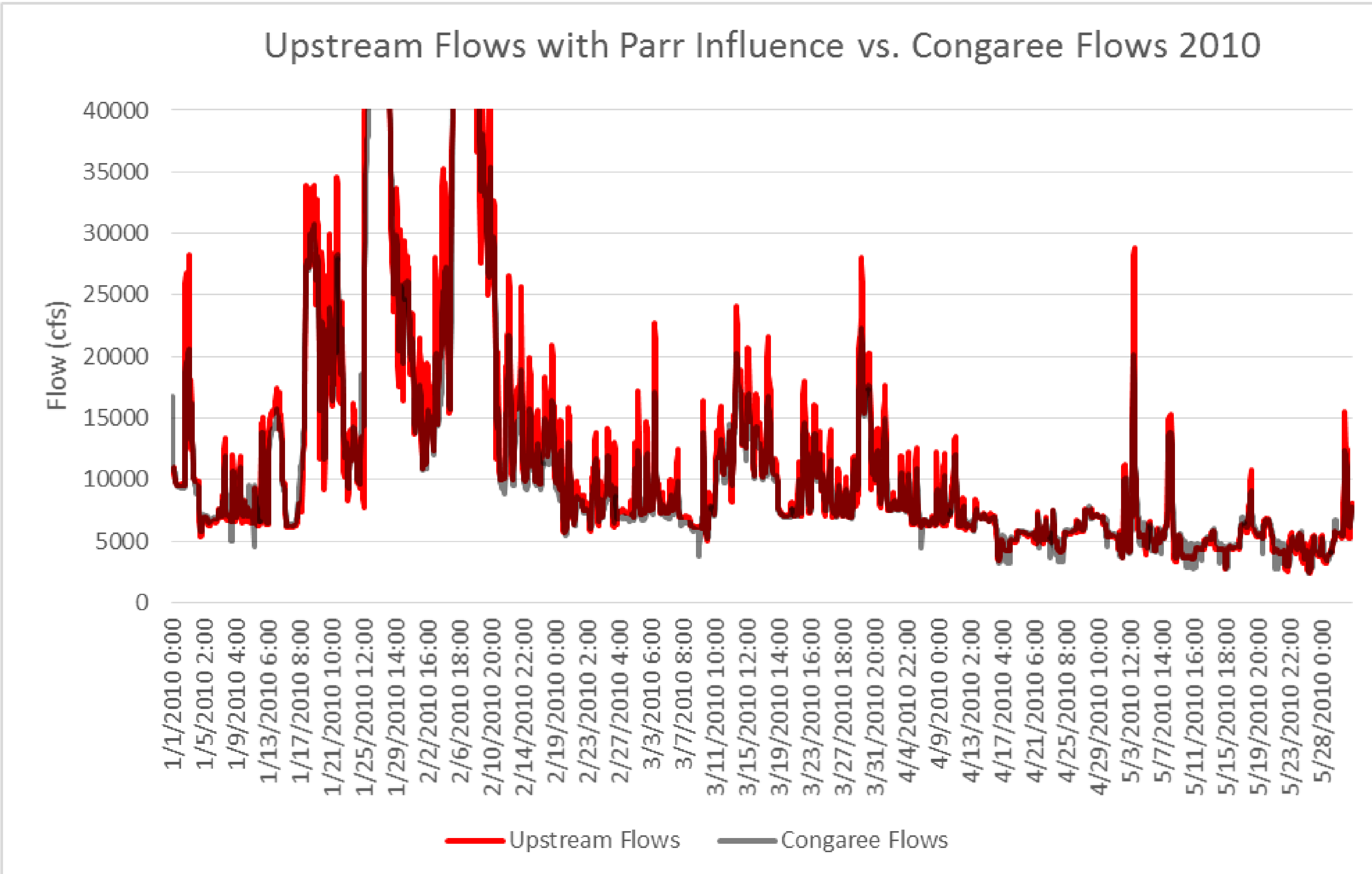

FIGURE 13 **2010 UPSTREAM FLOWS (ALSTON AND SALUDA GAGE) VS. CONGAREE FLOWS (CONGAREE RIVER GAGE)**

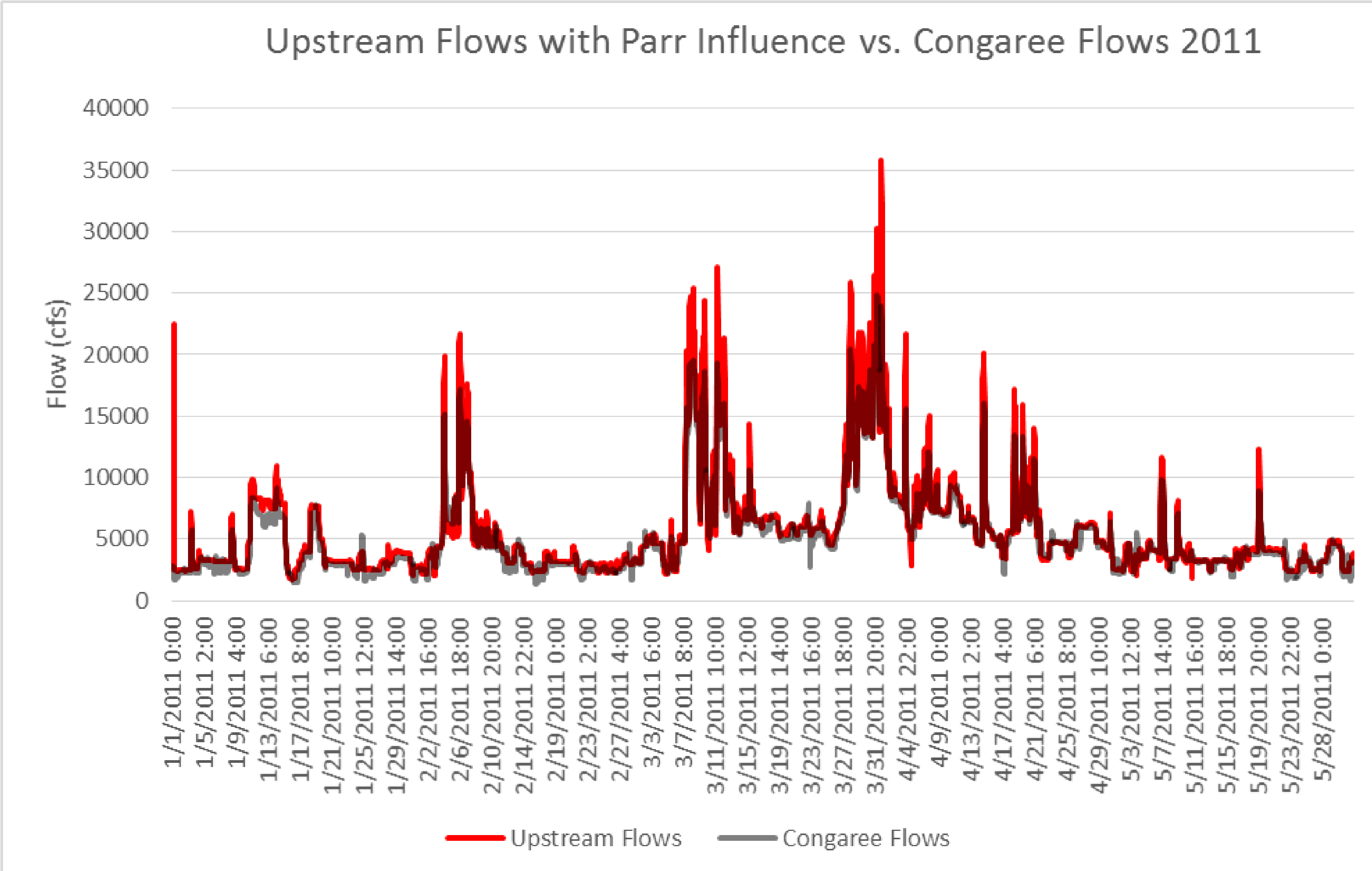

FIGURE 14 2011 UPSTREAM FLOWS (ALSTON AND SALUDA GAGE) VS. CONGAREE FLOWS (CONGAREE RIVER GAGE)

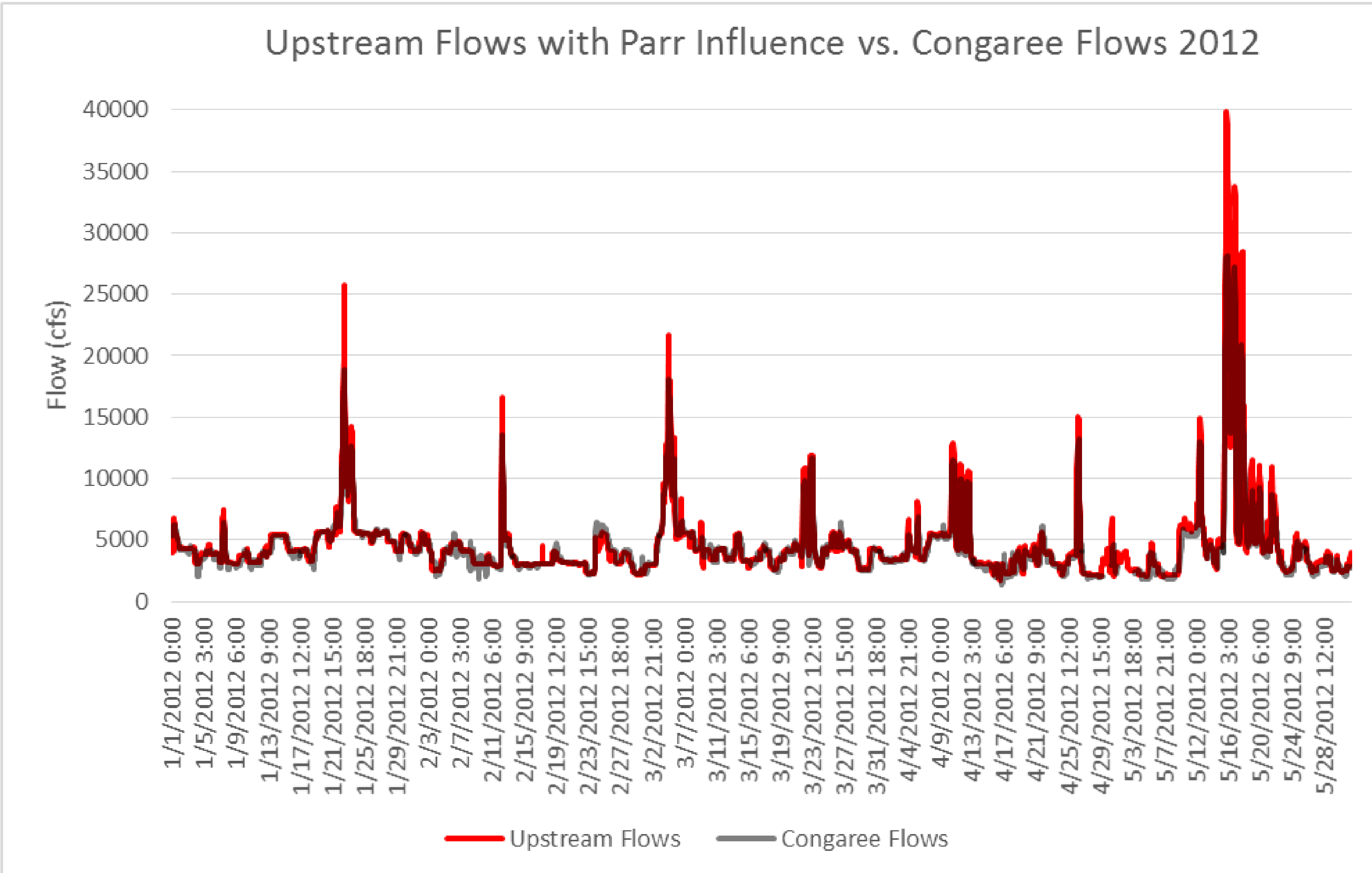

FIGURE 15 2012 UPSTREAM FLOWS (ALSTON AND SALUDA GAGE) VS. CONGAREE FLOWS (CONGAREE RIVER GAGE)

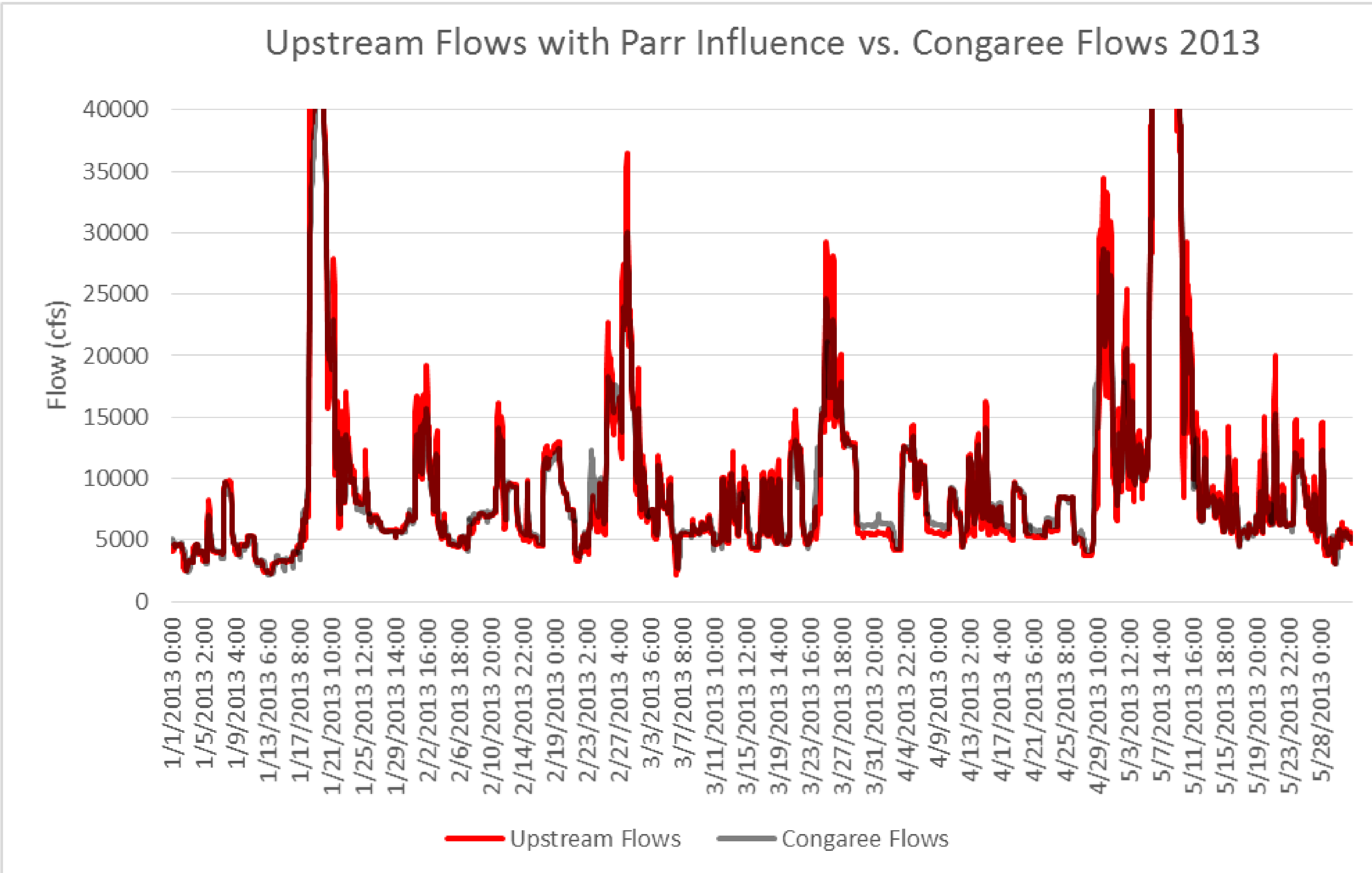

FIGURE 16 **2013 UPSTREAM FLOWS (ALSTON AND SALUDA GAGE) VS. CONGAREE FLOWS (CONGAREE RIVER GAGE)**

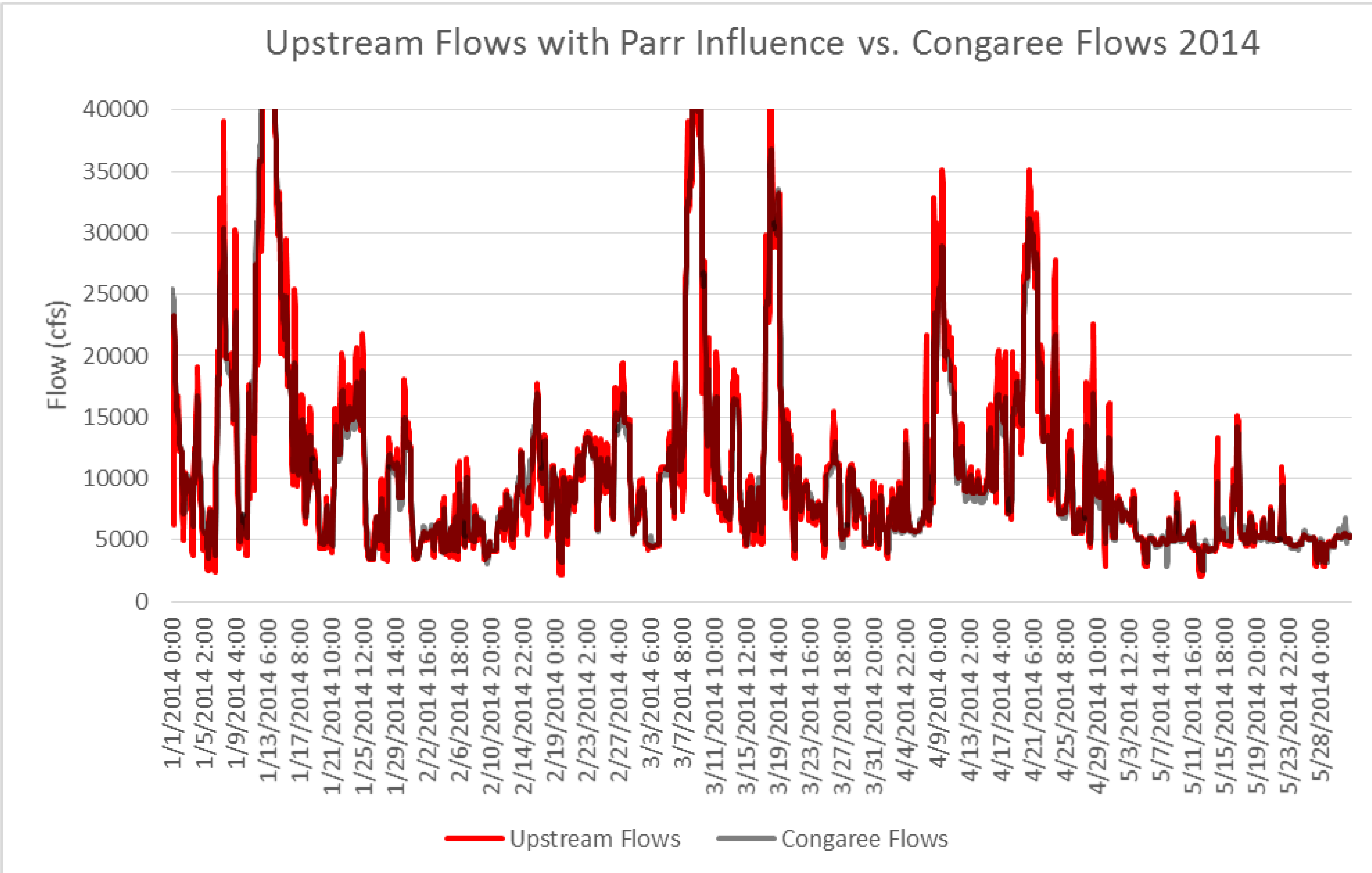

FIGURE 17 **2014 UPSTREAM FLOWS (ALSTON AND SALUDA GAGE) VS. CONGAREE FLOWS (CONGAREE RIVER GAGE)**

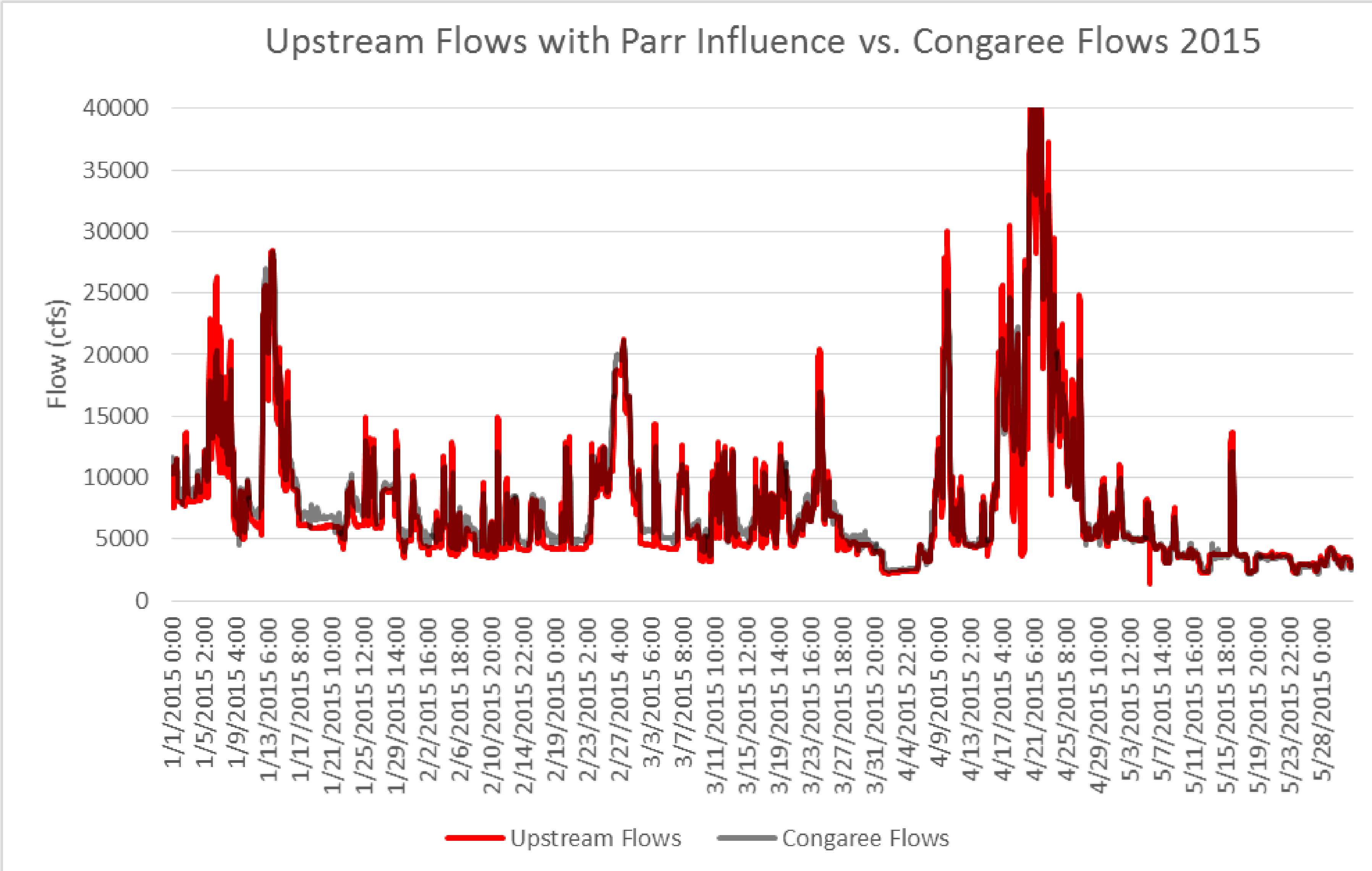

FIGURE 18 **2015 UPSTREAM FLOWS (ALSTON AND SALUDA GAGE) VS. CONGAREE FLOWS (CONGAREE RIVER GAGE)**

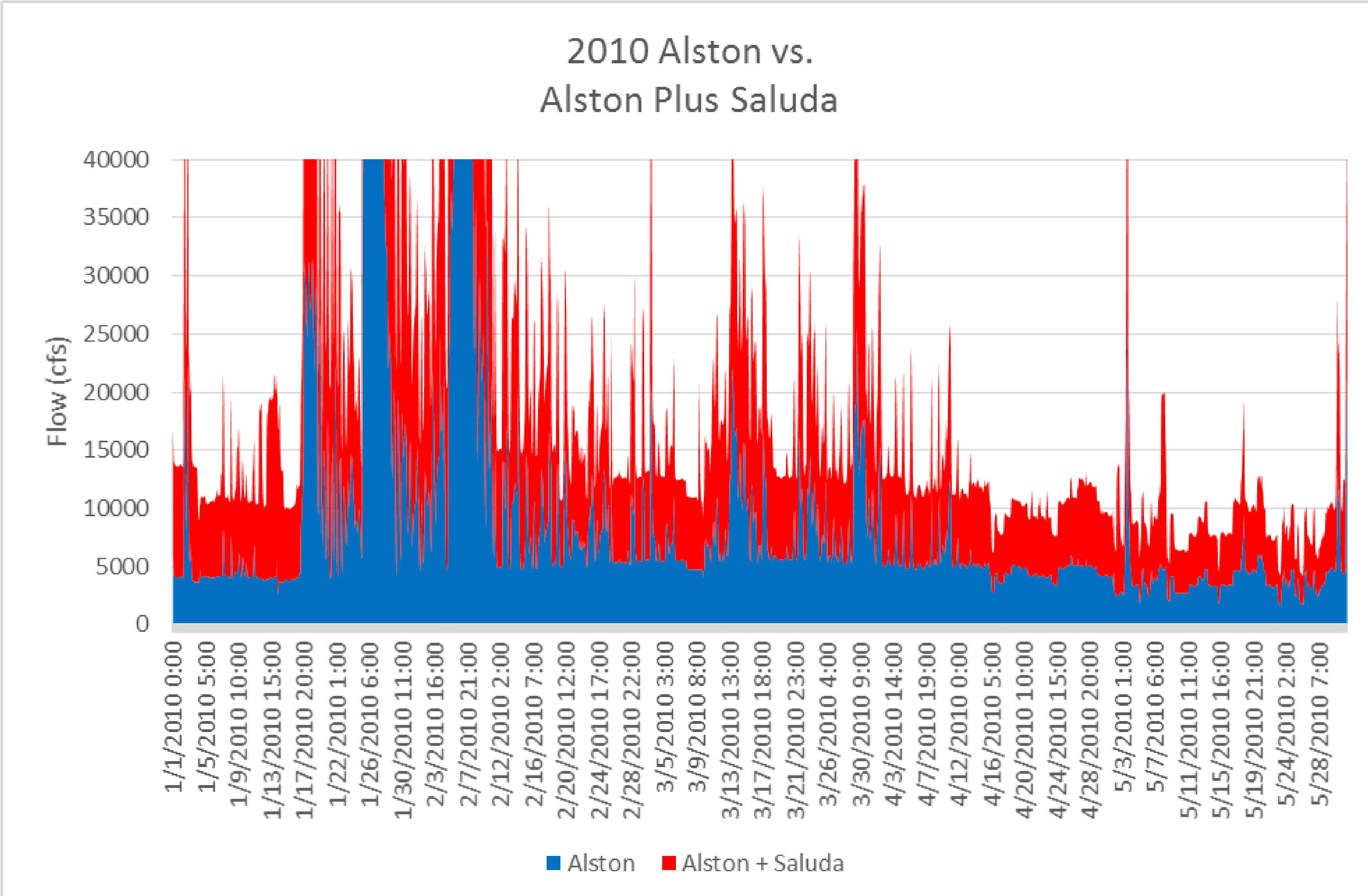

FIGURE 19 2010 ALSTON FLOWS VS. ALSTON AND SALUDA COMBINED FLOWS

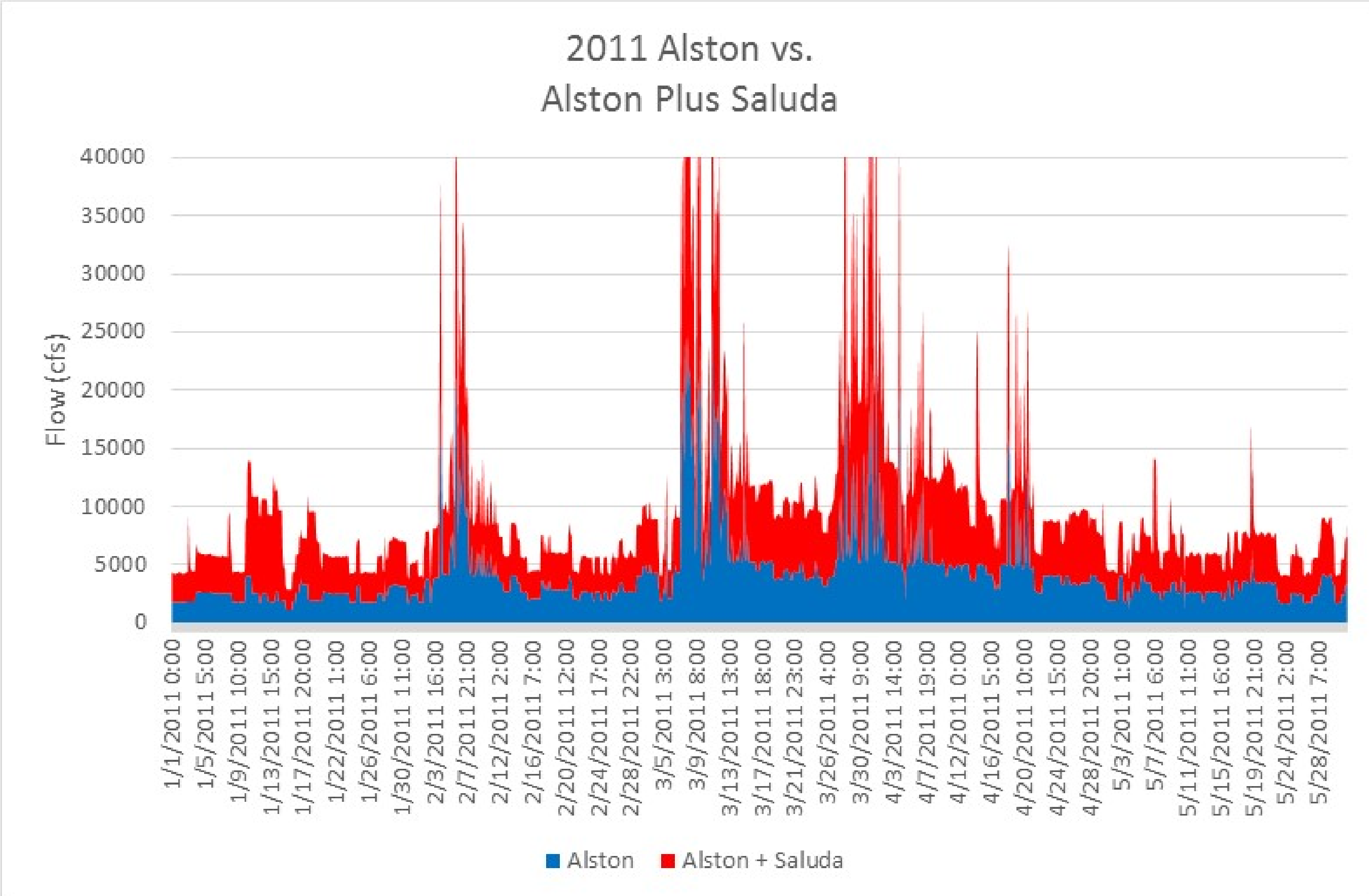

FIGURE 20 2011 ALSTON FLOWS VS. ALSTON AND SALUDA COMBINED FLOWS

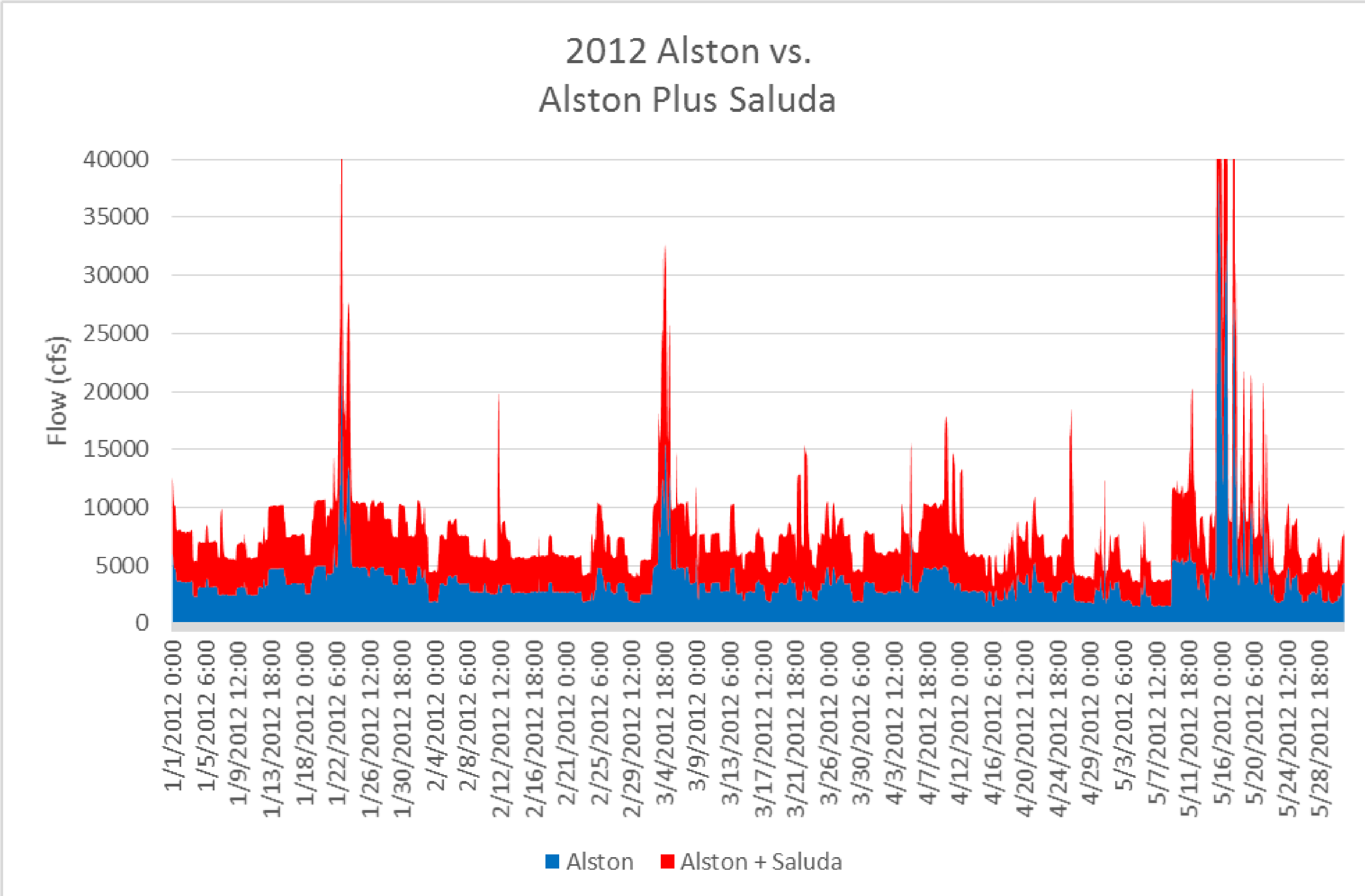

FIGURE 21 2012 ALSTON FLOWS VS. ALSTON AND SALUDA COMBINED FLOWS

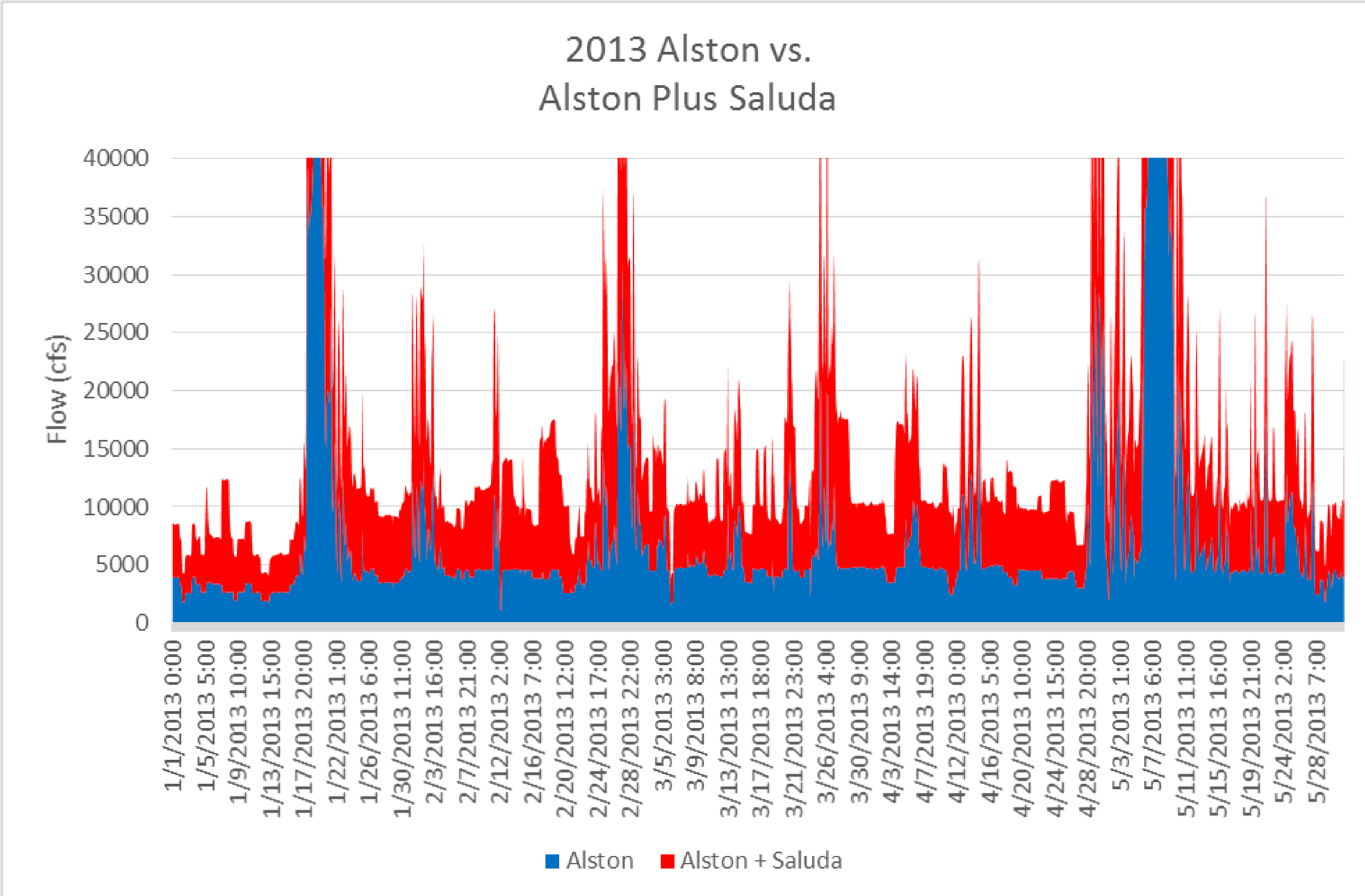

FIGURE 22 **2013 ALSTON FLOWS VS. ALSTON AND SALUDA COMBINED FLOWS**

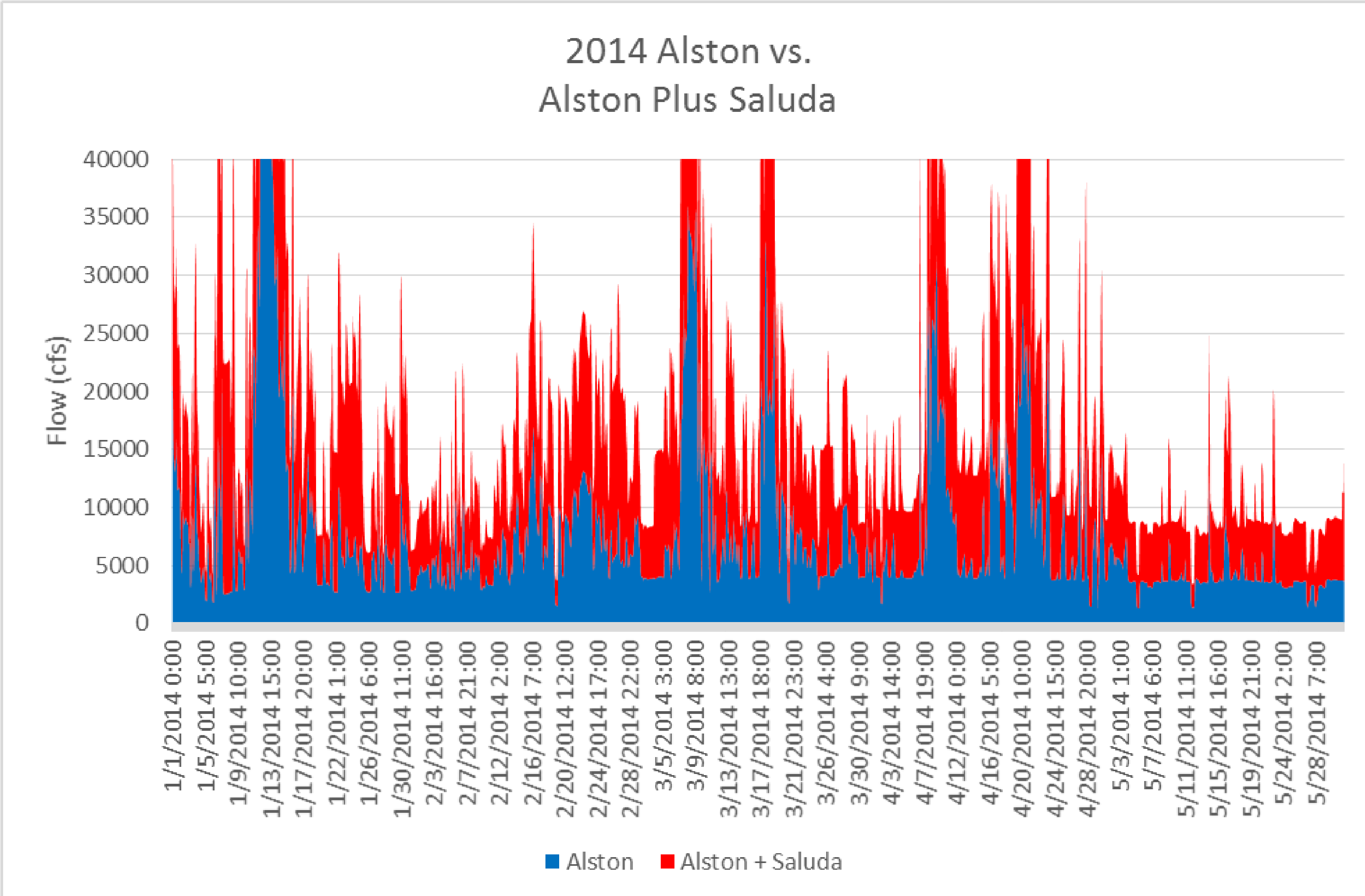

FIGURE 23 2014 ALSTON FLOWS VS. ALSTON AND SALUDA COMBINED FLOWS

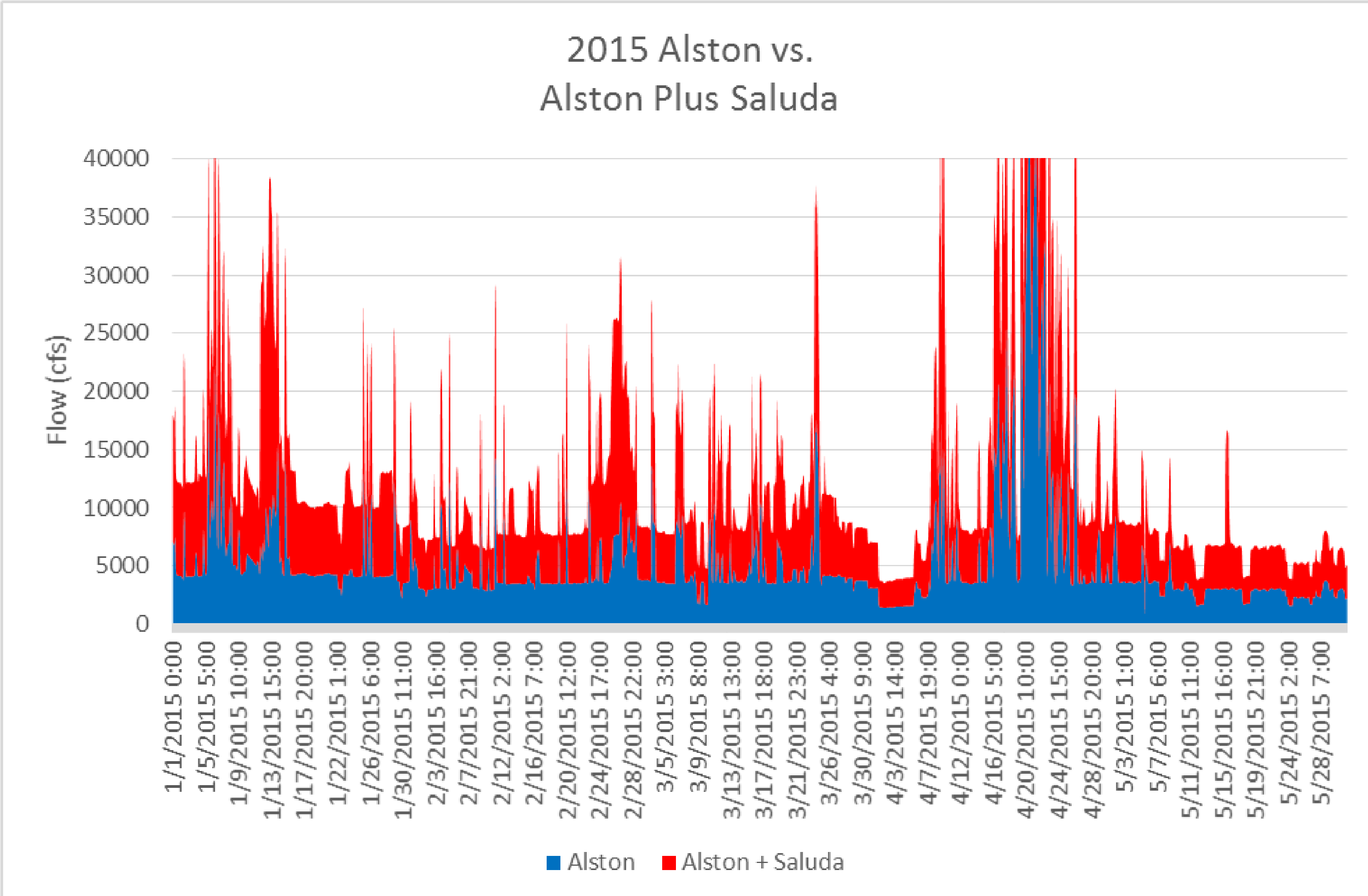

FIGURE 24 2015 ALSTON FLOWS VS. ALSTON AND SALUDA COMBINED FLOWS

Exhibit E-5 Fisheries Resources

Downstream Flow Evaluation Memo

June 9, 2016

PARR HYDROELECTRIC PROJECT – FERC NO. 1894
DOWNSTREAM FLOW EVALUATION – MEMORANDUM

TO: Parr/Fairfield Relicensing Water Quality, Fish and Wildlife Resource Conservation Group (RCG)

FROM: Bret Hoffman – Kleinschmidt Associates
Bruce Halverson – Kleinschmidt Associates

DATE: June 9, 2016

RE: Downstream Flow Evaluation – Initial Analysis

INTRODUCTION

The Parr Hydroelectric Project impounds the Parr Reservoir, which serves as the lower reservoir for the Fairfield Development, a pumped storage facility. Normal operations entail the filling of the upper reservoir during low power use periods, typically overnight, and generation during high power use periods. When inflow from the Broad River to the Parr Reservoir are within the generating capacity of the Parr Development, the powerhouse turbines pass the inflows, and usable storage remains stable. When inflows exceed the powerhouse release, either gradually or during a high inflow event, the usable project storage is exceeded, and flows are released from the Parr reservoir via spillway gate operation. The operation of gates results in pulses of flows downstream of the Parr Shoals Dam, which are variable in magnitude and duration. In response to stakeholder requests, the operational flow releases from the Parr Shoals Dam were evaluated to determine the influences of pulsing on downstream gage locations of interest.

The request from the stakeholders included developing a routing model for inflows to the Parr Reservoir; comparing those inflows to actual project releases as measured by the Alston gage; and using a downstream hydraulic model to examine the differences between a “run-of-river” scenario versus the actual project operational flows, downstream of the project at the Congaree River gage at Columbia, near the Congaree National Park.

Stakeholders were primarily interested in flows during the spring period (February through May); however, the flow data was continuous, and therefore the flow period modeled was year round from 2010 through 2015. This period was more than sufficient to capture a multitude of project operational influences, including pulsed flow releases and alteration to the natural inflow hydrograph.

METHODOLOGY

The methodology used included the following steps:

1. Develop flow data sets for the routing simulations being compared at the USGS gage on the Congaree River at Columbia:
    - Develop a run-of-river inflow data set for the Parr Reservoir node, using hydrologic routing model (HEC-HMS) based on three upstream gages. This is described in more detail below.

- Develop a model input flow data set for the actual Parr flow releases, which are assumed to be identical to the USGS flow data from the Alston gage #02161000.
- Develop a model input flow data set for the ungaged flows between the Alston gage site and the Congaree gage site, which would be added independently to the previous two data sets. This is described in in more detail below.
- Develop a model input flow data set for the Saluda River flows, which are assumed to be identical to the USGS gage #02169000.

2. Extend the river routing (HEC-RAS) model from the previous terminus at the Columbia dam, down to the USGS Congaree gage at Columbia.
3. Perform model (HEC-RAS) validation for the existing conditions, by simulating a period and comparing peak values and the timing of flow peaks and comparing with the Congaree gage data.
4. Performing simulations with the Parr run-of-river data, and comparing with existing conditions.

Flow dataset development – Ungaged Broad River Inflows

Discharge measurements from the USGS gage 02161000, Broad River at Alston, SC, were used as the basis of actual project releases. Additional flows downstream of the Parr Shoals Dam upstream of the Congaree National Park include runoff contributions and small, ungaged tributaries, as well as the influence of the Lower Saluda River at the confluence with the Broad River, where the Congaree River forms. The ungaged inflows included in the modeling were simulated as a pro-rated multiple of the Alston flow. The Alston data was multiplied by 1.025, which was developed statistically to provide the best-fit representation of the peak flows simulated at the Congaree gage site. The estimated ungaged flow was incorporated into both existing and run-of-river model simulations, so the magnitude of the ungaged flows introduces no bias into the comparison of the two scenarios.

Flow dataset development – Run-of-River Parr Outflows

While the existing condition Parr project outflows are directly estimated by the Alston gage, the run-of-river flows that could occur at the project are not measurable and therefore must be estimated. In a previous phase of this project, a statistical analysis was performed to estimate the net inflows to Parr Reservoir. The statistical analysis yielded a series of pro-rating coefficients to be applied to the flow data for the upstream gages on the Broad, Enoree and Tyger Rivers, resulting in a best-fit statistical estimate of the total inflow to Parr. The same statistical information and data were used to develop inflow from the ungaged portion of the watershed between the upstream gages and the Parr Reservoir.

This analysis required data with an increased temporal resolution (one hour vs. one day) compared to the reservoir routing analysis. The higher resolution flow data was developed by using a hydrologic model, HEC-HMS (USACE), to route and combine the upstream flows. The flow routing method used is referred to as kinematic wave, which estimates the numeric translation of flow pulses moving downstream. The model input for the kinematic wave technique includes the average channel slope between the model nodes, as well as an approximate channel size. The configuration of the model in Figure 1 shows the inflow nodes, routing reaches, flow combines, and the output node.

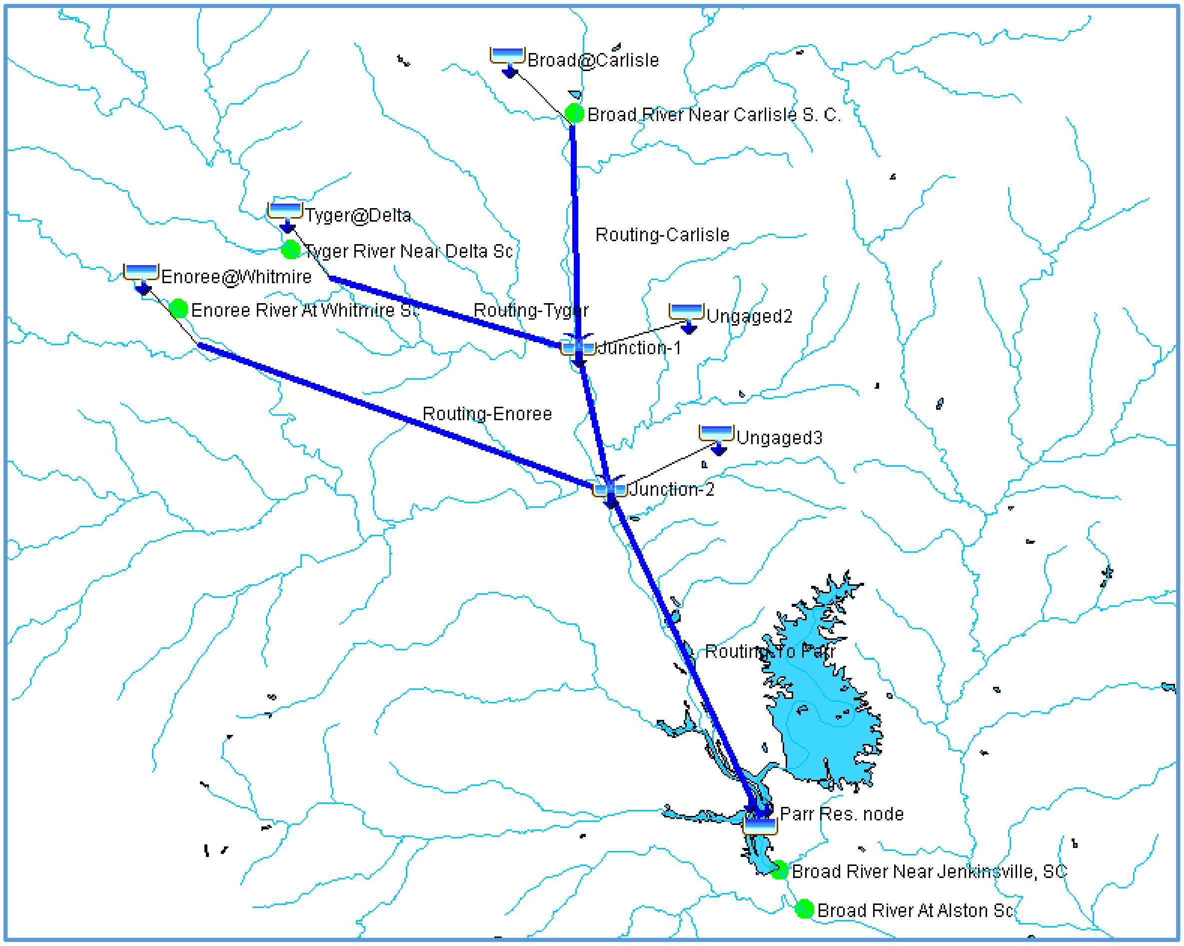

FIGURE 1 HEC-HMS MODEL CONFIGURATION

Flow Routing Models

An operational modeling suite has been established in support of the licensing process to facilitate evaluating changes in project operations. This modeling suite is comprised of a reservoir routing model (HEC-ResSim), and a river routing model (HEC-RAS). The primary function of the reservoir routing model is to evaluate operational constraints of the pumped storage project with respect to the effects on flow releases at the Parr project. The function of the river routing model is to simulate outflows from Parr reservoir, which provides a numerical representation of the flows and depths in the downstream reaches.

River Routing Model Revisions

The previously developed river model (HEC-RAS) domain spanned the reach between the Parr Shoals Dam and the Columbia Diversion Dam, approximately 24 miles downstream. For this downstream flow evaluation, the model was extended to incorporate the reach down to the Congaree National Park. The model extension was comprised of an additional 25 cross-sections over the reach of 3.3 miles. There were two major changes to the boundary conditions of the model. The Lower Saluda River flows were accounted for by adding 15-minute flow data from the USGS gage 02169000, Saluda River near Columbia, SC. The downstream boundary of the model was previously the Columbia Dam, but is now a rating curve that is based on the Congaree River gage 02169500.

Model Validation

Prior to using the modeling suite for analyzing operational scenarios, its performance was evaluated to determine the statistical reliability of the model results. In this case, the validation process was focused on three primary hydrologic simulation functions:

- The estimated/simulated inflows to Parr Reservoir
- The ungaged inflows between Parr Reservoir and the Congaree gage
- The simulation of the flow cycles, released from Parr Reservoir and arriving at the Congaree gage

As stated previously, the methodology and statistical validation for estimating inflows to Parr Reservoir were documented in a previous memo[1]. Given that the same methodology was used as before, the reliability of the flow estimate is equivalent to the previous analysis. In this analysis, the model domain was extended to the Congaree gage, and the updated model could now be validated at the Congaree gage location. The model output described in the next section provides a graphical representation of the performance of the modeling suite with respect to its ability to simulate the flow cycles in their progression from Parr to Columbia and beyond.

[1] Kleinschmidt, "Inflow Dataset Development: Statistical Methodology," May 2014.

<u>Results and Discussion</u>

The performance of the modeling suite requires an assessment that covers a wide range of hydrologic events. To accomplish this, Kleinschmidt performed simulations that included the period of 2010 through 2015. The Appendix contains a series of graphical representations of various flow events intended to demonstrate model functionality, with model output from various nodes of the hydrologic (HEC-HMS) and hydraulic (HEC-RAS) model and the significance of each graph is provided below.

Inflow Dataset Example Events

1. Figure 2 shows a simplified example of the relative contributions of the upstream tributaries to the total inflow at Parr Reservoir. This is representative of the majority of inflow events, with the Broad River being the primary contributor. The time offset between the Carlisle gage and the Parr Reservoir location is visible at the onset of the flow increases, as well as the peaks of the events.
2. Figure 3 shows a unique example of back-to-back Parr Reservoir inflow events in which first peak is largely due to Broad River flows, and the second is due to more localized events on the Enoree and Tyger Rivers, rather than upper basin contributions. The event is synonymous with major flooding that occurred throughout Columbia during early October, 2015.
3. Figure 4 is a demonstration of a Parr Reservoir inflow event that was largely influenced by a flow pulse from the Enoree River. The time lag between the Whitmire gage and the flow reaching the Parr Reservoir is clearly visible.

Validation of Downstream Model Simulation

4. Figure 5 shows the measured flow at the Alston gage, which was used as a surrogate of Parr outflow, and a comparison of the simulated vs. observed flow at the Congaree Columbia gage location. This graph demonstrates the ability of the model to closely replicate the timing of flow peaks reaching the Congaree gage location, and illustrates the accuracy of the estimated ungaged inflows between Parr and Columbia. The timing of the peaks is fairly accurate, as well as the magnitude of the peaks. The figure also illustrates that the estimated ungaged inflows might be slightly high for events that peak above 12,000 cfs, and slightly low for events that peak below 10,000 cfs. It should be noted that comparisons of flows at the Columbia gage are made with model produced data, whether they are existing (historical) operations or run-of-river routed operations. Therefore, any bias of the simulated flows at the Columbia gage location will be consistent, and will not affect the comparison.
5. Figure 6 provides a typical example of an inflow event that exceeds the Parr powerhouse capacity, and requires gate operation to pass flows. The existing operational effect at the Columbia gage can be visually compared with the run-of-river model simulated flows. In addition, the Alston gaged flow and the routed inflow to the Parr Reservoir can be seen to mimic simulated flows at the Columbia gage, albeit with some smoothing of the existing operations flow from the Alston gage, which occurs along the reach between them.

6. Figure 7 includes model output from both the hydrologic and hydraulic models, and flows from Saluda and Congaree gages. This event demonstrates that there are occasions when the flow changes at Congaree are due to the Saluda River inflows, and the Parr Reservoir outflows have minimal effect.
7. Figure 8 demonstrates the effect of the operations of Parr Reservoir at the Congaree gage location during a 25,000 cfs inflow event, with an additional flow contribution from the Saluda River occurring on the falling leg of the hydrograph.
8. Figure 9 shows an example of a flow pulse from an operational event at Parr Reservoir, with no significant change to Parr Reservoir's inflows. The flow measured at Alston translates downstream to the Columbia gage, whereas the run-of-river simulation would have been relatively stable.
9. Figure 10 is an example of a prolonged, above-average inflow period. Operating the Parr spillway gates to more closely match the inflow and outflow is much more challenging due to the magnitude and duration of the higher flows.

Conclusions

The models, acting in tandem, produce accurate representations of the flows moving downstream from the Carlisle, Enoree and Tyger gage locations to the Congaree Columbia gage location, as well as from the Alston gaged flows down to the Columbia gage. The difference in the amplitude of the simulated and measured peaks differ by small amounts, while the timing of the flow peaks appears to be very accurate. The model is suitable for simulating inflows to the Parr Reservoir, as well as the effects of the flow management at Parr Reservoir and comparing run-of-river releases at the Columbia gage.

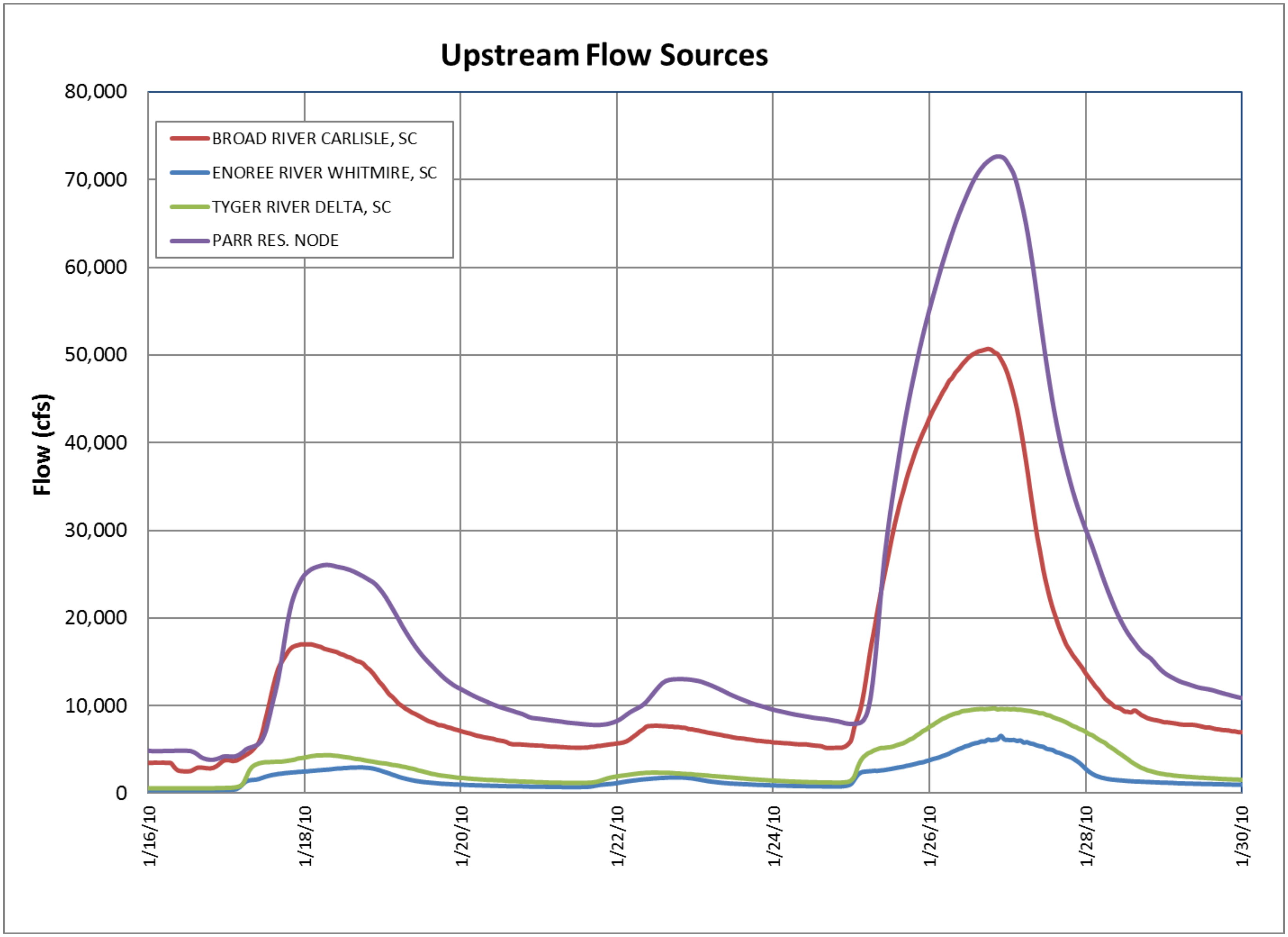

FIGURE 2 EXAMPLE OF TYPICAL UPSTREAM FLOW CONTRIBUTIONS

Kleinschmidt

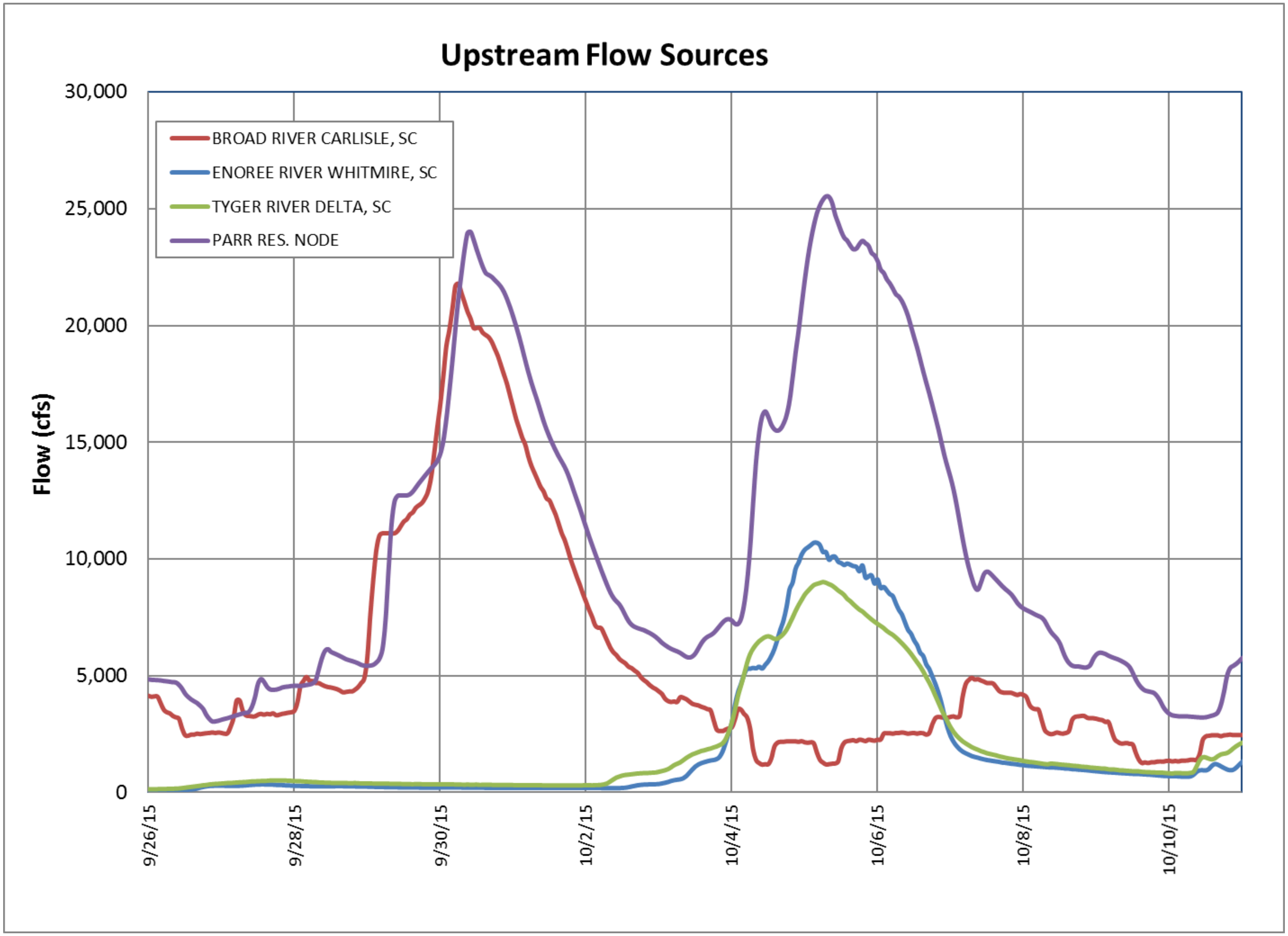

FIGURE 3 EXAMPLE OF VARIABLE UPSTREAM HYDROLOGY

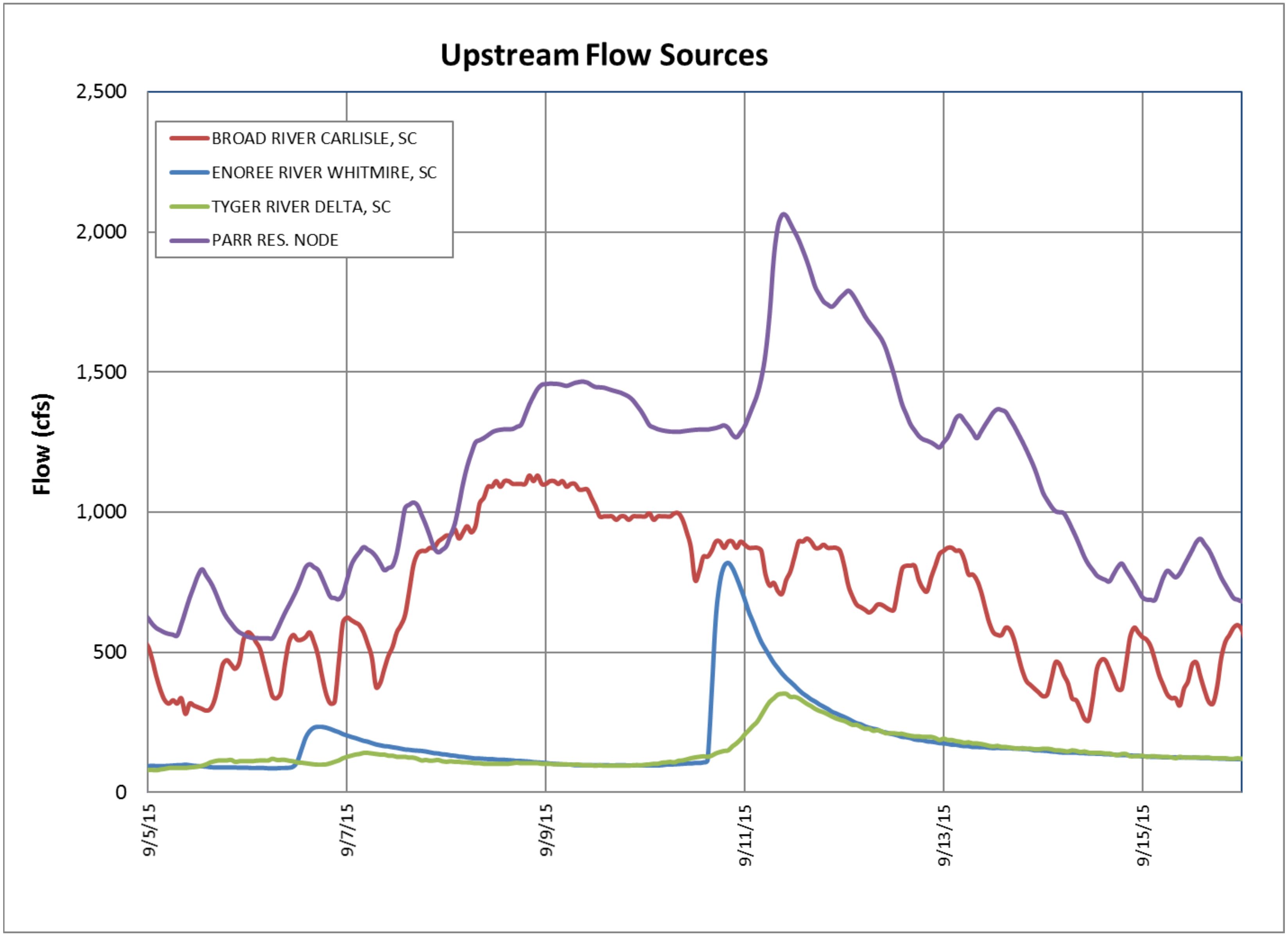

FIGURE 4 EXAMPLE OF VARIABLE UPSTREAM HYDROLOGY

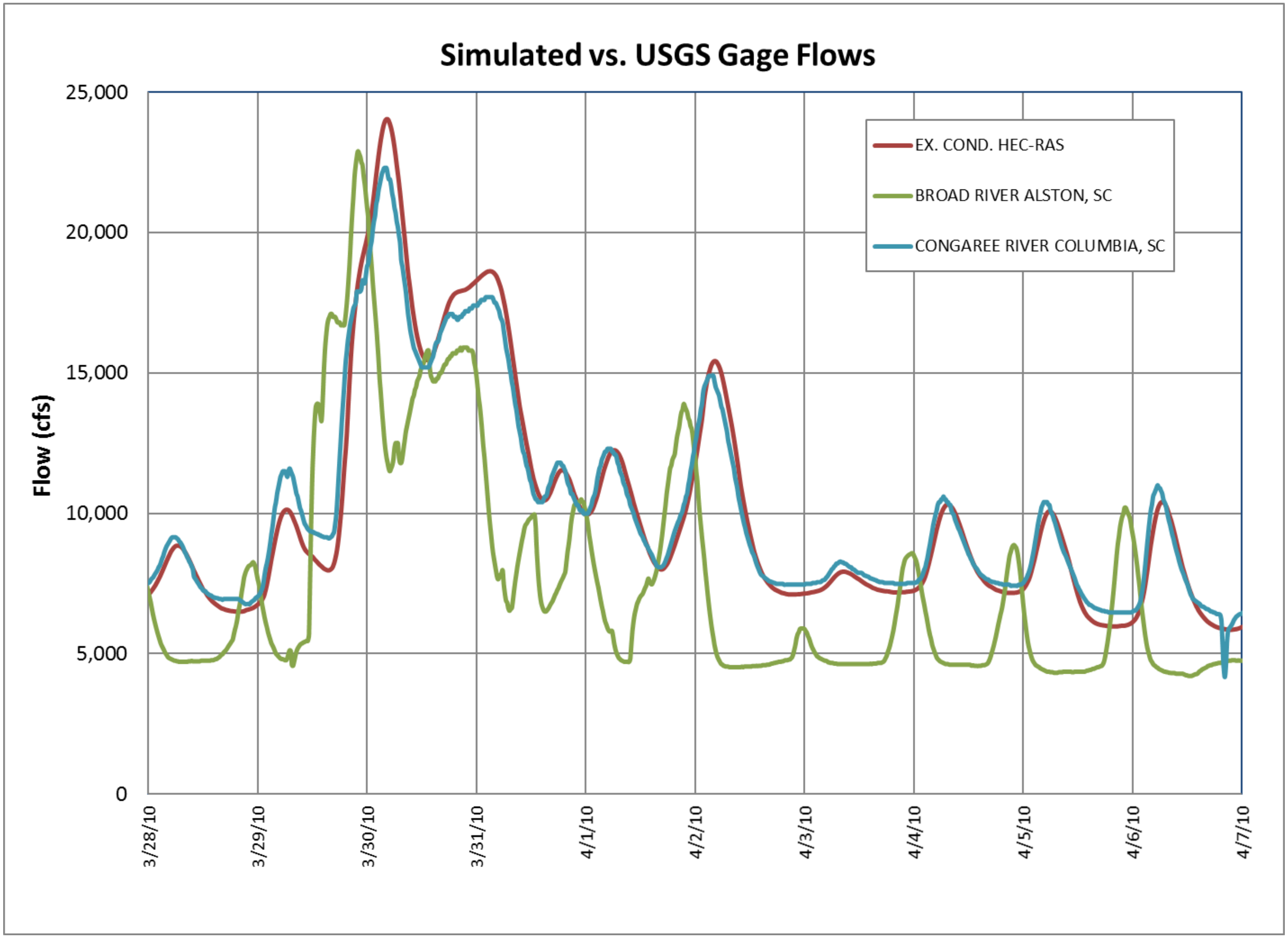

FIGURE 5 VALIDATION OF SIMULATED FLOW CYCLES

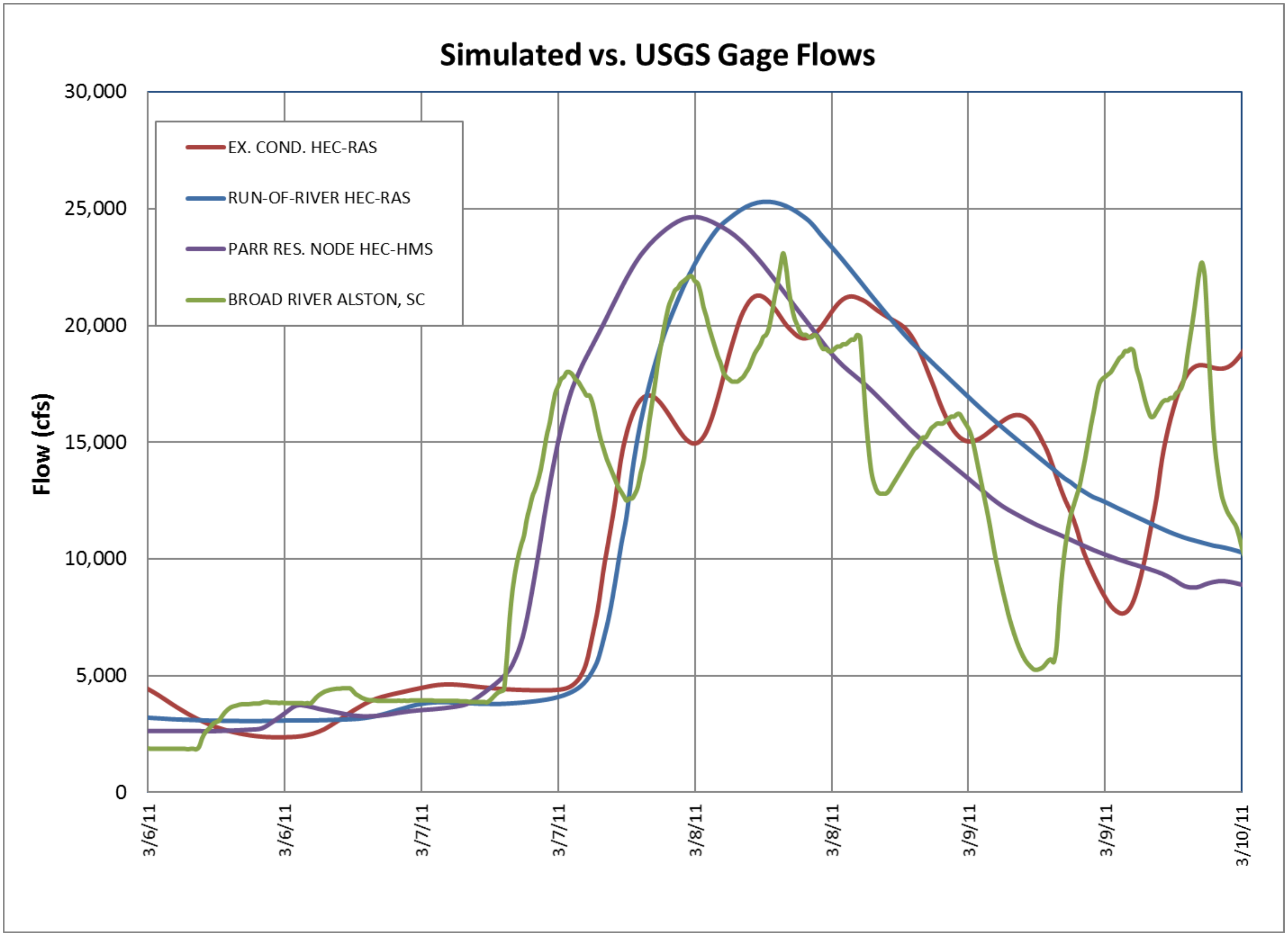

FIGURE 6 EXAMPLE OF SIMULATION OF EXISTING FLOW OPERATIONS VS. RUN-OF-RIVER ESTIMATE

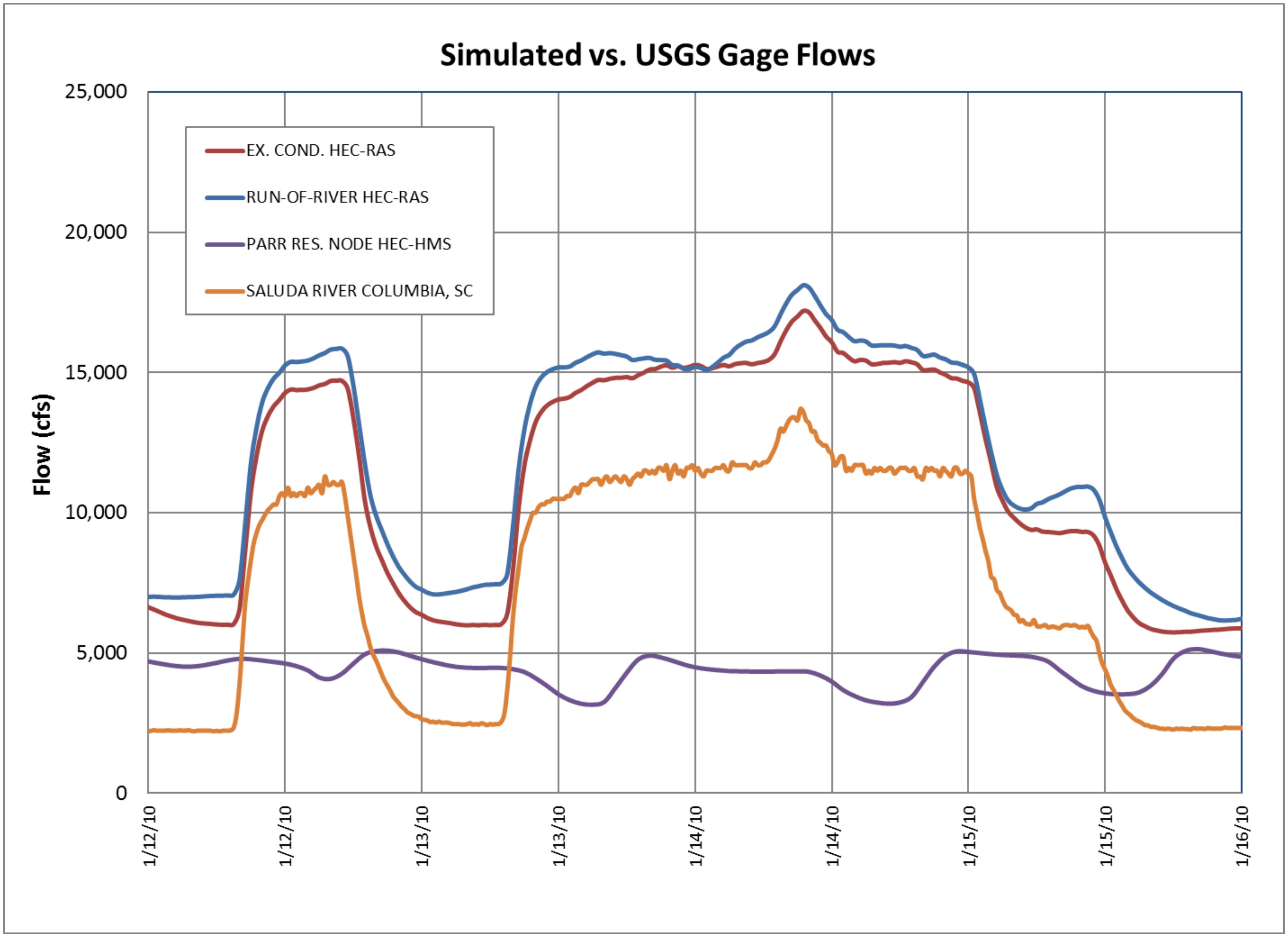

FIGURE 7 SIMULATION OF FLOWS PRIMARILY INFLUENCED BY SALUDA RIVER

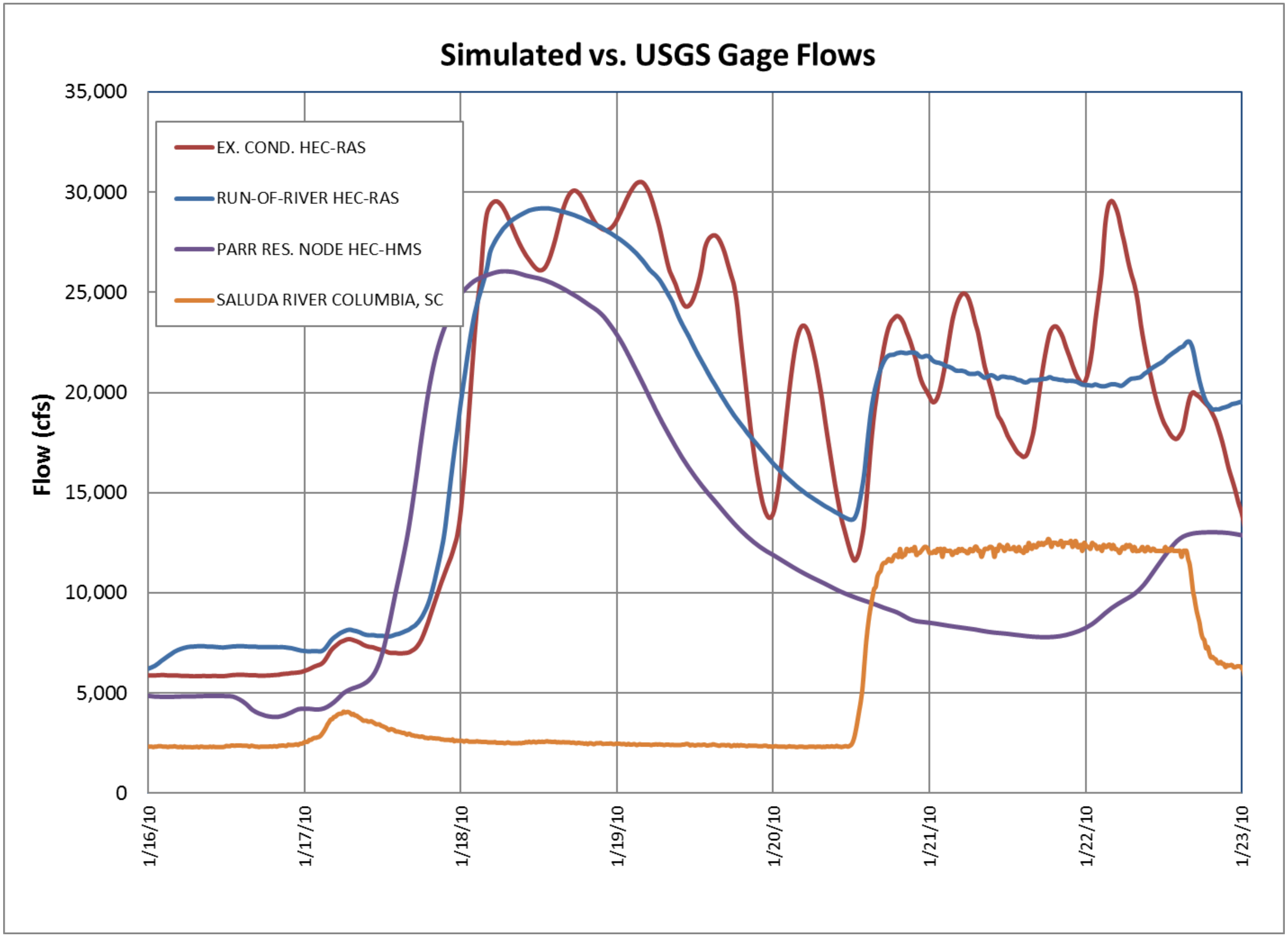

FIGURE 8 SIMULATION OF FLOW INFLUENCED BY EXISTING PARR OPERATIONS AND SALUDA RIVER

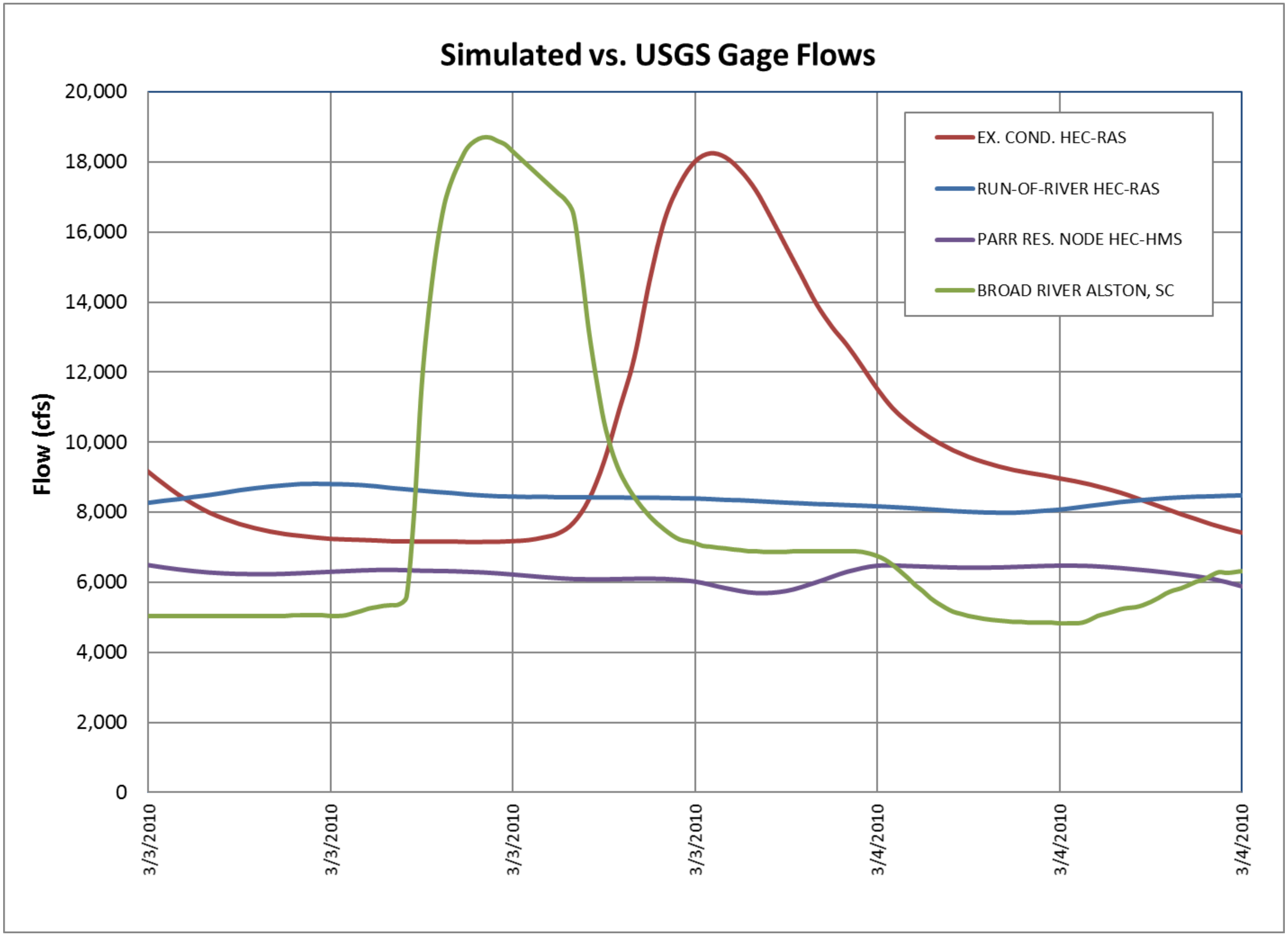

FIGURE 9 PARR OPERATIONAL FLOW RELEASE WITHOUT SIGNIFICANT INFLOW EVENT

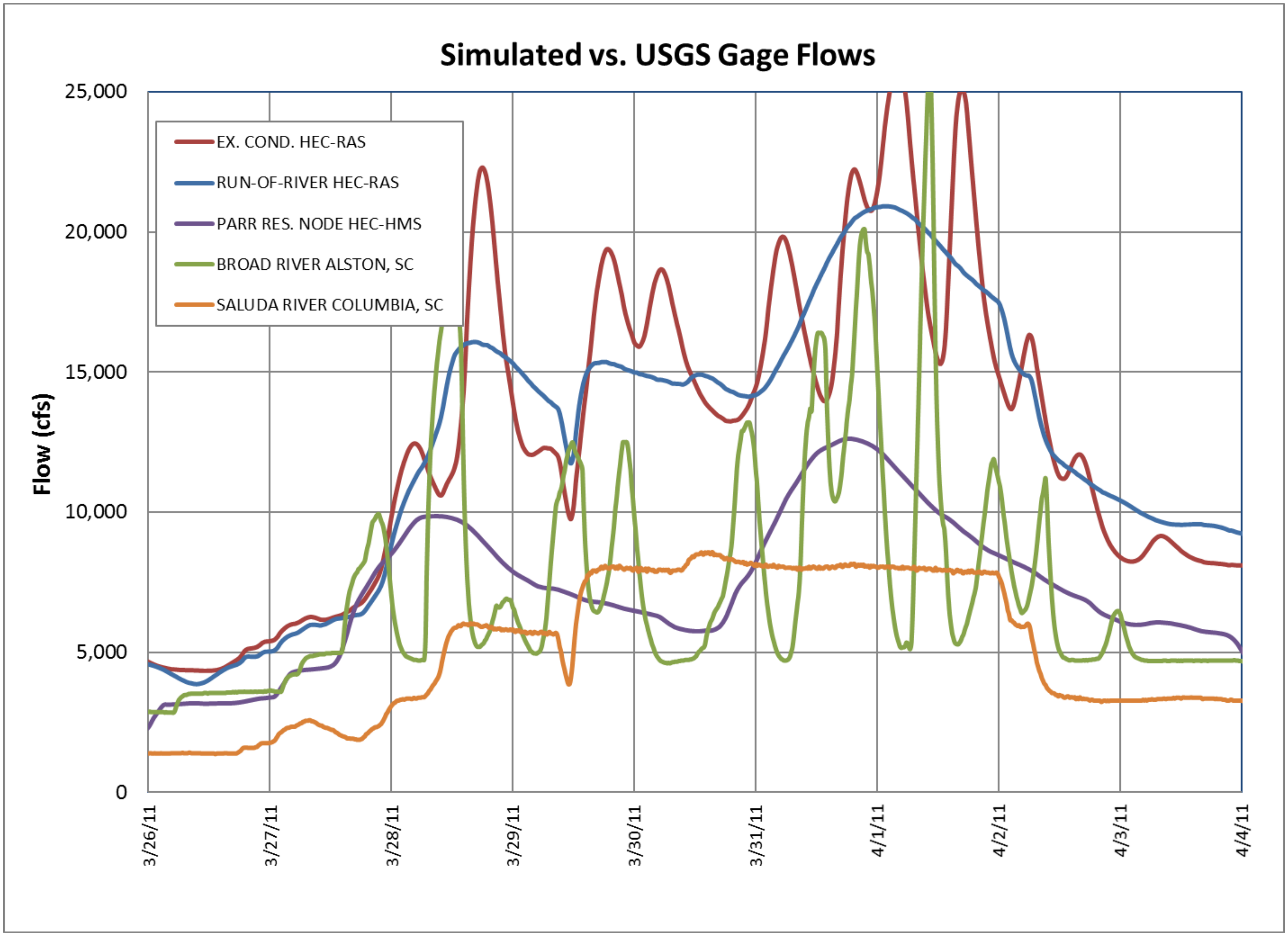

FIGURE 10 PROLONGED HEAVY INFLOW EVENT

Exhibit E-5 Fisheries Resources

Flow Fluctuations Downstream of Parr Shoals

Dam Adaptive Management Plan

ADAPTIVE MANAGEMENT PLAN

FLOW FLUCTUATIONS DOWNSTREAM OF PARR SHOALS DAM

SOUTH CAROLINA ELECTRIC & GAS COMPANY

FERC NO. 1894

Prepared by:

South Carolina Electric & Gas Company

June 2018

ADAPTIVE MANAGEMENT PLAN
FOR THE
FLOW FLUCTUATIONS DOWNSTREAM OF PARR SHOALS DAM

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DEFINITIONS OF TERMS, ACRONYMS, AND ABBREVIATIONS

AMP	Adaptive Management Plan
AR	American Rivers
CFR	Code of Federal Regulations
cfs	cubic feet per second
Commission	Federal Energy Regulatory Commission
CRK	Congaree Riverkeeper
CRSA	Comprehensive Relicensing Settlement Agreement
DLA	Draft License Application
FERC	Federal Energy Regulatory Commission
FLA	Final License Application
ft	foot
Generator capacity	the maximum amount of electricity that can be produced within the safety limitation of a generator
Head	the difference in the elevation of the upstream reservoir in relation to the tailrace elevation
Hydraulic capacity	the maximum amount of water that can be passed through the Project turbines
IFIM	Instream Flow Incremental Methodology
installed capacity	the nameplate megawatt rating of a generator or group of generators
interested parties	individuals and entities that have an interest in a proceeding
kW	Kilowatt
kWh	kilowatt-hour
Licensee	South Carolina Electric & Gas Company
Licensing/Relicensing	the process of acquiring an original FERC license for a new proposed hydropower project; or, the process of acquiring a new FERC license for an existing hydropower project after the previous license has expired.
Minimum Flow	A continuous flow, measured in CFS that is required to be released from the Project dam during specified periods of time.
Msl	mean sea level
MW	megawatt
MWh	megawatt-hour
Net inflow	The previous day's daily average inflow as calculated using the sum of the three upstream USGS gages (USGS 02156500, Broad River near Carlisle, SC; USGS 02160105, Tyger River near Delta, SC; and USGS 02160700, Enoree River at Whitmire, SC) minus evaporation from the reservoirs.
NGO	non-governmental organization
NMFS	National Marine Fisheries Services, also known as NOAA Fisheries
NOAA	National Oceanic and Atmospheric Administration, including NMFS
normal operating capacity	The maximum MW output of a generator or group of generators under normal maximum head and flow conditions
PM&E	protection, mitigation and enhancement measures

Project	Parr Hydroelectric Project (FERC No. 1894)
Project Area	Zone of potential, reasonably direct project effects within the FERC Project Boundary.
Project Boundary	The boundary line defined in the license issued by FERC that surrounds areas needed for Project purposes.
Review Committee	A group, including SCE&G and stakeholders, formed to direct the implementation of the Downstream Flow Fluctuation AMP. Members of the Review Committee must be signatories to the Comprehensive Relicensing Settlement Agreement.
SCDHEC	South Carolina Department of Health and Environmental Control
SCDNR	South Carolina Department of Natural Resources
SCE&G	South Carolina Electric & Gas Company
SHPO	State Historic Preservation Officer
Tailrace	Channel through which water is discharged from the turbines
TLP	Traditional Licensing Process
Turbine capacity	maximum shaft horsepower for an individual turbine at full gate
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WQFW RCG	Water Quality, Fish and Wildlife Resource Conservation Group
WUA	Weighted Usable Area

1.0 INTRODUCTION

South Carolina Electric & Gas Company (SCE&G) must file an application for a new license for its Parr Hydroelectric Project (Project) (FERC No. 1894) on the Broad River with the Federal Energy Regulatory Commission (FERC) by June 2018. SCE&G is currently involved in a multi-year relicensing process that requires a cooperative effort between SCE&G and stakeholders, including state and federal resource agencies, non-governmental organizations (NGOs) and concerned citizens, to address operational, recreational and ecological concerns associated with Project operations. During relicensing, the issue of downstream flow fluctuations associated with Project operations was identified by the Water Quality, Fish and Wildlife Resource Conservation Group (WQFW RCG) as an issue that needed to be resolved. The WQFW RCG includes representatives from SCE&G, South Carolina Department of Natural Resources (SCDNR), U.S. Fish and Wildlife Service (USFWS), South Carolina Department of Health and Environmental Control (SCDHEC), National Oceanic and Atmospheric Administration (NOAA), American Rivers and Congaree Riverkeeper. The WQFW RCG discussed and determined necessary changes to Project operations to stabilize downstream flows. Over the course of several WQFW RCG meetings, a framework for a Downstream Flow Fluctuation Adaptive Management Plan (AMP) was developed to address downstream flow stabilization during the new license term (Appendix A). This AMP outlines SCE&G's proposed actions for stabilizing downstream flows and will be implemented during the term of the new Project license.

1.1 PROJECT DESCRIPTION

The Parr Hydroelectric Project includes the 14.88-megawatt (MW) Parr Shoals Development (Parr Development) and the 511.2-MW Fairfield Pumped Storage Development (Fairfield Development) located in Fairfield and Newberry counties, South Carolina. Parr Reservoir is a 4,400-acre impoundment formed by the Broad River and the Parr Shoals Dam and serves as the lower reservoir for the Fairfield Development's pumped storage operations. Monticello

Reservoir is a 6,800-acre impoundment formed by a series of four earthen dams and serves as the upper reservoir for the Fairfield Development's pumped storage operations. The existing Project license was issued by FERC on August 28, 1974 for a period of 46 years, terminating on June 30, 2020. SCE&G intends to file for a new license with FERC on or before May 31, 2018.

2.0 DOWNSTREAM FLOW FLUCTUATION AMP REVIEW COMMITTEE

2.1 COMMITTEE MEMBERS

A Review Committee will be formed to direct the implementation of the AMP. Members of the Review Committee must be signatories to the Comprehensive Relicensing Settlement Agreement (CRSA) with the exception of NOAA Fisheries, USFWS, US Forest Service, South Carolina State Historic Preservation Office, SCDHEC and SCDNR.

SCE&G will serve as chairperson of the Review Committee, and be responsible for organizing meetings and distributing documents to committee members. Each entity will have the opportunity to select a representative to the Review Committee from within their organization.

The Review Committee will ultimately work to guide the decision-making processes specified in the Downstream Flow Fluctuation AMP. The Review Committee will not make decisions that conflict with state or federal law. The Review Committee's responsibilities may include, but are not limited to:

- Evaluating baseline information and study plans;
- Providing overall guidance for the AMP process;
- Evaluating other study (i.e., existing) information or information which becomes available during the time period of evaluations and would be applicable to the AMP;
- Establishing and documenting the goals and objectives of each action undertaken as part of the AMP and advising when modifications to metrics used for evaluation purposes are needed;
- Reviewing and considering long term impacts of operational modifications on the Project and Project economics when evaluating the feasibility of implementing modifications; and
- Advising on modifications to the AMP to be presented to FERC and advising if any amendment action is necessary during the term of the license.

2.2 BUDGET/RESOURCES

The responsibility for implementation of this AMP, including its funding, will rest primarily with SCE&G, as licensee for the Parr Project. SCE&G will also rely on other resources outside of its establishment including, but not limited to, the following:

- federal, state and local grants
- donated services (federal and state agency involvement)
- expertise (governmental, non-governmental, private)

2.3 COMMITTEE MEETINGS

The Review Committee is tentatively scheduled to consult once per year via an in-person meeting or conference call. The meetings would be held to review current procedures, set future targets, and continue to provide input on operating guidelines. These annual meetings would assess how closely SCE&G matched outflows to inflows during spring stabilization periods, and to evaluate whether the stabilization goals were met year-round and/or seasonally.

The frequency of meetings may be adjusted based on need. The tentative schedule is provided in Section 6.0 of this plan. Minutes from each meeting, as well as any pertinent materials discussed in the meetings will be filed with FERC as an appendix to the annual report of AMP activities, as described in Section 7.0 of this plan.

3.0 GOALS AND OBJECTIVES

The WQFW RCG has requested that SCE&G reduce the fluctuations downstream of Parr Shoals Dam that result from Project operations. Specifically, they requested two levels of reduced fluctuations. The first goal is to reduce year-round downstream flow fluctuations. This goal would benefit the aquatic resources in the Broad River downstream of Parr Shoals Dam by stabilizing wetted habitat and reducing large daily fluctuations by some amount. The second goal is to stabilize flows during two 14-day spawning periods. During the spawning periods, SCE&G would attempt to match inflow and outflow to potentially improve spawning conditions for several species of fish, including anadromous American shad, striped bass and the Congaree River population of shortnose sturgeon.

4.0 CURRENT OPERATIONS

During the current license, SCE&G has operated the Project to meet the requirements of the current license articles and FERC regulations. Under current operation guidelines, Parr Reservoir can fluctuate up to 10 feet daily and Monticello Reservoir can fluctuate up to 4.5 feet daily as part of the pumped storage operations of the Fairfield Development. SCE&G operators also do not allow Parr Reservoir to rise above full pool and pass water over the spillway crest gates in the closed position. The operators only have two options for managing Parr Reservoir level under variable inflow conditions. They can pass water through the Parr Shoals turbines or lower the spillway crest gates. The ten crest gates are operated in pairs, with each pair being 400 feet long. The crest gates can be lowered in 0.1 foot increments over a ten foot operating range to allow inflow in excess of Parr Shoals Hydro's hydraulic capacity to spill over the gates.

Article 39 of the current license requires SCE&G to operate the Project reservoirs in such a manner that releases from Parr Reservoir (during flood flows) are no greater than flows which would have occurred in the absence of the Project. Assessments conducted during the late 1970's and in 2014 both indicate that flows of 40,000-45,000 cfs would begin to inundate and flood lands downstream of Parr Shoals Dam. Several measures have been implemented during the current license to ensure that only natural inflows above 40,000 cfs pass downstream of the Parr Development, and that releases from the Fairfield Development do not increase the magnitude or frequency of downstream flooding. These measures include incrementally lowering spillway gates when inflow, as measured at the three upstream USGS gages (see Section 5.1.2) is between 6,000-8,000 cfs, and continuing until all ten gates are in the open (lowered) position by the time that inflows reach 40,000 cfs. Additionally, generation at the Fairfield Development is reduced as inflow increases and is completely curtailed by the time inflows reach 40,000 cfs. By the time that the 40,000 cfs threshold has been met, all gates must be lowered to the full open position and Fairfield Development generation must be curtailed. However, pump back operations at Fairfield may occur during high flow events, as these operations actually reduce the amount of flow passing through the Parr Development. This operating regime has proved to be successful in the past and SCE&G intends to continue operating in this manner during future high flow events.

During relicensing, stakeholders noted that when inflow to the Project is less than 40,000 cfs, frequent fluctuation events occur throughout the year that sometimes increase and decrease releases from the Project by 5,000 to 10,000 cfs daily. This issue was addressed during the relicensing process by the WQFW RCG. The RCG held meetings on August 26, 2015, January 1, 2016, August 17, 2016 and October 18, 2016 to discuss the magnitude of this issue. The notes from each meeting and additional information provided to the RCG are included in Appendix A. As part of these RCG discussions, SCE&G determined that two operational practices contribute to downstream flow fluctuations. First, current operations include daily or weekly "reservoir inventory management releases" through the Parr Shoals Dam spillway crest gates that causes some of the fluctuations in downstream flow. When inflow to Parr Reservoir is greater than the flows that the Parr Shoals powerhouse can pass, the reservoir level slowly rises during the week and water is then released by lowering crest gates. Current inventory management operations result in large, short duration pulses being released downstream. Second, some or all of the spillway gates are sometimes lowered and left in that position for several days to spill excess inflow, which increases the influence of Fairfield generation and pumping on downstream flows due to water spilling over the lowered gates as Parr Reservoir rises and falls during pumped storage operations. SCE&G plans to develop and begin to implement operational guidelines and procedures during the term of this AMP that will reduce the frequency and duration of these pulses and fluctuations and allow SCE&G to manage reservoir inventory more proactively under the new license.

5.0 AMP IMPLEMENTATION

The WQFW RCG identified the need to reduce downstream flow fluctuations in the Broad River caused by Project operations year-round. The WQFW RCG also identified the need for stable flows during specific fish spawning periods during the spring. The success of flow fluctuation reductions will be measured by comparing inflow to outflow at the Project, both qualitatively and using metrics such as deviation of outflow from inflow as described below in Section 5.1.2. Additionally, WUA data from the IFIM study performed during relicensing may potentially be used to evaluate the habitat improvements which may result from reductions in fluctuations. Because this AMP covers a five-year period, SCE&G will work with the Review Committee to set appropriate evaluation and compliance criteria each year. Compliance criteria will consider the effects of mechanical restrictions (turbines down for repair), high inflow event information for each year and will also include deviation criteria during the four weeks of spring spawning season.

5.1 GENERAL YEAR-ROUND DOWNSTREAM FLOW FLUCTUATION REDUCTIONS

System control operators will modify year-round inventory management release operations to reduce downstream flow fluctuations during all months. Parr spillway gates are currently only operated when the Project is manned (i.e. weekdays during daytime hours). This can result in flows being built up overnight or gates being left down, both of which contribute to downstream flow pulses. Additional guidelines will be developed for use by system control and plant operators to ensure that flows are released on a more even schedule.

A remote-control camera will be installed on the west side of the Parr Shoals Dam. This camera will allow offsite system control operators to determine if conditions are safe to raise or lower crest gates 1 and 2 when the plant is unmanned. Along with the remote-control camera, the capability for remote-control operation of crest gates 1 and 2 will be added. This will allow system control to make around the clock gate adjustments based on real time inflow and reservoir level data, as opposed to gate adjustments being limited to daytime hours when the powerhouse is manned.

SCE&G has agreed to investigate the potential for automating the crest gate operation using a Programmable Logic Controller (PLC) based system. A PLC is already used to position the gates, and it may be possible to incorporate inputs of inflow, reservoir level, and outflow and develop logic that will allow the gates to track changes in Parr Reservoir level so as to provide a more constant outflow during periods of spillage. Automated gate operation will be subject to SCE&G's ability to effectively monitor the gates for debris accumulation and other safety related conditions when gates are positioned.

Modifications or replacement of generators at the Parr Development may also be implemented during the new license if it is determined that these changes are mechanically and economically feasible. This change would allow increased hydraulic capacity through the powerhouse and would assist in regulating reservoir inventory and reduce the frequency of spillage at Parr Shoals Dam.

While the original hydraulic capacity (the maximum amount of water that can be passed through the Project turbines) of the Parr Development powerhouse was 6,000 cfs, the increase in head (the difference in the elevation of the upstream reservoir in relation to the tailrace elevation) during the construction of the Fairfield Development resulted in a turbine capacity (maximum shaft horsepower for an individual turbine at full gate) that exceeded the generator capacity (the maximum amount of electricity that can be produced within the safety limitation of a generator). The generator limitations actually limit the hydraulic capacity of the project to approximately 4,800 cfs, due to the need to operate the turbines at a reduced gate opening. Increasing the generator capacity would allow higher turbine flows, with a Project hydraulic capacity of approximately 6,000 cfs at low pond to 7,000 cfs when the Parr Reservoir is full.

Increasing the powerhouse hydraulic capacity will reduce the need to pass inflows using spillway gates, which will aid in reducing downstream flow fluctuations. To quantify the benefit of this increased control, the flow duration data was used to compare the existing and anticipated increase in hydraulic capacities. The difference between these represents the "benefit" of turbine-controlled releases.

For example, in Table 5-1, under current conditions the existing hydraulic capacity is exceeded 64.2 percent of the time during the month of March. By comparison, after all generators are upgraded, hydraulic capacity at minimum and maximum pond would be exceeded 48.3 and

38.2 percent of the time. This generator upgrade program results in spillway gate control of downstream flows being reduced 15.9 to 26.0 percent of the time.

TABLE 5-1 PERCENT OF TIME SPILLWAY FLOW CONTROL IS REDUCED

Station	Percent of Time Flow Exceeded												
Flow (cfs)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
4,800	52.2%	58.0%	64.2%	50.5%	31.9%	23.1%	14.9%	16.4%	9.5%	13.3%	21.3%	43.0%	33.0%
6,000	35.0%	41.3%	48.3%	38.5%	19.7%	12.7%	7.5%	10.8%	4.8%	9.0%	14.2%	26.8%	22.2%
7,000	28.6%	34.1%	38.2%	29.0%	14.2%	8.7%	6.5%	8.8%	3.6%	7.6%	11.4%	21.7%	17.5%
	Percent of Time Spillway Flow Control is Reduced												
6,000	17.1%	16.7%	15.9%	12.0%	12.2%	10.5%	7.5%	5.6%	4.8%	4.2%	7.1%	16.2%	10.8%
7,000	23.6%	23.9%	26.0%	21.4%	17.7%	14.5%	8.5%	7.6%	5.9%	5.6%	9.9%	21.4%	15.5%

5.2 SPRING SPAWNING STABILIZATION

Operational practices will be further modified during two 14-day spring spawning periods to further reduce downstream flow fluctuations. During these timeframes, the Project's operational goal will be to provide outflows that more closely match inflows. SCE&G will staff the Parr Shoals facility 24 hours/day during these periods to manipulate crest gates to more closely track Parr reservoir level and maintain a more constant discharge. Exceptions will be during periods when the inflow is less than the hydraulic capacity of the Parr Shoals turbines (when crest gates can be maintained in the raised position) and/or during flood events (when gates must be lowered progressively to limit backwater effects upstream of the dam). The periods of spawning flow stabilization will be determined annually by the Review Committee prior to the spawning period. Exact timing may vary from year to year but will generally be as follows:

- For 14 days during the last two weeks of March (March 15 through March 31) - flow stabilization for shortnose sturgeon in the Congaree River.
- Two 7-day blocks during April 1 through May 10 - flow stabilization for numerous species including striped bass, American shad, and robust redhorse.

During these stabilization periods, hourly inflow and mean deviation of outflow vs. inflow will be computed and tracked as a running measure each year. An example of how the mean deviation would be computed is included in Appendix B. Annual target reductions in mean deviation (correlated to mean inflow) will be set by the Review Committee each year during the 5-year monitoring period. This will guide operations with the goal of reducing downstream fluctuations. Project inflow will be computed as the sum of flows measured at the three USGS gage stations upstream of Parr Shoals Dam minus estimated evaporation from the Project reservoirs. Evaporation estimates used by SCE&G are based on standard methodology and are presented in Appendix C.

The three gages used to calculate inflow are:

- 02156500 Broad River near Carlisle, SC
- 02160105 Tyger River near Delta, SC
- 2160700 Enoree River near Whitmire, SC

As inflow increases, backwater restrictions (potential of flooding the railroad tracks at Section 13 of the USGS backwater profile as shown on drawing Exhibit G-9) will limit how far the crest gates can be raised as Parr Reservoir rises. At some level of inflow Fairfield operations may need to be curtailed, or it may be determined by the Review Committee that certain releases during periods of higher inflow will not negatively impact the species in the river and that adjusting the gates to track the reservoir level may not be necessary. When computing inflow, no correction will be made for travel time, and the measured discharge (total inflow) will not be prorated to account for un-gaged areas between the gage stations and Parr Shoals Dam.

5.3 Annual Analysis

A Review Committee meeting will be held annually to review the results of downstream flow fluctuation reductions, set compliance targets for the following year, and suggest additional changes to operating guidelines. For this meeting, SCE&G will prepare a summary report on the success of the downstream flow fluctuation efforts during the year. This assessment will be performed using metrics such as deviation of outflow from inflow, or other measures such as the percent of time that outflow was within “X” percent of inflow. The report will also include an assessment of flow fluctuation reductions both year round and during the two 14-day spawning periods. The annual report, along with Review Committee meeting notes, will be filed with FERC following each annual meeting.

Potential metrics being considered for evaluating reductions in flow fluctuation include:

- Computing the mean hourly deviation of outflow from inflow over a specific time period, i.e. the entire year, the spring flow stabilization period, or monthly. This computation would involve comparing hourly values of outflow and inflow, computing the absolute value of the difference each hour (the deviation), and taking the mean of the deviation values over the time period being evaluated. An example computation using actual inflow and outflow data is presented in Appendix B, along with a discussion of the relevance of this metric for evaluating the magnitude of fluctuations relative to inflow.

- Examining graphs of inflow and outflow to determine how closely the outflow hydrograph compares to the inflow hydrograph. Example graphs are included as Figure 1 and Figure 2.

Figure 1 shows a period during March 2012 when inflow to the Project was less than the hydraulic capacity of Parr Hydro, and the crest gates were maintained in a fully raised position (no spillage). Even with Fairfield Pumped Storage (FFPS) operating throughout the period, the crest gates were maintained in the fully raised position and the overall pattern of Project releases matched well with the overall pattern of inflow to the Project. Mean hourly deviation of outflow from inflow over this period was 567 cfs.

Figure 2 shows a period during March 2010 when inflow to the Project was greater than the hydraulic capacity of Parr Hydro, and several crest gates were maintained in a partly or fully lowered position (spillage occurred). With Fairfield Pumped Storage (FFPS) operating throughout the period, the overall pattern of Project releases did not match well with the overall pattern of inflow to the Project. Mean hourly deviation of outflow from inflow over this period was 1,641 cfs, nearly three times the mean hourly deviation shown in Figure 1. Figure 2 also shows that the amount of fluctuation becomes greater as inflow increases, due to the need to spill more of the inflow using the crest gates. This correlation of greater fluctuation with increasing inflow is discussed in more detail in Appendix B.

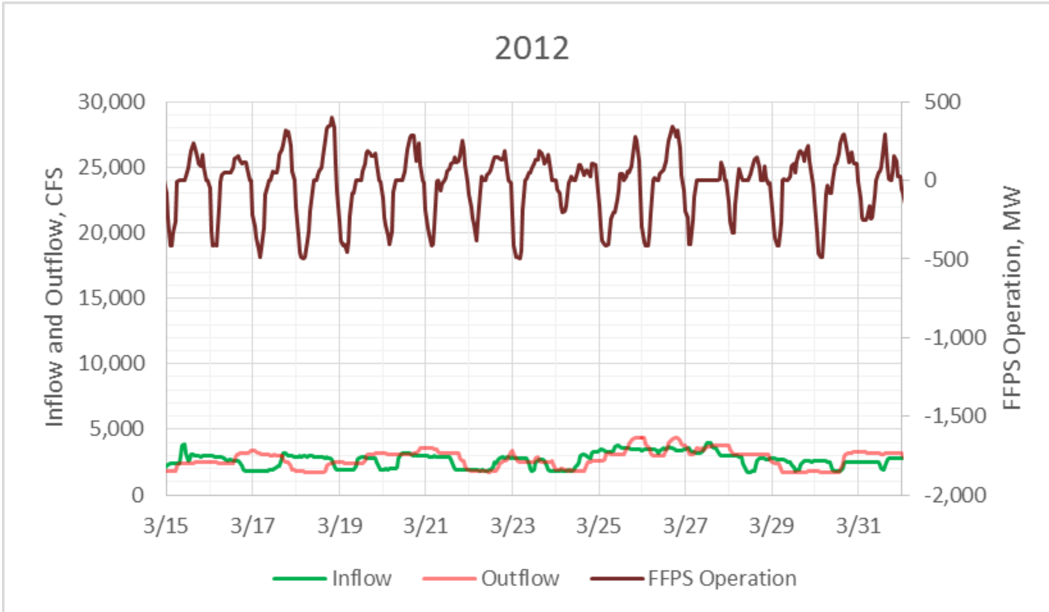


FIGURE 1 GRAPH ILLUSTRATING A PERIOD OF SMALLER FLUCTUATIONS (INFLOW < PARR HYDRO HYDRAULIC CAPACITY)

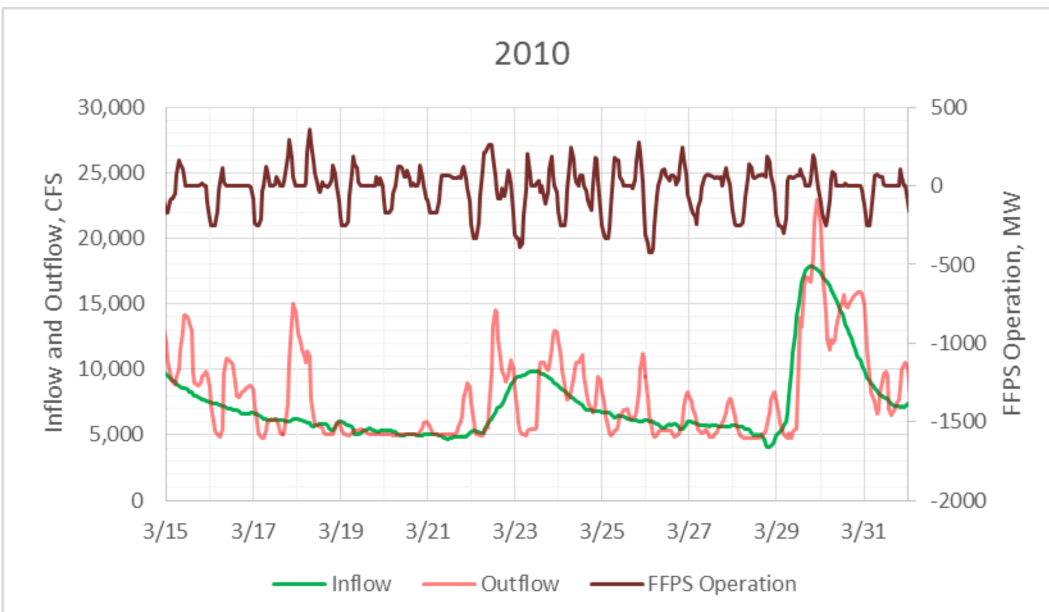


FIGURE 2 GRAPH ILLUSTRATING A PERIOD OF LARGER FLUCTUATIONS (INFLOW > PARR HYDRO HYDRAULIC CAPACITY)

6.0 SCHEDULE

The AMP schedule is described in the table below in relation to the issuance of the license by FERC.

TABLE 6-1 AMP IMPLEMENTATION SCHEDULE

Period	Item
Within 90 days of license issuance	Submit updated Downstream Flow Fluctuation AMP to FERC
Within 120 days of license issuance	Form Review Committee – develop "compliance criteria"
*Year 1- of new license	• Modify inventory management releases using guidelines to be developed by SCE&G • System Control implements new operating guidelines to reduce flow pulses throughout the year • Implement spring spawning flow stabilization (March and April-May) • Review Committee meeting to review results and set compliance criteria – February of the following year • File Annual Report with FERC – April 30 after Review Committee meeting
End of first calendar year following the year of license issuance	• Addition of remote control camera to west abutment of Parr Shoals Dam and provide System Control operators the ability to operate the camera • Add remote control operation of crest gates 1 and 2 and provide System Control operators the ability to operate these two gates
*Year 2 of new license	• System Control implements any modifications of operating guidelines to reduce flow pulses throughout the year • Implement spring spawning flow stabilization (March and April-May) • Review Committee meeting to review results and set compliance criteria for following year – February of the following year • File Annual Report with FERC – April 30 after Review Committee meeting
*Year 3 of new license	• System Control implements any modifications of operating guidelines to reduce flow pulses throughout the year • Implement spring spawning flow stabilization (March and April-May) • Review Committee meeting to review results and set compliance criteria for following year – February of the following year • File Annual Report with FERC – April 30 after Review Committee meeting
*Year 4 of new license	• System Control implements any modifications of operating guidelines to reduce flow pulses throughout the year

	• Implement spring spawning flow stabilization (March and April-May) • Review Committee meeting to review results and set compliance criteria for following year – February of the following year • File Annual Report with FERC – April 30 after Review Committee meeting
*Year 5 of new license	• System Control implements any modifications of operating guidelines to reduce flow pulses throughout the year • Implement spring spawning flow stabilization (March and April-May) • Review Committee meeting to review results and set compliance criteria for following year – February of the following year • Develop recommendation for completion or continuation of the AMP • File Annual Report with FERC – April 30 after Review Committee meeting

*Year 1 through 5 - Upgrade generators and expand hydraulic operating range, this could continue through year 10 after license issuance

7.0 COMPLIANCE

Compliance will be based on following the schedule in Section 6.0 and submission of an annual AMP report each year to FERC. The annual report will contain a summary of all AMP activities and data, including an assessment of the extent to which goals and objectives were achieved. The report will be made available to appropriate entities for review and comment at least 30 days prior to being submitted to FERC. All comments on the report, pertinent correspondence, and Review Committee meeting minutes will be appended to the annual report.

At the end of the 5-year AMP period, the Review Committee will provide final recommendations to FERC on extension or completion of the AMP. If the AMP is completed, then final compliance criteria will be proposed by the Review Committee for use during the remainder of the license.

8.0 REFERENCES

Federal Power Commission (FPC). 1974. Order Issuing New License (Major). Authorizing Project Redevelopment, Permitting use of Project Waters for Condenser Cooling Purposes, Vacating Hearing Order, and Permitting Withdrawal of Intervention. (Project No. 1894). Issued August 28, 1974.

APPENDIX A

SUMMARY OF CONSULTATION

Appendix A – Summary of Consultation

The Water Quality, Fish and Wildlife RCG convened often throughout the relicensing process to discuss the development of the Downstream Flow Fluctuations AMP. A list of meeting dates pertinent to the development of this AMP is included below. The complete consultation record for the development of this AMP, including notes from the meetings listed below, can be found in Appendix A of the Final License Application's Exhibit E.

- WQFW RCG Meeting – August 26, 2015
- WQFW RCG Meeting – January 21, 2016
- WQFW RCG Meeting – August 17, 2016
- WQFW RCG Meeting – October 18, 2016
- Joint[1] RCG Meeting – March 28, 2017
- Joint RCG Meeting – July 13, 2017

[1] A Joint RCG Meeting refers to a meeting where all RCGs are present, including the Water Quality, Fish and Wildlife RCG, the Lake and Land Management and Recreation RCG, and the Operations RCG.

APPENDIX B

MEAN DEVIATION EXAMPLE

Appendix B – Mean Hourly Deviation Example Calculations

Inflow to Parr Reservoir is computed as the sum of three upstream USGS gage station readings: Broad River near Carlisle, Tyger River near Delta, and the Enoree River near Whitmire. No adjustment is made for travel time of flow from the gages, and no scaling for ungaged area is applied. The discharge values for the three gages are provided in columns A – C of the tables below. Outflow from Parr Reservoir is measured at the Broad River at Alston USGS gage, located about one mile downstream of Parr Shoals Dam.

Using hourly Project inflow and outflow data for March 15, 2012 (first day of Figure 1 in Section 5.3), mean hourly deviation for the day (24 hourly values) is computed to be **568 CFS** as shown in the table below:

	A	B	C	D	E	F
Date/Time	Broad River CFS	Tyger River CFS	Enoree River CFS	Total Inflow (A+B+C) CFS	Outflow CFS	Deviation ABS(D-E) CFS
3/15/2012 0:00	1,470	411	311	2,192	1,850	342
3/15/2012 1:00	1,580	411	311	2,302	1,820	482
3/15/2012 2:00	1,650	409	311	2,370	1,810	560
3/15/2012 3:00	1,710	406	311	2,427	1,770	657
3/15/2012 4:00	1,730	406	309	2,445	1,770	675
3/15/2012 5:00	1,700	406	309	2,415	1,790	625
3/15/2012 6:00	1,730	406	307	2,443	2,190	253
3/15/2012 7:00	1,730	400	307	2,437	2,350	87
3/15/2012 8:00	2,320	406	307	3,033	2,380	653
3/15/2012 9:00	3,010	403	307	3,720	2,380	1,340
3/15/2012 10:00	3,110	406	307	3,823	2,400	1,423
3/15/2012 11:00	2,510	406	307	3,223	2,380	843
3/15/2012 12:00	1,890	409	307	2,606	2,400	206
3/15/2012 13:00	1,970	406	307	2,683	2,400	283
3/15/2012 14:00	2,320	409	307	3,036	2,410	626
3/15/2012 15:00	2,330	406	307	3,043	2,430	613
3/15/2012 16:00	2,320	406	305	3,031	2,450	581
3/15/2012 17:00	2,260	395	307	2,962	2,460	502
3/15/2012 18:00	2,300	400	305	3,005	2,460	545
3/15/2012 19:00	2,210	398	305	2,913	2,480	433
3/15/2012 20:00	2,280	398	305	2,983	2,480	503
3/15/2012 21:00	2,260	400	305	2,965	2,500	465
3/15/2012 22:00	2,280	395	305	2,980	2,510	470
3/15/2012 23:00	2,280	395	303	2,978	2,510	468
Mean Values:	**2,123**	**404**	**307**	**2,834**	**2,266**	**568**

This same calculation can be performed for any time period. For the 17 day (408 hour) period shown in Figure 1 in Section 5.3, the calculation of mean hourly deviation gives a value of **567 CFS**.

Appendix B – Mean Hourly Deviation Example Calculations

Using hourly Project inflow and outflow data for March 15, 2010 (first day of Figure 2 in Section 5.3), mean hourly deviation for the day (24 hourly values) is computed to be **2,228 CFS** as shown in the table below:

	A	B	C	D	E	F
Date/Time	Broad River CFS	Tyger River CFS	Enoree River CFS	Total Inflow (A+B+C) CFS	Outflow CFS	Deviation ABS(D-E) CFS
3/15/2010 0:00	7,600	1,210	844	9,654	12,100	2,446
3/15/2010 1:00	7,510	1,200	832	9,542	10,700	1,158
3/15/2010 2:00	7,380	1,190	819	9,389	9,700	311
3/15/2010 3:00	7,290	1,180	807	9,277	9,320	43
3/15/2010 4:00	7,200	1,160	798	9,158	9,040	118
3/15/2010 5:00	7,100	1,140	789	9,029	8,850	179
3/15/2010 6:00	6,990	1,130	780	8,900	9,400	500
3/15/2010 7:00	6,880	1,120	771	8,771	10,000	1,229
3/15/2010 8:00	6,740	1,120	762	8,622	11,500	2,878
3/15/2010 9:00	6,720	1,090	756	8,566	13,000	4,434
3/15/2010 10:00	6,740	1,090	748	8,578	14,100	5,522
3/15/2010 11:00	6,700	1,080	739	8,519	14,100	5,581
3/15/2010 12:00	6,630	1,070	733	8,433	13,900	5,467
3/15/2010 13:00	6,520	1,050	730	8,300	13,500	5,200
3/15/2010 14:00	6,440	1,060	727	8,227	13,000	4,773
3/15/2010 15:00	6,330	1,040	719	8,089	9,730	1,641
3/15/2010 16:00	6,260	1,040	716	8,016	8,970	954
3/15/2010 17:00	6,200	1,030	710	7,940	8,850	910
3/15/2010 18:00	6,150	1,020	704	7,874	8,800	926
3/15/2010 19:00	6,110	1,010	699	7,819	8,970	1,151
3/15/2010 20:00	6,030	999	693	7,722	9,470	1,748
3/15/2010 21:00	5,980	988	693	7,661	9,680	2,019
3/15/2010 22:00	5,960	980	687	7,627	9,810	2,183
3/15/2010 23:00	5,900	973	684	7,557	9,650	2,093
Mean Values:	**6,640**	**1,082**	**748**	**8,470**	**10,673**	**2,228**

Again, the same calculation can be performed for any time period. For the 17 day (408 hour) period shown in Figure 2 in Section 5.3, the calculation of mean hourly deviation gives a value of **1,641 CFS**.

The proposed use of mean hourly deviation of outflow from inflow as a metric for evaluating the effectiveness of reductions in downstream flow fluctuations is based on the strong correlation that exists between Project inflow and the mean hourly deviation of outflow from inflow. This can be shown using inflow and outflow data from the period 2000 – 2016 for three periods during the year: March 1 – May 31, March 15 – March 31, and April 1 – May 10. Mean hourly deviation was computed for these periods each year, and the results plotted against inflow.

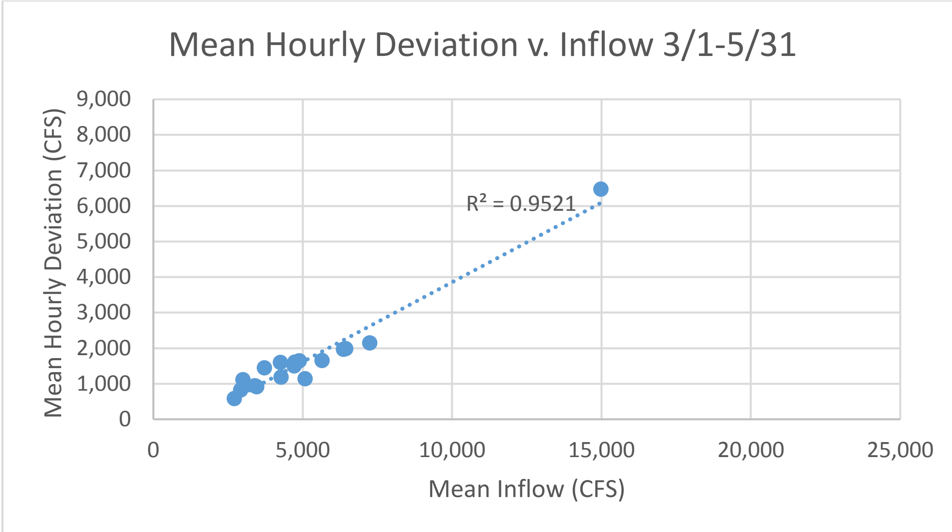
Appendix B – Mean Hourly Deviation Example Calculations

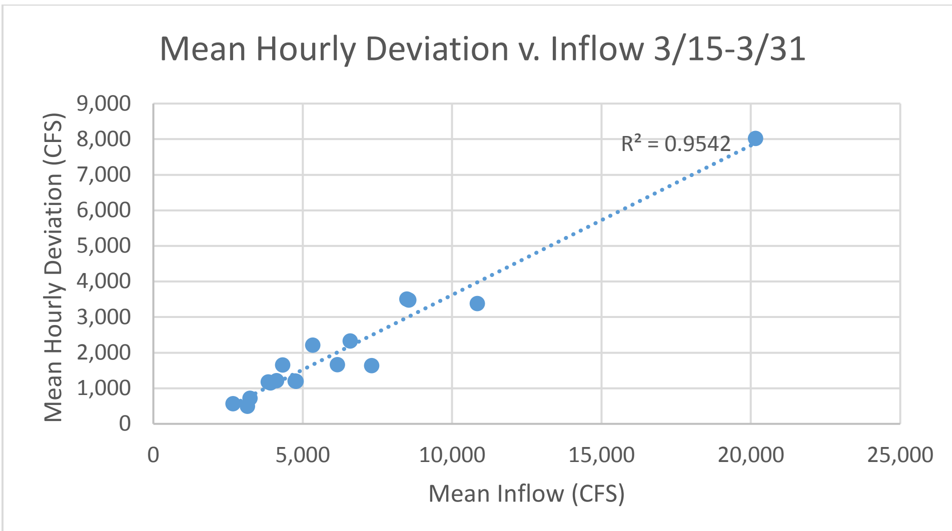
Year	Mean Inflow 3/1-5/31	Mean Hourly Deviation 3/1-5/31	Mean Inflow 3/15-3/31	Mean Hourly Deviation 3/15-3/31	Mean Inflow 4/1-5/10	Mean Hourly Deviation 4/1-5/10
2000	4,250	1,600	8,553	3,483	3,943	1,350
2001	3,716	1,446	8,491	3,506	3,034	1,212
2002	2,996	1,114	4,127	1,215	2,817	1,098
2003	14,980	6,472	20,161	8,018	14,730	6,232
2004	3,458	916	3,240	720	3,808	996
2005	6,438	1,991	10,841	3,384	6,047	2,003
2006	2,715	586	3,146	494	2,777	678
2007	4,889	1,642	4,327	1,655	3,573	911
2008	2,928	823	3,917	1,154	2,789	753
2009	5,644	1,650	6,158	1,667	4,931	1,428
2010	5,073	1,140	7,307	**1,641**	4,465	931
2011	4,278	1,186	4,780	1,197	3,917	1,061
2012	3,399	944	2,667	**567**	2,647	595
2013	7,247	2,147	4,750	1,202	9,943	3,190
2014	6,368	1,970	6,588	2,326	6,936	2,274
2015	4,717	1,499	3,845	1,181	6,542	2,235
2016	4,732	1,614	5,334	2,215	4,630	1,557
Mean	5,166	1,691	6,367	2,096	5,149	1,677

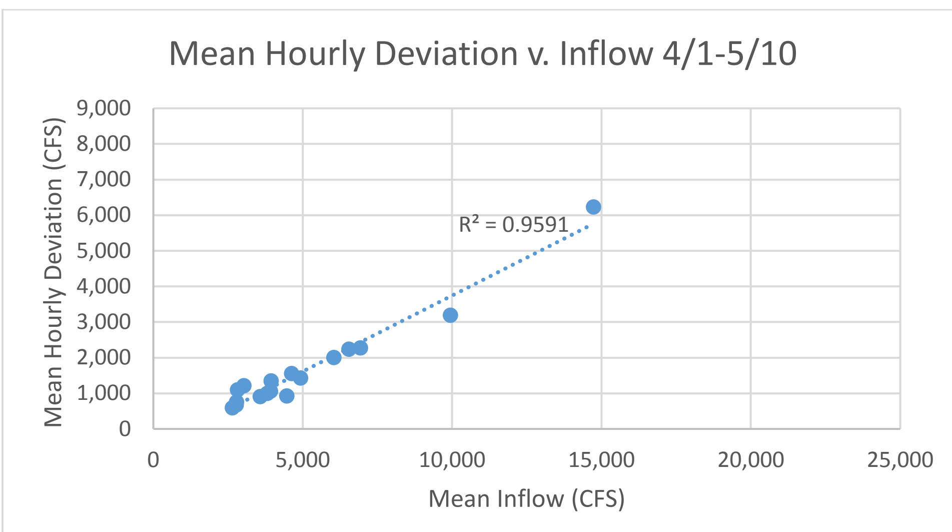
Graphs of mean inflow versus mean hourly deviation for the three time periods in the table above are included on the following page. The best fit linear regression line is shown along with the square of the correlation coefficient, indicating a greater than 95% correlation between mean inflow and mean hourly deviation of outflow from inflow.

In order to use this metric to evaluate the effectiveness of the proposed mitigation measures in reducing downstream flow fluctuations, the mean hourly deviation will be computed from hourly inflow and outflow data, and compared with the deviation that has occurred historically at the same mean inflow. This comparison will be a measure of the amount of fluctuation reduction being achieved. For example, during a future year's evaluation period of March 15 – March 31, use of the proposed fluctuation mitigation measures results in a mean hourly deviation of 1,500 cfs, and mean inflow during this period was 8,000 cfs. The relationship shown in the second graph on the next page indicates that a mean inflow of 8,000 cfs can be expected to result in a mean deviation of 3,000 cfs historically. For the future year in question, the mean hourly deviation was reduced by 50 percent during the evaluation period.

Appendix B – Mean Hourly Deviation Example Calculations







APPENDIX C

EVAPORATION METHODOLOGY

Estimated Evaporation from Parr and Monticello Reservoirs

Evaporation, Central SC			Reservoir Evaporation Loss Estimates in CFS					
	Avg. Monthly FWS Evap. (in).	Evap. Rate (CFS/1000 ac.)	Monticello Evap. Rate (CFS)	VCS Increased Evap. Rate (CFS)	Parr Evap. Rate, (CFS)	**Total Evap. Rate Incl. VCS (CFS)**	**Total Evap. Rate Not Incl. VCS (CFS)**	**Total Evaporation (ac-ft)**
January	1.29	1.75	12	20	8	**40**	**20**	**2,462**
February	1.82	2.74	19	21	12	**51**	**31**	**2,845**
March	3.19	4.33	29	21	19	**70**	**48**	**4,282**
April	4.50	6.31	43	23	28	**93**	**71**	**5,553**
May	5.24	7.10	48	24	31	**103**	**79**	**6,356**
June	5.53	7.75	53	25	34	**112**	**87**	**6,656**
July	5.77	7.82	53	26	34	**113**	**88**	**6,953**
August	5.00	6.78	46	25	30	**101**	**76**	**6,231**
September	4.03	5.64	38	24	25	**88**	**63**	**5,207**
October	3.08	4.18	28	23	18	**70**	**47**	**4,276**
November	2.00	2.80	19	21	12	**53**	**31**	**3,127**
December	1.37	1.85	13	20	8	**41**	**21**	**2,523**
Whole Year	**42.8**	**4.92**	**33**	**23**	**22**	**78**	**55**	**56,473**
May-October	**28.7**	**6.54**	**45**	**24**	**29**	**98**	**73**	**35,680**
	(Sum)	(Average)	(Average)	(Average)	(Average)	(Average)	(Average)	(Sum)

Source: Pan Evaporation Records for the South Carolina Area, John C. Purvis, South Carolina State Climatology Office
FWS values were computed as 75 percent of pan evaporation values.
This factor was estimated from a discussion in NOAA Technical Report NWS 33, Evaporation Atlas for the 48 Contiguous States.

Reservoir evaporation loss estimates are based on surface areas of 6,800 acres for Monticello and 4,400 acres for Parr.

The conversion from evaporation in inches to evaporation rate in CFS per thousand acres is:

(inches) x (1 ft/12 in) x (1 month/31 [or 30 or 28] days) x (43,560 SF/acre) x (1 day/86,400 sec) x (1,000 acres/thousand acres)

Increased evaporation from V.C. Summer Station is estimated using information provided by VCS, and is based on average ambient temperature for each month.

Exhibit E-5 Fisheries Resources

Habitat Enhancement Program

Habitat Enhancement Program Agreement
Parr-Fairfield Hydroelectric Project Relicensing
June, 2018

In response to Habitat Enhancement Program (HEP) discussions of the August 30, 2017 Comprehensive Relicensing Settlement Agreement (CRSA) meeting (CRSA #3 Meeting), stakeholders are proposing the following topics and related language to 1) be included in the CRSA to address the establishment of a HEP and 2) provide a framework to guide development of a charter for the HEP. Topics addressed in this proposal include:

- Purpose
- HEP funding formula
- Charter to be developed
- Eligible project proposals
    - Geographic area
    - Types of projects
- Proposal review process
- Conditions to limit contributions

Habitat Enhancement Program

Purpose

SCE&G will establish a Habitat Enhancement Program (HEP) for the purpose of restoring, enhancing, and protecting aquatic, wetland, and riparian habitats and the associated natural resources of the Parr-Fairfield Hydroelectric Project (Project) area and portions of the Broad, Saluda, and Congaree River watersheds. The goal of the HEP is to fund on-the-ground conservation actions. The HEP will exist for the term of the new license and be administered by SCE&G to encourage, review, evaluate and fund project proposals to accomplish this purpose.

HEP funding

SCE&G is proposing to make an annual contribution to the HEP equal to the amount deducted from the FERC and other federal agency administrative charges for pumping energy expended, after subtracting 10.6 percent for the cost of Transmission and Distribution (T&D)[1] of the power to Fairfield. Since the fluctuation of Parr Reservoir (and associated unavoidable impacts) during a given year correlates strongly with the amount of pumped storage operation that year, the annual HEP contribution will be greater in years with more pumped storage operation, and smaller in years with less pumped storage operation.

Per 18 CFR 11.1.C.3.iii,

> "For a mixed conventional-pumped storage project the charge factor is its authorized installed capacity plus 112.5 times its gross annual energy output in millions of kilowatt-

[1] Based on SCE&G General Service Class Rates 23 & 24 T&D percentage. This will stay constant for the term of the license.

hours less 75 times the annual energy used for pumped storage pumping in millions of kilowatt-hours."

SCE&G submits annual generation statements to FERC by November 1 of each year, showing generation and pumping energy for the period October 1 of the previous year through September 30 of the current year (the Federal fiscal year). FERC sends an invoice in July of the following year, with payment due by early September of that year. Note the multipliers given in the CFR are equivalent to 11.25 percent of gross energy output in MWH, and 7.5 percent of pumping energy in MWH. FERC also provides Unit Charge Factors each year for its own and other Federal agencies' estimated administrative charges. These factors are multiplied by the charge factor computed as described in the CFR to compute the total charges payable by the licensee.

These equations are as follows:

FERC Charge Factor (FCF):

FCF = a + (b ***** c – d ***** e)

a - Authorized KW from License Article 60 (1974 license) on Annual Charge Capacity (526,080)[#]

b - % from 18 CFR 11.1.C.3.i. Conventional Hydro (0.1125)[⌂]

c - Actual Annual MWH Generated (October 1 - September 30)[£]

d - % from 18 CFR 11.1.C.3.iii Mixed Conventional & Pumped Storage (0.075)[Ə]

e - Generation Used by Pump Storage Facility[£]

Pumping Energy Deduction (PED):

PED= (d ***** e) ***** (f + g)

d - % from 18 CFR 11.1.C.3.iii Mixed Conventional & Pumped Storage (0.075)[Ə]

e - Generation Used by Pump Storage Facility[£]

f - Current Year FERC Administrative Unit Charge Factor ($)[Ψ]

g - Current Year Other Federal Agencies Administrative Unit Charge Factor ($)[Ψ]

[#] - This value is 526,080 for the current license. This value may change after implementation of the Generator Upgrade or Replacement Plan

[⌂] - This value is currently equivalent to 11.25 percent of gross energy output in MWH (0.1125)

[£] - This value is provided to FERC by Licensee each October

[Ə] - This value is currently equivalent to 7.5 percent of pumping energy in MWH (0.075)

[Ψ] - This value is obtained from FERC each year

<u>Habitat Enhancement Funding (HEF)</u>:

HEF = PED – h

h - This value is T&D Costs (10.6% of PED value)

For the Parr Hydroelectric Project, the authorized installed capacity is 526,080 KW. For an example year (2012) in which annual energy output was 658,613 MWH and annual energy expended for pumping was 848,474, the charge factor would be computed as follows:

Charge Factor = 526,080 + (0.1125 * 658,613 – 0.075 * 848,474)

= 526,080 + 74,094 – 63,636

= 536,538

The deduction from the charge factor for pumping energy expended is 63,636 in this example. For the example year, the FERC provided unit charge factors of 1.546980 for FERC administrative charges, and 0.162896 for Other Federal Agencies (OFA) administrative charges. Multiplying the pumping energy deduction charge factor by the sum of these two unit charge factors gives the dollar amount deducted from the FERC annual charges for pumping energy expended, and subtracting the 10.6% T&D cost gives the HEP contribution:

63,636 * ($1.546980 + $0.162896) = $108,809
<u>Less T&D Cost @ 10.6%: ($11,534)</u>
Habitat Enhancement Funding: $97,275

Table 1 below shows the above computation using the generation and pumping energy over the last 14 Federal fiscal years:

Fiscal Year Annual Charges Paid	Pumping Energy (MWH, previous FY)	Charge Factor from 18 CFR	FERC Unit Charge Factor	Other Federal Agencies Charge Factor	Annual Charges Deduction for Pumping Energy Expended	HEP Contribution Net of Transmission & Distribution Cost (10.6%)	Parr Reservoir Average Daily Fluctuation (feet, previous FY/WY)
2004	1,082,358	81,177	1.427823	N/A[2]	$115,906	$103,620	5.20
2005	1,241,915	93,144	1.540103	N/A	$143,451	$128,245	5.73
2006	1,220,472	91,535	1.248321	0.133254	$126,463	$113,058	5.61
2007	1,201,038	90,078	1.153142	0.203692	$122,221	$109,265	5.77
2008	1,112,467	83,435	1.322620	0.208375	$127,739	$114,198	5.57
2009	1,121,484	84,111	1.455633	0.233334	$142,061	$127,003	5.41
2010	992,379	74,428	1.449217	0.199028	$122,676	$109,673	4.59
2011	833,344	62,501	1.508011	0.161098	$104,321	$93,263	4.28
2012	848,474	63,636	1.546980	0.162896	$108,809	$97,275	4.33
2013	859,564	64,467	1.500914	0.149766	$106,415	$95,135	4.19

[2] FERC did not provide a unit charge factor for other federal agencies in FY2004 or FY2005.

2014	625,794	49,935	1.402684	0.104162	$70,723	$63,226	3.25
2015	538,546	40,391	1.490838	0.088588	$63,795	$57,032	2.85
2016	700,422	52,532	1.566760	0.099777	$87,546	$78,266	3.69
2017	706,813	53,011	1.714956	0.096266	$96,015	$85,837	3.49

Table 1.

Figure 1 below shows the strong correlation over this same time period between pumping energy and average daily Parr Reservoir fluctuation.

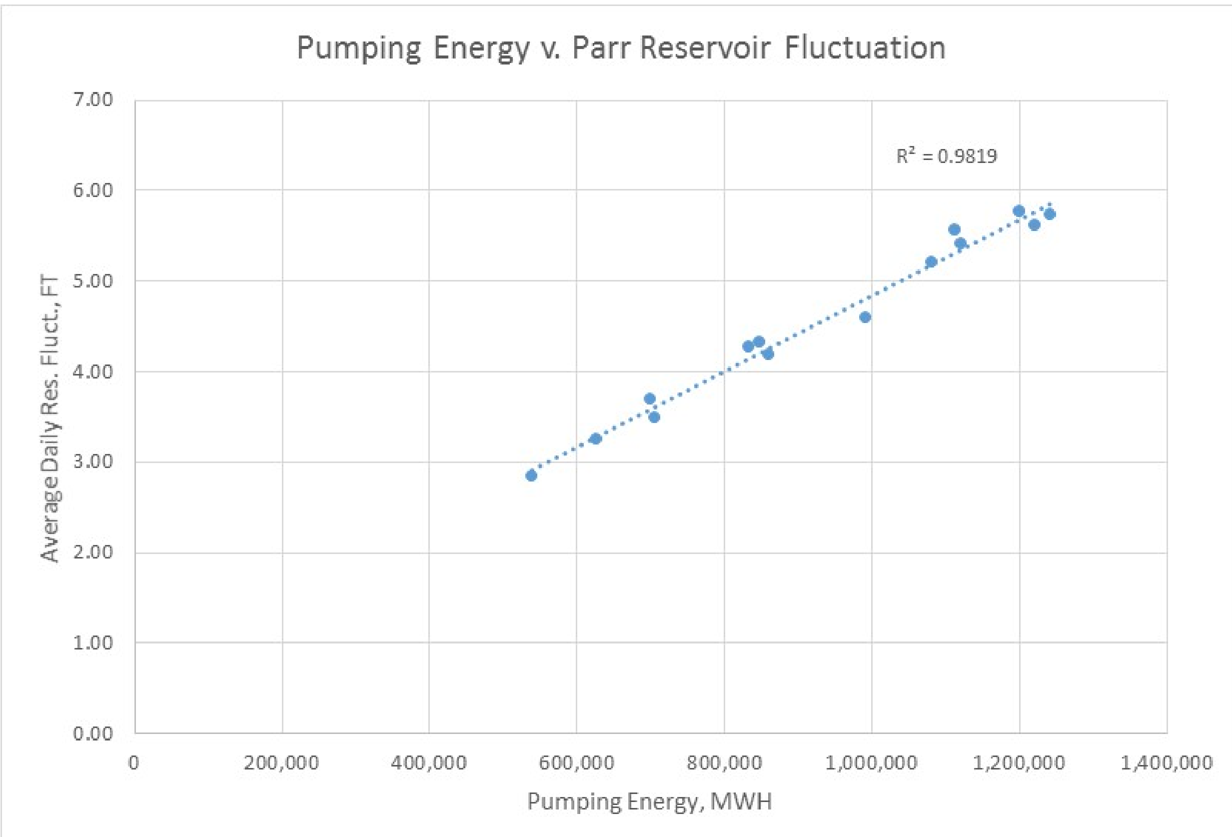


Figure 1.

A minimum annual contribution to the HEP by SCE&G will be established at $50,000 in the year the license is issued. Every five years, this figure will be adjusted according to the previous five year average of the Producer Price Index (PPI)[3]. In the event any elements of the HEP formula are changed pursuant to changes in law or FERC regulation, which result in substantial reduction or increase in annual contributions, SCE&G will convene the signatories to the CRSA to adopt an appropriate substitute funding mechanism.

[3] This is the Bureau of Labor Statistics Non-Seasonally Adjusted Overall Final Demand, 12-month percent change

Charter to be developed

Administration of the HEP and decisions of how to spend HEP funds will be in accordance with a charter developed by SCE&G in cooperation with other parties to the CRSA. The charter will be developed within one year after FERC issuance of the new Project license. SCE&G proposes to make the HEP contribution during the fourth quarter of the same calendar year in which the annual charges are paid. The funds will be held in an interest bearing account with a third party as agreed to by the Proposal Review Committee (PRC) at the time the charter is being developed.

Proposal Review Committee

A PRC will be established and consist of SCE&G, signatories to the CRSA with knowledge of Project related natural resources issues, and the agencies that may not be signatories to the CRSA but participated in Project relicensing and have regulatory authority relative to Project related natural resources issues. A provision will be included to allow for the addition of new parties if such parties are formed and would provide value to the PRC. The PRC will consist of at least five voting members. SCE&G will act as the administrator of the PRC. SCE&G will establish the PRC in accordance with the HEP charter and convene an initial coordination meeting of the PRC within six months after the charter is finalized by PRC.

Eligible project proposals

The PRC will establish an approach for evaluating and ranking proposals based on their potential to restore, enhance, and protect aquatic, wetland, and riparian habitats and the associated natural resources. Proposals will be accepted from any organization or individual including PRC members; however, if a PRC member submits a proposal then that member must recuse itself from deliberations and voting on the proposal. The PRC will have the flexibility to identify priority areas for funding plus specific criteria and other mechanisms for evaluating proposals; however, eligible projects will be subject to limits of locations and types of projects as described in the subsequent paragraphs.

The location of projects eligible for funding must be within a geographic area defined by the following watersheds or portions of watersheds (and federal hydrologic units codes (HUCs)) of the Broad, Saluda, and Congaree Rivers (see Figure 2 – map of the area):

- Lower Broad River 8 Digit Watershed: HUC 03050106 – entire watershed;
- Tyger River 8 Digit Watershed: HUC 03050107 – that portion downstream of the towns of Pacolet and Woodruff;
- Enoree River 8 Digit Watershed: HUC 03050108 – that portion downstream of the towns of Woodruff and Gray Court;
- Twelvemile Creek – Saluda River 10 digit Watershed: HUC 0305010914 – entire watershed;
- Congaree River 8 Digit Watershed: HUC 03050110 – entire watershed.

(Reference: SCDHEC Watershed Atlas - https://gis.dhec.sc.gov/watersheds/ – based on the National Watershed Boundary Dataset)

The types of projects eligible for funding will include (may be reevaluated on some frequency):

- Conservation of lands for the purpose of protecting aquatic resources by fee simple acquisition, conservation easements, or other conservation measures agreed to by the PRC;
- Restoration and enhancement of stream channels, stream banks, riparian areas, shorelines, and wetlands;
- Removal of barriers to aquatic species; (This would include voluntary aquatic habitat enhancements that are not compliance related activities such as FERC license or other regulatory agency requirements.)
- Conservation, restoration and enhancement of habitat for threatened and endangered species (T&E) and at-risk species, with an emphasis on aquatic species.
- Conducting research, monitoring, enhancement of T&E and at-risk species' populations, with an emphasis on aquatic species.
- Creation or construction of habitats and nesting boxes to support fish and wildlife species, with an emphasis on aquatic species;
- Fertilizing and aquatic plant control in the Monticello sub-impoundment;
- Conducting research and monitoring to support restoration of migratory fishes and other aquatic resources;
- Developing low-impact facilities to access waterways for fishing and boating; and
- Studies, design/engineering plans, monitoring, etc., are eligible for funding if their purpose is to support projects described in previous bullets.

Proposal review process

The PRC will review and evaluate all HEP proposals and decide which projects to fund. All PRC decisions will be by three-quarters majority vote (e.g. 4 of 5, 5 of 6, 5 of 7, or 6 of 8 members, etc.).

The PRC will issue an RFP within 60 days after the annual payment is made to the HEP fund. Proposals requesting HEP funds will be submitted to SCE&G. SCE&G will forward all proposals to the PRC for evaluation and recommendations. Final decisions on proposals received will made by the PRC within three months after the RFP submittal deadline. The distribution of funds will follow invoicing and accounting procedures to be outlined within the charter.

SCE&G will be responsible for the organization and administration of PRC meetings, arranging for dispersal of HEP funds, and collection and distribution of reports for funded projects.

Figure 2. Map of area for eligible HEP projects. The area is defined by the watersheds or portions of watersheds listed above.

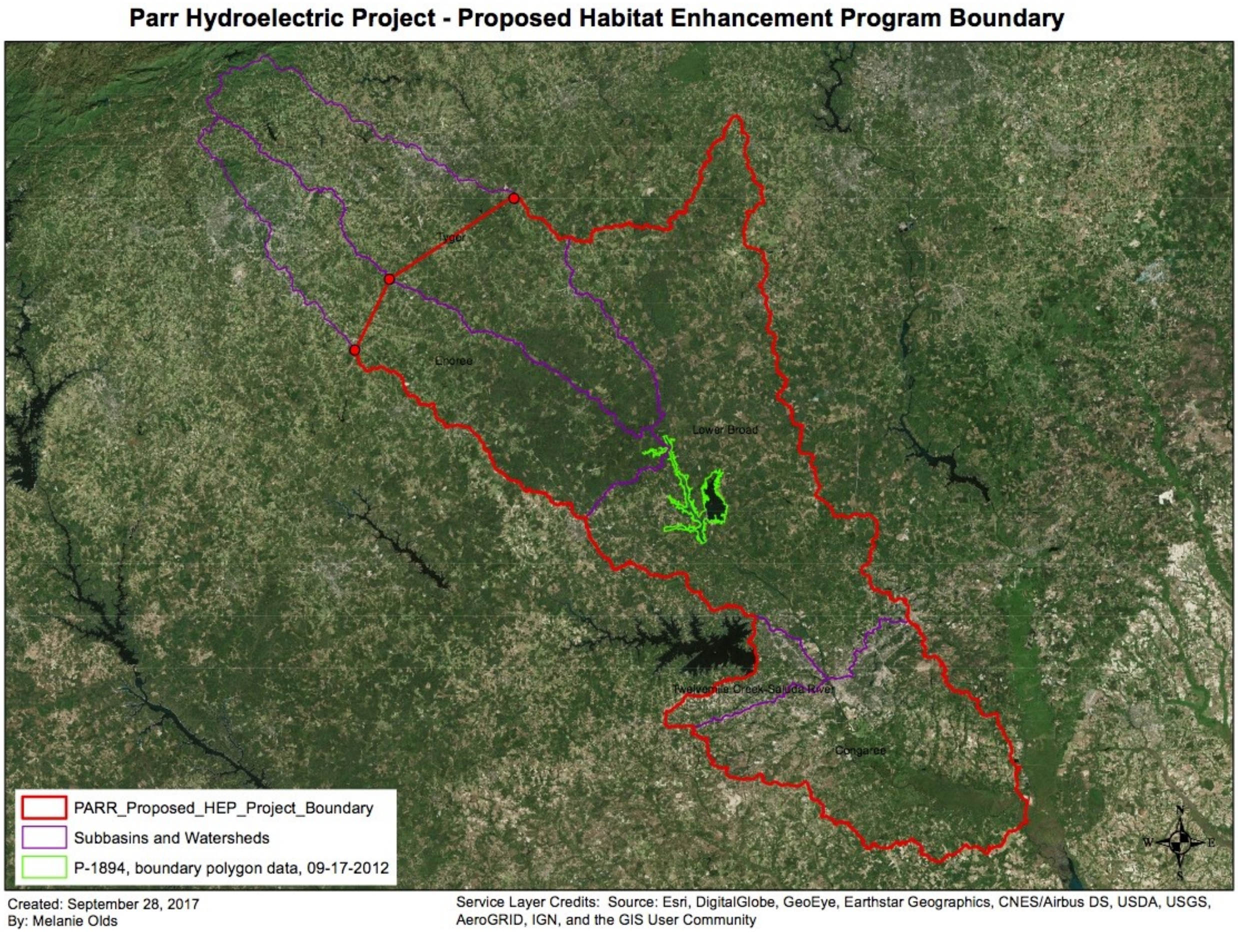


Figure 2

Exhibit E-5 Fisheries Resources

American Eel Abundance Study Plan

AMERICAN EEL (*ANGUILLA ROSTRATA*)
ABUNDANCE
STUDY PLAN

PARR HYDROELECTRIC PROJECT
(FERC NO. 1894)

Prepared for:

South Carolina Electric & Gas Company
Cayce, South Carolina

Prepared by:

Kleinschmidt

Lexington, South Carolina
www.KleinschmidtUSA.com

September 2014

AMERICAN EEL (*ANGUILLA ROSTRATA*) ABUNDANCE
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PARR HYDROELECTRIC PROJECT
(FERC NO. 1894)

SOUTH CAROLINA ELECTRIC & GAS COMPANY

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PARR HYDROELECTRIC PROJECT
(FERC NO. 1894)

SOUTH CAROLINA ELECTRIC & GAS COMPANY

1.0 INTRODUCTION

South Carolina Electric & Gas Company (SCE&G) is the Licensee of the Parr Hydroelectric Project (FERC No. 1894) (Project). The Project consists of the Parr Hydro Development and the Fairfield Pumped Storage Development. The developments are located along the Broad River in Fairfield and Newberry Counties, South Carolina.

The Project is currently involved in a relicensing process which involves cooperation and collaboration between SCE&G, as licensee, and a variety of stakeholders including state and federal resource agencies, state and local government, non-governmental organizations (NGO), and interested individuals. Collaboration and cooperation is essential for the identification of and treatment of operational, economic, and environmental issues associated with a new operating license for the Project. SCE&G has established several Technical Working Committees (TWC's) with members from among the interested stakeholders with the objective of achieving consensus regarding the identification and proper treatment of these issues in the context of a new license.

The Fisheries TWC has requested that American eel (*Anguilla rostrata*) studies be performed in 2015 to document the relative abundance of this species in the Broad River, directly downstream of the Parr Shoals Dam.

2.0 RELEVANT LIFE HISTORY INFORMATION

The American eel, *Anguilla rostrata,* is a catadromous species known to occur within river systems in South Carolina. Mature American eels spawn in the ocean and the egg and pre-larval stages mature into the leptocephalus stage, where they drift with ocean currents for approximately a year before metamorphosing into the glass eel stage. Glass eels migrate across the continental shelf, eventually entering estuaries and tidal rivers, where they mature into elvers.

Elvers migrate primarily at night and are able to overcome obstacles that often times prevent passage of other aquatic species. Vertical obstacles, such as a dam, can be traversed by small eels as long as the surface of the structure is textured and remains wet. As the small eels continue to mature into yellow eels, they may gradually move upstream over many years, with the greatest movement occurring during the moderate water temperatures of spring and fall (ASMFC 2000). Upstream migrations of small eels in the southeast appear to increase as water temperatures reach 15^{o}C and continue until water temperatures reach approximately 22 ^{o}C (USFWS 2014 and Haro 1991).

Although the American eel currently does not have special status under state or federal regulations, it has been identified by the South Carolina Department of Natural Resources (SCDNR) as a priority species (SCDNR 2005). The federal status of this species is currently under review by the U.S. Fish and Wildlife Service(USFWS) and has been reviewed by the USFWS and National Marine Fisheries Service (NMFS) several times over the past decade.

3.0 STUDY OBJECTIVE

The objective of this study is to document the relative abundance, size, and movement patterns of the American eel in the Broad River in the immediate area downstream of Parr Dam through the use of elver traps, elver fyke net, and electrofishing methods.

4.0 GEOGRAPHIC SCOPE

The study will focus on the Broad River immediately downstream of Parr Shoals Dam. Three to five elver traps of standard design will be positioned at two sites along the base of the dam located near the west bank and one site on the east bank of the Broad River, directly downstream of the powerhouse. Site selection was based on dam leakage, current flow, and safety for access and sampling. One elver trap will be placed in each area at the start of sampling and two additional traps (for a total of 5 traps) may be added to these areas during the sampling period based on the collection or observations of elvers (in the traps or during electrofishing) in those areas. An elver fyke net will be positioned in the west channel that drains a large portion of the leakage from the Parr Dam. Backpack electrofishing efforts will be performed in the pools and channel areas on the west side of the river and directly downstream of the dam with a focus on areas near each of the elver traps (Figure 1).

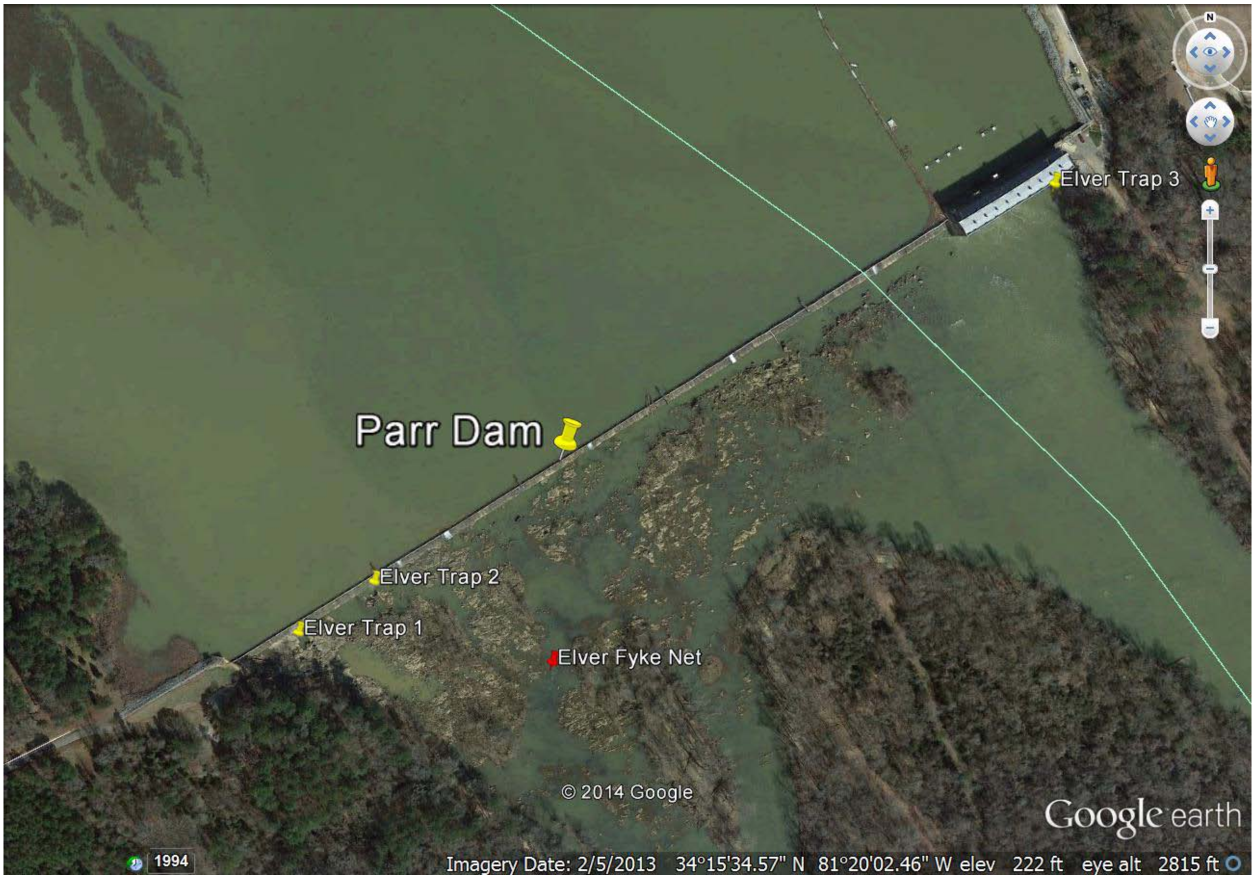

FIGURE 1. PARR PROJECT AMERICAN EEL – ELVER TRAP AND FYKE NET LOCATIONS

5.0 METHODOLOGY AND TEMPORAL SCOPE

Passive collection methods for elvers will consist of a metal ramp lined with landscape fabric climbing substrate (Enkamat or Akwadrain), an attraction flow, and a covered collection bucket with aeration or flow-through water supply. Ramp attraction flow will be provided by either gravity fed or pumped water supply (Figure 2). Elver traps in areas 2 and 3 will be fitted with double ramps that will sample in opposite directions to increase the chances of elvers using the ramp. The area 1 trap will only be fitted with a single ramp. An elver fyke net will also be used to collect eels moving upstream through the west channel area (Figure 3). We have identified an area of laminar flow, level bottom, and depths of approximately 2 to 3 feet that will be ideal for use of a fyke net. Spare equipment will be kept on hand in order to replace damaged or lost traps and nets to reduce "down time" and safely complete the study following subsidence of spill events.

American eel studies performed by the SCDNR on the Broad River, below the Columbia Diversion Dam, have indicated that the greatest frequency of catch occurs during April - June. However, a review of temperature data at the Parr Dam indicates water temperatures of 15°C could occur as early as the beginning of March. Therefore elver ramp traps will be deployed at the end of February 2015 and will be monitored beginning on March 2, 2015 and ending on June 15, 2015. Monitoring will also be performed in the fall during October 5 to November 15, 2015 (Figure 4). Monitoring during the spring period will occur once a week until water temperature reaches 15°C, then traps will be monitored three times a week (Monday, Wednesday, and Friday) until temperatures reach 22°C, and then spring monitoring will be discontinued. The elver traps will be placed back in position on October 5th and monitoring of the traps will occur three times per week until November 15 or until the water temperature drops below 15°C, and monitoring will be discontinued for the year. Trap entrances and attraction flows will be checked and repositioned as needed during each trap check event.

FIGURE 2. EXAMPLE OF A PORTABLE ELVER RAMP TRAP USED AT THE DOMINION PROJECT TAILRACE.

FIGURE 3. EXAMPLE OF AN ELVER FINE MESH FYKE NET PRODUCED BY FILMAR, INC.

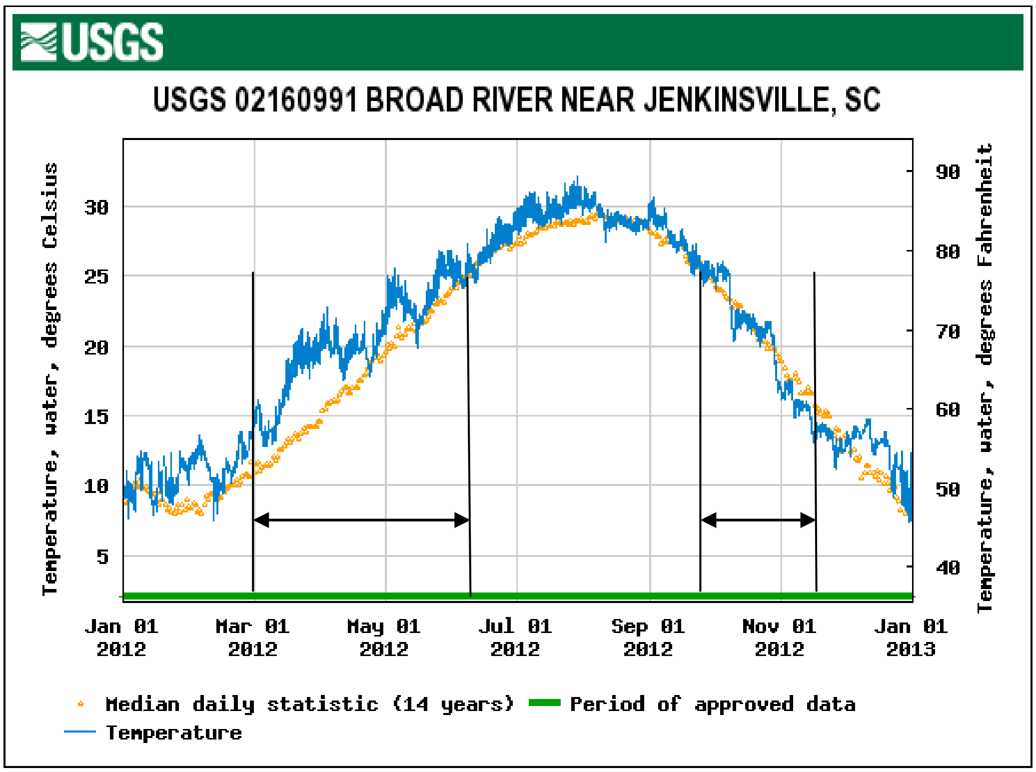

FIGURE 4. BROAD RIVER WATER TEMPERATURE AT PARR DAM – MEDIAN OVER 14 YEARS AND FOR 2012

Backpack electrofishing will be conducted once in late March, April, and May, 2015 and one sample in October during the fall period. Since American eels can be difficult to catch by electrofishing methods, one person will operate the backpack shocker and two additional people will assist in collecting eels during the effort. Backpack shocking will be conducted in the pools and runs located in the west channel side of the dam with a focus on areas close to the traps.

All eels collected will be measured, checked for visual implant elastomer (VIE) tags, recorded, and released to the Broad River upstream of Parr Dam. If the color of the VIE tag cannot be positively determined (especially pink or orange) the eels will be kept and preserved for dissection and color determination.

6.0 PRODUCTS

A final report summarizing the study findings will be issued within 120 days of completion of field work in 2015. Study methodology, timing and duration may be adjusted based on consultation with resource agencies and interested stakeholders.

7.0 USE OF STUDY RESULTS

Study results will be used as an information resource during discussion of relicensing issues and developing potential Protection, Mitigation and Enhancement measures with the South Carolina Department of Natural Resources, USFWS, Fisheries TWC, and other relicensing stakeholders.

8.0 REFERENCES

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Exhibit E-5 Fisheries Resources

American Eel Abundance Study Report

AMERICAN EEL (*ANGUILLA ROSTRATA*) ABUNDANCE STUDY REPORT

PARR HYDROELECTRIC PROJECT

(FERC NO. 1894)

Prepared for:

South Carolina Electric & Gas Company
Cayce, South Carolina

Prepared by:

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June 2016

AMERICAN EEL
(*ANGUILLA ROSTRATA*)
ABUNDANCE STUDY REPORT

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AMERICAN EEL (*ANGUILLA ROSTRATA*) ABUNDANCE STUDY REPORT

PARR HYDROELECTRIC PROJECT
(FERC NO. 1894)

SOUTH CAROLINA ELECTRIC & GAS COMPANY

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PARR HYDROELECTRIC PROJECT
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SOUTH CAROLINA ELECTRIC & GAS COMPANY

1.0 INTRODUCTION

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The Project is currently involved in a relicensing process which involves cooperation and collaboration between SCE&G, as Licensee, and a variety of stakeholders including state and federal resource agencies, state and local government, non-governmental organizations (NGO), and interested individuals. SCE&G has established several Technical Working Committees (TWC's) with members from among the interested stakeholders with the objective of achieving consensus regarding the identification and proper treatment of relicensing issues in the context of a new license.

The Fisheries TWC requested that SCE&G perform American eel (*Anguilla rostrata*) collections during 2015 to document the relative abundance of this species in the Broad River directly downstream of the Parr Shoals Dam. During a review of the 2015 study results at a Rare, Threatened and Endangered Species (RTE) TWC meeting, the TWC requested that SCE&G perform one more year of backpack electrofishing during 2016 to verify the 2015 study results.

2.0 RELEVANT LIFE HISTORY INFORMATION

The American eel, *Anguilla rostrata*, is a catadromous species known to occur within river systems in South Carolina. The present distribution of American eels in South Carolina is primarily downstream of the fall line (Rhode et al. 2009). Mature American eels spawn in the ocean and the egg and pre-larval stages mature into the leptocephalus stage, where they drift with ocean currents for approximately a year before metamorphosing into the glass eel stage. Glass eels migrate across the continental shelf, eventually entering estuaries and tidal rivers, where they mature into elvers. Elvers migrate primarily at night and are able to overcome obstacles that often times prevent passage of other aquatic species. Vertical obstacles, such as a dams, can be traversed by small eels as long as the surface of the structure is textured and remains wet. As the small eels continue to mature into yellow eels, they may gradually move upstream over many years, with the greatest movement occurring during the moderate water temperatures of spring and fall (ASMFC 2000). Upstream migrations of small eels in the southeast appear to increase as water temperatures reach 15^{o}C and continue until water temperatures reach approximately 22^{o}C (USFWS 2014 and Haro 1991).

Although the American eel currently does not have special status under state or federal regulations, it has been identified by United States Fish and Wildlife Service as an “at risk species” and the South Carolina Department of Natural Resources (SCDNR) as a priority species (SCDNR 2005).

3.0 STUDY OBJECTIVE

The objective of this study was to document the relative abundance, size, and movement patterns of the American eel in the Broad River in the immediate area downstream of Parr Shoals Dam through the use of elver traps, an elver fyke net, and backpack electrofishing. During 2016, backpack and boat electrofishing were used to verify the 2015 study findings.

4.0 METHODOLOGY

This study focused on collection of elvers in areas of the Broad River located immediately downstream of Parr Shoals Dam. Site selection for each collection method was based on attraction flows (dam leakage), safety for access and sampling, and input from the USFWS (USFWS 2014). Methodologies employed in this study were specified in the American Eel Abundance Study Plan (Appendix A).

Kleinschmidt personnel positioned two elver traps at the base of the dam in the west bank area and one trap on the east bank (directly downstream of the powerhouse). An elver fyke net was used to sample the flowing channel of water in the west channel of the Broad River.

Kleinschmidt personnel also sampled the pools and channel areas on the west side of the river and directly downstream of the dam (with a focus on areas near each of the elver traps) with a backpack electrofisher (Figure 1).

Elver traps were constructed using the design of Haro (2006) (Appendix B). Traps consisted of wooden ramps lined with landscape fabric as climbing substrate (Enkamat), an attraction flow, and a covered 44 gallon collection bucket with a flow-through water supply. Our water source for the traps on the west bank was supplied by gravity flow of leakage through the Parr Shoals Dam spillway gates (Photo 1). A reservoir height of 260.75 feet or greater was required for sufficient leakage flow to fill the collection buckets and water the traps. One of the elver traps was fitted with double ramps that sampled in different directions to increase the chances of elvers finding and using the ramps (Photo 2) and one trap was fitted with a single ramp (Photo 3). Flow for the east bank trap was provided by an electric water pump. This trap was also fitted with double ramps that sampled in opposite directions to increase the chances of elvers using the ramps.

Flow was delivered onto each of the ramps at a 45 degree angle over metal sheeting (Photo 4), so that any elvers that followed the flow up the ramp would then slide down the metal sheeting into the collection bucket. Hoses that provided attraction flow were secured at the bottom of the ramps using zip ties (Photo 5). Fine mesh screens were placed over the holes at the outlets of the collection buckets, to ensure that any elvers collected could not pass out of the traps.

Elver ramp traps were deployed and monitored from March 2, 2015 through June 12, 2015. Monitoring was also performed in the fall from October 9 to November 16, 2015. However, high flows during the month of October reduced the amount of time that the ramps effectively sampled during the fall sampling period. Traps were typically checked three times per week (Monday, Wednesday, and Friday), but only once or twice during high flow periods. Ramp flows and attraction flows were checked and repositioned as needed during each trap check event.

An elver fyke net was used to collect eels moving upstream through the west channel area (Photo 6). Kleinschmidt personnel identified an area of laminar flow and level bottom, with depths of approximately 2 to 3 feet that were ideal for use of a fyke net. The fyke net was initially placed in the main flow of the west channel. However, debris knocked the net over multiple times when it was set in this location, therefore the fyke net was moved to an area with moderate water velocity that was downstream and on the edge of the main west channel flow.

The fyke net was deployed and monitored from March 2, 2015 through June 12, 2015. Monitoring was also performed in the fall from October 9 to November 16, 2015. However, high flows during the month of October reduced the amount of time that the net sampled during the fall sampling period. The net was optimally checked three times a week (Monday, Wednesday, and Friday) and at least once or twice a week during high flow periods.

Backpack electrofishing sampling was conducted on April 1, May 1, and May 13, 2015. One electrofishing effort was also conducted during the fall period on November 16, 2015. Each electrofishing effort was conducted for 600-800 seconds. One person operated the backpack shocker, and either one or two additional people assisted in netting fish during sampling. Backpack shocking was conducted in the pools and runs located in the west channel side of the dam, with a focus on areas close to the traps.

FIGURE 1 PARR PROJECT AMERICAN EEL - ELVER TRAP AND FYKE NET LOCATIONS

PHOTO 1 LEAKAGE FLOW AND COLLECTION BUCKETS USED TO PROVIDE WATER TO WEST CHANNEL ELVER TRAPS

PHOTO 2 DOUBLE RAMP ELVER TRAP USED IN WEST CHANNEL

PHOTO 3 SINGLE RAMP ELVER TRAP USED IN WEST CHANNEL

PHOTO 4 NOZZLE SETUP FOR PROVIDING FLOWS ONTO RAMPS

PHOTO 5 EXAMPLES OF ATTRACTION FLOW AT THE BASE OF RAMPS

PHOTO 6 EXAMPLE OF FYKE NET USED DURING STUDY

5.0 RESULTS

ELVER TRAP SAMPLING

Each of the three traps were in place for a total of 2,448 hours during the spring sampling event. The two west bank traps each sampled effectively (water flowing on ramp and attraction flow flowing at the base of the ramp) for a total of 1,499 hours. Downtime periods when the traps were not fishing were associated with low reservoir levels (< 260.75 ft.) that didn't provide enough leakage flow to supply attraction flows to the ramps. Downtime periods were also associated with instances of flooding that completely submerged and/or damaged the traps, and instances where debris clogged up nozzles, blocking flow from reaching the ramps. The east bank trap sampled effectively for a total of 1,900 hours during the spring sampling event (Table 1). Downtime was caused by flooding that completely submerged the trap, and by the electric water pump being damaged during the sampling periods. Within several days of being set in the fall, all three traps were flooded out. A single ramp trap was reset in the west channel on October 16, 2015. However this trap and the east bank trap spent the majority of October underwater due to high flows, and therefore did not spend much time sampling (Table 1). No eels were collected with the elver traps.

FYKE NET SAMPLING

The fyke net sampled effectively for a total of 2,304 hours during spring sampling (Table 1). Vandals pulled the net onto the bank on two occasions during the study. The fyke net caught approximately two hundred fish and approximately thirteen crayfish, including longnose gar, piedmont darter, redbreast sunfish, bluegill, young of year smallmouth bass, bullhead species, and shiner/minnow species. No eels were collected in the fyke net. The fyke net sampled effectively for one week during the fall sampling period, catching minnow/shiner species and a piedmont darter (Table 1). No eels were collected with the fyke net.

BACKPACK ELECTROFISHING SAMPLING

Fish collected during backpack electrofishing efforts include American eel, shorthead redhorse, gizzard shad, bluegill, redbreast sunfish, white crappie, smallmouth bass, and piedmont darter. One 250 mm American eel was collected on the May 1, 2015 electrofishing effort (Table 2). This fish was in the "yellow eel" lifestage, and was collected approximately 40 meters from the west channel double ramp trap. A visual inspection of the eel showed no elastomer tags. No elvers were collected during this study. The combined catch per unit of effort (CPUE) for all three springtime electrofishing efforts was 1.7 eels/hour. No eels were collected during the fall electrofishing effort. The total CPUE over all four electrofishing efforts was 1.3 eels/hour.

TABLE 1 TIME THAT ELVER RAMPS AND FYKE NET SPENT FISHING IN THE BROAD RIVER

	TIME EFFECTIVELY SAMPLED (HOURS)	
	SPRING SAMPLING	FALL SAMPLING
Double Ramp Trap – West Bank	1,499	44
Single Ramp Trap – West Bank	1,499	271
Double Ramp Trap – East Bank	1,900	155
Fyke – Net West Channel	2,304	170

TABLE 2 DATES, SAMPLING TIME, AND NUMBER OF EELS COLLECTED DURING FOUR BACKPACK ELECTROFISHING EVENTS IN THE BROAD RIVER

DATE	SAMPLING TIME (SECONDS)	NUMBER OF EELS COLLECTED
4/1/2015	800	0
5/1/2015	608	1
5/13/2015	710	0
11/16/2015	600	0

6.0 ADDITIONAL COLLECTIONS DURING 2016

During a meeting on March 1, 2016, the RTE TWC (specifically NOAA Fisheries) requested that SCE&G perform additional American eel backpack electrofishing collections during 2016 to verify the relative abundance of eels in the study area downstream of the Parr Shoals Dam (see Appendix C). The backpack electrofishing collections in 2016 replicated methodologies from 2015 (see Section 4.0 of this report). In addition, boat electrofishing was also used to collect additional samples in the deeper portions of the tailrace along the downstream face of the powerhouse tailrace area. During collections, one person operated the boat, while one netter stood on the bow of the boat. Collection locations for each methodology are depicted in Figure 2.

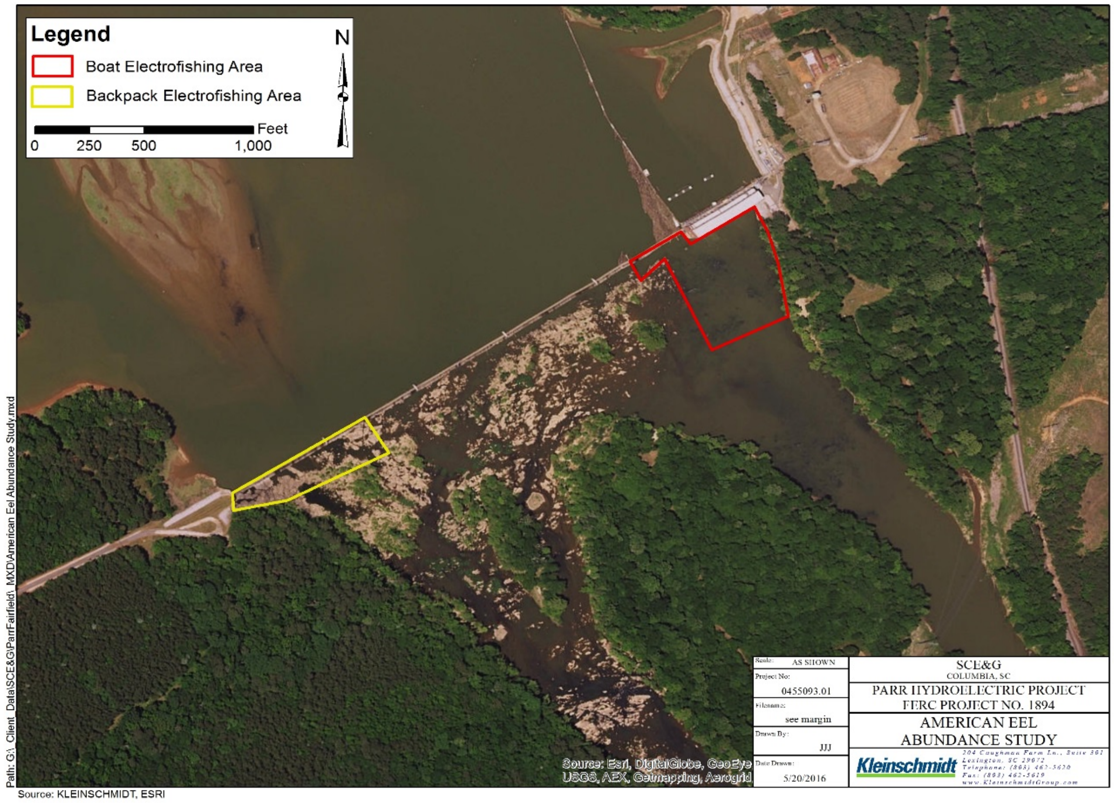

FIGURE 2 PARR PROJECT AMERICAN EEL - 2016 SAMPLING LOCATIONS

RESULTS

Fish collected during 2016 backpack electrofishing included similar species as the 2015 collections. One American eel was shocked but not netted during the April collections. Boat electrofishing detected one eel during the April collection also (Table 3). The eels observed were shocked but due to sampling conditions could not be netted. Both observed eels were yellow eels and appeared to be comparable in size to the yellow eel collected during 2015 sampling.

The combined catch per unit of effort (CPUE) for all three backpack electrofishing efforts was 1.4 eels/hour. The combined CPUE for all three boat electrofishing efforts was 0.9 eels/hour. Based on the total of 6,675 seconds of shock time, the total CPUE was 1.1 eels/hour.

TABLE 3 SUMMARY OF AMERICAN EEL COLLECTIONS DOWNSTREAM OF THE PARR SHOALS DAM DURING 2016

DATE	BACKPACK SHOCK TIME (SEC)	EELS OBSERVED	CPUE (EELS/HR)	BOAT SHOCK TIME (SEC)	EELS OBSERVED	CPUE (EELS/HR)
3/21	854	0	0.0	1,100	0	0
4/28	880	1	4.1	1,263	1	2.8
5/12	821	0	0.0	1,757	0	0
TOTALS	2,555	1	1.4	4,120	1	0.9

7.0 DISCUSSION

A one-year study was conducted in 2015 to determine the relative abundance, size and movement patterns of American eel in the Broad River immediately downstream from the Parr Shoals Dam. Despite using a variety of sampling methods , and sampling when water temperatures ranged from 7-24 ^{o}C during the spring sampling period, only one American eel was collected. The results of this study suggest that while American eels are present in the area downstream of Parr Shoals Dam, they do not appear to be abundant. The low numbers of eels collected could have resulted for several reasons, including low numbers of American eels in the vicinity of the project or inefficient sampling methods.

Low numbers of American eels collected could be related to the actual abundance of eels near the Project. There are a number of downstream blockages that hinder eels from reaching Parr Shoals Dam (i.e. multiple downstream dams). During 2010-2012, the SCDNR collected 13 eels downstream of the Columbia Hydroelectric Project dam (located on the Broad River 23.5 miles downstream of Parr Shoals Dam) by eel ramps (2), electrofishing (10), and Fukui trap (1) (SCDNR 2013). The mean annual backpack electrofishing CPUE at the Columbia Dam was 1.28 eels/hour (range of 0.61 – 2.35), which is comparable to the CPUE of 1.3 eels/hour experienced during our current study in the Parr tailrace. In separate studies during 2009-2014, the SCDNR collected a total of 21 yellow eels in the Broad River with 12 of those eels collected immediately downstream of Parr Shoals Dam via boat electrofishing. The 12 eels were collected over a total sampling time of 9600 seconds (CPUE=4.5 eels/hour), which is somewhat higher than the CPUE experienced during this study.

Three backpack and three boat electrofishing efforts were conducted in the spring of 2016 to provide an additional assessment of the abundance of American eels downstream of Parr Shoals Dam. A total of two yellow eels were observed during the collections. Combined springtime CPUE from the 2015 backpack electrofishing efforts (1.7 eels/hr) are comparable to the combined springtime CPUE for the 2016 backpack electrofishing efforts (1.4 eels/hr). The results of the 2016 study corroborate the findings of the previous 2015 eel sampling effort, that while American eels are present in the area downstream of Parr Shoals Dam, they do not appear to be abundant.

Low numbers of American eels collected could also be a result of the difficulty of catching eels with eel traps, fyke nets, and by boat or backpack electrofishing. Much of our study sampling effort targeted elvers or smaller yellow eels. Eels greater than 90 mm in length and over 14 months old are likely to have transitioned from the elver lifestage into yellow eels (Machut 2006, as cited in Pitman and Schmidt 2012). Therefore, it is possible that in the time it takes for most eels to reach the Parr project, they have matured into yellow eels. The Columbia Dam collections during 2010-2012 reinforce this theory in that all thirteen eels collected downstream of the Columbia Dam were greater than 128 mm in length (128 – 314 mm total length).

According to Rhode et al. (2009), “American eel are widespread and common in the Coastal Plain and the Piedmont up to the first migration barrier” and the SCDNR describes American eels as rare in the piedmont of the State (http://www.dnr.sc.gov/fish/species/americaneel.html). Regardless of the reasons for the low catch rates of American eel in this study, the results and conclusions of this study appear to be consistent with the current understanding of American eel distributions in South Carolina.

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APPENDIX A

AMERICAN EEL ABUNDANCE STUDY PLAN

AMERICAN EEL (*ANGUILLA ROSTRATA*) ABUNDANCE STUDY PLAN

PARR HYDROELECTRIC PROJECT (FERC NO. 1894)

Prepared for:

South Carolina Electric & Gas Company Cayce, South Carolina

Prepared by:

Kleinschmidt

Lexington, South Carolina
www.KleinschmidtUSA.com

September 2014

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SOUTH CAROLINA ELECTRIC & GAS COMPANY

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PARR HYDROELECTRIC PROJECT
(FERC NO. 1894)

SOUTH CAROLINA ELECTRIC & GAS COMPANY

1.0 INTRODUCTION

South Carolina Electric & Gas Company (SCE&G) is the Licensee of the Parr Hydroelectric Project (FERC No. 1894) (Project). The Project consists of the Parr Hydro Development and the Fairfield Pumped Storage Development. The developments are located along the Broad River in Fairfield and Newberry Counties, South Carolina.

The Project is currently involved in a relicensing process which involves cooperation and collaboration between SCE&G, as licensee, and a variety of stakeholders including state and federal resource agencies, state and local government, non-governmental organizations (NGO), and interested individuals. Collaboration and cooperation is essential for the identification of and treatment of operational, economic, and environmental issues associated with a new operating license for the Project. SCE&G has established several Technical Working Committees (TWC's) with members from among the interested stakeholders with the objective of achieving consensus regarding the identification and proper treatment of these issues in the context of a new license.

The Fisheries TWC has requested that American eel (*Anguilla rostrata*) studies be performed in 2015 to document the relative abundance of this species in the Broad River, directly downstream of the Parr Shoals Dam.

2.0 RELEVANT LIFE HISTORY INFORMATION

The American eel, *Anguilla rostrata,* is a catadromous species known to occur within river systems in South Carolina. Mature American eels spawn in the ocean and the egg and pre-larval stages mature into the leptocephalus stage, where they drift with ocean currents for approximately a year before metamorphosing into the glass eel stage. Glass eels migrate across the continental shelf, eventually entering estuaries and tidal rivers, where they mature into elvers.

Elvers migrate primarily at night and are able to overcome obstacles that often times prevent passage of other aquatic species. Vertical obstacles, such as a dam, can be traversed by small eels as long as the surface of the structure is textured and remains wet. As the small eels continue to mature into yellow eels, they may gradually move upstream over many years, with the greatest movement occurring during the moderate water temperatures of spring and fall (ASMFC 2000). Upstream migrations of small eels in the southeast appear to increase as water temperatures reach 15^{o}C and continue until water temperatures reach approximately 22 ^{o}C (USFWS 2014 and Haro 1991).

Although the American eel currently does not have special status under state or federal regulations, it has been identified by the South Carolina Department of Natural Resources (SCDNR) as a priority species (SCDNR 2005). The federal status of this species is currently under review by the U.S. Fish and Wildlife Service(USFWS) and has been reviewed by the USFWS and National Marine Fisheries Service (NMFS) several times over the past decade.

3.0 STUDY OBJECTIVE

The objective of this study is to document the relative abundance, size, and movement patterns of the American eel in the Broad River in the immediate area downstream of Parr Dam through the use of elver traps, elver fyke net, and electrofishing methods.

4.0 GEOGRAPHIC SCOPE

The study will focus on the Broad River immediately downstream of Parr Shoals Dam. Three to five elver traps of standard design will be positioned at two sites along the base of the dam located near the west bank and one site on the east bank of the Broad River, directly downstream of the powerhouse. Site selection was based on dam leakage, current flow, and safety for access and sampling. One elver trap will be placed in each area at the start of sampling and two additional traps (for a total of 5 traps) may be added to these areas during the sampling period based on the collection or observations of elvers (in the traps or during electrofishing) in those areas. An elver fyke net will be positioned in the west channel that drains a large portion of the leakage from the Parr Dam. Backpack electrofishing efforts will be performed in the pools and channel areas on the west side of the river and directly downstream of the dam with a focus on areas near each of the elver traps (Figure 1).

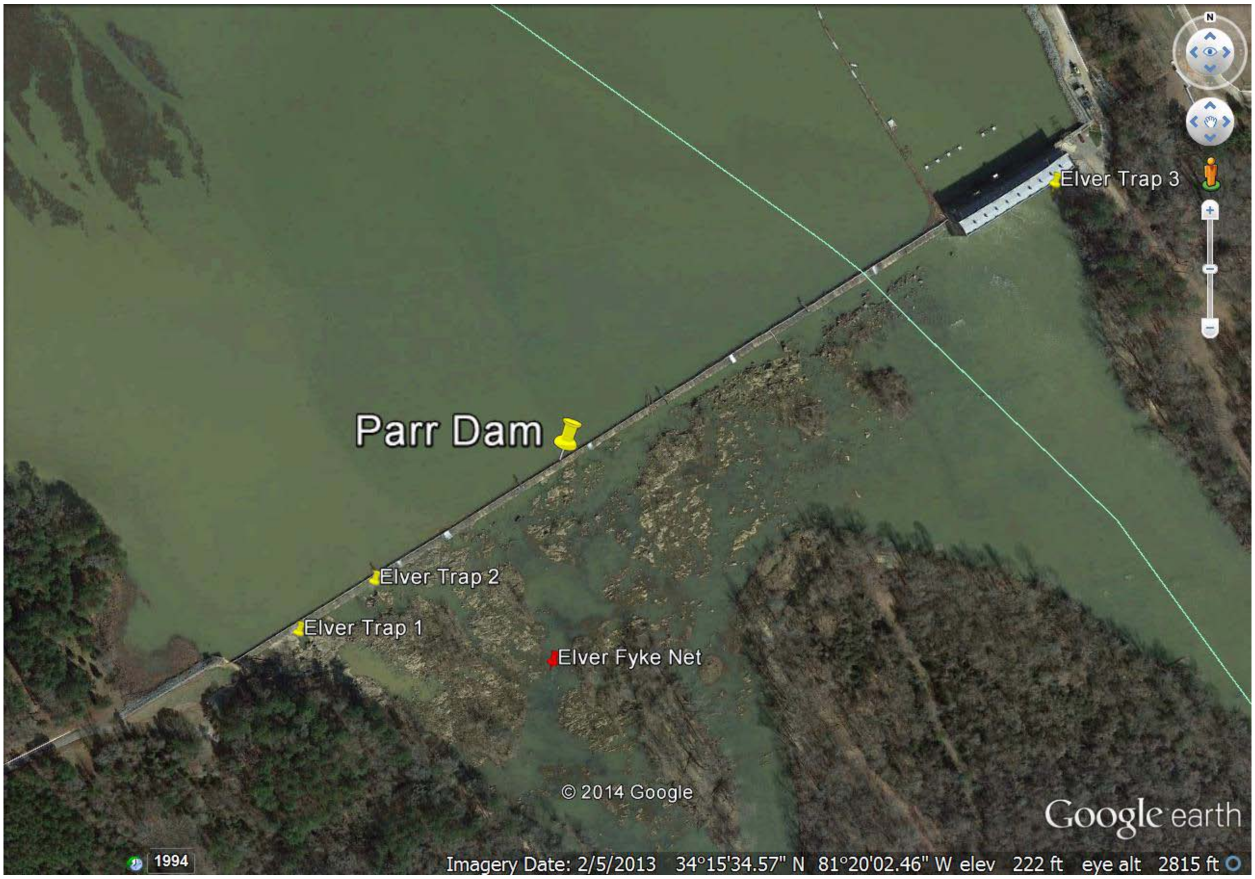

FIGURE 1. PARR PROJECT AMERICAN EEL – ELVER TRAP AND FYKE NET LOCATIONS

5.0 METHODOLOGY AND TEMPORAL SCOPE

Passive collection methods for elvers will consist of a metal ramp lined with landscape fabric climbing substrate (Enkamat or Akwadrain), an attraction flow, and a covered collection bucket with aeration or flow-through water supply. Ramp attraction flow will be provided by either gravity fed or pumped water supply (Figure 2). Elver traps in areas 2 and 3 will be fitted with double ramps that will sample in opposite directions to increase the chances of elvers using the ramp. The area 1 trap will only be fitted with a single ramp. An elver fyke net will also be used to collect eels moving upstream through the west channel area (Figure 3). We have identified an area of laminar flow, level bottom, and depths of approximately 2 to 3 feet that will be ideal for use of a fyke net. Spare equipment will be kept on hand in order to replace damaged or lost traps and nets to reduce "down time" and safely complete the study following subsidence of spill events.

American eel studies performed by the SCDNR on the Broad River, below the Columbia Diversion Dam, have indicated that the greatest frequency of catch occurs during April - June. However, a review of temperature data at the Parr Dam indicates water temperatures of 15^{o}C could occur as early as the beginning of March. Therefore elver ramp traps will be deployed at the end of February 2015 and will be monitored beginning on March 2, 2015 and ending on June 15, 2015. Monitoring will also be performed in the fall during October 5 to November 15, 2015 (Figure 4). Monitoring during the spring period will occur once a week until water temperature reaches 15^{o}C, then traps will be monitored three times a week (Monday, Wednesday, and Friday) until temperatures reach 22^{o}C, and then spring monitoring will be discontinued. The elver traps will be placed back in position on October 5th and monitoring of the traps will occur three times per week until November 15 or until the water temperature drops below 15^{o}C, and monitoring will be discontinued for the year. Trap entrances and attraction flows will be checked and repositioned as needed during each trap check event.

FIGURE 2. EXAMPLE OF A PORTABLE ELVER RAMP TRAP USED AT THE DOMINION PROJECT TAILRACE.

FIGURE 3. EXAMPLE OF AN ELVER FINE MESH FYKE NET PRODUCED BY FILMAR, INC.

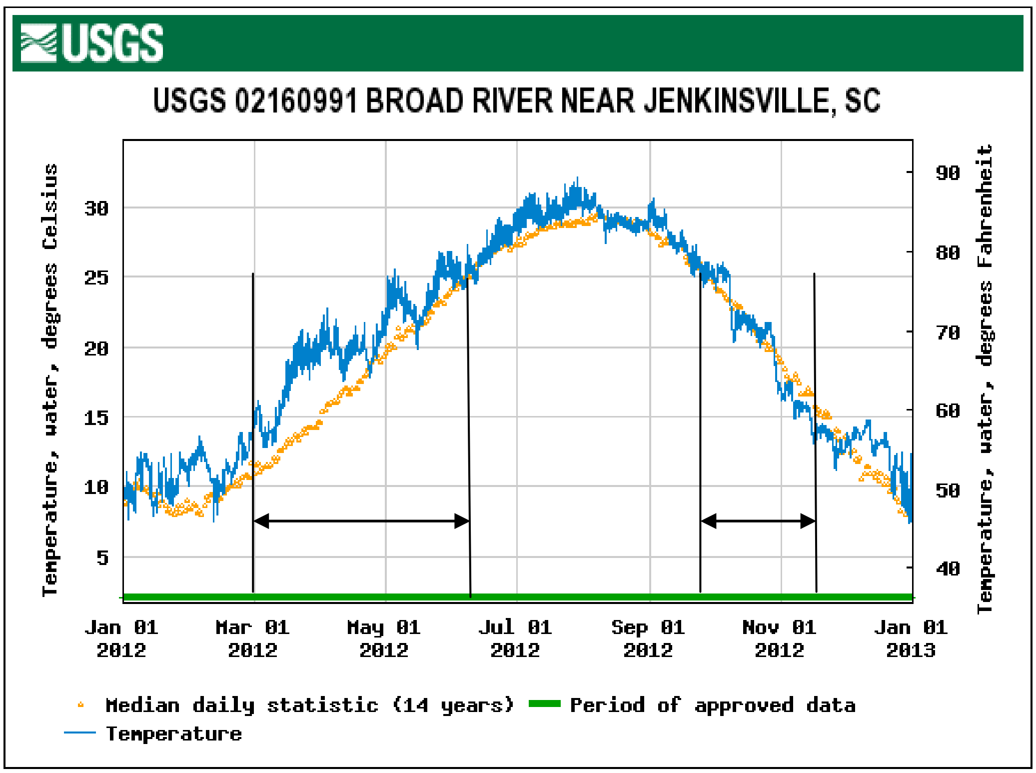

FIGURE 4. BROAD RIVER WATER TEMPERATURE AT PARR DAM – MEDIAN OVER 14 YEARS AND FOR 2012

Backpack electrofishing will be conducted once in late March, April, and May, 2015 and one sample in October during the fall period. Since American eels can be difficult to catch by electrofishing methods, one person will operate the backpack shocker and two additional people will assist in collecting eels during the effort. Backpack shocking will be conducted in the pools and runs located in the west channel side of the dam with a focus on areas close to the traps.

All eels collected will be measured, checked for visual implant elastomer (VIE) tags, recorded, and released to the Broad River upstream of Parr Dam. If the color of the VIE tag cannot be positively determined (especially pink or orange) the eels will be kept and preserved for dissection and color determination.

6.0 PRODUCTS

A final report summarizing the study findings will be issued within 120 days of completion of field work in 2015. Study methodology, timing and duration may be adjusted based on consultation with resource agencies and interested stakeholders.

7.0 USE OF STUDY RESULTS

Study results will be used as an information resource during discussion of relicensing issues and developing potential Protection, Mitigation and Enhancement measures with the South Carolina Department of Natural Resources, USFWS, Fisheries TWC, and other relicensing stakeholders.

8.0 REFERENCES

Atlantic States Marine Fisheries Commission (ASMFC). April 2000. Fishery Management Report No. 36. Interstate Fishery Management Plan for American Eel.

Haro, A. 1991. Thermal preferenda and behavior of Atlantic eels (genus *Anguilla*) in relation to their spawning migration. Environmental Biology of Fishes 31: 171-184.

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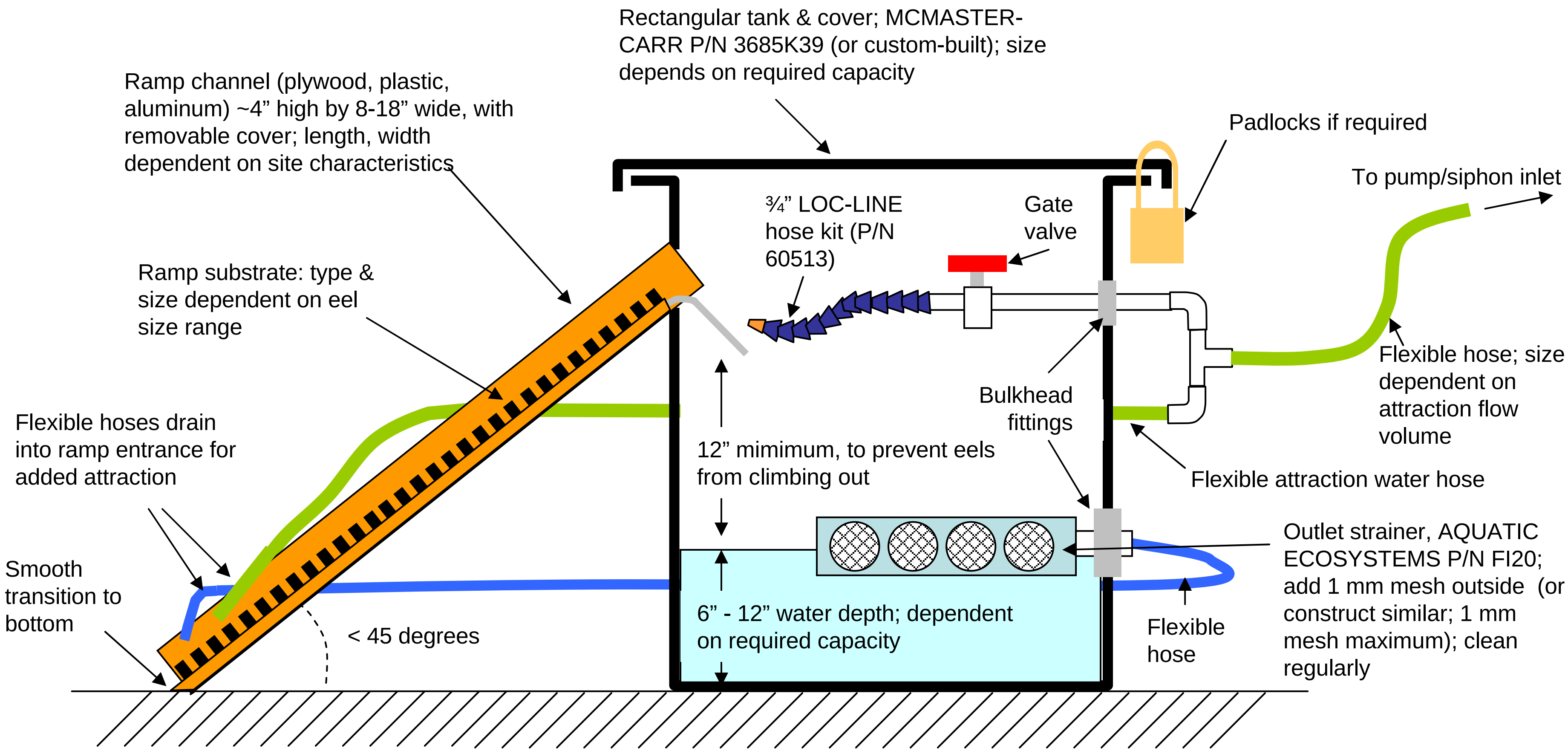
APPENDIX B

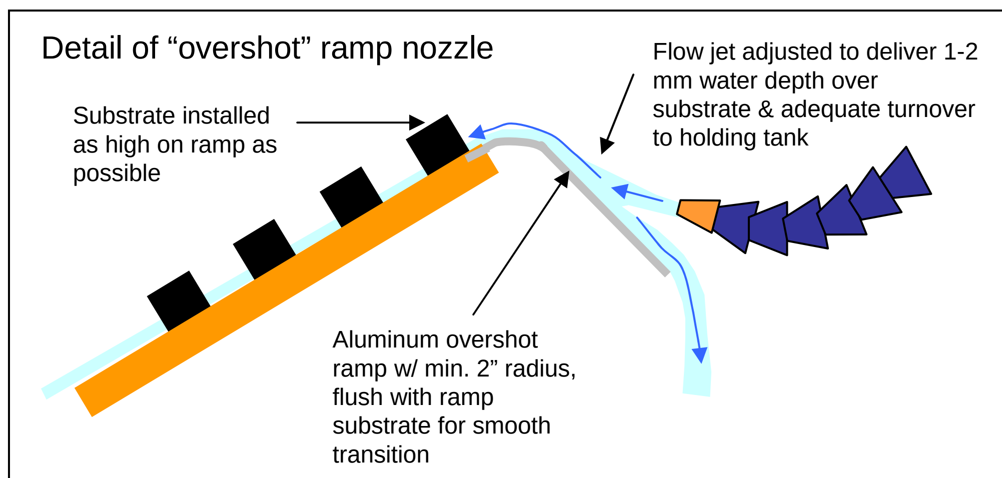
ELVER TRAP DESIGNS



“Generic” Temporary Eel Ramp Pass Trap

Design by Alex Haro
S.O. Conte Anadromous Fish Research Center,
U.S. Geological Survey, Biological Resources
Turners Falls, MA USA

March 2006



APPENDIX C

RTE TWC MEETING NOTES
MARCH 1, 2016

MEETING NOTES

SOUTH CAROLINA ELECTRIC & GAS COMPANY
Rare, Threatened and Endangered Species TWC Meeting

March 1, 2016

Final KMK 03-28-16

ATTENDEES:

Bill Argentieri (SCE&G)
Ray Ammarell (SCE&G)
Brandon Stutts (SCE&G)
Caleb Gaston (SCE&G)
Tom McCoy (USFWS)
Fritz Rohde (NOAA)
Bill Marshall (SCDNR)
Rusty Wenerick (SCDHEC)
David Eargle (SCDHEC)
Bill Stangler (Congaree Riverkeeper)
Henry Mealing (Kleinschmidt)
Shane Boring (Kleinschmidt)
Kelly Kirven (Kleinschmidt)
Jared Porter (Kleinschmidt)

These notes serve as a summary of the major points presented during the meeting and are not intended to be a transcript or analysis of the meeting.

The objective of the meeting was to review several reports that were issued to the TWC summarizing five studies that were completed during 2015, including the Rare, Threatened and Endangered Desktop Assessment, the American Eel Abundance Study, the Rocky Shoals Spider Lily Study, the Broad River Spiny Crayfish Study, and the Monticello Reservoir Mussel Survey. A brief PowerPoint presentation was prepared summarizing the methods and results of each study. This presentation is attached to the end of these notes. A second meeting objective was to identify any Protection, Mitigation, and Enhancement (PM&E) measures associated with the study issues for possible inclusion in the Settlement Agreement.

RTE Desktop Assessment

Henry said this report was originally issued in 2014, but after additional input from the USFWS, the report was revised and reissued in the late fall of 2015. The bald eagle is known to occur within the Project boundary, and SCE&G will continue to work with SCDNR on monitoring this species. There are also several fish that are known to occur within the Project boundary that will be further addressed through the IFIM study.

Bill Stangler said that the report has wording that suggests SCE&G is “likely to consult” with agencies on blueback herring and asked if there was a reason why they would not consult. This wording will be changed to remove “likely.” He also asked if striped bass and sturgeon spawning would be addressed during any additional studies. Henry said yes, striped bass will be looked at during the IFIM study, and both species will be studied further as part of the ongoing Downstream Flow Fluctuation investigation.

Bill Marshall said that SCDNR has noted that robust redhorse are known to occur in the Monticello Reservoir. He said that the SCDNR may have some concerns about entrainment impacts if it passed into that reservoir through the pumpback operations. Henry said that it probably did get there through pumpback operations at Fairfield, and that there may be mortality, but there is also survival. This may be something that will need to be addressed further as fish passage becomes an issue in the future.

Bill M. also said that a new State Wildlife Action Plan was completed last year, so the report may need to be updated to reflect those changes. Tom McCoy said that the official status of several of the species had also changed since the report was issued. These should be updated for the Draft and Final License Application. An addendum to the report will be prepared to address these changes. Bill M. and Tom M. were asked to send their recommended updates/edits to Kleinschmidt.

American Eel Abundance Report

Jared gave the group a summary of the American eel study that was completed in the spring and fall of 2015. Henry stated that Mark Cantrell with the USFWS accompanied Kleinschmidt and SCE&G on a site visit to help pick sites for installing the eel ramps. Jared noted that the ramps did not catch any eels or any other species and the fyke net didn't catch any eels either, although it did catch a wide variety of other species, including fish, crayfish and turtles. One backpack electrofishing effort did result in the collection of one American eel. The eel was a yellow eel; no elvers were found. These results are similar to the results of additional studies conducted by Ron Ahle with SCDNR.

Fritz asked what type of substrate was used on the eel ramps and Jared said Enkamat. Fritz pointed out that if the yellow eel life stage is what is located below the Project, Enkamat may not have been the best substrate. Henry agreed and said that during study plan development, everyone expected that elvers would be the dominant life stage of eel in the area, instead of the larger yellow eels. Henry said that based on the information collected during this study and the SCDNR study, future studies and fish passage should focus on the collection of larger eels. Fritz agreed and said he would send the group some additional information regarding eel passage.

Tom said that periodic monitoring as a PM&E measure in the new license might be a good idea. The group agreed that doing surveys on a 5-10 year basis, or when initiated by a pre-determined trigger, could be part of the Settlement Agreement. Henry said this could be tied into the fish passage requirements as described in the Accord Agreement. Tom said he would send the group some information on the triggers used for eel passage at the Wateree Project. Bill A. said that additional American eel studies could be initiated when a percentage of a trigger number is hit, similar to how fish passage study and design for American shad and blueback herring is set up in the Accord Agreement.

Fritz said that of the three methodologies used in the study, the only effective one was backpack electrofishing. He asked that the backpack electrofishing be replicated in the spring of 2016 to verify that yellow eels are the life stage of eel that are dominant below the Parr Shoals dam. This way, when additional studies are warranted, methodology can be targeted toward the collection of yellow eels. SCE&G agreed to do an additional year of backpack electrofishing downstream of the dam. Three sampling events will be scheduled during late March, mid-April and mid-May and the results will be issued as an addendum to the American Eel Abundance Report.

Rocky Shoals Spider Lily (RSSL) Report

Shane gave the group a summary of the RSSL study, and said that populations of the plant were concentrated around the top of Bookman Shoals and the top of Frost Shoals. Bill Stangler asked for clarification on the green polygons shown in the report. Shane said that the polygons were drawn around large population clusters of the plants. Henry said that transect elevation data is also being collected in some of the RSSL areas as part of the IFIM study.

Henry asked Bill S. if there was something specific that he wanted to see coming out of relicensing. Bill said that he would like to see something similar to what was done during the Columbia relicensing, such as long term monitoring and possible restoration efforts. If restoration isn't feasible in the Broad River downstream of the Project, it could be done elsewhere in the basin. Bill said that currently there is less usage in this stretch of the river, so the plant is less visible here than it is below Columbia. There is less human predation, but this could change if additional access is created downstream of Parr. Bill A stated that as part of the Saluda Project, SCE&G is a supporting member of the team that currently monitors the RSSL population below Columbia dam. SCE&G could carry this forward for consideration for the Parr Settlement Agreement – but more specific information will need to be added to the PM&E measure.

Broad River Spiny Crayfish Report

Jared gave an overview of the Broad River Spiny Crayfish study and said that Byron Hamstead (USFWS) accompanied Kleinschmidt staff to identify specific study areas for deploying crayfish traps. Jared said that ultimately, the traps did not collect any crayfish, but they did collect several fish species. He noted that the fyke net used during the American Eel Abundance Study collected many crayfish, but none of these were identified as the Broad River spiny crayfish. He noted that the traps were out during the months of September and October, and while flows were unusually high during October, which may have created unfavorable conditions for crayfish, the month of September was a typical month and provided prime conditions for crayfish.

Bill S. noted that the fyke net was deployed during spring and fall of 2015, and since crayfish were caught in the fyke net, asked if the timing was off during the crayfish study. Maybe the crayfish study should have occurred during the spring. Jared said that the study was planned for fall based on recommendations from Arnie Eversole and to make identification easier. He also noted that crayfish were also caught during the fall months in the fyke net.

Henry mentioned that during study plan development, Byron Hamstead noted that he did not believe any Broad River spiny crayfish were present in the study area, but he wanted the study to help verify this assumption.

Monticello Freshwater Mussel Survey Report

Shane gave an overview of the Monticello Freshwater Mussel survey and said that the study was conducted by Three Oaks during September and November in Monticello Reservoir and the Recreation Lake. No live mussels were found in the Recreation Lake and six species were found in Monticello Reservoir. David Eargle said that one of the species found in the reservoir, the Carolina creekshell, was unexpected, since it had never been identified in that area before. David stated that the genetic testing would be less than $1,000 based on discussions with Tim Savage (Three Oaks). He asked if genetics could be run on the samples collected, just to verify if that was the correct species, or if it was actually a similar species known to occur in the area. SCE&G agreed to contact Tim and have the additional testing completed on the samples. David said that knowing the correct identification wouldn't have any effect on Project operations, but it would be good information to know.

David said that he was curious as to why no mussels were found in the Recreation Lake. Ray said that there are racks on the intakes and fish cannot pass back and forth from the Recreation Lake and Monticello Reservoir. Upon initial filling, the Recreation Lake was treated with rotenone and stocked with fish. It is likely that mussels never had the opportunity to get established in that body of water.

David identified a few typos in the Three Oaks report and said he would send these over to Kleinschmidt to address.

<u>Protection, Mitigation and Enhancement Measures</u>

Several general PM&E measures were identified during the meeting, and are listed below. These should be developed with more detail through input from TWC members and will be considered as the relicensing process moves forward and a Settlement Agreement is developed.

- Periodic monitoring/studies for American eels throughout the term of the new license – possibly every 5-10 years, or based on a trigger system, similar to the triggers established in the Accord Agreement
- Establish long term monitoring of the Rocky Shoals Spider Lily populations located downstream of Parr Dam and upstream of Columbia Dam (similar to the monitoring already taking place downstream of Columbia Dam) – Possible restoration efforts for the species – Possible public outreach and education efforts (could tie into the education and outreach already established for the Columbia Project)

Action items identified during the meeting are listed below.

ACTION ITEMS:

- SCDNR and USFWS will send updates/edits for RT&E Desktop Assessment.
- Fritz will send Fish Passage Primer, which includes information on eel passage, to group.
- SCE&G and Kleinschmidt will perform 3 additional backpack electrofishing sessions during the spring of 2016 for American eels downstream of Parr Dam.
- David will send comments/edits for the Monticello Freshwater Mussel Survey Report to Kleinschmidt.
- Kleinschmidt will work with Three Oaks to get genetic testing done on mussel samples that are thought to be Carolina creekshell.

Rare Threatened and Endangered Species Desktop Assessment

Methods and Materials

- Objective- Identify RTE species potentially occurring in the Project vicinity
- Project Vicinity- Project Boundary and downstream reach of Broad River influenced by the Project
- USFWS and SCDNR county-level listings for Newberry, Fairfield, and Richland counties reviewed to find listed or at-risk species that may occur in study area
- Species on 2008 Birds of Conservation Concern list included for review
- Ten species considered priority species in the SCDNR Comprehensive Wildlife Conservation Strategy included for review

Results

- Some of the species reviewed may occur in the Project boundary
- Impacts are unlikely
- Species present in Project boundary not protected by state or federal law
- Of the 13 state and federally listed/protected species, only the bald eagle likely occurs in the study area regularly
- Fish species classified as SCDNR priority conservation species documented in study area
- Fish habitat requirements assessed further in IFIM Study

American Eel Abundance Report

Materials and Methods

- Objective- Characterize the abundance and distribution of American eels downstream of Parr Shoals Dam
- Two traps (3 ramps) set at base of dam near the west bank
- One trap (two ramps) set near powerhouse on east bank
- Fished from March 2-June 12 and October 9-November 16
- Fyke net set in west channel from March 2-June 12, and October 9-November 16
- Four backpack electrofishing efforts

Results

- One yellow eel collected over four total electrofishing efforts
- No elvers collected in traps or fyke net
- Ramp traps fished for a total of 3,428 hours
- Downtime associated with low leakage flows and flooding

Rocky Shoals Spider Lily Study Report

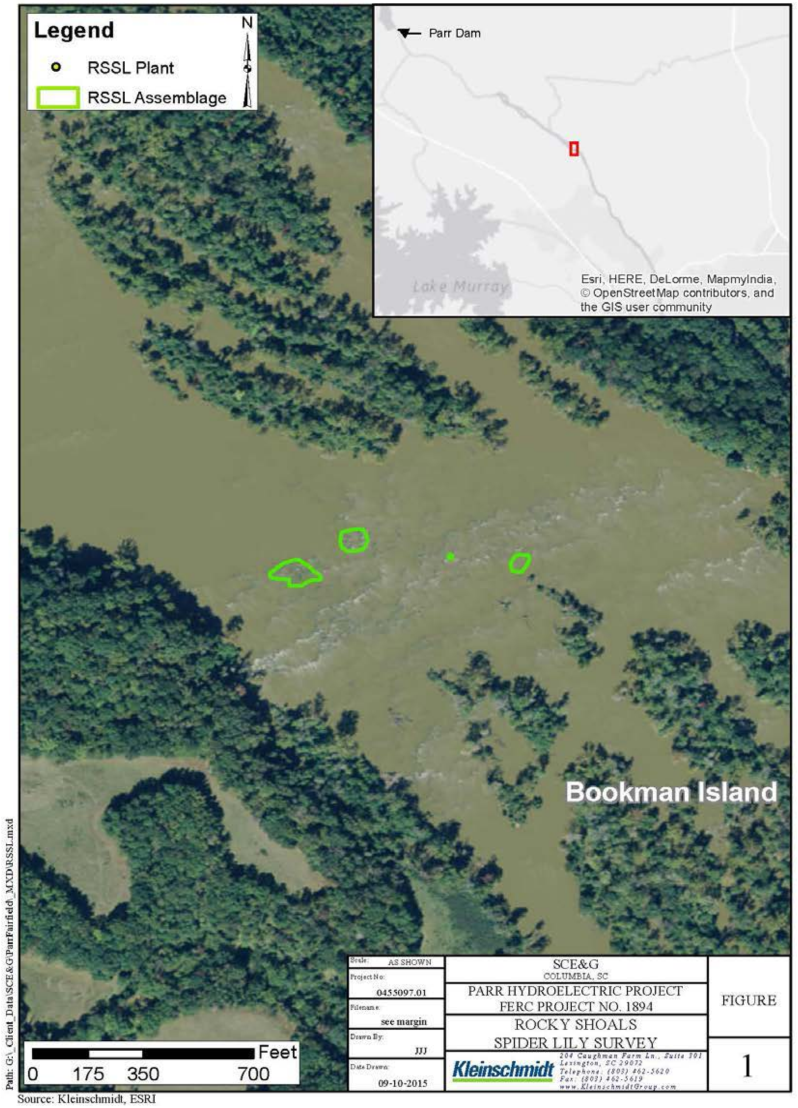
Materials and Methods

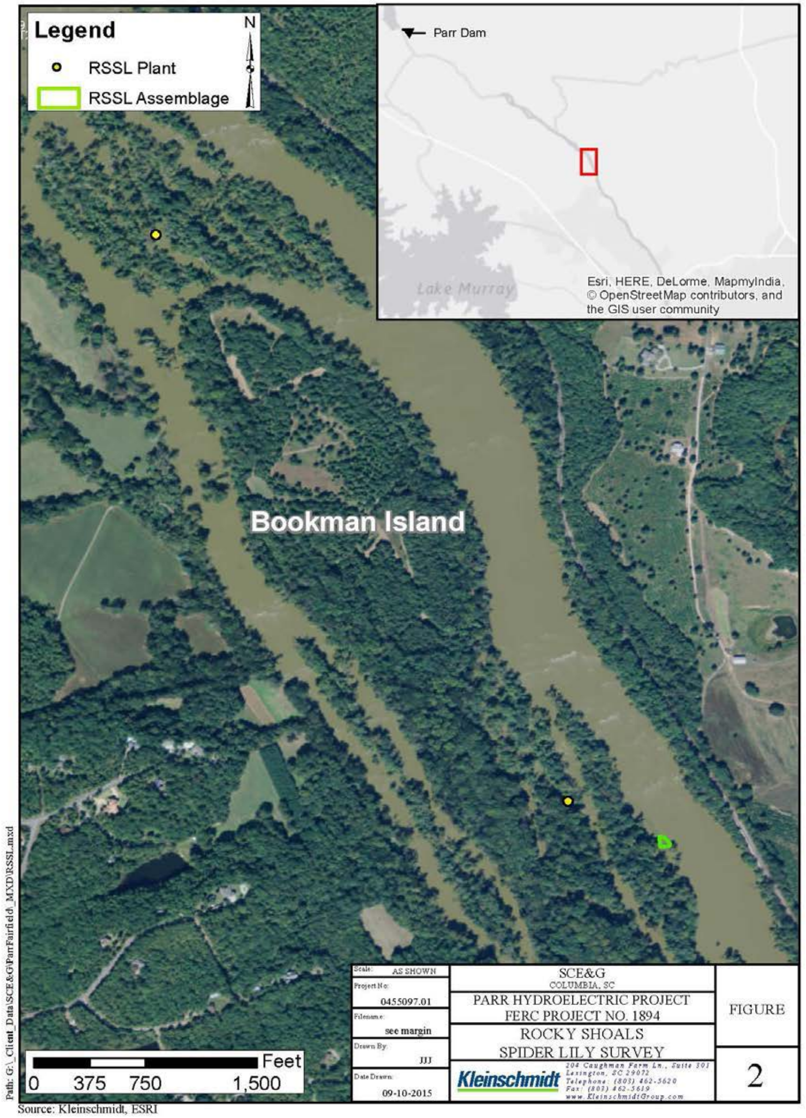
- Objective: Assess abundance and spatial distribution of RSSL between Parr Shoals Dam and Frost Shoals
- Crews floated Broad River between Parr Shoals Dam and Boatwright Island
- Study conducted during May 26-27(height of flowering season)
- Plants or clusters documented using handheld GPS
- Clusters of plants measured for length and width

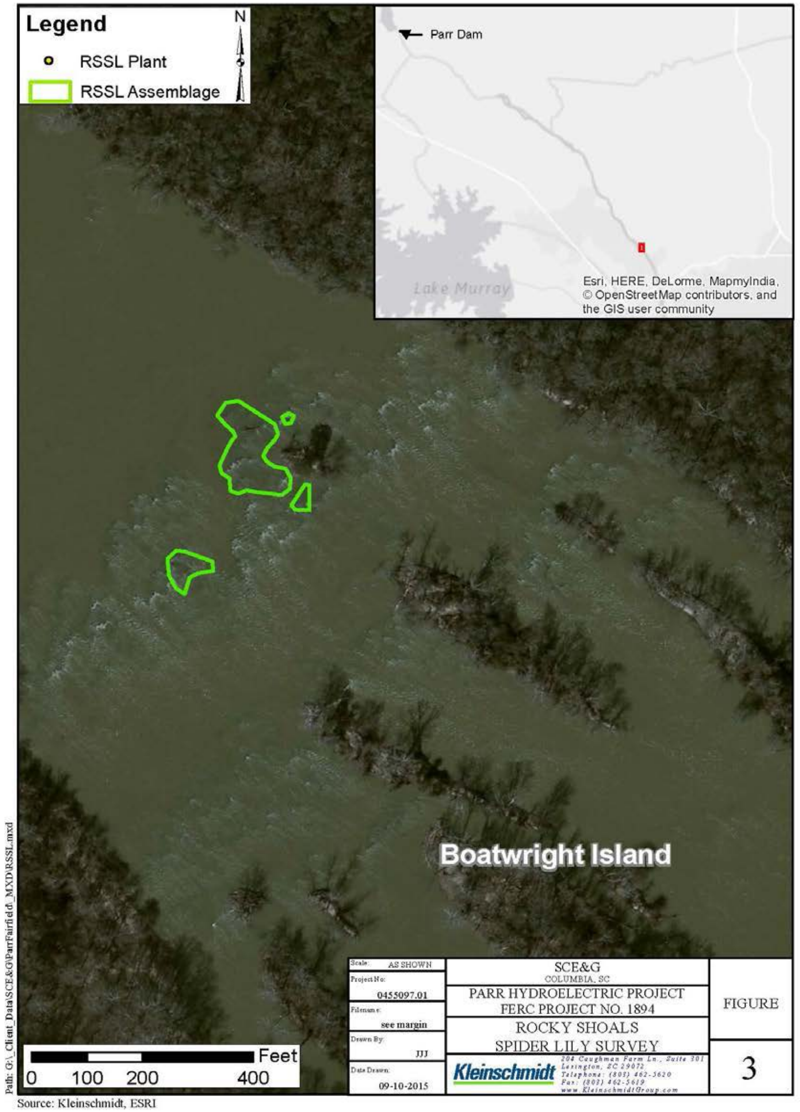
Results

- 81 plants or clumps of plants documented
- Occurrences were limited to Bookman Shoals and Frost Shoals
- Majority of plants located on bedrock ledges, in water depths of 0-30 inches
- Basal areas ranged from 0.05 m^2- 20,000 m^2

Locations of RSSL



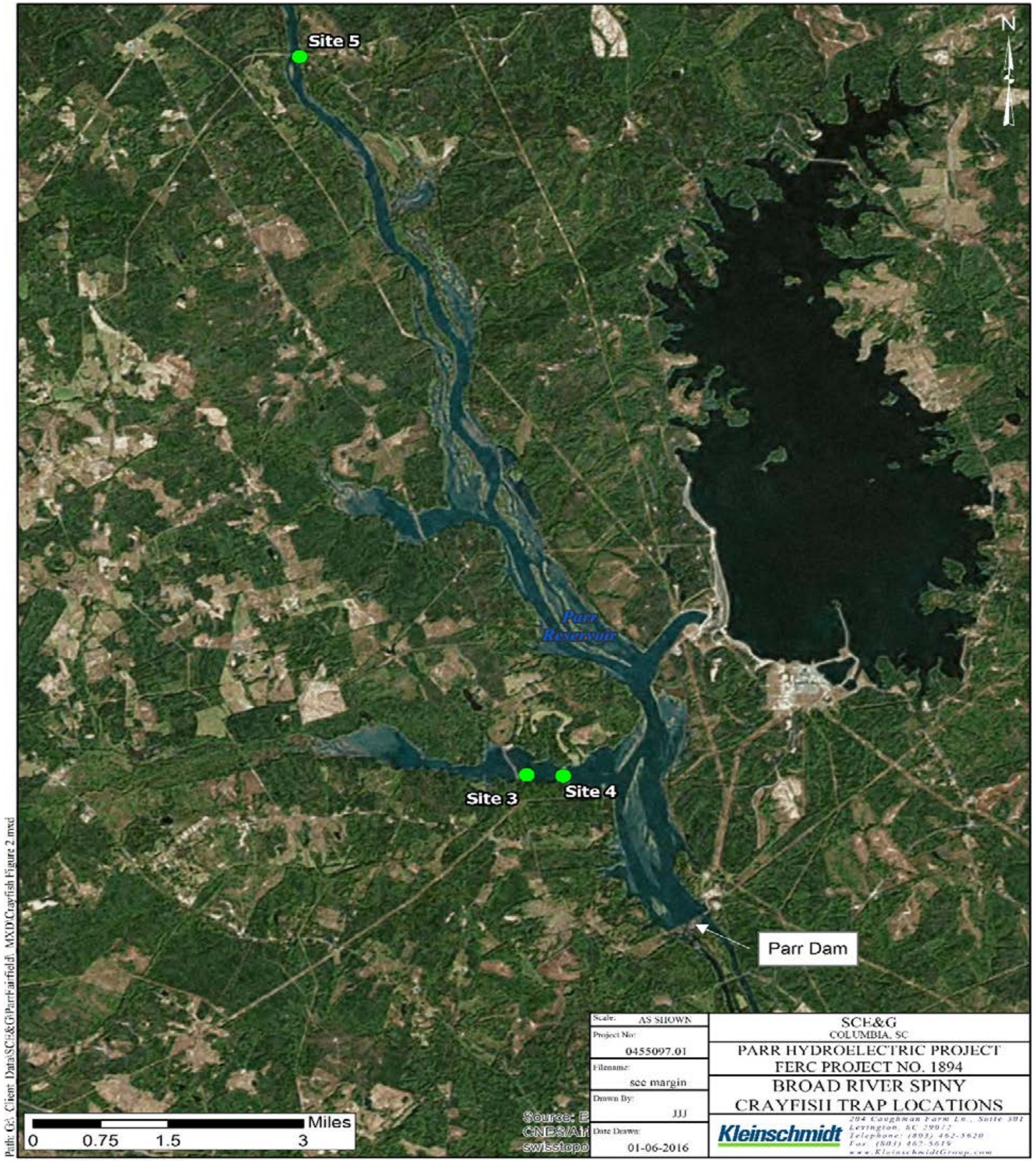




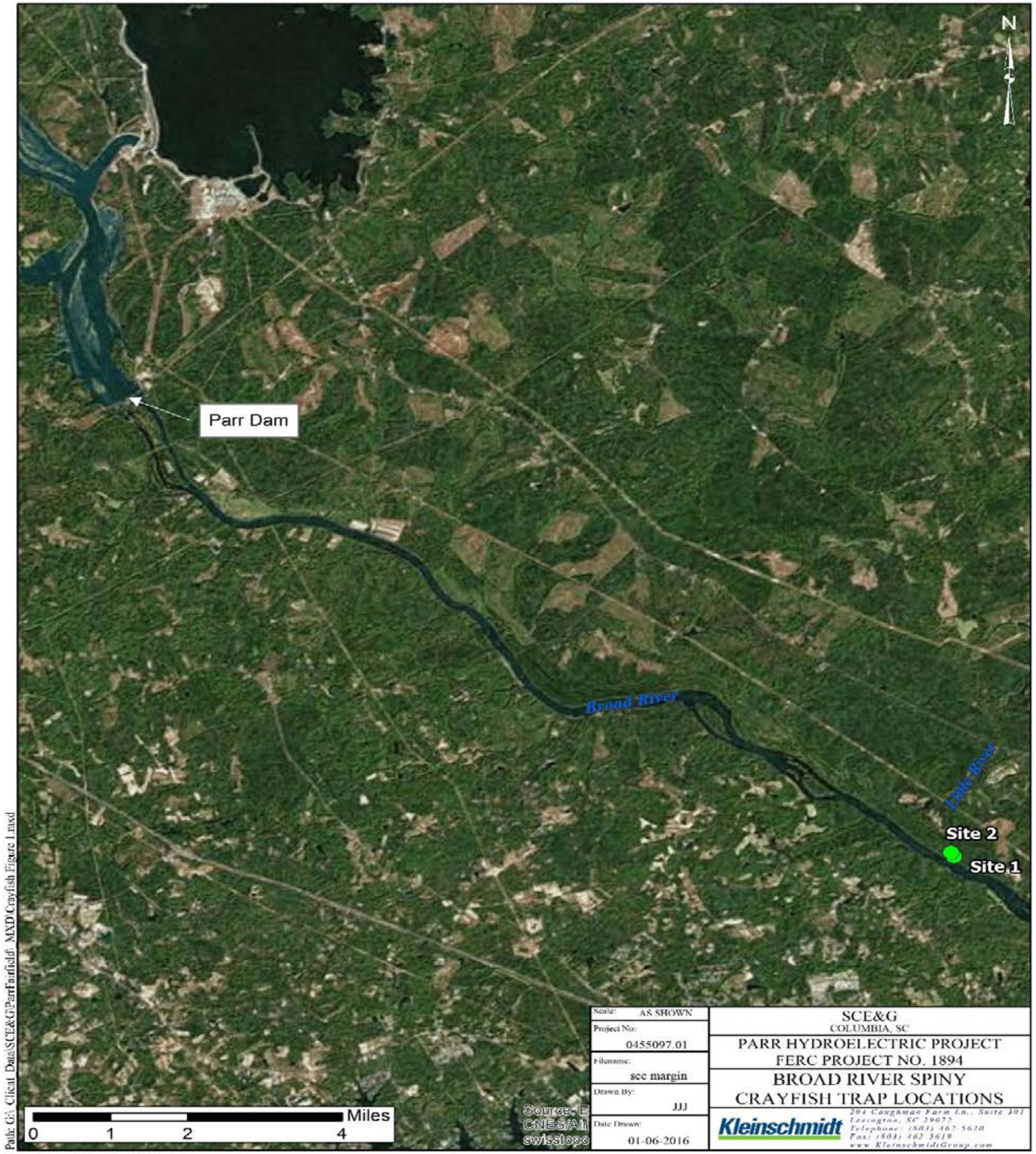
Broad River Spiny Crayfish Study Report

Objectives, Methods, and Materials

- Study Objective- Assess the presence of the Broad River Spiny Crayfish in Parr Shoals Reservoir and in the Broad River Downstream of Parr Shoals Dam
- Study site determinations w/ USFWS
- Double entry traps wire mesh crayfish traps baited, set, and regularly checked at 3 sites (September-October 2015)
    1. Broad river at the Hwy 34 bridge
    2. Cannon's Creek arm of Parr Shoals Reservoir
    3. Confluence of Little River and Broad River, downstream of Parr Shoals Dam



Source: Kleinschmidt, ESRI



Source: Kleinschmidt, ESRI

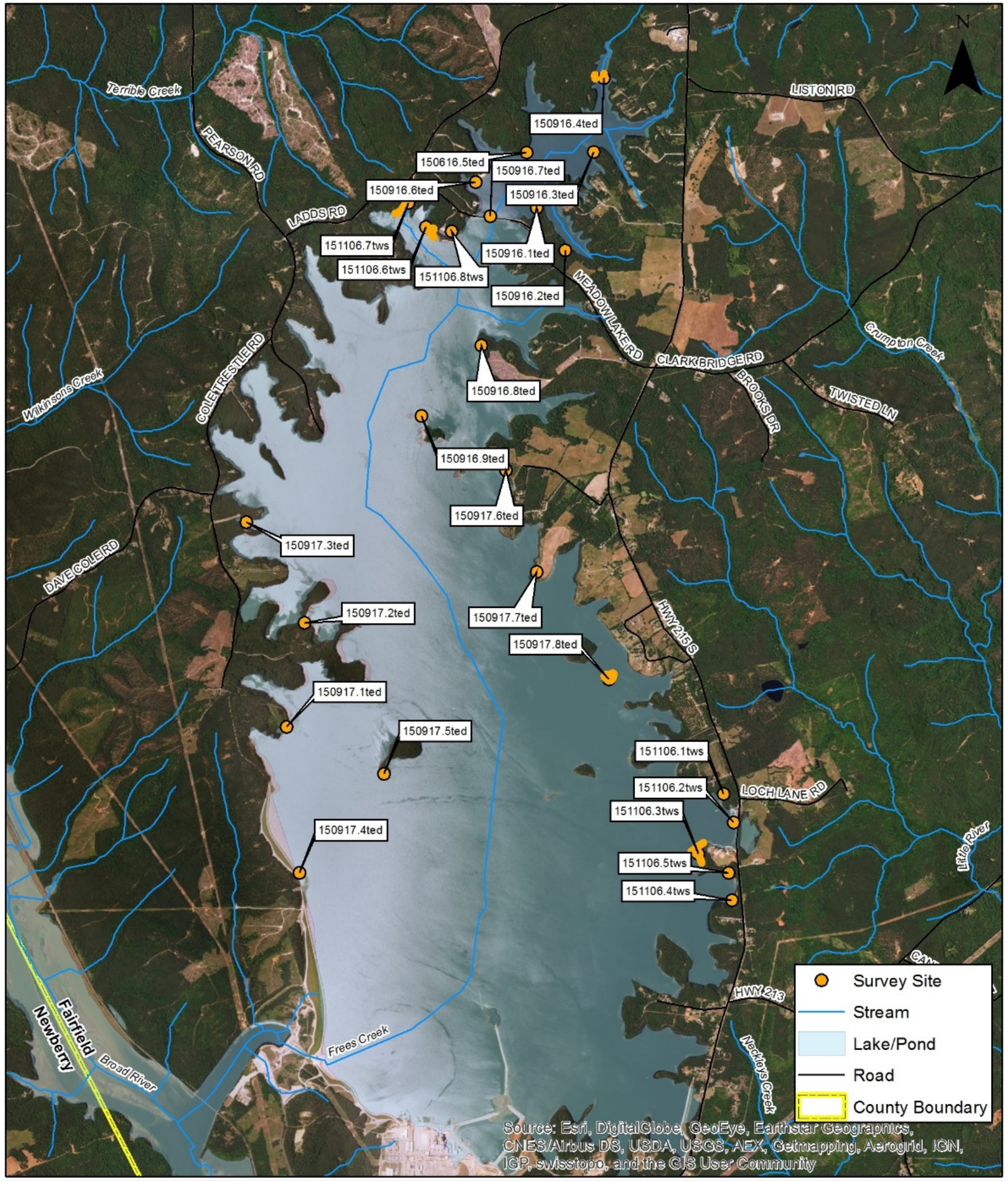
Results

- Water temperatures ranged from 12-28°C for duration of study
- Traps fished for a total of 9,996 hours
- No crayfish collected
- Traps collected small sunfish throughout study

Monticello Freshwater Mussel Survey Report

Methods and Materials

- Surveys conducted by Tim Savidge (Three Oaks/Catena) on September 16-17 and November 6, 2015
- 25 sites surveyed via SCUBA and snorkeling
- Surveyors worked from shoreline habitats towards deeper water
- All mussels identified, enumerated, and returned to substrate



Prepared For:

Kleinschmidt

Freshwater Mussel Survey
Monticello Reservoir

Fairfield County, South Carolina

Date:	December 2015
Scale	0 1,000 2,000 Feet
Job No.:	3396
Drawn By: KMS	Checked By: TS

Figure
1

Results

- Six species documented: Carolina Lance (moderate priority), Eastern Floater, Florida Pondhorn, Paper Pondshell, Eastern Creekshell (moderate priority), Carolina Creekshell (highest priority)
- Relic shell material (Paper Pondshell) found in rec lake
- Reproduction appears to occur for at least 5 species
- Federally protected species (Carolina Heelsplitter and Savannah Liliput) unlikely to occur in Monticello Reservoir and are not known from the Broad River Basin.

Exhibit E-5 Fisheries Resources

American Eel Abundance Monitoring Plan

AMERICAN EEL
(*ANGUILLA ROSTRATA*)
ABUNDANCE MONITORING PLAN

PARR HYDROELECTRIC PROJECT
(FERC NO. 1894)

Prepared for:

South Carolina Electric & Gas Company
Cayce, South Carolina

Prepared by:

Kleinschmidt

Lexington, South Carolina
www.KleinschmidtGroup.com

September 2017

AMERICAN EEL (*ANGUILLA ROSTRATA*)
ABUNDANCE MONITORING PLAN

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September 2017

AMERICAN EEL (*ANGUILLA ROSTRATA*)
ABUNDANCE MONITORING PLAN

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AMERICAN EEL (*ANGUILLA ROSTRATA*)
ABUNDANCE MONITORING PLAN

1.0 INTRODUCTION

South Carolina Electric & Gas Company (SCE&G) is the Licensee for the Parr Hydroelectric Project (FERC No. 1894) (Project), which consists of the Parr Shoals Development (Parr Development) and the Fairfield Pumped Storage Development (Fairfield Development). Both developments are located along the Broad River in Fairfield and Newberry counties, South Carolina. The current license for the Project is due to expire on June 30, 2020. SCE&G will file for a new license with the Federal Energy Regulatory Commission (FERC) on or before June 30, 2018.

The Parr Development creates a blockage for upstream fish passage on the Broad River, therefore stakeholders on the Fisheries Technical Working Committee (TWC) requested an assessment of American eel (*Anguilla rostrata*) abundance downstream of Parr Shoals Dam. The study results were used to determine if upstream passage of American eel was warranted at this time or at some point during the term of the new license. SCE&G and the stakeholders reviewed the study results and agreed to develop this American Eel Monitoring Plan to assess densities of American eel downstream of the Parr Shoals Dam during the term of the new license. This plan will be included as a Protection, Mitigation and Enhancement (PM&E) measure in the Comprehensive Relicensing Settlement Agreement (CRSA).

2.0 EXISTING INFORMATION

Information on the distribution and abundance of American eel in the Broad River is not well documented. The South Carolina Department of Natural Resources (SCDNR) currently operates an eel ramp at the St. Stephen Re-diversion Dam, located approximately 135 river miles downstream of the Project. This ramp provides passage of eels into the Santee Cooper Reservoir System, which connects with the Congaree and Wateree rivers. Little is known regarding the extent of passage of American eels upstream beyond the Santee Cooper reservoirs into the Congaree and further upstream above the Columbia Hydroelectric Project into the Broad River and to the base of the Parr Shoals Dam. During relicensing, stakeholders requested a study to assess eel abundance downstream of the Parr Shoals Dam. To fulfill this request, SCE&G conducted American eel surveys during 2015 and 2016. Ramp-style elver traps, a fyke net, and electrofishing efforts were utilized during spring 2015 and fall 2015 (Figure 2-1), and only one eel was collected via backpack electrofishing. Additional backpack and boat electrofishing efforts were performed in spring 2016 (Figure 2-2), which detected two additional eels. A total of three American eels, all in the yellow eel lifestage, were collected or observed during the entire study. All the eels were observed using electrofishing methods (Kleinschmidt 2016).

The SCDNR has conducted two separate American eel abundance studies in the Broad River. During 2010 through 2012, the SCDNR collected 13 eels downstream of the Columbia Hydroelectric Project dam (located on the Broad River 23.5 miles downstream of Parr Shoals Dam) via eel ramps, electrofishing, and Fukui traps. In separate collection efforts during 2009 through 2014, the SCDNR collected a total of 21 yellow eels in the Broad River via boat electrofishing, with 12 of those eels collected immediately downstream of Parr Shoals Dam. Results of these studies suggest that while American eels are present in the Broad River downstream of Parr Shoals Dam, they are not abundant.

FIGURE 2-1 PARR PROJECT AMERICAN EEL SAMPLING LOCATIONS – 2015

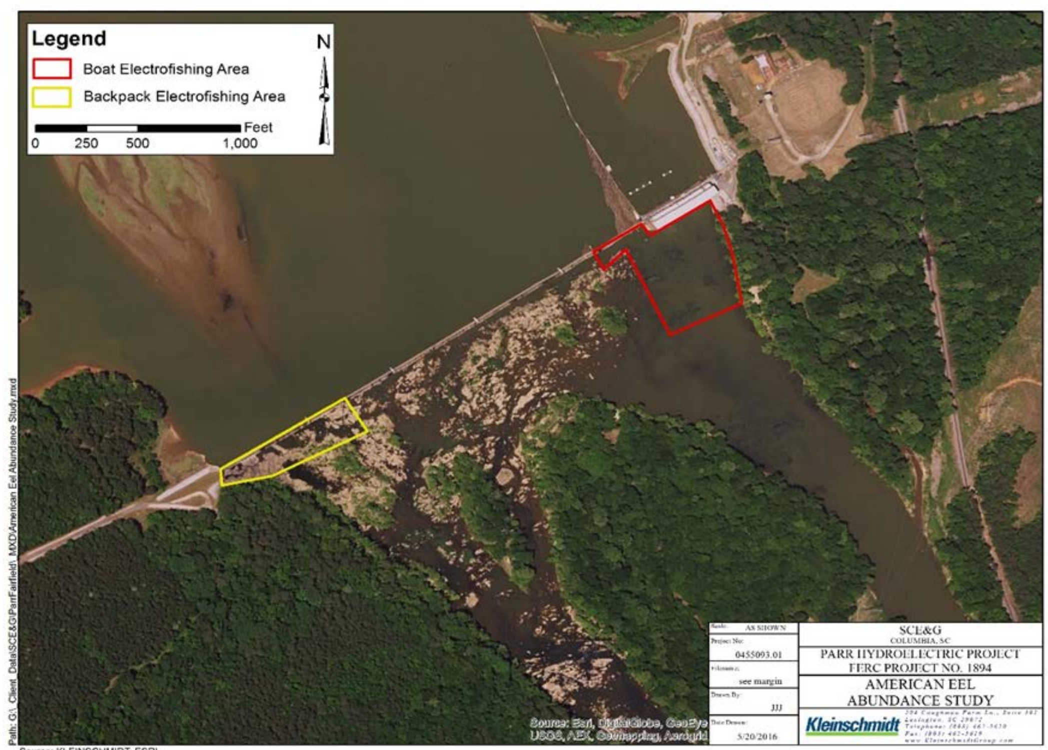

FIGURE 2-2 PARR PROJECT AMERICAN EEL SAMPLING LOCATIONS – 2016

3.0 PROPOSED PM&E MEASURE

Current distribution of American eel downstream of Parr Shoals Dam does not warrant construction of an eel ramp, but densities in the future may increase during the new FERC operating license. To address future concerns, SCE&G will conduct electrofishing sampling efforts to monitor the distribution and abundance of American eels downstream of the Parr Shoals Dam for the duration of their new license for the Project. A study plan detailing monitoring frequency, timing, and location will be developed by the American Eel Review Committee[1] following issuance of the new license. SCE&G will then submit this study plan to FERC for approval. Preliminary methods for American eel monitoring are included below.

3.1 PRELIMINARY AMERICAN EEL MONITORING METHODS

Electrofishing methods will target the yellow eel lifestage and will include backpack electrofishing in pools downstream of Parr Shoals Dam along the west side of the dam and boat electrofishing in the shoal and riffle habitats downstream of the powerhouse, as well as along the face of the dam near the powerhouse. Surveys will be conducted during the first year after the license is issued and the American Eel Monitoring Study Plan has been approved by the FERC; and then every 5 years thereafter (i.e., years 6, 11, 16, etc. after license issuance) (Table 4-1). Sampling will be increased to once every 3 years upon the completion of eel passage at the Santee Cooper Project. During each sampling year, sampling efforts will be conducted over three days in April, May, and June, not necessarily with one day in each month, except during the first year of sampling. After the first year of sampling, the Review Committee will determine when the three days of sampling will occur, to potentially include other months such as October. On each sampling day, backpack electrofishing will occur for ½ hour and boat electrofishing will occur for 1 hour. Sampling locations are outlined in Figure 3-1. The monitoring results will be reported to the Review Committee within two months of the close of monitoring each collection year. Sampling results will be assessed at a Review Committee meeting the February following a monitoring year, and a report will be filed with FERC by April 30 of that year. The Review Committee will use the data collected under this monitoring plan to determine the trigger for

[1] Members of the American Eel Review Committee must be signatories to the CRSA with the exception of National Oceanic and Atmospheric Administration (NOAA) Fisheries, US Fish and Wildlife Service (USFWS) and SCDNR.

construction and implementation of an eel ramp at the Parr Shoals Dam. However, the Project currently has a plan with triggers established for implementing passage of American shad and blueback herring at the Parr Shoals Dam. SCE&G will consider inclusion of an American eel ramp as part of that fishway design and construction when triggers are met for fish passage.

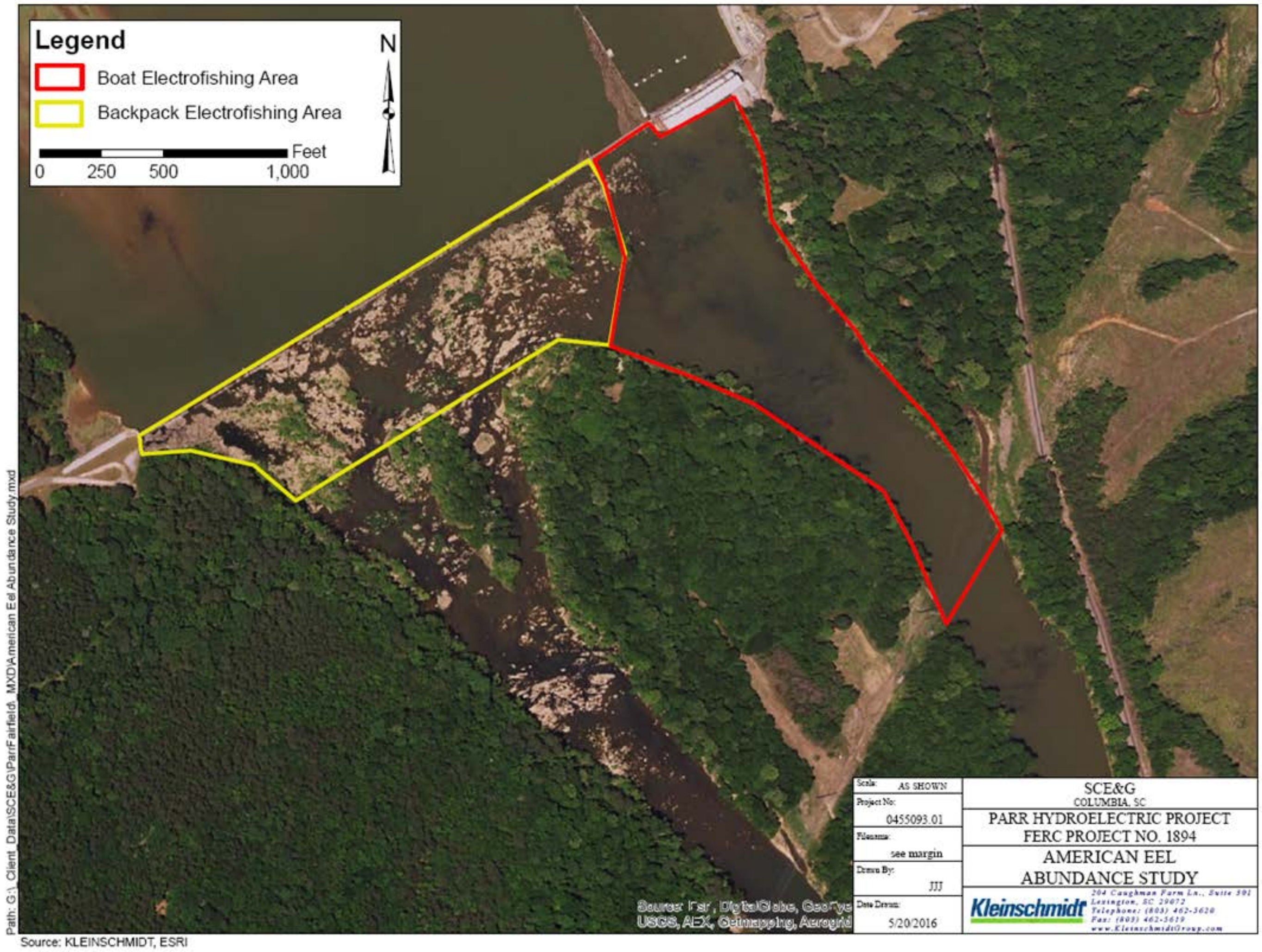

FIGURE 3-1 AMERICAN EEL MONITORING LOCATIONS

4.0 SCHEDULE

The monitoring schedule is described in the table below in relation to the issuance of the license by FERC.

TABLE 4-1 AMERICAN EEL MONITORING PLAN SCHEDULE

PERIOD[2]	ITEM
Within 180 days of license issuance	Form Review Committee, review American Eel Monitoring Plan and submit American Eel Monitoring Study Plan to FERC
Year 1 of new license	• Conduct 3 surveys - April-June • Report results to Review Committee within 2 months after end of monitoring • Review Committee meeting- February of following year • File Annual Report with FERC- April 30th of following year
Year 6 of new license	• Conduct 3 surveys - April-June or other months as determined by Review Committee • Report results to Review Committee within 2 months after end of monitoring • Review Committee meeting- February of following year • File Annual Report with FERC- April 30th of following year
Year 11 of new license	• Conduct 3 surveys - April-June or other months as determined by Review Committee • Report results to Review Committee within 2 months after end of monitoring • Review Committee meeting- February of following year • File Annual Report with FERC- April 30th of following year
Year 16 of new license	• Conduct 3 surveys - April-June or other months as determined by Review Committee • Report results to Review Committee within 2 months after end of monitoring • Review Committee meeting- February of following year • File Annual Report with FERC- April 30th of following year

[2] Sampling will increase to once every three years upon completion of eel passage at the Santee Cooper Project.

Year 21 of new license	• Conduct 3 surveys - April-June or other months as determined by Review Committee • Report results to Review Committee within 2 months after end of monitoring • Review Committee meeting- February of following year • File Annual Report with FERC- April 30th of following year
Year 26 of new license	• Conduct 3 surveys - April-June or other months as determined by Review Committee • Report results to Review Committee within 2 months after end of monitoring • Review Committee meeting- February of following year • File Annual Report with FERC- April 30th of following year
Year 31 of new license[3]	• Conduct 3 surveys - April-June or other months as determined by Review Committee • Report results to Review Committee within 2 months after end of monitoring • Review Committee meeting- February of following year • File Annual Report with FERC- April 30th of following year

[3] Sampling will continue throughout the term of the license. This schedule will be adjusted depending on the license term issued by FERC

5.0 LITERATURE CITED

Kleinschmidt Associates. 2016. American eel (*Anguilla rostrata*) Abundance Study Report. June 2016.

Exhibit E-5 Fisheries Resources

Macroinvertebrate and Mussel Report

MACROINVERTEBRATE AND MUSSEL REPORT

PARR FAIRFIELD HYDROELECTRIC PROJECT
FERC No. 1894

Prepared for:

South Carolina Electric & Gas Company
Cayce, South Carolina

Prepared by:

Kleinschmidt

November 2013

MACROINVERTEBRATE AND MUSSEL REPORT

PARR FAIRFIELD HYDROELECTRIC PROJECT
FERC No. 1894

Prepared for:

South Carolina Electric & Gas Company
Cayce, South Carolina

Prepared by:

Kleinschmidt

November 2013

MACROINVERTEBRATE AND MUSSEL REPORT

PARR FAIRFIELD HYDROELECTRIC PROJECT
FERC NO. 1894

SOUTH CAROLINA ELECTRIC & GAS COMPANY

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1.0 INTRODUCTION

The Parr Fairfield Hydroelectric Project ("Parr Fairfield" or "Project") (FERC No. 1894) is a federally licensed hydroelectric facility owned and operated by South Carolina Electric & Gas Company (SCE&G), a subsidiary of SCANA Corporation. The Parr Fairfield Project consists of two separate developments, including the Parr Hydroelectric Development and the Fairfield Pumped Storage Development. Since 1954, the Project has maintained a Federal Energy Regulatory Commission (FERC) license for operation and is actively seeking renewal for the current license, which expires in June, 2020.

Originating in the Blue Ridge Mountains of North Carolina, the Broad River predominately flows southeasterly into South Carolina to meet the Saluda River, forming the Congaree River and later the Santee River, along its course to the Atlantic Ocean. The Project is located in Fairfield and Newberry Counties, South Carolina, near the town of Jenkinsville. Situated on the Broad River, Parr Shoals Dam creates the 4,400 acre Parr Reservoir, which acts as the lower reservoir for the Fairfield Pumped Storage Development. Lake Monticello, formed by a series of four earthen dams at Frees Creek, is the 6,800 acre upper reservoir of the Fairfield Pumped Storage Development. The Project Boundary Line is depicted in Figure 1-1.

As part of the relicensing process, SCE&G is examining the water quality within the Project area by assessing the macroinvertebrate and mussel populations within the project area waterways, including the Broad River, Parr Reservoir, Parr Shoals Dam tailrace, and Monticello Reservoir. This report includes a compilation of the mussel surveys conducted by the South Carolina Department of Natural Resources (SCDNR) and SCANA Services personnel with Alderman Environmental Services, Inc., and macroinvertebrate studies conducted by SCANA Services personnel with Carnagey Biological Services, LLC.

FIGURE 1-1 PARR FAIRFIELD PROJECT BOUNDARY LINE

1.1 GOALS AND OBJECTIVES

The goal of this report is to collect and present existing macroinvertebrate and mussel data for the Parr Reservoir, Lake Monticello, and the downstream reach of the Broad River below the Parr Dam, to assist in describing the past and current water quality of these areas. In addition, this report serves to establish a baseline for the macroinvertebrate and mussel communities found within the Project Area.

1.2 BACKGROUND INFORMATION

Mussel and macroinvertebrate surveys were conducted to evaluate the condition of the waters associated with the Project. Freshwater mussels and benthic organisms commonly serve as indicators, or biological monitors, of water quality. As natural filter feeders, mussels strain out suspended particles and pollutants from the water column and help improve water quality (NRCS, 2007). The presence or absence of certain species can indicate the level of water quality in a specific area.

Macroinvertebrates are also excellent indicators of water quality. As with mussels, the taxonomic composition of the macroinvertebrate community at a specific site can accurately depict the health of that waterbody. Since macroinvertebrates have limited mobility, a site-specific assessment is assured.

2.0 METHODOLOGY

2.1 MUSSELS

2.1.1 SCDNR MUSSEL SURVEY

During 2007, a survey was conducted by the SCDNR to assess the status of freshwater mussels on the Broad River and Parr Reservoir. The team, led by a SCDNR malacologist, surveyed 60 sites along the Broad River, and 5 sites on selected tributaries. The survey sites are depicted on Figure 2-1.

Search methods for this survey differed based on water depth and clarity, and included visual searches, and searches utilizing snorkeling, SCUBA diving, and bathyscopes. Depending on various factors such as suitable habitat present, water clarity and search effectiveness, the amount of time spent searching each site varied. Repeated trips were made to the sites at the Parr Reservoir so that SCUBA could be utilized to examine the deeper areas of the reservoir. Identification of the mussel species collected occurred on site by the survey team.

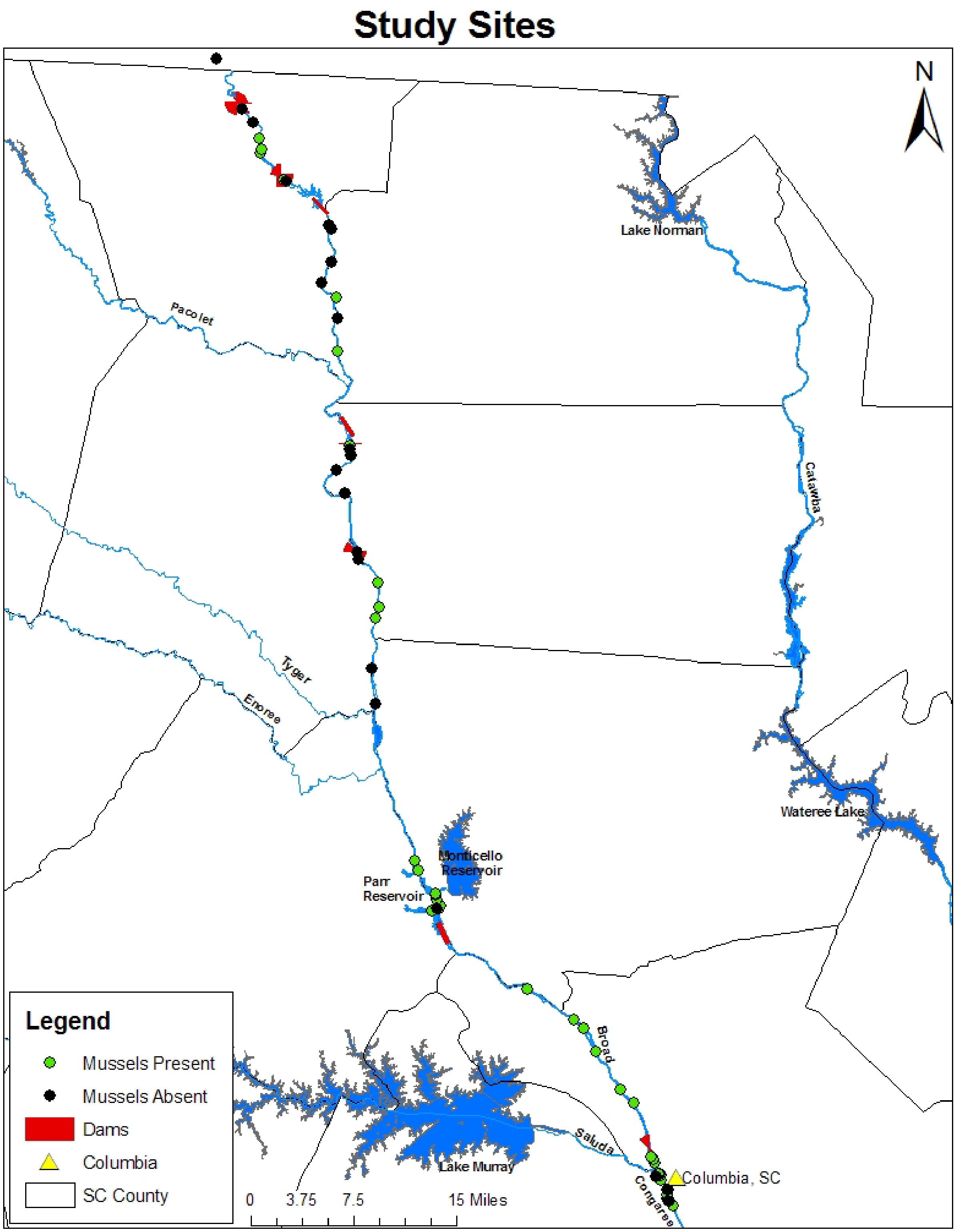


FIGURE 2-1 MUSSEL SURVEY SITES ON THE BROAD RIVER AND PARR RESERVOIR

2.1.2 SCANA MUSSEL SURVEY

In 2012, Alderman Environmental Services Inc. was contracted by SCANA Services, Inc. to perform a freshwater mussel survey on the Broad River immediately downstream of the Parr Shoals Dam, as a follow-up to the macroinvertebrate community assessment conducted by Carnagey Biological Services, LLC (see Section 2.2). The survey area included the Broad River east of Hampton Island on the Fairfield/Newberry county line and immediately downstream of the Parr Hydroelectric Development. The exact survey area is displayed in Figure 2-2.

During the study, flows were maintained by SCE&G at low levels to facilitate the surveys. Thirteen areas were surveyed by a team of four malacologists for freshwater mussels using bathyscopes and tactile techniques. Specific sites within the survey areas were selected due to various mussel species' microhabitat needs. The survey was conducted on October 22 and 23, 2012.

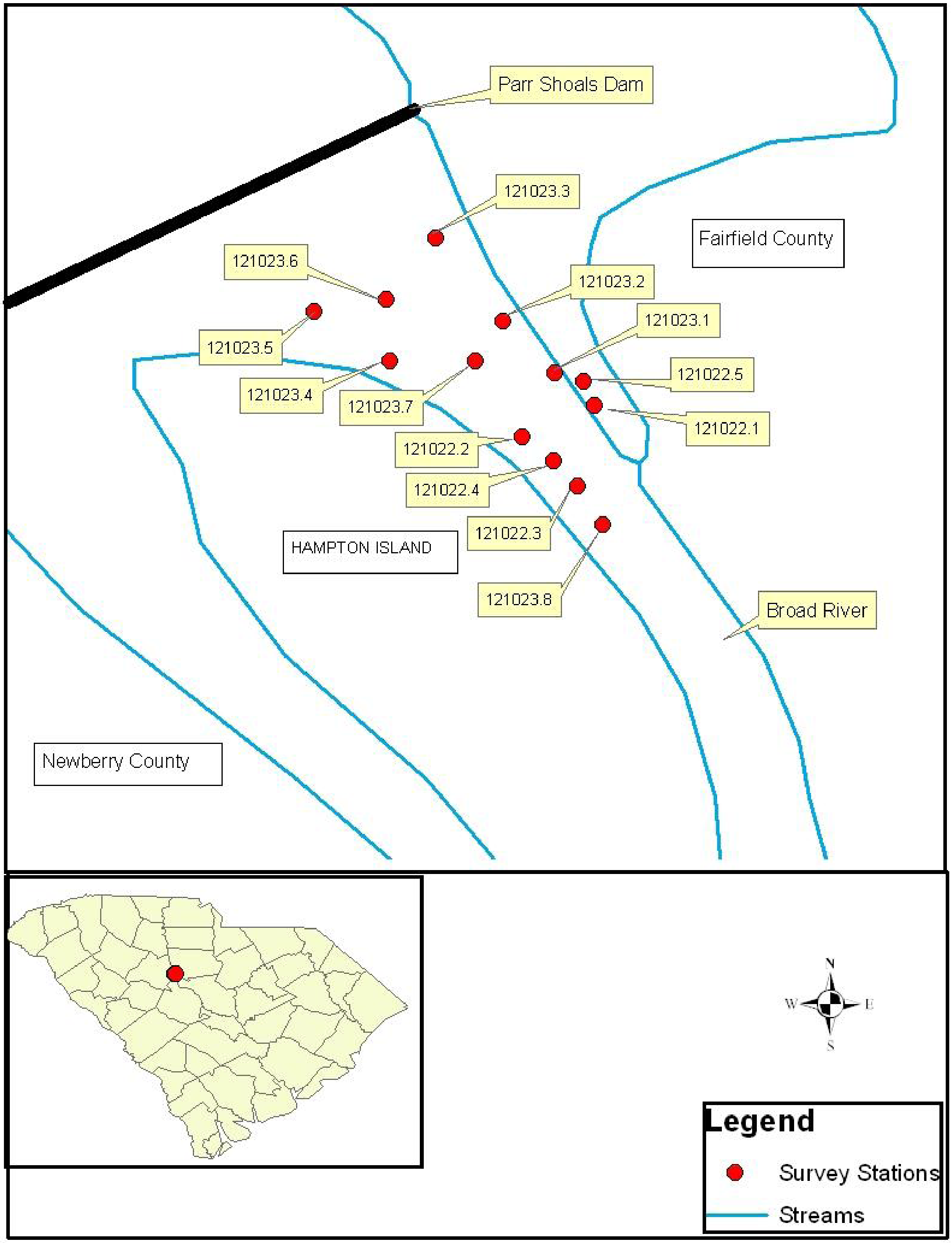


FIGURE 2-2 MUSSEL STUDY AREA AND SURVEY STATIONS

2.2 MACROINVERTEBRATES

In association with the Virgil C. Summer Nuclear Station (VCSNS) expansion, SCE&G conducted baseline studies to examine the macroinvertebrate communities within Parr Reservoir and Lake Monticello. In order to maintain the provisions of the Clean Water Act Section 401 water quality certification issued to the VCSNS Units 2 & 3, SCE&G has continued to monitor these macroinvertebrate populations in Parr Reservoir.

2.2.1 BASELINE STUDIES

In conjunction with the Nuclear Regulatory Commission (NRC) licensing process for the expansion of VCSNS, SCE&G conducted macroinvertebrate community assessments at various locations on Lake Monticello and Parr Reservoir during 2008 and 2009. The objective of these assessments was twofold with the first objective being to determine the condition of the macroinvertebrate community at the new water treatment intake and new raw water intake in Lake Monticello, as well as the condition of the macroinvertebrate community at the new cooling tower blowdown discharge location in Parr Reservoir. The second objective of this study was to document the macroinvertebrate community in and around the VCSNS.

In order to accomplish these objectives, SCANA Services personnel collected petite Ponar macroinvertebrate samples from five locations within Lake Monticello and Parr Reservoir on several different occasions. Samples were collected on June 18, 2008, September 18, 2008, January 22-23, 2009, April 27, 2009, and September 11, 2012. The collected samples were identified and the data analyzed by Carnagey Biological Services, LLC.

Macroinvertebrate sampling was performed at five sites within Parr Reservoir and Lake Monticello. The Parr Reservoir Control site was located upstream of Hellers Creek, approximately 9.0 kilometers above the Parr Shoals Dam. The Parr Reservoir New Blowdown Discharge site was located at the location of the proposed new cooling tower blowdown discharge from the proposed two new nuclear units at the VCSNS, and approximately 1.0 kilometers upstream of the Parr Shoals Dam. The Monticello Reservoir Control was located on the western side of the lake, approximately 5.0 kilometers north of the VCSNS. The Monticello Reservoir New Water Treatment Intake was located at the proposed intake point for the water treatment plant. The Monticello Reservoir Raw Water Intake was located at the proposed intake point for the VCSNS. These five sample sites are shown on Figure 2-3.

Quantitative sampling was performed using a petite Ponar grab sampler, as described in method 10500 (APHA, 1995). Five random replicate (15 X 15 cm) Ponar grab samples of sediment were collected from the lake at each location. Replicates were sieved in the field with a U.S. Standard No. 35 sieve (0.500 mm mesh), then placed individually in plastic bags, preserved with 85% ethanol, and transported to the laboratory for analysis. Upon return to the laboratory, all samples were washed over a U.S. Standard No. 35 sieve and organisms were sorted from the remaining material using forceps and the aid of a stereomicroscope. The organisms were preserved in 70% ethanol, and identified to the lowest positive taxonomic level.

In order to extract the greatest amount of information possible from the data collected, several types of analyses were performed. Bioassessment metrics allow for the comparison of macroinvertebrate communities at the various sampling sites and are based the overall taxonomic composition and the known tolerance levels and life history strategies of the organisms encountered. Changes in taxonomic composition were determined using the metrics outlined in Rapid Bioassessment Protocol III of *Rapid bioassessment protocols for use in streams and rivers* (Plafkin et al. 1989). These metrics include taxa richness, EPT index, Chironomidae taxa and abundance, ratio of EPT and Chronomidae abundance, ratio of scraper/scraper and filtering collectors, percent contribution of dominant taxon, and the North Carolina biotic index (NCBI). Single factor ANOVA analyses were also performed on the data, to detect trends and differences between the two bodies of water, Lake Monticello and Parr Reservoir.

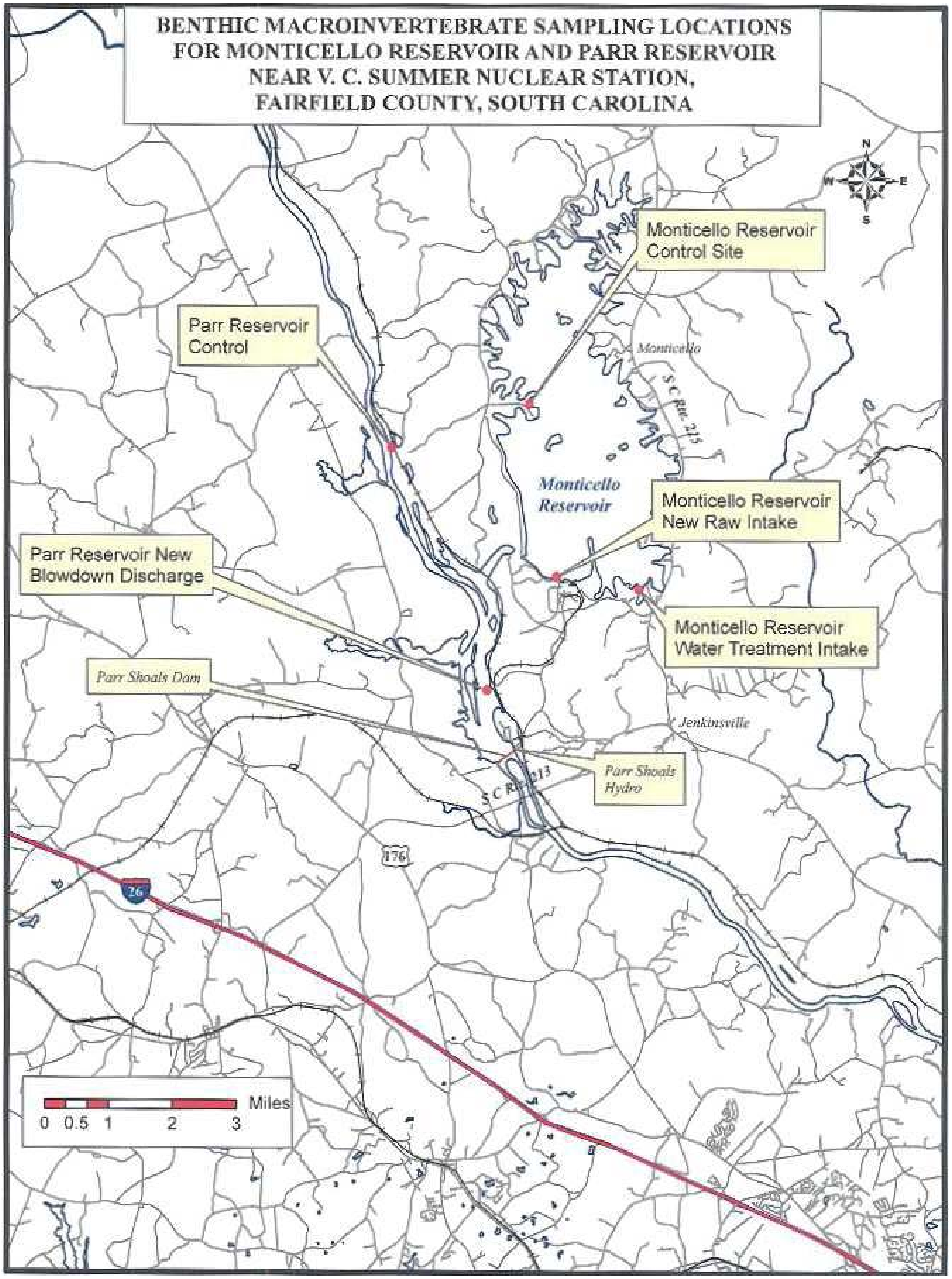


FIGURE 2-3 BASELINE MACROINVERTEBRATE ASSESSMENT SAMPLING LOCATIONS

2.2.2 ONGOING STUDIES

In addition to the baseline studies performed in 2008 and 2009, SCE&G has continued its study of Parr Reservoir with a macroinvertebrate assessment completed on September 11, 2012, to satisfy provisions of the Clean Water Act Section 401 water quality certification issued by the South Carolina Department of Health and Environmental Control (SCDHEC) for the VCSNS expansion. The objective of this and future assessments is to monitor the condition of the macroinvertebrate community in Parr Reservoir and the Broad River immediately below the Parr Shoals Dam to determine if there are any effects due to construction and operation of the cooling tower blowdown discharge diffuser associated with the VCSNS expansion. Samples will continue to be collected on an annual basis between the months of August and October until 5 years after the start-up of the VCSNS Unit 3. Unit 3 is scheduled to come online in 2018.

Collections of macroinvertebrates were made from two sampling transects in Parr Reservoir near the VCSNS and one location below Parr Shoals Dam. Parr Upstream sampling site was located upstream of Hellers Creek, approximately 9.0 kilometers above Parr Shoals Dam. Units 2 & 3 Discharge sampling site was located within the area of the proposed new cooling tower blowdown discharge from the two new nuclear units at the VCSNS, and approximately 1.0 kilometers upstream of the Parr Shoals Dam. Parr Tailrace sampling site is located approximately 75 meters below Parr Shoals Dam. Sampling sites are shown in Figure 2-4.

FIGURE 2-4 ONGOING MACROINVERTEBRATE ASSESSMENT SAMPLING LOCATIONS

Quantitative sampling of the macroinvertebrate communities from the Parr Upstream and Units 2 & 3 Discharge sampling transects was performed using a petite Ponar grab sampler, as described in method 10500 (APHA, 1995). Five random replicate (15 X 15 cm) Ponar grab samples of sediment were collected from the reservoir at each sampling point along the two transects. Replicates were sieved in the field with a U.S. Standard No. 35 sieve (0.500 mm mesh), then placed individually in plastic bags, preserved with 85% ethanol, and transported to the laboratory for analysis.

Due to the rocky substrate at the Parr Tailrace sampling site, dredge samples were not collected. Instead an instream macroinvertebrate community rapid bioassessment was conducted at this location. Macroinvertebrates were qualitatively collected at the Parr Tailrace location from all available habitats (e.g., stream margins, leaf packs, aquatic vegetation, water soaked logs and sand deposits) using a D-frame aquatic dip net and by picking organisms from substrates with forceps. Collections from all habitat types were combined to form one aggregate sample and preserved in the field with 80% ethanol.

Upon return to the laboratory, all petite Ponar samples were washed over a U.S. Standard No. 35 sieve to remove any remaining fine debris. Organisms from all three sample locations were sorted from the remaining material using forceps and the aid of a stereomicroscope. The organisms were retained in 80% ethanol, and identified to the lowest positive taxonomic level.

In order to extract the greatest amount of information possible from the data collected, several types of analyses were performed. Bioassessment metrics allow for the comparison of macroinvertebrate communities at the two transects and are based the overall taxonomic composition and the known tolerance levels and life history strategies of the organisms encountered. Changes in taxonomic composition were determined using the metrics outlined in Rapid Bioassessment Protocol III of *Rapid bioassessment protocols for use in streams and rivers* (Plafkin et al. 1989). These metrics include taxa richness, EPT index, Chironomidae taxa and abundance, ratio of EPT and Chronomidae abundance, ratio of scraper/scraper and filtering collectors, percent contribution of dominant taxon, and the North Carolina biotic index (NCBI). Single factor ANOVA analyses were also performed on the data, to detect trends and differences between the two Parr Reservoir transects. Data from Parr Tailrace was analyzed separately.

SCE&G is also conducting a macroinvertebrate study in the Broad River below the Neal Shoals Dam, located above the Parr Reservoir. The collected samples have been identified and the data analyzed by Carnagey Biological Services, LLC. This study is ongoing, but information collected thus far is presented in Appendix A.

3.0 RESULTS

3.1 MUSSELS

3.1.1 SCDNR MUSSEL SURVEY

The habitat of the surveyed stretch of the Broad River above Parr Dam was turbid, with lower substrate heterogeneity and less stable river bed substrates. Because of this many of the sites surveyed yielded few or no mussel species.

The section of the river from Parr Reservoir down to the Columbia Dam contained dense populations of mussels, although the diversity was low compared to other surveyed areas. The habitat within this area included fairly clear water and very stable substrates of gravel beds and large boulders. Shoals and rapids were also abundantly present in this stretch of the river, which contributed to an increased dissolved oxygen content. Within Parr Reservoir, the habitat is unique due to the water level fluctuations caused by the Fairfield Pumped Storage Development. Because of this, and the riverine characteristic of the reservoir, the species composition of Parr Reservoir is similar to that of the non-impounded sections of the Broad River.

A general inventory of species collected during the study is displayed in Table 3-1.

TABLE 3-1 GENERAL INVENTORY OF MUSSELS IN BROAD RIVER, 2007[A B]

site no.	latitude	longitude	date	person-hours	species	no. live	no. shells	CPUE
Upper Congaree River								
1	33.9688	-81.04007	5/31	0.4	*E. lanceolata* complex	1	0	2.5
					E. roanokensis	1	0	2.5
2	33.97004	-81.03893	5/31	0.5	*E. complanata*	2	0	4.0
					E. lanceolata complex	3	0	6.0
					E. roanokensis	2	0	4.0
					V. delumbis	1	0	2.0
3	33.97513	-81.04359	5/31	0.33	*E. lanceolata* complex	1	0	3.0
					E. roanokensis	5	0	15.0
					L. cariosa	1	0	3.0
4	33.97782	-81.04698	5/16	0.67	*E. roanokensis*	1	0	1.5
5	33.97812	-81.04536	5/16	1.67	*E. complanata*	5	0	3.0
					E. lanceolata complex	1	1	0.6
					E. roanokensis	26	0	15.6
					L. cariosa	2	0	1.2
					V. delumbis	1	0	0.6
6	33.98165	-81.04714	4/25	0.47	*E. complanata*	0	1	0.0
					E. lanceolata complex	1	0	2.1
7	33.98669	-81.04763	5/16	1.25	none	-	-	-
8	33.98708	-81.04551	5/16	3.75	*E. complanata*	9	0	2.4
					E. congaraea	1	0	0.3
					E. lanceolata complex	2	0	0.5
					E. roanokensis	73	0	19.5
					L. cariosa	1	0	0.3
					V. delumbis	1	0	0.3
			5/31	0.83	*E. complanata*	5	0	6.0
					E. lanceolata complex	3	0	3.6
					E. roanokensis	51	0	61.4
					L. cariosa	1	0	1.2
			8/14	1.5	*E. complanata*	1	0	0.7
					E. lanceolata complex	3	0	2.0
					E. roanokensis	12	0	8.0
					L. cariosa	4	0	2.7
					V. delumbis	1	0	1.2
9	33.996	-81.052	5/16	0.67	*E. complanata*	1	0	1.5
					E. lanceolata complex	1	1	1.5
10	33.99732	-81.05421	4/25	0.43	*E. complanata*	0	2	-
					E. lanceolata complex	0	2	-
					E. roanokensis	0	1	-
11	34.00077	-81.06044	4/25	0.17	None	-	-	-
12	34.00301	-81.05532	6/20	1.0	*E. complanata*	1	0	1
					E. roanokensis	1	0	1
13	34.00421	-81.05748	5/15	5.0	*E. complanata*	8	0	1.6
					E. congaraea	3	0	0.6
					E. lanceolata complex	21	1	4.2
					E. roanokensis	22	0	4.4
					L. radiata	2	0	0.4
					L. nasuta	1	0	0.2
					Villosa delumbis	14	1	2.8
Broad River below Parr Reservoir								
18	34.07909	-81.08981	3/27	1.5	*E. complanata*	48	1	32
					E. lanceolata complex	26	0	17.3
					V. delumbis	1	0	0.4
19	34.0934	-81.10606	3/27	1.17	*E. complanata*	27	6	23.1
					E. lanceolata complex	1	14	0.9
					U. carolinanus	10	0	8.5
20	34.13413	-81.13848	3/28	0.5	*E. complanata*	37	0	74
					E. lanceolata complex	14	0	28

21	34.15881	-81.15317	3/28	0.5	*E. complanata*	4	0	8
					E. lanceolata complex	4	0	8
22	34.16693	-81.16542	3/28	0.75	*E. complanata*	44	0	58.7
					E. lanceolata complex	4	0	5.3
					U. carolinanus	1	0	1.3
					V. delumbis	2	0	2.6
23	34.19955	-81.22483	3/28	1.33	*E. complanata*	3	0	2.3
					E. lanceolata complex	8	0	6.0
					U. carolinanus	38	0	28.5
					V. delumbis	7	0	5.3
24	missing	missing	3/29	0.75	*E. complanata*	13	0	17.3
					E. lanceolata complex	24	0	32.0
					V. delumbis	2	0	2.7
25	missing	missing	3/29	1.0	*E. complanata*	63	0	63.0
					E. lanceolata complex	35	0	35.0
					V. delumbis	11	0	11.0
Parr Reservoir								
26	34.28227	-81.34766	8/31	0.75	*E. complanata*	1	0	1.3
					E. lanceolata complex	47	16	62.7
					V. delumbis	3	0	4.0
			9/26	2.17	*E. complanata*	1	0	0.5
					E. lanceolata complex	25	9	11.5
					U. carolinanus	1	0	0.5
					V. delumbis	4	1	1.8
27	34.28503	-81.34099	9/26	2.33	none	0	0	-
28	34.2859	-81.33821	8/31	0.33	*E. lanceolata* complex	1	6	3.0
			9/26	2.0	*E. lanceolata* complex	4	4	2.0
					U. carolinanus	2	0	1.0
					U. imbecillis	0	1	-
					V. delumbis	1	0	0.5
29	34.29477	-81.34232	9/27	2.0	*E. lanceolata* complex	16	7	8.0
					U. carolinanus	2	0	1.0
					V. delumbis	2	0	1.0
30	34.30006	-81.34343	8/31	0.58	*E. complanata*	1	0	1.7
					E. lanceolata complex	18	3	31.0
			9/26	2.0	*E. lanceolata* complex	2	0	1.0
					V. delumbis	16	0	8.0
31	34.32524	-81.36617	9/7	0.5	*E. lanceolata* complex	3	0	6.0
					V. delumbis	1	0	2.0
			9/27	2.0	*E. lanceolata* complex	1	0	0.5
32	34.33614	-81.37004	9/7	0.5	*E. lanceolata* complex	0	2	4.0
Broad River above Parr Reservoir								
33	34.50299	-81.42056	4/26	0.27	none	0	0	-
34	34.54028	-81.42664	4/26	0.67	none	0	0	-
35	34.5933	-81.42075	7/16	1.33	*E. lanceolata* complex	11	0	8.3
					V. delumbis	1	0	0.8
36	34.60525	-81.4172	7/16	0.67	*E. lanceolata* complex	1	0	1.5
37	34.63086	-81.41812	7/16	0.67	*E. lanceolata* complex	1	0	1.5
38	34.65604	-81.44328	7/16	0.5	none	0	0	-
39	34.66316	-81.44566	7/16	0.33	none	0	0	-
40	34.72609	-81.46175	8/16	0.17	none	0	0	-
41	34.75092	-81.47244	8/16	0.5	none	0	0	-

42	34.76659	-81.45328	8/16	0.67	none	0	0	-
43	34.77276	-81.45538	8/16	0.67	none	0	0	-
44	34.77607	-81.45499	8/16	1.0	*E. lanceolata* complex	3	1	3.0
45	34.8766	-81.47118	8/22	1.0	*E. lanceolata* complex	2	0	2.0
46	34.91208	-81.47171	8/22	1.0	none	0	0	0.0
47	34.93425	-81.47374	8/22	1.67	*E. lanceolata* complex	5	1	3.0
48	34.94893	-81.49248	7/19	0.5	none	0	0	-
49	34.97158	-81.48045	7/19	0.33	none	0	0	-
50	35.00663	-81.48038	7/19	0.5	none	0	0	-
51	35.01047	-81.48329	7/19	0.57	none	0	0	-
52	35.02319	-81.21877	7/19	0.67	none	0	0	-
53	35.05651	-81.5395	9/13	0.83	none	0	0	-
54	35.05773	-81.54175	9/13	1.25	*E. lanceolata* complex	1	0	0.8
55	35.08725	-81.57247	9/5	0.5	*E. lanceolata* complex	3	0	6.0
56	35.09025	-81.57183	9/5	1.0	*E. complanata* *E. lanceolata* complex *E. roanokensis*	1 2 1	2 0 0	1.0 2.0 1.0
57	35.10257	-81.57387	9/5	0.83	*E. complanata* complex	0	1	-
58	35.11959	-81.58197	9/5	0.5	none	0	0	-
59	35.1335	-81.59599	9/5	0.33	none	0	0	-
60	35.1869	-81.6302	9/18	1.5	none	0	0	-

Selected tributaries of the Upper Broad								
Guyon Moore Creek	34.98664	-81.47167	10/9	1.0	none	0	0	-
Buffalo Creek	35.1275	-81.55068	10/9	1.33	none	0	0	-
Kings Creek	35.04171	-81.47832	10/9	1.5	none	0	0	-
Thickety Creek	34.92847	-81.52916	10/11	1.0	none	0	0	-
Pacolet River	34.8736	-81.53146	10/11	2.5	none	0	0	-

[a] CPUE= catch per unit effort in live mussels per person hour
[b] Data from SCDNR's 2009 Fish Passage on the Broad River: an assessment of the benefits to freshwater mussels

3.1.2 SCANA MUSSEL SURVEY

According to Alderman, the survey reach provides significant freshwater mussel habitat. During the survey, the highest freshwater mussel diversity in the Broad River Subbasin in North and South Carolina upriver from the Columbia Canal Dam was observed. For many of the species, their highest recorded abundances also occur within this specific river reach. Also, this survey found the most upriver occurrence of the yellow lampmussel (*Lampsilis cariosa*) within the Broad River Subbasin to date. Also, it seems the Roakoke slabshell (*Elliptio roanokensis*) juveniles, which require an anadromous fish host, is being recruited to this area of the Broad

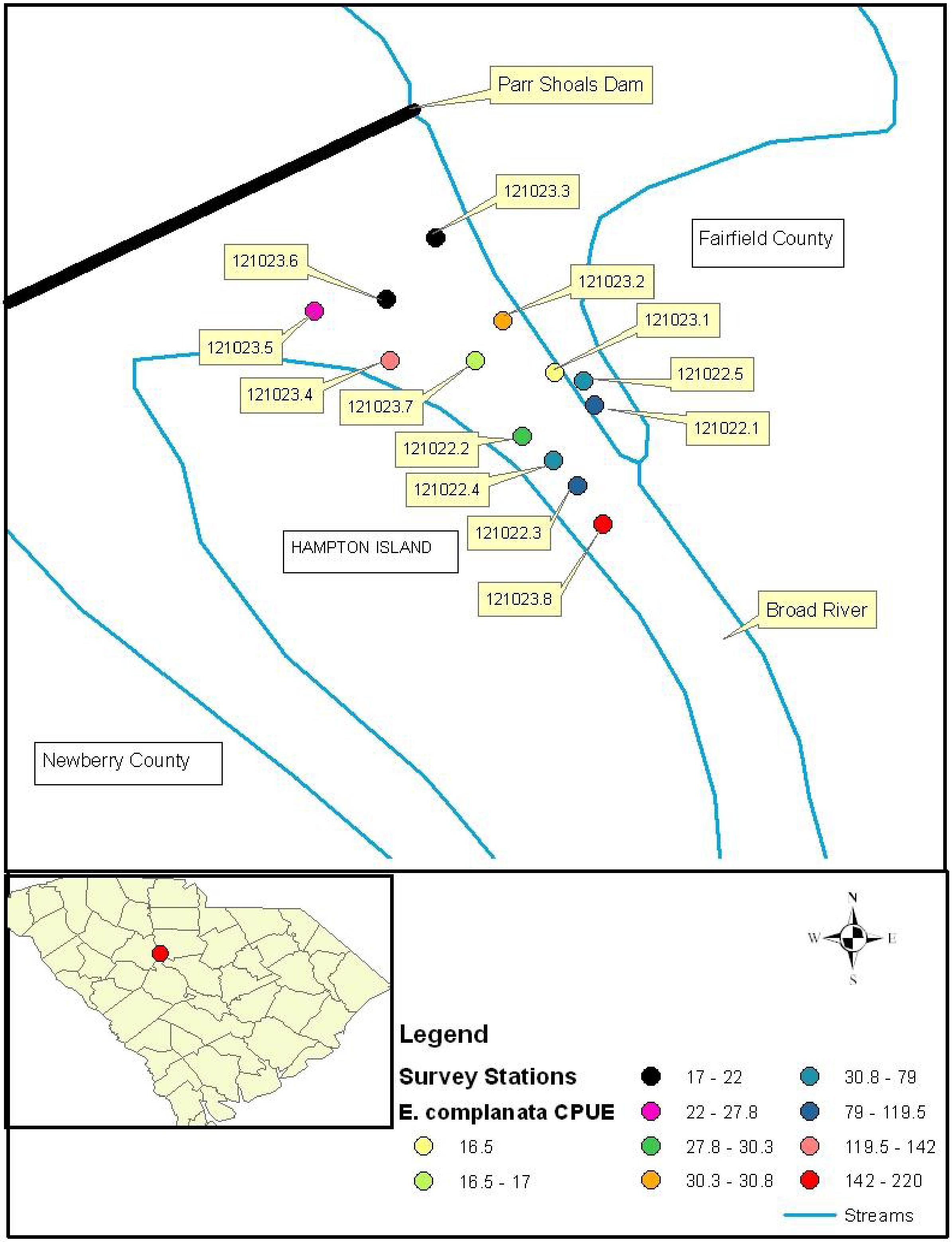
River. This study also found the greatest large river extant eastern creekshell (*Villosa delumbis*) population within the entire Santee Cooper River Basin in North and South Carolina.

Nine freshwater mussel species were documented as existing within the areas surveyed and are listed in Table 3-2.

TABLE 3-2 SCANA SURVEY FRESHWATER MUSSEL INVENTORY

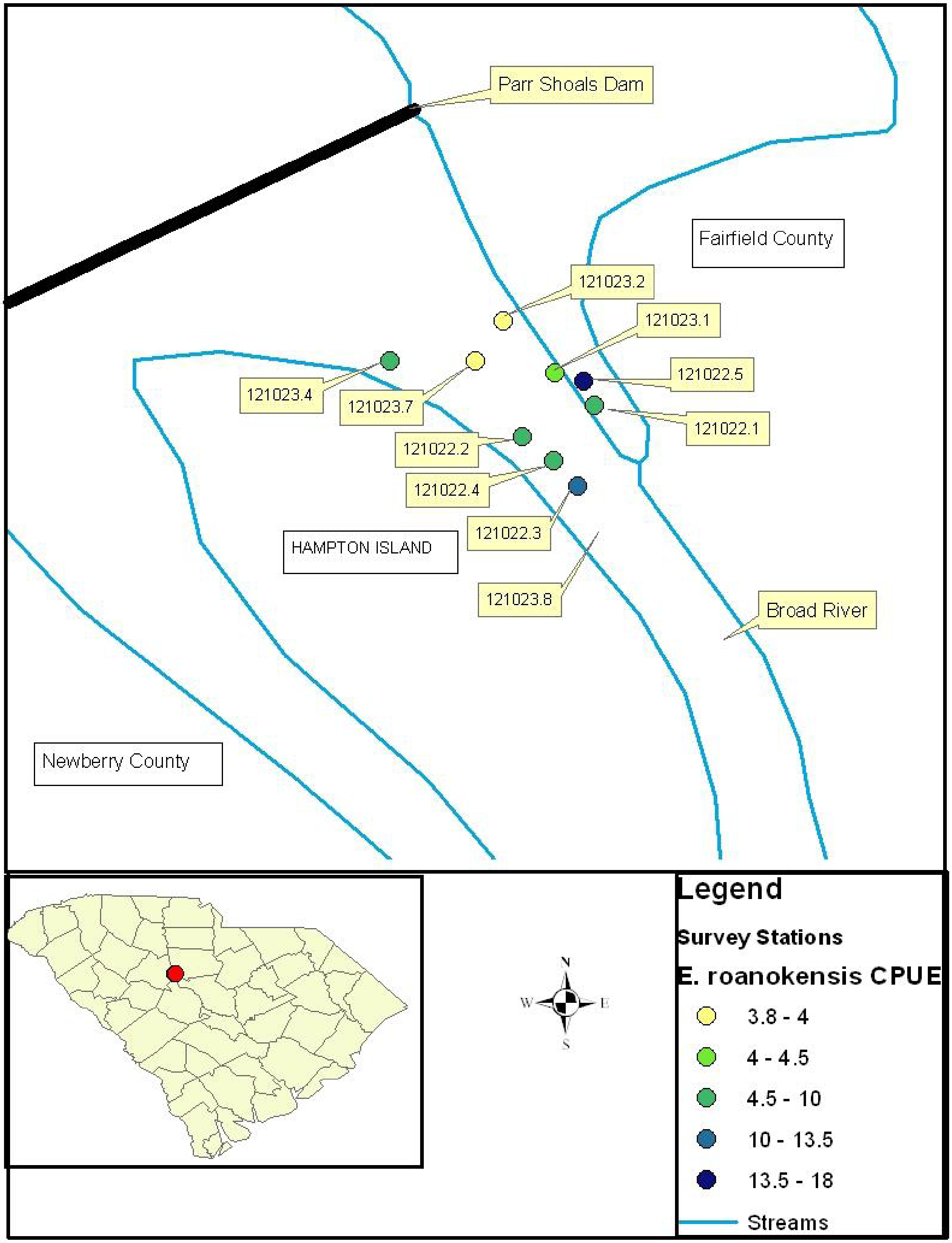
SPECIES DOCUMENTED
Elliptio complanata
E. roanokensis
E. icterina
E. angustata
E. fisheriana
Uniomerus carolinianus
Utterbackia imbecillis
Villosa delumbis
Lampsilis cariosa

The catch-per-unit-effort (CPUE) at each sampling site, for each species, is documented in the figures below.



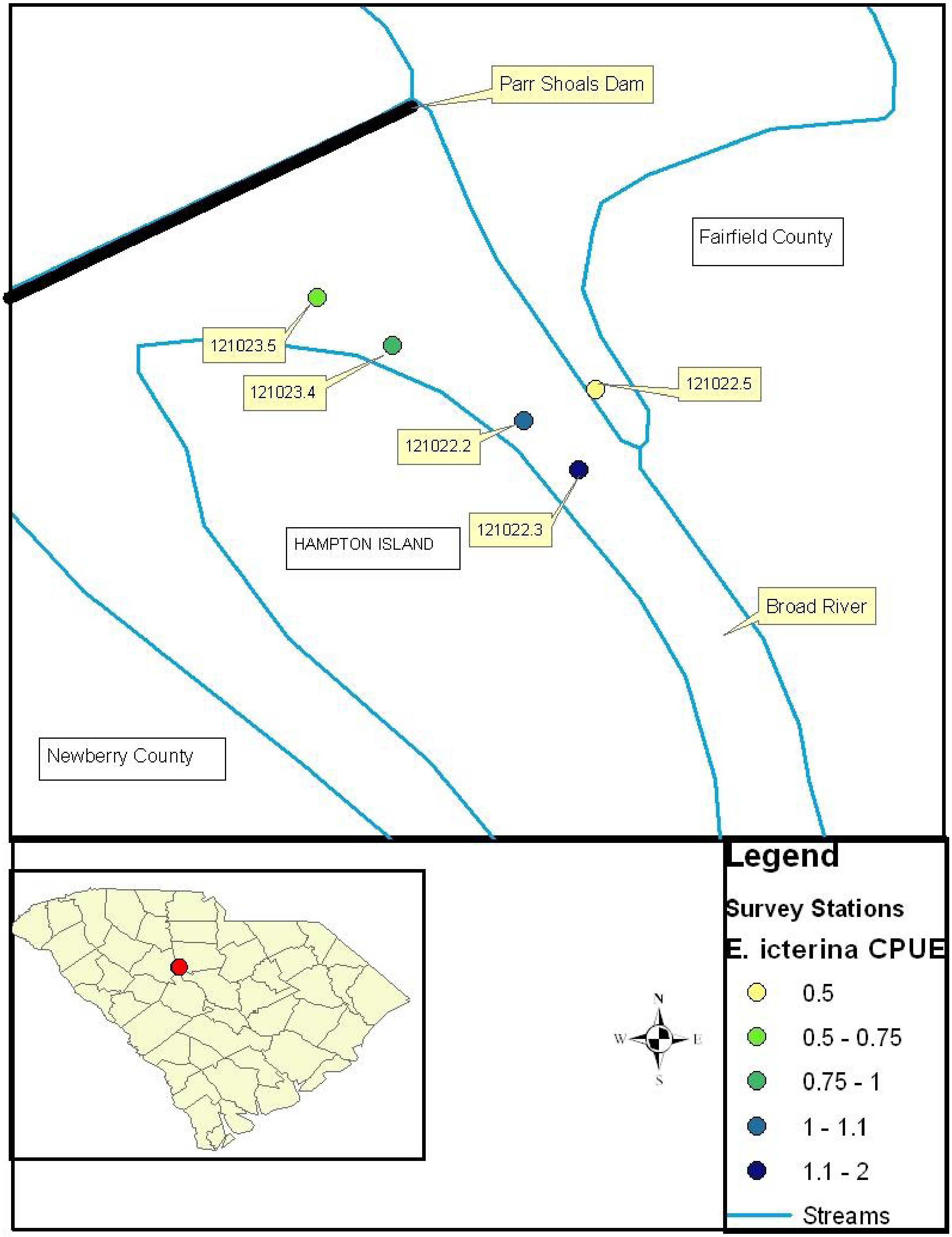
Source: 2012 Alderman Study

FIGURE 3-1 CPUE FOR *ELLIPTIO COMPLANATA*



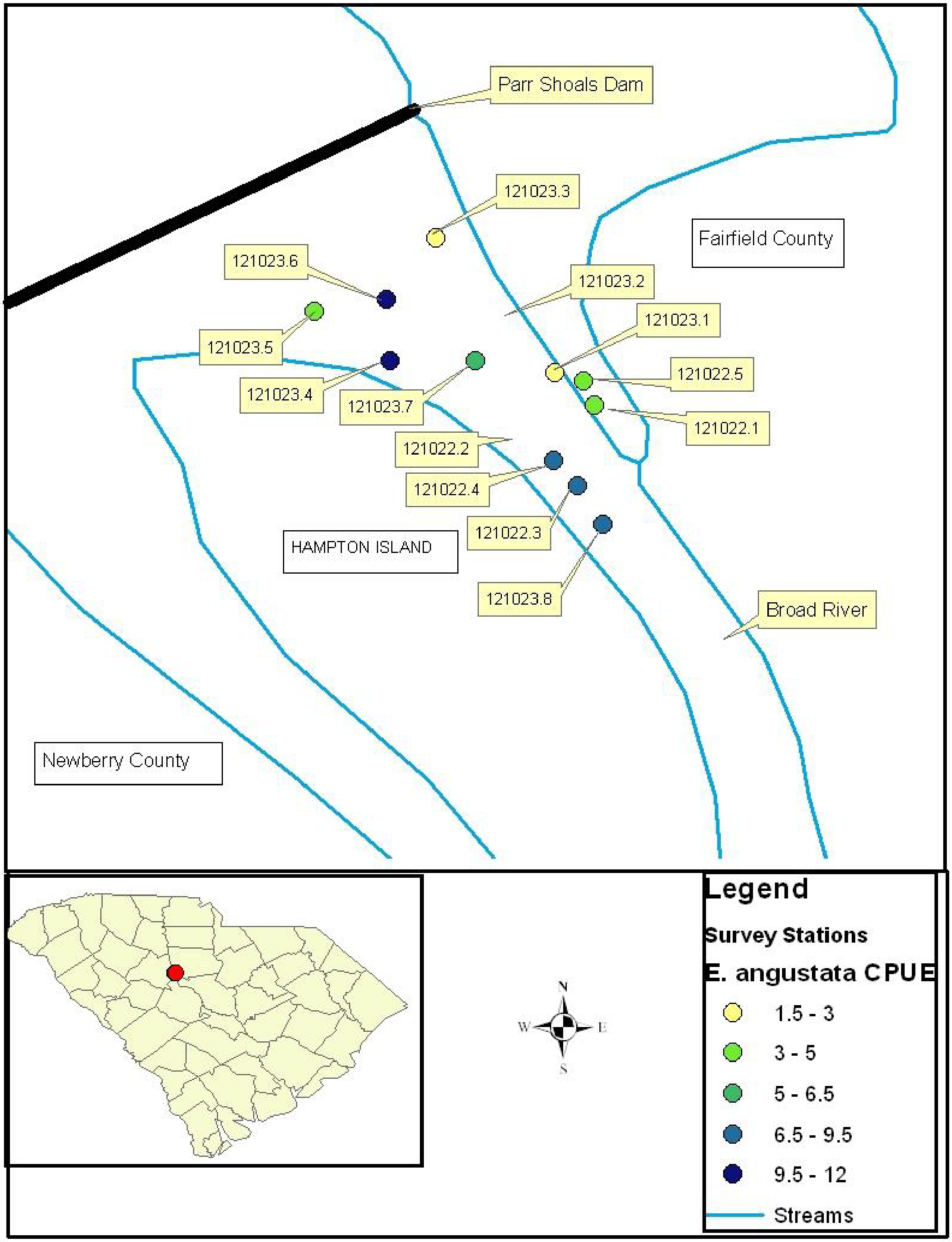
Source: 2012 Alderman Study

FIGURE 3-2 CPUE FOR *ELLIPTIO ROANOKENSIS*



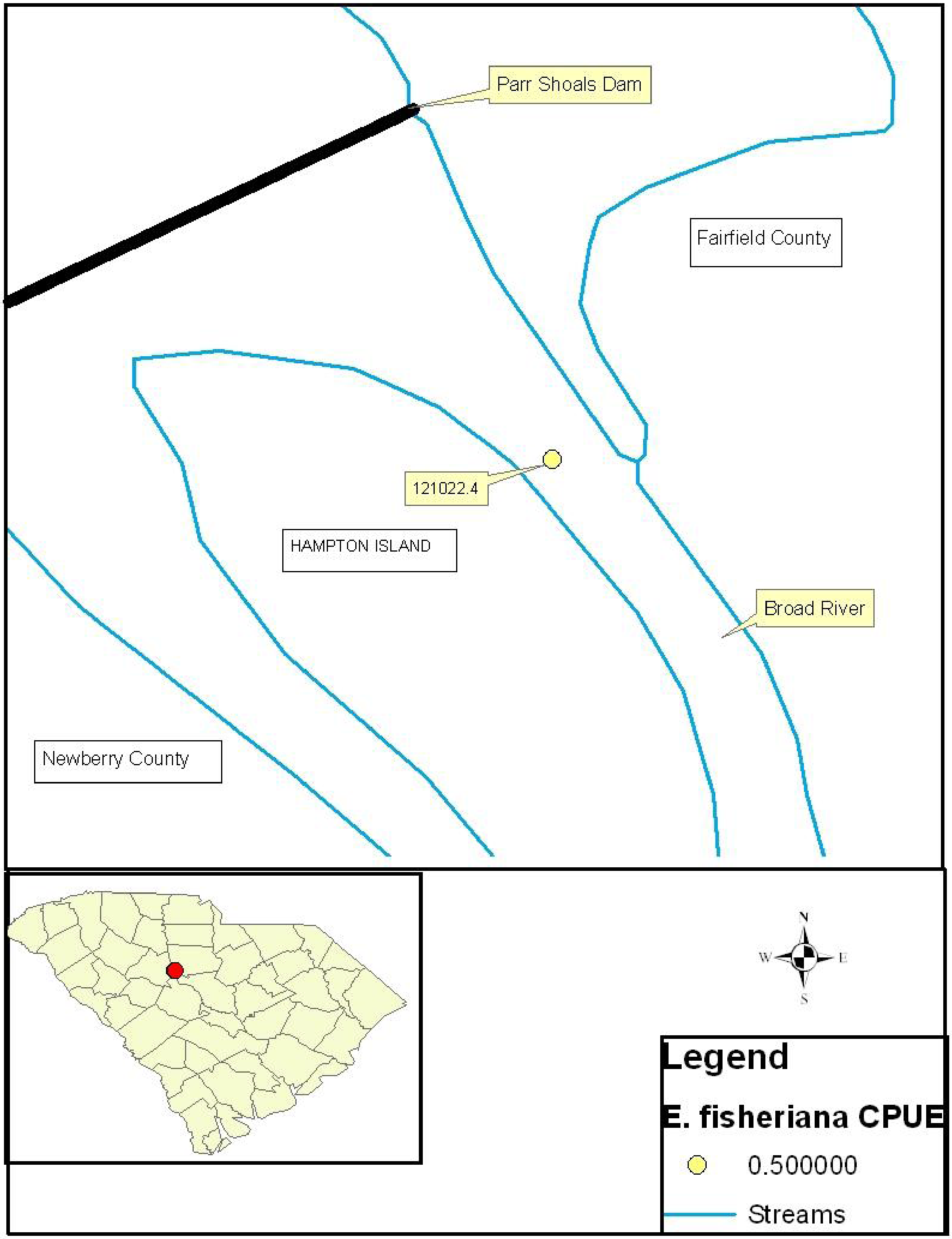
Source: 2012 Alderman Study

FIGURE 3-3 CPUE FOR *ELLIPTIO ICTERINA*



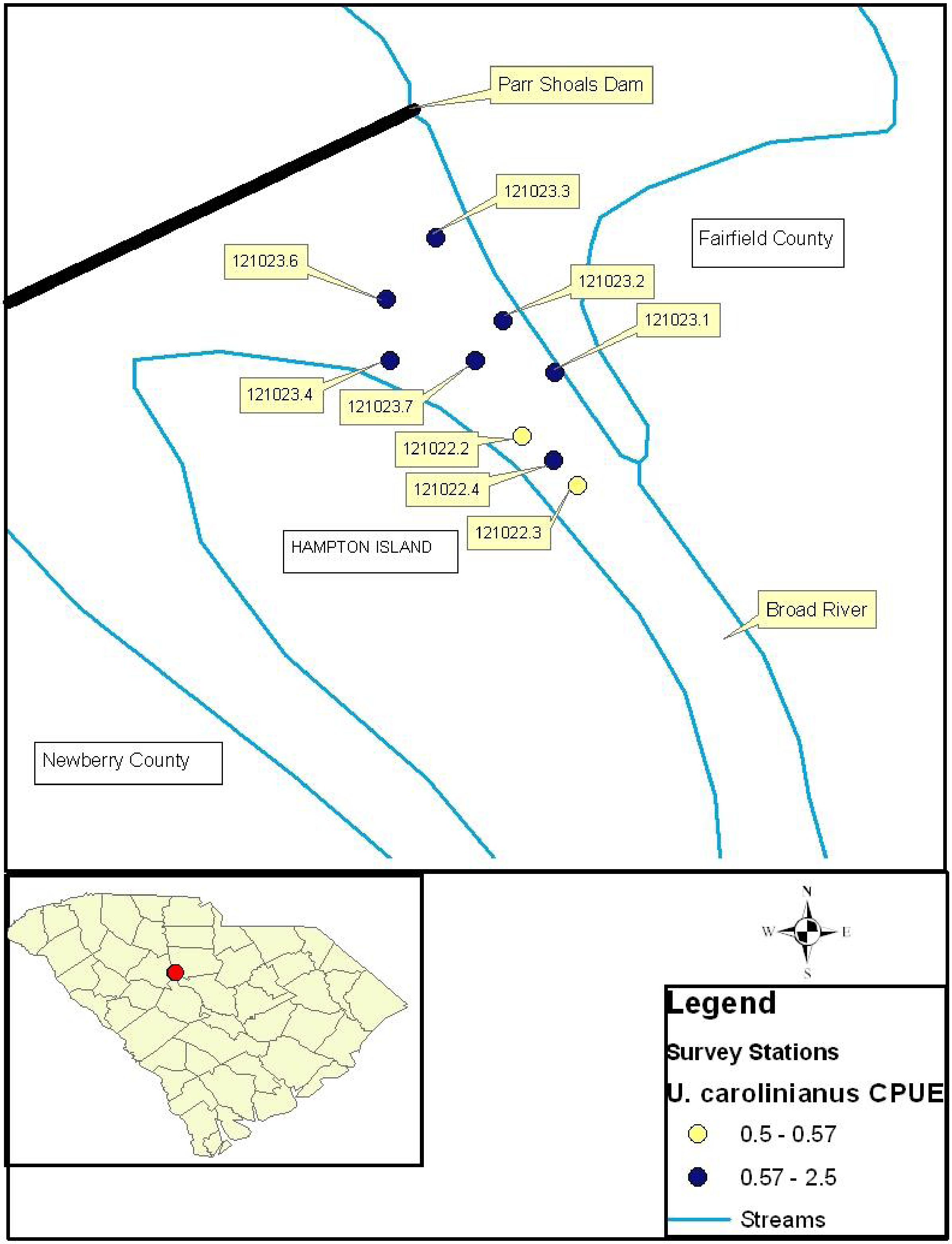
Source: 2012 Alderman Study

FIGURE 3-4 CPUE FOR *ELLIPTIO ANGUSTATA*



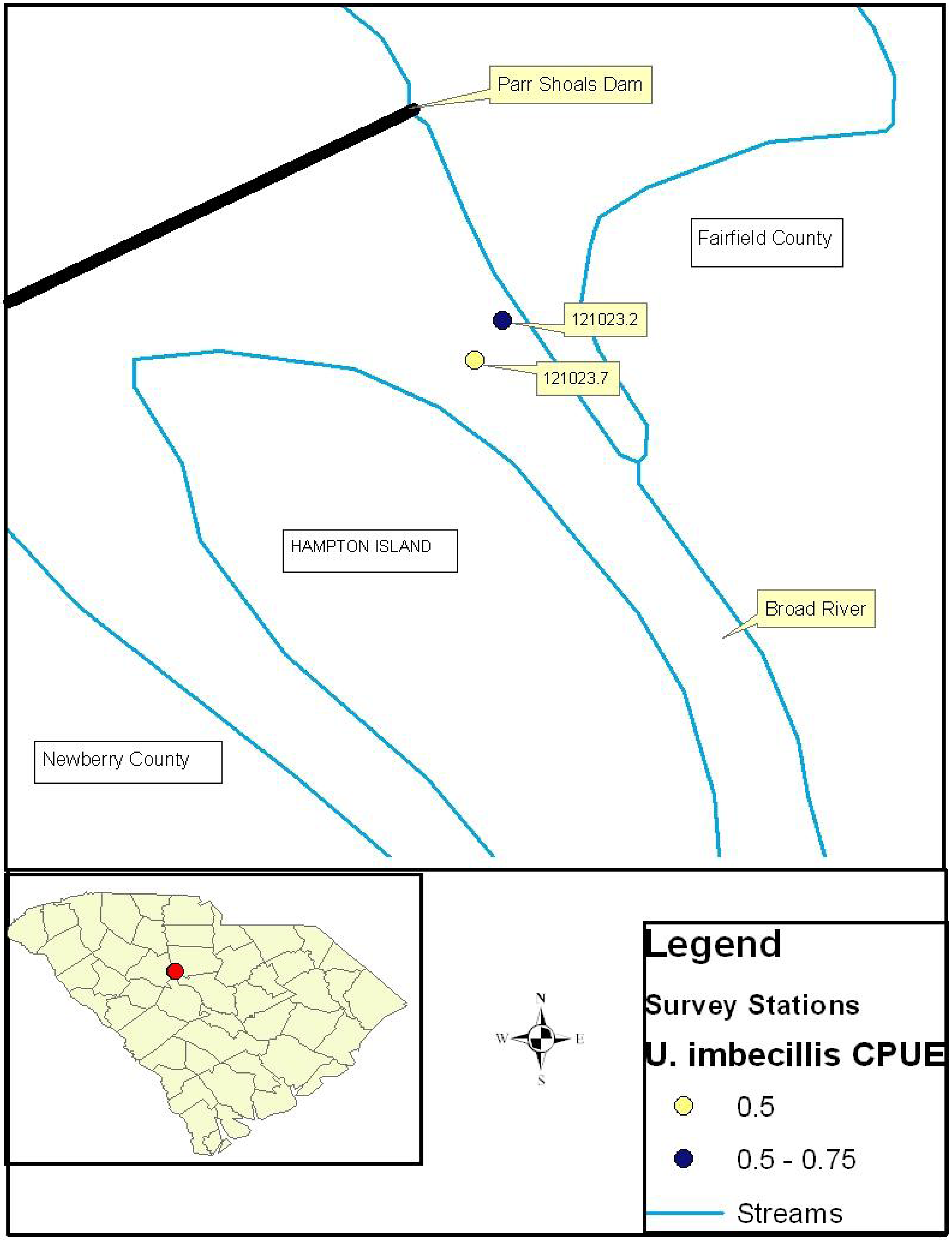
Source: 2012 Alderman Study

FIGURE 3-5 CPUE FOR *ELLIPTIO FISHERIANA*



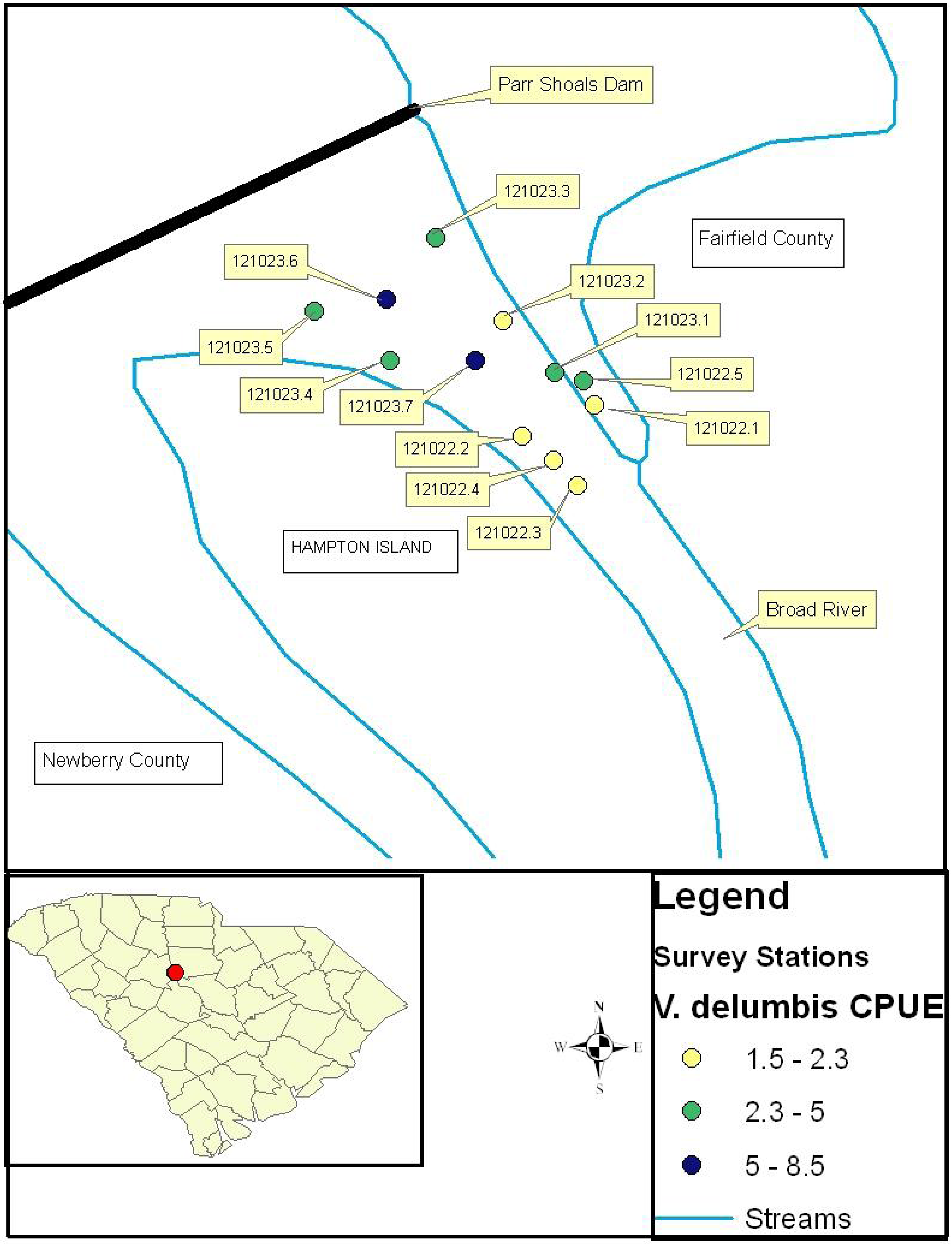
Source: 2012 Alderman Study

FIGURE 3-6 CPUE FOR *UNIOMERUS CAROLINIANUS*



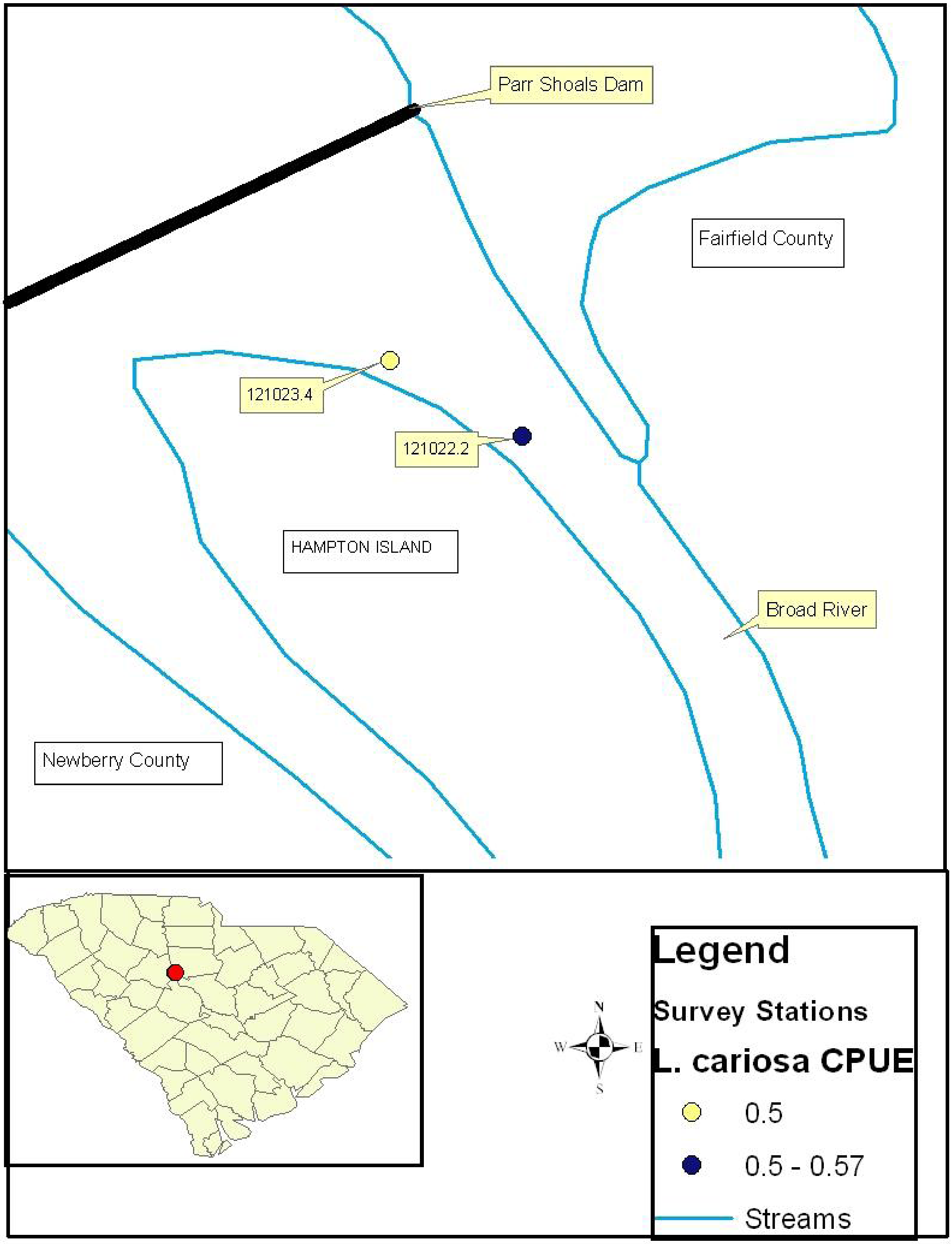
Source: 2012 Alderman Study

FIGURE 3-7 CPUE FOR *UTTERBACKIA IMBECILLIS*



Source: 2012 Alderman Study

FIGURE 3-8 CPUE FOR *VILLOSA DELUMBIS*



Source: 2012 Alderman Study

FIGURE 3-9 CPUE FOR *LAMPSILIS CARIOSA*

3.2 MACROINVERTEBRATES

3.2.1 BASELINE STUDIES

3.2.1.1 PARR RESERVOIR

The macroinvertebrate community in Parr Reservoir was sampled on June 18, 2008, September 18, 2008, January 22-23, 2009 and April 27, 2009. The number of specimens collected and the number of taxa represented from each sample date are shown in Table 3-3.

TABLE 3-3 TOTAL MACROINVERTEBRATE SPECIMENS AND TAXA REPRESENTED IN PARR RESERVOIR

SAMPLE DATE	TOTAL # OF SPECIMENS	TOTAL # OF TAXA
June 18, 2008	400	26
September 18, 2008	321	13
January 22-23, 2009	254	19
April 27, 2009	201	12

The number of specimens collected, their NCBI tolerance values, bioassessment metrics, and functional feeding groups for each sample date are included in Table 3-4 through Table 3-11.

The bioassessment metrics conducted by Carnagey on June 18, 2008 indicated some differences between the two sampling locations on Parr Reservoir. The control location was dominated by scrapers in two of the replicates and by collector-filterers in three of the replicates. The blowdown discharge location was dominated by collector-filterers in all five replicates.

On September 18, 2008, bioassessment metrics indicated that the Parr Reservoir control point and the discharge were similar. The EPT index values for the blowdown discharge point were somewhat higher than at the control. The control had three replicates at 0 and two replicates with indices of 1, while the blowdown discharge point had three replicates with a value of 1 and two replicates with values of 2. All five replicates at the Parr Reservoir control were collector-filterers. At the blowdown discharge point, two replicates were majority collector-filterers, two scrapers and one predator. The blowdown discharge also showed a correspondingly higher EPT abundance.

On January 22-23, 2009, the bioassessment metrics indicated very few differences between sampling locations. The control was dominated by predators in three of the replicates and by collector-filterers in two replicates (Table 3-4). The blowdown discharge point was dominated by collector-filterers in four replicates and predators in one.

The bioassessment metrics from the April 27, 2009 survey indicated very few differences between sample locations. The control was dominated by scrapers in four of the replicates and by collector-filterers in one replicate. The blowdown discharge location was dominated by scrapers in all five replicates.

TABLE 3-4 MACROINVERTEBRATES, THEIR NCBI TOLERANCE VALUES (TV), AND FUNCTIONAL FEEDING GROUPS (FG) FOR THE TWO PARR RESERVOIR SAMPLE LOCATIONS FOR JUNE 18, 2008[A]

				Control					New Blowdown Discharge				
Seq	Taxon	TV	FG	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
Annelida													
Hirudinea													
Rhynchobdellida													
Glossiphoniidae													
1	Helobdella stagnalis	8.63	P										8
Oligochaeta													
Lumbriculida													
Lumbriculidae													
2	Lumbriculidae Genus species	7.03	SC			1			1				3
Tubificida													
Tubificidae													
3	Tubifex tubifex	10.00	SC	14	2	1		8	1	6	7	9	3
Arthropoda													
Crustacea													
Amphipoda													
Talitridae													
4	Hyalella azteca	7.75	OM										1
Isopoda													
Asellidae													
5	Caecidotea sp.	9.11	SC										2

				Control					New Blowdown Discharge				
Seq	**Taxon**	**TV**	**FG**	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 4**	**Rep 5**	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 4**	**Rep 5**
Hexapoda													
Diptera													
Ceratopogonidae													
6	Bezzia/Palpomyia sp.	6.86	P	2									2
Chironomidae													
7	Ablabesmyia annulata	2.04	P						1				
8	Ablabesmyia mallochi	7.19	P										1
9	Chironomus sp.	9.63	CG						7	6	10	6	5
10	Clinotanypus sp.		P										
11	Cryptochironomus sp.	6.40	P		1				1				1
12	Cryptotendipes sp.	6.19	CG										
13	Dicrotendipes sp.	8.10	CG										
14	Fissimentum sp. A		CG	2									
15	Microtendipes sp.	5.53	CF	3			2						
16	Paracladopelma undine	4.93	CG	2									1
17	Polypedilum halterale gr.	7.31	SH								1		
18	Procladius sp.	9.10	P						4	2			7
19	Rheotanytarsus exiguus gr.	5.89	CF						1				1
20	Tanytarsus sp.	6.76	CF										
21	Tribelos sp.	6.31	CG		1		1	1					

				Control					New Blowdown Discharge				
Seq	**Taxon**	**TV**	**FG**	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 4**	**Rep 5**	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 4**	**Rep 5**
Ephemeroptera													
Ephemeridae													
22	Hexagenia limbata	4.90	CG						3				1
Odonata													
Gomphidae													
23	Gomphus sp.	5.80	P						1				
Mollusca													
Bivalvia													
Unionoida													
Corbiculidae													
24	Corbicula fluminea	6.12	CF	5	4	3	5	3	72	31	18	13	97
Gastropoda													
Limnophila													
Physidae													
25	Physa sp.	8.84	SC										1
Planorbidae													
26	Promenetus exacuous		SC						2	1			1

Functional feeding groups: CF = collector-filterer, CG = collector-gatherer, OM = omnivore, P = predator, SC = scraper, SH = shredder

[a] Data from Carnagey's June 2008 Macroinvertebrate Assessment

TABLE 3-5 BIOASSESSMENT METRICS FOR PARR RESERVOIR FOR JUNE 18, 2008[A]

	Station									
	Control					New Blowdown Discharge				
Metric	Rep 1	Rep 2	Rep 1	Rep 2	Rep 1	Rep 2	Rep 1	Rep 2	Rep 1	Rep 2
Taxa Richness	6	4	3	3	3	11	5	4	3	16
Number of Specimens	28	8	5	8	12	94	46	36	28	135
EPT Index	0	0	0	0	0	0	0	0	0	1
EPT Abundance	0	0	0	0	0	0	0	0	0	1
Chironomidae Taxa	3	2	0	2	1	5	3	3	3	7
Chironomidae Abundance	7	2	0	3	1	82	43	35	28	116
EPT/Chironomidae Abundance	0.00	0.00	-	0.00	0.00	0.00	0.00	0.00	0.00	0.01
North Carolina Biotic Index	8.15	6.85	7.08	6.04	7.81	6.66	5.84	6.11	5.84	6.35
SCDHEC Bioclassification	1.0	1.5	1.5	2.0	1.0	1.5	2.0	2.0	2.0	2.0
Percent Collector-Filterers	28.57	50.00	60.00	87.50	25.00	77.66	67.39	50.00	46.43	74.07
Percent Collector-Gatherers	14.29	12.50	0.00	12.50	8.33	3.19	13.04	19.44	32.14	4.44
Percent Omnivores	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.48
Percent Predators	7.14	12.50	0.00	0.00	0.00	9.57	15.22	30.56	21.43	4.44
Percent Scrapers	50.00	25.00	40.00	0.00	66.67	9.57	4.35	0.00	0.00	9.63
Percent Shredders	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.93
Scraper/Scraper & Collector-Filterers	1.75	0.50	0.67	0.00	2.67	0.12	0.06	0.00	0.00	0.13
Percent Dominant Taxon	50.00	50.00	60.00	62.50	66.67	76.60	67.39	50.00	46.43	71.85
Number Of Dominant Taxa	6	4	3	3	3	2	3	3	3	3

[a] Data from Carnagey's June 2008 Macroinvertebrate Assessment

TABLE 3-6 MACROINVERTEBRATES, THEIR NCBI TOLERANCE VALUES (TV), AND FUNCTIONAL FEEDING GROUPS (FG) FOR THE TWO PARR RESERVOIR SAMPLE LOCATIONS FOR SEPTEMBER 18, 2008[A]

				Control					New Blowdown Discharge				
Seq	Taxon	TV	FG	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
Annelida													
Hirudinidae													
1	Hirudinea Genus species		P	1					6	3	14	14	4
Oligochaeta													
Lumbriculida													
Lumbriculidae													
2	Lumbriculidae Genus species	7.13	SC			1							
Tubificida													
Tubificidae													
3	Tubifex tubifex	10.10	SC			2	5	7		11	7	6	17
Arthropoda													
Hexapoda													
Coleoptera													
Elmidae													
4	Dubiraphia sp.	6.03	CG					1					
Diptera													
Athericidae													
5	Atherix sp.	2.20	P			1							
Ceratopogonidae													
6	Culicoides sp.	7.80	P					1					
Chironomidae													
7	Clinotanypus sp.		P	5	1	4	4	3		2		1	1
8	Procladius sp.	9.20	P								1	1	1
9	Rheotanytarsus exiguus gr.	5.99	CF								1		1
Ephemeroptera													
Ephemerellidae													
10	Ephemerella sp.	2.14	CG	1					3	5	2	2	5
Odonata													
Gomphidae													
11	Gomphus sp.	5.90	P					1					
Trichoptera													
Leptoceridae													
12	Oecetis inconspicua complex	1.95	P					1			2		1
Mollusca													
Bivalvia													
Unionoida													
Corbiculidae													
13	Corbicula fluminea	6.22	CF	36	21	8	33	9	5	8	17	18	16

Functional feeding groups: CF = collector-filterer, CG = collector-gatherer, OM = omnivore, P = predator, SC = scraper, SH = shredder

[a] Data from Carnagey's September 2008 Macroinvertebrate Assessment

TABLE 3-7 BIOASSESSMENT METRICS FOR PARR RESERVOIR FOR SEPTEMBER 18, 2008[A]

	Station									
	Control					New Blowdown Discharge				
Metric	Rep 1	Rep 2	Rep 1	Rep 2	Rep 1	Rep 2	Rep 1	Rep 2	Rep 1	Rep 2
Taxa Richness	4	2	5	3	7	3	5	7	6	8
Number of Specimens	43	22	16	42	23	14	29	44	42	46
EPT Index	1	0	0	0	1	1	1	2	1	2
EPT Abundance	1	0	0	0	1	3	5	4	2	6
Chironomidae Taxa	1	1	1	1	1	0	1	2	2	3
Chironomidae Abundance	5	1	4	4	3	0	2	2	2	3
EPT/Chironomidae Abundance	0.20	0.00	0.00	0.00	0.33	-	2.50	2.00	1.00	2.00
North Carolina Biotic Index	5.85	6.22	6.35	7.12	7.06	4.18	7.88	6.58	6.92	7.18
SCDHEC Bioclassification	2.0	2.0	2.0	1.5	1.5	3.0	1.0	1.5	1.5	1.5
Percent Collector-Filterers	83.72	95.45	50.00	78.57	39.13	35.71	27.59	40.91	42.86	36.96
Percent Collector-Gatherers	2.33	0.00	0.00	0.00	4.35	21.43	17.24	4.55	4.76	10.87
Percent Omnivores	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Percent Predators	13.95	4.55	31.25	9.52	26.09	42.86	17.24	38.64	38.10	15.22
Percent Scrapers	0.00	0.00	18.75	11.90	30.43	0.00	37.93	15.91	14.29	36.96
Percent Shredders	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Scraper/Scraper & Collector-Filterers	0.00	0.00	0.38	0.15	0.78	0.00	1.38	0.39	0.33	1.00
Percent Dominant Taxon	83.72	95.45	50.00	78.57	39.13	42.86	37.93	38.64	42.86	36.96
Number Of Dominant Taxa	2	1	5	3	3	3	5	3	3	4

[a] Data from Carnagey's September 2008 Macroinvertebrate Assessment

TABLE 3-8 MACROINVERTEBRATES, THEIR NCBI TOLERANCE VALUES (TV), AND FUNCTIONAL FEEDING GROUPS (FG) FOR THE TWO PARR RESERVOIR SAMPLE LOCATIONS FOR JANUARY 22-23, 2009[A]

				Control					New Blowdown Discharge				
Seq	**Taxon**	**TV**	**FG**	**Rep. 1**	**Rep. 2**	**Rep. 3**	**Rep. 4**	**Rep. 5**	**Rep. 1**	**Rep. 2**	**Rep. 3**	**Rep. 4**	**Rep. 5**
Annelida													
Hirudinea													
1	Hirudinea Genus species		P							5	11		
Oligochaeta													
Tubificida													
Naididae													
2	Branchiura sowerbyi	8.38	SC	1					3			2	
3	Limnodrilus hoffmeisteri	9.57	SC	6	1	3	1	6	5	2	1	5	
4	Tubifex tubifex	10.10	SC	4	1	2	1	2	3		1	4	
Arthropoda													
Insecta													
Coleoptera													
Elmidae													
5	Macronychus glabratus	4.68	CG					1					
Diptera													
Ceratopogonidae													
6	Bezzia/Palpomyia sp.	6.96	P				2						
7	Culicoides sp.	7.80	P				2						
Chaoboridae													
8	Chaoborus sp.	8.60	P	1									

				Control					New Blowdown Discharge				
Seq	**Taxon**	**TV**	**FG**	**Rep. 1**	**Rep. 2**	**Rep. 3**	**Rep. 4**	**Rep. 5**	**Rep. 1**	**Rep. 2**	**Rep. 3**	**Rep. 4**	**Rep. 5**
Chironomidae													
9	Chironomus sp.	9.73	CG		2	4	4	1		5	1		
10	Clinotanypus sp.		P	8		1	7	12			2		
11	Cryptochironomus sp.	6.50	P						1			1	
12	Polypedilum illinoense gr.	9.10	SH						1				
13	Procladius sp.	9.20	P	3		4	4	2					
Ephemeroptera													
Ephemeridae													
14	Hexagenia sp.	5.00	CG					1	2				
Odonata													
Gomphidae													
15	Stylurus plagiatus		P			1	1						
Trichoptera													
Hydroptilidae													
16	Hydroptilidae Genus species		0		2		1						
Leptoceridae													
17	Oecetis sp.	4.80	P								2		

				Control					New Blowdown Discharge				
Seq	**Taxon**	**TV**	**FG**	**Rep. 1**	**Rep. 2**	**Rep. 3**	**Rep. 4**	**Rep. 5**	**Rep. 1**	**Rep. 2**	**Rep. 3**	**Rep. 4**	**Rep. 5**
Mollusca													
Bivalvia													
Unionoida													
Corbiculidae													
18	Corbicula fluminea	6.22	CF	2	2	1	13	17	12	39	4	12	1
Sphaeriidae													
19	Sphaeriidae Genus species		CF			2							

Functional feeding groups: CF = collector-filterer, CG = collector-gatherer, OM = omnivore, P = predator, SC = scraper, SH = shredder

[a] Data from Carnagey's January 2009 Macroinvertebrate Assessment

TABLE 3-9 BIOASSESSMENT METRICS FOR PARR RESERVOIR FOR JANUARY 22-23, 2009[A]

Metric	Station									
	Control					New Blowdown Discharge				
	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
Taxa Richness	7	5	8	10	8	7	4	7	5	1
Number of Specimens	25	8	18	36	42	27	51	22	24	1
EPT Index	0	1	0	1	1	1	0	1	0	0
EPT Abundance	0	2	0	1	1	2	0	2	0	0
Chironomidae Taxa	2	1	3	3	3	2	1	2	1	0
Chironomidae Abundance	11	2	9	15	15	2	5	3	1	0
EPT/Chironomidae Abundance	0.00	1.00	0.00	0.07	0.07	1.00	0.00	0.67	0.00	-
North Carolina Biotic Index	9.15	8.91	9.26	7.67	7.20	7.59	7.21	7.55	7.56	6.22
SCDHEC Bioclassification	1.0	1.0	1.0	1.0	1.5	1.0	1.5	1.0	1.0	2.0
Percent Collector-Filterers	8.00	50.00	16.67	38.89	40.48	44.44	76.47	18.18	50.00	100.00
Percent Collector-Gatherers	0.00	25.00	22.22	11.11	7.14	7.41	9.80	4.55	0.00	0.00
Percent Omnivores	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Percent Predators	48.00	0.00	33.33	44.44	33.33	3.70	9.80	68.18	4.17	0.00
Percent Scrapers	44.00	25.00	27.78	5.56	19.05	40.74	3.92	9.09	45.83	0.00
Percent Shredders	0.00	0.00	0.00	0.00	0.00	3.70	0.00	0.00	0.00	0.00
Scraper/Scraper & Collector-Filterers	5.50	0.50	1.67	0.14	0.47	0.92	0.05	0.50	0.92	0.00
Percent Dominant Taxon	32.00	25.00	22.22	36.11	40.48	44.44	76.47	50.00	50.00	100.00
Number Of Dominant Taxa	5	5	8	6	3	5	3	4	4	1

[a] Data from Carnagey's January 2009 Macroinvertebrate Assessment

TABLE 3-10 MACROINVERTEBRATES, THEIR NCBI TOLERANCE VALUES (TV), AND FUNCTIONAL FEEDING GROUPS (FG) FOR THE TWO PARR RESERVOIR SAMPLE LOCATIONS FOR APRIL 27, 2009[A]

				Control					New Blowdown Discharge				
Seq	**Taxon**	**TV**	**FG**	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 4**	**Rep 5**	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 4**	**Rep 5**
Annelida													
Oligochaeta													
Tubificida													
Naididae													
1	Limnodrilus hoffmeisteri	9.47	SC				2	1		3	6		4
2	Naididae Genus species		SC	5	13	16	10	11	4	13	12	15	8
Arthropoda													
Insecta													
Diptera													
Ceratopogonidae													
3	Bezzia/Palpomyia sp.	6.86	P		1		2	1					
Chironomidae													
4	Chironomus sp.	9.63	CG		1				1	1			2
5	Clinotanypus sp.		P			1	1						
6	Cryptochironomus sp.	6.40	P	1									
7	Harnischia sp.	9.07	CG		2								
8	Polypedilum halterale gr.	7.31	SH				1						
9	Procladius sp.	9.10	P		1			1					
10	Thienemannimyia gr.	8.42	P			1							

				Control					New Blowdown Discharge				
Seq	**Taxon**	**TV**	**FG**	**Rep. 1**	**Rep. 2**	**Rep. 3**	**Rep. 4**	**Rep. 5**	**Rep. 1**	**Rep. 2**	**Rep. 3**	**Rep. 4**	**Rep. 5**
Mollusca													
Bivalvia													
Unionoida													
Corbiculidae													
18	Corbicula fluminea	6.22	CF	2	2	1	13	17	12	39	4	12	1
Sphaeriidae													
19	Sphaeriidae Genus species		CF			2							

Functional feeding groups: CF = collector-filterer, CG = collector-gatherer, OM = omnivore, P = predator, SC = scraper, SH = shredder

[a] Data from Carnagey's April 2009 Macroinvertebrate Assessment

TABLE 3-11 BIOASSESSMENT METRICS FOR PARR RESERVOIR FOR APRIL 27, 2009[A]

Metric	Station									
	Control					New Blowdown Discharge				
	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
Taxa Richness	3	6	5	6	5	3	5	3	2	4
Number of Specimens	12	25	24	21	25	8	22	21	18	25
EPT Index	0	0	1	0	0	0	1	0	0	0
EPT Abundance	0	0	1	0	0	0	1	0	0	0
Chironomidae Taxa	1	3	2	2	1	1	1	0	0	1
Chironomidae Abundance	1	4	2	2	1	1	1	0	0	2
EPT/Chironomidae Abundance	0.00	0.00	0.50	0.00	0.00	0.00	1.00	-	-	0.00
North Carolina Biotic Index	6.19	7.57	6.34	7.00	6.66	7.00	7.66	7.80	6.12	7.09
SCDHEC Bioclassification	2.0	1.0	2.0	1.5	1.5	1.5	1.0	1.0	2.0	1.5
Percent Collector-Filterers	50.00	28.00	20.83	23.81	44.00	37.50	18.18	14.29	16.67	44.00
Percent Collector-Gatherers	0.00	12.00	4.17	0.00	0.00	12.50	9.09	0.00	0.00	8.00
Percent Omnivores	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Percent Predators	8.33	8.00	8.33	14.29	8.00	0.00	0.00	0.00	0.00	0.00
Percent Scrapers	41.67	52.00	66.67	57.14	48.00	50.00	72.73	85.71	83.33	48.00
Percent Shredders	0.00	0.00	0.00	4.76	0.00	0.00	0.00	0.00	0.00	0.00
Scraper/Scraper & Collector-Filterers	0.83	1.86	3.20	2.40	1.09	1.33	4.00	6.00	5.00	1.09
Percent Dominant Taxon	50.00	52.00	66.67	47.62	44.00	50.00	59.09	57.14	83.33	44.00
Number Of Dominant Taxa	3	3	2	4	2	3	3	3	2	4

[a] Data from Carnagey's April 2009 Macroinvertebrate Assessment

Single factor ANOVA analyses were also completed at each site. These results are shown in Table 3-12, Table 3-13, Table 3-14 and Table 3-15.

One-way ANOVA results from June 18, 2008 show significant differences in bioassessment metrics in SCDHEC bioclassification (p-value = 0.0482), and NCBI rating (p-value = 0.0333) at the Parr Reservoir blowdown discharge point. All other metrics show no significant difference. One-way ANOVA results from September 18, 2008 show significant differences in bioassessment metrics in percentage of dominant taxon (p-value = 0.0194), EPT Index values (p-value = 0.0187), EPT abundance (p-value = 0.0005) at the Parr Reservoir control point. All other metrics show no significant difference.

One-way ANOVA results from January 22-23, 2009 show significant differences in bioassessment metrics in NCBI (p-value = 0.0429), and percentage of dominant taxon (p-value = 0.0065) at the Parr Reservoir control point. All other metrics show no significant difference.

One-way ANOVA results from April 27, 2009 show no significant differences in bioassessment metrics between the points. The control point was dominated by scrapers in four of the five replicates and collector-filterers in one. The blowdown discharge point was dominated by scrapers in all five replicates.

TABLE 3-12 RESULTS OF THE SINGLE FACTOR ANOVA FOR PARR RESERVOIR, JUNE 18, 2008[A]

ANOVA for Taxa Richness

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F-crit*
Between Stations	0.1079	1	0.1079	2.6291	0.1436	5.3177
Within Stations	0.3282	8	0.0410			
Total	0.4361	9				

ANOVA for EPT Abundance

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F-crit*
Between Stations	0.0091	1	0.0091	1.0000	0.3466	5.3177
Within Stations	0.0725	8	0.0091			
Total	0.0816	9				

ANOVA for Total Abundance

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F-crit*
Between Stations	1.2609	1	1.2609	17.2042	0.0032	5.3177
Within Stations	0.5863	8	0.0733			
Total	1.8473	9				

ANOVA for NCBI

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F-crit*
Between Stations	0.0081	1	0.0081	6.5873	0.0333	5.3177
Within Stations	0.0098	8	0.0012			
Total	0.0178	9				

ANOVA for percentage of the dominant taxon

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F-crit*
Between Stations	0.0019	1	0.0019	0.3031	0.5970	5.3177
Within Stations	0.0496	8	0.0062			
Total	0.0515	9				

ANOVA for SCDHEC Bioclassification

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F-crit*
Between Stations	0.0186	1	0.0186	5.4249	0.0482	5.3177
Within Stations	0.0274	8	0.0034			
Total	0.0460	9				

ANOVA for EPT Index

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F-crit*
Between Stations	0.0091	1	0.0091	1.0000	0.3466	5.3177
Within Stations	0.0725	8	0.0091			
Total	0.0816	9				

[a] Data from Carnagey's June 2008 Macroinvertebrate Assessment

TABLE 3-13 RESULTS OF THE SINGLE FACTOR ANOVA FOR PARR RESERVOIR, SEPTEMBER 18, 2008[A]

ANOVA for Taxa Richness						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F-crit*
Between Stations	0.0388	1	0.0388	1.7165	0.2265	5.3177
Within Stations	0.1810	8	0.0226			
Total	0.2199	9				

ANOVA for EPT Abundance						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F-crit*
Between Stations	0.7836	1	0.7836	32.4438	0.0005	5.3177
Within Stations	0.1932	8	0.0242			
Total	0.9769	9				

ANOVA for Total Abundance						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F-crit*
Between Stations	0.0132	1	0.0132	0.3441	0.5736	5.3177
Within Stations	0.3058	8	0.0382			
Total	0.3189	9				

ANOVA for NCBI						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F-crit*
Between Stations	0.0001	1	0.0001	0.0109	0.9194	5.3177
Within Stations	0.0372	8	0.0046			
Total	0.0372	9				

ANOVA for percentage of the dominant taxon						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F-crit*
Between Stations	0.1150	1	0.1150	8.5067	0.0194	5.3177
Within Stations	0.1081	8	0.0135			
Total	0.2231	9				

ANOVA for SCDHEC Bioclassification						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F-crit*
Between Stations	0.0017	1	0.0017	0.2415	0.6364	5.3177
Within Stations	0.0563	8	0.0070			
Total	0.0580	9				

ANOVA for EPT Index						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F-crit*
Between Stations	0.1576	1	0.1576	8.6368	0.0187	5.3177
Within Stations	0.1460	8	0.0182			
Total	0.3035	9				

[a] Data from Carnagey's September 2008 Macroinvertebrate Assessment

TABLE 3-14 RESULTS OF THE SINGLE FACTOR ANOVA FOR PARR RESERVOIR, JANUARY 22-23, 2009[A]

ANOVA for Taxa Richness						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F-crit*
Between Stations	0.1096	1	0.1096	3.0905	0.1168	5.3177
Within Stations	0.2836	8	0.0355			
Total	0.3932	9				

ANOVA for EPT Abundance						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F-crit*
Between Stations	0.0016	1	0.0016	0.0278	0.8717	5.3177
Within Stations	0.4491	8	0.0561			
Total	0.4507	9				

ANOVA for Total Abundance						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F-crit*
Between Stations	0.0392	1	0.0392	0.2113	0.6580	5.3177
Within Stations	1.4827	8	0.1853			
Total	1.5219	9				

ANOVA for NCBI						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F-crit*
Between Stations	0.0087	1	0.0087	5.7831	0.0429	5.3177
Within Stations	0.0120	8	0.0015			
Total	0.0206	9				

ANOVA for percentage of the dominant taxon						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F-crit*
Between Stations	0.2188	1	0.2188	13.3530	0.0065	5.3177
Within Stations	0.1311	8	0.0164			
Total	0.3500	9				

ANOVA for SCDHEC Bioclassification						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F-crit*
Between Stations	0.0031	1	0.0031	0.7516	0.4112	5.3177
Within Stations	0.0330	8	0.0041			
Total	0.0361	9				

ANOVA for EPT Index						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F-crit*
Between Stations	0.0091	1	0.0091	0.3333	0.5796	5.3177
Within Stations	0.2175	8	0.0272			
Total	0.2265	9				

[a] Data from Carnagey's January 2009 Macroinvertebrate Assessment

TABLE 3-15 RESULTS OF THE SINGLE FACTOR ANOVA FOR PARR RESERVOIR, APRIL 27, 2009[A]

ANOVA for Taxa Richness

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F-crit*
Between Stations	0.0476	1	0.0476	4.1768	0.0752	5.3177
Within Stations	0.0912	8	0.0114			
Total	0.1389	9				

ANOVA for EPT Abundance

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F-crit*
Between Stations	0.0000	1	0.0000	0.0000	1.0000	5.3177
Within Stations	0.1450	8	0.0181			
Total	0.1450	9				

ANOVA for Total Abundance

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F-crit*
Between Stations	0.0110	1	0.0110	0.4410	0.5253	5.3177
Within Stations	0.2001	8	0.0250			
Total	0.2111	9				

ANOVA for NCBI

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F-crit*
Between Stations	0.0011	1	0.0011	0.9349	0.3619	5.3177
Within Stations	0.0090	8	0.0011			
Total	0.0101	9				

ANOVA for percentage of the dominant taxon

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F-crit*
Between Stations	0.0052	1	0.0052	0.6939	0.4290	5.3177
Within Stations	0.0598	8	0.0075			
Total	0.0650	9				

ANOVA for SCDHEC Bioclassification

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F-crit*
Between Stations	0.0031	1	0.0031	0.5690	0.4723	5.3177
Within Stations	0.0436	8	0.0054			
Total	0.0467	9				

ANOVA for EPT Index

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F-crit*
Between Stations	0.0000	1	0.0000	0.0000	1.0000	5.3177
Within Stations	0.1450	8	0.0181			
Total	0.1450	9				

[a] Data from Carnagey's April 2009 Macroinvertebrate Assessment

3.2.1.2 LAKE MONTICELLO

The macroinvertebrate community in Lake Monticello was sampled on June 18, 2008, September 18, 2008, January 22-23, 2009 and April 27, 2009. The number of specimens collected and the number of taxa represented from each sample date are shown in Table 3-16.

TABLE 3-16 TOTAL MACROINVERTEBRATE SPECIMENS AND TAXA REPRESENTED IN LAKE MONTICELLO

SAMPLE DATE	TOTAL # OF SPECIMENS	TOTAL # OF TAXA
June 18, 2008	341	27
September 18, 2008	262	24
January 22-23, 2009	277	16
April 27, 2009	405	24

The number of specimens collected, their NCBI tolerance values, functional feeding groups and bioassessment metrics for each sample date are included in Table 3-17 through Table 3-24.

The bioassessment metrics from June 18, 2008 indicate few differences between the sample locations. The control sample point was predominately collector-filters, but did include one replicate with a majority of scrapers. The control SCDHEC bioclassification values were the same as the other two stations when replicates were averaged. The Raw Intake point had all "fair" bioclassification ratings and had a majority (4 out of 5) of collector feeders. The Water Treatment Intake point had three "fair" and two "good-fair" bioclassification ratings. The Treatment Intake point was also dominated by collector-filterers in all five replicates.

According to the bioassessment metrics from September 18, 2008 the control sample point feeding types showed mixed dominant feeders. Collector-filters and scrapers were the largest ratio in two replicates each, and predators were majority of one. The control SCDHEC bioclassification values were the lowest of the three stations. The Raw Intake point received two "fair" and three "good-fair" bioclassification ratings. The Raw intake point contained a majority (4 out of 5) of predator feeders. Parallel to the previous sample date, the Water Treatment Intake point had three "fair" and two "good-fair" bioclassification ratings. The Treatment Intake point was also dominated by collector-filterers in three replicates, and predators in two.

On January 22-23, 2009 the control sample point was predominately collector/filters, but did include one replicate with a majority of collector/gatherers (Table). The control SCDHEC bioclassification values were slightly lower than the other two stations. The Raw intake point contained a majority of collector/filterer feeders. The raw water intake point was the only location in which any EPT taxa were collected. The Water Treatment Intake point feeding type majority was collector/filterers. The Treatment Intake point was also dominated by collector-filterers.

According to the bioassessment metrics from April 27, 2009 the control sample point was predominately collector/filters, but did include one replicate with a majority of collector/gatherers (Table). The control SCDHEC bioclassification values were slightly lower than the other two stations. The Raw intake point contained a majority of collector/filterer feeders. The raw water intake point was the only location in which any EPT taxa were collected. The Water Treatment Intake point feeding type majority was collector/filterers. The Treatment Intake point was also dominated by collector-filterers.

TABLE 3-17 MACROINVERTEBRATES, THEIR NCBI TOLERANCE VALUES (TV), AND FUNCTIONAL FEEDING GROUPS (FG) FOR THE THREE LAKE MONTICELLO SAMPLE LOCATIONS FOR JUNE 18, 2008[A]

				Control					New Water Treatment Intake					New Raw Intake				
Seq	Taxon	TV	FG	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
Annelida																		
Hirudinea																		
Rhynchobdellida																		
Glossiphoniidae																		
1	Helobdella stagnalis	8.63	P	2														1
Oligochaeta																		
Lumbriculida																		
Lumbriculidae																		
2	Lumbriculidae Genus species	7.03	SC					2										
Tubificida																		
Tubificidae																		
3	Tubifex tubifex	10.00	SC		18	8	2	4										1
Arthropoda																		
Crustacea																		
Cladocera																		
Daphnidae																		
4	Daphnia sp.		CF												1		1	
Cyclopoida																		
Cyclopidae																		
5	Eucyclops agilis		OM		1				2	1				2	3			
Ostracoda																		
6	Ostracoda Genus species		CF												1			
Hexapoda																		
Diptera																		
Ceratopogonidae																		
7	Bezzia/Palpomyia sp.	6.86	P												1	1		
Chaoboridae																		
8	Chaoborus sp.	8.50	P														2	
Chironomidae																		
9	Ablabesmyia annulata	2.04	P				1						1				1	
10	Chironomus sp.	9.63	CG					1	2		1	1			2	3	3	2
11	Clinotanypus sp.		P	2	1				2	2	1	1	1		1		1	1
12	Cryptochironomus sp.	6.40	P		5			1		1				4	1		1	1
13	Cryptotendipes sp.	6.19	CG		1							1	1					
14	Dicrotendipes sp.	8.10	CG		1													
15	Fissimentum sp. A		CG	1		1	2							1				
16	Microtendipes sp.	5.53	CF		1		1				1						1	1
17	Paracladopelma undine	4.93	CG												7			1
18	Polypedilum halterale gr.	7.31	SH		1	3									1		1	
19	Procladius sp.	9.10	P	3	3	1		1	2						4	1		4
20	Pseudochironomus sp.	5.36	CG		2													
21	Rheotanytarsus exiguus gr.	5.89	CF												1		1	
22	Tanytarsus sp.	6.76	CF		4	1								4			1	

				Control					New Water Treatment Intake					New Raw Intake				
Seq	Taxon	TV	FG	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
Ephemeroptera																		
Ephemeridae																		
23	Hexagenia limbata	4.90	CG	4			2		5	3	2	2	4	2	7	5	5	1
Trichoptera																		
Hydroptilidae																		
24	Orthotrichia sp.	8.29	SC			1												
Mollusca																		
Bivalvia																		
Unionoida																		
Corbiculidae																		
25	Corbicula fluminea	6.12	CF	20	18	19	5	4	5	5	5	10	9	7	10	5		5
Unionidae																		
26	Elliptio complanata complex	5.14	CF		7	1				1					1			
Nematoda																		
27	Nematoda Genus species	6.02	OM												1			

Functional feeding groups: CF = collector-filterer, CG = collector-gatherer, OM = omnivore, P = predator, SC = scraper, SH = shredder

[a] Data from Carnagey's June 2008 Macroinvertebrate Assessment

TABLE 3-18 BIOASSESSMENT METRICS FOR LAKE MONTICELLO FOR JUNE 18, 2008[A]

	Station														
	Control					New Water Treatment Intake					New Raw Intake				
Metric	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 4**	**Rep 5**	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 4**	**Rep 5**	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 4**	**Rep 5**
Taxa Richness	6	13	8	6	6	6	5	5	5	6	6	15	5	11	10
Number of Specimens	32	63	35	13	13	13	10	15	16	20	18	42	15	18	18
EPT Index	1	0	1	1	0	1	1	1	1	1	1	1	1	1	1
EPT Abundance	4	0	1	2	0	3	2	2	4	2	5	7	5	5	1
Chironomidae Taxa	3	9	4	3	3	2	3	3	3	3	3	7	2	8	6
Chironomidae Abundance	6	19	6	4	3	3	3	3	3	9	6	17	4	10	10
EPT/Chironomidae Abundance	0.67	0.00	0.17	0.50	0.00	1.00	0.67	0.67	1.33	0.22	0.83	0.41	1.25	0.50	0.10
North Carolina Biotic Index	6.58	7.46	7.12	5.83	8.05	5.58	6.40	6.30	5.16	6.27	6.47	6.36	7.08	6.62	7.36
SCDHEC Bioclassification	1.5	1.3	1.5	2.2	1.0	2.5	2.0	2.0	2.8	2.0	1.8	2.0	1.5	1.5	1.5
Percent Collector-Filterers	62.50	47.62	60.00	46.15	30.77	46.15	60.00	66.67	56.25	55.00	27.78	33.33	33.33	22.22	33.33
Percent Collector-Gatherers	15.63	6.35	2.86	30.77	7.69	23.08	30.00	26.67	31.25	15.00	38.89	38.10	53.33	44.44	22.22
Percent Omnivores	0.00	1.59	0.00	0.00	0.00	7.69	0.00	0.00	0.00	10.00	11.11	9.52	0.00	0.00	0.00
Percent Predators	21.88	14.29	2.86	7.69	15.38	23.08	10.00	6.67	12.50	20.00	22.22	16.67	13.33	27.78	38.89
Percent Scrapers	0.00	28.57	25.71	15.38	46.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.56
Percent Shredders	0.00	1.59	8.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.38	0.00	5.56	0.00
Scraper/Scraper & Collector-Filterers	0.00	0.60	0.43	0.33	1.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17
Percent Dominant Taxon	62.50	28.57	54.29	38.46	30.77	38.46	50.00	66.67	56.25	35.00	27.778	23.81	33.333	27.778	27.778
Number Of Dominant Taxa	5	5	3	6	6	6	5	5	5	6	6	5	5	11	10

[a] Data from Carnagey's June 2008 Macroinvertebrate Assessment

TABLE 3-19 MACROINVERTEBRATES, THEIR NCBI TOLERANCE VALUES (TV), AND FUNCTIONAL FEEDING GROUPS (FG) FOR THE THREE LAKE MONTICELLO SAMPLE LOCATIONS FOR SEPTEMBER 18, 2008[A]

				Control					New Water Treatment Intake					New Raw Intake				
Seq	Taxon	TV	FG	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
Annelida																		
Hirudinea																		
1	Hirudinea Genus species		P	1				14					2	11	7	14	8	8
Oligochaeta																		
Lumbriculida																		
Lumbriculidae																		
2	Lumbriculidae Genus species	7.13	SC		2	13	1	5										1
Tubificida																		
Tubificidae																		
3	Limnodrilus sp.	9.60	SC					1										
4	Tubifex tubifex	10.10	SC	1	1		2											
Arthropoda																		
Arachnoidea																		
Acariformes																		
Arrenuridae																		
5	Arrenurus sp.	5.63	P					1										
Hexapoda																		
Diptera																		
Chironomidae																		
6	Ablabesmyia peleensis	9.77	P				1	1								1		
7	Clinotanypus sp.		P		1			4		1		2	4	2	2			1
8	Cryptochironomus sp.	6.50	P			1		1								1		
Chironomidae cont.																		
9	Fissimentum sp. A		CG		1													
10	Parachironomus sp.	9.52	P			1												
11	Polypedilum halterale gr.	7.41	SH			2												
12	Procladius sp.	9.20	P									1		1				
13	Pseudochironomus sp.	5.46	CG					2										
14	Rheotanytarsus exiguus gr.	5.99	CF	1	1	2		1										
15	Tanytarsus sp.	6.86	CF					3										
Ephemeroptera																		
Ephemerellidae																		
16	Ephemerella sp.													2	2	7	5	15
Odonata																		
Gomphidae																		
17	Gomphus sp.	5.90	P	1														
Libellulidae																		
18	Macromia taeniolata	6.26	P									7						
Trichoptera																		
Leptoceridae																		
19	Oecetis inconspicua complex	1.95	P					1										
Polycentropodidae																		
20	Cyrnellus fraternus	7.44	CF					2										

Seq	Taxon	TV	FG	Control					New Water Treatment Intake					New Raw Intake				
				Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
Mollusca																		
Bivalvia																		
Unionoida																		
Corbiculidae																		
21	Corbicula fluminea	6.22	CF	12	4	6		15	2	2	3	7	4					
Unionidae																		
22	Elliptio lanceolata complex	5.20	CF	1														
Gastropoda														5	3	2	3	6
Limnophila																		
Physidae																		
23	Physa sp.	8.94	SC										1					
Mesogastropoda																		
Viviparidae																		
24	Bellamya japonica		SC	1		1		8								2		

[a] Data from Carnagey's September 2008 Macroinvertebrate Assessment

TABLE 3-20 BIOASSESSMENT METRICS FOR LAKE MONTICELLO FOR SEPTEMBER 18, 2008[A]

	Station														
	Control					New Water Treatment Intake					New Raw Intake				
Metric	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 4**	**Rep 5**	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 4**	**Rep 5**	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 4**	**Rep 5**
Taxa Richness	7	6	7	3	14	1	2	1	4	4	5	4	6	3	5
Number of Specimens	18	10	26	4	59	2	3	3	17	11	21	14	27	16	31
EPT Index	0	0	0	0	2	0	0	0	0	0	1	1	1	1	1
EPT Abundance	0	0	0	0	3	0	0	0	0	0	2	2	7	5	15
Chironomidae Taxa	1	3	4	1	6	0	1	0	2	1	2	1	2	0	1
Chironomidae Abundance	1	3	6	1	12	0	1	0	3	4	3	2	2	0	1
EPT/Chironomidae Abundance	0.00	0.00	0.00	0.00	0.25	-	0.00	-	0.00	0.00	0.67	1.00	3.50	-	15.00
North Carolina Biotic Index	6.39	6.98	7.02	9.00	6.52	6.22	6.22	6.22	6.66	6.90	6.00	5.20	5.41	4.18	3.37
SCDHEC Bioclassification	2.0	1.5	1.5	1.0	1.7	2.0	2.0	2.0	1.5	1.5	2.0	2.7	2.5	3.0	3.0
Percent Collector-Filterers	77.78	50.00	30.77	0.00	35.59	100.00	66.67	100.00	41.18	36.36	23.81	21.43	7.41	18.75	19.35
Percent Collector-Gatherers	0.00	10.00	0.00	0.00	3.39	0.00	0.00	0.00	0.00	0.00	9.52	14.29	25.93	31.25	48.39
Percent Omnivores	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Percent Predators	11.11	10.00	7.69	25.00	37.29	0.00	33.33	0.00	58.82	54.55	66.67	64.29	59.26	50.00	29.03
Percent Scrapers	11.11	30.00	53.85	75.00	23.73	0.00	0.00	0.00	0.00	9.09	0.00	0.00	7.41	0.00	3.23
Percent Shredders	0.00	0.00	7.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Scraper/Scraper & Collector-Filterers	0.14	0.60	1.75	-	0.67	0.00	0.00	0.00	0.00	0.25	0.00	0.00	1.00	0.00	0.17
Percent Dominant Taxon	66.67	40.00	50.00	50.00	25.42	100.00	66.67	100.00	41.18	36.36	52.381	50	51.852	50	48.387
Number Of Dominant Taxa	7	6	4	3	6	1	2	1	4	4	4	4	4	3	3

[a] Data from Carnagey's September 2008 Macroinvertebrate Assessment

TABLE 3-21 MACROINVERTEBRATES, THEIR NCBI TOLERANCE VALUES (TV), AND FUNCTIONAL FEEDING GROUPS (FG) FOR THE THREE LAKE MONTICELLO SAMPLE LOCATIONS FOR JANUARY 22-23, 2009[A]

				Control					New Water Treatment					New Raw Intake				
Seq	Taxon	TV	FG	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
Annelida																		
Hirudinea																		
1	Hirudinea Genus species		P	1									1	1		2		1
Oligochaeta																		
Lumbriculida																		
Lumbriculidae																		
2	Eclipidrilus lacustris	7.13	SC	1												1		
Tubificida																		
Naididae																		
3	Branchiura sowerbyi	8.38	SC								2	1	1	1	2	5	3	
4	Limnodrilus hoffmeisteri	9.57	SC	15	4	2		3					1		1		1	
Arthropoda																		
Insecta																		
Diptera																		
Chironomidae																		
5	Ablabesmyia mallochi	7.29	P	1														
6	Chironomus sp.	9.73	CG			1		2							1	2		1
7	Cladotanytarsus sp.	4.19	CG					2										
8	Clinotanypus sp.		P							6	3		2	1		1		
9	Cryptochironomus sp.	6.50	P	4													1	
10	Dicrotendipes neomodestus	8.20	CG															1
11	Procladius sp.	9.20	P	2									1	1				
Chironomidae cont.																		
12	Rheotanytarsus exiguus gr.	5.99	CF				4						1			4	1	
13	Tanytarsus sp.	6.86	CF										2				1	1
Ephemeroptera																		
Ephemeridae																		
14	Hexagenia sp.	5.00	CG											2		6	6	6
Mollusca																		
Bivalvia																		
Unionoida																		
Corbiculidae																		
15	Corbicula fluminea	6.22	CF	76	12	13	2	2	3	7	3	2	11	5	9	6	2	3
Gastropoda																		
Limnophila																		
Physidae																		
16	Physa sp.	8.94	SC	3											1			

Functional feeding groups: CF = collector-filterer, CG = collector-gatherer, OM = omnivore, P = predator, SC = scraper, SH = shredder

[a] Data from Carnagey's January 2009 Macroinvertebrate Assessment

TABLE 3-22 BIOASSESSMENT METRICS FOR LAKE MONTICELLO FOR JANUARY 22-23, 2009[A]

	Station														
	Control					New Water Treatment Intake					New Raw Intake				
Metric	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 4**	**Rep 5**	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 4**	**Rep 5**	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 4**	**Rep 5**
Taxa Richness	8	2	3	2	4	1	2	3	2	8	6	5	8	7	6
Number of Specimens	103	16	16	6	9	3	13	8	3	20	11	14	27	15	13
EPT Index	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1
EPT Abundance	0	0	0	0	0	0	0	0	0	0	2	0	6	6	6
Chironomidae Taxa	3	0	1	1	2	0	1	1	0	4	2	1	3	3	3
Chironomidae Abundance	7	0	1	4	4	0	6	3	0	6	2	1	7	3	3
EPT/Chironomidae Abundance	0.00	-	0.00	0.00	0.00	-	0.00	0.00	-	0.00	1.00	0.00	0.86	2.00	2.00
North Carolina Biotic Index	7.86	6.99	6.79	6.05	8.14	6.22	6.22	6.76	7.30	6.81	6.87	7.90	6.69	6.84	6.49
SCDHEC Bioclassification	1.0	1.5	1.5	2.0	1.0	2.0	2.0	1.5	1.5	1.5	1.5	1.0	1.5	1.5	1.7
Percent Collector-Filterers	73.79	75.00	81.25	100.00	22.22	100.00	53.85	37.50	66.67	70.00	45.45	64.29	37.04	26.67	30.77
Percent Collector-Gatherers	0.00	0.00	6.25	0.00	44.44	0.00	0.00	0.00	0.00	0.00	18.18	7.14	29.63	40.00	61.54
Percent Omnivores	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Percent Predators	7.77	0.00	0.00	0.00	0.00	0.00	46.15	37.50	0.00	20.00	27.27	0.00	11.11	6.67	7.69
Percent Scrapers	18.45	25.00	12.50	0.00	33.33	0.00	0.00	25.00	33.33	10.00	9.09	28.57	22.22	26.67	0.00
Percent Shredders	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Scraper/Scraper & Collector-Filterers	0.25	0.33	0.15	0.00	1.50	0.00	0.00	0.67	0.50	0.14	0.20	0.44	0.60	1.00	0.00
Percent Dominant Taxon	73.79	75.00	81.25	66.67	33.33	100.00	53.85	37.50	66.67	55.00	45.45	64.29	22.22	40.00	46.15
Number Of Dominant Taxa	2	2	3	2	4	1	2	3	2	8	6	5	6	7	6

[a] Data from Carnagey's January 2009 Macroinvertebrate Assessment

TABLE 3-23 MACROINVERTEBRATES, THEIR NCBI TOLERANCE VALUES (TV), AND FUNCTIONAL FEEDING GROUPS (FG) FOR THE THREE LAKE MONTICELLO SAMPLE LOCATIONS FOR APRIL 27, 2009[A]

				Control					New Water Treatment Intake					Raw Water Intake				
Seq	**Taxon**	**TV**	**FG**	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 4**	**Rep 5**	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 4**	**Rep 5**	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 4**	**Rep 5**
Annelida																		
Hirudinea																		
1	Hirudinea Genus species		P													1	1	
Oligochaeta																		
Tubificida																		
Naididae																		
2	Branchiura sowerbyi	8.28	SC						1		1	1	1	1	1	1		1
3	Limnodrilus hoffmeisteri	9.47	SC			1					4							
4	Limnodrilus sp.	9.50	SC				1											
5	Naididae Genus species		SC	1			1	2	3		5	2					1	
Arthropoda																		
Copepoda																		
6	Copepoda Genus species		OM						1									
Insecta																		
Diptera																		
Chironomidae																		
7	Ablabesmyia annulata	2.04	P												1	2		
8	Chironomus sp.	9.63	CG		2	3	5	2		1		1	1					
9	Cladopelma sp.	3.49	CG						1	3	2		2		1			
10	Cladotanytarsus sp.	4.09	CG	2	1	18	3	5	10	8	14		8					
11	Clinotanypus sp.		P								1							

				Control					New Water Treatment Intake					Raw Water Intake				
Seq	**Taxon**	**TV**	**FG**	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 4**	**Rep 5**	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 4**	**Rep 5**	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 4**	**Rep 5**
Chironomidae cont.																		
12	Cryptochironomus sp.	6.40	P			2					1							
13	Dicrotendipes sp.	8.10	CG		1						1							
14	Nanocladius sp.	7.07	CG								1							
15	Orthocladius sp.	5.94	SH		2													
16	Phaenopsectra obediens gr.	6.50	SC											1				
17	Polypedilum halterale gr.	7.31	SH	1		2			9	3	15	1	8	1		1	2	1
18	Procladius sp.	9.10	P						1						1			
19	Rheotanytarsus exiguus gr.	5.89	CF		1				2		1		4					
20	Tanytarsus sp.	6.76	CF						2		1							
Ephemeroptera																		
Ephemeridae																		
21	Hexagenia limbata	4.90	CG											1	9	3	5	5
Mollusca																		
Bivalvia																		
Unionoida																		
Corbiculidae																		
22	Corbicula fluminea	6.12	CF	15	14	18	9	11	19	12	19	10	12	6	11	10	14	4
Unionidae																		
23	Pyganodon cataracta		CF											1				

				Control					New Water Treatment Intake					Raw Water Intake				
Seq	**Taxon**	**TV**	**FG**	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 4**	**Rep 5**	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 4**	**Rep 5**	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 4**	**Rep 5**
Gastropoda																		
Limnophila																		
Physidae																		
24	Physa sp.	8.84	SC						1			1						

Functional feeding groups: CF = collector-filterer, CG = collector-gatherer, OM = omnivore, P = predator, SC = scraper, SH = shredder

[a] Data from Carnagey's April 2009 Macroinvertebrate Assessment

TABLE 3-24 BIOASSESSMENT METRICS FOR LAKE MONTICELLO FOR APRIL 27, 2009[A]

	Station														
	Control					New Water Treatment Intake					Raw Water intake				
Metric	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
Taxa Richness	4	6	6	5	4	11	5	13	6	7	6	6	6	5	4
Number of Specimens	19	21	44	19	20	50	27	66	16	36	11	24	18	23	11
EPT Index	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1
EPT Abundance	0	0	0	0	0	0	0	0	0	0	1	9	3	5	5
Chironomidae Taxa	2	5	4	2	2	6	4	9	2	5	2	3	2	1	1
Chironomidae Abundance	3	7	25	8	7	25	15	37	2	23	2	3	3	2	1
EPT/Chironomidae Abundance	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1	3	1	3	5
North Carolina Biotic Index	6.05	6.32	5.93	6.90	5.94	5.74	5.78	6.24	6.80	6.11	6.48	5.81	5.85	5.94	6.08
SCDHEC Bioclassification	2.0	2.0	2.0	1.5	2.0	2.3	2.3	2.0	1.5	2.0	1.8	2.2	2.0	2.0	2.0
Percent Collector-Filterers	78.95	71.43	40.91	47.37	55.00	2.00	0.00	3.03	6.25	2.78	9.09	8.33	16.67	0.00	9.09
Percent Collector-Gatherers	10.53	19.05	47.73	42.11	35.00	62.00	59.26	59.09	87.50	58.33	72.73	45.83	61.11	73.91	45.45
Percent Omnivores	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Percent Predators	0.00	0.00	4.55	0.00	0.00	6.00	0.00	3.03	6.25	0.00	0.00	4.17	0.00	0.00	0.00
Percent Scrapers	5.26	0.00	2.27	10.53	10.00	6.00	11.11	6.06	0.00	5.56	18.18	41.67	22.22	26.09	45.45
Percent Shredders	5.26	9.52	4.55	0.00	0.00	24.00	29.63	22.73	0.00	33.33	0.00	0.00	0.00	0.00	0.00
Scraper/Scraper & Collector-Filterers	0.07	0.00	0.06	0.22	0.18	3.00	-	2.00	0.00	2.00	2.00	5.00	1.33	-	5.00
Percent Dominant Taxon	78.95	66.67	40.91	47.37	55.00	38.00	44.44	28.79	62.50	33.33	54.55	45.83	55.56	60.87	45.45
Number Of Dominant Taxa	4	3	3	5	4	4	4	5	6	5	6	2	6	3	4

[a] Data from Carnagey's April 2009 Macroinvertebrate Assessment

Single factor ANOVA analyses were also completed at each site on Lake Monticello. These results are shown in Table 3-25, Table 3-26, Table 3-27 and Table 3-28.

The three Lake Monticello sample points (control, new water treatment intake, and new raw intake) from June 18, 2008 indicate a few significant differences in bioassessment metrics through one-way ANOVA comparison. Percentage of dominant taxon (p-value = 0.01879), EPT abundance (p-value = 0.04360), NCBI values (p-value = 0.04624), and SCDHEC bioclassification values (p-value = 0.01450) indicate significant difference between the stations. All other metrics show no significant difference.

The September 18, 2008 sample points indicate a few significant differences in bioassessment metrics through one-way ANOVA comparison. Taxa richness (p=0.01234), total abundance (p-value = 0.04412), EPT Index value (p-value=0.00676), EPT abundance (p-value = 0.00050), NCBI values (p-value = 0.00361), and SCDHEC bioclassification values (p-value = 0.00172) indicate significant difference between the stations. All other metrics show no significant difference.

The January 22-23, 2009 sample points indicate a few significant differences in bioassessment metrics through one-way ANOVA comparison. EPT Index value (p-value=0.00041), and EPT abundance (p-value = 0.00097) indicate significant difference between the stations. All other metrics show no significant difference.

The April 27, 2009 sample points indicate a few significant differences in bioassessment metrics through one-way ANOVA comparison (Table). Taxa richness (p-value = 0.04737), EPT Index value, EPT abundance (p-value = 0.00001), and SCDHEC bioclassification values (p-value = 0.04309) indicate significant difference between the stations. All other metrics show no significant difference.

TABLE 3-25 RESULTS OF THE SINGLE FACTOR ANOVA FOR LAKE MONTICELLO, JUNE 18, 2008[A]

ANOVA for Taxa Richness

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Stations	0.08822	2	0.04411	2.69272	0.10814	3.88529
Within Stations	0.19658	12	0.01638			
Total	0.2848	14				

ANOVA for EPT Abundance

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Stations	0.43168	2	0.21584	4.11342	0.0436	3.88529
Within Stations	0.62967	12	0.05247			
Total	1.06135	14				

ANOVA for Total Abundance

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Stations	0.1528	2	0.0764	1.88877	0.19358	3.88529
Within Stations	0.48538	12	0.04045			
Total	0.63818	14				

ANOVA for NCBI

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Stations	0.0106	2	0.0053	4.01487	0.04624	3.88529
Within Stations	0.01585	12	0.00132			
Total	0.02645	14				

ANOVA for Percentage of the Dominant Taxon

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Stations	0.13756	2	0.06878	5.6369	0.01879	3.88529
Within Stations	0.14643	12	0.0122			
Total	0.28399	14				

ANOVA for SCDHEC Bioclassification

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Stations	0.03764	2	0.01882	6.15018	0.0145	3.88529
Within Stations	0.03673	12	0.00306			
Total	0.07437	14				

ANOVA for EPT Index

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Stations	0.04833	2	0.02417	2.66667	0.1101	3.88529
Within Stations	0.10874	12	0.00906			
Total	0.15707	14				

[a] Data from Carnagey's June 2008 Macroinvertebrate Assessment

TABLE 3-26 RESULTS OF THE SINGLE FACTOR ANOVA FOR LAKE MONTICELLO, SEPTEMBER 18, 2008[A]

ANOVA for Taxa Richness

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Stations	0.38943	2	0.19471	6.48194	0.01234	3.88529
Within Stations	0.36047	12	0.03004			
Total	0.7499	14				

ANOVA for EPT Abundance

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Stations	1.7058	2	0.8529	15.327	0.0005	3.8853
Within Stations	0.6678	12	0.0557			
Total	2.3735	14				

ANOVA for Total Abundance

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Stations	0.8222	2	0.4111	4.0934	0.0441	3.8853
Within Stations	1.2051	12	0.1004			
Total	2.0273	14				

ANOVA for NCBI

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Stations	0.061	2	0.0305	9.3186	0.0036	3.8853
Within Stations	0.0393	12	0.0033			
Total	0.1002	14				

ANOVA for Percentage of the Dominant Taxon

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Stations	0.0585	2	0.0293	1.352	0.2954	3.8853
Within Stations	0.2597	12	0.0216			
Total	0.3182	14				

ANOVA for SCDHEC Bioclassification

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Stations	0.0661	2	0.033	11.335	0.0017	3.8853
Within Stations	0.035	12	0.0029			
Total	0.101	14				

ANOVA for EPT Index

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Stations	0.2367	2	0.1183	7.7972	0.0068	3.8853
Within Stations	0.1821	12	0.0152			
Total	0.4188	14				

[a] Data from Carnagey's September 2008 Macroinvertebrate Assessment

TABLE 3-27 RESULTS OF THE SINGLE FACTOR ANOVA FOR LAKE MONTICELLO, JANUARY 22-23, 2009[A]

ANOVA for Taxa Richness

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Stations	0.24645	2	0.12322	3.58529	0.06016	3.88529
Within Stations	0.41243	12	0.03437			
Total	0.65887	14				

ANOVA for EPT Abundance

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Stations	1.20995	2	0.60498	13.0738	0.00097	3.88529
Within Stations	0.55529	12	0.04627			
Total	1.76524	14				

ANOVA for Total Abundance

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Stations	0.33227	2	0.16613	1.52273	0.25743	3.88529
Within Stations	1.30922	12	0.1091			
Total	1.64148	14				

ANOVA for NCBI

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Stations	0.00177	2	0.00089	0.7502	0.49318	3.88529
Within Stations	0.01419	12	0.00118			
Total	0.01596	14				

ANOVA for Percentage of the Dominant Taxon

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Stations	0.09522	2	0.04761	1.92634	0.18814	3.88529
Within Stations	0.29659	12	0.02472			
Total	0.39181	14				

ANOVA for SCDHEC Bioclassification

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Stations	0.00842	2	0.00421	1.27477	0.31477	3.88529
Within Stations	0.03965	12	0.0033			
Total	0.04807	14				

ANOVA for EPT Index

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Stations	0.19332	2	0.09666	16	0.00041	3.88529
Within Stations	0.0725	12	0.00604			
Total	0.26582	14				

[a] Data from Carnagey's January 2009 Macroinvertebrate Assessment

TABLE 3-28 RESULTS OF THE SINGLE FACTOR ANOVA FOR LAKE MONTICELLO, APRIL 27, 2009[A]

ANOVA for Taxa Richness

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Stations	0.09011	2	0.04506	3.9747	0.04737	3.88529
Within Stations	0.13603	12	0.01134			
Total	0.22614	14				

ANOVA for EPT Abundance

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Stations	1.59565	2	0.79783	35.3732	0.00001	3.88529
Within Stations	0.27065	12	0.02255			
Total	1.86631	14				

ANOVA for Total Abundance

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Stations	0.24547	2	0.12273	3.65038	0.05776	3.88529
Within Stations	0.40347	12	0.03362			
Total	0.64893	14				

ANOVA for NCBI

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Stations	0.00034	2	0.00017	0.3393	0.71889	3.88529
Within Stations	0.00601	12	0.0005			
Total	0.00635	14				

ANOVA for Percentage of the Dominant Taxon

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Stations	0.05831	2	0.02915	2.78199	0.10171	3.88529
Within Stations	0.12575	12	0.01048			
Total	0.18406	14				

ANOVA for SCDHEC Bioclassification

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Stations	0.01936	2	0.00968	4.13354	0.04309	3.88529
Within Stations	0.02811	12	0.00234			
Total	0.04747	14				

ANOVA for EPT Index

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Stations	0.30206	2	0.15103	65535	-	3.88529
Within Stations	0	12	0			
Total	0.30206	14				

[a] Data from Carnagey's April 2009 Macroinvertebrate Assessment

3.2.2 ONGOING STUDIES

3.2.2.1 PARR RESERVOIR

On September 11-12, 2012, 1051 specimens were collected from the three sample locations on Parr Reservoir, representing 51 taxa. The number of specimens collected, their NCBI tolerance values, functional feeding groups, and bioassessment metrics are displayed in Table 3-29 through Table 3-35.

The bioassessment metrics indicated that Parr Reservoir upstream and the discharge were similar. The Parr Reservoir upstream location had much lower taxa richness than the discharge location. Bioassessment metrics for Parr Tailrace downstream of Parr Reservoir were also calculated using instream benthic macroinvertebrate community rapid bioassessment. Due to the different bioassessment sampling protocol, and environment, the metrics were not compared to those at the upstream and discharge locations.

TABLE 3-29 MACROINVERTEBRATES, THEIR NCBI TOLERANCE VALUES (TV) AND FUNCTIONAL FEEDING GROUPS (FG) FOR THE PARR UPSTREAM REPLICATES IN PARR RESERVOIR, SEPTEMBER 11, 2012[A]

				Sample Point 1					Sample Point 2					Sample Point 3				
Seq	Taxon	TV	FG	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
Annelida																		
Hirudinea																		
1	Hirudinea Genus species	5.00	P															
Oligochaeta																		
Tubificida																		
Naididae																		
2	Branchiura sowerbyi	8.28	SC								1	1						
3	Dero sp.		SC															
4	Limnodrilus sp.	9.50	SC															
5	Naididae Genus species		SC			3			2		1		1	1				1
6	Pristina osborni		SC															
7	Spirosperma ferox	5.40	SC							1		1						
Arthropoda																		
Insecta																		
Diptera																		
Chironomidae																		
8	Ablabesmyia peleensis	9.67	P															
9	Chironomus sp.	9.63	CG															
10	Cladopelma sp.	4.09	CG															
11	Cladotanytarsus sp. B		CG										1					

				Sample Point 1					Sample Point 2					Sample Point 3				
Seq	**Taxon**	**TV**	**FG**	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 4**	**Rep 5**	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 4**	**Rep 5**	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 4**	**Rep 5**
Chironomidae cont.																		
12	Clinotanypus sp.		P															
13	Cryptochironomus sp.	6.40	P	1		1	1			1	1					2		
14	Polypedilum halterale gp.	7.30	SH													1		
15	Procladius sp.	9.10	P															
16	Tanytarsus sp.	6.76	CF															
Ephemeroptera																		
Ephemeridae																		
17	Hexagenia limbata	4.90	CG									1						
Odonata																		
Gomphidae																		
18	Gomphus sp.	5.80	P															
Trichoptera																		
Hydroptilidae																		
19	Hydroptila sp.	6.22	SC															
Malacostraca																		
Cladocera																		
Sididae																		
20	Sida sp.		CF															
Cyclopoida																		
Cyclopidae																		
21	Eucyclops sp.		OM															

				Sample Point 1					Sample Point 2					Sample Point 3				
Seq	**Taxon**	**TV**	**FG**	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 4**	**Rep 5**	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 4**	**Rep 5**	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 4**	**Rep 5**
Mollusca																		
Bivalvia																		
Unionoida																		
Corbiculidae																		
22	Corbicula fluminea	6.12	CF	30	17	20	20	20	60	21	54	67	67	2	10	11	3	1

Functional feeding groups: CF = collector-filterer, CG = collector-gatherer, OM = omnivore, P = predator, SC = scraper, SH = shredder

[a] Data from Carnagey's September 2012 Macroinvertebrate Assessment

TABLE 3-30 MACROINVERTEBRATES, THEIR NCBI TOLERANCE VALUES (TV) AND FUNCTIONAL FEEDING GROUPS (FG) FOR THE UNITS 2 & 3 DISCHARGE REPLICATES IN PARR RESERVOIR, SEPTEMBER 11, 2012[A]

				Sample Point 1					Sample Point 2					Sample Point 3				
Seq	**Taxon**	**TV**	**FG**	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 4**	**Rep 5**	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 4**	**Rep 5**	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 4**	**Rep 5**
Annelida																		
Hirudinea																		
1	Hirudinea Genus species	5.00	P	10	1	16	24	8	2	2			5					
Oligochaeta																		
Tubificida																		
Naididae																		
2	Branchiura sowerbyi	8.28	SC			5	4	2		1			1		1		5	
3	Dero sp.		SC	1	1	1	2											
4	Limnodrilus sp.	9.50	SC		2	1	3	2	1						1			
5	Naididae Genus species		SC	6	7	3	8	18		1	3		5		5		3	3
6	Pristina osborni		SC						1			1	1				1	
7	Spirosperma ferox	5.40	SC													1	1	
Arthropoda																		
Insecta																		
Diptera																		
Chironomidae																		
8	Ablabesmyia peleensis	9.67	P												1		1	
9	Chironomus sp.	9.63	CG												1			1
10	Cladopelma sp.	4.09	CG			2	1	2										
11	Cladotanytarsus sp. B		CG			1												
Chironomidae cont.																		
12	Clinotanypus sp.		P					1						1	1			1
13	Cryptochironomus sp.	6.40	P	1	1	1	1								2		2	1
14	Polypedilum halterale gp.	7.30	SH		1													
15	Procladius sp.	9.10	P	1		1				1								
16	Tanytarsus sp.	6.76	CF	1														
Ephemeroptera																		
Ephemeridae																		
17	Hexagenia limbata	4.90	CG											1	1			
Odonata																		
Gomphidae																		
18	Gomphus sp.	5.80	P			1												
Trichoptera																		
Hydroptilidae																		
19	Hydroptila sp.	6.22	SC														2	
Malacostraca																		
Cladocera																		
Sididae																		
20	Sida sp.		CF			2												
Cyclopoida																		
Cyclopidae																		
21	Eucyclops sp.		OM				1								1			
Mollusca																		
Bivalvia																		
Unionoida																		
Corbiculidae																		
22	Corbicula fluminea	6.12	CF	19	17	4	20	22	1	13	2	5	8	2	8	7	4	2

Functional feeding groups: CF = collector-filterer, CG = collector-gatherer, OM = omnivore, P = predator, SC = scraper, SH = shredder

[a] Data from Carnagey's September 2012 Macroinvertebrate Assessment

TABLE 3-31 MACROINVERTEBRATES, THEIR NCBI TOLERANCE VALUES (TV), FUNCTIONAL FEEDING GROUPS (FG), AND RELATIVE ABUNDANCE FOR PARR TAILRACE AT PARR RESERVOIR, SEPTEMBER 12, 2012[A]

Seq	Taxon	TV	FG	No. of Individuals	Relative Abundance
Annelida					
Hirudinea					
1	Hirudinea Genus species	5.00	P	3	0.01
Rhynchobdellida					
Glossiphoniidae					
2	Helobdella sp.	9.00	P	2	0.01
Oligochaeta					
Tubificida					
Naididae					
3	Stylaria lacustris	9.40	SC	1	0.00
Arthropoda					
Insecta					
Diptera					
Chironomidae					
4	Ablabesmyia peleensis	9.67	P	1	0.00
5	Nanocladius crassicornis/cf. rectinervis	7.07	CG	8	0.03
6	Orthocladius robacki		SH	1	0.00
7	Parachironomus carinatus	9.42	P	1	0.00
8	Polypedilum flavum	4.90	SH	2	0.01
9	Rheocricotopus robacki	7.28	CG	3	0.01
Simuliidae					
10	Simulium luggeri		CF	52	0.18
Ephemeroptera					
Baetidae					
11	Baetis intercalaris	4.99	CG	3	0.01
Heptageniidae					
12	Maccaffertium integrum	5.80	SC	2	0.01
13	Maccaffertium modestum	5.50	SC	26	0.09
Isonychiidae					
14	Isonychia sp.	3.45	CF	2	0.01
Leptohyphidae					
15	Tricorythodes sp.	5.06	CG	24	0.08

Seq	Taxon	TV	FG	No. of Individuals	Relative Abundance
Megaloptera					
Corydalidae					
16	Corydalus cornutus	5.16	P	11	0.04
Odonata					
Coenagrionidae					
17	Argia moesta	8.17	P	11	0.04
Libellulidae					
18	Neurocordulia virginiensis	2.05	P	3	0.01
Trichoptera					
Hydropsychidae					
19	Cheumatopsyche sp.	6.22	CF	12	0.04
20	Hydropsyche bidens		CF	20	0.07
21	Macrostemum carolina	3.52	CF	27	0.10
Hydroptilidae					
22	Hydroptila sp.	6.22	SC	7	0.02
Lepidostomatidae					
23	Lepidostoma sp.	0.90	SH	1	0.00
Leptoceridae					
24	Ceraclea nepha/protonepha	2.01	CG	18	0.06
25	Oecetis persimilis	4.70	P	7	0.02
26	Triaenodes injustus	2.47	SH	1	0.00
Philopotamidae					
27	Chimarra sp.	2.76	CF	2	0.01
Polycentropodidae					
28	Neureclipsis crepuscularis	4.19	CF	1	0.00
Malacostraca					
Amphipoda					
Gammaridae					
29	Gammarus sp.	9.10	OM	2	0.01
Mollusca					
Bivalvia					
Unionoida					
Corbiculidae					
30	Corbicula fluminea	6.12	CF	5	0.02

Seq	Taxon	TV	FG	No. of Individuals	Relative Abundance
Gastropoda					
Mesogastropoda					
Hydrobiidae					
31	Somatogyrus virginicus	6.40	SC	8	0.03
Pleuroceridae					
32	Goniobasis catenaria catenaria		SC	12	0.04
Platyhelminthes					
Turbellaria					
Tricladida					
Planariidae					
33	Dugesia tigrina	7.50	OM	5	0.02

Functional feeding groups: CF = collector-filterer, CG = collector-gatherer, OM = omnivore, P = predator, SC = scraper, SH = shredder

[a] Data from Carnagey's September 2012 Macroinvertebrate Assessment

TABLE 3-32 BIOASSESSMENT METRICS FOR THE PARR UPSTREAM REPLICATES IN PARR RESERVOIR, SEPTEMBER 11, 2012[A]

	Parr Upstream														
	Sample Point 1					Sample Point 2					Sample Point 3				
Metric	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 4**	**Rep 5**	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 4**	**Rep 5**	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 4**	**Rep 5**
Taxa Richness	2	1	3	2	1	2	3	4	4	3	2	1	3	1	2
Number of Specimens	31	17	24	21	20	62	23	57	70	69	3	10	14	3	2
EPT Index	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
EPT Abundance	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Chironomidae Taxa	1	0	1	1	0	0	1	1	0	1	0	0	2	0	0
Chironomidae Abundance	1	0	1	1	0	0	1	1	0	1	0	0	3	0	0
EPT/Chironomidae Abundance	0.00	-	0.00	0.00	-	-	0.00	0.00	-	0.00	-	-	0.00	-	-
North Carolina Biotic Index	6.15	6.12	6.15	6.15	6.12	6.12	6.08	6.32	6.14	6.12	6.12	6.12	6.24	6.12	6.12
SCDHEC Bioclassification	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Percent Collector-Filterers	96.77	100.00	83.33	95.24	100.00	96.77	91.30	94.74	95.71	97.10	66.67	100.00	78.57	100.00	50.00
Percent Collector-Gatherers	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.43	1.45	0.00	0.00	0.00	0.00	0.00
Percent Omnivores	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Percent Predators	3.23	0.00	4.17	4.76	0.00	0.00	4.35	1.75	0.00	0.00	0.00	0.00	14.29	0.00	0.00
Percent Scrapers	0.00	0.00	12.50	0.00	0.00	3.23	4.35	3.51	2.86	1.45	33.33	0.00	0.00	0.00	50.00
Percent Shredders	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.14	0.00	0.00
Scraper/Scraper & Collector-Filterers	0.00	0.00	0.15	0.00	0.00	0.03	0.05	0.04	0.03	0.01	0.50	0.00	0.00	0.00	1.00
Percent Dominant Taxon	96.77	100.00	83.33	95.24	100.00	96.77	91.30	94.74	95.71	97.10	66.67	100.00	78.57	100.00	50.00
Number Of Dominant Taxa	1	1	2	1	1	1	1	1	1	1	2	1	3	1	2

[a] Data from Carnagey's September 2012 Macroinvertebrate Assessment

TABLE 3-33 BIOASSESSMENT METRICS FOR THE UNITS 2 & 3 DISCHARGE REPLICATES IN PARR RESERVOIR, SEPTEMBER 11, 2012[A]

	Units 2 & 3 Discharge														
	Sample Point 1					Sample Point 2					Sample Point 3				
Metric	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 4**	**Rep 5**	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 4**	**Rep 5**	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 4**	**Rep 5**
Taxa Richness	7	7	12	9	7	4	5	2	2	5	3	10	2	8	5
Number of Specimens	39	30	38	64	55	5	18	5	6	20	4	22	8	19	8
EPT Index	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0
EPT Abundance	0	0	0	0	0	0	0	0	0	0	1	1	0	2	0
Chironomidae Taxa	3	2	4	2	2	0	1	0	0	0	1	4	0	2	3
Chironomidae Abundance	3	2	5	2	3	0	1	0	0	0	1	5	0	3	3
EPT/Chironomidae Abundance	0.00	0.00	0.00	0.00	0.00	-	0.00	-	-	-	1.00	0.20	-	0.67	0.00
North Carolina Biotic Index	5.80	6.39	6.10	6.25	6.13	6.87	6.43	6.12	6.12	5.95	5.51	7.42	5.94	7.09	7.38
SCDHEC Bioclassification	2.2	2.0	2.0	2.0	2.0	1.5	2.0	2.0	2.0	2.0	2.5	1.5	2.0	1.5	1.5
Percent Collector-Filterers	51.28	56.67	15.79	31.25	40.00	20.00	72.22	40.00	83.33	40.00	50.00	36.36	87.50	21.05	25.00
Percent Collector-Gatherers	0.00	0.00	7.89	1.56	3.64	0.00	0.00	0.00	0.00	0.00	25.00	9.09	0.00	0.00	12.50
Percent Omnivores	0.00	0.00	0.00	1.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.55	0.00	0.00	0.00
Percent Predators	30.77	6.67	50.00	39.06	16.36	40.00	16.67	0.00	0.00	25.00	25.00	18.18	0.00	15.79	25.00
Percent Scrapers	17.95	33.33	26.32	26.56	40.00	40.00	11.11	60.00	16.67	35.00	0.00	31.82	12.50	63.16	37.50
Percent Shredders	0.00	3.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Scraper/Scraper & Collector-Filterers	0.35	0.59	1.67	0.85	1.00	2.00	0.15	1.50	0.20	0.88	0.00	0.88	0.14	3.00	1.50
Percent Dominant Taxon	48.72	56.67	42.11	37.50	40.00	40.00	72.22	60.00	83.33	40.00	50.00	36.36	87.50	26.32	37.50
Number Of Dominant Taxa	3	3	6	4	3	4	5	2	2	5	3	3	2	8	5

[a] Data from Carnagey's September 2012 Macroinvertebrate Assessment

TABLE 3-34 BIOASSESSMENT METRICS FOR THE COMBINED DATA COLLECTED AT THE PARR UPSTREAM AND UNITS 2 & 3 DISCHARGE LOCATIONS IN PARR RESERVOIR, SEPTEMBER 11, 2012[A]

Metric	Parr Upstream	Units 2 & 3 Discharge
Taxa Richness	8	22
Number of Specimens	426	341
EPT Index	1	2
EPT Abundance	1	4
Chironomidae Taxa	3	9
Chironomidae Abundance	9	28
EPT/Chironomidae	0.11	0.14
North Carolina Biotic Index	6.25	7.08
SCDHEC Bioclassification	2.0	1.5
Percent Collector-Filterers	94.60	40.18
Percent Collector-Gatherers	0.47	2.93
Percent Omnivores	0.00	0.59
Percent Predators	1.64	25.51
Percent Scrapers	3.05	30.50
Percent Shredders	0.23	0.29
Scraper/Collector-Filterers	0.03	0.76
Percent Dominant Taxon	94.60	39.30
Number Of Dominant Taxa	1	4

[a] Data from Carnagey's September 2012 Macroinvertebrate Assessment

TABLE 3-35 BIOASSESSMENT METRICS FOR PARR TAILRACE DOWNSTREAM OF PARR RESERVOIR, SEPTEMBER 12, 2012[A]

Metric	Parr Tailrace
Taxa Richness	8
Number of Specimens	426
EPT Index	1
EPT Abundance	1
Chironomidae Taxa	3
Chironomidae Abundance	9
EPT/Chironomidae Abundance	0.11
North Carolina Biotic Index	6.25
SCDHEC Bioclassification	2.0
Percent Collector-Filterers	94.60
Percent Collector-Gatherers	0.47
Percent Omnivores	0.00
Percent Predators	1.64
Percent Scrapers	3.05
Percent Shredders	0.23
Scraper/Collector-Filterers	0.03
Percent Dominant Taxon	94.60
Number Of Dominant Taxa	1

[a] Data from Carnagey's September 2012 Macroinvertebrate Assessment

Single factor ANOVA analyses were also completed at each site on Parr Reservoir. These results are shown in Table 3-36.

One-way ANOVA results show significant differences in bioassessment metrics in taxa richness (p-value = 0.00009), and percentage of dominant taxon (p-value = 0.000001) at the Parr Reservoir upstream location. At the Parr Reservoir discharge point, ANOVA results show significant differences in bioassessment metrics in percentage of dominant taxon (p-value = 0.03499), EPT Index values (p-value = 0.00592), EPT abundance (p-value = 0.00010). All other metrics show no significant difference.

TABLE 3-36 RESULTS OF THE SINGLE FACTOR ANOVA ON PARR RESERVOIR, 11 SEPTEMBER 2012[A]

ANOVA for Taxa Richness

Source of Variation	SS	df	MS	F	P-value	F crit
Between Transects	1.81337	6	0.30223	13.9683	0.000001	2.50819
Within Transects	0.51928	24	0.02164			
Total	2.33265	30				

ANOVA for EPT Index

Source of Variation	SS	df	MS	F	P-value	F crit
Between Transects	1.81337	6	0.30223	13.9683	0.000001	2.50819
Within Transects	0.51928	24	0.02164			
Total	2.33265	30				

ANOVA for Total Abundance

Source of Variation	SS	df	MS	F	P-value	F crit
Between Transects	1.81337	6	0.30223	13.9683	0.000001	2.50819
Within Transects	0.51928	24	0.02164			
Total	2.33265	30				

ANOVA for EPT Abundance

Source of Variation	SS	df	MS	F	P-value	F crit
Between Transects	1.81337	6	0.30223	13.9683	0.000001	2.50819
Within Transects	0.51928	24	0.02164			
Total	2.33265	30				

ANOVA for the Percentage of the Dominant Taxon

Source of Variation	SS	df	MS	F	P-value	F crit
Between Transects	1.81337	6	0.30223	13.9683	0.000001	2.50819
Within Transects	0.51928	24	0.02164			
Total	2.33265	30				

ANOVA for NCBI

Source of Variation	SS	df	MS	F	P-value	F crit
Between Transects	1.81337	6	0.30223	13.9683	0.000001	2.50819
Within Transects	0.51928	24	0.02164			
Total	2.33265	30				

ANOVA for the Percentage of the Dominant Taxon

Source of Variation	SS	df	MS	F	P-value	F crit
Between Transects	1.81337	6	0.30223	13.9683	0.000001	2.50819
Within Transects	0.51928	24	0.02164			
Total	2.33265	30				

ANOVA for SCDHEC Bioclassification

Source of Variation	SS	df	MS	F	P-value	F crit
Between Transects	1.81337	6	0.30223	13.9683	0.000001	2.50819
Within Transects	0.51928	24	0.02164			
Total	2.33265	30				

[a] Data from Carnagey's September 2012 Macroinvertebrate Assessment

4.0 DISCUSSION AND CONCLUSIONS

The Parr Fairfield Project operations do not appear to affect the overall water quality of the Parr Reservoir, Lake Monticello, and the Broad River below Parr Shoals Dam, according to mussel and macroinvertebrate studies. The data presented within the report depicts an overall healthy water system, providing suitable habitat for a variety of aquatic species. Ongoing monitoring efforts within the Project area will examine the macroinvertebrate community for any changes in water quality.

4.1 MUSSELS

The two freshwater mussel surveys conducted in 2007 and 2012 covered a large portion of the Broad River and Parr Reservoir, well documenting the mussel species in and around the Project area. Because of these studies, a current and comprehensive inventory of the freshwater mussels within the Project area exists.

The 2012 study revealed that the area of the Broad River immediately downstream of the Parr Shoals Dam provides a significant freshwater mussel habitat. Species were documented never before been seen in that area of the Broad River, while diversity at the study site was the greatest recorded in the Broad River Subbasin in North and South Carolina upriver from the Columbia Canal Dam (Alderman, 2012).

The 2007 study covered an expansive area, documenting the mussel species above and below Parr Shoals Dam, as well as within Parr Reservoir. The reservoir was determined to have the same diversity as the unimpounded sections of the river below Parr Shoals Dam. The stretch of the Broad River between Parr Shoals Dam and Columbia Dam was found to provide an excellent habitat for mussels.

4.2 MACROINVERTEBRATES

Baseline studies performed in 2008 and 2009 provide an inventory of macroinvertebrate species within the Project area. Monitoring efforts resumed in 2012 and will continue throughout the construction of the VCSNS expansion, and for five years after construction is complete.

Data collection and comparison of macroinvertebrate biometrics indicate neither spatial nor temporal significant difference within the Project Vicinity. The latest data concludes a SCDHEC score of “good-fair” and NCBI score of “good” immediately downstream of the Project location at the Parr Tailrace.

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APPENDIX A

NEAL SHOALS MACROINVERTEBRATE ASSESSMENT

MEMORANDUM

To: Alan Stuart, Kleinschmidt Associates
From: Daniel Carnagey, Carnagey Biological Services, LLC
Date: 21 June 2012
Subject: Preliminary Conclusions From the Neal Shoals Macroinvertebrate Assessment, 24-25 Apr 2012

Based on the collections made below Neal Shoals Dam, and a previous study made at Parr Reservoir (Parr) in 2008 and 2009, a number of conclusions may be drawn. However, a number of items should be noted. First, neither the North Carolina Biotic Index (NCBI), nor the SCDHEC Bioclassification index SCDHEC BI)are robust if the number of specimens collected is under 100. Their robustness is also compromised if a large number of the specimens collected are without a tolerance value. Second, because there is not a control station, nor data from before the sand release, comparisons are somewhat difficult. Finally, the Parr collections were nor made using the Rapid Bioassessment Protocol, but were petite Ponar Dredge samples. This means that they were collected from a somewhat different habitat (sediment from deeper and more open water) and that each repetition at a given stations has generally has a lower number of specimens and taxa richness.

The bioassessment metrics for the Neal Shoals collection are listed below in Table 1. Note that the NCBI and the SCDHEC BI values are suspect at Stations 2E and 2W for the reasons listed above. Otherwise all stations are quite similar in NCBI and SCDHEC BI scores.

Because most of the Parr replicates had less than 100 specimens, all the replicates at each station during each sampling event were combined. The combined data is in Table 2 and the bioassessment metrics are in Table 3. When compared to the Neal Shoals collections, the Parr samples are much poorer in nearly all metrics. In general, NCBI and SCDHEC BI were higher at Neal Shoals than at Parr. In addition, EPT indices and abundance was much higher at all Neal Shoals stations than at Parr. This is due, at least in part, to the collection methods.

In conclusion, the Neal Shoals samples showed significantly better results than the previous Parr samples. The Parr samples also indicate that the taxa richness in Neal Shoals seems to be what would be expected given the sampling constraints discussed in the Memo dated 18 June 2012.

Table 1. Bioassessment metrics for the six Broad River rapid bioassessment stations downstream from the Neal Shoals Dam operated by SOUTH CAROLINA ELECTRIC & GAS COMPANY, 24-25 April 2012.

	Sta. 1E	Sta. 1W	Sta. 2E	Sta. 2W	Sta. 3E	Sta. 3W
Taxa Richness	31.00	38.00	16.00	16.00	42.00	16.00
Number of Specimens	194.00	127.00	73.00	119.00	106.00	106.00
EPT Index	13.00	13.00	8.00	3.00	13.00	9.00
EPT Abundance	88.00	59.00	21.00	15.00	50.00	63.00
Chironomidae Taxa	12.00	9.00	3.00	1.00	8.00	2.00
Chironomidae Abundance	82.00	21.00	3.00	1.00	25.00	19.00
EPT/Chironomidae Abundance	1.07	2.81	7.00	15.00	2.00	3.32
NCBI	6.18	6.33	5.72	7.20	6.34	5.68
SCDHEC Bioclassification	2.50	2.50	2.80	1.50	2.50	2.80
%C-F	13.92	14.17	0.00	0.00	12.26	0.94
%C-G	11.34	6.30	5.48	10.08	30.19	17.92
%OM	1.55	0.79	5.48	1.68	6.60	0.00
%P	14.95	21.26	50.68	47.90	20.75	36.79
%SC	26.29	49.61	36.99	39.50	16.98	26.42
%SH	31.96	7.87	1.37	0.84	13.21	17.92
SC/C-F	1.89	3.50	-	-	1.38	28.00
SH/Total	0.32	0.08	0.01	0.01	0.13	0.18
%Dom Taxon	24.74	11.81	36.99	37.82	16.04	20.75
# Dom Taxa	7.00	6.00	5.00	7.00	5.00	7.00

Table 2. Macroinvertebrates, their NCBI tolerance values (TV), functional feeding groups (FG), and relative abundance for Broad River petite Ponar stations near the Parr Reservoir operated by SOUTH CAROLINA ELECTRIC & GAS COMPANY.

				Sep-08		Jun-08		Jan-09		Apr-09	
Seq	**Taxon**	**TV**	**FG**	**Control**	**New Blowdown Discharge**	**Control**	**New Blowdown Discharge**	**Control**	**New Blowdown Discharge**	**Control**	**New Blowdown Discharge**
Annelida											
Hirudinea											
1	Hirudinea Genus species		P	1	41				16		
Rhynchobdellida											
Glossiphoniidae											
2	Helobdella stagnalis	8.63	P				8				
Oligochaeta											
Lumbriculida											
Lumbriculidae											
3	Lumbriculidae Genus species	7.03	SC	1		1	4				
Tubificida											
Naididae											
4	Branchiura sowerbyi	8.28	SC					1	5		
5	Limnodrilus hoffmeisteri	9.47	SC					17	13	3	13
6	Naididae Genus species		SC							55	52
7	Tubifex tubifex	10	SC	14	41	25	26	10	8		
Arthropoda											
Insecta											
Coleoptera											
Elmidae											
8	Dubiraphia sp.	5.93	CG	1							
9	Macronychus glabratus	4.58	CG					1			

Table 2. Continued.

				Sep-08	Jun-08	Jan-09	Apr-09

Seq	Taxon	TV	FG	Control	New Blowdown Discharge	Control	New Blowdown Discharge	Control	New Blowdown Discharge	Control	New Blowdown Discharge
Diptera											
Athericidae											
10	Atherix sp.	2.1	P	1							
Ceratopogonidae											
11	Bezzia/Palpomyia sp.	6.86	P			2	2	2		4	
12	Culicoides sp.	7.7	P	1				2			
Chaoboridae											
13	Chaoborus sp.	8.5	P					1			
Chironomidae											
14	Ablabesmyia annulata	2.04	P				1				
15	Ablabesmyia mallochi	7.19	P				1				
16	Chironomus sp.	9.63	CG				34	11	6	1	4
17	Clinotanypus sp.		P	17	4			28	2	2	
18	Cryptochironomus sp.	6.4	P			1	2		2	1	
19	Cryptotendipes sp.	6.19	CG								
20	Dicrotendipes sp.	8.1	CG								
21	Fissimentum sp. A		CG			2					
22	Harnischia sp.	9.07	CG							2	
23	Microtendipes sp.	5.53	CF			5					
24	Paracladopelma undine	4.93	CG			2	1				
25	Polypedilum halterale gr.	7.31	SH				1			1	
26	Polypedilum illinoense gr.	9	SH						1		
27	Procladius sp.	9.1	P		3		13	13		2	
28	Rheotanytarsus exiguus gr.	5.89	CF		2		2				

Table 2. Continued.

				Sep-08		Jun-08		Jan-09		Apr-09	
Seq	**Taxon**	**TV**	**FG**	**Control**	**New Blowdown Discharge**	**Control**	**New Blowdown Discharge**	**Control**	**New Blowdown Discharge**	**Control**	**New Blowdown Discharge**
Chironomidae cont.											
29	Tanytarsus sp.	6.76	CF								
30	Thienemannimyia gr.	8.42	P							1	
31	Tribelos sp.	6.31	CG			3					
Ephemeroptera											
Ephemerellidae											
32	Ephemerella sp.	2.04	CG	1	17						
Ephemeridae											
33	Hexagenia limbata	4.9	CG				4			1	1
34	Hexagenia sp.	4.9	CG					1	2		
Odonata											
Gomphidae											
35	Gomphus sp.	5.8	P	1			1				
36	Stylurus plagiatus		P					2			
Trichoptera											
Hydroptilidae											
37	Hydroptilidae Genus species		0					3			
Leptoceridae											
38	Oecetis inconspicua complex	1.85	P	1	3						
39	Oecetis sp.	4.7	P						2		
Malacostraca											
Amphipoda											
Talitridae											
40	Hyalella azteca	7.75	OM				1				

Table 2. Continued.

				Sep-08		Jun-08		Jan-09		Apr-09	
Seq	**Taxon**	**TV**	**FG**	**Control**	**New Blowdown Discharge**	**Control**	**New Blowdown Discharge**	**Control**	**New Blowdown Discharge**	**Control**	**New Blowdown Discharge**
Isopoda											
Asellidae											
41	Caecidotea sp.	9.11	SC				2				
Mollusca											
Bivalvia											
Unionoida											
Corbiculidae											
42	Corbicula fluminea	6.12	CF	107	64	20	231	35	68	34	24
Sphaeriidae											
43	Sphaeriidae Genus species		CF					2			
Gastropoda											
Limnophila											
Physidae											
44	Physa sp.	8.84	SC				1				
Planorbidae											
45	Promenetus exacuous		SC				4				
TOTAL				146	175	61	339	129	125	107	94

Table 3. Bioassessment metrics for the Broad River rapid bioassessment stations near Parr reservoir operated by SOUTH CAROLINA ELECTRIC & GAS COMPANY.

	Sep-08		Jun-08		Jan-09		Apr-09	
	Control	New Blowdown Discharge	Control	New Blowdown Discharge	Control	New Blowdown Discharge	Control	New Blowdown Discharge
Taxa Richness	11	8	9	19	15	11	12	5
Number of Specimens	146	175	61	339	129	125	107	94
EPT Index	2	2	0	1	2	2	1	1
EPT Abundance	2	20	0	4	4	4	1	1
Chironomidae Taxa	1	3	5	8	3	4	7	1
Chironomidae Abundance	17	9	13	55	52	11	10	4
EPT/Chironomidae Abundance	0.12	2.22	0.00	0.07	0.08	0.36	0.10	0.25
NCBI	7.17	5.96	7.40	8.04	8.64	8.02	7.17	7.90
SCDHEC Bioclassification	1.5	2	1.5	1	1	1	1.5	1
%C-F	73.29	37.71	40.98	68.73	28.68	54.40	31.78	25.53
%C-G	1.37	9.71	11.48	11.50	10.08	6.40	3.74	5.32
%OM	0.00	0.00	0.00	0.29	0.00	0.00	0.00	0.00
%P	15.07	29.14	4.92	8.26	37.21	17.60	9.35	0.00
%SC	10.27	23.43	42.62	10.91	21.71	20.80	54.21	69.15
%SH	0.00	0.00	0.00	0.29	0.00	0.80	0.93	0.00
SC/C-F	0.14	0.62	1.04	0.16	0.76	0.38	1.71	2.71
%Dom Taxon	73.29	36.57	40.98	68.14	27.13	54.40	51.40	55.32
# Dom Taxa	3	4	3	3	6	4	2	3

MEMORANDUM

To: Alan Stuart, Kleinschmidt Associates
From: Daniel Carnagey, Carnagey Biological Services, LLC
Date: 17 May 2013
Subject: Neal Shoals Macroinvertebrate Assessment of 10-11 April 2013

On 10-11 April 2013, personnel from CARNAGEY BIOLOGICAL SERVICES, LLC (SCDHEC Laboratory Certification No. 32010) and Kleinschmidt Associates conducted an instream benthic macroinvertebrate community rapid bioassessment on the Broad River, downstream of the Neal Shoals Dam operated by South Carolina Electric & Gas Company (SCE&G).

One sample was collected from each bank in each of the three segments specified in the study plan. Sampling lasted for 30 minutes on each bank. Sampling consisted of using a D-ring dip net to sample habitat along the bank, as well as examining submerged logs and rocks for invertebrates. The water depth did not allow for sampling at any distance from the bank.

RESULTS

A total of 905 specimens representing 86 taxa were collected from the six stations during this assessment. Bioassessment metrics for the 2013 collection are listed in Table 1. The number of specimens collected, their NCBI tolerance values, functional feeding groups, and relative abundance at each station are presented in Table 3. Tables 2 and 4 are the values for the Spring 2012 collections. Both have been corrected for the season (spring) and use the most up to date available tolerance values from SCDHEC (2012).

Comparison to Spring 2012 Assessment

With the exception of Segment 2, taxa richness and EPT index values were similar for the two years. In Segment 2, both were much higher in 2013. Spring 2013 EPT abundance was higher in Segments 2 and 3, and were very similar to 2012 in Segment 1. The 2013 North Carolina Biotic Index (NCBI) and SCDHEC bioclassifications scores were numerically better at all stations than in 2012.

Comparison to the 2008 and 2009 collections made in Parr Reservoir

As noted in a previous memo (21 June 2012), the Parr Reservoir metrics were much poorer in nearly all metrics than the Spring 2012 Neal Shoals collection. This is also true for the Spring 2013 collection. That memo should be referenced for the Parr Reservoir data and a short discussion of the difficulties in comparing these studies.

Conclusion

In conclusion, while the collections made in Spring 2012 and Spring 2013 were similar, the 2013 collections had better scores at all stations. This was especially true in Segment 2. The difference in EPT taxa between the two collections is the largest cause of this difference. Both of the Neal Shoals collections have shown much better metric scores than previous studies in Parr Reservoir.

Table 1. Bioassessment metrics for the six Broad River rapid bioassessment stations downstream from the Neal Shoals Dam operated by SOUTH CAROLINA ELECTRIC & GAS COMPANY, 10-11 April 2013.

	Sta. 1E	Sta. 1W	Sta. 2E	Sta. 2W	Sta. 3E	Sta. 3W
Taxa Richness	24	36	40	39	39	33
Number of Specimens	118	113	173	146	175	180
EPT Index	13	13	20	14	13	11
EPT Abundance	88	58	143	75	122	123
Chironomidae Taxa	7	13	9	10	15	13
Chironomidae Abundance	24	36	15	52	36	36
EPT/Chironomidae Abundance	3.67	1.61	9.53	1.44	3.39	3.42
NCBI	5.03	6.22	5.41	6.28	5.69	5.67
SCDHEC Bioclassification	3.7	2.7	4.2	2.8	3.2	3.0
%C-F	24.58	39.82	38.73	8.90	8.57	43.33
%C-G	19.49	9.73	5.78	30.82	52.57	10.56
%OM	0.00	2.65	0.00	1.37	0.57	0.00
%P	31.36	24.78	16.18	17.81	15.43	11.11
%SC	10.17	7.96	37.57	34.25	13.14	27.78
%SH	14.41	15.04	1.73	6.85	9.71	7.22
SC/C-F	0.41	0.20	0.97	3.85	1.53	0.64
SH/Total	0.14	0.15	0.02	0.07	0.10	0.07
%Dom Taxon	24.58	20.35	19.08	21.23	17.14	17.78
# Dom Taxa	8	5	5	3	5	6

Table 2. Bioassessment metrics for the six Broad River rapid bioassessment stations downstream from the Neal Shoals Dam operated by SOUTH CAROLINA ELECTRIC & GAS COMPANY, 24-25 April 2012.

	Sta. 1E	Sta. 1W	Sta. 2E	Sta. 2W	Sta. 3E	Sta. 3W
Taxa Richness	31	38	16	16	42	16
Number of Specimens	194	127	73	119	106	106
EPT Index	13	13	8	3	13	9
EPT Abundance	88	59	21	15	50	63
Chironomidae Taxa	12	9	3	1	8	2
Chironomidae Abundance	82	21	3	1	25	19
EPT/Chironomidae Abundance	1.07	2.81	7.00	15.00	2.00	3.32
NCBI	6.49	6.47	6.00	7.50	6.81	5.98
SCDHEC Bioclassification	2.2	2.3	2.3	1.2	2.0	2.3
%C-F	13.92	14.17	0.00	0.00	12.26	0.94
%C-G	11.34	6.30	5.48	10.08	30.19	17.92
%OM	1.55	0.79	5.48	1.68	6.60	0.00
%P	14.95	21.26	50.68	47.90	20.75	36.79
%SC	26.29	49.61	36.99	39.50	16.98	26.42
%SH	31.96	7.87	1.37	0.84	13.21	17.92
SC/C-F	1.89	3.50	-	-	1.38	28.00
SH/Total	0.32	0.08	0.01	0.01	0.13	0.18
%Dom Taxon	24.74	11.81	36.99	37.82	16.04	20.75
# Dom Taxa	7	6	5	7	5	7

Table 3. Macroinvertebrates, their NCBI tolerance values (TV), functional feeding groups (FG), and relative abundance for six Broad River rapid bioassessment stations downstream from the Neal Shoals Dam operated by SOUTH CAROLINA ELECTRIC & GAS COMPANY, 10-11 April 2013.

				No. of Individuals						Relative Abundance					
Seq	**Taxon**	**TV**	**FG**	**Sta. 1 E**	**Sta. 1 W**	**Sta. 2 E**	**Sta. 2 W**	**Sta. 3 E**	**Sta. 3 W**	**Sta. 1 E**	**Sta. 1 W**	**Sta. 2 E**	**Sta. 2 W**	**Sta. 3 E**	**Sta. 3 W**
Annelida															
Hirudinea															
Rhynchobdellida															
Glossiphoniidae															
1	Helobdella sp.	9.30	P						1.00						0.01
Oligochaeta															
Haplotaxida															
Lumbricidae															
2	Lumbricidae Genus species		SC			1						0.01			
Lumbriculida															
Lumbriculidae															
3	Eclipidrilus lacustris	7.33	SC			1						0.01			
Tubificida															
Naididae															
4	Branchiura sowerbyi	8.58	SC				2						0.01		
5	Dero sp.		SC		1	1	1	2	1.00		0.01	0.01	0.01	0.01	0.01
6	Limnodrilus sp.	9.80	SC				1						0.01		
7	Stylaria lacustris	9.70	SC						1.00						0.01
Arthropoda															
Arachnoidea															
Acariformes															
Hydrachnidae															
8	Hydrachna sp.	5.83	P	2						0.02					

* Functional feeding groups: CF = collector-filterer, CG = collector-gatherer, OM = omnivore, P = predator, SC = scraper, SH = shredder

Table 3. Continued.

				No. of Individuals						Relative Abundance					
Seq	**Taxon**	**TV**	**FG**	**Sta. 1 E**	**Sta. 1 W**	**Sta. 2 E**	**Sta. 2 W**	**Sta. 3 E**	**Sta. 3 W**	**Sta. 1 E**	**Sta. 1 W**	**Sta. 2 E**	**Sta. 2 W**	**Sta. 3 E**	**Sta. 3 W**
Insecta															
Coleoptera															
Elmidae															
9	Ancyronyx variegatus	6.79	CG			1		2	4.00			0.01		0.01	0.02
10	Dubiraphia quadrinotata	6.23	CG					1						0.01	
11	Macronychus glabratus	4.88	CG			1		4	2.00			0.01		0.02	0.01
Gyrinidae															
12	Dineutus discolor	5.84	P		1						0.01				
Haliplidae															
13	Peltodytes bradleyi	9.03	SH				1						0.01		
14	Peltodytes duodecimpunctatus	9.03	SH				1						0.01		
Noteridae															
15	Hydrocanthus atripennis	7.44	P	1						0.01					
Diptera															
Chironomidae															
16	Ablabesmyia mallochi	7.49	P		2	2	3	1			0.02	0.01	0.02	0.01	
17	Ablabesmyia peleensis	9.97	P		5	2		1	1.00		0.04	0.01		0.01	0.01
18	Brillia flavifrons	5.50	SH					1						0.01	
19	Chironomus sp.	9.93	CG					1	1.00					0.01	0.01
20	Corynoneura sp.		CG			2	2		2.00			0.01	0.01		0.01
21	Cricotopus sp.		SH		2			1	1.00		0.02			0.01	0.01
22	Dicrotendipes neomodestus	8.40	CG	1				2		0.01				0.01	
23	Eukiefferiella brehmi gr.	3.00	CG	2	3	1	2			0.02	0.03	0.01	0.01		
24	Hydrobaenus sp.	9.84	SC	3	1		1	1		0.03	0.01		0.01	0.01	
25	Nanocladius distinctus	7.37	CG		2				2.00		0.02				0.01
26	Omisus sp.		CG					3						0.02	

* Functional feeding groups: CF = collector-filterer, CG = collector-gatherer, OM = omnivore, P = predator, SC = scraper, SH = shredder

Table 3. Continued.

				No. of Individuals						Relative Abundance					
Seq	**Taxon**	**TV**	**FG**	**Sta. 1 E**	**Sta. 1 W**	**Sta. 2 E**	**Sta. 2 W**	**Sta. 3 E**	**Sta. 3 W**	**Sta. 1 E**	**Sta. 1 W**	**Sta. 2 E**	**Sta. 2 W**	**Sta. 3 E**	**Sta. 3 W**
Chironomidae cont.															
27	Orthocladius sp.		SH	8	6	1	5	2	2.00	0.07	0.05	0.01	0.03	0.01	0.01
28	Paralauterborniella nigrohalterale	5.07	CG			1						0.01			
29	Parametriocnemus sp.	3.95	CG	1					5.00	0.01					0.03
30	Polypedilum flavum	5.20	SH	8	2	1	1	2	10.00	0.07	0.02	0.01	0.01	0.01	0.06
31	Polypedilum halterale gr.	7.60	SH		3		1	7			0.03		0.01	0.04	
32	Polypedilum illinoense gr.	9.30	SH		2			2			0.02			0.01	
33	Rheocricotopus robacki	7.58	CG		2				2.00		0.02				0.01
34	Rheotanytarsus exiguus gr.	6.19	CF		2	2			7.00		0.02	0.01			0.04
35	Stictochironomus sp.	6.82	CG				31	6	1.00				0.21	0.03	0.01
36	Tanytarsus sp.	7.06	CF				2	2	1.00				0.01	0.01	0.01
37	Zavrelimyia sp.		P	1	4	3	4	4	1.00	0.01	0.04	0.02	0.03	0.02	0.01
Simuliidae															
38	Simulium slossanae		CF	2				1		0.02				0.01	
Tipulidae															
39	Tipula sp.	7.63	SH					1						0.01	
Ephemeroptera															
Baetidae															
40	Baetis intercalaris	5.29	CG	3	1					0.03	0.01				
41	Plauditus puntiventris	4.30	CG					30						0.17	
Caenidae															
42	Caenis sp.	7.71	CG		1		4	22			0.01		0.03	0.13	
Ephemerellidae															
43	Dannella simplex	3.91	CG	6	1	1	1	4		0.05	0.01	0.01	0.01	0.02	
44	Ephemerella sp.	2.34	CG	10	1	1		15		0.08	0.01	0.01		0.09	
45	Eurylophella funeralis	2.35	CG			1	5					0.01	0.03		

* Functional feeding groups: CF = collector-filterer, CG = collector-gatherer, OM = omnivore, P = predator, SC = scraper, SH = shredder

Table 3. Continued.

				No. of Individuals						Relative Abundance					
Seq	**Taxon**	**TV**	**FG**	**Sta. 1 E**	**Sta. 1 W**	**Sta. 2 E**	**Sta. 2 W**	**Sta. 3 E**	**Sta. 3 W**	**Sta. 1 E**	**Sta. 1 W**	**Sta. 2 E**	**Sta. 2 W**	**Sta. 3 E**	**Sta. 3 W**
	Ephemeridae														
46	Hexagenia limbata	5.20	CG			1						0.01			
	Heptageniidae														
47	Maccaffertium integrum	6.10	SC	2	3	25	24	10	27.00	0.02	0.03	0.14	0.16	0.06	0.15
48	Maccaffertium modestum	5.80	SC	6	3	33	20	8	14.00	0.05	0.03	0.19	0.14	0.05	0.08
49	Stenacron interpunctatum	7.17	SC			1	1	2				0.01	0.01	0.01	
	Isonychiidae														
50	Isonychia sp.	3.75	CF	2	5	19	1	5	24.00	0.02	0.04	0.11	0.01	0.03	0.13
	Leptophlebiidae														
51	Leptophlebia sp.	6.53	CG					2						0.01	
	Odonata														
	Aeshnidae														
52	Boyeria vinosa	6.19	P					1						0.01	
	Calopterygidae														
53	Calopteryx sp.	8.08	P					1						0.01	
	Coenagrionidae														
54	Argia moesta	8.47	P				2						0.01		
55	Argia tibialis	8.47	P			3	2					0.02	0.01		
56	Enallagma sp.	9.21	P		1	1	2				0.01	0.01	0.01		
	Gomphidae														
57	Erptogomphus designatus		P		1		1				0.01		0.01		
58	Gomphus sp.	6.10	P		1		1	1	1.00		0.01		0.01	0.01	0.01
	Libellulidae														
59	Epicordulia princeps	5.90	P			2	1					0.01	0.01		
60	Macromia taeniolata	6.46	P		2		1		2.00		0.02		0.01		0.01

* Functional feeding groups: CF = collector-filterer, CG = collector-gatherer, OM = omnivore, P = predator, SC = scraper, SH = shredder

Table 3. Continued.

				No. of Individuals						Relative Abundance					
Seq	**Taxon**	**TV**	**FG**	**Sta. 1 E**	**Sta. 1 W**	**Sta. 2 E**	**Sta. 2 W**	**Sta. 3 E**	**Sta. 3 W**	**Sta. 1 E**	**Sta. 1 W**	**Sta. 2 E**	**Sta. 2 W**	**Sta. 3 E**	**Sta. 3 W**
Plecoptera															
Nemouridae															
61	Amphinemura sp.	3.63	SH					1						0.01	
Perlidae															
62	Agnetina sp.	0.30	P	1						0.01					
63	Neoperla sp.	1.79	P			3	1					0.02	0.01		
64	Paragnetina fumosa	3.66	P			1						0.01			
65	Perlesta sp.	5.00	P	29	7	9	6	18	12.00	0.25	0.06	0.05	0.04	0.10	0.07
Perlodidae															
66	Isoperla bilineata	5.74	P	3	3	1			2.00	0.03	0.03	0.01			0.01
Pteronarcyidae															
67	Pteronarcys sp.	1.97	SH	1						0.01					
Trichoptera															
Hydropsychidae															
68	Cheumatopsyche sp.	6.52	CF	18	23	29	6	4	32.00	0.15	0.20	0.17	0.04	0.02	0.18
69	Hydropsyche incommoda	5.07	CF	6	7	1			4.00	0.05	0.06	0.01			0.02
70	Hydropsyche simulans/rossi		CF	1		3	2	1	2.00	0.01		0.02	0.01	0.01	0.01
71	Hydropsyche venularis	5.26	CF						4.00						0.02
Hydroptilidae															
72	Hydroptila sp.	6.52	SC			1						0.01			
Leptoceridae															
73	Nectopsyche exquisita	4.40	SH		2						0.02				
74	Oecetis persimilis	5.00	P		1	1	2				0.01	0.01	0.01		
Limnephilidae															
75	Pycnopsyche sp.	2.82	SH			1	1					0.01	0.01		

* Functional feeding groups: CF = collector-filterer, CG = collector-gatherer, OM = omnivore, P = predator, SC = scraper, SH = shredder

Table 3. Continued.

				No. of Individuals						Relative Abundance					
Seq	**Taxon**	**TV**	**FG**	**Sta. 1 E**	**Sta. 1 W**	**Sta. 2 E**	**Sta. 2 W**	**Sta. 3 E**	**Sta. 3 W**	**Sta. 1 E**	**Sta. 1 W**	**Sta. 2 E**	**Sta. 2 W**	**Sta. 3 E**	**Sta. 3 W**
	Philopotamidae														
76	Chimarra sp.	3.06	CF			3			1.00			0.02			0.01
	Polycentropodidae														
77	Neureclipsis crepuscularis	4.49	CF			8	1		1.00			0.05	0.01		0.01
Malacostraca															
	Amphipoda														
	Gammaridae														
78	Gammarus sp.	9.40	OM		1						0.01				
	Talitridae														
79	Hyalella azteca	8.05	OM				1						0.01		
	Decapoda														
	Cambaridae														
80	Cambaridae Genus species	7.80	OM					1						0.01	
Mollusca															
Bivalvia															
	Unionoida														
	Corbiculidae														
81	Corbicula fluminea	6.42	CF		8	2	1	2	2.00		0.07	0.01	0.01	0.01	0.01
Gastropoda															
	Limnophila														
	Lymnaeidae														
82	Lymnaea columella		SC	1						0.01					
	Physidae														
83	Physa sp.	9.14	SC			1						0.01			
	Planorbidae														
84	Helisoma anceps	6.53	SC			1						0.01			

* Functional feeding groups: CF = collector-filterer, CG = collector-gatherer, OM = omnivore, P = predator, SC = scraper, SH = shredder

Table 3. Continued.

				No. of Individuals						Relative Abundance					
Seq	**Taxon**	**TV**	**FG**	**Sta. 1 E**	**Sta. 1 W**	**Sta. 2 E**	**Sta. 2 W**	**Sta. 3 E**	**Sta. 3 W**	**Sta. 1 E**	**Sta. 1 W**	**Sta. 2 E**	**Sta. 2 W**	**Sta. 3 E**	**Sta. 3 W**
Mesogastropoda															
Pleuroceridae															
85	Goniobasis catenaria catenaria		SC		1				7.00		0.01				0.04
Platyhelminthes															
Turbellaria															
Tricladida															
Planariidae															
86	Dugesia tigrina	7.80	OM		2		1				0.02		0.01		

* Functional feeding groups: CF = collector-filterer, CG = collector-gatherer, OM = omnivore, P = predator, SC = scraper, SH = shredder

Table 4. Macroinvertebrates, their NCBI tolerance values (TV), functional feeding groups (FG), and relative abundance for six Broad River rapid bioassessment stations downstream from the Neal Shoals Dam operated by SOUTH CAROLINA ELECTRIC & GAS COMPANY, 24-25 April 2012.

				No. of Individuals						Relative Abundance					
Seq	**Taxon**	**TV**	**FG**	**Sta. 1 E**	**Sta. 1 W**	**Sta. 2 E**	**Sta. 2 W**	**Sta. 3 E**	**Sta. 3 W**	**Sta. 1 E**	**Sta. 1 W**	**Sta. 2 E**	**Sta. 2 W**	**Sta. 3 E**	**Sta. 3 W**
Annelida															
Hirudinea															
1	Hirudinea Genus species	5.30	P				1						0.01		
Rhynchobdellida															
Glossiphoniidae															
2	Helobdella sp.	9.30	P		1						0.01				
Oligochaeta															
Haplotaxida															
Lumbricidae															
3	Lumbricidae Genus species		SC					2						0.02	
Lumbriculida															
Lumbriculidae															
4	Eclipidrilus lacustris	7.33	SC		1						0.01				
5	Lumbriculus variegatus	7.33	SC		4			1			0.04			0.01	
Tubificida															
Naididae															
6	Branchiura sowerbyi	8.58	SC		1						0.01				
7	Pristina jenkinae		SC					1	1					0.01	0.01
8	Pristina osborni		SC		2						0.02				
9	Slavina appendiculata	7.36	CG	1						0.01					

* Functional feeding groups: CF = collector-filterer, CG = collector-gatherer, OM = omnivore, P = predator, SC = scraper, SH = shredder

Table 4. Continued.

				No. of Individuals						Relative Abundance					
Seq	**Taxon**	**TV**	**FG**	**Sta. 1 E**	**Sta. 1 W**	**Sta. 2 E**	**Sta. 2 W**	**Sta. 3 E**	**Sta. 3 W**	**Sta. 1 E**	**Sta. 1 W**	**Sta. 2 E**	**Sta. 2 W**	**Sta. 3 E**	**Sta. 3 W**
Arthropoda															
Insecta															
Coleoptera															
Dytiscidae															
10	Neoporus clypealis	8.92	P					1						0.01	
11	Neoporus dilatatus	8.92	P					6						0.06	
12	Neoporus striatopunctatus	8.92	P					1						0.01	
Elmidae															
13	Ancyronyx variegatus	6.79	CG				7						0.06		
14	Macronychus glabratus	4.88	CG		1	1	5	5	3		0.01	0.01	0.04	0.05	0.03
15	Stenelmis sp.	5.40	SC	2						0.01					
Haliplidae															
16	Peltodytes bradleyi	9.03	SH					1						0.01	
17	Peltodytes duodecimpunctatus	9.03	SH					1						0.01	
Hydrophilidae															
18	Sperchopsis tessellatus	6.43	CG					1						0.01	
Noteridae															
19	Hydrocanthus atripennis	7.44	P			1		1	1			0.01		0.01	0.01
Diptera															
Ceratopogonidae															
20	Bezzia/Palpomyia sp.	7.16	P		1			1			0.01			0.01	
Chironomidae															
21	Ablabesmyia mallochi	7.49	P	5	7			3		0.03	0.06			0.03	
22	Chironomus sp.	9.93	CG					1						0.01	
23	Corynoneura sp.		CG	3		1		2		0.02		0.01		0.02	

* Functional feeding groups: CF = collector-filterer, CG = collector-gatherer, OM = omnivore, P = predator, SC = scraper, SH = shredder

Table 4. Continued.

				No. of Individuals						Relative Abundance					
Seq	**Taxon**	**TV**	**FG**	**Sta. 1 E**	**Sta. 1 W**	**Sta. 2 E**	**Sta. 2 W**	**Sta. 3 E**	**Sta. 3 W**	**Sta. 1 E**	**Sta. 1 W**	**Sta. 2 E**	**Sta. 2 W**	**Sta. 3 E**	**Sta. 3 W**
	Chironomidae cont.														
24	Cricotopus sp.		SH	1						0.01					
25	Dicrotendipes neomodestus	8.40	CG	1						0.01					
26	Dicrotendipes sp.	8.40	CG			1						0.01			
27	Orthocladius sp.		SH	48	6			11		0.26	0.05			0.10	
28	Paratanytarsus sp.	8.75	CF		1						0.01				
29	Polypedilum fallax gr.	6.69	SH				1	1	16				0.01	0.01	0.15
30	Polypedilum flavum	5.20	SH	1	1					0.01	0.01				
31	Polypedilum illinoense gr.	9.30	SH	11	1	1			3	0.06	0.01	0.01			0.03
32	Polypedilum scalaenum gr.	8.70	SH	1						0.01					
33	Procladius sp.	9.40	P					2						0.02	
34	Pseudochironomus sp.	5.66	CG		1						0.01				
35	Tanytarsus sp.	7.06	CF	3	1			4		0.02	0.01			0.04	
36	Thienemanniella similis	6.20	CG	5						0.03					
37	Thienemanniella xena	6.20	CG	1	1			1		0.01	0.01			0.01	
38	Thienemannimyia gr.		P	2	2					0.01	0.02				
	Ephemeroptera														
	Baetidae														
39	Baetis intercalaris	5.29	CG	2	1	1		4	14	0.01	0.01	0.01		0.04	0.13
40	Heterocloeon sp.	3.78	SC	1		1		1	2	0.01		0.01		0.01	0.02
41	Procloeon sp.	5.30	OM	2	1	4	2	6		0.01	0.01	0.05	0.02	0.06	
	Caenidae														
42	Caenis sp.	7.71	CG		3			17			0.03			0.16	
	Ephemerellidae														
43	Dannella simplex	3.91	CG					1						0.01	

* Functional feeding groups: CF = collector-filterer, CG = collector-gatherer, OM = omnivore, P = predator, SC = scraper, SH = shredder

Table 4. Continued.

				No. of Individuals						Relative Abundance					
Seq	**Taxon**	**TV**	**FG**	**Sta. 1 E**	**Sta. 1 W**	**Sta. 2 E**	**Sta. 2 W**	**Sta. 3 E**	**Sta. 3 W**	**Sta. 1 E**	**Sta. 1 W**	**Sta. 2 E**	**Sta. 2 W**	**Sta. 3 E**	**Sta. 3 W**
	Heptageniidae														
44	Maccaffertium integrum	6.10	SC	18	13	7	12	6	8	0.10	0.11	0.10	0.10	0.06	0.08
45	Maccaffertium modestum	5.80	SC	4	10	2	1	3	1	0.02	0.09	0.03	0.01	0.03	0.01
46	Stenacron interpunctatum	7.17	SC	1	3	2				0.01	0.03	0.03			
	Isonychiidae														
47	Isonychia sp.	3.75	CF	1				3		0.01				0.03	
	Leptohyphidae														
48	Tricorythodes sp.	5.36	CG	3	1					0.02	0.01				
	Leptophlebiidae														
49	Leptophlebia sp.	6.53	CG						2						0.02
	Heteroptera														
	Gerridae														
50	Rheumatobates sp.		P		7	27	45		13		0.06	0.37	0.38		0.12
	Mesoveliidae														
51	Mesovelia mulsanti		P					1						0.01	
	Nepidae														
52	Ranatra nigra	8.10	P					1						0.01	
	Megaloptera														
	Corydalidae														
53	Corydalus cornutus	5.46	P		1						0.01				
	Odonata														
	Aeshnidae														
54	Boyeria vinosa	6.19	P					1						0.01	

* Functional feeding groups: CF = collector-filterer, CG = collector-gatherer, OM = omnivore, P = predator, SC = scraper, SH = shredder

Table 4. Continued.

				No. of Individuals						Relative Abundance					
Seq	**Taxon**	**TV**	**FG**	**Sta. 1 E**	**Sta. 1 W**	**Sta. 2 E**	**Sta. 2 W**	**Sta. 3 E**	**Sta. 3 W**	**Sta. 1 E**	**Sta. 1 W**	**Sta. 2 E**	**Sta. 2 W**	**Sta. 3 E**	**Sta. 3 W**
Coenagrionidae															
55	Argia apicalis	8.47	P				4						0.03		
56	Argia tibialis	8.47	P				5						0.04		
Gomphidae															
57	Gomphus consanguis	6.10	P			6		1				0.08		0.01	
58	Gomphus sp.	6.10	P				2						0.02		
Libellulidae															
59	Macromia illinoense	6.46	P		1						0.01				
Plecoptera															
Perlidae															
60	Acroneuria sp.		P		2						0.02				
61	Neoperla sp.	1.79	P		1				3		0.01				0.03
62	Perlesta sp.	5.00	P	20	4	3		2	22	0.11	0.04	0.04		0.02	0.21
Trichoptera															
Hydropsychidae															
63	Cheumatopsyche sp.	6.52	CF	12	3			1	1	0.07	0.03			0.01	0.01
64	Hydropsyche sp.		CF					4						0.04	
Hydroptilidae															
65	Hydroptila sp.	6.52	SC	16	15	1		1	10	0.09	0.13	0.01		0.01	0.09
Leptoceridae															
66	Ceraclea tarsipunctata	2.31	CG	6						0.03					
67	Oecetis persimilis	5.00	P	2						0.01					
68	Triaenodes sp.	4.76	SH		2						0.02				
Polycentropodidae															
69	Polycentropus sp.	3.83	P					1						0.01	

* Functional feeding groups: CF = collector-filterer, CG = collector-gatherer, OM = omnivore, P = predator, SC = scraper, SH = shredder

Table 4. Continued.

				No. of Individuals						Relative Abundance					
Seq	**Taxon**	**TV**	**FG**	**Sta. 1 E**	**Sta. 1 W**	**Sta. 2 E**	**Sta. 2 W**	**Sta. 3 E**	**Sta. 3 W**	**Sta. 1 E**	**Sta. 1 W**	**Sta. 2 E**	**Sta. 2 W**	**Sta. 3 E**	**Sta. 3 W**
Malacostraca															
Amphipoda															
Gammaridae															
70	Gammarus sp.	9.40	OM	1						0.01					
Talitridae															
71	Hyalella azteca	8.05	OM					1						0.01	
Cladocera															
Sididae															
72	Sida sp.		CF	1						0.01					
Isopoda															
Asellidae															
73	Caecidotea sp.	9.40	SC		3		10	1			0.03		0.08	0.01	
Mollusca															
Bivalvia															
Unionoida															
Corbiculidae															
74	Corbicula fluminea	6.42	CF	10	13			1							
Gastropoda															
Limnophila															
Physidae															
75	Physa sp.	9.14	SC	9	5		9	1	6	0.05	0.04		0.08	0.01	0.06
Planorbidae															
76	Helisoma anceps	6.53	SC				7						0.06		
77	Menetus dilatatus	8.53	SC		1		7	1			0.01		0.06	0.01	

* Functional feeding groups: CF = collector-filterer, CG = collector-gatherer, OM = omnivore, P = predator, SC = scraper, SH = shredder

Table 4. Continued.

				No. of Individuals						Relative Abundance					
Seq	**Taxon**	**TV**	**FG**	**Sta. 1 E**	**Sta. 1 W**	**Sta. 2 E**	**Sta. 2 W**	**Sta. 3 E**	**Sta. 3 W**	**Sta. 1 E**	**Sta. 1 W**	**Sta. 2 E**	**Sta. 2 W**	**Sta. 3 E**	**Sta. 3 W**
Mesogastropoda															
Pleuroceridae															
78	Goniobasis catenaria catenaria		SC		3	14	1				0.03	0.19	0.01		
Viviparidae															
79	Campeloma decisum	6.75	SC		2						0.02				

* Functional feeding groups: CF = collector-filterer, CG = collector-gatherer, OM = omnivore, P = predator, SC = scraper, SH = shredder

Exhibit E-5 Fisheries Resources

Monticello Reservoir Freshwater Mussel Reconnaissance Survey Study Plan

MONTICELLO RESERVOIR FRESHWATER MUSSEL RECONNAISSANCE SURVEY STUDY PLAN

PARR HYDROELECTRIC PROJECT (FERC NO. 1894)

Prepared for:

South Carolina Electric & Gas Company
Cayce, South Carolina

Prepared by:

Kleinschmidt

Lexington, South Carolina
www.KleinschmidtUSA.com

November 2013

MONTICELLO RESERVOIR FRESHWATER MUSSEL RECONNAISSANCE SURVEY

STUDY PLAN

PARR HYDROELECTRIC PROJECT

(FERC NO. 1894)

Prepared for:

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MONTICELLO RESERVOIR FRESHWATER MUSSEL RECONNAISSANCE SURVEY

PARR HYDROELECTRIC PROJECT
(FERC NO. 1894)

SOUTH CAROLINA ELECTRIC & GAS COMPANY

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PARR HYDROELECTRIC PROJECT
(FERC NO. 1894)

SOUTH CAROLINA ELECTRIC & GAS COMPANY

1.0 INTRODUCTION

The Parr-Fairfield Hydro Project (FERC No. 1894) (Project) is a 525 megawatt (MW) licensed hydroelectric facility owned and operated by South Carolina Electric & Gas (SCE&G). The Project consists of the Parr Hydro Development and the Fairfield Pumped Storage Development. Both developments are located along the Broad River in Fairfield and Newberry Counties, South Carolina (Figure 1).

The Parr Hydro Development forms Parr Reservoir along the Broad River. The Development consists of a 37-foot-high, 200-foot-long concrete gravity spillway dam with a powerhouse housing generating units with a combined licensed capacity of 14.9 MW. Parr Hydro operates in a modified run-of-river mode and normally operates to continuously pass Broad River flow. The 13-mile-long Parr Reservoir has a surface area of 4,400 acres at full pool and serves as the lower reservoir for pumped-storage operations.

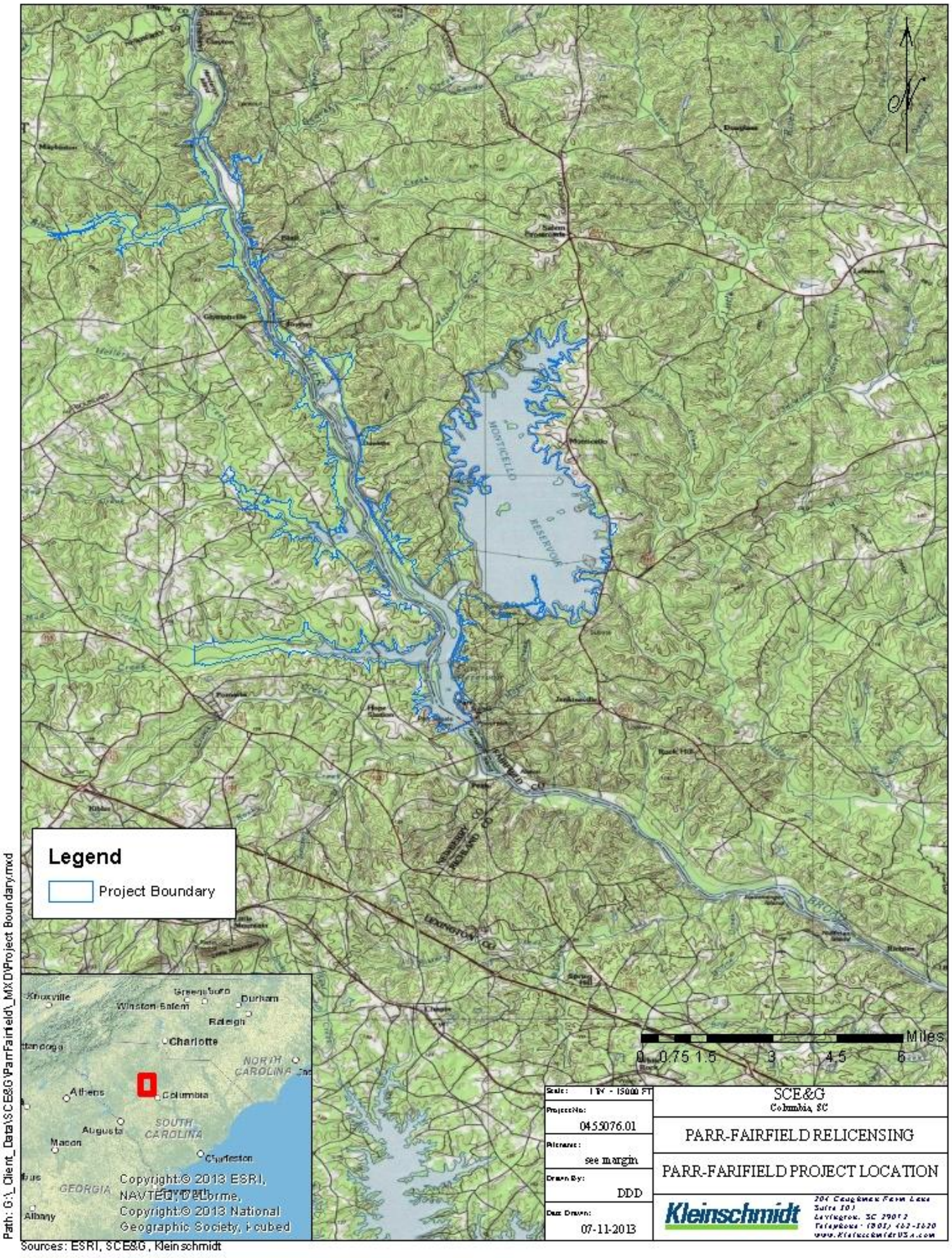
The Fairfield Pumped Storage Development is located directly off of the Broad River and forms the 6,800-acre upper reservoir, Monticello Reservoir, with four earthen dams. As noted, Parr Reservoir serves as the lower reservoir for pumped storage operations. The Fairfield Development has a licensed capacity of 511.2 MW and is primarily used for peaking operations, reserve generation, and power usage.

The Project is currently involved in a relicensing process which involves cooperation and collaboration between SCE&G, as licensee, and a variety of stakeholders including state and federal resource agencies, state and local government, non-governmental organizations (NGO’s), and interested individuals. Their collaboration and cooperation is essential to the identification of and treatment of operational, economic, and environmental issues associated with a new operating license for the Project. SCE&G has established several Technical Working

Committees (TWC's) with members from among the interested stakeholders with the objective of achieving consensus regarding the identification and proper treatment of these issues in the context of a new license.

During early meetings aimed at scoping appropriate relicensing studies, the Rare, Threatened and Endangered Species (RT&E) TWC requested information describing the status of freshwater mussels in Parr and Monticello reservoirs, as well as in the downstream reach of the Broad River influenced by Project operations. A subsequent TWC review of existing mussel data for the Project vicinity determined that recent surveys conducted by the South Carolina Department of Natural Resources (SCDNR) (Price, 2010) and Alderman Environmental Services (Alderman and Alderman, 2012) were adequate for characterizing the mussel fauna of Parr Reservoir and the downstream reach of the Broad. The TWC further determined that no such data were available for Monticello Reservoir; thus a qualitative survey would be needed. This Study Plan was prepared pursuant to that determination.

FIGURE 1 PROJECT LOCATION MAP



2.0 STUDY OBJECTIVE

The study objective will be to determine whether native freshwater mussels are present within the pool of Monticello Reservoir, and if so, gather qualitative data describing the diversity, spatial distribution and relative abundance of the mussel fauna inhabiting the lake.

3.0 GEOGRAPHIC AND TEMPORAL SCOPE

The reconnaissance survey described herein will focus on selected habitats within the Monticello Reservoir pool that are likely to support populations of native freshwater mussels. Surveys will be conducted in 2015, likely during the summer to early fall months when water clarity and temperatures are sufficiently high to support wading and other in-water survey methods.

4.0 METHODOLOGY

Freshwater mussel surveys in Monticello will utilize qualitative methods that allow for rapid coverage of larger survey areas and have proven more robust at determining diversity of surveyed areas (Miller and Payne, 1993). Qualitative surveys will involve timed visual and/or tactile inspections of suitable habitat for presence of live freshwater mussels and/or shell material and will be conducted by a qualified malacologist with expertise in Broad River fauna. Although the number and specific location of qualitative survey points will likely be refined in the field based on professional judgment of the lead malacologist, it is expected that a minimum of 30 representative sites will be distributed throughout the reservoir[1]. Particular attention will be placed upon the examination of potential Savannah lilliput (*Toxolasma pullus)* (federal At Risk Species and state Species of Concern) habitat within backwater areas of the reservoir.

Exact methods for conducting visual and tactile searches will vary depending on water depth. However, it should be noted that water levels on Monticello Reservoir typically fluctuate up to 4.5 ft daily as a result of pumping operations, and as such, mussel surveys will focus primarily on those areas below the 4.5 ft depth contour where mussels are likely to become established. Depending upon water depths, wading, batiscope, snorkeling, or SCUBA will be used to conduct timed surveys at each of the selected sites:

[1] It is estimated that each site will require an average of 30 man-minutes to conduct a reconnaissance level survey.

- Wading – Where water is relatively shallow, clear, and flat (no disturbances by wind), a biologist walks over an area to conduct a visual and/or tactile survey for live mussels and shells. This method is typically focused upon examinations of exposed near-shore habitats.
- Batiscope or snorkeling – In clear to slightly turbid waters up to 2 meters deep, or in waters with wind-disturbed surfaces, a batiscope or snorkeling will be used to conduct a visual and/or tactile survey for live mussels and shells.
- SCUBA – In survey areas of Monticello Reservoir with depths from 1 to 8+ meters, a biologist will traverse the lake bottom using SCUBA to conduct a visual and/or tactile survey for mussel species that prefer deeper waters and may not be detected at near-shore sites.

Live and fresh dead mussels collected during the survey will be identified to species, enumerated and returned to their habitat, although some shell material and/or live specimens may be preserved and returned to the laboratory for taxonomic confirmation. All sampling stations, as well as any significant mussel beds found during sampling, will be documented using a Global Positioning System (GPS) receiver. Mussel habitat surveyed at each sample location, as well the species collected during the survey, will also be photo documented. Basic water quality parameters (temperature, dissolved oxygen and conductivity) will be collected near the substrate at representative sample areas.

5.0 REPORTING

A report will be prepared for TWC review and comment. The report will document methods and results as encountered in the field including:

- A species list documenting the diversity of mussel fauna of Monticello Reservoir.
- GIS maps depicting spatial distribution of mussel populations.
- Tabular summaries comparing Catch per Unit Effort and relative abundance of species encountered.
- Water quality data from the survey period.

6.0 SCHEDULE AND REQUIRED CONDITIONS

As previously noted, it is expected that field surveys will be conducted during the summer or fall of 2015. It is expected that this effort will require 2-3 days of field work to complete. A final report summarizing the study findings will be issued subsequent to the completion of field work. The methodology for this survey may be revised or supplemented based on consultation with the RT&E TWC and other interested stakeholders.

7.0 USE OF STUDY RESULTS

Study findings will be used as an information resource during discussion of RT&E species issues and for developing potential Protection, Mitigation and Enhancement measures with the TWC and other relicensing stakeholders.

8.0 REFERENCES

Alderman, J.M. and J.D. Alderman. 2012. Freshwater Mussel Surveys within The Broad River, East of Hampton Island. Prepared by Alderman Environmental Services, Inc. for SCANA Services, Inc. October 29, 2012. 48 pp.

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Exhibit E-5 Fisheries Resources

Freshwater Mussel Survey Report

Freshwater Mussel Survey Report

In Monticello Reservoir
Parr Hydroelectric Project
(FERC No. 1894)

Fairfield and Newberry Counties, South Carolina

Monticello Reservoir Shoreline Habitat

Prepared For:

South Carolina Electric & Gas Company &

Kleinschmidt Associates
204 Caughman Farm Lane, Suite 301
Lexington, SC 29072

April 14, 2016

Prepared by:

Three Oaks Engineering
1000 Corporate Drive, Suite 101
Hillsborough, NC 27278

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1.0 INTRODUCTION

The Parr Hydro Project (FERC No. 1894) consists of the Parr Shoals Development and the Fairfield Pumped Storage Development; both are located along the Broad River in Fairfield and Newberry Counties, South Carolina. The Parr Shoals Development forms the lower reservoir, Parr Reservoir, along the Broad River. The Fairfield Pumped Storage Development is located directly off of the Broad River and forms the 6,800-acre upper reservoir, Monticello Reservoir, with four earthen dams. The Fairfield Development has a licensed capacity of 511.2 MW and is used for peaking operations, reserve generation, and power usage.

As part of the Federal Energy Regulatory Commission (FERC) re-licensing coordination, the Rare, Threatened and Endangered Species (RT&E) Technical Working Group made up of stakeholders including state and federal resource agencies requested information describing the status of freshwater mussels in Parr and Monticello reservoirs, as well as in the downstream reach of the Broad River influenced by Project operations. Review of existing freshwater mussel data for the Project vicinity determined that recent survey data existed and were adequate for characterizing the mussel fauna of Parr Reservoir and the downstream reach of the Broad River; thus, new survey information was only needed within Monticello Reservoir, and the Monticello Subimpoundment (herein referred to as the recreational lake) adjacent to the reservoir.

Three Oaks Engineering, Inc. (3Oaks) was retained to develop and implement a mussel survey plan for the Monticello Reservoir portion of the project area.

2.0 TARGET FEDERALLY PROTECTED SPECIES DESCRIPTION: Carolina Heelsplitter (*Lasmigona decorata*)

*2.1 Species Characteristic*s

The Carolina Heelsplitter, originally described as *Unio decoratus* by (Lea 1852), synonymized with *Lasmigona subviridis* (Conrad 1835, Johnson 1970), and later separated as a distinct species (Clarke 1985), is a federally Endangered freshwater mussel, historically known from several locations within the Catawba and Pee Dee River systems in North Carolina and the Pee Dee, Savannah, and possibly the Saluda River systems in South Carolina.

The Carolina Heelsplitter can reach a length of 118 mm, with a height of 68 mm and a width of 39 mm. Based on specimens collected by Keferl and Shelley (1988) from three different streams and rivers, the mean length is 78 mm, the mean height is 43 mm and the mean width is 27 mm. The shell is an ovate trapezoid. The dorsal margin is straight and may end with a slight wing. The umbo is flattened. The beaks are depressed and project a little above the hinge line. The beak sculpture is double looped. The unsculptured shell can have a yellowish, greenish or brownish periostracum. The Carolina Heelsplitter can have greenish or blackish rays. The lateral teeth may or may not be well developed; in most cases they are thin. The pseudo-cardinal teeth are lamellar and parallel to the dorsal margin, and there is a slight interdentum. The nacre varies from an iridescent white to a mottled pale orange. The shell's nacre is often pearly white to bluish white, grading to orange in the area of the umbo (Keferl 1991). The hinge teeth are well developed and heavy and the beak sculpture is double looped (Keferl and Shelly 1988). Morphologically, the shell of the Carolina Heelsplitter is very similar to the shell of the Green Floater (Clarke 1985), with the exception of a much larger size and thickness in the Carolina Heelsplitter (Keferl and Shelly 1988).

Prior to collections in 1987 and 1990 by Keferl (1991), the Carolina Heelsplitter had not been collected in the 20th century and was known only from shell characteristics. Because of its rarity, very little information of this species' biology, life history, and habitat requirements was known until very recently. Feeding strategy and reproductive cycle of the Carolina Heelsplitter have not been fully documented, but are likely similar to other native freshwater mussels (USFWS 1996).

The feeding processes of freshwater mussels are specialized for the removal (filtering) of suspended microscopic food particles from the water column (Pennak 1989). Documented food sources for freshwater mussels include detritus, diatoms, phytoplankton, and zooplankton (USFWS 1996).

Freshwater mussels have complex reproductive cycles, which include a larval stage (glochidium) that is an obligatory parasite on a fish. The glochidia develop into juvenile mussels and detach from the "fish host" and sink to the stream bottom where they continue to develop, provided suitable substrate and water conditions are available (USFWS 1996). For more details regarding general freshwater mussel reproductive biology, McMahon and Bogan (2001) and Pennak (1989) should be consulted.

At the time of listing, nothing was known about the host species(s) for the Carolina Heelsplitter (USFWS 1996, Bogan 2002). Starnes and Hogue (2005) identified the most likely fish host candidates (15 species) based on fish community surveys in occupied streams throughout the range of the Carolina Heelsplitter. Captive propagation efforts for this species had not been attempted in the past; however, due to the critical level of imperilment of the North Carolina populations, acting on recommendations from the NC Scientific Council on Mollusks, the NC Wildlife Resources Commission (NCWRC) funded a life history/captive propagation study, which allowed for salvage of individuals from the Goose/Duck and Sixmile Creek populations to be used in the study. A total of nine minnow species (Cyprinidae) were identified as suitable, and two sunfish species (*Lepomis* spp.) were identified as marginally suitable host species (Eads and Levine 2008, Eads et al. 2010). All of these species may occur in habitat types known to be occupied by the Carolina Heelsplitter; however, "it is always possible that it may use a combination of fish host species and some may not be native to all streams inhabited by this mussel" (Starnes and Hogue 2005). Another member of the genus *Lasmigona*, the Green Floater (*L. subviridis*), perhaps a close relative to the Carolina Heelsplitter, has been documented to be capable of in situ early development with glochidia developing within the marsupium of the female (Barfield and Watters 1998), thus it is possible that the Carolina Heelsplitter may also be able to propagate by direct transformation.

2.2 Distribution and Habitat Requirements

Currently, the Carolina Heelsplitter has a very fragmented, relict distribution. Until recently, it was known to be surviving in only six streams and one small river (USFWS 1996); however, recent discoveries have increased the number of known populations to eleven:

Pee Dee River Basin:
1. Duck Creek/Goose Creek - Mecklenburg/Union counties, NC
2. Flat Creek/Lynches River - Lancaster/Chesterfield/Kershaw counties, SC
Catawba River Basin:
3. Sixmile Creek (Twelvemile Creek Subbasin) - Lancaster County, SC
4. Waxhaw Creek - Union County, NC and Lancaster County, SC
5. Cane Creek/Gills Creek - Lancaster County, SC
6. Fishing Creek Subbasin - Chester County, SC
7. Rocky Creek Subbasin (Bull Run Creek/UT Bull Run Creek/Beaverdam Creek - Chester County, SC
Saluda River Basin:
8. Redbank Creek - Saluda County, SC
9. Halfway Swamp Creek- Greenwood/Saluda County, SC
Savannah River Basin:
10. Little Stevens Creek/Mountain Creek/Sleepy Creek /Turkey Creek (Stevens Creek Subbasin) - Edgefield/McCormick counties, SC.
11. Cuffytown Creek (Stevens Creek Subbasin) - Greenwood/McCormick counties, SC

All of these populations occur in stream reaches within the Piedmont Physiographic Province, particularly within two northeast trending lithostratigraphic belts of the Carolina Terrane, the Carolina Slate Belt and the Charlotte Belt. The Carolina Slate Belt is a band of greenschist faces metavolcanic rock formations positioned in the central and lower Piedmont province extending from south-central Virginia to extreme eastern Georgia (Howell 2005, Butler and Secor 1991). The Charlotte Belt extends from north central North Carolina to eastern Georgia and is comprised of amphibolite faces metavolcanic and metaplutonic rock (Howell 2005, Butler and Secor 1991). These hard formations strongly dictate the channel morphology and character of stream substrates where they intersect. Starnes and Hogue (2005) describe such reaches as "generally characterized by dark, often tilted, bedrock stream bottom with associated large and small rock rubble interspersed with pockets of sand, silt, and gravel." Habitat for this species has been reported from small to large streams and rivers as well as ponds. The ponds are believed to be millponds on some of the smaller streams within the species' historic range (Keferl 1991). Keferl and Shelly (1988) and Keferl (1991) reported that most individuals have been found along well-shaded streambanks with mud, muddy sand, or muddy gravel substrates; however, numerous individuals in several of the populations have been found in cobble and gravel dominated substrate in stream reaches intersecting the hard rock formations described above (T. W. Savidge personal observations). The stability of stream banks appears to be very important to this species (Keferl 1991).

2.3 Threats to Species

The cumulative effects of several factors, including sedimentation, point and non-point discharge, and stream modification (impoundments, channelization, etc.) have contributed to low numbers and restricted range of surviving populations; therefore, they are extremely vulnerable to extirpation from a single catastrophic event or activity (USFWS 1996).

Siltation resulting from improper sedimentation control of various land usage practices, including agriculture, forestry, and development activities, has been recognized as a major contributing factor to the degradation of mussel populations (USFWS 1996). Siltation has been documented to be extremely detrimental to mussel populations by degrading substrate and water quality, increasing potential exposure to other pollutants, and by direct smothering of mussels (Ellis 1936, Markings and Bills 1979). Sediment accumulations of less than one inch have been shown to cause high mortality in most mussel species (Ellis 1936). Feral hog (*Sus scrofa*) activity has been observed to be another source of siltation in a number of Carolina Heelsplitter populations (Tim Savidge, personal observations).

Loss of riparian buffers can lead to degradation of adjacent aquatic habitats. The role of forested riparian buffers in protecting aquatic habitats is well documented (NCWRC 2002). The Recovery Plan for the Carolina Heelsplitter (USFWS 1996) identifies the establishment of stream buffer zones as a major Recovery Objective (Task 1.4). Riparian buffers provide many functions including pollutant reduction and filtration, a primary source of carbon for aquatic food web, stream channel stability, and maintenance of water and air temperatures. Numerous studies have recommended a range of buffer widths needed to maintain these functions. Recommended widths vary greatly depending on the parameter or function evaluated. Wide contiguous buffers of 100-300 feet (30-91 meters) are recommended to adequately perform all functions (NCWRC 2002). The NCWRC recommends a minimum of 200 foot (61 meter) native, forested buffer on perennial streams and a 100 foot (30 meter) forested buffer on intermittent streams in watersheds that support federally endangered and threatened aquatic species (NCWRC 2002). Although not officially adopted, the USFWS uses the NCWRC recommendations as guidance when addressing federally protected aquatic species in North Carolina and South Carolina.

Other factors threatening mussel species include sewage treatment effluent (Goudreau et al. 1988), dams, and other impoundments (USFWS 1992a, Neves 1993, USFWS 1996, USFWS 1992b), and the introduction of exotic species such as the Asian Clam (*Corbicula fluminea*) and Zebra Mussel (*Dreissena polymorpha*) (Fuller and Powell 1973, USFWS 1996, Neves and Widlack 1987, Alderman 1995).

2.4 Designated Critical Habitat

In accordance of Section 4 of the ESA, Critical Habitat for listed species consists of:

(1) The specific areas within the geographical area occupied by the species at the time it is listed in which are found those physical or biological features (constituent elements) that are:

a. essential to the conservation of the species, and
b. which may require special management considerations or protection

(2) Specific areas outside the geographical area occupied by the species at the time it is listed in accordance with the provisions of Section 4 of the Act, upon a determination by the Secretary that such areas are "essential for the conservation of the species."

When designating Critical Habitat, the USFWS identifies physical and biological features (primary constituent elements) that are essential to the conservation of the species and that may require special management considerations or protection. The primary constituent elements essential for the conservation of the Carolina Heelsplitter (USFWS 2002) include:

1. permanent flowing, cool, clean water
2. geomorphically stable stream and river channels and banks
3. pool, riffle, and run sequences within the channel
4. stable substrates with no more than low amounts of fine sediment
5. moderate stream gradient
6. periodic natural flooding
7. fish hosts, with adequate living, foraging, and spawning areas for them.

Critical habitat for the Carolina Heelsplitter was designated in 2002 (USFWS 2002). The designated area totals approximately 92 miles (148 kilometers) of nine creeks and one river in North and South Carolina. These areas are considered essential to the conservation of the Carolina Heelsplitter. Six areas (Units) have been designated as critical habitat and a description of each follows.

Unit 1: Goose Creek and Duck Creek (Pee Dee River System), Union County, NC

Unit 1 encompasses approximately 4.5 miles (7.2 km) of the main stem of Goose Creek, Union County, NC, from the N.C. Highway 218 Bridge, downstream to its confluence with the Rocky River, and approximately 6.4 mi (10.3 km) of the main stem of Duck Creek, Union County, NC, from the Mecklenburg/Union County line downstream to its confluence with Goose Creek. The Carolina heelsplitter was first discovered in Goose Creek in 1987 (Keferl 1991) and in Duck Creek in 2000 (NCWRC Database). Between 1993 and 1999, a total of 15 live individuals had been recorded in Goose Creek. NCWRC surveys in early 2002, found 16 live individuals in Duck Creek (NCWRC Database); however, following extreme drought conditions in late 2002, where much of the streambed in both creeks was dry, status surveys in Duck Creek yielded only four live and more than 40 fresh dead. One fresh-dead shell was also found in Goose Creek during the 2002 drought surveys just below US 601. Pools and wet streambeds were much more common in lower Goose Creek, apparently providing refuge from desiccation during the drought. Between 2004 and 2005, four live individuals were found at two locations within Goose Creek, and 12 live individuals were found at six locations within Duck Creek. Prolonged severe drought conditions persisted in the Goose Creek watershed in 2006 through 2007. A total of nine individuals have been found in Duck Creek between 2006 and 2009. Three of the individuals were found on more than one occasion. Four of these individuals were taken into captivity, as much of the stream channel was dry when they were found. A survey conducted in

2011 of the critical habitat portion of Goose Creek, from the Rocky River confluence to the NC 218 crossing, located a total of 12 live individuals and one fresh dead shell (Catena 2012a). All of the live individuals were taken into captivity for a joint propagation effort between North Carolina State University and the North Carolina Wildlife Resources Commission. The majority of the individuals were estimated to be <5 years of age based on shell condition and growth rests, indicating relatively recent reproduction. Repeated survey efforts in Duck Creek in 2011 and 2012 have not located any live individuals post drought.

Unit 2: Waxhaw Creek (Catawba River System), Union County, NC

Unit 2 encompasses approximately 12.2 mi (19.6 km) of the main stem of Waxhaw Creek, Union County, NC, from the N.C. Highway 200 Bridge, downstream to the North Carolina/South Carolina state line. Very few Carolina Heelsplitter individuals have been found in Waxhaw Creek since they were first discovered in 1987. Keferl (1991) found one live individual in 1987 and two in 1990. Subsequent surveys failed to find any individuals until one weathered shell was found in 1996, followed by one live individual in 1998, one weathered shell in 2005, and three live individuals at three separate sites in 2006 (NCWRC Database). Surveys of Waxhaw Creek in South Carolina, conducted in 2004, documented only two live individuals at a single site – one of only a couple of sites in the stream below the North Carolina/South Carolina state line that appeared to provide suitable substrate for the Heelsplitter (USFWS 2007). On-going surveys conducted in 2015 have yielded ten individuals to date (Tim Savidge, personal observations).

Unit 3: Gills Creek (Catawba River System), Lancaster County, SC

Unit 3 encompasses approximately 6.0 mi (9.6 km) of the main stem of Gills Creek, Lancaster County, SC, from the County Route S-29-875, downstream to the SC Route 51 Bridge, east of the City of Lancaster. One 88.0 mm fresh shell and one 67.0 mm live individual discovered in 1998, represent this population (Alderman 1998). No additional surveys have been completed in this section of Gills Creek since 1998. In 2006, Catena discovered the species (two live and one shell) at three sites in Cane Creek, a tributary to Gills Creek (USFWS 2007). One weathered shell was found in 2015 (Tim Savidge, personal observations). While Cane Creek is not within the boundaries of Unit 3, Gills Creek and Cane Creek are considered a single population from a management perspective, as there are no physical barriers that would isolate the two areas. The discovery of the Carolina Heelsplitter in Cane Creek demonstrates that this population has been reduced to small pockets of habitat in the watershed.

Unit 4: Flat Creek (Pee Dee River System), Lancaster County, SC, and the Lynches River (Pee Dee River System), Lancaster, Chesterfield, and Kershaw Counties, SC

Unit 4 encompasses approximately 11.4 mi (18.4 km) of the main stem of Flat Creek, Lancaster County, SC, from the SC Route 204 Bridge, downstream to its confluence with the Lynches River, and approximately 14.6 mi (23.6 km) of the main stem of the Lynches River, Lancaster and Chesterfield Counties, SC, from the confluence of Belk Branch, Lancaster County, northeast (upstream) of the U.S. Highway 601 Bridge, downstream to the SC Highway 903 Bridge in Kershaw County, SC. Within this unit, the Lynches River local population is represented most recently (2005 to 2007) by 14 live and two fresh dead shells (54-87mm) found above SC 265 Chesterfield/Lancaster Co. SC in 2007 (USFWS 2007, USFWS 2012). Between 1994 and 1997, the Flat Creek local population was represented by 28 live individuals ranging in length from 54.15 to 94.1 mm and by four shells ranging in length from 41.0 to 86.1 mm (Alderman 1998). In 2007, Alderman conducted surveys of two reaches of Flat Creek, one in upper Flat Creek and one in middle-lower Flat Creek, and documented 16 live Carolina Heelsplitter individuals, including several age classes, some likely less than five years of age based on shell measurements (USFWS 2007). In 2010, Alderman found 42 live and one weathered shell in Flat Creek, with a large number of size classes represented (Alderman 2010, pers. comm.).

Multiple survey efforts have been conducted in 2014 and 2015 in this unit and numerous individuals were found in both Flat Creek and the Lynches River. This data is not readily available at the time of writing this report (Tim Savidge, John Fridell, personal communication).

Unit 5: Mountain and Beaverdam Creeks (Savannah River System), Edgefield County, SC, and Turkey Creek (Savannah River System), Edgefield and McCormick Counties, SC

Unit 5 encompasses approximately 7.0 mi (11.2 km) of the main stem of Mountain Creek, Edgefield County, SC, from the SC Route 36 Bridge, downstream to its confluence with Turkey Creek; approximately 6.7 mi (10.8 km) of Beaverdam Creek, Edgefield County, from the SC Route 51 Bridge, downstream to its confluence with Turkey Creek; and approximately 11.4 mi (18.4 km) of Turkey Creek, from the SC. Route 36 Bridge, Edgefield County, downstream to the SC Route 68 Bridge, Edgefield and McCormick Counties, SC.

The Mountain Creek local population is represented by 15 live individuals ranging in length from 38.7 to 84.9 mm and by 15 shells ranging in length from 53.0 to 98.0 mm (Alderman 1998, 2002). During 2002, two additional local populations of Carolina Heelsplitter were discovered within the Turkey Creek Subbasin, one in Little Stevens Creek represented by a shell fragment, and one in Sleepy Creek represented by seven live individuals ranging in length from 51.1 to 73.0 mm and by three shells ranging in length from 61.4 to 71.0 mm (Alderman 2002). Seven live and one moribund individuals were documented in Little Stevens Creek in 2007 (USFWS 2007).

The Turkey Creek local population is represented by a few shells discovered in 1995, and by one live individual discovered in 1997 (Mcdougal 1997). Ten 10 individuals were found at eight locations in 2012-2013 (Catena 2013), and one individual was found just above the SC 68 bridge in December 2015 (Tim Savidge, personal observation). Within this unit, only a single shell of the Carolina Heelsplitter has been found in Beaverdam Creek (Alderman 1995) and additional surveys of the stream have failed to locate any individuals (USFWS 2007). This portion of the population may be extirpated or exist only in very low numbers (USFWS 2007).

A single shell of the Carolina Heelsplitter was found in Beaverdam Creek (Alderman 1995) and additional surveys of the stream failed to locate any individuals, and it was suggested that this portion of the population may have extirpated or exist only in very low numbers (USFWS 2007). However, two live individuals and three fresh shells were found in 2015 (Three Oaks 2015).

Unit 6: Cuffytown Creek (Savannah River System), Greenwood and McCormick Counties, SC

Unit 6 encompasses approximately 12.9 mi (20.8 km) of the main stem of Cuffytown Creek, from the confluence of Horsepen Creek, northeast (upstream) of the SC Route 62 Bridge in Greenwood County, SC, downstream to the U.S. Highway 378 Bridge in McCormick County. Within this unit, the population is represented by five live individuals (three discovered in 1998 and two discovered in 2001) with lengths ranging from 53.5 to 71.5 mm and by one shell discovered in 1998 with a length of 63.0 mm (Alderman 1998, 2002).

Five of the eleven Carolina Heelsplitter populations listed in Section 2.2: Sixmile Creek, Fishing Creek, Rocky Creek, Redbank Creek, and Halfway Swamp Creek, were discovered after Critical Habitat was designated. Like most of the other Carolina Heelsplitter populations, these populations are also limited in size and distribution. Live individuals have been found in 2015 in the Sixmile Creek (Tom Dickinson, personal observations), Fishing Creek and Rocky Creek populations (Tim Savidge, personal observations).

3.0 TARGET PETITIONED FEDERALLY PROTECTED SPECIES DESCRIPTION: Savannah Lilliput (*Toxolasma pullus*)

3.1 Species Characteristics

Savannah Lilliput was described by Conrad (1838) from the Wateree River in South Carolina, this species ranges from the Altamaha River basin in Georgia north to the Neuse River basin in North Carolina (Johnson 1970). The Savannah Lilliput is a small mussel with an oval or elliptical shell. The color of the shell is usually blackish but can also be brownish, greenish or olive with fine, green rays. A large individual's metrics would range from 30-35 mm long with a height of 19-20 mm and a width of 15-16 mm. Shells are usually inflated with a broadly rounded to angular double posterior ridge. Shells are sexually dimorphic. Periostracum is coarse due to numerous closely spaced growth lines and is blackish to brown-greenish with fine rays that are usually not visible. Nacre is bluish white with a pink to purplish iridescence towards the posterior. Individuals from the lower Savannah River have a slight different morphology and were once thought to be a different species (Bates 1966).

3.2 Distribution and Habitat Requirements

The historical range of the Savannah Lilliput included the Neuse River basin in North Carolina to the Altamaha basin in Georgia (Bogan and Alderman 2004). After rapid decline the range has been narrowed to select areas. In South Carolina, it has been recently found in the Pee-Dee, Santee, and Savannah River basins.

The species is found in creeks, rivers, and impounded habitats; it is rarely found in deeper lake waters. It is typically located in sand, silty-sand or mud substrates and appears to prefer near shore, still or low velocity shallow water habitats. The fish host species for the Savannah Lilliput is unknown (Bogan and Alderman 2004).

3.3 *Threats to Species*

Due to its distribution in shallow water, the Savannah Lilliput is susceptible to droughts, water drawdowns and off-road vehicle traffic. One particular event in January 2005, during a draw down in Lake Marion, SC, which is occupied by this species, resulted in numerous mussels stranded on near the shoreline attempting to move to lower water; many had dried up on the banks. The small size and limited distribution of many of this species populations make it vulnerable to events such as these.

4.0 SURVEY EFFORTS

In order to provide current data on the freshwater mussel fauna with regards to species composition, distribution, and relative abundance within the FERC project boundary, qualitative surveys were conducted in both the recreational and main lake of Monticello Reservoir (Figure 1).

4.1 Mussel Surveys for this Project

Surveys were conducted by 3Oaks personnel Tom Dickinson, Tim Savidge, and Evan Morgan on September 16-17, 2015, and by Tim Savidge and Nathan Howell on November 06, 2015. Nicole Riddle of SCDOT provided support for survey efforts on November 06. Weather conditions were sunny and warm during the September 16-17 surveys, and cloudy/rainy and cool during the November 06 surveys. The water was very clear during all surveys.

4.2 Methodology

Visual surveys were conducted using SCUBA and mask/snorkel techniques. Personnel using mask and snorkel covered a depth range of 0-3 feet (ft), while personnel using SCUBA covered a depth range of 3-18 ft. Surveys began at a distinct point along the shoreline and the surveyors evaluated the substrate for mussels from the shoreline out to a point where mussels were no longer present. Generally, mussels were present at depths of 2-4 ft down to 15-18 ft. The depth at which mussels were found varied from site to site, but were more related to water levels at the time than distance from the shoreline, as there is a wide daily fluctuation in water levels within the reservoir. Surveys began at approximately 9:00 am on all three days and ended at 7:00 pm on September 16-17 and at 6:00 pm on November 06. Water levels, measured as pool elevation dropped steadily from the beginning to the end of the surveys on all three days:

a) 09-16: 423.7204895 ft. to 422.7026062 ft.

b) 09-17: 423.8225098 ft. to 422.1596985 ft.

c) 11-06: 423.3981934 ft. to 422.5299988 ft.

Survey sites are denoted by the last two digits of the year (15 for 2015), followed by the two-digit month (09 for September, etc.) and two-digit day followed by a period and the survey number for that date (i.e.1,2,3….) and the initials for the survey lead (tws for Tim Savidge, or ted for Tom Dickinson). For instance, the first survey conducted on September 16 by Tom Dickinson corresponds to site 150916.1ted.

Ten survey locations were larger in area than the others in terms of a starting and endpoint and overlapped. These sites were combined as appropriate due to proximity into five sites (150916.4ted, 150917.8ted, 151106.3tws, 151106.6tws and 151106.7tws).

All freshwater bivalves were recorded and returned to the substrate. Representative photographs of each species were taken. Timed survey efforts provided Catch per Unit Effort (CPUE) data for each species found. Relative abundance estimates for freshwater snails and freshwater clam species were developed using the following criteria:

- (VA) Very abundant > 30 per square meter
- (A) Abundant 16-30 per square meter
- (C) Common 6-15 per square meter
- (U) Uncommon 3-5 per square meter
- (R) Rare 1-2 per square meter
- (P-) Ancillary adjective "Patchy" indicates an uneven distribution of the species within the sampled site.

5.0 RESULTS

Six species of freshwater mussels were found in Monticello Reservoir, only one of which was found within the recreational lake (relict shell evidence only). The survey results for each site are presented below.

5.1 Site 150916.1ted

This site was located at the mouth of a cove on the southeast side of the recreational lake, and was surveyed to a depth of 10 ft. The substrate along the shoreline consisted of mud and gradually transitioned to a sandy mud in the deeper areas. Large mats of Water Willow (*Justicia americana*) occurred along the shoreline. Surveys were conducted for 1.0 person hour, and one relict shell of the Paper Pondshell (*Utterbackia imbecillis*) was found. Other mollusk species found include the Japanese Mysterysnail (*Cipangopaludina japonica*) and the Asian Clam (*Corbicula fluminea*), which were uncommon (Table 1). Although live individuals of the Asian Clam were uncommon, relict shells were fairly common suggesting a large die off in recent years.

Table 1. Results in Monticello Reservoir Recreational Lake, Site 150916.1ted

Scientific Name	Common Name	Number	CPUE (#/hr)
Freshwater Mussels			
Utterbackia imbecillis	Paper Pondshell	1 shell	~

Freshwater Snails and Clams			Relative Abundance
Cipangopaludina japonica	Japanese Mysterysnail	~	U
Corbicula fluminea	Asian Clam	~	U

5.2 Site 150916.2ted

This site was located at the upper portion of the cove where Site # 150916.1ted is located. Habitat conditions were similar to the site at the mouth of the cove; with the exception of maximum depth, which was 6 ft. Surveys were conducted for 1.17 person hours. Relict shells of the Japanese Mysterysnail and Asian Clam were found in low numbers (Table 2).

Table 2. Results in Monticello Reservoir Recreational Lake, Site 150916.2ted

Scientific Name	Common Name	Number	CPUE (#/hr)
Freshwater Mussels			
None	~	~	~
Freshwater Snails and Clams			**Relative Abundance**
Cipangopaludina japonica	Japanese Mysterysnail	~	Shell only
Corbicula fluminea	Asian Clam	~	Shell Only

5.3 Site 150916.3ted

This site was located along a large point in the northeast portion of the recreational lake. The substrate consisted of large accumulations of silt over gravel. Surveys were conducted from the shoreline down to a depth of 12 ft for 1.0 person hour. Relict shells of the Asain Clam were uncommon (Table 3).

Table 3. Results in Monticello Reservoir Recreational Lake, Site 150916.3ted

Scientific Name	Common Name	Number	CPUE (#/hr)
Freshwater Mussels			
None	~	~	~
Freshwater Snails and Clams			**Relative Abundance**
Corbicula fluminea	Asian Clam	~	Shell Only

5.4 Site 150916.4ted

This combined site was located on both sides of the northern most cove within the recreational lake; surveys were conducted along both shorelines as well as in the middle of the cove, which had a maximum depth of 15 ft. The substrate consisted of mud and sand. Surveys were conducted for 2.0 person hours, and live individuals of the Asian Clam were rare; however, relict shells were fairly common (Table 4).

Table 4. Results in Monticello Reservoir Recreational Lake, Site 150916.4ted

Scientific Name	Common Name	Number	CPUE (#/hr)
Freshwater Mussels			
None	~	~	~
Freshwater Snails and Clams			**Relative Abundance**
Corbicula fluminea	Asian Clam	~	R

5.5 Site 150916.5ted

This site was located along a wide point in the northwest portion of the recreational lake. Several old pilings were present in this area. The substrate consisted of sand with submerged and emergent vegetation. Surveys were conducted to a depth of 6.5 ft for 1.0 person hour. The Asian Clam was found in low numbers (Table 5).

Table 5. Results in Monticello Reservoir Recreational Lake, Site 150916.5ted

Scientific Name	Common Name	Number	CPUE (#/hr)
Freshwater Mussels			
None	~	~	~
Freshwater Snails and Clams			**Relative Abundance**
Corbicula fluminea	Asian Clam	~	R

5.6 Site 150916.6ted

This site was located within the vicinity of the swimming area of the recreational lake. Substrate consisted of sand and clay. Surveys were conducted to a maximum depth of 8 ft for 1.50 person hours. The Asian Clam was rare (Table 6).

Table 6. Results in Monticello Reservoir Recreational Lake, Site 150916.6ted

Scientific Name	Common Name	Number	CPUE (#/hr)
Freshwater Mussels			
None	~	~	~
Freshwater Snails and Clams			**Relative Abundance**
Corbicula fluminea	Asian Clam	~	R

5.7 Site 150916.7ted

This site was located within the recreational lake along the causeway that separates the lake from Monticello Reservoir. The substrate consisted of rock rip/rap with sand and silt in-between. Surveys were conducted to a depth of 8 ft for 0.67 person hour. Asian Clam shells were uncommon as were live Japanese Mystersnail individuals (Table 7).

Table 7. Results in Monticello Reservoir Recreational Lake, Site 150916.7ted

Scientific Name	Common Name	Number	CPUE (#/hr)
Freshwater Mussels			
None	~	~	~
Freshwater Snails and Clams			**Relative Abundance**
Cipangopaludina japonica	Japanese Mysterysnail	~	Uncommon
Corbicula fluminea	Asian Clam	~	Shell Only

5.8 Site 150916.8ted

This site was located off a point in the northeast portion of Monticello Reservoir. The substrate consisted of sand overlain with silt. Surveys were conducted from the shoreline to a maximum depth of 14 ft; however, the majority of mussels were found between 4 and 10 ft. Three native freshwater mussel species, the Carolina Lance (*Elliptio angustata*), Eastern Floater (*Pyganadon cataracta*) and Eastern Creekshell (*Villosa delumbis*) were found, along with the Asian Clam, Japanese Mysterysnail and the Banded Mysterysnail (*Viviparus georgianus*) in 1.5 person hours (Table 8).

Table 8. Results in Monticello Reservoir, Site 150916.8ted

Scientific Name	Common Name	Number	CPUE (#/hr)
Freshwater Mussels			
Elliptio angustata	Carolina Lance	12	8.0/hr
Pyganadon cataracta	Eastern Floater	39	26.0/hr
Villosa delumbis	Eastern Creekshell	5	3.3/hr
Freshwater Snails and Clams			**Relative Abundance**
Cipangopaludina japonica	Japanese Mysterysnail	~	C
Corbicula fluminea	Asian Clam	~	C
Viviparus georgianus	Banded Mysterysnail	~	R

5.9 Site 150916.9ted

This site was located in the vicinity of a small island in the northeast portion of Monticello Reservoir. Surveys were conducted on both sides of the island from the shoreline to a maximum depth of 14 ft. The substrate consisted of a mixture of sand and gravel. Three mussel species, the Carolina Lance, Eastern Floater and Florida Pondhorn (*Uniomerus carolinianus*) were found in 1.75 person hours (Table 9.

Table 9. Results in Monticello Reservoir, Site 150916.9ted

Scientific Name	Common Name	Number	CPUE (#/hr)
Freshwater Mussels			
Elliptio angustata	Carolina Lance	18	10.29/hr
Pyganadon cataracta	Eastern Floater	41	23.43/hr
Uniomerus carolinianus	Florida Pondhorn	1	0.57/hr
Freshwater Snails and Clams			**Relative Abundance**
Cipangopaludina japonica	Japanese Mysterysnail	~	C
Corbicula fluminea	Asian Clam	~	C
Viviparus georgianus	Banded Mysterysnail	~	R

5.10 Site 150917.1ted

This site was located along a broad point on the western shore in the central portion of Monticello Reservoir. Surveys were conducted from the shoreline to a maximum depth of 15 feet; however, the majority of mussels were found between 5 and 10 ft deep. The substrate consisted of sand overlain with silt. Five mussel species were found in 1.5 person hours (Table 10).

Table 10. Results in Monticello Reservoir, Site 150917.1ted

Scientific Name	Common Name	Number	CPUE (#/hr)
Freshwater Mussels			
Elliptio angustata	Carolina Lance	53	29.3/hr
Pyganadon cataracta	Eastern Floater	47	5.3/hr
Uniomerus carolinianus	Florida Pondhorn	2	8.0/hr
Utterbackia imbecillis	Paper Pondshell	3	7.3/hr
Villosa delumbis	Eastern Creekshell	3	
Freshwater Snails and Clams			**Relative Abundance**
Cipangopaludina japonica	Japanese Mysterysnail	~	C
Corbicula fluminea	Asian Clam	~	C
Viviparus georgianus	Banded Mysterysnail	~	PC

5.11 Site 150917.2ted

This site was located along the west shoreline on the north side of a large peninsula in the central portion of Monticello Reservoir. Surveys were conducted to a maximum depth of 14 ft; however, the majority of effort was located between 6 to 8 ft. The substrate consisted of a mixture of sand and mud. Five mussel species were found in 1.0 person hours (Table 11).

Table 11. Results in Monticello Reservoir, Site 150917.2ted

Scientific Name	Common Name	Number	CPUE (#/hr)
Freshwater Mussels			
Elliptio angustata	Carolina Lance	123	123.0/hr
Pyganadon cataracta	Eastern Floater	76	76.0/hr
Unimoerus carolinianus	Florida Pondhorn	2	2.0/hr
Utterbackia imbecillis	Paper Pondshell	5	5.0/hr
Villosa delumbis	Eastern Creekshell	10	10.0/hr
Freshwater Snails and Clams			**Relative Abundance**
Cipangopaludina japonica	Japanese Mysterysnail	~	C
Corbicula fluminea	Asian Clam	~	VA
Viviparus georgianus	Banded Mysterysnail	~	U

5.12 Site 150917.3ted

This site was located along the west shore within a small cove in the north-central portion of Monticello Reservoir. Surveys were conducted to a maximum depth of 14 ft; however, the majority of effort occurred between 6 to 8 ft. The substrate consisted of a mixture of sand and cobble. Four mussel species were found in 1.67 person hours (Table 12).

Table 12. Results in Monticello Reservoir, Site 150917.3ted

Scientific Name	Common Name	Number	CPUE (#/hr)
Freshwater Mussels			
Elliptio angustata	Carolina Lance	24	14.4/hr
Pyganadon cataracta	Eastern Floater	34	20.4/hr
Utterbackia imbecillis	Paper Pondshell	3	1.84/hr
Villosa delumbis	Eastern Creekshell	6	3.6/hr
Freshwater Snails and Clams			**Relative Abundance**
Cipangopaludina japonica	Japanese Mysterysnail	~	C
Corbicula fluminea	Asian Clam	~	C
Viviparus georgianus	Banded Mysterysnail	~	C

5.13 Site 150917.4ted

This site was located along the west shoreline in the south central portion of Monticello Reservoir. The shoreline has been armored with rip rap to stabilize the adjacent roadbed. Surveys were conducted to a maximum depth of 18 ft; however, the majority of effort occurred between 6 and 8 ft. The substrate consisted of a mixture of sand and gravel beyond the rip rap. All six mussel species found during this survey effort were found in 1.23 person hours (Table 13).

Table 13. Results in Monticello Reservoir, Site 150917.4ted

Scientific Name	Common Name	Number	CPUE (#/hr)
Freshwater Mussels			
Elliptio angustata	Carolina Lance	69	56.1/hr
Pyganadon cataracta	Eastern Floater	50	40.7/hr
Uniomerus carolinianus	Florida Pondhorn	10	8.1/hr
Utterbackia imbecillis	Paper Pondshell	4	3.7/hr
Villosa delumbis	Eastern Creekshell	12	9.8/hr
Villosa vaughaniana	Carolina Creekshell	3	2.4/hr
Freshwater Snails and Clams			**Relative Abundance**
Cipangopaludina japonica	Japanese Mysterysnail	~	C
Corbicula fluminea	Asian Clam	~	A
Viviparus georgianus	Banded Mysterysnail	~	C

5.14 Site 150917.5ted

This site was located adjacent to an island in the west central portion of Monticello Reservoir. Surveys were conducted from the western shoreline of the island to a maximum depth of 12 ft; however, the majority of effort occurred between 3 and 8 ft. The substrate consisted of sand overlain with silt. Five mussel species were found in 1.0 person hours (Table 14).

Table 14. Results in Monticello Reservoir, Site 150917.5ted

Scientific Name	Common Name	Number	CPUE (#/hr)
Freshwater Mussels			
Elliptio angustata	Carolina Lance	112	112.0/hr
Pyganadon cataracta	Eastern Floater	58	58.0/hr
Uniomerus carolinianus	Florida Pondhorn	4	4.0/hr
Utterbackia imbecillis	Paper Pondshell	1	1.0/hr
Villosa delumbis	Eastern Creekshell	3	3.0/hr
Freshwater Snails and Clams			**Relative Abundance**
Cipangopaludina japonica	Japanese Mysterysnail	~	A
Corbicula fluminea	Asian Clam	~	C
Viviparus georgianus	Banded Mysterysnail	~	C

5.15 Site 150917.6ted

This site was located along the east shoreline in the north-central portion of Monticello Reservoir. Surveys were conducted from the sandy beach along the shore to a maximum depth of 12 ft; however, the majority of effort occurred between 3 and 5 ft. The substrate consisted of sand with some silt. Four mussel species were found in 1.1 person hours (Table 15).

Table 15. Results in Monticello Reservoir, Site 150917.6ted

Scientific Name	Common Name	Number	CPUE (#/hr)
Freshwater Mussels			
Elliptio angustata	Carolina Lance	20	18.2/hr
Pyganadon cataracta	Eastern Floater	21	19.1/hr
Utterbackia imbecillis	Paper Pondshell	3	2.7/hr
Villosa delumbis	Eastern Creekshell	1	0.9/hr
Freshwater Snails and Clams			**Relative Abundance**
Cipangopaludina japonica	Japanese Mysterysnail	~	C
Corbicula fluminea	Asian Clam	~	C
Viviparus georgianus	Banded Mysterysnail	~	C

5.16 Site 150917.7ted

This site was located adjacent to a narrow peninsula along the east shoreline in the central portion of Monticello Reservoir. A bedrock outcropping extends from the point of the peninsula, with the remainder of the shoreline consisting of a sandy beach. Surveys were conducted to a maximum depth of 14 ft, with the majority of mussels found between 3 and 8 ft. Six mussel species were found in 1.7 person hours (Table 16).

Table 16. Results in Monticello Reservoir, Site 150917.7ted

Scientific Name	Common Name	Number	CPUE (#/hr)
Freshwater Mussels			
Elliptio angustata	Carolina Lance	60	35.3/hr
Pyganadon cataracta	Eastern Floater	48	28.2/hr
Uniomerus carolinianus	Florida Pondhorn	2	1.2/hr
Utterbackia imbecillis	Paper Pondshell	3	1.8/hr
Villosa delumbis	Eastern Creekshell	4	2.4/hr
Villosa vaughaniana	Carolina Creekshell	1	0.6/hr
Freshwater Snails and Clams			**Relative Abundance**
Cipangopaludina japonica	Japanese Mysterysnail	~	C
Corbicula fluminea	Asian Clam	~	U
Viviparus georgianus	Banded Mysterysnail	~	C

5.17 Site 150917.8ted

This combined site was located in the vicinity of a small island off the eastern shoreline in the central portion of Monticello Reservoir. The shoreline of the island is rocky. All sides of the island were surveyed to a depth of 14 ft. Pockets of sand covered the rocks along the bottom. Five mussel species were found in 2.01 person hours (Table 17).

Table 17. Results in Monticello Reservoir, Site 150917.8ted

Scientific Name	Common Name	Number	CPUE (#/hr)
Freshwater Mussels			
Elliptio angustata	Carolina Lance	26	12.9/hr
Pyganadon cataracta	Eastern Floater	29	14.4/hr
Uniomerus carolinianus	Florida Pondhorn	6	3.0/hr
Utterbackia imbecillis	Paper Pondshell	7	3.5/hr
Villosa delumbis	Eastern Creekshell	7	3.5/hr
Freshwater Snails and Clams			**Relative Abundance**
Cipangopaludina japonica	Japanese Mysterysnail	~	A
Corbicula fluminea	Asian Clam	~	A
Viviparus georgianus	Banded Mysterysnail	~	PU

5.18 Site 151106.1tws

This site was located adjacent to the boat landing along the eastern shore off of SC 215 in the southern portion of Monticello Reservoir. The shoreline has been armored with rip rap to stabilize the parking area. Surveys were conducted from the shoreline to a maximum depth of 20 ft. The substrate graded from the rip rap along the shoreline to sand. Most of the mussels were found between 4 and 10 ft. Four mussel species were found in 1.5 person hours (Table 18).

Table 18. Results in Monticello Reservoir, Site 151106.1tws

Scientific Name	Common Name	Number	CPUE (#/hr)
Freshwater Mussels			
Elliptio angustata	Carolina Lance	44	29.3/hr
Pyganadon cataracta	Eastern Floater	8	5.3/hr
Utterbackia imbecillis	Paper Pondshell	12	8.0/hr
Villosa delumbis	Eastern Creekshell	11	7.3/hr
Freshwater Snails and Clams			**Relative Abundance**
Cipangopaludina japonica	Japanese Mysterysnail	~	A
Corbicula fluminea	Asian Clam	~	A
Viviparus georgianus	Banded Mysterysnail	~	PU

5.19 Site 151106.2tws

This site was located just south of the SC 215 boat landing and extended from the sandy beach on the shoreline to a depth of 18 ft, with the majority of mussels found between 6 and 12 ft. The substrate consisted of a mixture of sand and gravel. Five mussel species were found in 1.0 person hours (Table 19).

Table 19. Results in Monticello Reservoir, Site 151106.2tws

Scientific Name	Common Name	Number	CPUE (#/hr)
Freshwater Mussels			
Elliptio angustata	Carolina Lance	24	24.0/hr
Pyganadon cataracta	Eastern Floater	2	2.0/hr
Uniomerus carolinianus	Florida Pondhorn	1 shell	~
Utterbackia imbecillis	Paper Pondshell	6	6.0/hr
Villosa delumbis	Eastern Creekshell	18	18.0/hr
Freshwater Snails and Clams			**Relative Abundance**
Cipangopaludina japonica	Japanese Mysterysnail	~	A
Corbicula fluminea	Asian Clam	~	A
Viviparus georgianus	Banded Mysterysnail	~	PU

5.20 Site 151106.3tws

This combined site was located adjacent to Monticello Park off SC 215 along the eastern shore of Monticello Reservoir. The surveyed reaches extend along the shoreline of long peninsula around the point. Surveys were conducted to a depth of 18 ft; however, most mussels were found between 6 and 12 ft. The substrate consisted of sand and cobble. Five mussel species were found in 2.0 person hours (Table 20).

Table 20. Results in Monticello, Site 151106.3tws

Scientific Name	Common Name	Number	CPUE (#/hr)
Freshwater Mussels			
Elliptio angustata	Carolina Lance	71	35.5/hr
Pyganadon cataracta	Eastern Floater	9	4.5/hr
Uniomerus carolinianus	Florida Pondhorn	3	1.5/hr
Utterbackia imbecillis	Paper Pondshell	9	4.5/hr
Villosa delumbis	Eastern Creekshell	13	6.5/hr
Freshwater Snails and Clams			**Relative Abundance**
Cipangopaludina japonica	Japanese Mysterysnail	~	A
Corbicula fluminea	Asian Clam	~	A
Viviparus georgianus	Banded Mysterysnail	~	PU

5.21 Site 151106.4tws

This site was located south of the Monticello Park off of SC 215, and was accessed from a pull off on SC 215. Surveys were conducted from the shoreline to a maximum depth of 18 ft. The substrate graded from clay along the banks to sand downslope. The majority of mussels were found in 3 to 8 ft of water in sandy clay substrate. Five mussel species were found in 1.0 person hours (Table 21).

Table 21. Results in Monticello Reservoir, Site 151106.4tws

Scientific Name	Common Name	Number	CPUE (#/hr)
Freshwater Mussels			
Elliptio angustata	Carolina Lance	48	48.0/hr
Pyganadon cataracta	Eastern Floater	14	14.0/hr
Uniomerus carolinianus	Florida Pondhorn	2	2.0/hr
Utterbackia imbecillis	Paper Pondshell	5	5.0/hr
Villosa delumbis	Eastern Creekshell	14	14.0/hr
Freshwater Snails and Clams			**Relative Abundance**
Cipangopaludina japonica	Japanese Mysterysnail	~	A
Corbicula fluminea	Asian Clam	~	A
Viviparus georgianus	Banded Mysterysnail	~	PU

5.22 Site 151106.5tws

This site was located adjacent to the southern edge of Monticello Park. Surveys were conducted from the shoreline to a maximum depth of 20 ft. Although a few mussels were found at the maximum depth, most were found between 6 and 10 ft. The substrate consisted of sand and cobble. Five mussel species were found in 1.2 person hours (Table 22).

Table 22. Results in Monticello Reservoir, Site 151106.5tws

Scientific Name	Common Name	Number	CPUE (#/hr)
Freshwater Mussels			
Elliptio angustata	Carolina Lance	48	40.0/hr
Pyganadon cataracta	Eastern Floater	23	11.6/hr
Uniomerus carolinianus	Florida Pondhorn	1 shell	~
Utterbackia imbecillis	Paper Pondshell	1	0.8/hr
Villosa delumbis	Eastern Creekshell	12	10.0/hr
Freshwater Snails and Clams			**Relative Abundance**
Cipangopaludina japonica	Japanese Mysterysnail	~	A
Corbicula fluminea	Asian Clam	~	A
Viviparus georgianus	Banded Mysterysnail	~	PU

5.23 Site 151106.6tws

This combined site was located adjacent to the boat landing off of Ladds Road in the northern portion of Monticello Reservoir and extended into the cove northwest of the parking area. The maximum depth surveyed was 21 ft, although most mussels were found between 4 and 10 ft. Substrate consisted of sand and cobble. Six mussel species were found in 1.95 person hours (Table 23).

Table 23. Results in Monticello Reservoir, Site 151106.6tws

Scientific Name	Common Name	Number	CPUE (#/hr)
Freshwater Mussels			
Elliptio angustata	Carolina Lance	6	3.1/hr
Pyganadon cataracta	Eastern Floater	89	45.6/hr
Uniomerus carolinianus	Florida Pondhorn	7	3.6/hr
Utterbackia imbecillis	Paper Pondshell	33	16.9/hr
Villosa delumbis	Eastern Creekshell	5	2.6/hr
Villosa vaughaniana	Carolina Creekshell	2	1.0/hr
Freshwater Snails and Clams			**Relative Abundance**
Campeloma deisum	Pointed Campeloma	~	PU
Cipangopaludina japonica	Japanese Mysterysnail	~	A
Corbicula fluminea	Asian Clam	~	A
Viviparus georgianus	Banded Mysterysnail	~	PU

5.24 Site 151106.7tws

This combined site extended along a cove northwest of the Ladds Road boat landing and was accessed via a foot trail through the woods originating next to the parking area. Multiple transects were surveyed along the cove extending from the shoreline to a depth of 18 ft. The substrate graded from mud along the shoreline to sand at greater depths. Six freshwater mussel species were found in 1.9 person hours (Table 24).

Table 24. Results in Monticello Reservoir, Site 151106.7tws

Scientific Name	Common Name	Number	CPUE (#/hr)
Freshwater Mussels			
Elliptio angustata	Carolina Lance	5	2.63/hr

Pyganadon cataracta	Eastern Floater	58	30.52/hr
Uniomerus carolinianus	Florida Pondhorn	2	1.1/hr
Utterbackia imbecillis	Paper Pondshell	40	21.1/hr
Villosa delumbis	Eastern Creekshell	8	4.2/hr
Villosa vaughaniana	Carolina Creekshell	1	0.5/hr
Freshwater Snails and Clams			**Relative Abundance**
Campeloma deisum	Pointed Campeloma	~	PU
Cipangopaludina japonica	Japanese Mysterysnail	~	A
Corbicula fluminea	Asian Clam	~	A
Viviparus georgianus	Banded Mysterysnail	~	PU

5.25 Site 151106.8tws

This site was located just east of the Ladds Road boat landing, and extended from the shoreline to a maximum depth of 18 ft. A small area along the shoreline was armored with rip rap. The substrate was dominated by a mixture of sand and cobble. Five mussel species were found in 1.3 person hours (Table 25).

Table 25. Results in Monticello Reservoir, Site 151106.8tws

Scientific Name	Common Name	Number	CPUE (#/hr)
Freshwater Mussels			
Elliptio angustata	Carolina Lance	13	10.0/hr
Pyganadon cataracta	Eastern Floater	22	16.9/hr
Uniomerus carolinianus	Florida Pondhorn	2	1.5/hr
Utterbackia imbecillis	Paper Pondshell	9	6.9/hr
Villosa delumbis	Eastern Creekshell	5	3.8/hr
Freshwater Snails and Clams			**Relative Abundance**
Cipangopaludina japonica	Japanese Mysterysnail	~	C
Corbicula fluminea	Asian Clam	~	A
Viviparus georgianus	Banded Mysterysnail	~	PU

6.0 MUSSEL SPECIES FOUND

The survey results indicate that at least six freshwater mussel species occur in Monticello Reservoir; however, only one species of freshwater mussel (Paper Pondshell), represented by a single relict shell was observed in the adjacent, and hydrologically connected recreational lake. Brief descriptions of the six freshwater mussel species found are provided below.

6.1 Carolina Lance (Elliptio angustata)

This species was described from the Cooper River, South Carolina (Lea 1831). The shell is more than twice as long as high coming to a posterior point, below the midline between the dorsal and ventral margins. The dorsal margin is straight and essentially parallel to the ventral margin. Umbos are slightly elevated with beak sculpture consisting of strong ridges. Johnson (1970) synominized this species and over 20 other named species of lance-shaped elliptio mussels into Elliptio lanceolata. Recent genotypic and phenotypic analysis suggests that some of these formally described species are valid, including “true” Elliptio lanceolata (type locality-Tar River). The Carolina Lance ranges from the Ogeechee, Georgia north to the Potomac River in Maryland and Virginia. The species is usually found in large steams or rivers in thalweg habitat and is associated with coarse substrates. It is not typically found in reservoir habitats (personal observations). This species was found at every site sampled within Monticello Reservoir and was the most abundant species encountered (776 total live individuals). Williams et al. (1993) list this species as special concern.

6.2 Eastern Floater *(Pyganadon cataracta)*

Described by Say (1817) in the deep part of a milldam presumably near Philadelphia, this species is wide ranging in the Atlantic drainages from the lower St. Lawrence River Basin south to the Altamaha River Basin, Georgia, and in the Alabama-Coosa River drainage, and the Apalachicola and Coctawhatchee River Basins, Florida. The shells of this species are uniformly thin, and lack hinge teeth. The shell shape is ovate, subelliptical and elongate, with an evenly rounded anterior margin and a broadly rounded ventral margin. The periostracum is light to dark green with broad green rays on the posterior slope. Ortman (1919) recognized three generalized shell forms, the pond form, the creek/small river form and the big river form, that were related to environmental conditions. The pond form occurs in small ponds with muddy substrates, and is characterized by very thin elongate inflated shells. The creek form occurs in riffle-pool habitats in gravel substrates, and is much thicker and more compressed. The big river form is generally short and inflated and occurs in soft substrates. It often occurs in reservoirs, and was found at every site sampled in Monticello Reservoir and was second in total numbers (668 individuals. This species is considered common and currently stable throughout its range (Williams et al. 1993).

6.3 Florida Pondhorn *(Uniomerus carolinianus)*

Described by (Bosc 1801-1804) from “the Carolinas,” this species ranges from Ocmulgee River in Georgia north to the Chowan River in Virginia. Shells are usually inflated rhomboid, to long rhomboid and reach lengths to 114 mm. The species generally exhibits a dark brown to black periostracum with a slightly roughened, satiny sheen. Teeth of the left valve contain two subequal pseudocardinals, often with a vestigal tooth above them, and one lateral tooth. It was found at eleven sites within Monticello Reservoir in fairly low numbers (41 total). This species is considered common and currently stable throughout its range (Williams et al. 1993).

6.4 Paper Pondshell *(Utterbackia imbecillis)*

Described from the Wabash River in Indiana, this mussel occurs throughout the Mississippi River and Great Lakes drainages, as well as sporadically along the Atlantic slope (Say 1829). It has an extremely thin shell that is oblong and inflated. The dorsal and ventral margins are nearly straight and parallel. The periostracum is greenish yellow with fine green rays. It was found at all but two of the sites sampled in Monticello Reservoir, and was the third most abundant species encountered (144 individuals). With the exception of two sites in the northern portion of the reservoir (151106.7tws and 151106.6tws) it was generally found in low numbers; however, a total of 40 and 33 individuals were recorded respectively at these sites. It was the only freshwater mussel species observed in the recreational lake; however, it was represented by only one relict shell. This species is considered common throughout its range (Williams et al. 1993).

6.5 Eastern Creekshell *(Villosa delumbis)*

This species, described by Conrad (1834) from small streams near the Cooper River South Carolina, ranges from Ocmulgee River, Georgia north to the Cape Fear River in North Carolina. Johnson (1970) synonomized three other species described from the greater CSB with *V. delumbis*. One of these, *V. vaughaniana*, is currently recognized as a valid species (Bogan and Alderman 2008), and was found during this study (see description below). The Eastern Creekshell has a generally thin shell that is ovate in outline. Like other members of this genus, this species is sexually dimorphic, with the shells of the male being more elongate, and the females more rounded and swollen, particularly in the posterior margin. The periostracum is yellow with numerous green rays that are broken along the prominent growth lines. It was found at all but one of the sites sampled in Monticello Reservoir (150916.9ted). It was the fourth most abundant species encountered (137 individuals). Williams et al. (1993) consider this species to be stable; however, Bogan and Alderman (2008) propose it a conservation status of special concern in South Carolina.

6.6 Carolina Creekshell (*Villosa vaughaniana*)

This species was described from Sawney's Creek near Camden, South Carolina (Lea 1838). As discussed above under the description for *V. delumbis*, Johnson (1970) synonomized this species under *V. delumbis*; however, it is currently recognized as a valid species (Bogan and Alderman 2004). The previously reported range extends from the Wateree River Basin portion of the Greater Cooper Santee Basin in South Carolina north to the Cape Fear River Basin in North Carolina (Bogan and Alderman 2008). Like other members of this genus, this species is sexually dimorphic, with the shells of the male being more elongate, and the females more inflated and rounded in the posterior margin. The periostracum is usually dark yellow brown with many green, unbroken rays. The shell of this species is generally thicker, with more prominent pseudocardinal teeth than the similar (in shell characteristics) Eastern Creekshell. A total of seven individuals were found at 4 sites in Monticello Reservoir. The species is usually restricted to small, or medium size streams and is rarely found in large bodies of water, and has not previously been reported from reservoirs (John Alderman and Art Bogan, personal communication). Given that it is uncommon to find this species outside of stream habitats, it is possible that these individuals are simply unusual specimens of the Eastern Creekshell. However, the seven individuals identified as Carolina Creekshell were done so based on conchological (shell), and soft part anatomy characteristics, and should be considered as such until further study proves otherwise. Two voucher specimens were preserved in 95% ethanol and will be deposited in an appropriate museum collection to allow for genetic evaluation to be performed. Williams et al. (1993) lists this species as special concern. It is proposed as Endangered in South Carolina (Bogan and Alderman 2008).

7.0 CONCLUSIONS

The survey results indicate that Monticello Reservoir supports a mussel fauna of at least six species. Mussels were found at every site sampled and most likely occur throughout the reservoir in areas that are not exposed during the daily water fluctuations, down to depths of 16-20 ft. With the exception of the Carolina Creekshell, multiple size (= age) classes of all species were observed, suggesting that the daily water level fluctuation regime is not limiting population sustainability of these species. Three of these species, Carolina Creekshell, Carolina Lance, and Eastern Creekshell have some reported level of conservation concern (see Sections 6.6, 6.1 and 6.5 respectively).

The two most common species encountered, the Carolina Lance and the Eastern Floater, were found at every site sampled; however, the Eastern Floater was definitely more common than the Carolina Lance at the sites sampled in the northern portion of the lake. Likewise, the Paper Pondshell which typically occupies similar habitats (ponded conditions, soft substrate) as the Eastern Floater, was more common in the northern portion of the reservoir than anywhere else. It is unclear however, if this is due to location within the reservoir, or simply related to site specific habitat conditions.

Considering the level of coverage within the reservoir and the relative consistent species distribution between sites, it is unlikely that other freshwater mussel species occur within the reservoir. The two target species, the Carolina Heelsplitter and the Savannah Liliput described in Section 2.0 and 3.0 respectively, are not known from the Broad River Basin and are very unlikely to occur in the reservoir. The Carolina Heelsplitter is known to occur only within lotic habitats. While historically it was reported from mill ponds, it is now believed that these were likely occurrences just below mill ponds as site locality data were often not very specific (i.e. lat/long coordinates) and a mill pond is a recognizable landmark. The Savannah Liliput is known to occur within reservoirs; however, it usually occupies very shallow habitats along the shoreline. The daily fluctuations of water levels in Monticello Reservoir would likely preclude this species from ever becoming established.

The recreational lake does not currently appear to support a viable mussel fauna. The reasons for this are unclear; however, physical habitat conditions (substrate, water depth) do not appear to be limiting factors.

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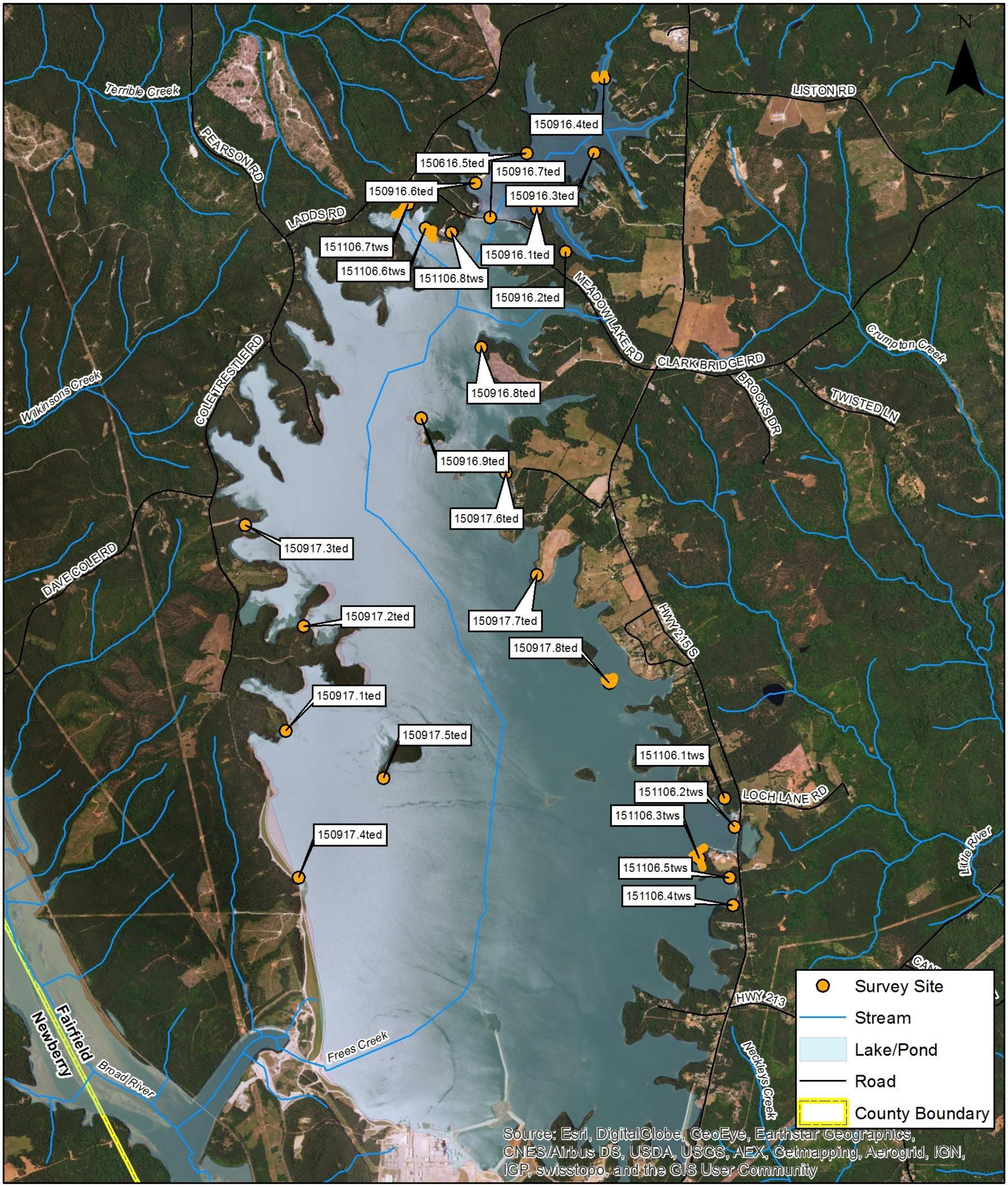
APPENDIX A: Figure 1



Prepared For:

Kleinschmidt

Freshwater Mussel Survey
Monticello Reservoir

Date: December 2015

Scale 0 1,000 2,000 Feet

Job No.:

Figure

1

APPENDIX B: Select Photographs

Exhibit E-5 Fisheries Resources

Freshwater Mussel Genetics Study

Freshwater Mussel Genetics Study

In Monticello Reservoir
Parr Hydroelectric Project
(FERC No. 1894)

Fairfield and Newberry Counties, South Carolina

Monticello Reservoir Shoreline Habitat

Prepared For:

South Carolina Electric & Gas Company &

Kleinschmidt

Kleinschmidt Associates
204 Caughman Farm Lane, Suite 301
Lexington, SC 29072

January 19, 2018

Prepared by:

Three Oaks Engineering
1000 Corporate Drive, Suite 101
Hillsborough, NC 27278

TABLE OF CONTENTS

1.0 INTRODUCTION

The Parr Hydro Project (FERC No. 1894) consists of the Parr Shoals Development and the Fairfield Pumped Storage Development; both are located along the Broad River in Fairfield and Newberry Counties, South Carolina. The Parr Shoals Development forms the lower reservoir, Parr Reservoir, along the Broad River. The Fairfield Pumped Storage Development is located directly off of the Broad River and forms the 6,800-acre upper reservoir, Monticello Reservoir, with four earthen dams. The Fairfield Development has a licensed capacity of 511.2 MW and is used for peaking operations, reserve generation, and power storage and usage.

Three Oaks was retained by Kleinschmidt to perform freshwater mussel surveys in the Monticello Reservoir in Fairfield and Newberry Counties, South Carolina in the summer/fall of 2015 for the Monticello Reservoir Parr Hydroelectric Project, a SCANA Corporation (SCANA) Federal Energy Regulatory Commission (FERC) project (FERC No. 1894). The details of the survey efforts were presented in the Freshwater Mussel Survey Report for Monticello Reservoir submitted to Kleinschmidt in April 2016 (Appendix A).

Freshwater mussels were consistently found throughout the reservoir; the fauna was comprised of six species, most of which are considered common. However, a total of seven individuals identified as the Carolina Creekshell (*Villosa vaughaniana*) were found at four sites. The species is usually restricted to small or medium size streams, is rarely found in large bodies of water, and has not previously been reported from reservoirs (John Alderman and Art Bogan, personal communication). Given that it is uncommon to find this species outside of stream habitats, there was some question as to whether these individuals were simply unusual specimens of the more common Eastern Creekshell (*V. delumbis*). However, the seven individuals identified as Carolina Creekshell were done so based on conchological (shell) and soft part anatomy characteristics (ivory-white as opposed to black band on edge of marsupium). At the time, three *V. vaughaniana* and five Eastern Creekshell (*V. delumbis*) voucher specimens were preserved in 95% ethanol to allow for future genetic evaluation to be performed. Both species are listed in the South Carolina's 2015 State Wildlife Action Plan (SWAP) as conservation priority species (SCDNR 2014), with *V. vaughaniana* considered Highest Priority and *V. delumbis* considered Moderate Priority.

2.0 METHODOLOGY

Following agency review of these findings, SCANA and Kleinschmidt asked Three Oaks in the spring of 2017 to develop a protocol for arriving at a clearer resolution for identifying these specimens using genetic analysis. Dr. Michael Gangloff at Appalachian State University was selected to perform this task. The original specimens were preserved in 95% ethanol at the time of their collection, and remained in the Three Oaks office with no additional curation (ethanol changes) until they were delivered to Dr. Gangloff of Appalachian State University (ASU). In anticipation that some of the specimens collected in 2015 would not yield adequate DNA sequences, due to the amount of time since collection as well as the need for a larger dataset, additional material was collected in Monticello Reservoir, as well as in a tributary to Fishing Creek. The last of the specimens collected were delivered to ASU in late June 2017, and genetic information was extracted and analyzed.

2.1 Additional Specimen Collection

On March 13, 2016, four specimens presumed to be *V. vaughaniana* were collected by Tim Savidge from an unnamed tributary to Fishing Creek in Chester County, South Carolina, the closest known population to the type locality (Sawney's Creek in Kershaw County, SC) in the Santee River Basin. On June 23, 2017, Tim Savidge and Hannah Slyce with Three Oaks collected three specimens presumed to be *V. vaughaniana*, seven specimens presumed to be *V. delumbis,* and one unknown specimen of the tribe Lampsilini (of which the genus *Villosa* belongs to) adjacent to the boat ramp in Moticello Reservoir near Jenkinsville. This unknown specimen was very elongate, and the shell was weathered to a point where identification based on conchology was difficult. These mussels were preserved in 95% ethanol with a complete change of ethanol after 24 hours. The specimens were delivered to ASU on June 28, 2017.

2.2 DNA Analysis

Upon receipt at ASU, each specimen was assigned a unique number, which either reflected the site collection number or the date they were received at ASU (Table 1).

Table 1. Study Specimens Analyzed

Specimen Id #	Putative Identification	Collection Site/date
3-16-1	*V. vaughaniana*	Monticello Reservoir 2015
3-16-2	*V. vaughaniana*	Monticello Reservoir 2015
3-16-3	*V. delumbis*	Monticello Reservoir 2015
3-16-4	*V. delumbis*	Monticello Reservoir 2015
3-16-5	*V. delumbis*	Monticello Reservoir 2015
3-16-6	*V. vaughaniana*	Monticello Reservoir 2015
3-16-7	*V. vaughaniana*	UT Fishing Creek 2016
3-16-8	*V. vaughaniana*	UT Fishing Creek 2016
3-16-9	*V. vaughaniana*	UT Fishing Creek 2016
3-16-10	*V. vaughaniana*	UT Fishing Creek 2016
170623.1-1	*V. delumbis*	Monticello Reservoir 2017
170623.1-2	*V. vaughaniana*	Monticello Reservoir 2017
170623.1-3	*V. delumbis*	Monticello Reservoir 2017
170623.1-4	*V. vaughaniana*	Monticello Reservoir 2017
170623.1-5	*V. vaughaniana*	Monticello Reservoir 2017
170623.1-6	*V. delumbis*	Monticello Reservoir 2017
170623.1-7	*V. delumbis*	Monticello Reservoir 2017
170623.1-8	*V. delumbis*	Monticello Reservoir 2017
170623.1-9	*V. delumbis*	Monticello Reservoir 2017
170623.1-10	*V. delumbis*	Monticello Reservoir 2017

Specimen Id #	Putative Identification	Collection Site/date
170623.1-11	Unknown Lampsilini	Monticello Reservoir 2017

After cataloging, soft tissue clippings from each specimen were taken and DNA was extracted, then sequenced. Amplified portions of the mitochondrial COI gene were evaluated and compared to a referenced sequence of the type species Downy Rainbow (*V. villosa*). COI has been widely used to identify unknown or cryptic species in a range of taxa including freshwater mussels. The details of the methodologies and results of the genetic analysis are included in Appendix B.

3.0 RESULTS

Three specimens (3-16-1, 3-16-2 and 3-16-3) from 2015 and one (170623.1-3) from 2017 Monticello collections did not yield any data. The remaining 21 specimens yielded sufficient data. Analysis of the COI gene indicates that the Villosa specimens collected from Monticello Reservoir form two distinct clades, indicating two *Villosa* species are present in the reservoir. Sequence divergence rates within each clade were low (<1.0%) but were relatively high between the two *Villosa* taxa (8.1 to 8.4%, Table 2). Observed inter-specific divergence rates were well beyond the ~2% divergence rate seen between many freshwater mussel taxa (Perkins et al. 2017, Smith et al. 2018).

Individuals that were morphologically similar to *V. vaughaniana* from Monticello Reservoir (Fig. 1) formed a monphyletic group that was distinct from the putative *V. delumbis* clade (Fig. 2). All other specimens, including the putative *V. vaughaniana* from the UT to Fishing Creek formed a second clade that appears to represent *V. delumbis*. The Unknown Lampsilini from the reservoir (specimen 170623.1-11) appears to represent a third Lampsilini taxon and appears to be an elongate, lake-form of Eastern Lampmussel (*Lampsilis radiata*) (Fig. 2). However, sequence reads from this individual were not very robust. Further details and explanations of the results are included in Appendix B.

Table 2. Uncorrected pairwise distances among sequences obtained from *Villosa delumbis*, *V. vaughaniana* and *Lampsilis radiata* specimens collected from Monticello Reservoir (Broad River Drainage) and an unnamed tributary to Fishing Creek (Catawba River Drainage).

Sample	**Taxon**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
1.170623-1-2	*V. vaughaniana*-Monticello	--																
2.170623-1-4	*V. vaughaniana*-Monticello	0	--															
3.170623-1-5	*V. vaughaniana*-Monticello	0	0	--														
4.170623-1-1	*V. delumbis*-Monticello	.084	.084	.084	--													
5.170623-1-6	*V. delumbis*-Monticello	.084	.084	.084	.005	--												
6.170623-1-7	*V. delumbis*-Monticello	.084	.084	.084	.005	0	--											
7.170623-1-8	*V. delumbis*-Monticello	.084	.084	.084	.005	.005	.005	--										
8.170623-1-9	*V. delumbis*-Monticello	.081	.081	.081	.007	.002	.002	.007	--									
9.170623-1-10	*V. delumbis*-Monticello	.084	.084	.084	.005	0	0	.005	.002	--								
10. 3-16-4	*V. delumbis*-Monticello	.087	.087	.087	.007	.007	.007	.005	.010	.007	--							
11. 3-16-5	*V. delumbis*-Monticello	.087	.087	.087	.007	.007	.007	.005	.010	.007	0	--						
12. 3-16-6	*V.* delumbis-Monticello	.087	.087	.087	.007	.007	.007	.002	.010	.007	.007	.007	--					
13. 3-16-7	*V. vaughaniana*-Fishing	.084	.084	.084	.005	.005	.005	0	.007	.005	.005	.005	.002	--				
14. 3-16-8	*V. vaughaniana*-Fishing	.087	.087	.087	.007	.007	.007	.005	.010	.007	0	0	.007	.005	--			

Sample	Taxon	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
15. 3-16-9	*V. vaughaniana*-Fishing	.084	.084	.084	.005	.005	.005	0	.007	.005	.005	.005	.002	0	.005	--		
16. 3-16-10	*V. vaughaniana*-Fishing	.084	.084	.084	.005	.005	0	.005	.002	0	.007	.007	.007	.005	.007	.005	--	
17. 170623-1-11	*L. radiata*-Monticello	.094	.094	.094	.080	.080	.080	.080	.083	.080	.081	.081	.083	.080	.081	.080	.080	--

Figure 1. Specimen of *Villosa vaughaniana* collected from Monticello Reservoir on 23 June 2017.

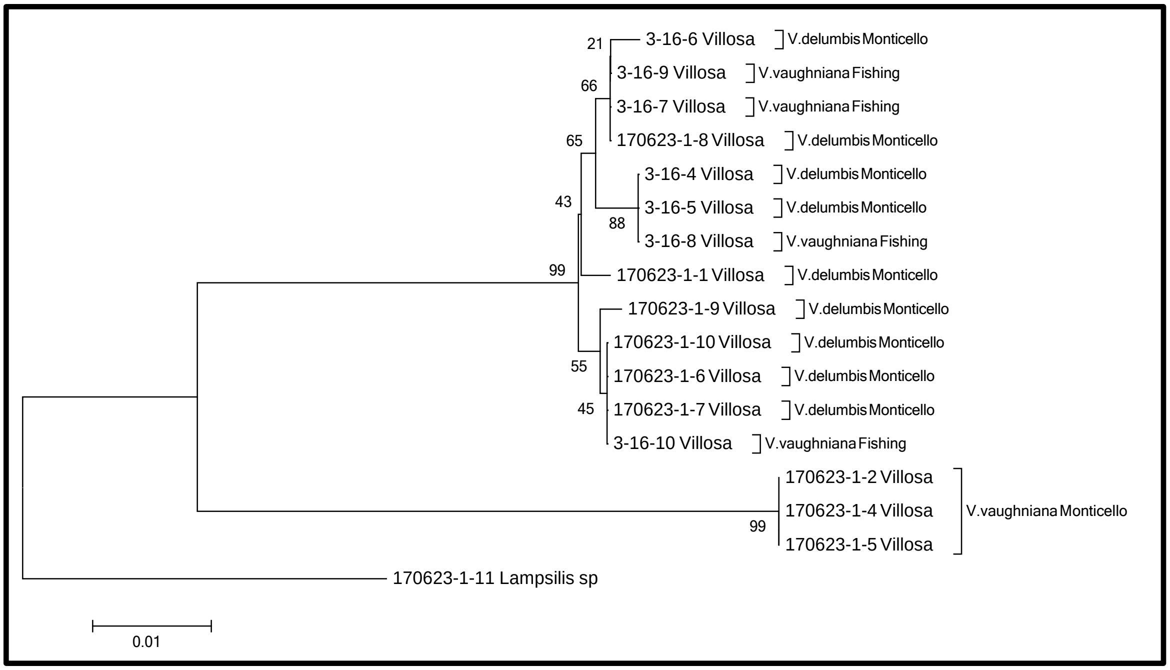


Figure 2. Neighbor-joining phylogeny showing the genetic distance between *Villosa* and *Lampsilis* taxa collected from Monticello Reservoir (Broad River Drainage) and a tributary to Fishing Creek (Catawba River Drainage). Nodal support indices are bootstrap values (10,000 replicates). Scale bar represents 1% difference among sequences.

4.0 CONCLUSIONS

The results of this study support the conclusions from the survey report (Appendix A) that two *Villosa* species are present in Monticello Reservoir. The specimens from Monticello that were putatively identified as *V. vaughaniana* form a distinct clade from those identified from the reservoir as *V. delumbis*, suggesting both species are present. However, the specimens collected from a "known" *V. vaughaniana* population (UT to Fishing Creek) allied with the *V. delumbis* specimens rather than *V. vaughaniana* from the reservoir making it difficult to reach a definitive conclusion of which species are present from the small sample size. A more detailed analysis examining specimens of *V. vaughaniana* and *V. delumbis* from other populations within their respective ranges, as well as the two other *Villosa* species known to occur in South Carolina, *V. constricta* and *V. vibex*, is needed to fully understand the taxonomic relationship and distribution of the *Villosa* genus in the state. While there is some level of uncertainty, it is clear that there are two *Villosa* species in Monticello Reservoir that are morphometrically and genetically distinct from each other.

The results also indicate that a third Lampsilini taxon is present in the reservoir, as the unknown specimen appears to be *Lampsilis radiata* (Eastern Lampmussel), which is considered a "High Priority" conservation species in South Carolina (SCDNR 2014).

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Exhibit E-5 Fisheries Resources

Freshwater Mussel Monitoring Plan

FRESHWATER MUSSEL MONITORING PLAN

PARR HYDROELECTRIC PROJECT
(FERC NO. 1894)

Prepared for:

South Carolina Electric & Gas Company
Cayce, South Carolina

Prepared by:

Kleinschmidt

Lexington, South Carolina
www.KleinschmidtGroup.com

December 2017

FRESHWATER MUSSEL MONITORING PLAN

PARR HYDROELECTRIC PROJECT
(FERC NO. 1894)

Prepared for:

South Carolina Electric & Gas Company
Cayce, South Carolina

Prepared by:

Kleinschmidt

Lexington, South Carolina
www.KleinschmidtGroup.com

December 2017

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SOUTH CAROLINA ELECTRIC & GAS COMPANY

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SOUTH CAROLINA ELECTRIC & GAS COMPANY

1.0 INTRODUCTION

South Carolina Electric & Gas Company (SCE&G) is the Licensee for the Parr Hydroelectric Project (FERC No. 1894) (Project). The Project consists of the Parr Shoals Development (Parr Development) and the Fairfield Pumped Storage Development (Fairfield Development). Both developments are located along the Broad River in Fairfield and Newberry counties, South Carolina. The current license for the Project is due to expire on June 30, 2020. Therefore, SCE&G will file for a new license with the Federal Energy Regulatory Commission (FERC) on or before June 30, 2018.

During relicensing efforts, the United States Fish and Wildlife Service (USFWS) requested that SCE&G perform periodic assessments of the composition and abundance of freshwater mussel species in or adjacent to the Project throughout the course of the new license. SCE&G and stakeholders have agreed to develop this Freshwater Mussel Monitoring Plan and it will be included as a Protection, Mitigation and Enhancement (PM&E) measure in the Comprehensive Relicensing Settlement Agreement (CRSA).

2.0 EXISTING INFORMATION

Information on the species composition, abundance, and distribution of mussel species in Monticello Reservoir, Parr Reservoir, and upstream and downstream of Parr Reservoir is documented in several studies (Price 2009; Alderman 2012; Three Oaks Engineering 2016; and Price, et.al. 2016).

The South Carolina Department of Natural Resources (SCDNR) conducted surveys in 2007 and 2008 to assess the status of freshwater mussels on the Broad River and in Parr Reservoir (Price 2009). The SCDNR, led by a licensed malacologist, surveyed 60 sites along the Broad River and five sites on adjacent tributaries. Visual search methods including snorkeling, SCUBA diving, and bathyscopes were utilized. The section of the Broad River between Parr Shoals Dam and the Columbia Dam contained dense populations of mussels, with four species collected. Habitat included relatively clear water and stable substrates that are suitable for numerous mussel species (Price 2009). In 2016, North Carolina State University surveyed 14 sites between the Columbia Dam and the Parr Shoals Dam. Six of the 14 sites corresponded with some of the exact locations surveyed in 2007. The report provides a summary of freshwater mussel species occurrence and abundance changes over the ten-year period (Price et.al. 2016).

SCE&G personnel and Alderman Environmental Services, Inc. conducted freshwater mussel surveys on the Broad River downstream of Parr Shoals Dam in 2012. Thirteen areas were surveyed over two days by a team of four malacologists using bathyscopes and tactile techniques. The highest freshwater mussel diversity in the Broad River sub-basin in North and South Carolina upriver of the Columbia Dam was observed. This survey also found the most upriver occurrence of the yellow lampmussel (*Lampsilis cariosa*) within the Broad River sub-basin to date. Roanoke slabshell (*Elliptio roanokensis*) juveniles, which require an anadromous fish host, was also observed in this stretch of the Broad River. A total of nine mussel species were collected (Alderman and Alderman 2012).

SCE&G and Three Oaks Engineering Personnel conducted freshwater mussel surveys in Monticello Reservoir during 2016. A total of 25 sites were surveyed, and five mussel species were collected. Multiple life stages were observed for all species collected, suggesting that recruitment from juvenile to adult lifestages occurs within the reservoir for all five species

(Three Oaks Engineering 2016). During this study, several individuals were tentatively identified as Carolina creekshell (*Villosa vaughaniana*), a species considered to be critically imperiled by the state of South Carolina (SCDNR 2017). In order to confirm this finding, Three Oaks Engineering performed an additional survey and accompanying genetic analysis during the summer of 2017. The genetic testing confirmed that the Carolina creekshell mussel is present in Monticello Reservoir. The survey and genetic analysis also confirmed that Eastern creekshell (*Villosa delumbis*) and Eastern lampmussel (*Lampsilis radiata*) are also located in Monticello Reservoir, which are listed as apparently secure and imperiled, respectively, by the state of South Carolina (SCDNR 2017).

3.0 PROPOSED PM&E MEASURE

During the new license, SCE&G will perform monitoring of mussel populations in areas of Monticello Reservoir and the Broad River downstream of Parr Shoals Dam. Specific areas of Monticello Reservoir will be monitored with the goal of tracking the distribution and abundance of freshwater mussel species present with an emphasis on Carolina creekshell mussel populations. In addition, more information is required to fully assess how new Project operations of the Parr Shoals Development may influence mussels in the Broad River downstream of the dam. Therefore, freshwater mussels will be monitored for abundance, distribution, and species composition downstream of Parr Shoals Dam during the new license.

A Mussel Review Committee[1] will develop a study plan for these monitoring efforts following issuance of the new license. SCE&G will then submit this study plan to FERC for approval. Preliminary methods for mussel monitoring are included below.

3.1 PRELIMINARY MUSSEL MONITORING METHODS

SCE&G will work with a malacologist (agreed upon by the Review Committee) to monitor abundance, distribution, and species composition of mussel species in Monticello Reservoir and the Broad River downstream of Parr Shoals Dam. Sampling efforts in Monticello will focus on

[1] Members of the Mussel Review Committee must be signatories to the CRSA, with the exception of National Oceanic and Atmospheric Administration (NOAA) Fisheries, USFWS, SCDNR and the South Carolina Department of Health and Environmental Control (SCDHEC).

areas identified during the 2016 and 2017 surveys (Figure 3-1). Specifically, each area surveyed will be sampled by utilizing bathyscopes, snorkeling, and/or tactile searches to locate, identify and enumerate mussel species. Sampling will be performed over a two-day period. Surveys will be designed to identify the diversity, abundance, and size distribution of mussel species present.

Sampling in the Broad River downstream of Parr Dam will focus on the reach of river immediately downstream of the Parr powerhouse and several sections of the west channel of the Broad River. Specifically, one segment immediately downstream of the powerhouse will be surveyed along with three smaller segments on the west side of Hampton Island (Figure 3-2). Within each survey segment, sampling will be conducted by utilizing bathyscopes, snorkeling, and/or tactile searches to locate, identify and enumerate mussel species. Timed searches will be conducted for up to 30 minutes in each of the smaller west channel segments and up to 2 hours in the larger segment downstream of the powerhouse. Surveys will be designed to identify the diversity, abundance, and size distribution of mussel species present.

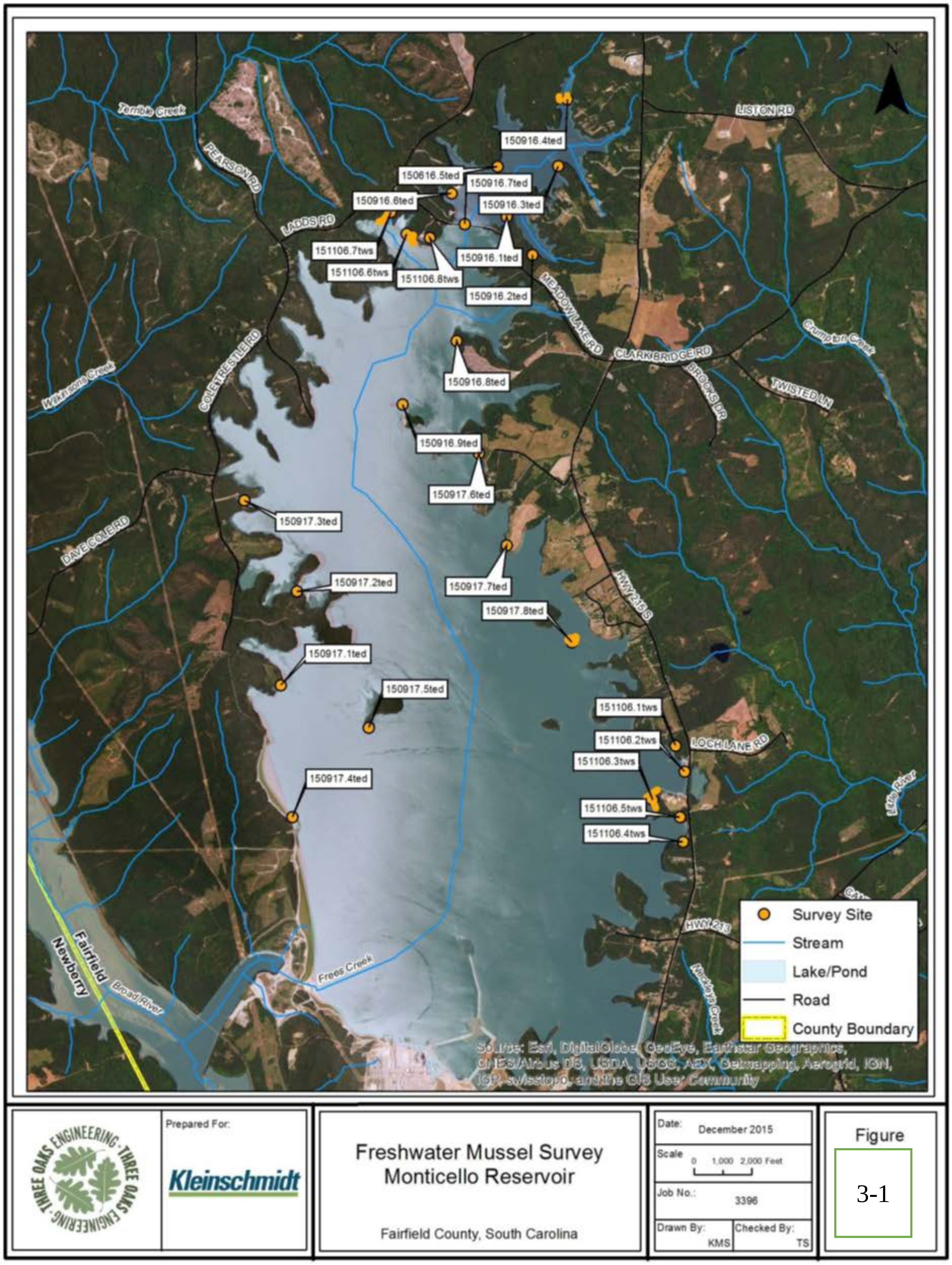

FIGURE 3-1 MUSSEL SAMPLING LOCATIONS IN MONTICELLO DURING 2016 & 2017.

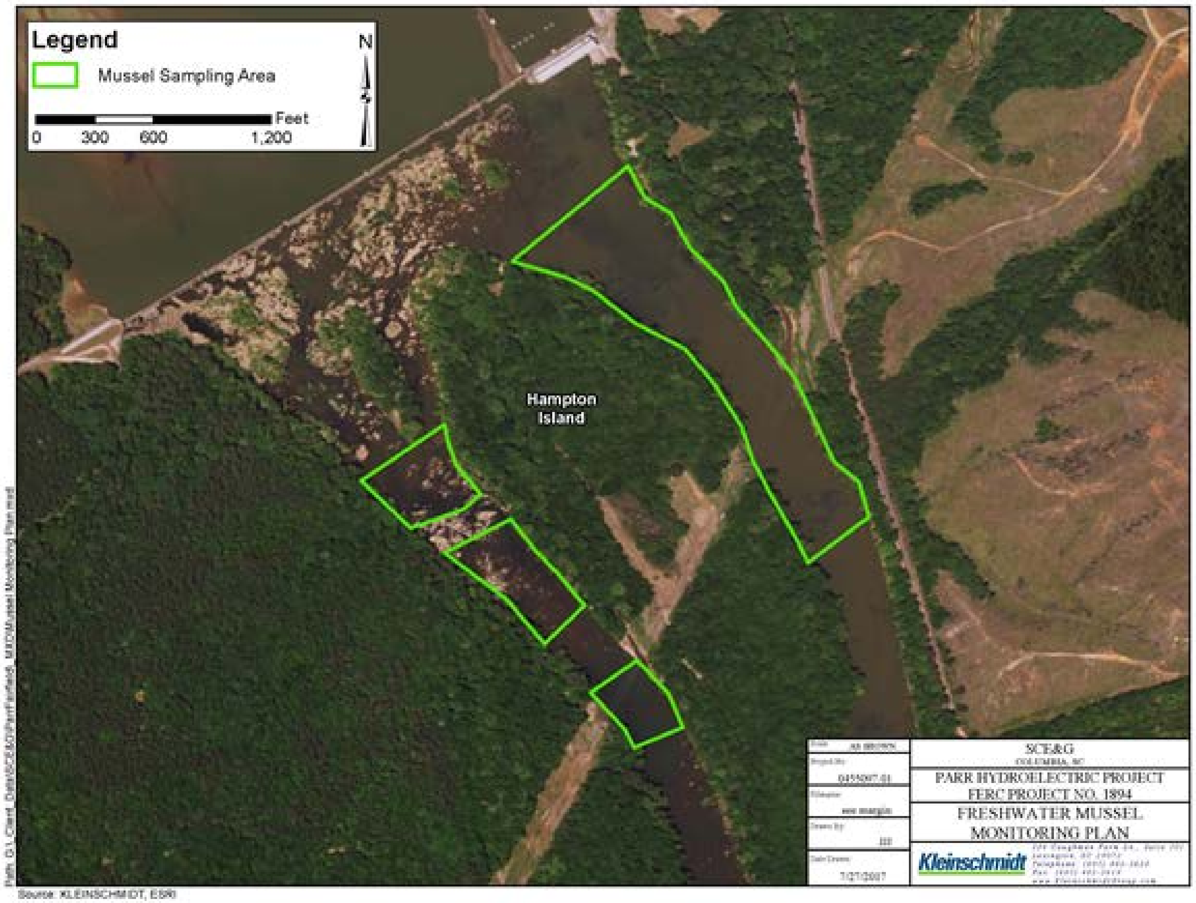

FIGURE 3-2 MUSSEL SAMPLING LOCATIONS IN THE BROAD RIVER DOWNSTREAM OF PARR SHOALS DAM.

Sampling in Monticello Reservoir and in the Broad River downstream of Parr Shoals Dam will occur on the same schedule. The first (baseline) mussel survey will be conducted during the first year after the license has been issued and the Mussel Monitoring Study Plan has been approved by the FERC. The second survey will occur 6 years later (i.e. 7 years after the license is issued). Additional studies will be conducted 10 years thereafter for the course of the new license term. The Review Committee will meet to adjust the frequency of mussel monitoring if fish passage is implemented at the Project. Monitoring results will be distributed to the Review Committee for review and comment by December 31st of each year of sampling. An annual report will be filed with FERC by April 30th of the following year.

Survey methods may be altered if the USFWS develops new standard mussel sampling methods during the term of the license. SCE&G will consult with the Review Committee to potentially update the frequency and location of mussel monitoring in the event that fish passage is installed at the Project during the term of the new license. Fish passage installation would potentially increase the range and abundance of host fish species upstream of the Project, and would be a factor in determining updates to the monitoring plan that may include monitoring within Parr and Monticello reservoirs during the remainder of the license. Another factor that would initiate the Review Committee to amend the study schedule would be observed negative changes in mussel populations. The Review Committee would meet to discuss the potential for increasing monitoring frequency in the event that mussel populations decline when compared to historic or new baseline data.

4.0 SCHEDULE

The monitoring schedule is described in the table below in relation to the issuance of the license by FERC.

TABLE 4-1 FRESHWATER MUSSEL MONITORING PLAN SCHEDULE

PERIOD[2]	ITEM
Within 180 days of license issuance	Form Review Committee, review Freshwater Mussel Monitoring Plan and submit Mussel Monitoring Study Plan to FERC
Year 1 of new license	• Conduct mussel survey • Report results to Review Committee by December 31st • Review Committee meeting- February of following year • File Annual Report with FERC by April 30th of following year
Year 7 of new license	• Conduct mussel survey • Report results to Review Committee- by December 31st • Review Committee meeting- February of following year • File Annual Report with FERC by April 30th of following year
Year 17 of new license	• Conduct mussel survey • Report results to Review Committee- by December 31st • Review Committee meeting- February of following year

[2] Sampling frequency will be adjusted if fish passage is installed at the Project during the term of the new license. Sampling frequency may also be adjusted if a decline in mussel population is observed.

	• File Annual Report with FERC by April 30th of following year
Year 27 of new license[3]	• Conduct mussel survey • Report results to Review Committee- by December 31st • Review Committee meeting- February of following year • File Annual Report with FERC by April 30th of following year

[3] Sampling will continue throughout the term of the license. This schedule will be adjusted depending on the license term issued by FERC.

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Three Oaks Engineering 2016. Freshwater Mussel Survey Report in Monticello Reservoir. Prepared for South Carolina Electric and Gas Company & Kleinschmidt Associates.

Exhibit E-5 Fisheries Resources

Desktop Fish Entrainment Study Plan

DESKTOP FISH ENTRAINMENT STUDY PLAN

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SOUTH CAROLINA ELECTRIC & GAS COMPANY

1.0 INTRODUCTION

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The Project is currently involved in a relicensing process which involves cooperation and collaboration between SCE&G, as licensee, and a variety of stakeholders including state and federal resource agencies, state and local government, non-governmental organizations (NGO), and interested individuals. Collaboration and cooperation is essential in the identification of and treatment of operational, economic, and environmental issues associated with a new operating license for the Project. SCE&G has established several Technical Working Committees (TWC's) comprised of interested stakeholders with the objective of achieving consensus regarding the identification and proper treatment of these issues in the context of a new license.

The TWC determined that a desktop fish entrainment and mortality study should be conducted to determine the likely effects of Project-induced entrainment and impingement based on the physical characteristics of the Project. This study plan outlines the process for a desktop analysis.

2.0 BACKGROUND AND EXISTING INFORMATION

As noted, the Project is comprised of two developments. The Parr Hydro Development forms Parr Reservoir along the Broad River. The Development consists of a 37-foot-high, 200-foot-long concrete gravity spillway dam with a powerhouse housing generating units with a combined licensed capacity of 14.9 MW. Parr Hydro operates in a modified run-of-river mode and normally operates continuously to pass Broad River flow. Current minimum flow license articles require that 1,000 cubic feet-per-second (cfs), or average daily natural inflow to Parr Reservoir[1], whichever is less, be provided downstream of Parr Dam from March through May. During the remainder of the year, 800 cfs daily average flow and 150 cfs minimum flow, or natural inflow, whichever is less, are required downstream of the Parr Dam. The 13-mile-long Parr Reservoir has a surface area of 4,400 acres at full pool and serves as the lower reservoir for pumped-storage operations at the Fairfield Pumped Storage Development.

The Fairfield Pumped Storage Development is located directly off of the Broad River. Four earthen dams form the 6,800-acre upper reservoir, Monticello Reservoir. As noted, Parr Reservoir serves as the lower reservoir for pumped storage operations. The Fairfield Development has a licensed capacity of 511.2 MW and is primarily used for peaking operations, reserve generation, and power usage.

The Project area supports warmwater fish communities typical of impounded river reaches in the Piedmont of South Carolina. Recent survey work within the Project area has documented 30 species of fish occurring in Parr Reservoir and 24 species in Monticello Reservoir (Table 1). Although some seasonal variations in community structure have been documented, the fish communities are generally similar between the two reservoirs, with gizzard shad, blue catfish, bluegill, channel catfish and white perch being the dominant species (Normandeau 2007, 2008, 2009; SCANA 2013). No state or federally listed threatened or endangered species have been documented in Monticello or Parr reservoirs, although robust redhorse, which is considered a

[1] Evaporative loss from Parr and Monticello Reservoirs is subtracted from average daily natural inflow to determine flows downstream of Parr Dam.

species of highest conservation concern by the SCDNR (2005), has been documented in limited[2] numbers in both reservoirs.

TABLE 1 FISH SPECIES DOCUMENTED AT PARR AND MONTICELLO RESERVOIRS (SOURCE: NORMANDEAU 2007, 2008, 2009; SCANA 2013)

COMMON NAME	SCIENTIFIC NAME	PARR	MONTICELLO
black crappie	*Pomoxis nigromaculatus*	x	x
blue catfish	*Ictalurus furcatus*	x	x
bluegill	*Lepomis macrochirus*	x	x
channel catfish	*Ictalurus punctatus*	x	x
flat bullhead	*Ameiurus platycephalus*	x	x
flathead catfish	*Pylodictis olivaris*	x	
gizzard shad	*Dorosoma cepedianum*	x	x
golden shiner	*Notemigonus chrysoleucas*	x	x
highfin carpsucker	*Carpiodes velifer*	x	
largemouth bass	*Micropterus salmoides*	x	x
longnose gar	*Lepisosteus osseus*	x	
northern hogsucker	*Hypentelium nigricans*	x	x
notchlip redhorse	*Moxostoma collapsum*	x	x
pumpkinseed	*Lepomis gibbosus*	x	x
quillback	*Carpiodes cyprinus*	x	x
redbreast sunfish	*Lepomis auritus*	x	x
redear sunfish	*Lepomis microlophus*	x	x
robust redhorse	*Moxostoma robustum*	x	x
sandbar shiner	*Notropis scepticus*	x	
shorthead redhorse	*Moxostoma macrolepidotum*	x	x
smallmouth bass	*Micropterus dolomieu*	x	x
snail bullhead	*Ameiurus brunneus*		x
spottail shiner	*Notropis hudsonius*	x	x
threadfin shad	*Dorosoma petenense*	x	x
warmouth	*Lepomis gulosus*	x	
white bass	*Morone chrysops*	x	
white catfish	*Ameiurus catus*	x	x
white perch	*Morone americana*	x	x
whitefin shiner	*Cyprinella nivea*	x	x
yellow bullhead	*Amierus natalis*	x	x
yellow perch	*Perca flavescens*	x	x

[2] To date, 2 robust redhorse have been documented in Monticello Reservoir and 3 robust redhorse have been documented in Parr Reservoir.

3.0 STUDY GOALS AND OBJECTIVES

The goal of the desktop fish entrainment and mortality study is to develop additional information necessary to estimate potential fish entrainment and impingement at the Project. This will provide a basis for understanding the effects of entrainment, impingement and turbine mortality on fisheries resources in the Project area. The study objective is to characterize and provide an order-of-magnitude estimate of entrainment at both developments using existing literature and site-specific information.

4.0 PROJECT NEXUS

Fish that reside in the Project area could be susceptible to impingement on the Project trashracks or entrainment through the Project turbines. Evaluation of the physical characteristics of each Project development along with an evaluation of expected fish behavior at the intake structures utilizing existing information will help in the understanding of the potential for continued Project operations to affect the fishery.

5.0 GEOGRAPHIC SCOPE

As this analysis is a desktop exercise, no field reconnaissance will be implemented. Fish species present within the Project vicinity that are determined to be potentially susceptible to impingement and/or entrainment through the Project will be analyzed in this study.

6.0 METHODOLOGY

Fish impingement and entrainment at the Project may occur when fish that elect to enter into the project intake flow field during periods of operation may become impinged on the trashracks or entrained through the turbines. Fish that are small enough to pass through the projects trashracks will be considered susceptible to entrainment while those physically excluded due to size (i.e. length, width, and/or depth) will be considered as potential candidates for impingement. Not all fish species occurring in the Project reservoirs may be equally susceptible to entrainment or impingement because of their habitat use, behavior and swimming abilities relative to the project intake velocity. As noted, fish entrainment at the Project developments will be assessed through a desktop study. The primary inputs for this analysis will be as follows:

1. Develop an entrainment and turbine mortality database that can be applied to the Parr and Monticello developments.

2. Calculate and estimate fish entrainment rates, seasonally if possible, at each Project development. Entrainment rates are defined as: number of Fish/volume of water entrained.

3. Characterize the species composition of potential fish entrainment.

4. Apply any physical or biological filters that may influence entrainment.

5. Estimate the total annual entrainment for the Project based on normal operation.

6. Estimate potential turbine mortality for fish entrainment based on turbine mortality estimates from similar project studies.

7. Estimate impingement mortality for fish eliminated from entrainment estimates.

These inputs are described in more detail below.

<u>Development of an Entrainment Database</u>

Over seventy site-specific studies of resident fish entrainment at hydroelectric sites in the United States have been reported to date, which provide order-of-magnitude estimates of annual fish entrainment (FERC, 1995). Descriptive information will be gathered from available entrainment studies and will include:

- Location: geographic proximity (preference given to same river basin).
- Project size: discharge capacity and power production.
- Mode of operation - e.g., peaking, run-of-river, etc.
- Biological factors: fish species composition.
- Impoundment characteristics: general water quality, impoundment size, flow regime.
- Physical project characteristics: trash rack spacing, intake velocity, etc.

This information will be assembled into a “matrix” of data to be used as a database for the desktop study. After review of the “matrix”, specific studies that are most applicable to the Project developments will be selected for use in the entrainment database. Key criteria to be used in acceptance of candidate studies may include:

- Similar geographic location, with preference given to projects located in the same river basin.
- Similar station hydraulic capacity.
- Similar station operation (peaking, run-of-river, etc.).

- Biological similarities: fish species, assemblage and water quality.
- Availability and type of entrainment data (netting vs hydroacoustic).

Estimation of Fish Entrainment

Fish entrainment by species for the proposed Project will be estimated on a monthly basis (if possible) to provide an order-of-magnitude fish entrainment estimate. As noted, the entrainment rates will be presented in fish entrained per hour of operation and fish per volume of water passed through project turbines (fish/million cubic feet). The data will be grouped by season, where appropriate, to determine an entrainment density for each season of the year. The seasonal data from each entrainment study will be averaged to develop a seasonal mean entrainment estimate at each Project development.

Species Composition Analysis

Species composition data from the accepted entrainment studies will be analyzed and compiled to determine the fish species typically entrained at other hydroelectric projects. This information will be grouped to yield predicted seasonal estimates of species-specific data for entrained fish to determine:

- Likelihood of entrainment by species.
- Expected relative abundance of each species identified as potentially entrained.
- Prediction of seasonal entrainment by species and size, if applicable.

Application of Physical or Biological Filters

Adjustment of fish entrainment rates based on site-specific characteristics of the Project may be appropriate. Factors potentially affecting entrainment rates that may warrant adjustment of estimates include:

- Trashrack spacing.
- Fish habitat available at the intakes.
- Other site specific factors as determined during the study.

Some limited boat electrofishing will also be conducted in the Fairfield development forebay in Monticello Reservoir and in the Fairfield development tailrace canal in Parr Reservoir for purposes of characterizing the fish communities occurring in the intake vicinities. Sampling will be conducted in the spring and fall of the 2014 and 2015, concurrent with fish tissue sampling required as part of environmental compliance activities for the VC Summer Nuclear Station. All fish encountered will be identified to species, measured for total length, and either returned alive to the river or retained for fish tissue sampling. While ancillary to the entrainment and impingement estimates described above, the sampling will provide qualitative data describing spatial and temporal patterns of fish occurring in the intake zone. Existing fish community data for Parr Reservoir (summarized in the Parr and Fairfield Baseline Fisheries Report) will also be used to better understand spatial and temporal fish distribution trends as part of developing entrainment estimates for both developments.

Total Annual Entrainment Estimate

Total fish entrainment for each Project development will be estimated on an annual basis to provide an order of-magnitude entrainment estimate. The total fish entrainment estimate will be produced for a typical water and operating year.

Turbine Mortality

As fish move through hydroelectric turbines, a percentage are killed due to turbine mortality (i.e. blade strikes, shear forces, and pressure changes, etc.). Turbine passage survival studies have been performed at numerous hydroelectric projects throughout the country. Characteristics of these known project studies will be compared to the characteristics of the Parr and Monticello development turbines and appropriate studies will be selected for the transfer of turbine mortality data. Selected turbine survival rate data will also be obtained from the literature and used to estimate the number of fish lost due to turbine mortality. Important turbine characteristics viewed as general criteria for accepting turbine mortality studies will include but are not limited to:

- Turbine design type.
- Operating head.
- Turbine runner speed.
- Turbine diameter, and peripheral runner velocity.

Species specific turbine mortality rate data available from source studies will also be reviewed and consolidated. Where multiple tests are available for a given fish genus or family, a mean survival rate will be computed. For genus or families where no acceptable data can be identified, the survival rate data from surrogate genus and/or family groups will be utilized.

Once turbine mortality rates are developed from the study database, the rates will be applied to the fish entrainment estimates for the Project. This will be accomplished by multiplying fish entrainment estimates by the composite mortality rates for each family/genus group (where applicable).

Impingement Estimates

Fish eliminated from entrainment estimates due to their size in relation to the trashrack spacing will be considered susceptible to impingement. Swim speed information for these species and size groups will be compared to intake velocities to estimate the potential for impingement. Those species or size groups lacking the ability to avoid impingement will be considered impinged and subsequently killed due to impingement mortality.

7.0 SCHEDULE AND PRODUCTS

Our goal is to complete this study by the end of 2015. Based on review of an earlier draft of the study plan, the TWC identified several "hold points," associated with the 7 primary study inputs identified in Section 6.0. Specifically, "hold points" were requested following completion of Step 1 (entrainment and turbine mortality database development), Step 3 (characterization of species composition), and Step 5 (estimate of total annual entrainment). At each of these hold points, the TWC will be convened to review the study progress to date prior to proceeding with the next phase of the analysis.

Comments from the TWC will be addressed during each phase of the analysis. Upon completion of the study, a draft report will be prepared and distributed to the TWC for review and comment. The draft report will summarize the results obtained in the study; will contain appropriate tables and figures depicting estimated fish entrainment; and will contain all supporting correspondence among the TWC members. After receipt of all comments, the draft report will be revised to address final comments by TWC members and will be resubmitted as the Final Report.

8.0 USE OF STUDY RESULTS

Study results will be used as an information resource during discussion of relicensing issues and developing potential Protection, Mitigation and Enhancement measures with the South Carolina Department of Natural Resources, USFWS, Fisheries TWC, and other relicensing stakeholders.

9.0 REFERENCES

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Exhibit E-5 Fisheries Resources

Desktop Fish Entrainment Report

PARR HYDROELECTRIC PROJECT
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FINAL
DESKTOP FISH ENTRAINMENT
STUDY RESULTS

Prepared for:

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FINAL DESKTOP FISH ENTRAINMENT STUDY RESULTS

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PARR HYDROELECTRIC PROJECT
FERC NO. 1894

DESKTOP FISH ENTRAINMENT STUDY RESULTS

1.0 INTRODUCTION

South Carolina Electric & Gas Company (SCE&G) is the Licensee of the Parr Hydroelectric Project (FERC No. 1894) (Project). The Project consists of the Parr Shoals Development and the Fairfield Pumped Storage Development. Both Developments are located along the Broad River in Fairfield and Newberry Counties, South Carolina.

The Project is currently involved in a relicensing process which involves a variety of stakeholders including state and federal resource agencies, state and local government, non-governmental organizations (NGO), and interested individuals. SCE&G established several Technical Working Committees (TWC's) comprised of interested stakeholders with the objective of identifying and addressing environmental issues associated with the Project.

The Fisheries TWC recommended that a desktop fish entrainment and turbine mortality study be conducted as part of relicensing to determine the potential impacts of operating the two Developments on the fisheries communities in Parr and Monticello reservoirs. The Fisheries TWC developed a study plan to address this issue, which was filed with the Federal Energy Regulatory Commission (FERC) in the Preliminary Application Document (Parr Project Desktop Fish Entrainment Study Plan – Kleinschmidt 2014 – Appendix A). This report provides a summary of the study results. As part of that plan, SCE&G prepared four progress Memos (Appendix B) that were reviewed and discussed with the Fisheries TWC. The notes from those progress meetings are presented in Appendix C.

1.1 PROJECT DESCRIPTION

The Parr Shoals Dam forms the 13 mile long Parr Reservoir along the Broad River. The Parr Development has 6 vertical-shaft Francis turbines, each rated at 3,600 horsepower (hp) under a net head of 35 feet and a combined licensed capacity of 14.9 MW. The maximum hydraulic capacity of each turbine is approximately 1,000 cubic feet per second (cfs), and the minimum unit turndown has an estimated flow of 150 cfs. Parr Development typically operates in a modified run-of-river mode and normally operates continuously to pass Broad River flows.

The Fairfield Development is located directly off of the Broad River and uses the 6,800 acre Monticello Reservoir as its upper pool and Parr Reservoir as the lower pool for pumped storage operations. The Fairfield Development has eight vertical-shaft reversible Francis pump turbines. The turbines have a maximum combined licensed capacity of 511.2 MW. The maximum hydraulic capacity of each pump-turbine in generating mode is 6,300 cfs, and the minimum turndown flow is approximately 2,500 cfs. In pumping mode, the turbines each have an average rated hydraulic capacity of 5,225 cfs across the total dynamic head range of 158 to 173 feet. The Fairfield Development is primarily used for peaking operations, reserve generation, and power usage.

2.0 METHODOLOGY

Fish impingement and entrainment may occur when fish enter into the project intake area during periods of operation and become either impinged on the trashracks (dependent on bar rack spacing size and fish size) or become entrained through the turbines. As fish pass through a turbine they are subjected to pressure changes, shear stress, and mechanical injury. Each of these stresses will influence the number of fish killed by turbine passage. Fish entrainment in the southeast was historically evaluated through onsite testing with tailrace netting and/or hydroacoustics. The Fisheries TWC agreed that the impacts of the Parr and Fairfield Developments can be determined through an alternative desktop entrainment analysis. In this analysis, we used the results of prior entrainment and turbine mortality field studies to approximate the potential number of fish entrained and the percentage of those fish that are killed by the project turbines.

The primary inputs for this desktop analysis were developed through a series of evaluations that were reviewed by the Fisheries TWC through four Memos (Appendix B). The Memo results covered the following steps:

1. Develop a fish entrainment and turbine mortality database that can be applied to the Parr Shoals and Fairfield Developments.
2. Calculate and estimate fish entrainment rates, seasonally if possible, for each Development. Entrainment rates are defined as: number of fish/volume of water entrained.
3. Characterize the species composition of potential fish entrainment.
4. Apply any physical or biological filters that may influence entrainment.
5. Estimate impingement mortality for fish eliminated from entrainment estimates.
6. Estimate the total annual entrainment for the Project based on an average of a range of hydrologic years including high, normal, and low years.
7. Estimate potential turbine mortality for fish entrainment based on turbine mortality estimates from similar turbine studies.

2.1 DEVELOPMENT OF AN ENTRAINMENT DATABASE

Over seventy site-specific studies of resident fish entrainment at hydroelectric sites in the United States have been reported to date, which provide order-of-magnitude estimates of annual fish entrainment (FERC, 1995). Descriptive information was gathered from available entrainment studies which include:

- Location: geographic proximity to the Project (preference given to same river basin).
- Project size: discharge capacity and power production.
- Mode of operation - e.g., peaking, run-of-river, etc.
- Biological factors: similarity of fish species composition.
- Impoundment characteristics: general water quality, impoundment size, flow regime.
- Physical project characteristics: trash rack spacing, intake velocity, etc.

This information was assembled into a “matrix” of data that was used as a database for the desktop study. After review of the “matrix”, specific studies that were most applicable to the Project Developments were selected for use in the entrainment analysis. Key criteria used in acceptance of candidate studies included:

- Similar geographic location, with preference given to projects located in the same river basin.
- Similar station hydraulic capacity.
- Similar station operation (peaking, run-of-river, etc.).

- Biological similarities: fish species, assemblage and water quality.
- Availability and type of entrainment data (netting vs. hydroacoustic).

Based on these criteria, the list of entrainment studies accepted for transfer to the Project was winnowed to five sites for the Parr Development (Table 1) and three sites for the Fairfield Development (Table 2). The sites for Parr included the Holidays Bridge (FERC No. 2465), Saluda (FERC No. 2406), Neal Shoals (FERC No. 2315), Gaston Shoals (FERC No. 2332) and Ninety-Nine Islands (FERC No. 2331) projects. The Gaston Shoals, Ninety-nine Islands, and Neal Shoals projects are located on the Broad River (the same as the Project) and the Holliday's Bridge and Saluda projects are located on the Saluda River (a basin adjacent to the Broad River). The sites for Fairfield Development included the Richard B. Russell (USACOE), Bad Creek (FERC No. 2503), and Jocassee (FERC No. 2503) projects. All three of these projects are located in the Savannah River drainage (same eco-region as the Project) (Memo 1 – Appendix B).

2.2 Fish Entrainment Rates

The entrainment rate information from the five source studies for the Parr Development and the three source studies for the Fairfield Development were consolidated to provide seasonal fish entrainment rate estimates for each Development (Memo 1 Appendix B). Entrainment rates were presented in fish per volume of water passed through project turbines (fish/million cubic feet). The data was grouped by season, where appropriate, to determine an entrainment estimate for each season of the year. The seasonal data from each entrainment study was then averaged to develop a seasonal mean entrainment rate estimate to use at the Parr and Fairfield Developments, respectively.

2.3 Species Composition Analysis

Species composition data from the source studies was analyzed to estimate species composition of fish potentially entrained at the Parr Development and the Fairfield Development (Memo 2 – Appendix B). Monthly species specific data was compiled for each of the source studies and combined to provide seasonal species composition. To account for species-level differences between source studies and fisheries data collected on Parr Reservoir, species composition was further analyzed to produce a family level composition of fish potentially entrained. Due to their species compositions being dominated by shad and not representative of the Fairfield Development, Bad Creek and Jocassee data were excluded from the species composition calculations and only the Russell project species composition data was used for the Fairfield estimates. Due to differences in body shape and associated turbine mortality, the Centrarchidae family was subdivided into Panfish and Black Bass for both Developments.

TABLE 2-1 COMPARISON OF SITE CHARACTERISTICS OF RECOMMENDED SOURCE STUDIES FOR ESTIMATING ENTRAINMENT AT THE PARR DEVELOPMENT (EPRI 1997)

PROJECT	LOCATION		TURBINE CONFIGURATION				OPERATION	IMPOUNDMENT/POWER CANAL DATA				BIOLOGICAL DATA AVAILABLE				
														Entertainment Sampling		
Name FERC NO.	State	River	Capacity (MW) (CFS)	Turbine Type	Bar Rack Spacing (in)	Depth of Intake (ft)	Peaking or Run of River	Impoundment/ Power Canal	Surface Acres	Volume (acre/ft.)	Ave. Depth	Baseline Survey	Fishery Type	Netting	Hydroacoustics	Mortality Study
Parr Hydro Development No. 1894	*SC*	*Broad*	*14.88 MW 6,000 cfs*	*Vertical Francis*	*2.25*	*From 10 ft. above bottom up to 10 ft. below WSEL*	*Run of River*	*Impoundment*	*4,400*	*32,000*	*na*	*Yes*	*Warm*	*n/a*	*n/a*	n/a
Holidays Bridge No. 2465	SC	Saluda	3.5 MW 1,850 cfs	Horizontal Francis Vertical Francis	2.0	Bottom oriented 18 ft. below the water surface	Modified Peaking	Impoundment Power Canal	466 1.5	6000 na	>6 ft. na	Yes	Warm	Full Recovery Netting on Unit 3	Yes	Yes
Saluda Dam No. 2406	SC	Saluda	2.4 MW 1,280 cfs	Horizontal Francis		Bottom oriented 14 ft. below the water surface	Modified Peaking	Impoundment	566	7228	6 ft.	Yes	Warm	Full Recovery Netting on Unit 1	Yes	No
Neal Shoals No. 2315	SC	Broad	4.42 MW 4,000 cfs	Horizontal Francis		Intake pulls from entire water column	Run of River	Impoundment	na	na	na	Yes	Warm	Full Recovery Netting on Unit 3	Yes	Yes
Gaston Shoals No. 2332	SC	Broad	9.1 MW 2,800 cfs	Horizontal Francis Vertical Francis	2.5	Bottom oriented 13.5 ft. below the water surface	Modified Peaking	Impoundment	300	2500	>30 ft.	Yes	Warm	Full Recovery Netting on Unit 6	Yes	No
Ninety-nine Islands No. 2331	SC	Broad	18 MW 3,992 cfs	Horizontal Francis		Bottom oriented 11.5 ft. below the water surface	Modified Peaking	Impoundment	433	2300	>6 ft.	Yes	Warm	Full Recovery Netting on Unit 4	Yes	Yes

TABLE 2-2 COMPARISON OF SITE CHARACTERISTICS OF FAIRFIELD DEVELOPMENT TO POTENTIAL ENTRAINMENT SOURCE STUDIES

PROJECT	LOCATION		TURBINE CONFIGURATION				OPERATION	IMPOUNDMENT/POWER CANAL DATA				BASELINE SURVEY	FISHERY TYPE	ENTERTAINMENT SAMPLING		MORTALITY STUDY
Name	State	River	Capacity (MW) (CFS)	Turbine Type	Bar Rack Spacing (in)	Depth Generation Intake (ft)	Peaking or Run of River	Impoundment/ Power Canal	Surface Acres	Volume (acre/ft.)	Ave. Depth (ft)			Netting	Hydroacoustics	
Fairfield No. 1894	*SC*	*Broad*	*511.20 MW 50,400 cfs (gen.) 41,800 (pump)*	*Francis*	*6.0*	*Surface to 65 ft below normal maximum pool*	*Peaking & Reserve*	*Impoundment*	*6,800*	*400,000*	*59*	*Yes*	*Warm*	*n/a*	*n/a*	n/a
Richard B. Russell USACOE	GA/SC	Savannah	648 MW 60,000 cfs (gen) 30,000 (pump)	Francis	8.0	Mid-depth 100 ft	Peaking	Impoundment	26,653	1,026,244	39	Yes	Warm	Full recovery	Yes	Yes
Bad Creek No.2503	SC	Bad Creek	1,065 MW (gen) (pump)	Francis	4.0		Peaking	Impoundment	333	27,148		Yes	Cool	Full recovery	Yes	No
Jocassee No. 2503	SC	Keowee	750 MW (gen) (pump)	Francis		43-66 ft	Peaking	Impoundment	7,980	1,391,670	158	Yes	Cool	No	Yes	No

2.4 TURBINE FLOWS

Turbine flow through each Development was used to estimate the total number of fish potentially entrained at the Project. For this analysis, we used data from calendar years 2000 through 2010. We compared those years with the entire period of annual average flow data available from the USGS Alston Gage (1981 – 2013) and found that the selected dataset included two years with the lowest average flow (2001 and 2008), as well as the highest average flow year (2003). The remaining years included years both above and below the median flow. Overall, this selected dataset may be slightly on the low side of the overall flow median (Memo 3; Appendix B).

Flows through the Parr Shoals powerhouse are limited to the station hydraulic capacity of 6,000 cfs. To account for this in our analysis, daily average flows for the entire period of record were capped at 6,000 cfs for comparison with 2000 through 2010 dataset. For the dataset used in the entrainment evaluation (2000 – 2010), the flows during summer were about 15% lower than the long term average. The flows during the winter and early spring are closer to the long term average (Memo 3; Appendix B).

Flows through Fairfield are truncated during high inflows to prevent downstream flooding, therefore high inflow events occurring several times in one year would reduce the pumped storage operations. This would result in high inflow years having lower pumped storage operations. Similarly, low inflow years with fewer high flow events would suggest higher pumped storage average flows. While some consideration for these inflow effects is warranted, pumped storage flows are far more attributable to the load demand on the pumped storage. If low inflow years are associated with very hot temperatures, the pumped storage operations could be significantly higher. Associating high inflow years with cooler temperatures would have the opposite effect. Future load demands at Fairfield may increase flows through the turbines on average, but the selected dataset (2000 – 2010) appears to have representative years of low inflow coupled with excessive load demand (Memo 3; Appendix B).

2.5 APPLICATION OF PHYSICAL OR BIOLOGICAL FILTERS – TRASHRACK IMPINGEMENT

Physical and biological filters refer to the physical layout of the project intakes or some biological reason that could influence entrainment. Examples of this are: trash rack spacing that is so small that fish cannot enter the intakes; intake velocities that are so low that fish would not be entrained into the intakes; and/or lake stratification that would create a hostile environment for fish to be present in the intake areas. We did not identify any filter(s) that should be applied to the Parr or Fairfield Development entrainment estimates.

The trashrack spacing on the Parr Development is 2.25 inches wide. Trashrack spacing at other reference projects is listed as 2.0 inches wide and those studies did not list impingement as a project impact. Therefore, we have assumed that impingement at the Parr Development is not likely a project issue. Spacing at the Fairfield Development is 6.0 inches wide. It is most likely that any fish that are entrained into the project intake area would move through the trashracks and into the turbine units. Therefore entrainment rather than impingement is likely the project impact. Trashrack impingement for either project was not considered to be an impact issue and was not evaluated further.

2.6 TOTAL ANNUAL ENTRAINMENT ESTIMATE

The proposed calculation of entrainment estimates for the Parr and Fairfield Developments is a four-step process, utilizing the inputs described in the previous sections. These steps are described below.

Step #1 Estimate Total Number of Fish Entrained by Month
Step #2 Estimate Total Number of Fish Entrained by Season
Step #3 Estimate Total Number of Fish in each Family/Genus-group by Season
Step #4 Apply Appropriate Entrainment Filters – Not applied on either Development

The Estimated Number of Fish Entrained by Month (Step #1) is calculated by multiplying the seasonal entrainment rates derived from the study database by the mean monthly project flow (2000-2010) for each Development. Step # 2 is calculated by adding the three months of entrainment together for each season (Winter–Dec-Jan-Feb; Spring–Mar-Apr-May; Summer–Jun-Jul-Aug; Fall–Sep-Oct-Nov). In Step #3, results from #2 are multiplied by seasonal species composition percentages derived for each Development from the study database. These results of these steps yield the estimated number of fish entrained by season and by species for each Development.

2.7 TURBINE MORTALITY

Survival rates for fish passing through the turbines at the Parr and Fairfield Developments were determined based on data gathered from the EPRI (1992, 1997) turbine survival and entrainment database (Memo 1; Appendix B). Data from tests conducted at each of the source studies was combined into a list of species and their associated survival rates for each of the Developments separately. Data for species tested multiple times at a single project were combined to yield an average survival rate for the species. Species data from each source study was then combined by family and converted to represent turbine mortality. For the Parr turbine mortality estimates, there were no survival test data for the family Moronidae available in the database. Therefore, black bass data was used as a surrogate for Moronidae based on similar size and shape of the two groups (Memo 4; Appendix B). For the Fairfield turbine mortality estimates, there was no survival test data available for several species/family groups: Clupeidae, Fundulidae, Ictaluridae, Moronidae, and Lepisosteidae. Data from the Cyprinidae family was used as a surrogate for both Clupeidae and Fundulidae. An average of the black bass and Catastomidae groups were used as a surrogate for both Ictaluridae and Moronidae. Esocidae data was used as a surrogate for the Lepisoteidae family (Memo 4; Appendix B). Fish turbine mortality estimates were then calculated by applying the turbine mortality rates to the entrainment estimates for each Development.

3.0 RESULTS

The calculation of annual estimated fish entrainment impacts for the Parr and Fairfield Developments is based on methodology described in the Parr Project Desktop Fish Entrainment Study Plan (Kleinschmidt 2014 – Appendix A).

3.1 FISH ENTRAINMENT RATES

Table 3-1 and Table 3-2 depict entrainment rate information from the entrainment study databases for both the Parr and Fairfield Developments in fish/million cubic feet of water (mcf).

TABLE 3-1 PARR STUDY SEASONAL ENTRAINMENT RATES (FISH/MILLION CF) FROM ENTRAINMENT DATABASE STUDIES (MEMO 1 – APPENDIX B)

STUDY SITE	WINTER	SPRING	SUMMER	FALL	ANNUAL MEAN
Holidays Bridge	2.1	7.3	7.1	2.4	4.7
Saluda Dam	5.4	NA[1]	8.0	7.6	5.3
Neal Shoals[2]	3.5	5.0	8.7	4.9	5.5
Gaston Shoals	1.1	2.4	8.7	2.1	3.6
Ninety-nine Islands	2.8	2.5	4.5	3.8	3.4
Mean	2.97	3.41	7.40	4.17	4.5

[1] NA = data not available
[2] seasonal rate prorated – Kleinschmidt 1996

TABLE 3-2 FAIRFIELD STUDY SEASONAL ENTRAINMENT RATES (FISH/MILLION CF) FROM ENTRAINMENT DATABASE STUDIES (MEMO 1 – APPENDIX B)

STUDY SITE	WINTER	SPRING	SUMMER	FALL	ANNUAL MEAN
Conventional Generation					
Richard B. Russell	13.8	0.9	0.7	1.2	4.2
Jocassee	4.7	4.0	2.7	3.9	3.8
Mean	9.2	2.5	1.7	2.6	
Pump Back Operation					
Richard B. Russell	NA	24.5	49.2	40.0	39.5
Bad Creek	2.8	2.9	2.3	0.7	2.2
Bad Creek	0.5	0.1	0.5	0.8	0.5
Jocassee	6.4	3.7	13.8	13.9	9.5
Mean	3.2	6.3	16.4	11.5	

3.2 TURBINE FLOWS

Turbine operations for year 2000 through 2010 were averaged monthly to yield a Mean Monthly Turbine Flow for the Parr and Fairfield Developments. The flow was converted to million cubic feet and is listed in Table 3-3.

TABLE 3-3 PARR AND FAIRFIELD DEVELOPMENT MONTHLY MEAN FLOWS – 2000 TO 2010 IN MILLION CUBIC FEET

MONTH	PARR DEVELOPMENT TOTAL MONTHLY TURBINE FLOW (MCF)	FAIRFIELD DEVELOPMENT TOTAL MONTHLY TURBINE FLOW (MCF)
January	9,786	14,203
February	9,528	11,969
March	12,131	14,483
April	10,481	18,237
May	8,416	23,287
June	6,932	26,274
July	6,163	28,142
August	5,645	29,049
September	5,348	23,895
October	5,070	19,622
November	6,206	16,077
December	9,167	15,413

3.3 SPECIES COMPOSITION

Species composition of entrained fishes (by percent) for the Parr and Fairfield Developments are presented in Table 3-4, Table 3-5, and Table 3-6. Species composition was calculated by determining percentages of fish collected during entrainment studies conducted at sites used in the entrainment database.

TABLE 3-4 PROPOSED SPECIES COMPOSITION BY FAMILY AND SEASON FOR THE PARR PROJECT BASED ON PROJECTED MAXIMUM PROJECT GENERATION

FAMILY	WINTER	SPRING	SUMMER	FALL
Catostomidae	4.15%	20.99%	3.96%	5.81%
Panfishes	13.28%	38.00%	44.58%	44.95%
Black Bass	0.41%	1.51%	2.08%	1.01%
Clupeidae	36.93%	12.07%	10.00%	15.40%
Cyprinidae	4.98%	10.70%	12.08%	9.60%
Ictaluridae	35.68%	15.50%	27.08%	20.45%
Moronidae	0.83%	0.14%	0.00%	1.77%
Percidae	3.73%	1.10%	0.21%	1.01%
TOTALS	**100%**	**100%**	**100%**	**100%**

TABLE 3-5 PROPOSED SPECIES COMPOSITION BY FAMILY AND SEASON FOR THE FAIRFIELD DEVELOPMENT – CONVENTIONAL GENERATION

FAMILY	WINTER	SPRING	SUMMER	FALL
Catostomidae	0.01%	0.03%	0.02%	0.00%
Black Bass	0.00%	0.01%	0.05%	0.04%
Panfish	0.17%	4.62%	10.53%	1.40%
Clupeidae	93.58%	42.59%	70.05%	77.35%
Cyprinidae	0.11%	0.48%	0.49%	0.60%
Ictaluridae	3.44%	0.72%	2.54%	18.52%
Lepisosteidae	0.00%	0.00%	0.02%	0.00%
Moronidae	0.00%	5.03%	0.34%	0.03%
Percidae	2.68%	46.45%	15.94%	2.05%
TOTALS	**100%**	**100%**	**100%**	**100%**

TABLE 3-6 PROPOSED SPECIES COMPOSITION BY FAMILY AND SEASON FOR THE FAIRFIELD DEVELOPMENT – PUMP-BACK GENERATION

FAMILY	WINTER	SPRING	SUMMER	FALL
Catostomidae	0.01%	0.00%	0.00%	0.01%
Black Bass	0.05%	0.00%	0.63%	0.05%
Panfish	0.29%	9.81%	0.45%	0.29%
Clupeidae	98.75%	74.01%	96.36%	98.75%
Cyprinidae	0.01%	1.07%	0.24%	0.01%
Ictaluridae	0.67%	1.84%	0.29%	0.67%
Lepisosteidae	0.00%	0.00%	0.00%	0.00%
Moronidae	0.19%	11.75%	1.78%	0.19%
Percidae	0.04%	1.51%	0.21%	0.04%
Fundulidae	0.00%	0.00%	0.01%	0.00%
Esocidae	0.00%	0.00%	0.01%	0.00%
TOTALS	**100%**	**100%**	**100%**	**100%**

3.4 TOTAL ANNUAL ENTRAINMENT

Total annual entrainment for each Development was calculated by applying total monthly project flows to the calculated entrainment rates (Table 3-7 and Table 3-9). Percent species composition was then applied to the entrainment estimates to produce an estimated number of fish entrained in each family group (Table 3-8, Table 3-10 and Table 3-11).

TABLE 3-7 ESTIMATED NUMBER OF FISH ENTRAINED MONTHLY, SEASONALLY, AND ANNUALLY AT THE PARR DEVELOPMENT BASED ON HISTORIC PROJECT OPERATIONS

	MONTH	SEASONAL ENTRAINMENT RATE (FISH/MCF)	TOTAL MONTHLY PROJECT FLOWS (MCF)	TOTAL ESTIMATED FISH ENTRAINED BY MONTH	TOTAL ESTIMATED NUMBER FISH ENTRAINED BY SEASON
Winter	December	2.97	9,167	**27,226**	**84,590**
	January	2.97	9,786	**29,065**	
	February	2.97	9,528	**28,299**	
Spring	March	3.41	12,131	**41,367**	**105,806**
	April	3.41	10,481	**35,740**	
	May	3.41	8,416	**28,699**	
Summer	June	7.4	6,932	**51,300**	**138,679**
	July	7.4	6,163	**45,606**	
	August	7.4	5,645	**41,773**	
Fall	September	4.17	5,348	**22,302**	**69,322**
	October	4.17	5,070	**21,141**	
	November	4.17	6,206	**25,879**	
ANNUAL TOTAL					**398,397**

TABLE 3-8 ESTIMATED SPECIES TOTAL ENTRAINMENT BY FAMILY AND SEASON FOR THE PARR DEVELOPMENT BASED ON HISTORIC PROJECT OPERATIONS

FAMILY	WINTER	SPRING	SUMMER	FALL	ANNUAL
Catostomidae	3,510	22,206	5,489	4,026	34,942
Panfish	11,232	40,204	61,828	31,161	144,425
Black Bass	351	1,597	2,889	700	5,537
Clupeidae	31,239	12,772	13,868	10,678	68,557
Cyprinidae	4,212	11,321	16,757	6,652	38,942
Ictaluridae	30,186	16,401	37,559	14,179	98,325
Moronidae	702	145	0	1,225	2,072
Percidae	3,159	1,161	289	700	5,309
TOTAL	**84,591**	**105,806**	**138,679**	**69,322**	**398,398**

TABLE 3-9 ESTIMATED NUMBER OF FISH ENTRAINED MONTHLY, SEASONALLY, AND ANNUAL AT THE FAIRFIELD DEVELOPMENT BASED ON HISTORIC PROJECT OPERATION

	Month	Seasonal Entrainment Rate (fish/mcf) **Conventional** Generation	Seasonal Entrainment Rate (fish/mcf) **Pump-back** Generation	Total Monthly Project Flows (mcf)	Total Estimated Fish Entrained by Month **Conventional** Generation	Total Estimated Fish Entrained by Month **Pump-back** Generation	Total Estimated Fish Entrained by Season **Conventional** Generation	Total Estimated Fish Entrained by Season **Pump-back** Generation
Winter	December	9.20	3.20	14,203	130,668	45,450	374,026	130,096
	January	9.20	3.20	11,969	110,115	38,301		
	February	9.20	3.20	14,483	133,244	46,346		
Spring	March	2.50	6.30	18,237	45,593	114,893	169,495	427,127
	April	2.50	6.30	23,287	58,218	146,708		
	May	2.50	6.30	26,274	65,685	165,526		
Summer	June	1.70	16.40	28,142	47,841	461,529	137,846	1,329,810
	July	1.70	16.40	29,049	49,383	476,404		
	August	1.70	16.40	23,895	40,622	391,878		
Fall	September	2.60	11.50	19,622	51,017	225,653	132,891	587,788
	October	2.60	11.50	16,077	41,800	184,886		
	November	2.60	11.50	15,413	40,074	177,250		
TOTAL							**814,258**	**2,474,822**

TABLE 3-10 ESTIMATED TOTAL ENTRAINMENT BY FAMILY AND SEASON FOR THE FAIRFIELD DEVELOPMENT – CONVENTIONAL GENERATION

FAMILY	WINTER	SPRING	SUMMER	FALL	ANNUAL
Catostomidae	25	44	33	0	102
Black Bass	3	21	69	56	149
Panfish	633	7,830	14,520	1,861	24,844
Clupeidae	350,027	72,192	96,559	102,794	621,572
Cyprinidae	407	815	679	794	2,695
Icatluridae	12,872	1,224	3,507	24,617	42,220
Lepisosteidae	3	0	31	0	34
Moronidae	15	8,532	465	43	9,055
Percidae	10,028	78,737	21,982	2,725	113,472
TOTAL	**374,013**	**169,393**	**137,846**	**132,891**	**814,143**

TABLE 3-11 ESTIMATED TOTAL ENTRAINMENT BY FAMILY AND SEASON FOR THE FAIRFIELD DEVELOPMENT – PUMP-BACK GENERATION

FAMILY	WINTER	SPRING	SUMMER	FALL	ANNUAL
Catostomidae	8	9	3	37	57
Black Bass	62	0	8,385	279	8,726
Panfish	371	41,921	6,032	1,677	50,001
Clupeidae	128,476	316,097	1,281,433	580,469	2,306,475
Cyprinidae	15	4,557	3,234	66	7,872
Ictaluridae	867	7,874	3,916	3,918	16,575
Lepisosteidae	1	0	22	3	26
Moronidae	250	50,188	23,711	1,130	75,279
Percidae	46	6,464	2,851	209	9,570
Fundulidae	0	18	154	0	172
Esocidae	0	0	69	0	69
TOTAL	**130,096**	**427,128**	**1,329,810**	**587,788**	**2,474,822**

3.5 TURBINE MORTALITY RATES

Turbine mortality rates (immediate, 24-hour, and 48-hour) for each family group are presented in Tables 3-12 through Table 3-14. At the request of the Fisheries TWC, we also included turbine mortality rates for latent mortality (24-hour and 48-hour) where the data was available.

TABLE 3-12 PARR DEVELOPMENT - TURBINE MORTALITY RATES BY FAMILY GROUP – IMMEDIATE 24 HOUR AND 48 HOUR

PARR MORTALITY RATES	IMMEDIATE MORTALITY	24 HR MORTALITY	48 HR MORTALITY
Panfish	7%	12%	17%
Black Bass	20%	22%	25%
Cyprinidae	14%	30%	42%
Percidae	13%	25%	32%
Catostomidae	12%	25%	28%
Clupeidae	2%	4%	15%
Ictaluridae	1%	n/a	2%
Moronidae[1]	20%	22%	25%

[1] Black bass used as surrogate

TABLE 3-13 FAIRFIELD DEVELOPMENT – TURBINE MORTALITY RATES BY FAMILY GROUP – IMMEDIATE, 24 HOUR AND 48 HOUR

FAIRFIELD MORTALITY RATES	IMMEDIATE MORTALITY	24 HR MORTALITY	48 HR MORTALITY
Panfish	33%	37%	38%
Percidae	32%	37%	40%
Cyprinidae	22%	34%	36%
Black Bass	40%	63%	66%
Catostomidae	35%	44%	47%
Esocidae	12%	24%	24%
Clupeidae	12%	24%	24%
Ictaluridae[2]	37%	49%	52%
Lepisosteidae[3]	12%	24%	24%
Moronidae[2]	37%	49%	52%
Fundulidae[1]	22%	34%	36%

[1] Cyprinidae used as surrogate

[2] average of Catostomids and Black Bass used as surrogate

[3] Esocidae used as surrogate

3.6 TURBINE MORTALITY ESTIMATES

The turbine mortality rates were multiplied with the fish entrainment estimates presented in Tables 3-8, 3-10 and Table 3-11 to provide estimates of fish killed immediately due to turbine mortality (Table 3-14, Table 3-17 and Table 3-20). At the request of the Fisheries TWC, we also included estimates for latent turbine mortality: 24 hours (Table 3-15, Table 3-18, and Table 3-21); and 48 hours (Table 3-16, Table 3-19 and Table 3-22).

TABLE 3-14 PARR DEVELOPMENT – ESTIMATED NUMBER OF FISH KILLED BASED ON IMMEDIATE TURBINE MORTALITY RATES

IMMEDIATE MORTALITY	WINTER	SPRING	SUMMER	FALL	TOTAL ANNUAL
Panfish	735	2,629	4,043	2,038	9,445
Black Bass	70	319	578	140	1,107
Cyprinidae	570	1,532	2,267	900	5,269
Percidae	418	154	38	93	703
Catostomidae	436	2,758	682	500	4,341
Clupeidae	681	279	303	233	1,496
Ictaluridae	343	186	427	161	1,117
Moronidae	140	29	0	245	415

TABLE 3-15 PARR DEVELOPMENT – ESTIMATED NUMBER OF FISH KILLED BASED ON 24 HOUR TURBINE MORTALITY RATES

24 HOUR MORTALITY	WINTER	SPRING	SUMMER	FALL	TOTAL ANNUAL
Panfish	1,338	4,791	7,368	3,713	17,211
Black Bass	77	348	630	153	1,208
Cyprinidae	1,275	3,427	5,072	2,013	11,787
Percidae	796	293	73	176	1,338
Catostomidae	887	5,610	1,387	1,017	8,827
Clupeidae	1,270	519	564	434	2,787
Ictaluridae	n/a	n/a	n/a	n/a	n/a
Moronidae	153	32	0	267	452

TABLE 3-16 PARR DEVELOPMENT - ESTIMATED NUMBER OF FISH KILLED BASED ON 48 HOUR TURBINE MORALITY RATES

48 HOUR MORTALITY	WINTER	SPRING	SUMMER	FALL	TOTAL ANNUAL
Panfish	1,865	6,675	10,266	5,174	23,980
Black Bass	89	406	735	178	1,409
Cyprinidae	1,789	4,808	7,117	2,825	16,540
Percidae	1,010	371	92	224	1,698
Catostomidae	994	6,287	1,554	1,140	9,893
Clupeidae	4,707	1,924	2,090	1,609	10,330
Ictaluridae	686	373	854	322	2,235
Moronidae	179	37	0	312	528

TABLE 3-17 FAIRFIELD DEVELOPMENT CONVENTIONAL GENERATION – ESTIMATED NUMBER OF FISH KILLED BASED ON IMMEDIATE TURBINE MORTALITY RATES

CONVENTIONAL GENERATION IMMEDIATE MORTALITY	WINTER	SPRING	SUMMER	FALL	TOTAL ANNUAL
Catostomidae	9	16	12	0	36
Black Bass	1	8	27	22	59
Panfish	208	2,568	4,762	610	8,148
Clupeidae	42,003	8,663	11,587	12,335	74,589
Cyprinidae	90	180	150	176	597
Icatluridae	4,716	448	1,285	9,019	15,468
Lepisosteidae	0	0	4	0	4
Moronidae	6	3,126	170	16	3,318
Percidae	3,259	25,587	7,133	886	36,865

TABLE 3-18 FAIRFIELD DEVELOPMENT CONVENTIONAL GENERATION – ESTIMATED NUMBER OF FISH KILLED BASED ON 24 HOUR TURBINE MORTALITY RATES

CONVENTIONAL GENERATION 24 HOUR MORTALITY	WINTER	SPRING	SUMMER	FALL	TOTAL ANNUAL
Catostomidae	11	19	15	0	45
Black Bass	2	13	44	36	94
Panfish	233	2,883	5,346	685	9,147
Clupeidae	84,007	17,326	23,174	24,671	149,177
Cyprinidae	137	274	228	267	907
Icatluridae	6,319	601	1,722	12,085	20,727
Lepisosteidae	1	0	7	0	8
Moronidae	8	4,189	228	21	4,446
Percidae	3,754	29,478	8,218	1,020	42,470

TABLE 3-19 FAIRFIELD DEVELOPMENT CONVENTIONAL GENERATION – ESTIMATED NUMBER OF FISH KILLED BASED ON 48 HOUR TURBINE MORTALITY RATES

CONVENTIONAL GENERATION 48 HOUR MORTALITY	WINTER	SPRING	SUMMER	FALL	TOTAL ANNUAL
Catostomidae	12	21	16	0	48
Black Bass	2	14	46	37	99
Panfish	242	2,993	5,551	711	9,497
Clupeidae	84,007	17,326	23,174	24,671	149,177
Cyprinidae	148	297	247	289	982
Icatluridae	6,688	636	1,822	12,791	21,937
Lepisosteidae	1	0	7	0	8
Moronidae	8	4,433	242	23	4,705
Percidae	4,041	31,725	8,844	1,098	45,708

TABLE 3-20 FAIRFIELD DEVELOPMENT PUMP-BACK GENERATION – ESTIMATED NUMBER OF FISH KILLED BASED ON IMMEDIATE TURBINE MORTALITY RATES

PUMP-BACK GENERATION IMMEDIATE MORTALITY	WINTER	SPRING	SUMMER	FALL	TOTAL ANNUAL
Cleupidae	15,417	37,932	153,772	69,656	276,777
Moronidae	92	18,388	8,687	414	27,581
Black Bass	25	0	3,349	112	3,485
Panfish	122	13,749	1,978	550	16,399
Ictaluridae	318	2,885	1,435	1,435	6,073
Percidae	15	2,101	926	68	3,110
Cyprinidae	3	1,009	716	15	1,742
Fundulidae	0	4	34	0	38
Esocidae	0	0	8	0	8
Catostomidae	3	3	1	13	20
Lepisosteidae	0	0	3	0	3

TABLE 3-21 FAIRFIELD DEVELOPMENT PUMP-BACK GENERATION – ESTIMATED NUMBER OF FISH KILLED BASED ON TURBINE 24 HOUR MORTALITY RATES

PUMP-BACK GENERATION 24 HOUR MORTALITY	WINTER	SPRING	SUMMER	FALL	TOTAL ANNUAL
Cleupidae	30,834	75,863	307,544	139,313	553,554
Moronidae	123	24,639	11,641	555	36,957
Black Bass	39	0	5,316	177	5,533
Panfish	137	15,434	2,221	617	18,409
Ictaluridae	426	3,866	1,923	1,923	8,138
Percidae	17	2,420	1,067	78	3,583
Cyprinidae	5	1,533	1,088	22	2,648
Fundulidae	0	6	52	0	58
Esocidae	0	0	17	0	17
Catostomidae	4	4	1	16	25
Lepisosteidae	0	0	5	1	6

TABLE 3-22 FAIRFIELD DEVELOPMENT PUMP-BACK GENERATION – ESTIMATED NUMBER OF FISH KILLED BASED ON TURBINE 48 HOUR MORTALITY RATES

PUMP-BACK GENERATION 48 HOUR MORTALITY	WINTER	SPRING	SUMMER	FALL	TOTAL ANNUAL
Cleupidae	30,834	75,863	307,544	139,313	553,554
Moronidae	130	26,077	12,320	587	39,114
Black Bass	41	0	5,573	186	5,800
Panfish	142	16,025	2,306	641	19,114
Ictaluridae	451	4,091	2,035	2,036	8,612
Percidae	19	2,605	1,149	84	3,856
Cyprinidae	5	1,660	1,178	24	2,868
Fundulidae	0	6	56	0	62
Esocidae	0	0	17	0	17
Catostomidae	4	4	1	17	26
Lepisosteidae	0	0	5	1	6

4.0 DISCUSSION

This desktop analysis presents an order of magnitude estimate for potential entrainment and turbine mortality for fish passing through the Parr and Fairfield Development projects. These estimates are based on hydroelectric projects that were selected due to their similarities to the Developments.

APPENDIX A

DESKTOP FISH ENTRAINMENT STUDY PLAN

DESKTOP FISH ENTRAINMENT STUDY PLAN

PARR HYDROELECTRIC PROJECT (FERC NO. 1894)

Prepared for:

South Carolina Electric & Gas Company
Cayce, South Carolina

Prepared by:

Kleinschmidt

Lexington, South Carolina
www.KleinschmidtUSA.com

February 2014

DESKTOP FISH ENTRAINMENT
STUDY PLAN

PARR HYDROELECTRIC PROJECT
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DESKTOP FISH ENTRAINMENT STUDY PLAN

PARR HYDROELECTRIC PROJECT
(FERC NO. 1894)

SOUTH CAROLINA ELECTRIC & GAS COMPANY

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DESKTOP FISH ENTRAINMENT STUDY PLAN

PARR HYDROELECTRIC PROJECT
(FERC NO. 1894)

SOUTH CAROLINA ELECTRIC & GAS COMPANY

1.0 INTRODUCTION

South Carolina Electric & Gas Company (SCE&G) is the Licensee of the Parr Hydroelectric Project (FERC No. 1894) (Project). The Project consists of the Parr Hydro Development and the Fairfield Pumped Storage Development. Both developments are located along the Broad River in Fairfield and Newberry Counties, South Carolina.

The Project is currently involved in a relicensing process which involves cooperation and collaboration between SCE&G, as licensee, and a variety of stakeholders including state and federal resource agencies, state and local government, non-governmental organizations (NGO), and interested individuals. Collaboration and cooperation is essential in the identification of and treatment of operational, economic, and environmental issues associated with a new operating license for the Project. SCE&G has established several Technical Working Committees (TWC's) comprised of interested stakeholders with the objective of achieving consensus regarding the identification and proper treatment of these issues in the context of a new license.

The TWC determined that a desktop fish entrainment and mortality study should be conducted to determine the likely effects of Project-induced entrainment and impingement based on the physical characteristics of the Project. This study plan outlines the process for a desktop analysis.

2.0 BACKGROUND AND EXISTING INFORMATION

As noted, the Project is comprised of two developments. The Parr Hydro Development forms Parr Reservoir along the Broad River. The Development consists of a 37-foot-high, 200-foot-long concrete gravity spillway dam with a powerhouse housing generating units with a combined licensed capacity of 14.9 MW. Parr Hydro operates in a modified run-of-river mode and normally operates continuously to pass Broad River flow. Current minimum flow license articles require that 1,000 cubic feet-per-second (cfs), or average daily natural inflow to Parr Reservoir[1], whichever is less, be provided downstream of Parr Dam from March through May. During the remainder of the year, 800 cfs daily average flow and 150 cfs minimum flow, or natural inflow, whichever is less, are required downstream of the Parr Dam. The 13-mile-long Parr Reservoir has a surface area of 4,400 acres at full pool and serves as the lower reservoir for pumped-storage operations at the Fairfield Pumped Storage Development.

The Fairfield Pumped Storage Development is located directly off of the Broad River. Four earthen dams form the 6,800-acre upper reservoir, Monticello Reservoir. As noted, Parr Reservoir serves as the lower reservoir for pumped storage operations. The Fairfield Development has a licensed capacity of 511.2 MW and is primarily used for peaking operations, reserve generation, and power usage.

The Project area supports warmwater fish communities typical of impounded river reaches in the Piedmont of South Carolina. Recent survey work within the Project area has documented 30 species of fish occurring in Parr Reservoir and 24 species in Monticello Reservoir (Table 1). Although some seasonal variations in community structure have been documented, the fish communities are generally similar between the two reservoirs, with gizzard shad, blue catfish, bluegill, channel catfish and white perch being the dominant species (Normandeau 2007, 2008, 2009; SCANA 2013). No state or federally listed threatened or endangered species have been documented in Monticello or Parr reservoirs, although robust redhorse, which is considered a

[1] Evaporative loss from Parr and Monticello Reservoirs is subtracted from average daily natural inflow to determine flows downstream of Parr Dam.

species of highest conservation concern by the SCDNR (2005), has been documented in limited[2] numbers in both reservoirs.

TABLE 1 FISH SPECIES DOCUMENTED AT PARR AND MONTICELLO RESERVOIRS (SOURCE: NORMANDEAU 2007, 2008, 2009; SCANA 2013)

COMMON NAME	SCIENTIFIC NAME	PARR	MONTICELLO
black crappie	*Pomoxis nigromaculatus*	x	x
blue catfish	*Ictalurus furcatus*	x	x
bluegill	*Lepomis macrochirus*	x	x
channel catfish	*Ictalurus punctatus*	x	x
flat bullhead	*Ameiurus platycephalus*	x	x
flathead catfish	*Pylodictis olivaris*	x	
gizzard shad	*Dorosoma cepedianum*	x	x
golden shiner	*Notemigonus chrysoleucas*	x	x
highfin carpsucker	*Carpiodes velifer*	x	
largemouth bass	*Micropterus salmoides*	x	x
longnose gar	*Lepisosteus osseus*	x	
northern hogsucker	*Hypentelium nigricans*	x	x
notchlip redhorse	*Moxostoma collapsum*	x	x
pumpkinseed	*Lepomis gibbosus*	x	x
quillback	*Carpiodes cyprinus*	x	x
redbreast sunfish	*Lepomis auritus*	x	x
redear sunfish	*Lepomis microlophus*	x	x
robust redhorse	*Moxostoma robustum*	x	x
sandbar shiner	*Notropis scepticus*	x	
shorthead redhorse	*Moxostoma macrolepidotum*	x	x
smallmouth bass	*Micropterus dolomieu*	x	x
snail bullhead	*Ameiurus brunneus*		x
spottail shiner	*Notropis hudsonius*	x	x
threadfin shad	*Dorosoma petenense*	x	x
warmouth	*Lepomis gulosus*	x	
white bass	*Morone chrysops*	x	
white catfish	*Ameiurus catus*	x	x
white perch	*Morone americana*	x	x
whitefin shiner	*Cyprinella nivea*	x	x
yellow bullhead	*Amierus natalis*	x	x
yellow perch	*Perca flavescens*	x	x

[2] To date, 2 robust redhorse have been documented in Monticello Reservoir and 3 robust redhorse have been documented in Parr Reservoir.

3.0 STUDY GOALS AND OBJECTIVES

The goal of the desktop fish entrainment and mortality study is to develop additional information necessary to estimate potential fish entrainment and impingement at the Project. This will provide a basis for understanding the effects of entrainment, impingement and turbine mortality on fisheries resources in the Project area. The study objective is to characterize and provide an order-of-magnitude estimate of entrainment at both developments using existing literature and site-specific information.

4.0 PROJECT NEXUS

Fish that reside in the Project area could be susceptible to impingement on the Project trashracks or entrainment through the Project turbines. Evaluation of the physical characteristics of each Project development along with an evaluation of expected fish behavior at the intake structures utilizing existing information will help in the understanding of the potential for continued Project operations to affect the fishery.

5.0 GEOGRAPHIC SCOPE

As this analysis is a desktop exercise, no field reconnaissance will be implemented. Fish species present within the Project vicinity that are determined to be potentially susceptible to impingement and/or entrainment through the Project will be analyzed in this study.

6.0 METHODOLOGY

Fish impingement and entrainment at the Project may occur when fish that elect to enter into the project intake flow field during periods of operation may become impinged on the trashracks or entrained through the turbines. Fish that are small enough to pass through the projects trashracks will be considered susceptible to entrainment while those physically excluded due to size (i.e. length, width, and/or depth) will be considered as potential candidates for impingement. Not all fish species occurring in the Project reservoirs may be equally susceptible to entrainment or impingement because of their habitat use, behavior and swimming abilities relative to the project intake velocity. As noted, fish entrainment at the Project developments will be assessed through a desktop study. The primary inputs for this analysis will be as follows:

1. Develop an entrainment and turbine mortality database that can be applied to the Parr and Monticello developments.

2. Calculate and estimate fish entrainment rates, seasonally if possible, at each Project development. Entrainment rates are defined as: number of Fish/volume of water entrained.

3. Characterize the species composition of potential fish entrainment.

4. Apply any physical or biological filters that may influence entrainment.

5. Estimate the total annual entrainment for the Project based on normal operation.

6. Estimate potential turbine mortality for fish entrainment based on turbine mortality estimates from similar project studies.

7. Estimate impingement mortality for fish eliminated from entrainment estimates.

These inputs are described in more detail below.

Development of an Entrainment Database

Over seventy site-specific studies of resident fish entrainment at hydroelectric sites in the United States have been reported to date, which provide order-of-magnitude estimates of annual fish entrainment (FERC, 1995). Descriptive information will be gathered from available entrainment studies and will include:

- Location: geographic proximity (preference given to same river basin).
- Project size: discharge capacity and power production.
- Mode of operation - e.g., peaking, run-of-river, etc.
- Biological factors: fish species composition.
- Impoundment characteristics: general water quality, impoundment size, flow regime.
- Physical project characteristics: trash rack spacing, intake velocity, etc.

This information will be assembled into a "matrix" of data to be used as a database for the desktop study. After review of the "matrix", specific studies that are most applicable to the Project developments will be selected for use in the entrainment database. Key criteria to be used in acceptance of candidate studies may include:

- Similar geographic location, with preference given to projects located in the same river basin.
- Similar station hydraulic capacity.
- Similar station operation (peaking, run-of-river, etc.).

- Biological similarities: fish species, assemblage and water quality.
- Availability and type of entrainment data (netting vs hydroacoustic).

Estimation of Fish Entrainment

Fish entrainment by species for the proposed Project will be estimated on a monthly basis (if possible) to provide an order-of-magnitude fish entrainment estimate. As noted, the entrainment rates will be presented in fish entrained per hour of operation and fish per volume of water passed through project turbines (fish/million cubic feet). The data will be grouped by season, where appropriate, to determine an entrainment density for each season of the year. The seasonal data from each entrainment study will be averaged to develop a seasonal mean entrainment estimate at each Project development.

Species Composition Analysis

Species composition data from the accepted entrainment studies will be analyzed and compiled to determine the fish species typically entrained at other hydroelectric projects. This information will be grouped to yield predicted seasonal estimates of species-specific data for entrained fish to determine:

- Likelihood of entrainment by species.
- Expected relative abundance of each species identified as potentially entrained.
- Prediction of seasonal entrainment by species and size, if applicable.

Application of Physical or Biological Filters

Adjustment of fish entrainment rates based on site-specific characteristics of the Project may be appropriate. Factors potentially affecting entrainment rates that may warrant adjustment of estimates include:

- Trashrack spacing.
- Fish habitat available at the intakes.
- Other site specific factors as determined during the study.

Some limited boat electrofishing will also be conducted in the Fairfield development forebay in Monticello Reservoir and in the Fairfield development tailrace canal in Parr Reservoir for purposes of characterizing the fish communities occurring in the intake vicinities. Sampling will be conducted in the spring and fall of the 2014 and 2015, concurrent with fish tissue sampling required as part of environmental compliance activities for the VC Summer Nuclear Station. All fish encountered will be identified to species, measured for total length, and either returned alive to the river or retained for fish tissue sampling. While ancillary to the entrainment and impingement estimates described above, the sampling will provide qualitative data describing spatial and temporal patterns of fish occurring in the intake zone. Existing fish community data for Parr Reservoir (summarized in the Parr and Fairfield Baseline Fisheries Report) will also be used to better understand spatial and temporal fish distribution trends as part of developing entrainment estimates for both developments.

Total Annual Entrainment Estimate

Total fish entrainment for each Project development will be estimated on an annual basis to provide an order of-magnitude entrainment estimate. The total fish entrainment estimate will be produced for a typical water and operating year.

Turbine Mortality

As fish move through hydroelectric turbines, a percentage are killed due to turbine mortality (i.e. blade strikes, shear forces, and pressure changes, etc.). Turbine passage survival studies have been performed at numerous hydroelectric projects throughout the country. Characteristics of these known project studies will be compared to the characteristics of the Parr and Monticello development turbines and appropriate studies will be selected for the transfer of turbine mortality data. Selected turbine survival rate data will also be obtained from the literature and used to estimate the number of fish lost due to turbine mortality. Important turbine characteristics viewed as general criteria for accepting turbine mortality studies will include but are not limited to:

- Turbine design type.
- Operating head.
- Turbine runner speed.
- Turbine diameter, and peripheral runner velocity.

Species specific turbine mortality rate data available from source studies will also be reviewed and consolidated. Where multiple tests are available for a given fish genus or family, a mean survival rate will be computed. For genus or families where no acceptable data can be identified, the survival rate data from surrogate genus and/or family groups will be utilized.

Once turbine mortality rates are developed from the study database, the rates will be applied to the fish entrainment estimates for the Project. This will be accomplished by multiplying fish entrainment estimates by the composite mortality rates for each family/genus group (where applicable).

<u>Impingement Estimates</u>

Fish eliminated from entrainment estimates due to their size in relation to the trashrack spacing will be considered susceptible to impingement. Swim speed information for these species and size groups will be compared to intake velocities to estimate the potential for impingement. Those species or size groups lacking the ability to avoid impingement will be considered impinged and subsequently killed due to impingement mortality.

7.0 SCHEDULE AND PRODUCTS

Our goal is to complete this study by the end of 2015. Based on review of an earlier draft of the study plan, the TWC identified several "hold points," associated with the 7 primary study inputs identified in Section 6.0. Specifically, "hold points" were requested following completion of Step 1 (entrainment and turbine mortality database development), Step 3 (characterization of species composition), and Step 5 (estimate of total annual entrainment). At each of these hold points, the TWC will be convened to review the study progress to date prior to proceeding with the next phase of the analysis.

Comments from the TWC will be addressed during each phase of the analysis. Upon completion of the study, a draft report will be prepared and distributed to the TWC for review and comment. The draft report will summarize the results obtained in the study; will contain appropriate tables and figures depicting estimated fish entrainment; and will contain all supporting correspondence among the TWC members. After receipt of all comments, the draft report will be revised to address final comments by TWC members and will be resubmitted as the Final Report.

8.0 USE OF STUDY RESULTS

Study results will be used as an information resource during discussion of relicensing issues and developing potential Protection, Mitigation and Enhancement measures with the South Carolina Department of Natural Resources, USFWS, Fisheries TWC, and other relicensing stakeholders.

9.0 REFERENCES

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APPENDIX B

FISHERIES TWC MEMOS 1, 2, 3, 4, AND 5

MEMORANDUM

TO: Parr Hydro Relicense - Fisheries Technical Working Committee
FROM: Henry Mealing and Shane Boring
DATE: October 20, 2014
RE: Fish Entrainment and Turbine Mortality Desktop Study – Revised First Hold Point – Establishing the Database and Entrainment Rates

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The Parr-Fairfield Fish Entrainment and Turbine Mortality Study Plan (Plan) was approved by the Fisheries Technical Working Committee (TWC) on December 19, 2013. The Plan identifies several "hold points" associated with completion of the study. The purpose of each hold point is to allow the TWC members an opportunity to review the study progress to date prior to proceeding to the next phase of the analysis. This memo is prepared pursuant to the first hold point which includes two steps:

1. Develop an entrainment and turbine mortality database that can be applied to the Parr and Fairfield developments. We have provided a list of recommended source entrainment and turbine mortality studies to use in developing fish entrainment estimates and turbine mortality estimates for the two developments.

2. Calculate and estimate fish entrainment rates (seasonally if possible) for each development. Entrainment rates are defined as: number of fish/volume of water entrained. We have provided monthly data from the proposed studies and grouped the data to provide seasonal entrainment rates for the Parr and Fairfield developments.

The original version of this Memo was revised to address questions and comments submitted by the USFWS on June 24, 2014.

RECOMMENDED ENTRAINMENT DATABASE

PARR DEVELOPMENT

In developing an entrainment database for the Parr Development, we reviewed a database of over seventy site-specific studies of resident fish entrainment at hydroelectric projects in the US (EPRI 1997). A matrix of site-specific characteristics relevant to fish entrainment was used to narrow the database down to those studies that best matched the Parr Development. The characteristics were:

- Location: geographic proximity of reference study (preference given to same river basin)
- Project size: discharge capacity and power production
- Mode of operation: peaking, run-of-river, etc.
- Biological factors: fish species composition
- Impoundment characteristics: general water quality, impoundment size, flow regime
- Physical project characteristics: trash rack spacing, intake velocity, etc.

This review identified five reference studies that were most similar to the Parr Development (Table 1). Each of the proposed reference studies is from the Saluda or Broad rivers in South Carolina and is geographically and operationally similar to the Parr Development. Entrainment rates at each of the reference studies were based on tailrace netting. These five studies were also used in a previous desktop entrainment study for a project on the Broad River (Kleinschmidt 1996).

FAIRFIELD DEVELOPMENT

Using the same matrix of site characteristics, we identified three pump storage studies that could be used as reference studies for the Fairfield Development (Table 2). The Richard B. Russell (RBR) Project is a pump storage project located on the Savannah River, GA, with a reservoir that supports a warmwater fishery. Studies at RBR included the use of both hydroacoustics and full recovery netting to determine fish entrainment rates for operations. The Bad Creek and Jocassee developments are located in the foothills of SC. These projects include cool water oligotrophic reservoirs that are not as similar to the Fairfield Development, but both are pump storage projects. Entrainment sampling at Bad Creek included tailrace netting and hydroacoustics. The Jocassee Project entrainment sampling included hydroacoustics and purse seine netting in the tailrace area.

USFWS CONSULTATION

The USFWS requested that we also review the Buzzard Roost study (Lake Greenwood) for applicability at either or both developments, because “the Buzzard’s Roost Project has a similar geography, (RM 60, Saluda R.), generation capacity (15.0 MW), hydraulic capacity (3300 cfs) and fishery (warm water). Moreover, the Buzzard’s Roost study made an effort to equally divide monitoring across daytime and nighttime”.

We reviewed the Buzzard’s Roost study and found that the entrainment rates were significantly greater (on average 17 times higher) in comparison to the smaller, riverine reservoirs identified as potential source studies for the Parr Development, as well as the three pump-back studies identified for estimation of entrainment for the Fairfield Development. Buzzard Roost is located on Lake Greenwood, which is a storage reservoir with a warmwater fishery dominated by shad as a forage species. This is reflected in the resulting entrainment rates, as far greater numbers of shad (threadfin and gizzard shad) were entrained when schools periodically moved into the intake area. We do not recommend inclusion of the Buzzard Roost project in the data set for two reasons:

- The huge discrepancy in entrainment rates associated with high densities of shad in the reservoir would shift the entrainment estimates up several orders of magnitude.
- The high proportion of shad in the entrainment catches would cause a significant shift in the overall <u>species</u> entrainment estimates and would likely not be representative of either the Parr or Monticello reservoir species composition.

TABLE 1. COMPARISON OF SITE CHARACTERISTICS OF RECOMMENDED SOURCE STUDIES FOR ESTIMATING ENTRAINMENT AT THE PARR DEVELOPMENT (EPRI 1997)

PROJECT	LOCATION		TURBINE CONFIGURATION				OPERATION	IMPOUNDMENT/POWER CANAL DATA				BIOLOGICAL DATA AVAILABLE				
Name FERC NO.	State	River	Capacity (MW) (CFS)	Turbine Type	Bar Rack Spacing (in)	Depth of Intake (ft)	Peaking or Run of River	Impoundment/ Power Canal	Surface Acres	Volume (acre/ft.)	Ave. Depth	Baseline Survey	Fishery Type	Entertainment Sampling Netting	Entertainment Sampling Hydroacoustics	Mortality Study
Parr Hydro Development No. 1894	*SC*	*Broad*	*14.88 MW 6,000 cfs*	*Vertical Francis*	*2.25*	*From 10 ft. above bottom up to 10 ft. below WSEL*	*Run of River*	*Impoundment*	*4,400*	*32,000*	*na*	*Yes*	*Warm*	*n/a*	*n/a*	n/a
Holidays Bridge No. 2465	SC	Saluda	3.5 MW 1,850 cfs	Horizontal Francis Vertical Francis	2.0	Bottom oriented 18 ft. below the water surface	Modified Peaking	Impoundment Power Canal	466 1.5	6000 na	>6 ft. na	Yes	Warm	Full Recovery Netting on Unit 3	Yes	Yes
Saluda Dam No. 2406	SC	Saluda	2.4 MW 1,280 cfs	Horizontal Francis		Bottom oriented 14 ft. below the water surface	Modified Peaking	Impoundment	566	7228	6 ft.	Yes	Warm	Full Recovery Netting on Unit 1	Yes	No
Neal Shoals No. 2315	SC	Broad	4.42 MW 4,000 cfs	Horizontal Francis		Intake pulls from entire water column	Run of River	Impoundment	na	na	na	Yes	Warm	Full Recovery Netting on Unit 3	Yes	Yes
Gaston Shoals No. 2332	SC	Broad	9.1 MW 2,800 cfs	Horizontal Francis Vertical Francis	2.5	Bottom oriented 13.5 ft. below the water surface	Modified Peaking	Impoundment	300	2500	>30 ft.	Yes	Warm	Full Recovery Netting on Unit 6	Yes	No
Ninety-nine Islands No. 2331	SC	Broad	18 MW 3,992 cfs	Horizontal Francis		Bottom oriented 11.5 ft. below the water surface	Modified Peaking	Impoundment	433	2300	>6 ft.	Yes	Warm	Full Recovery Netting on Unit 4	Yes	Yes

TABLE 2. COMPARISON OF SITE CHARACTERISTICS OF FAIRFIELD DEVELOPMENT TO POTENTIAL ENTRAINMENT SOURCE STUDIES

PROJECT	LOCATION		TURBINE CONFIGURATION				OPERATION	IMPOUNDMENT/POWER CANAL DATA				BASELINE SURVEY	FISHERY TYPE	ENTERTAINMENT SAMPLING		MORTALITY STUDY
Name	State	River	Capacity (MW) (CFS)	Turbine Type	Bar Rack Spacing (in)	Depth Generation Intake (ft)	Peaking or Run of River	Impoundment/ Power Canal	Surface Acres	Volume (acre/ft.)	Ave. Depth (ft)			Netting	Hydroacoustics	
Fairfield No. 1894	*SC*	*Broad*	*511.20 MW 50,400 cfs (gen.) 41,800 (pump)*	*Francis*	*6.0*	*Surface to 65 ft below normal maximum pool*	*Peaking & Reserve*	*Impoundment*	*6,800*	*400,000*	*59*	*Yes*	*Warm*	*n/a*	*n/a*	n/a
Richard B. Russell USACOE	GA/SC	Savannah	648 MW 60,000 cfs (gen) 30,000 (pump)	Francis	8.0	Mid-depth 100 ft	Peaking	Impoundment	26,653	1,026,244	39	Yes	Warm	Full recovery	Yes	Yes
Bad Creek No.2503	SC	Bad Creek	1,065 MW (gen) (pump)	Francis	4.0		Peaking	Impoundment	333	27,148		Yes	Cool	Full recovery	Yes	No
Jocassee No. 2503	SC	Keowee	750 MW (gen) (pump)	Francis		43-66 ft	Peaking	Impoundment	7,980	1,391,670	158	Yes	Cool	No	Yes	No

ENTRAINMENT RATES

Parr Development

Entrainment rates for the five reference entrainment studies for use with the Parr Development are presented in Table 3. Fish entrainment is based on fish/million cubic feet of water passed through the project. The entrainment data provided in Table 3 were obtained from the original entrainment reports, analyzed, and presented in the *Lockhart Project Fish Entrainment Analysis* (Kleinschmidt 1996). The Saluda Dam study had missing data points for March, April, and May, and the Neal Shoals report only presented an annual entrainment rate. As part of the Lockhart Study, the SCDNR, USFWS, and Kleinschmidt prorated entrainment data for the Neal Shoals study and also combined the monthly data into seasonal entrainment rates (Table 4) (Kleinschmidt 1996). Seasons were grouped in the following manner:

- Winter = December, January, and February
- Spring = March, April, and May
- Summer = June, July, and August
- Fall = September, October, and November

TABLE 3. PARR STUDY MONTHLY ENTRAINMENT RATES (FISH/MILLION CF) FROM ENTRAINMENT DATABASE STUDIES. (KLEINSCHMIDT 1996)

STUDY SITE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL RATE
Holidays Bridge	2.2	0.8	6.5	3.7	11.6	7.1	7.1	7.1	2.9	3.1	1.2	3.3	
Saluda Dam	5.4	5.4	NA[1]	NA[1]	NA[1]	10.1	8.1	5.8	5.5	12.6	4.8	5.4	
Neal Shoals	NG[2]	NG[2]	NG[2]	NG[2]	NG[2]	NG[2]	NG[2]	NG[2]	NG[2]	NG[2]	NG[2]	NG[2]	5.5
Gaston Shoals	1.3	1.4	0.6	5.0	1.5	8.8	9.0	8.3	3.6	2.3	0.4	0.5	
Ninety-nine Islands	2.8	5.6	0.8	2.1	4.5	4.5	4.5	4.5	2.7	5.5	3.3	0.0	
Mean	2.9	3.3	2.6	3.6	5.9	7.6	7.2	6.4	3.7	5.9	2.4	2.3	

[1]NA = data not collected

[2]NG = monthly data not given in report – Annual entrainment rate provided

TABLE 4. PARR STUDY SEASONAL ENTRAINMENT RATES (FISH/MILLION CF) FROM ENTRAINMENT DATABASE STUDIES. (KLEINSCHMIDT 1996)

STUDY SITE	WINTER	SPRING	SUMMER	FALL	ANNUAL MEAN
Holidays Bridge	2.1	7.3	7.1	2.4	4.7
Saluda Dam	5.4	NA[1]	8.0	7.6	5.3
Neal Shoals[2]	3.5	5.0	8.7	4.9	5.5
Gaston Shoals	1.1	2.4	8.7	2.1	3.6
Ninety-nine Islands	2.8	2.5	4.5	3.8	3.4
Mean	2.97	3.41	7.40	4.17	4.5

[1]NA = data not available

[2] seasonal rate prorated – Kleinschmidt 1996

Fairfield Development

The three reference pump-back entrainment projects have a combination of both conventional generation entrainment and pump-back entrainment rates available. The RBR and the Jocassee studies include both conventional and pump-back data. The Bad Creek study only included pump-back data.

We reviewed the reports from each of the three projects and noted that each study identified shad and herring as the largest sources of fish entrainment in the generation and pump-back operations. Therefore, with the exception of the Jocassee Project, we also presented entrainment rates for "All" species combined, for "Shad-Herring", and "Other" species (Table 5). We believe that these projects represent the best sources of pump-back entrainment in the southeast. However, we also recommend that the TWC discuss the potential differences in shad-herring population densities between the source studies and the Monticello Reservoir and tailrace. Upon review, it may be appropriate to modify the entrainment rates to reflect what would be observed at the Fairfield Development.

We grouped the data into seasons and calculated a Seasonal Entrainment Rate for both conventional generation and pump-back operation (Table 6). This rate is based on all of the data for both shad and other species. Because the seasonal rates presented in Table 6 are based on reservoirs with high densities of shad and herring, these rates should be considered provisional and could be reduced based on discussion within the TWC.

TABLE 5. FAIRFIELD STUDY ENTRAINMENT RATES (FISH/MILLION CF) FROM ENTRAINMENT DATABASE STUDIES

STUDY SITE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVG.
Richard B. Russell – Conventional Generation													
	6.8	33.6	1.0	1.2	0.5	0.3	0.5	1.3	0.6	0.4	2.6	1.1	4.1
Jocassee (2013) - Conventional Generation													
	5.8	5.0	3.1	4.1	4.8	1.7	3.0	3.4	3.3	2.7	5.7	3.2	3.8
Richard B. Russell – Pump-Back Operation													
Pump Back "ALL"				23.8	25.2	8.7	46.7	92.0	51.2	28.9			
Pump Back – Shad and Herring				17.1	18.9	6.6	46.0	91.4	50.7	28.3			
Pump-Back – Other species				6.7	6.3	2.2	0.71	0.7	0.5	0.6			
Bad Creek (1991)													
Pump Back Total	2.9	1.3	1.1	1.5	1.8	1.0	2.2	0.3	0.8	0.1	0.1	0.0	1.1
Pump Back – Shad and Herring	2.7	1.2	1.1	1.4	0.7	0.8	0.8	0.0	0.4	0.1	0.1	0.0	0.8
Pump-Back – Other species	0.1	0.0	0.0	0.1	1.2	0.1	1.4	0.2	0.4	0.0	0.0	0.0	0.3
Bad Creek (1992)													
Pump Back Total	0.1	0.5	0.1	0.0	0.0	0.2	0.2	0.3	0.4	0.3	0.5	0.2	0.2
Pump Back – Shad and Herring	0.1	0.5	0.1	0.0	0.0	0.2	0.2	0.0	0.2	0.0	0.5	0.2	0.2
Pump-Back – Other Species	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.2	0.3	0.0	0.0	0.1
Jocassee (2013) Pump Back													
	7.4	2.4	4.8	3.2	3.2	6.3	18.4	16.8	13.0	15.8	13.0	9.3	9.5
Study assumption that almost all fish entrained were Shad													

TABLE 6. FAIRFIELD STUDY SEASONAL ENTRAINMENT RATES (FISH/MILLION CF) FROM ENTRAINMENT DATABASE STUDIES

STUDY SITE	WINTER	SPRING	SUMMER	FALL	ANNUAL MEAN
Conventional Generation					
Richard B. Russell	13.8	0.9	0.7	1.2	4.2
Jocassee	4.7	4.0	2.7	3.9	3.8
Mean	9.2	2.5	1.7	2.6	
Pump Back Operation					
Richard B. Russell	NA	24.5	49.2	40.0	39.5
Bad Creek	2.8	2.9	2.3	0.7	2.2
Bad Creek	0.5	0.1	0.5	0.8	0.5
Jocassee	6.4	3.7	13.8	13.9	9.5
Mean	3.2	6.3	16.4	11.5	

TURBINE MORTALITY DATABASE

The most frequently cited mortality factors relating to fish moving through Francis runners are runner speed, peripheral runner velocity, and cavitations (EPRI 1992). For a given turbine size, the faster the runner is rotating, the opening through which the fish must pass is effectively clear less often. Revolutions per minute (rpm) therefore indicate the frequency and duration of the opening between the turbine and the unit housing through which the fish pass. The amount of project head directly affects turbine mortality by dictating Francis turbine design and operating characteristics, such as peripheral runner velocity and cavitation, which in turn are believed to directly affect fish survival. Literature suggests that for large fish, the size of wicket gates and number of blades, along with operating efficiency, influence turbine mortality (EPRI 1992). While larger fish stand the greatest chance of experiencing mortality due to collision with turbine hardware, such as blades (Cada 1990), smaller fish are less likely to strike gates and stay vanes but are more prone to runner injury and hydraulically-related mortality, such as cavitation (Eicher 1987).

The Parr Development has an operating head of 35 ft, six Francis turbines with a rotational speed of 100 rpm, and a hydraulic capacity of 1,000 cfs per unit. The Fairfield Development has an operating head of 150 ft, eight Francis turbines with a rotational speed of 150 rpm and a hydraulic capacity of 5,225 cfs per unit. We reviewed the EPRI (1997) turbine mortality database (using turbine type, rated head, rated flow, speed of turbines, and fish species assessed) to identify potential source studies that could be used for this desktop analysis. We identified multiple projects for Parr (blue) and Fairfield (grey) that are presented in Table 7. We will use the data from each of these studies to develop turbine mortality estimates for each species or family that are anticipated to be entrained at the project.

TABLE 7. COMPARISON OF PHYSICAL AND HYDRAULIC CHARACTERISTICS OF HYDROELECTRIC DAMS EQUIPPED WITH FRANCIS TURBINES AT WHICH TURBINE PASSAGE SURVIVAL WAS ESTIMATED

STATION	DESIGNED TURBINE FLOW (CFS)	NUMBER OF BUCKETS	RUNNER SPEED (RPM)	HEAD (FT)	RUNNER DIAMETER (IN)	FISH GROUPS TESTED
Parr	**1,000**		**100**	**35**		**n/a**
Fairfield	**5,225**	**9**	**150**	**150**	**206**	**n/a**
Alcona, MI	615	16	90	43	100	Warmwater
Alcona, MI	1155 -1660	16	90		100	Warmwater
Bond Falls, MI	450		300	210		Warmwater
Caldron Falls, WI (Unit 1)			226	80	72	Warmwater
Centralia, WI (Unit 1)	510					Warmwater
Centralia, WI (Unit 2)	510		90	20	28	Warmwater

Station	Designed Turbine Flow (cfs)	Number of Buckets	Runner Speed (rpm)	Head (ft)	Runner Diameter (in)	Fish Groups Tested
Centralia, WI	variable			15.5		Warmwater
Columbia, SC	833	14	164	28	64	Warmwater
Colton, NY	497	19	360	265	59	Warmwater
Cushman Plant 2, WA	800	17	300	450	83	Salmoinds
Cushman Plant 2, WA (1960)	800	17	300		83	Salmoinds
E. J. West, NY	2,700	15	113	63	131	Warmwater
Finch Pruyn, NY (Unit 4)				9-16	41	Warmwater
Finch Pruyn, NY (Unit 5)				9-16	41	Warmwater
Five Channels, MI	675	16	150	36	55	Warmwater
Five Channels, MI	1034 -1167	16	150		55	Warmwater
Grand Rapids, WI (U 1,2,4 comb)	645		90			Warmwater
Grand Rapids, WI (Unit 2)	645		150	28	58	Warmwater
Grand Rapids, WI (Unit 4)	926		180	28	72	Warmwater
Hardy, MI (Unit 2)	510	16	163.6	100.2	83.75	Warmwater
Highley, NY	675	13	257	46	48	Warmwater
Hoist, MI	300		360	142		Clupieds
Holtwood, PA(U10/single runner)	3,500	16	94.7	62	149.5	Clupieds
Holtwood, PA (U3/double runner)	3,500	17	102.8	62	112	Clupieds
Holtwood, PA	3,500	16	95	55	164	Clupieds
Luray, VA	369	12	164	18	62.75	Angulidae
Minetto, NY	1,500	16	72	17	139	Warmwater
Peshtigo, WI (Unit 4)	460		100	13	80	Warmwater
Potato Rapids, WI (Unit 1)	500		123	17	84	Warmwater
Potato Rapids, WI (Unit 2)	440		135	17	80	Warmwater
Pricket, MI	326		257	54	53.5	Warmwater
Rogers, MI (units 1 & 2)	383	15	150	39	60	Warmwater
Ruskin, BC	4,000		120	130	149	Salmoinds
Sandstone Rapids,WI			150	42	87	Warmwater
Seton Creek, BC	4,500		120	150	114	Warmwater
Shasta, WA	3,200	15	138.5	380	184	Warmwater
Shasta, WA	3,200	15	138.5		184	Warmwater
Stevens Creek, SC	1,000	14	75	28	135	Warmwater
Vernon, VT/NH	1,834	15	74	34	156	Warmwater

SCE&G will hold a conference call with the Fisheries TWC within approximately two weeks of distribution of this Memo to discuss these proposed studies for the desktop analysis.

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MEMORANDUM

TO: Parr/Fairfield Fisheries Technical Working Committee

FROM: Shane Boring and Henry Mealing

DATE: October 22, 2014

RE: Fish and Entrainment and Turbine Mortality Study
Second Hold Point – Species Composition

The Parr-Fairfield Fish Entrainment and Turbine Mortality Study Plan (Plan) was approved by the Fisheries Technical Working Committee (TWC) on December 19, 2013[1]. The Plan identifies several "hold points" associated with completion of the study. The purpose of each hold point is to allow the TWC members an opportunity to review the study progress to date prior to proceeding to the next phase of the analysis. Hold Point One (memorandum issued June 12, 2014 and revised October 20, 2014) focused on development of an entrainment and turbine mortality database for the Parr Project based on a review of projects that have had site-specific studies conducted and that are similar to the Parr Project. Hold Point One identified five studies that best matched the Parr Development for purposes of estimating entrainment: Gaston Shoals, Ninety-nine Islands, Neal Shoals, Holliday's Bridge, and Saluda Station. Similarly, three studies were identified for estimating entrainment at the Fairfield Development: Richard B. Russell, Jocassee, and Bad Creek. Based on additional consultation with the U.S. Fish and Wildlife Service, Buzzard's Roost was also considered but not included as a source study for entrainment estimates.

This memo was prepared pursuant to the requirement of Hold Point Two and focuses on presenting the species composition of the each of the proposed reference studies. Monthly fish entrainment species composition for each of the Parr Development source studies is summarized below in Tables 1-12. For purposes of estimating species composition for the Fairfield Development, monthly species composition data for both generation and pumping at the Richard B. Russell Project are presented below in Tables 13 and 14, respectively. Monthly species composition for pumping at the Bad Creek Project is presented in Table 15.

Upon agreement from the TWC, all numbers will be consolidated to prepare a separate species percent composition for the Parr and for the Fairfield developments.

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[1] Plan was reviewed for the final time at the December 19, 2013, Fisheries TWC meeting, with the Final Study Plan distributed to the TWC on February 25, 2014.

TABLE 1 JANUARY SPECIES COMPOSITION FOR PARR

Species	Gaston Shoals	Ninety-nine Islands	Neal Shoals	Holliday's Bridge	Saluda Hydro
black crappie				7	
bluegill				11	
gizzard shad				63	
golden shiner				2	
northern hogsucker				2	
Piedmont darter				2	
sandbar shiner				2	
seagreen darter				2	
snail bullhead				2	
yellow perch				7	
Total				100	
Total Fish				46	

TABLE 2 FEBRUARY SPECIES COMPOSITION FOR PARR

Species	Gaston Shoals	Ninety-nine Islands	Neal Shoals	Holliday's Bridge	Saluda Hydro
bluegill	36	1			
bluehead chub	4				
central stoneroller	4				
channel catfish	8	69			
creek chub		1			
gizzard shad	12	2		64	
golden shiner				9	
hybrid sunfish	8				
largemouth bass	4				
northern hogsucker		1		9	
redbreast sunfish	4				
redear sunfish	4				
sandbar shiner				9	
seagreen darter				9	
shorthead redhorse		1			
silvery minnow		1			
striped jumprock	4				
white catfish	8	21			
white sucker	4	1			
Total	100	100		100	
Total Fish	25	85		11	

TABLE 3 MARCH SPECIES COMPOSITION FOR PARR

Species	Gaston Shoals	Ninety-nine Islands	Neal Shoals	Holliday's Bridge	Saluda Hydro
black redhorse			53		
blueback herring		33			
bluegill	50		1	13	
brown bullhead			1		
channel catfish		8	1		
common carp			3		
dollar sunfish			1		
flat bullhead				2	
gizzard shad	17	50	2	10	
largemouth bass			1	2	
northern hogsucker			1	2	
Piedmont darter				3	
pumkinseed				3	
quillback			1		
redbreast sunfish	22		12	2	
redear sunfish			1		
redeye bass				2	
shorthead redhorse			12		
silver redhorse				52	
snail bullhead		8			
spottail shiner			6		
striped jumprock				3	
tesselated darter			2		
thicklip chub	6				
threadfin shad	6		3		
v-lip redhorse				2	
white perch				2	
whitefin shiner				3	
Total	100	100	100	100	
Total Fish	18	12	101	60	

TABLE 4 APRIL SPECIES COMPOSITION FOR PARR

Species	Gaston Shoals	Ninety-nine Islands	Neal Shoals	Holliday's Bridge	Saluda Hydro
black crappie		4			
bluegill	8	22		44	
bluehead chub	1				
brown bullhead	11	4			
channel catfish	1				
flat bullhead	2				
gizzard shad	1	11			
golden shiner	3			3	
hybrid sunfish	14				
largemouth bass	1				
margined madtom	2				
Piedmont darter		4		3	
pumkinseed				3	
quillback		4			
redbreast sunfish	8				
redear sunfish	7	4		8	
redeye bass				3	
silver redhorse	1	7			
smallfin redhorse		11			
snail bullhead	8				
striped jumprock	26	22			
threadfin shad		4			
warmouth	1			5	
white catfish	3	4			
whitefin shiner	1			33	
Total	100	100		100	
Total Fish	89	27		39	

TABLE 5 MAY SPECIES COMPOSITION FOR PARR

Species	Gaston Shoals	Ninety-nine Islands	Neal Shoals	Holliday's Bridge	Saluda Hydro
black crappie			5	2	
black redhorse			6		
blackbanded darter			1		
blueback herring			10		
bluegill	40	20	13	65	
bluehead chub	10				
brown bullhead			5		
central stoneroller	10				
channel catfish	20		32		
common carp	10	4	6		
creekchub	10			1	
flat bullhead		1			
flier			1		
gizzard shad		1	1		
golden shiner		1		1	
largemouth bass			3		
pumkinseed				1	
redbreast sunfish		1	5	5	
redear sunfish			10	3	
roseyface chub			1		
smallmouth bass		1			
snail bullhead		14		2	
spottail shiner		4			
striped jumprock			2		
threadfin shad		49		1	
v-lip redhorse				1	
warmouth				3	
white catfish				1	
whitefin shiner		3		15	
yellow perch			1		
yellowfin shiner				1	
Total	100	100	100	100	
Total Fish	10	77	172	124	

TABLE 6 JUNE SPECIES COMPOSITION FOR PARR

Species	Gaston Shoals	Ninety-nine Islands	Neal Shoals	Holliday's Bridge	Saluda Hydro
black crappie					2
bluegill	9	40		81	90
brown bullhead	3				
channel catfish	13			4	
common carp	2				
fathead minnow	1				
fieryblack shiner	2				
flat bullhead	1				
gizzard shad		23			
golden shiner	1			1	
green sunfish				1	
largemouth bass				2	4
margined madtom	1				
redbreast sunfish	16	7		1	
redear sunfish	2			1	
redeye bass				2	
shorthead redhorse		2			
silver redhorse	1				
smallfin redhorse	1				
smallmouth bass	1				
snail bullhead	36	5		1	
spottail shiner	1	5			
striped jumprock	2	2			
threadfin shad		13			
white catfish	8				4
whitefin shiner		5		5	
yellow perch					2
Total	100	100		100	100
Total Fish	134	62		83	57

TABLE 7 JULY SPECIES COMPOSITION FOR PARR

Species	Gaston Shoals	Ninety-nine Islands	Neal Shoals	Holliday's Bridge	Saluda Hydro
No Data for July					

TABLE 8 AUGUST SPECIES COMPOSITION FOR PARR

Species	Gaston Shoals	Ninety-nine Islands	Neal Shoals	Holliday's Bridge	Saluda Hydro
American eel			1		
black redhorse			9		
black bullhead			2		
blueback herring			3		
bluegill			6		43
brown bullhead			5		
channel catfish			18		7
common carp			6		
gizzard shad			5		
largemouth bass			3		
redbreast sunfish			1		
redear sunfish			4		
river chub			1		
snail bullhead					3
spottail shiner			12		43
striped jumprock			1		
threadfin shad			15		
white catfish			5		3
white crappie			1		
whitefin shiner			3		
Total			100		100
Total Fish			114		30

TABLE 9 SEPTEMBER SPECIES COMPOSITION FOR PARR

Species	Gaston Shoals	Ninety-nine Islands	Neal Shoals	Holliday's Bridge	Saluda Hydro
black crappie				3	3
bluegill	34	33		20	29
channel catfish	36	14		37	
common carp	1				
fieryblack shiner					3
flat bullhead					7
gizzard shad		4			
golden shiner	3			13	
largemouth bass		2			7
Piedmont darter	1				
redbreast sunfish	6	2		3	
redear sunfish				3	
sandbar shiner					48
shorthead redhorse		4			
snail bullhead	10	6			
striped jumprock	1	2			
threadfin shad	3	29			
white catfish	1			20	3
white crappie	1				
whitefin shiner	1	4			
Total	100	100		100	100
Total Fish	70	51		30	31

TABLE 10 OCTOBER SPECIES COMPOSITION FOR PARR

Species	Gaston Shoals	Ninety-nine Islands	Neal Shoals	Holliday's Bridge	Saluda Hydro
black crappie		4		3	
bluegill		54		45	72
channel catfish		8		3	
fieryblack shiner				7	2
flat bullhead		2		3	
gizzard shad		2			2
golden shiner		2			
redbreast sunfish		6		3	2
redear sunfish		2		7	8
redeye bass					2
smallfin redhorse		2			
snail bullhead		2			2
spottail shiner					2
striped jumprock		14			
white catfish				7	2
white perch					4
whitebass					4
whitefin shiner		2		21	
Total		100		100	100
Total Fish		50		29	53

TABLE 11 OCTOBER SPECIES COMPOSITION FOR PARR

Species	Gaston Shoals	Ninety-nine Islands	Neal Shoals	Holliday's Bridge	Saluda Hydro
black crappie		5			59
bluegill		5		43	11
channel catfish	20	2		14	
flat bullhead		5			
gizzard shad	20	47		43	11
northern hogsucker		2			
redbreast sunfish		14			
silver redhorse	20				
snail bullhead		2			
striped jumprock	20	16			
white crappie	20				
white perch					7
whitesucker					7
yellow perch		2			4
Total	100	100		100	100
Total Fish	5	43		7	27

TABLE 12 DECEMBER SPECIES COMPOSITION FOR PARR

Species	Gaston Shoals	Ninety-nine Islands	Neal Shoals	Holliday's Bridge	Saluda Hydro
black crappie				8	
bluegill				19	
channel catfish	14				
gizzard shad				62	83
Piedmont darter	14			3	
smallfin redhorse	43				
snail bullhead	14			3	
tesselated darter	14				
white catfish					3
whitebass					7
yellow perch				5	7
Total	100			100	100
Total Fish	7			37	30

TABLE 13 RBR SPECIES COMPOSITION BY PERCENTAGE DURING CONVENTIONAL GENERATION

Common Name	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
black crappie					5	17	2	1				
white crappie				1		2						
blueback herring	10	4	21	30	41	31	9	24	5	24	1	1
threadfin shad	87	96	17	17	2	15	64	66	78	28	95	84
carp							1			2		
spottail shiner			1									
brown bullhead							2		6	1		6
channel catfish					1						1	
white catfish					1	1	1	1	5	40	3	4
yellow bullhead							1					
white perch			1	5	9	1						
yellow perch	3	1	59	41	39	29	16	3	3	3		4
bluegill				4	2	3	3	3	2	2		

TABLE 14 RBR SPECIES COMPOSITION BY PERCENTAGE DURING PUMPBACK

Common Name	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
black crappie				3	11							
blueback herring				7	68	0	2	3	1			
bluegill					1							
channel catfish				2	2					1		
creek chub						1						
spottail shiner				2	1	6						
spotted bass						22						
striped bass						5						
tesselated darter						1						
threadfin shad				64	7		97	96	98	97		
white crappie						2						
white perch				17	9	53						
yellow bullhead						7						
yellow perch				3	1	2						

TABLE 15 BAD CREEK SPECIES COMPOSITION

Common Name	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	NOV	DEC	AVERAGE YEARLY
blueback herring	6	20	24	30	18	65	30	9	100	85	34
threadfin shad	89	78	72	61	20	23	18	1	0	9	29
common carp					4	1					0
golden shiner					1						0
white catfish				2	18	2	14	41			10
flat bullhead					1			2			0
channel catfish					1						0
brown trout					2	1					0
redbreast sunfish					3		6	13			3
warmouth				2	4	1	2				1
bluegill				2	24	7	30	32		5	18
largemouth bass					1						0
black crappie					1						1
yellow perch	5	2	3	2	2			1			1
Total Fish	100	100	100	100	100	100	100	100	100	100	100

**average of data for years 1991 and 1992*

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ATTACHMENT 1

PARR MONTHLY SPECIES COMPOSITION

January

Species	Gaston Shoals		Ninety-nine		Neal Shoals		Hollidays Bridge		Saluda Hydro		Total	
	No. Fish	%	No. Fish	%	No. Fish	%	No. Fish	%	No. Fish	%	No. Fish	%
black crappie							3	6.5			3	6.5
bluegill							5	10.9			5	10.9
gizzard shad							29	63.0			29	63.0
golden shiner							1	2.2			1	2.2
northern hogsucker							1	2.2			1	2.2
Piedmont darter							1	2.2			1	2.2
sandbar shiner							1	2.2			1	2.2
seagreen darter							1	2.2			1	2.2
snail bullhead							1	2.2			1	2.2
yellow perch							3	6.5			3	6.5
TOTAL							46	100			46	100

February

Species	**Gaston Shoals**		**Ninety-nine**		**Neal Shoals**		**Hollidays Bridge**		**Saluda Hydro**		**Total**	
	No. Fish	**%**	**No. Fish**	**%**	**No. Fish**	**%**	**No. Fish**	**%**	**No. Fish**	**%**	**No. Fish**	**%**
bluegill	9	36.0	1	1.2							10	8.3
bluehead chub	1	4.0									1	0.8
central stoneroller	1	4.0									1	0.8
channel catfish	2	8.0	59	69.4							61	50.4
creek chub			1	1.2							1	0.8
gizzard shad	3	12.0	2	2.4			7	63.6			12	9.9
golden shiner							1	9.1			1	0.8
hybrid sunfish	2	8.0									2	1.7
largemouth bass	1	4.0									1	0.8
northern hogsucker			1	1.2			1	9.1			2	1.7
redbreast sunfish	1	4.0									1	0.8
redear sunfish	1	4.0									1	0.8
sandbar shiner							1	9.1			1	0.8
seagreen darter							1	9.1			1	0.8
shorthead redhorse			1	1.2							1	0.8
silvery minnow			1	1.2							1	0.8
striped jumprock	1	4.0									1	0.8
white catfish	2	8.0	18	21.2							20	16.5
white sucker	1	4.0	1	1.2							2	1.7
TOTAL	25	100	85	100			11	100			121	100

March

Species	Gaston Shoals		Ninety-nine		Neal Shoals		Hollidays Bridge		Saluda Hydro		Total	
	No. Fish	%	No. Fish	%	No. Fish	%	No. Fish	%	No. Fish	%	No. Fish	%
black redhorse					53	52.5					53	27.7
blueback herring			4	33.3							4	2.1
bluegill	9	50.0			1	1.0	8	13.3			18	9.4
brown bullhead					1	1.0					1	0.5
channel catfish			1	8.3	1	1.0					2	1.0
common carp					3	3.0					3	1.6
dollar sunfish					1	1.0					1	0.5
flat bullhead							1	1.7			1	0.5
gizzard shad	3	16.7	6	50.0	2	2.0	6	10.0			17	8.9
largemouth bass					1	1.0	1	1.7			2	1.0
northern hogsucker					1	1.0	1	1.7			2	1.0
Piedmont darter							2	3.3			2	1.0
pumkinseed							2	3.3			2	1.0
quillback					1	1.0					1	0.5
redbreast sunfish	4	22.2			12	11.9	1	1.7			17	8.9
redear sunfish					1	1.0					1	0.5
redeye bass							1	1.7			1	0.5
shorthead redhorse					12	11.9					12	6.3
silver redhorse							31	51.7			31	16.2
snail bullhead			1	8.3							1	0.5
spottail shiner					6	5.9					6	3.1
striped jumprock							2	3.3			2	1.0
tesselated darter					2	2.0					2	1.0
thicklip chub	1	5.6									1	0.5
threadfin shad	1	5.6			3	3.0					4	2.1
v-lip redhorse							1	1.7			1	0.5
white perch							1	1.7			1	0.5
whitefin shiner							2	3.3			2	1.0
TOTAL	18	100	12	100	101	100	60	100			191	100

April

Species	Gaston Shoals		Ninety-nine		Neal Shoals		Hollidays Bridge		Saluda Hydro		Total	
	No. Fish	%	No. Fish	%	No. Fish	%	No. Fish	%	No. Fish	%	No. Fish	%
black crappie			1	3.7							1	0.6
bluegill	7	7.8	6	22.2			17	43.6			30	19.2
bluehead chub	1	1.1									1	0.6
brown bullhead	10	11.1	1	3.7							11	7.1
channel catfish	1	1.1									1	0.6
flat bullhead	2	2.2									2	1.3
gizzard shad	1	1.1	3	11.1							4	2.6
golden shiner	3	3.3					1	2.6			4	2.6
hybrid sunfish	12	13.3									12	7.7
largemouth bass	1	1.1									1	0.6
margined madtom	2	2.2									2	1.3
Northern hogsucker	1	1.1									1	0.6
Piedmont darter			1	3.7			1	2.6			2	1.3
pumkinseed							1	2.6			1	0.6
quillback			1	3.7							1	0.6
redbreast sunfish	7	7.8									7	4.5
redear sunfish	6	6.7	1	3.7			3	7.7			10	6.4
redeye bass							1	2.6			1	0.6
silver redhorse	1	1.1	2	7.4							3	1.9
smallfin redhorse			3	11.1							3	1.9
snail bullhead	7	7.8									7	4.5
striped jumprock	23	25.6	6	22.2							29	18.6
threadfin shad			1	3.7							1	0.6
warmouth	1	1.1					2	5.1			3	1.9
white catfish	3	3.3	1	3.7							4	2.6
whitefin shiner	1	1.1					13	33.3			14	9.0
TOTAL	90	100	27	100			39	100			156	100

May

Species	Gaston Shoals		Ninety-nine		Neal Shoals		Hollidays Bridge		Saluda Hydro		Total	
	No. Fish	%	No. Fish	%	No. Fish	%	No. Fish	%	No. Fish	%	No. Fish	%
black crappie					8	4.7	2	1.6			10	2.6
black redhorse					11	6.4					11	2.9
blackbanded darter					1	0.6					1	0.3
blueback herring					17	9.9					17	4.4
bluegill	4	40.0	15	19.5	23	13.4	80	64.5			122	31.9
bluehead chub	1	10.0									1	0.3
brown bullhead					9	5.2					9	2.3
central stoneroller	1	10.0									1	0.3
channel catfish	2	20.0			55	32.0					57	14.9
common carp	1	10.0	3	3.9	10	5.8					14	3.7
creek chub	1	10.0					1	0.8			2	0.5
flat bullhead			1	1.3							1	0.3
flier					1	0.6					1	0.3
gizzard shad			1	1.3	1	0.6					2	0.5
golden shiner			1	1.3			1	0.8			2	0.5
largemouth bass					5	2.9					5	1.3
pumkinseed							1	0.8			1	0.3
redbreast sunfish			1	1.3	8	4.7	6	4.8			15	3.9
redear sunfish					17	9.9	4	3.2			21	5.5
roseyface chub					2	1.2					2	0.5
smallmouth bass			1	1.3							1	0.3
snail bullhead			11	14.3			2	1.6			13	3.4
spottail shiner			3	3.9							3	0.8
striped jumprock					3	1.7					3	0.8
threadfin shad			38	49.4			1	0.8			39	10.2
v-lip redhorse							1	0.8			1	0.3
warmouth							4	3.2			4	1.0
white catfish							1	0.8			1	0.3
whitefin shiner			2	2.6			19	15.3			21	5.5
yellow perch					1	0.6					1	0.3
yellowfin shiner							1	0.8			1	0.3
TOTAL	10	100	77	100	172	100	124	100			383	100

June

Species	Gaston Shoals		Ninety-nine		Neal Shoals		Hollidays Bridge		Saluda Hydro		Total	
	No. Fish	%	No. Fish	%	No. Fish	%	No. Fish	%	No. Fish	%	No. Fish	%
black crappie									1	1.8	1	0.3
bluegill	12	9.0	25	40.3			67	80.7	51	89.5	155	46.1
brown bullhead	4	3.0									4	1.2
channel catfish	17	12.7					3	3.6			20	6.0
common carp	3	2.2									3	0.9
fathead minnow	1	0.7									1	0.3
fieryblack shiner	3	2.2									3	0.9
flat bullhead	1	0.7									1	0.3
gizzard shad			14	22.6							14	4.2
golden shiner	1	0.7					1	1.2			2	0.6
green sunfish							1	1.2			1	0.3
largemouth bass							2	2.4	2	3.5	4	1.2
margined madtom	1	0.7									1	0.3
redbreast sunfish	22	16.4	4	6.5			1	1.2			27	8.0
redear sunfish	3	2.2					1	1.2			4	1.2
redeye bass							2	2.4			2	0.6
shorthead redhorse			1	1.6							1	0.3
silver redhorse	1	0.7									1	0.3
smallfin redhorse	1	0.7									1	0.3
smallmouth bass	1	0.7									1	0.3
snail bullhead	48	35.8	3	4.8			1	1.2			52	15.5
spottail shiner	1	0.7	3	4.8							4	1.2
striped jumprock	3	2.2	1	1.6							4	1.2
threadfin shad			8	12.9							8	2.4
white catfish	11	8.2							2	3.5	13	3.9
whitefin shiner			3	4.8			4	4.8			7	2.1
yellow perch									1	1.8	1	0.3
TOTAL	134	100	62	100			83	100	57	100	336	100

July

No Data

August

Species	Gaston Shoals		Ninety-nine		Neal Shoals		Hollidays Bridge		Saluda Hydro		Total	
	No. Fish	%	No. Fish	%	No. Fish	%	No. Fish	%	No. Fish	%	No. Fish	%
American eel					1	0.9					1	0.7
black redhorse					10	8.8					10	6.9
black bullhead					2	1.8					2	1.4
blueback herring					3	2.6					3	2.1
bluegill					7	6.1			13	43.3	20	13.9
brown bullhead					6	5.3					6	4.2
channel catfish					21	18.4			2	6.7	23	16.0
common carp					7	6.1					7	4.9
gizzard shad					6	5.3					6	4.2
largemouth bass					3	2.6					3	2.1
redbreast sunfish					1	0.9					1	0.7
redear sunfish					4	3.5					4	2.8
river chub					1	0.9					1	0.7
snail bullhead									1	3.3	1	0.7
spottail shiner					14	12.3			13	43.3	27	18.8
striped jumprock					1	0.9					1	0.7
threadfin shad					17	14.9					17	11.8
white catfish					6	5.3			1	3.3	7	4.9
white crappie					1	0.9					1	0.7
whitefin shiner					3	2.6					3	2.1
TOTAL					114	100			30	100	144	100

September

Species	Gaston Shoals		Ninety-nine		Neal Shoals		Hollidays Bridge		Saluda Hydro		Total	
	No. Fish	%	No. Fish	%	No. Fish	%	No. Fish	%	No. Fish	%	No. Fish	%
black crappie							1	3.3	1	3.2	2	1.1
bluegill	24	34.3	17	33.3			6	20.0	9	29.0	56	30.8
channel catfish	25	35.7	7	13.7			11	36.7			43	23.6
common carp	1	1.4									1	0.5
fieryblack shiner									1	3.2	1	0.5
flat bullhead									2	6.5	2	1.1
gizzard shad			2	3.9							2	1.1
golden shiner	2	2.9					4	13.3			6	3.3
largemouth bass			1	2.0					2	6.5	3	1.6
Piedmont darter	1	1.4									1	0.5
redbreast sunfish	4	5.7	1	2.0			1	3.3			6	3.3
redear sunfish							1	3.3			1	0.5
sandbar shiner									15	48.4	15	8.2
shorthead redhorse			2	3.9							2	1.1
snail bullhead	7	10.0	3	5.9							10	5.5
striped jumprock	1	1.4	1	2.0							2	1.1
threadfin shad	2	2.9	15	29.4							17	9.3
white catfish	1	1.4					6	20.0	1	3.2	8	4.4
white crappie	1	1.4									1	0.5
whitefin shiner	1	1.4	2	3.9							3	1.6
TOTAL	70	100	51	100			30	100	31	100	182	100

October

Species	Gaston Shoals		Ninety-nine		Neal Shoals		Hollidays Bridge		Saluda Hydro		Total	
	No. Fish	%	No. Fish	%	No. Fish	%	No. Fish	%	No. Fish	%	No. Fish	%
black crappie			2	4.0			1	3.4			3	2.3
bluegill			27	54.0			13	44.8	38	71.7	78	59.1
channel catfish			4	8.0			1	3.4			5	3.8
fieryblack shiner							2	6.9	1	1.9	3	2.3
flat bullhead			1	2.0			1	3.4			2	1.5
gizzard shad			1	2.0					1	1.9	2	1.5
golden shiner			1	2.0							1	0.8
redbreast sunfish			3	6.0			1	3.4	1	1.9	5	3.8
redear sunfish			1	2.0			2	6.9	4	7.5	7	5.3
redeye bass									1	1.9	1	0.8
smallfin redhorse			1	2.0							1	0.8
snail bullhead			1	2.0					1	1.9	2	1.5
spottail shiner									1	1.9	1	0.8
striped jumprock			7	14.0							7	5.3
white bass									2	3.8	2	1.5
white catfish							2	6.9	1	1.9	3	2.3
white perch									2	3.8	2	1.5
whitefin shiner			1	2.0			6	20.7			7	5.3
TOTAL			50	100			29	100	53	100	132	100

November

Species	Gaston Shoals		Ninety-nine		Neal Shoals		Hollidays Bridge		Saluda Hydro		Total	
	No. Fish	%	No. Fish	%	No. Fish	%	No. Fish	%	No. Fish	%	No. Fish	%
black crappie			2	4.7					3	11.1	5	6.1
bluegill			2	4.7			3	43	2	7.4	7	8.5
channel catfish	1	20.0	1	2.3			1	14			3	3.7
flat bullhead			2	4.7							2	2.4
gizzard shad	1	20.0	20	46.5			3	43	16	59.3	40	48.8
Northern hogsucker			1	2.3							1	1.2
redbreast sunfish			6	14.0							6	7.3
silver redhorse	1	20.0									1	1.2
snail bullhead			1	2.3							1	1.2
striped jumprock	1	20.0	7	16.3							8	9.8
white crappie	1	20.0									1	1.2
white perch									3	11.1	3	3.7
white sucker									1	3.7	1	1.2
yellow perch			1	2.3					2	7.4	3	3.7
TOTAL	5	100	43	100			7	100	27	100	82	100

December

Species	Gaston Shoals		Ninety-nine		Neal Shoals		Hollidays Bridge		Saluda Hydro		Total	
	No. Fish	%	No. Fish	%	No. Fish	%	No. Fish	%	No. Fish	%	No. Fish	%
black crappie							3	8.1			3	4.1
bluegill							7	18.9			7	9.5
channel catfish	1	14.3									1	1.4
gizzard shad							23	62.2	25	83.3	48	64.9
Piedmont darter	1	14.3					1	2.7			2	2.7
smallfin redhorse	3	42.9									3	4.1
snail bullhead	1	14.3					1	2.7			2	2.7
tesselated darter	1	14.3									1	1.4
white bass									2	6.7	2	2.7
white catfish									1	3.3	1	1.4
yellow perch							2	5.4	2	6.7	4	5.4
TOTAL	7	100					37	100	30	100	74	100

ATTACHMENT 2

PARR ANNUAL SPECIES COMPOSITION

Common Name	January		February		March		April		May		June		July		August		September		October		November		December		Annual	
	No. Fish	%	No. Fish	%	No. Fish	%	No. Fish	%	No. Fish	%	No. Fish	%	No. Fish	%	No. Fish	%	No. Fish	%	No. Fish	%	No. Fish	%	No. Fish	%	No. Fish	%
Bluegill	5	10.9	10	8.3	18	9.4	30	19.2	122	31.9	155	46.1			20	13.9	56	30.8	78	59.1	7	8.5	7	9.5	508	27.5
Channel Catfish			61	50.4	2	1.0	1	0.6	57	14.9	20	6.0			23	16.0	43	23.6	5	3.8	3	3.7	1	1.4	216	11.7
Gizzard Shad	29	63.0	12	9.9	17	8.9	4	2.6	2	0.5	14	4.2			6	4.2	2	1.1	2	1.5	40	48.8	48	64.9	176	9.5
Snail Bullhead	1	2.2			1	0.5	7	4.5	13	3.4	52	15.5			1	0.7	10	5.5	2	1.5	1	1.2	2	2.7	90	4.9
Threadfin Shad					4	2.1	1	0.6	39	10.2	8	2.4			17	11.8	17	9.3							86	4.7
Redbreast Sunfish			1	0.8	17	8.9	7	4.5	15	3.9	27	8.0			1	0.7	6	3.3	5	3.8	6	7.3			85	4.6
Black Redhorse					53	27.7			11	2.9					10	6.9									74	4.0
Whitefin Shiner					2	1.0	14	9.0	21	5.5	7	2.1			3	2.1	3	1.6	7	5.3			4	5.4	61	3.3
Striped Jumprock			1	0.8	2	1.0	29	18.6	3	0.8	4	1.2			1	0.7	2	1.1	7	5.3	8	9.8			57	3.1
White Catfish			20	16.5			4	2.6	1	0.3	13	3.9			7	4.9	8	4.4	3	2.3			1	1.4	57	3.1
Redear Sunfish			1	0.8	1	0.5	10	6.4	21	5.5	4	1.2			4	2.8	1	0.5	7	5.3					49	2.7
Spottail Shiner					6	3.1			3	0.8	4	1.2			27	18.8			1	0.8					41	2.2
Silver Redhorse					31	16.2	3	1.9			1	0.3									1	1.2			36	1.9
Brown Bullhead					1	0.5	11	7.1	9	2.3	4	1.2			6	4.2									31	1.7
Black Crappie	3	6.5					1	0.6	10	2.6	1	0.3					2	1.1	3	2.3	5	6.1	3	4.1	28	1.5
Common Carp					3	1.6			14	3.7	3	0.9			7	4.9	1	0.5							28	1.5
Blueback Herring					4	2.1			17	4.4					3	2.1									24	1.3
Largemouth Bass			1	0.8	2	1.0	1	0.6	5	1.3	4	1.2			3	2.1	3	1.6							19	1.0
Golden Shiner	1	2.2	1	0.8			4	2.6	2	0.5	2	0.6					6	3.3	1	0.8					17	0.9
Sandbar Shiner	1	2.2	1	0.8													15	8.2							17	0.9
Shorthead Redhorse			1	0.8	12	6.3					1	0.3					2	1.1							16	0.9
Hybrid Sunfish			2	1.7			12	7.7																	14	0.8
Flat Bullhead					1	0.5	2	1.3	1	0.3	1	0.3					2	1.1	2	1.5	2	2.4			11	0.6
Piedmont Darter	1	2.2			2	1.0	2	1.3									1	0.5					2	2.7	8	0.4
Smallfin Redhorse							3	1.9			1	0.3							1	0.8			3	4.1	8	0.4
Yellow Perch	3	6.5							1	0.3	1	0.3									3	3.7			8	0.4
Fieryblack Shiner											3	0.9					1	0.5	3	2.3					7	0.4
Northern Hogsucker	1	2.2	2	1.7	2	1.0	1	0.6													1	1.2			7	0.4
Warmouth							3	1.9	4	1.0															7	0.4
White Perch					1	0.5													2	1.5	3	3.7			6	0.3
Redeye Bass					1	0.5	1	0.6			2	0.6							1	0.8					5	0.3
Pumkinseed					2	1.0	1	0.6	1	0.3															4	0.2
White Bass																			2	1.5			2	2.7	4	0.2
Bluehead Chub			1	0.8			1	0.6	1	0.3															3	0.2
Creek Chub			1	0.8					2	0.5															3	0.2
Margined Madtom							2	1.3			1	0.3													3	0.2
Tesselated Darter					2	1.0																	1	1.4	3	0.2
White Crappie															1	0.7	1	0.5			1	1.2			3	0.2
White Sucker			2	1.7																	1	1.2			3	0.2
Black Bullhead															2	1.4									2	0.1
Central Stoneroller			1	0.8					1	0.3															2	0.1
Quillback					1	0.5	1	0.6																	2	0.1
Roseyface Chub									2	0.5															2	0.1
Seagreen Darter	1	2.2	1	0.8																					2	0.1
Smallmouth Bass									1	0.3	1	0.3													2	0.1
V-Lip Redhorse					1	0.5			1	0.3															2	0.1
American Eel															1	0.7									1	0.1
Blackbanded Darter									1	0.3															1	0.1
Dollar Sunfish					1	0.5																			1	0.1
Fathead Minnow											1	0.3													1	0.1
Flier									1	0.3															1	0.1
Green Sunfish											1	0.3													1	0.1
River Chub															1	0.7									1	0.1
Silvery Minnow			1	0.8																					1	0.1
Thicklip Chub					1	0.5																			1	0.1
Yellowfin Shiner									1	0.3															1	0.1
Total	46	100	121	100	191	100	156	100	383	100	336	100	0	0	144	100	182	100	132	100	82	100	74	100	1847	100

ATTACHMENT 3

FAIRFIELD: RBR MONTHLY SPECIES COMPOSITION DURING CONVENTIONAL AND PUMPBACK OPERATION

Conventional Common Name	JAN %	FEB %	MAR %	APR %	MAY %	JUN %	JUL %	AUG %	SEP %	OCT %	NOV %	DEC %	Annual %
Threadfin Shad	86.798	95.520	17.048	17.031	1.698	15.139	64.410	66.436	78.329	28.024	94.987	83.700	87.244
Blueback Herring	10.093	3.521	21.222	29.502	41.176	30.836	8.507	24.185	5.218	24.152	0.793	1.070	6.651
Yellow Perch	2.778	0.903	59.092	41.451	38.701	28.765	15.677	3.160	2.682	3.128	0.342	4.360	4.039
White Catfish	0.110	0.025	0.402	0.225	0.718	1.005	1.107	1.499	5.019	39.807	2.646	3.800	0.754
Bluegill	0.074	0.009	0.479	4.354	1.726	2.968	3.414	3.120	2.358	1.596	0.122	0.320	0.347
Brown Bullhead	0.000	0.000	0.016	0.000	0.129	0.081	2.375	0.000	5.812	0.927	0.032	6.140	0.268
Black Crappie	0.024	0.002	0.106	0.372	5.288	17.490	1.871	0.709	0.000	0.000	0.064	0.040	0.222
White Perch	0.000	0.009	0.830	4.701	9.137	0.942	0.071	0.000	0.044	0.000	0.039	0.000	0.214
Channel Catfish	0.014	0.002	0.000	0.026	0.526	0.081	0.075	0.229	0.207	0.097	0.837	0.110	0.069
Spottail Shiner	0.057	0.006	0.579	0.411	0.308	0.187	0.000	0.000	0.000	0.000	0.000	0.230	0.042
White Crappie	0.000	0.000	0.000	1.154	0.071	1.610	0.056	0.129	0.000	0.000	0.000	0.000	0.040
Carp	0.000	0.000	0.000	0.062	0.030	0.238	0.943	0.049	0.086	1.707	0.000	0.030	0.033
Gizzard Shad	0.008	0.001	0.058	0.042	0.000	0.067	0.496	0.070	0.163	0.369	0.023	0.040	0.020
Yellow Bullhead	0.024	0.000	0.000	0.000	0.000	0.000	0.642	0.000	0.000	0.000	0.000	0.000	0.011
Warmouth	0.008	0.000	0.000	0.133	0.117	0.000	0.000	0.040	0.061	0.000	0.000	0.030	0.010
Flathead Catfish	0.000	0.000	0.000	0.011	0.000	0.000	0.000	0.000	0.000	0.097	0.092	0.050	0.007
Hybrid Bass	0.003	0.000	0.107	0.081	0.133	0.000	0.000	0.000	0.000	0.000	0.015	0.000	0.006
Black Bullhead	0.000	0.000	0.016	0.096	0.000	0.207	0.000	0.262	0.000	0.000	0.000	0.000	0.004
Spotted Bass	0.000	0.000	0.000	0.000	0.000	0.069	0.000	0.080	0.000	0.000	0.009	0.000	0.003
Green Sunfish	0.000	0.000	0.000	0.015	0.021	0.106	0.056	0.000	0.000	0.000	0.000	0.000	0.002
Snail Bullhead	0.000	0.000	0.000	0.000	0.000	0.071	0.000	0.000	0.000	0.000	0.000	0.050	0.002
Striped Bass	0.000	0.000	0.030	0.035	0.027	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002
Largemouth Bass	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.022	0.097	0.000	0.000	0.002
Redbreast Sunfish	0.000	0.000	0.000	0.023	0.000	0.000	0.000	0.032	0.000	0.000	0.000	0.000	0.002
Golden Shiner	0.003	0.000	0.000	0.044	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
Silver Redhorse	0.000	0.000	0.000	0.005	0.074	0.000	0.000	0.000	0.000	0.000	0.000	0.020	0.001
Tesselated Darter	0.000	0.000	0.000	0.000	0.106	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
Whitefin Shiner	0.000	0.000	0.000	0.008	0.000	0.000	0.061	0.000	0.000	0.000	0.000	0.000	0.001
Longnose Gar	0.002	0.000	0.000	0.000	0.000	0.067	0.000	0.000	0.000	0.000	0.000	0.000	0.001
Rainbow Trout	0.000	0.000	0.000	0.000	0.000	0.000	0.071	0.000	0.000	0.000	0.000	0.000	0.001
Walleye	0.000	0.001	0.000	0.012	0.000	0.000	0.169	0.000	0.000	0.000	0.000	0.000	0.001
Northern Hogsucker	0.000	0.000	0.000	0.000	0.000	0.073	0.000	0.000	0.000	0.000	0.000	0.000	0.001
Smallmouth Bass	0.000	0.000	0.000	0.022	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
White Bass	0.000	0.000	0.015	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Coosa Bass	0.000	0.000	0.000	0.000	0.015	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Blackbanded Darter	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total	100	100	100	100	100	100	100	100	100	100	100	100	100

Pumpback Common Name	JAN		FEB		MAR		APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		Total	
	No. Fish	%	No. Fish	%	No. Fish	%	No. Fish	%	No. Fish	%	No. Fish	%	No. Fish	%	No. Fish	%	No. Fish	%	No. Fish	%	No. Fish	%	No. Fish	%	No. Fish	%
Threadfin Shad							65968.34	64.33	17953.99	7.24	0.00	0.00	736668.82	96.60	1302574.28	96.26	880021.42	98.01	417382.73	97.44					3420569.59	88.772
Blueback Herring							7648.02	7.46	167784.34	67.64	0.00	0.00	14322.97	1.88	41100.96	3.04	9253.95	1.03	1901.62	0.44					242011.86	6.281
White Perch							17904.00	17.46	22086.28	8.90	32267.70	53.33	1324.07	0.17	2064.03	0.15	1188.40	0.13	1203.62	0.28					78038.12	2.025
Black Crappie							3012.52	2.94	27821.94	11.22	0.00	0.00	2430.49	0.32	2379.90	0.18	1006.57	0.11	461.66	0.11					37113.08	0.963
Channel Catfish							1958.78	1.91	4208.82	1.70	10.26	0.02	665.06	0.09	904.04	0.07	2091.07	0.23	3742.78	0.87					13580.80	0.352
Spotted Bass							0.00	0.00	0.00	0.00	13117.41	21.68	0.00	0.00	10.89	0.00	123.39	0.01	0.00	0.00					13251.69	0.344
Yellow Perch							2726.30	2.66	2565.38	1.03	1354.32	2.24	1281.75	0.17	1481.31	0.11	175.34	0.02	296.78	0.07					9881.18	0.256
Bluegill							350.18	0.34	2722.07	1.10	0.00	0.00	2666.29	0.35	942.16	0.07	1331.27	0.15	857.38	0.20					8869.34	0.230
Spottail Shiner							2078.70	2.03	1570.56	0.63	3888.54	6.43	423.22	0.06	266.85	0.02	0.00	0.00	76.94	0.02					8304.82	0.216
Yellow Bullhead							0.00	0.00	10.93	0.00	4170.69	6.89	0.00	0.00	21.78	0.00	0.00	0.00	0.00	0.00					4203.41	0.109
Striped Bass							353.38	0.34	404.48	0.16	2898.45	4.79	42.32	0.01	81.69	0.01	58.45	0.01	60.46	0.01					3899.23	0.101
Gizzard Shad							79.95	0.08	47.37	0.02	12.83	0.02	2200.74	0.29	283.19	0.02	759.80	0.08	401.21	0.09					3785.09	0.098
White Cate'Ish							68.76	0.07	178.56	0.07	0.00	0.00	120.92	0.02	364.88	0.03	1253.34	0.14	1527.89	0.36					3514.35	0.091
White Crappie							36.78	0.04	225.93	0.09	1143.99	1.89	0.00	0.00	27.23	0.00	64.94	0.01	0.00	0.00					1498.87	0.039
Largemouth Bass							0.00	0.00	0.00	0.00	0.00	0.00	126.97	0.02	462.91	0.03	331.19	0.04	175.87	0.04					1096.94	0.028
Tesselated Darter							0.00	0.00	0.00	0.00	371.93	0.61	126.97	0.02	49.01	0.00	0.00	0.00	0.00	0.00					547.91	0.014
Hybrid Bass							228.66	0.22	218.64	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	32.98	0.01					480.27	0.012
Creek Chub							8.00	0.01	0.00	0.00	382.19	0.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00					390.18	0.010
Striped Killifish							0.00	0.00	14.58	0.01	251.37	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00					265.95	0.007
Warmouth							23.99	0.02	109.32	0.04	0.00	0.00	0.00	0.00	38.12	0.00	25.98	0.00	16.49	0.00					213.89	0.006
Whitefin Shiner							0.00	0.00	0.00	0.00	130.82	0.22	0.00	0.00	16.34	0.00	0.00	0.00	60.46	0.01					207.61	0.005
Brown Bullhead							22.39	0.02	0.00	0.00	0.00	0.00	42.32	0.01	54.46	0.00	51.95	0.01	32.98	0.01					204.10	0.005
White Bass							3.20	0.00	0.00	0.00	110.30	0.18	0.00	0.00	16.34	0.00	6.49	0.00	0.00	0.00					136.33	0.004
Black Bullhead							4.80	0.00	10.93	0.00	0.00	0.00	18.14	0.00	0.00	0.00	84.42	0.01	16.49	0.00					134.78	0.003
Golden Shiner							65.56	0.06	0.00	0.00	0.00	0.00	24.18	0.00	32.68	0.00	0.00	0.00	10.99	0.00					133.41	0.003
Chain Pickerel							0.00	0.00	0.00	0.00	94.91	0.16	18.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00					113.04	0.003
Redbreast							0.00	0.00	25.51	0.01	28.22	0.05	36.28	0.00	16.34	0.00	0.00	0.00	0.00	0.00					106.34	0.003
Redbreast Sunfish							0.00	0.00	0.00	0.00	94.91	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00					94.91	0.002
Carp							0.00	0.00	0.00	0.00	92.34	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00					92.34	0.002
Silver Redhorse							0.00	0.00	7.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	82.44	0.02					89.73	0.002
Green Sunfish							11.19	0.01	58.30	0.02	10.26	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00					79.76	0.002
Redear							0.00	0.00	14.58	0.01	7.70	0.01	12.09	0.00	21.78	0.00	19.48	0.00	0.00	0.00					75.63	0.002
Flathead Catfish							0.00	0.00	0.00	0.00	10.26	0.02	0.00	0.00	16.34	0.00	38.96	0.00	0.00	0.00					65.56	0.002
River Chub							0.00	0.00	18.22	0.01	35.91	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00					54.13	0.001
Longnose Gar							0.00	0.00	0.00	0.00	0.00	0.00	36.28	0.00	0.00	0.00	6.49	0.00	0.00	0.00					42.77	0.001
Flier							0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.34	0.00	0.00	0.00	0.00	0.00					16.34	0.000
Blackbanded Darter							0.00	0.00	14.58	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00					14.58	0.000
Blue Catfish							0.00	0.00	0.00	0.00	7.70	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00					7.70	0.000
Coosa Bass							0.00	0.00	0.00	0.00	5.13	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00					5.13	0.000
Northern Hogsucker							0.00	0.00	0.00	0.00	5.13	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00					5.13	0.000
Margined Madtom							0.00	0.00	0.00	0.00	2.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00					2.57	0.000
Pumpkinseed							0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00					0.00	0.000
River Carpsucker							0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00					0.00	0.000
TOTAL							102553.46	100.00	248072.59	100.00	60505.79	100.00	762588.03	100.00	1353243.86	100.00	897892.91	100.00	428341.75	100.00					3853198.39	100.00

ATTACHMENT 4

FAIRFIELD: BAD CREEK MONTHLY SPECIES COMPOSITION DURING PUMPBACK OPERATION

Common Name	January		February		March		April		May		June		July		August		September		October		November		December		Average Year	
	No. Fish	%	No. Fish	%	No. Fish	%	No. Fish	%	No. Fish	%	No. Fish	%	No. Fish	%	No. Fish	%	No. Fish	%	No. Fish	%	No. Fish	%	No. Fish	%	No. Fish	%
Blueback herring	87	5.60	521	20.46	232	24.18	1013	30.17	646	17.61	2220	65.40	2778	29.56	177	8.74	1466	27.93	410	27.56	2242	99.89	679	84.88	12468	34.01
Threadfin shad	1380	89.35	1984	77.95	694	72.43	2047	61.00	747	20.36	779	22.93	1694	18.03	24	1.19	1298	24.73			1	0.04	74	9.19	10719	29.24
Bluegill							58	1.73	864	23.57	221	6.51	2831	30.12	646	31.90	1563	29.78	539	36.24			40	5.00	6761	18.44
White catfish					3	0.31	66	1.97	671	18.30	67	1.97	1286	13.68	837	41.31	543	10.35	308	20.71			1	0.13	3781	10.31
Redbreast sunfish							9	0.27	110	3.00	5	0.13	607	6.45	261	12.86	176	3.35			1	0.02	1	0.13	1168	3.18
Warmouth							62	1.85	156	4.24	32	0.93	203	2.16			25	0.47	26	1.71					502	1.37
Yellow perch	78	5.05	41	1.59	28	2.92	75	2.22	74	2.00					28	1.36	38	0.71			1	0.02	4	0.44	364	0.99
Black crappie							9	0.27	37	1.00	1	0.01					11	0.21	205	13.78			2	0.25	264	0.72
Common carp									139	3.78	27	0.80					6	0.10							171	0.47
Brown trout							9	0.27	75	2.03	18	0.52													101	0.28
Flat bullhead									28	0.75					48	2.35									75	0.20
Largemouth bass									19	0.50	9	0.25			2	0.07	38	0.71							66	0.18
White bass									1	0.03	5	0.15					57	1.08			1	0.02			63	0.17
Channel catfish					1	0.05			30	0.82	5	0.13			2	0.07									37	0.10
Whitefin shiner									10	0.27							25	0.47							35	0.09
Golden shiner					1	0.10	9	0.27	19	0.50	5	0.13													33	0.09
Blackbanded darter									9	0.25	5	0.13			2	0.07									15	0.04
Spottail shiner									9	0.25															9	0.02
Yellowfin shiner									9	0.25															9	0.02
Quillback									9	0.25															9	0.02
Redear sunfish									9	0.25															9	0.02
Redeye bass																	6	0.10							6	0.02
Green sunfish															2	0.07									2	0.00
Total	1545	100	2545	100	958	100	3356	100	3666	100	3395	100	9397	100	2025	100	5247	100	1488	100	2245	100	800	100	36663	100

MEMORANDUM

TO: Parr/Fairfield Fisheries Technical Working Committee

FROM: Henry Mealing and Jordan Johnson

DATE: December 15, 2014

RE: Fish Entrainment and Turbine Mortality Study
Third Hold Point – Annual Entrainment Estimation

The Parr-Fairfield Fish Entrainment and Turbine Mortality Study Plan (Plan) was approved by the Fisheries Technical Working Committee (TWC) on December 19, 2013. The Plan identified several "hold points" associated with completion of the study. The purpose of each hold point is to allow the TWC members an opportunity to review the study progress to date prior to proceeding to the next phase of the analysis. Two previous memoranda have been issued, which include:

- Hold Point One memo focused on creation of an entrainment database and turbine mortality database for the Parr and Fairfield developments based on a review of entrainment and mortality studies conducted at projects similar to the two developments. Hold Point One memo also proposed entrainment rates for the Parr and Fairfield developments.
- Hold Point Two memo presented species composition data for use with entrainment estimates at the Parr and Fairfield developments.

This memo presents Hold Point Three, which includes:

- an annual fish entrainment estimate (Parr conventional generation, Fairfield conventional generation, and Fairfield pumpback operation) based on the proposed entrainment rates presented in the Hold Point One memo;
- the final proposed species/family group composition for Parr and Fairfield developments based on the species composition information presented in Hold Point Two; and
- the annual fish entrainment estimate by species/family group composition.

Parr Development Seasonal and Annual Entrainment Estimates

Total monthly project flows for the Parr development were determined based on operation records from 2000 through 2010 and are presented in Table 1. The seasonal fish entrainment rates were then multiplied with the project flow to yield a monthly fish entrainment estimate. These were summed both seasonally and annually (Table 1).

TABLE 1 ESTIMATED NUMBER OF FISH ENTRAINED MONTHLY, SEASONALLY, AND ANNUALLY AT THE PARR DEVELOPMENT BASED ON HISTORIC PROJECT OPERATIONS

	Month	Seasonal Entrainment Rate (fish/mcf)	Total Monthly Project Flows (mcf)	Total Estimated Fish Entrained by Month	Total Estimated Number Fish Entrained by Season
Winter	December	2.97	9,167	**27,226**	
	January	2.97	9,786	**29,065**	**84,590**
	February	2.97	9,528	**28,299**	
Spring	March	3.41	12,131	**41,367**	
	April	3.41	10,481	**35,740**	**105,806**
	May	3.41	8,416	**28,699**	
Summer	June	7.4	6,932	**51,300**	
	July	7.4	6,163	**45,606**	**138,679**
	August	7.4	5,645	**41,773**	
Fall	September	4.17	5,348	**22,302**	
	October	4.17	5,070	**21,141**	**69,322**
	November	4.17	6,206	**25,879**	
Annual Total					**398,397**

The Parr species composition data presented in the Hold Point Two memo was grouped and summed by percent composition for each family group and by season and are presented in Table 2. The centrachidae family, was separated into black bass and panfish due to the differences in body shapes and associated turbine mortality.

TABLE 2 PROPOSED SPECIES COMPOSITION BY FAMILY AND SEASON FOR THE PARR PROJECT BASED ON PROJECTED MAXIMUM PROJECT GENERATION

Family	Winter	Spring	Summer	Fall
Catostomidae	4.15%	20.99%	3.96%	5.81%
Panfishes	13.28%	38.00%	44.58%	44.95%
Black Bass	0.41%	1.51%	2.08%	1.01%
Clupeidae	36.93%	12.07%	10.00%	15.40%
Cyprinidae	4.98%	10.70%	12.08%	9.60%
Ictaluridae	35.68%	15.50%	27.08%	20.45%
Moronidae	0.83%	0.14%	0.00%	1.77%
Percidae	3.73%	1.10%	0.21%	1.01%
Totals	100%	100%	100%	100%

The entrainment estimates (Table 1) were then multiplied by the family group percent compositions (Table 2) to produce an estimate of fish entrainment by family for each season and then summed annually. This yields the average potential fish entrainment (approximately 398,000 fish) that could occur at the Parr development based on the entrainment database information and historic flow data for the development.

TABLE 3 PROPOSED SPECIES TOTAL ENTRAINMENT BY FAMILY AND SEASON FOR THE PARR DEVELOPMENT BASED ON HISTORIC PROJECT OPERATIONS

Family	Winter	Spring	Summer	Fall	Annual
Catostomidae	3,510	22,206	5,489	4,026	34,942
Panfish	11,232	40,204	61,828	31,161	144,425
Black Bass	351	1,597	2,889	700	5,537
Clupeidae	31,239	12,772	13,868	10,678	68,557
Cyprinidae	4,212	11,321	16,757	6,652	38,942
Ictaluridae	30,186	16,401	37,559	14,179	98,325
Moronidae	702	145	0	1,225	2,072
Percidae	3,159	1,161	289	700	5,309
Total	84,591	105,806	138,679	69,322	398,398

Fairfield Development Seasonal and Annual Entrainment Estimates

Total monthly project flows for the Fairfield development (conventional generation and pumpback operation) were determined based on operation records from 2000 through 2010 and are presented in Table 4. The seasonal fish entrainment rates were then multiplied with the project flow to yield a monthly fish entrainment estimate for conventional generation and pumpback operations. These were summed both seasonally and annually for each operation type.

TABLE 4. ESTIMATED NUMBER OF FISH ENTRAINED MONTHLY, SEASONALLY, AND ANNUALLY AT THE FAIRFIELD DEVELOPMENT BASED ON HISTORIC PROJECT OPERATION

	Month	Seasonal Entrainment Rate (fish/mcf) **Conventional** Generation	Seasonal Entrainment Rate (fish/mcf) **Pumpback** Generation	Total Monthly Project Flows (mcf)	Total Estimated Fish Entrained by Month **Conventional** Generation	Total Estimated Fish Entrained by Month **Pumpback** Generation	Total Estimated Fish Entrained by Season **Conventional** Generation	Total Estimated Fish Entrained by Season **Pumpback** Generation
Winter	December	9.20	3.20	14,203	130,668	45,450	374,026	130,096
	January	9.20	3.20	11,969	110,115	38,301		
	February	9.20	3.20	14,483	133,244	46,346		
Spring	March	2.50	6.30	18,237	45,593	114,893	169,495	427,127
	April	2.50	6.30	23,287	58,218	146,708		
	May	2.50	6.30	26,274	65,685	165,526		
Summer	June	1.70	16.40	28,142	47,841	461,529	137,846	1,329,810
	July	1.70	16.40	29,049	49,383	476,404		
	August	1.70	16.40	23,895	40,622	391,878		
Fall	September	2.60	11.50	19,622	51,017	225,653	132,891	587,788
	October	2.60	11.50	16,077	41,800	184,886		
	November	2.60	11.50	15,413	40,074	177,250		
Total							814,258	2,474,822

The Fairfield development species composition data presented in Hold Point Two memo was grouped and summed by percent composition for each family group and by season and are presented in Table 5 for conventional generation and Table 6 for pumpback operation. Species composition from the entrainment database was slightly different between conventional and pumpback and was therefore presented separately. The centrachidae family, was separated into black bass and panfish due to the differences in body shapes and associated turbine mortality.

TABLE 5. PROPOSED SPECIES COMPOSITION BY FAMILY AND SEASON FOR THE FAIRFIELD DEVELOPMENT - CONVENTIONAL GENERATION

Family	Winter	Spring	Summer	Fall
Catostomidae	0.01%	0.03%	0.02%	0.00%
Black Bass	0.00%	0.01%	0.05%	0.04%
Panfish	0.17%	4.62%	10.53%	1.40%
Clupeidae	93.58%	42.59%	70.05%	77.35%
Cyprinidae	0.11%	0.48%	0.49%	0.60%
Ictaluridae	3.44%	0.72%	2.54%	18.52%
Lepisosteidae	0.00%	0.00%	0.02%	0.00%
Moronidae	0.00%	5.03%	0.34%	0.03%
Percidae	2.68%	46.45%	15.94%	2.05%
Totals	100%	100%	100%	100%

TABLE 6. PROPOSED SPECIES COMPOSITION BY FAMILY AND SEASON FOR THE FAIRFIELD DEVELOPMENT - PUMPBACK GENERATION

Family	Winter	Spring	Summer	Fall
Catostomidae	0.01%	0.00%	0.00%	0.01%
Black Bass	0.05%	0.00%	0.63%	0.05%
Panfish	0.29%	9.81%	0.45%	0.29%
Clupeidae	98.75%	74.01%	96.36%	98.75%
Cyprinidae	0.01%	1.07%	0.24%	0.01%
Ictaluridae	0.67%	1.84%	0.29%	0.67%
Lepisosteidae	0.00%	0.00%	0.00%	0.00%
Moronidae	0.19%	11.75%	1.78%	0.19%
Percidae	0.04%	1.51%	0.21%	0.04%
Fundulidae	0.00%	0.00%	0.01%	0.00%
Esocidae	0.00%	0.00%	0.01%	0.00%
Totals	100%	100%	100%	100%

The entrainment estimates (Table 4) were then multiplied by the family group percent compositions (Table 5 & 6) to produce an estimate of potential fish entrainment by family for each season and then summed annually for conventional generation (Table 7) and pumpback operation (Table 8). These estimates represent an order-of-magnitude for potential fish entrainment that could occur at the Fairfield development based on the entrainment database information and historic flow data for the development.

TABLE 7. PROPOSED TOTAL ENTRAINMENT BY FAMILY AND SEASON FOR THE FAIRFIELD DEVELOPMENT - CONVENTIONAL GENERATION

Family	Winter	Spring	Summer	Fall	Annual
Catostomidae	25	44	33	0	102
Black Bass	3	21	69	56	149
Panfish	633	7,830	14,520	1,861	24,844
Clupeidae	350,027	72,192	96,559	102,794	621,572
Cyprinidae	407	815	679	794	2,695
Icatluridae	12,872	1,224	3,507	24,617	42,220
Lepisosteidae	3	0	31	0	34
Moronidae	15	8,532	465	43	9,055
Percidae	10,028	78,737	21,982	2,725	113,472
Total	374,013	169,393	137,846	132,891	814,143

TABLE 8. PROPOSED TOTAL ENTRAINMENT BY FAMILY AND SEASON FOR THE FAIRFIELD DEVELOPMENT - PUMPBACK GENERATION

Family	Winter	Spring	Summer	Fall	Annual
Catostomidae	8	9	3	37	57
Black Bass	62	0	8,385	279	8,726
Panfish	371	41,921	6,032	1,677	50,001
Clupeidae	128,476	316,097	1,281,433	580,469	2,306,475
Cyprinidae	15	4,557	3,234	66	7,872
Ictaluridae	867	7,874	3,916	3,918	16,575
Lepisosteidae	1	0	22	3	26
Moronidae	250	50,188	23,711	1,130	75,279
Percidae	46	6,464	2,851	209	9,570
Fundulidae	0	18	154	0	172
Esocidae	0	0	69	0	69
Total	130,096	427,128	1,329,810	587,788	2,474,822

The Hold Point Four memo will present turbine mortality estimates that will be applied to these entrainment estimates to produce potential average annual fish entrainment estimates for the Parr and Fairfield developments.

Discussion

The Parr Development estimate of approximately 398,000 fish potentially entrained annually through the Parr Shoals turbines is based on several entrainment studies from projects on similar hydroelectric projects within the same or adjacent river systems. Therefore, we believe that these results represent a reasonable order-of-magnitude estimate of potential fish entrainment at the Parr Shoals Development.

The estimates of potential annual entrainment for the Fairfield Development (approximately 814,000 for conventional generation and 2,475,000 for pumpback) are based on much larger reservoirs within the same geographic region, but not within the Broad River Basin. The projects used represented the best available data that we could identify for preparing an "order of magnitude" fish entrainment estimate: however, in each of the reference studies, entrainment estimates for clupeids (threadfin shad, gizzard shad and blueback herring) significantly influenced the entrainment rates and species compositions. Although we used the best information we could identify, we believe that this portion of the study may be somewhat flawed in that clupeid densities in Monticello and in the Fairfield tailrace (Parr Reservoir) are likely not as high as the reference studies. This would create an overestimate of overall entrainment and especially for the clupeid family. We would welcome suggestions from the TWC on possible ways to adjust these estimates based on site specific information or on professional expertise.

LITERATURE CITED

Cada, G.F. 1990. A review of studies relating to the effects of propeller-type turbine passage on fish early life stages. North American Journal of Fisheries Management 10:418-426.

Electric Power Research Institute. 1992. Final Report. Fish Entrainment and Turbine Mortality Review and Guidelines. Project 2694-01. Prepared for Stone & Webster Environmental Services, Boston, MA.

EPRI. 1997. Turbine entrainment and survival database – field tests. Prepared by Alden Research Laboratory, Inc. EPRI Report No. 108630. 13 pp, Palo Alto, CA.

MEMORANDUM

TO: Parr/Fairfield Fisheries Technical Working Committee

FROM: Henry Mealing and Jordan Johnson – Kleinschmidt Associates

DATE: January 30, 2015

RE: Fish Entrainment and Turbine Mortality Study
Fourth Hold Point – Turbine Mortality

The Parr-Fairfield Fish Entrainment and Turbine Mortality Study Plan (Plan) was approved by the Fisheries Technical Working Committee (TWC) on December 19, 2013. The Plan identified several "hold points" associated with completion of the study. The purpose of each hold point is to allow the TWC members an opportunity to review the study progress to date prior to proceeding to the next phase of the analysis. Three previous memoranda have been issued, which include:

- Hold Point Memo One focused on creation of an entrainment database and turbine mortality database for the Parr Shoals and Fairfield developments based on a review of entrainment and mortality studies conducted at projects similar to the two developments. Hold Point Memo One also proposed entrainment rates for the Parr Shoals and Fairfield developments.
- Hold Point Memo Two presented species composition data for use with entrainment estimates at the Parr Shoals and Fairfield developments.
- Hold Point Memo Three presented: 1) an annual fish entrainment estimate (Parr Shoals conventional generation, Fairfield conventional generation, and Fairfield pumpback operation) based on the proposed entrainment rates presented in the Memo One, 2) the final proposed species/family group composition for Parr Shoals and Fairfield developments based on the species composition information presented in Memo Two, and 3) the estimated annual fish entrainment by species/family group composition for each development.

This Hold Point Memo Four presents proposed fish survival rates for turbine passage by species and family group. We used the “survival” estimate terminology because the database presented information in percent turbine survival – not “mortality”. We can adjust that terminology based on input from the TWC.

After the TWC approves Hold Point Memo Four, we will combine all of the memos into a Draft Report of potential entrainment and turbine mortality impacts for the Parr Shoals and Fairfield Developments.

Parr Shoals Development Survival Estimate

Survival estimates for fish passing through the Parr Shoals turbines were determined based on data gathered from the EPRI (1992, 1997) turbine survival and entrainment database. Source projects selected and used were originally presented in Table 7 of Memo One. Data from tests conducted at each of these source projects was combined into a single database for use at the Parr Shoals Development. Data for all tests conducted at a source project were combined into a list of species and their associated survival rates (Appendix). Data for species tested multiple times at a single project were combined to yield an average survival rate for the species. Species data from each source study was then combined by family, shown in Table 1. There were no survival test data of the family Moronidae available in the database. Therefore, we propose to use the black bass data as a surrogate for Moronidae based on similar size and shape of the two groups.

Fairfield Development Survival Estimate

Survival estimates for fish passing through the Fairfield development turbines were determined in the same fashion as the Parr Shoals analysis. A database of projects with similar turbine types and characteristics was developed using the EPRI (1992;1997) database. Of the eight projects we initially selected for estimating Fairfield turbine mortality, we did not use the Shasta, Ruskin, and Seton Creek projects because these only provided survival data for salmonids, which do not occur at the Fairfield Development. The remaining data was consolidated to create an average estimated survival rate for each species/family group listed in the Fairfield Development species composition. There was no survival test data available for several species/family groups: Clupeidae, Fundulidae, Ictaluridae, Moronidae, and Lepisosteidae. We propose to use data from the Cyprinidae family for both Clupeidae and Fundulidae. We propose to use an average of the black bass and Catastomidae groups as a surrogate for both Ictaluridae and Moronidae. Ew also propose to use the Esocidae data as a surrogate for the Lepisoteidae family.

TABLE 1. PARR SHOALS DEVELOPMENT – TURBINE SURVIVAL TEST DATA BY FAMILY GROUP

Project	Panfish	Black Bass	Cyprinidae	Percidae	Catostomidae	Clupeidae	Ictaluridae	Moronidae[1]
Alcona	90%		93%	70%	92%			
Five Channels	96%		95%	86%	80%			
Grand Rapids	91%				94%			
Rogers	95%	80%	87%	94%	91%			80%
Sandstone Rapids	90%		71%		71%			
Stevens Creek	95%			97%		97%		
Columbia	98%					99%	99%	
Average Survival	93%	80%	86%	87%	86%	98%	99%	80%

[1] black bass used as surrogate

TABLE 2 FAIRFIELD DEVELOPMENT – TURBINE SURVIVAL TEST DATA BY FAMILY GROUP

Project	Panfish	Percidae	Cyprinidae	Black Bass	Catostomidae	Esocidae	Clupeidae[1]	Ictaluridae[2]	Lepisosteidae[3]	Moronidae[2]	Fundulidae[1]
Bond Falls	80%	79%	72%				72%				72%
Caldron Falls	92%		65%		65%		65%	65%		65%	65%
Colton	15%	36%		25%	46%			36%		36%	
Hardy	96%	87%	97%	95%	84%	88%	97%	90%	88%	90%	97%
Hoist	52%										
Average Survival	67%	68%	78%	60%	65%	88%	78%	63%	88%	63%	78%

[1] Cyprinidae used as surrogate

[2] average of Catostomids and Black Bass used as surrogate

[3] Esocidae used as surrogate

Discussion

The Parr Shoals and Fairfield fish survival estimates are based on multiple turbine mortality studies from projects with similar turbine types and characteristics. Therefore, we believe that these results represent reasonable fish survival estimates that can be used for the estimation of the number of fish potentially killed when entrained at the Parr Shoals and Fairfield developments.

After discussion and agreement on fish survival (turbine mortality) rates, we will compile the information from the four memos into a draft report for the TWC's review.

LITERATURE CITED

Electric Power Research Institute. 1992. Final Report. Fish Entrainment and Turbine Mortality Review and Guidelines. Project 2694-01. Prepared for Stone & Webster Environmental Services, Boston, MA.

EPRI. 1997. Turbine entrainment and survival database – field tests. Prepared by Alden Research Laboratory, Inc. EPRI Report No. 108630. 13 pp, Palo Alto, CA.

Appendix

Parr Turbine Survival Database

ALCONA	# released	# recovered	immediate # live	survival recovered
bluegill	199	182	164	90%
spottail shiner	40	35	33	94%
yellow perch	100	95	61	64%
golden shiner	109	101	92	91%
northern pike	44	43	24	56%
grass pickerel	30	30	29	97%
w alleye	92	92	69	75%
w hite sucker	114	114	105	92%
Five Channels	# released	# recovered	immediate # live	survival recovered
bluegill	186	172	165	96%
spottail shiner	30	11	11	100%
yellow perch	55	51	46	90%
golden shiner	119	103	93	90%
w alleye	115	115	95	83%
w hite sucker	116	97	78	80%
northern pike	31	29	26	90%
Grand Rapids	# released	# recovered	immediate # live	survival recovered
bluegill	no data	974	887	91%
w hite sucker	no data	1967	1853	94%
Rogers	# released	# recovered	immediate # live	survival recovered
bluegill	182	174	165	95%
spottail shiner	no data	31	25	81%
yellow perch	no data	117	110	94%
golden shiner	94	77	72	94%
largemouth bass	60	55	44	80%
northern pike	47	42	39	93%
w alleye	no data	38	36	95%
w hite sucker	no data	90	82	91%
Sandstone Rapids	# released	# recovered	immediate # live	survival recovered
bluegill, bluegill x green sunfish hybrid	316	285	256	90%
fathead minnow , creek chub, w hite sucker, golden/shorthead redhorse	897	775	550	71%
Stevens Creek	# released	# recovered	immediate # live	survival recovered
blueback herring	131	123	119	97%
sunfish spp	110	110	104	95%
yellow perch/spotted sucker	120	120	116	97%
Columbia	# released	# recovered	immediate # live	survival recovered
channel catfish	95	88	87	99%
bluegill, redbreast sunfish	100	96	94	98%
blueback herring	100	90	89	99%

Fairfield Turbine Survival Database

Bond Falls				
	# released	# recovered	immediate # live	survival recovered
yellow perch	no data	297	236	79%
golden shiner	no data	285	205	72%
bluegill	no data	542	435	80%
Caldron Falls				
	# released	# recovered	immediate # live	survival recovered
bluegill, bluegill x green sunfish hybrid	361	342	316	92%
fathead minnow , creek chub, w hite sucker, golden/shorthead redhorse	844	803	520	65%
Colton				
	# released	# recovered	immediate # live	survival recovered
w hite sucker	no data	433	200	46%
bluegill	no data	172	25	15%
largemouth bass	no data	479	121	25%
yellow perch	no data	88	43	49%
w alleye	no data	151	35	23%
Hardy				
	# released	# recovered	immediate # live	survival recovered
bluegill	123	83	80	96%
golden shiner	119	97	94	97%
largemouth bass	60	39	37	95%
northern pike	58	50	44	88%
w alleye	42	40	31	78%
w hite sucker	119	83	70	84%
yellow perch	120	87	84	97%
Hoist				
	# released	# recovered	immediate # live	survival recovered
bluegill	300	164	86	52%

MEMORANDUM

TO: Parr/Fairfield Fisheries Technical Working Committee

FROM: Henry Mealing and Jordan Johnson – Kleinschmidt Associates

DATE: February 9, 2015

RE: Fish Entrainment and Turbine Mortality Study
Fourth Hold Point – Turbine Mortality ADDENDUM - USFWS Comments

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We issued the Hold Point Memo Four – Turbine Mortality information to the Fisheries TWC on January 30, 2015 for review and comment. Byron Hamstead forwarded the US Fish and Wildlife Service (USFWS) comments on February 3, 2015. We have copied his comments and questions below and provided clarifications as they are available.

USFWS Recommendation

USFWS Question 1) *It seems that you calculated fish survival using the method below. Can you confirm this?*
Survival rate = (number of test fish recovered live immediately following the test) / (the total number of fish recovered)
I suggest outlining whatever equation we decide on in the HP4 memo.

Kleinschmidt Response: Yes, we used the reported number of test fish recovered alive immediately after the turbine test divided by the total number of fish recovered during the test.

Fish Survival % = # of test fish recovered live immediately / # of test fish recovered

The reason we did this is based on some common testing methods that have been utilized during turbine survival tests over the past 20 years. Turbine testing is not a perfect art, but many investigators have refined testing methods over time. There are two primary types of test fish recovery that are represented in our database – netting recovery and balloon tag recovery.

Netting recovery typically utilizes a large conical net fitted with a live-car in the tailrace area that will sample the full discharge of the test turbine. Fish are introduced into the turbine intake and then recovered in the live car. Some researchers have even used "control" fish in their study to adjust the number of recovered fish (EPRI 1992, 1997). Based on our experience, there are a couple of factors that can influence the number of fish recovered in turbine testing: net efficiency was not 100% (could not recover all control fish) and large predator fish were present in the net and may have impacted the number of test fish retrieved (H. Mealing pers. observation).

Balloon tag recovery utilizes a balloon attached to the test fish that is activated prior to injection into the turbine. Through a chemical reaction the balloon becomes buoyant during turbine passage and floats the fish to the surface in the tailrace where it is retrieved. Researchers have adjusted survival numbers for these tests based on the inability to retrieve test fish because the balloon malfunctioned and the fish did not float up or based on control or test fish that were introduced to the tailrace and were not retrieved because of some unique dynamic in the tailrace where fish were trapped and could not be retrieved (Normandeau Associates 2015).

USFWS Question 2) *For a given study, the number of fish that were recovered is sometimes less than the number of fish tested (released). I am concerned that the above equation does not account for the number of test fish that were not recovered but died from entrainment injuries. Since we have no way of knowing whether an un-recovered entrained test fish survived, I propose that we assume that half of them did not.*

Kleinschmidt Response: We originally presented individual turbine test data in the Appendix of Hold Point Memo 4 (January 30, 2015). We recalculated the survival rates presented in those Appendices to reflect the USFWS recommendation to use the total number of fish tested and assume that ½ of them died and ½ of them lived. The revised information is presented in Tables 1 and 2.

USFWS Question 3) *The EPRI database includes data that measures fish survival according to the proportion of live fish recovered 24hrs and also 48hrs after the test. I propose that we use the 48hr survival rate data for a more accurate mortality estimate keeping in mind that some of these fish recovered live may die due to their injuries (infection, predation, etc.) sometime after that 48hr period. These proposals would yield the following equation:*
Survival rate = (0.5(# released - # recovered) + (# live after 48hrs)) / (# released)

Kleinschmidt Response: We went back through the database, pulled, and summarized the 24 and 48 hour latent mortality data and have also included those both with and without the "USFWS Recommendation" for number of fish recovered (Tables 1 and 2).

Summary Data

We summarized the original and revised turbine mortality data for each family group and presented those in Tables 3 and 4. This summary data provides an easy way to evaluate the changes in overall turbine mortality with the proposed "USFWS Recommendation".

TABLE 1 PARR SHOALS DEVELOPMENT – TURBINE SURVIVAL TEST DATA BY FAMILY GROUP

ALCONA	Number of Fish Released	Number of Fish Recovered	Number Live Immediate	Number Alive 24 hr	Number Alive 48 hr	USFWS Equation Immediate Survival	USFWS Equation 24 hr Survival	USFWS Equation 48 hr Survival	Study Data Immediate Survival	Study Data 24 hr Survival	Study Data 48 hr Survival
Bluegill	199	182	164	147	132	87%	78%	71%	90%	81%	73%
Spottail Shiner	40	35	33	27	13	89%	74%	39%	94%	77%	37%
Yellow Perch	100	95	61	48	40	64%	51%	43%	64%	51%	42%
Golden Shiner	109	101	92	85	80	88%	82%	77%	91%	84%	79%
Northern Pike	44	43	24	22	22	56%	51%	51%	56%	51%	51%
Grass Pickerel	30	30	29	27	26	97%	90%	87%	97%	90%	87%
Walleye	92	92	69	44	22	75%	48%	24%	75%	48%	24%
White Sucker	114	114	105	100	98	92%	88%	86%	92%	88%	86%
Five Channels											
Bluegill	186	172	165	161	149	92%	90%	84%	96%	94%	87%
Spottail Shiner	30	11	11	4	2	68%	45%	38%	100%	36%	18%
Yellow Perch	55	51	46	45	33	87%	85%	64%	90%	88%	65%
Golden Shiner	119	103	93	87	82	85%	80%	76%	90%	84%	80%
Walleye	115	115	95	85	81	83%	74%	70%	83%	74%	70%
White Sucker	116	97	78	78	76	75%	75%	74%	80%	80%	78%
Northern Pike	31	29	26	26	26	87%	87%	87%	90%	90%	90%
Grand Rapids											
bluegill	no data	974	887	851	801	n/a	n/a	n/a	91%	87%	82%
white sucker	no data	1967	1853	851	801	n/a	n/a	n/a	94%	43%	41%
Rogers											
bluegill	182	174	165	157	150	93%	88%	85%	95%	90%	86%
spottail shiner	no data	31	25	no data	22	n/a	n/a	n/a	81%	n/a	71%
yellow perch	no data	117	110	no data	105	n/a	n/a	n/a	94%	n/a	90%
golden shiner	94	77	72	65	47	86%	78%	59%	94%	84%	61%
largemouth bass	60	55	44	43	41	78%	76%	73%	80%	78%	75%
northern pike	47	42	39	39	35	88%	88%	80%	93%	93%	83%
walleye	no data	38	36	no data	31	n/a	n/a	n/a	95%	n/a	82%
white sucker	no data	90	82	0	74	n/a	n/a	n/a	91%	n/a	82%

Sandstone Rapids	Number of Fish Released	Number of Fish Recovered	Number Live Immediate	Number Alive 24 hr	Number Alive 48 hr	**Immediate Survival**	**24 hr Survival**	**48 hr Survival**	**Immediate Survival**	**24 hr Survival**	**48 hr Survival**
bluegill, bluegill x green sunfish hybrid	316	285	256	244	226	86%	82%	76%	90%	86%	79%
fathead minnow, creek chub, white sucker, golden/shorthead redhorse	897	775	550	528	442	68%	66%	56%	71%	68%	57%

Stevens Creek	Number of Fish Released	Number of Fish Recovered	Number Live Immediate	Number Alive 24 hr	Number Alive 48 hr	**Immediate Survival**	**24 hr Survival**	**48 hr Survival**	**Immediate Survival**	**24 hr Survival**	**48 hr Survival**
blueback herring	131	123	119	118	116	94%	93%	92%	97%	96%	94%
sunfish spp	110	110	104	100	88	95%	91%	80%	95%	91%	80%
yellow perch spotted sucker	120	120	116	113	103	97%	94%	86%	97%	94%	86%

Columbia	Number of Fish Released	Number of Fish Recovered	Number Live Immediate	Number Alive 24 hr	Number Alive 48 hr	**Immediate Survival**	**24 hr Survival**	**48 hr Survival**	**Immediate Survival**	**24 hr Survival**	**48 hr Survival**
Channel Catfish	95	88	87	no data	86	95%	n/a	94%	99%	n/a	98%
Bluegill, Redbreast Sunfish	100	96	94	no data	93	96%	n/a	95%	98%	n/a	97%
blueback herring	100	90	89	no data	68	94%	n/a	73%	99%	n/a	76%

TABLE 2. FAIRFIELD DEVELOPMENT – TURBINE SURVIVAL TEST DATA BY FAMILY GROUP

						USFWS Equation			Study Data		
Bond Falls	Number of Fish Released	Number of Fish Recovered	Number Live Immediate	Number Alive 24 hr	Number Alive 48 hr	**Immediate Survival**	**24 hr Survival**	**48 hr Survival**	**Immediate Survival**	**24 hr Survival**	**48 hr Survival**
yellow perch	no data	297	236	227	226	n/a	n/a	n/a	79%	76%	76%
golden shiner	no data	285	205	162	147	n/a	n/a	n/a	72%	57%	52%
bluegill	no data	542	435	391	381	n/a	n/a	n/a	80%	72%	70%
Caldron Falls											
bluegill, bluegill x green sunfish hybrid	361	342	316	311	304	90%	89%	87%	92%	91%	89%
fathead minnow, creek chub, white sucker, golden/shorthead redhorse	844	803	520	513	488	64%	63%	60%	65%	64%	61%
Colton											
white sucker	no data	433	200	155	134	n/a	n/a	n/a	46%	36%	31%
bluegill	no data	172	25	5	2	n/a	n/a	n/a	15%	3%	1%
largemouth bass	no data	479	121	19	2	n/a	n/a	n/a	25%	4%	0%
yellow perch	no data	88	43	33	29	n/a	n/a	n/a	49%	38%	33%
walleye	no data	151	35	29	20	n/a	n/a	n/a	23%	19%	13%
Hardy											
bluegill	123	83	80	72	72	81%	75%	75%	96%	87%	87%
golden shiner	119	97	94	76	76	88%	73%	73%	97%	78%	78%
largemouth bass	60	39	37	27	26	79%	63%	61%	95%	69%	67%
northern pike	58	50	44	38	38	83%	72%	72%	88%	76%	76%
walleye	42	40	31	30	29	76%	74%	71%	78%	75%	73%
white sucker	119	83	70	57	57	74%	63%	63%	84%	69%	69%
yellow perch	120	87	84	79	76	84%	80%	77%	97%	91%	87%
Hoist											
bluegill	300	164	86	no data	no data	51%	n/a	n/a	52%	n/a	n/a

Table 3. Parr Shoals Development – Turbine Survival Test Data by Family Group

	USFWS Equation			Study Data		
Family Group	Immediate Survival	24 hr Survival	48 hr Survival	Immediate Survival	24 hr Survival	48 hr Survival
Panfish	91%	86%	82%	93%	88%	83%
Black Bass	78%	76%	73%	80%	78%	75%
Cyprinidae	80%	71%	58%	86%	70%	58%
Percidae	84%	74%	62%	87%	75%	68%
Catostomidae	83%	81%	75%	88%	75%	72%
Clupeidae	94%	93%	82%	98%	96%	85%
Ictaluridae	95%	n/a	94%	99%	n/a	98%
Moronidae[1]	78%	76%	73%	80%	78%	75%
[1] Black bass used as surrogate						

TABLE 4. FAIRFIELD DEVELOPMENT – TURBINE SURVIVAL TEST DATA BY FAMILY GROUP

	USFWS Equation			Study Data		
Family Group	Immediate Survival	24 hr Survival	48 hr Survival	Immediate Survival	24 hr Survival	48 hr Survival
Panfish	64%	60%	58%	67%	63%	62%
Percidae	65%	60%	58%	68%	63%	60%
Cyprinidae	75%	64%	62%	78%	66%	64%
Black Bass	52%	33%	31%	60%	37%	34%
Catostomidae	61%	54%	51%	65%	56%	53%
Esocidae	83%	72%	72%	88%	76%	76%
Clupeidae[1]	83%	72%	72%	88%	76%	76%
Ictaluridae[2]	59%	49%	46%	63%	51%	48%
Lepisosteidae[3]	83%	72%	72%	88%	76%	76%
Moronidae[2]	59%	49%	46%	63%	51%	48%
Fundulidae[1]	75%	64%	62%	78%	66%	64%
[1] Cyprinidae used as surrogate						
[2] average of Catostomids and Black Bass used as surrogate						
[3] Esocidae used as surrogate						

Discussion

The USFWS has requested that we increase the "released numbers" to account for the fish that were "lost" in the turbine testing experiment. The use of the higher fish released numbers lowered the overall survival estimates. The USFWS has also requested that we use the 48 hour survival estimates for a "more accurate number". We point out that both 24 and 48 hour survival reflect higher mortality associated with the impacts of both turbine passage and turbine testing. However, we are not sure that each of these studies use control fish to correct for non-turbine effects such as netting, handling, and tank stresses associated with holding fish for 48 hours in a recovery tank.

After discussion and agreement on which fish survival (turbine mortality) rates that we will use, we will revise the family group estimates and send those back out to the TWC. We will then proceed with compiling the information from the four memos into a draft report for the TWC's review.

LITERATURE CITED

Electric Power Research Institute. 1992. Final Report. Fish Entrainment and Turbine Mortality Review and Guidelines. Project 2694-01. Prepared for Stone & Webster Environmental Services, Boston, MA.

EPRI. 1997. Turbine entrainment and survival database – field tests. Prepared by Alden Research Laboratory, Inc. EPRI Report No. 108630. 13 pp, Palo Alto, CA.

Normandeau Associates. 2015. Southern Division American Fisheries Society – Spring Meeting – January 29, 2015 Savannah, GA. Joanne Phipps and Carlos Avalos.

MEMORANDUM

TO: Parr Hydro Relicense - Fisheries Technical Working Committee

FROM: Henry Mealing

DATE: September 11, 2015

RE: Fish Entrainment and Turbine Mortality Desktop Study
Technical Memo #5 - Response to Comments on the Draft Report

The Draft Parr-Fairfield Fish Entrainment and Turbine Mortality Study Report (Report) was distributed to the Fisheries Technical Working Committee (TWC) for review on April 21, 2015. To date, we have received only two comments (both from the SCDNR). We have provided a response to both of those comments in this Technical Memo #5. We propose to include this response in an Appendix of the Final Report. The results of this study will be used in describing the potential order-of-magnitude impact of turbine entrainment and mortality on fish in the Parr Project in the license application. This report is also available for use during Settlement Agreement discussions and during development of recommendations from the Fisheries TWC to address the potential impacts of fish entrainment and turbine mortality at the Parr Project.

SCDNR Comment 1 – [We] have reviewed the draft entrainment report for Parr Hydro Project and have some issues with it. [Our] primary concern is the lack of information on entrainment mortality with an emphasis on clupeid survival. These fragile fish are very different from other fish in their tolerance ranges and generally have high mortality at pumpback operations for reasons other than turbine strikes. The draft report appears to address entrainment mortality in terms of turbine strikes as provided in Table 3-13. This is good information, but this report needs to address the total entrainment mortality to provide a better understanding of the operational impacts. Studies done at Richard B Russell, a pumpback project with similar turbines and similar capacity, addressed total entrainment mortality. In the attached RBR document on page 376 it is stated that

> "Mortality rates ranged from 65.0 to 100.0 percent for clupeids (blueback herring, threadfin shad, and gizzard shad), 29.5 to 85.0 percent for sunfish and crappie, 0.0 to 28.5 percent for catfish, 17.8 to 72.1 percent for yellow perch, and 45.3 to 81.8 percent for Morone sp. (striped bass, hybrid bass, and white perch). A significant positive relationship between water temperature and mortality was found for clupeids, catfish, and Morone sp. (as water temperature increases mortality increases)."

Summary tables for immediate, 24 hr, and 48 hr mortality are also provided in the same document in the section entitled "**Pumpback Fish Mortality Studies"** from page 376-395**.** This type of information is needed in the entrainment report for Parr Hydro Project. [We] believe this type of project information (from RBR) is more relevant to the Fairfield pump storage development than the turbine studies cited in the EPRI documents. Frankly, the mortality estimates from RBR may be more relevant than the number of fish entrained. In recent TWC meetings, questions were raised about the numbers of clupeids entrained at RBR verses Fairfield mainly based on fish present. This may be a legitimate issue, but it does not change the mortality rate which should be based on the percentage of fish that actually die as a result of entrainment.
SCE&G Response 1 – We reviewed the RBR Pump-back report referenced by the SCDNR initially as part of this study and did include the study results for developing an <u>entrainment</u>

estimate for the Fairfield Project. We noted in our TWC discussions that the entrainment data from RBR would likely yield an overestimate of entrainment for Clupeids at the Fairfield Project. However, entrainment data for pump-back operations is limited, and this was the best available data we could find for our Fairfield entrainment estimates.

However, we did not include the turbine mortality rates from the RBR study based on the knowledge that all of the RBR mortality rates are skewed towards an overestimate. We have included multiple references from the RBR study report that noted the shortcomings of the mortality studies that were performed at the project. We have listed those below:

Summary – Page 376 first paragraph states:

> "Reliable estimates of mortality for many of the inducted fish experiments could not be used due to high mortality among control fish, due mainly to the poor condition of fish received from the hatchery. Most mortality estimates in Phase III were obtained from entrained fish."

Page 376 – second paragraph:

> "A majority of entrained sunfish and crappie were descaled on one side of their body. Heavy scale loss was also found with control bluegill sunfish inducted directly into the net without going through the turbines, also suggesting a net affect."

Introduction – Page 377:

> "Multiple controls were performed by inducting fish into the penstocks (all effects of induction system but without turbine passage) or holding marked fish without induction to determine the effects of marking and handling. For fragile species such as threadfin shad and blueback herring, entrained fish were recovered at the recovery barge to determine immediate and delayed (recovered fish were held in tanks for 48 hours) mortality. Control tests could not be performed for fragile fish species because control mortality was 100 percent. Therefore, estimates of turbine passage mortality are conservative because they have not been adjusted for handling mortality." [emphasis added]

Discussion – Page 380 – first paragraph:

> "These results provide a conservative (over) estimate of mortality due because all sources of stress and damage caused by the net, handling, and transport could not be eliminated. To provide a turbine related mortality estimate, it is necessary to reduce stress incurred due to the experimental protocol. This usually means reducing control mortality below 10 percent (Ruggles 1991). Except for catfish, we did not meet this criterion. The inability to reduce excess control mortality was the primary reason for use of entrained fish for passage mortality estimation." [emphasis added]

During the RBR study, the researchers observed extremely high mortality rates for fish that were used as controls; therefore, they were forced to use fish from the entrainment net sample to determine turbine mortality. This method did not allow them to discriminate between actual fish mortality due to passage through the penstock, units, and draft tube and the mortality associated with net stress and handling after fish were collected from the entrainment net, which could be significant. The studies that we used for developing turbine mortality rates for Fairfield were based on studies that met the accepted criterion for testing with control fish and are the best data available data for estimating turbine mortality rates at Fairfield. Use of the RBR data would skew turbine mortalities by 2 to 3 times those that SCE&G has proposed as reasonable turbine mortality estimates, therefore we decline to include the RBR study in our analysis for the Fairfield turbine mortality estimates.

SCDNR Comment 2 – Another thing [we] do not understand about the report is how (as indicated in Table 3-13) the Clupeidae family has a lower mortality rate than their surrogate Cyprinidae. Maybe this is a typo.

SCE&G Response 2 – This is a typo. Both the Clupeidae and Cyprinidae mortality estimates are based on turbine mortality test data at multiple projects. We will correct this in the Final Report.

APPENDIX C

STAKEHOLDER CONSULTATION

MEETING NOTES

SOUTH CAROLINA ELECTRIC & GAS COMPANY
Fisheries TWC Meeting

November 04, 2014

Draft HGM 11-06-2014

ATTENDEES via Conference Calls:

Bill Argentieri (SCE&G)
Amy Bresnahan (SEC&G)
Byron Hamstead (USFWS)
Bill Marshall (SCDNR)
Henry Mealing (Kleinschmidt)
Milton Quattlebaum (SCANA)
Fritz Rohde (NOAA)
Steve Summer (SCANA)
Shane Boring (Kleinschmidt)

These notes serve as a summary of the major points presented during the meeting and are not intended to be a transcript or analysis of the meeting.

Henry opened the meeting with a brief discussion of big picture. Each of these Memos are "building blocks" that we will use to prepare an estimate of potential entrainment and turbine mortality for the Parr and Fairfield developments.

Revised Memo #1

Henry began the discussions on Entrainment Memo #1. This memo provides several elements for entrainment evaluation:

- the proposed entrainment study database
- database entrainment rates for "Parr-type" studies and "Fairfield-type" studies
- proposed mean seasonal entrainment rates for Parr and Fairfield
- the proposed turbine mortality study database

We discussed the recommendation from Byron about considering the use of the Buzzard Roost Study as part of the entrainment database. Review of the Buzzard Roost study determined that entrainment rates were vastly different from the other studies that were included. The group agreed with the recommendation not to include Buzzard Roost in the evaluation.

The group was in general agreement with the seasonal entrainment rates proposed for use in the Parr estimates (Table 5) and Fairfield estimates Tables 13 & 14.

The turbine mortality database provides a range of projects where turbine mortality testing has been performed on a variety of species. The next Memo on Turbine Mortality will provide specific mortality rates for multiple species/family groups for both developments.

Memo #2

Shane then reviewed the information in Memo #2, which solely focused on species composition data for entrainment. The group agreed with the species proposed for application to the Parr development. Shane noted that we would use the raw data to develop seasonal percent composition for each family group and that Centrarchids would be subdivided into "panfish" (bluegill, redbreast, crappie, ect.) and "fusiforme" (black basses) species.

However, the group had some discussions about the species composition for use at Fairfield. The Richard B. Russell (RBR) project documented a range of species that were entrained during generation and pump-back. The data for Bad Creek (BC) is dominated by shad/herring and combination of the two data sets could reduce the percent contribution of other non-shad species. The same observation applies to the Jocassee study which assumed that almost 100% of the species entrained were shad and herring.

The group suggested that Henry discuss this issue with Dick Christie (SDCNR) and get his recommendations.
NOTE: Henry and Dick discussed this briefly a day after the meeting. Dick provided some SCDNR reports to Henry that will provide additional data to aid in describing the species composition of Monticello Reservoir.

Next Memo

Shane stated that the next memo will include the proposed seasonal species/family group percent composition to be used for Parr estimates. We will also provide a proposed seasonal species/family group percent composition for Fairfield – both with RBR only and with RBR/BC combined.

The next memo will also include an extrapolation of the estimated number of fish entrained for each development. This will be based on Entrainment Rate X Volume of Water passed through each development. We will also multiply the species composition to this estimate to give a breakdown of species entrained. We will also include species composition data that Milton has been collecting in the forebay and tailrace areas of Fairfield.

We will also include the proposed turbine mortality rates that could be used in the evaluation.

ACTION ITEMS:

- Henry to discuss species composition with Dick Christie and develop proposed species composition for the evaluation.

- Develop next Entrainment Evaluation Memo.

Kleinschmidt

PARR SHOALS HYDROELECTRIC PROJECT FERC NO. 1894

Fisheries TWC – Entrainment and Turbine Mortality

MEETING NOTES
January 06, 2015

Draft H. Mealing 01-12-2015

ATTENDEES via Conference Calls:

Bill Argentieri (SCE&G)	Milton Quattlebaum (SCANA)
Amy Bresnahan (SEC&G)	Fritz Rohde (NOAA)
Steve Summer (SCANA)	Hal Beard (SCDNR)
Bill Marshall (SCDNR)	Ron Ahle (SCDNR)
Dick Christie (SCDNR)	Shane Boring (Kleinschmidt)
Jordan Johnson (Kleinschmidt)	Henry Mealing (Kleinschmidt)

These notes serve as a summary of the major points presented during the meeting and are not intended to be a transcript or analysis of the meeting.

Henry opened the meeting with a brief reminder that the overall goal of the Entrainment Study is to provide the TWC with an "order of magnitude" potential impact of fish entrainment at the Parr and Fairfield Developments. We have finalized the first building blocks for this estimate in Memos 1 & 2 and the purpose of this meeting is to review Memo 3 which contains 1) the final proposed species/family group composition estimates and 2) the final extrapolated estimate of fish entrained by development, season, and family group.

Henry opened the discussion by recapping the memo results and asking for questions. He also noted that Byron had submitted questions prior to the call, because he could not attend. His questions were:

1) *Does the proposed seasonal entrained species composition for Fairfield under pump-back generation include data from Bad Creek? I think we discussed developing two iterations of seasonal fish composition, with and without data from Bad Creek (see meeting notes for hold point 2). Since data for Bad Creek are dominated by shad/herring, including these data could underestimate the percent contribution of non-shad species in the entrained composition.*

Henry stated that the final estimates for Fairfield did not include the Bad Creek data for species composition, but we did include the Bad Creek <u>entrainment rate</u> information in our analysis. During our last TWC call, we did question the use of the Bad Creek species composition data because it was dominated by shad. Use of the species data would skew the species composition to shad and overlook other species that are present in the two reservoirs. This decision was also based on SCDNR fisheries sampling data from the two reservoirs.

The SCDNR reports "Fisheries Investigations in Lake and Streams District IV July 1, 1989 to June 30, 1992" and "Fisheries Investigations in Lakes and Streams July 1, 1996 thru June 30, 1997" noted a couple of items. There are discussions in both reports of threadfin shad (TFS) and gizzard shad (GZS) populations. Also, that there is a higher composition of GZS over TFS in the dam/intake area. TFS form a large part of the Age 0 prey base but GZS grow to larger sizes and make up more of the shad biomass of the reservoir. Both reports provide a description of cove rotenone collections in Lake Monticello. General observations are that the shad densities in the lake are lower than other nearby lakes due to lower nutrient levels. There is also a section of both reports that describe the use and success of fish attractors on Lake Monticello. Henry will send the SCDNR reports to the TWC members in a separate email (completed 01-14-2015). The TWC is encouraged to review the cove rotenone information to better understand this issue.

2) *What is the basis for using operation record data from 2000-2010? What is the likelihood that generation, project flows, and therefore fish entrainment might significantly increase from this period of record over the term of the new license?*

We used 2000-2010 because it was readily available for other analysis (power production, flow record, etc.) that Kleinschmidt is performing for SCE&G. The Group discussed looking closer at this data to see if it is representative of the flow years experienced at the project. Kleinschmidt will look at the distribution of Drought, Normal, and High flow years within the 2000-2010 dataset and compare it with the flow record at the project. Kleinschmidt performed an analysis of the flow record with a discussion of how use of the 10-year record may influence our current entrainment estimates. This analysis is attached in a section at the end of these notes.

In general, the type of flow year will influence the two developments in the following ways.

The higher the river flow – the more water that will pass through Parr (up to its hydraulic capacity of 6,000 cfs – then spill occurs) and the higher potential entrainment would be. Higher water years don't impact Fairfield as much but 1) they can reduce operations, due to cooler air temps (reduced demand) associated with rainy periods and 2) operations could be reduced because Fairfield operations cannot contribute to downstream flooding.

In a lower flow year, the opposite happens. Less water means Parr operates less = less entrainment. Fairfield may operate more frequently: 1) to meet energy demands with warmer weather (higher energy demand) and 2) the downstream flooding restriction associated with operations wouldn't typically apply during those years.

Bill Marshall noted that he had talked with Byron and an additional question was – will the operation of Fairfield change with the new VC Summer stations being added – will there be less power demand on Fairfield.

Bill A. explained that the addition of the VC Summer plants will likely increase the use of Fairfield for helping to stabilize the grid during non-peak periods. Nuclear facilities don't typically ramp up and down but produce a stable level of power. During periods when there is "extra" power, SCE&G can use the power to run the pump back operations at Fairfield to keep the nuclear plant from having to alter their operations.

The Group also discussed the question at the end of Memo 3 where Henry stated that the entrainment estimates for Fairfield were likely an overestimate due to lower shad populations in Monticello. There was some discussion with the final point being that estimates should not be adjusted because there is not an accurate way of making this adjustment and shad are susceptible to entrainment. The TWC decided to analyze fish entrainment with a desktop study rather than a field study, so we have the best estimates we can make based on similar projects. Henry stated that when we pull the final report together that we would likely state that the estimates are most likely high and then the TWC can comment on that for the record.

Dick Christie reminded the Group that the fish entrainment study can point us in the right direction for developing protection measures (seasonal or location) that can help to reduce entrainment. These can include sound deterrents, reduced lighting in the intake area, increased lighting in areas away from the intakes, or possibly other alternatives.

Next Memo

Henry stated that the next memo will include the proposed turbine mortality rates by family group that we will apply to the entrainment estimates. This extrapolation will identify the potential mortality impact of the two developments on the fishery.

ACTION ITEMS:

- Henry will send the TWC the pdf. copies of the SCDNR fishery survey reports for the two developments. ** This was completed on 1-14-2015.

- TWC members will review the cove rotenone data in the SCDNR reports on Monticello Reservoir. This will help us understand if the entrainment estimates are an overestimate or not.

- Kleinschmidt will analyze the flow years 2000-2010 and compare to flow record to make sure we are using representative flow years in our estimates. ** ATTACHED at the end of these Meeting Notes.

- Kleinschmidt will develop the turbine mortality rates for the next Entrainment Evaluation Memo.

Introduction

At the request of the members of the Fisheries TWC, a comparison of the period or record used in the entrainment analysis (2000 – 2010, calendar years) with the entire period of annual average flow data available from the USGS Alston Gage (1981 – 2013) was made to determine whether representative flow years are being used in the entrainment analysis. The selected dataset is known to have periods of extreme drought, therefore annual flow averages were checked to determine if some normal and wet years were also included.

Evaluation

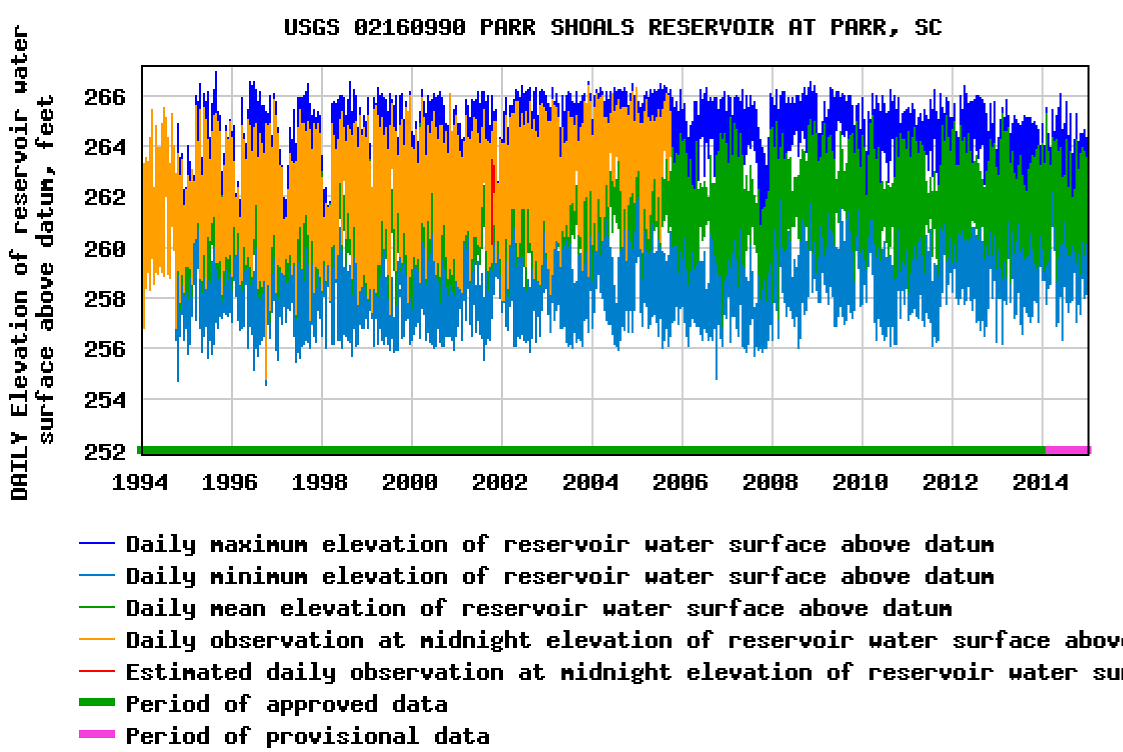
Considering the statistical ranking of the annual average flows, the period 2000 – 2010 includes the two years with the lowest average flow (2001 and 2008), as well as the highest average flow year (2003). The remaining years are at the 50 percent ranking or below, with 6 years in the lowest quartile. While the bulk of the years are below the median, four are within the central third of the rank.

Point	*Flow cfs*	*Rank*	*Percent*	*Calendar Yr*
23	**8,791**	**1**	**100.00%**	**2003**
15	8,187	2	96.80%	1995
4	7,743	3	93.70%	1984
13	7,558	4	90.60%	1993
18	7,482	5	87.50%	1998
3	7,399	6	84.30%	1983
10	7,203	7	81.20%	1990
16	6,917	8	78.10%	1996
12	6,821	9	75.00%	1992
11	6,530	10	71.80%	1991
33	6,382	11	68.70%	2013
14	6,091	12	65.60%	1994
2	6,076	13	62.50%	1982
17	5,949	14	59.30%	1997
7	5,795	15	56.20%	1987
9	5,536	16	53.10%	1989
25	**5,490**	**17**	**50.00%**	**2005**
5	5,295	18	46.80%	1985
24	**5,146**	**19**	**43.70%**	**2004**
29	**4,718**	**20**	**40.60%**	**2009**
30	**4,538**	**21**	**37.50%**	**2010**
6	4,002	22	34.30%	1986
19	3,350	23	31.20%	1999
1	3,313	24	28.10%	1981

26	**3,186**	**25**	**25.00%**	**2006**
22	**3,164**	**26**	**21.80%**	**2002**
20	**3,015**	**27**	**18.70%**	**2000**
27	**2,922**	**28**	**15.60%**	**2007**
8	2,897	29	12.50%	1988
32	2,499	30	9.30%	2012
31	2,483	31	6.20%	2011
21	**2,418**	**32**	**3.10%**	**2001**
28	**2,115**	**33**	**0.00%**	**2008**

Because the flows through Fairfield are truncated during high inflows to prevent downstream flooding, high inflow events occurring several times in one year would reduce the pumped storage operations. Intuitively, this would result in high inflow years having lower pumped storage operations. Similarly, low inflow years with fewer high flow events would suggest higher pumped storage average flows.

While some consideration for these inflow effects is warranted, pumped storage flows are far more attributable to the load demand on the pumped storage. If low inflow years are associated with very hot temperatures, the pumped storage operations would be significantly higher. Associating high inflow years with cooler temperatures would have the opposite effect. Future load demands may increase the flows on average, but the selected dataset appears to have representative years of low inflow coupled with excessive load demand (based on reservoir fluctuation records, daily maximum and minimum elevation lines in blue).



Kleinschmidt

Flows for entrainment through the Parr powerhouse are limited to the station hydraulic capacity, 6,000 cfs. To account for this, daily average flows for the entire period of record were capped at 6,000 cfs for comparison of the datasets. Statistically, the entire period of record has 12,053 days of flow data, of which 2,702 are above the station capacity (approximately 22.4 percent). For the dataset used in the entrainment evaluation, there were a total of 4,018 days of flow data, of which 591 are above station capacity (or 14.7 percent). The total long term daily average flows within the powerhouse hydraulic capacity have an average of 3,596 cfs; the truncated period average flow is 3,040 cfs (approximately 15 percent lower).

A generalized approach in considering the long-term average impact of higher flows through the Parr powerhouse could be done simply by increasing the entrainment values by 15%. Increasing the flows on a monthly (or seasonally) basis may be of value, as the winter and early spring averages are closer to the long-term average then the summer averages.

Table 2. Parr Shoals Development Monthly Average Flows

	Total Flows at Alston USGS Gage	Parr Powerhouse Flow	Powerhouse Monthly MCF	Total Flows at Alston USGS Gage	Parr Powerhouse Flow	Powerhouse Monthly MCF	Percent below long-term avg
	1981 - 2013			2000 - 2010 flows			
January	7,252	4,477	11,991	5,055	3,806	10,195	15.0%
February	7,877	4,693	11,353	5,397	4,073	9,854	13.2%
March	9,023	5,003	13,400	7,643	4,627	12,393	7.5%
April	6,606	4,612	11,954	5,624	4,087	10,594	11.4%
May	5,033	3,848	10,307	3,875	2,990	8,008	22.3%
June	3,791	3,298	8,549	3,352	2,687	6,964	18.5%
July	3,198	2,686	7,194	2,673	2,158	5,780	19.7%
August	3,475	2,586	6,925	2,392	1,938	5,191	25.0%
September	2,760	2,369	6,142	2,993	2,072	5,370	12.6%
October	3,502	2,509	6,720	2,220	1,960	5,250	21.9%
November	3,989	3,037	7,871	3,179	2,576	6,677	15.2%
December	5,828	4,094	10,966	5,295	3,570	9,562	12.8%

<u>Summary</u>

Based on the data evaluated, the period used in the dataset does represent lower-than-average flows in general. While this does indicate flows through the Parr powerhouse are likely higher on a long-term basis, it does not signify lower flows through the pumped storage development. Parr flows appear to be about 15% lower, but the pumped storage operation is probably representative of future conditions.

PARR HYDROELECTRIC PROJECT FERC NO. 1894

Fisheries TWC – Entrainment and Turbine Mortality

MEETING NOTES
February 10, 2015

Draft 02-11-2015

ATTENDEES via Conference Call:

Bill Argentieri (SCE&G)	Milton Quattlebaum (SCANA)
Brandon Stutts (SCANA)	Steve Summer (SCANA)
Hal Beard (SCDNR)	Bill Marshall (SCDNR)
Ron Ahle (SCDNR)	Dick Christie (SCDNR)
Jordan Johnson (Kleinschmidt)	Henry Mealing (Kleinschmidt)
Shane Boring (Kleinschmidt)	

These notes serve as a summary of the major points presented during the meeting and are not intended to be a transcript or analysis of the meeting.

Henry opened the meeting and noted that the group had two major actions. The first is to review the status of old action items from our last meeting. The second is to discuss the Hold Point 4 Memo (January 30, 2015) which presents average fish turbine mortality/survival rates developed from the turbine mortality database presented in Memo 1, and review the Hold Point 4 Addendum (February 9, 2015) which responds to the USFWS comments on the Hold Point 4 Memo.

Old Action Items

Project flow analysis - At the request of the members of the Fisheries TWC, we performed a comparison of the period of record used in the entrainment analysis (2000 – 2010) with the period of record available for the USGS Alston Gage (1981 – 2013) to determine whether representative flow years are being used in the entrainment analysis. The analysis was provided in the last set of Fisheries TWC notes.

The selected dataset includes years of high, average, and low flows. Overall the dataset appears to be about 15% lower for Parr Shoals operations, but is representative of pumpback operations.

SCDNR annual fishery reports **–** Henry noted that Kelly Miller has distributed PDF copies of SCDNR annual reports to TWC members via email on. Attendees noted that these were received.

Cove rotenone review **–** Henry provided his observations on the cove rotenone data for Monticello in the last Fisheries TWC meeting notes. The analysis was intended to provide information on whether the Fairfield entrainment estimate is an overestimate or not.

Henry asked for comments or questions on these three items. Attendees had no additional comments and the group agreed that the information was sufficient for moving forward to the next phase of the study.

Hold Point 4 Memo

Henry noted that the Hold Point 4 Memo (January 30, 2015) presented proposed fish survival rates for turbine passage by species and family group. Hal asked which projects in the turbine mortality database were most similar to Parr Shoals. Henry noted that the Stevens Creek turbines were of similar vintage and design and were most similar from a project design standpoint. From a turbine survival data quality standpoint, Henry noted that he was most confident in the Columbia Hydro data since he was on-site for the testing process. Ron expressed concern that the source studies selected for turbine mortality data for Parr Shoals might not be transferrable to Fairfield due to the unique characteristic of the pumped storage operation. Henry agreed and reminded that we have separate turbine mortality estimates for the Parr Shoals and Fairfield developments based on different projects in the database.

The group discussed the Hold Point 4 Addendum. Henry noted that Byron Hamstead (USFWS) had provided comments on Hold Point Memo 4 via email on February 3, 2015, and that the Addendum was developed to address his comments. The USFWS Question 1 was simply a request for clarification regarding the calculation of survival rates, which is provided in the addendum. The group then discussed the addendum in the context of the remaining 2 questions from USFWS.

USFWS Question 2 addressed modifying the study data based on adjusting the number of tested and recovered test fish. Henry noted that we recalculated the survival rates based on the USFWS recommendation to use the total number of fish tested and assume that ½ of them died. He noted that this information was presented in several Tables in the Addendum. Several attendees expressed concern that arbitrarily modifying turbine survival rates across all projects could likely introduce error into our "order-of-magnitude" estimates and assuming that 50% of the unrecovered fish had died or survived was simply "pulling a number out of the air,". The group generally agreed that we should use the original data reported from the turbine mortality/survival studies and that we should follow up with Byron to make sure we properly understand the USFWS concerns and recommendation.

USFWS Question 3 addressed the use of including 24-hr and 48-hr latent mortality information where it is available. Henry noted that 24 & 48 hour latent mortality rates had been compiled from the source studies and were presented in the Addendum. The group had a general discussion of the how some studies were done better than others and how these could be magnified in latent mortality estimates. After discussion, the group agreed that the final entrainment report should present fish mortality estimates for Immediate, 24-hr, and 48-hr fish mortality.

In closing, Henry noted that the next step would be to apply the turbine mortality to the family level entrainment estimates summarized in previous hold point memoranda and to compile the result of the overall process into a draft report for TWC review.

ACTION ITEMS:

- Henry, Dick, and Bill A will conference call with Byron to discuss the USFWS Recommendations further.
- Kleinschmidt will prepare a draft entrainment report for TWC review.

Exhibit E-5 Fisheries Resources

Revised Fairfield Entrainment Mortality Estimate Memo

MEMORANDUM

TO: Parr Relicensing – Fisheries Technical Working Committee

FROM: Jordan Johnson and Henry Mealing – Kleinschmidt Associates

DATE: May 30, 2017

RE: Revised Fairfield Entrainment Mortality Estimate

The Desktop Fish Entrainment Study for the Parr Hydroelectric Project (FERC No. 1894) (Project) was finalized after review by the Fisheries Technical Working Committee (TWC) on September 14, 2015. The 2015 study provided conservative estimates of potential fish entrainment and subsequent turbine mortality estimates for both the Parr and Fairfield developments based on data from other hydropower projects. Recently, the South Carolina Department of Natural Resources (SCDNR) questioned the magnitude of potential entrainment and turbine mortality at the Fairfield Development (Fairfield). They noted that additional information from the South Carolina based Jocassee Pump Storage Station (JPSS) (Keowee-Toxaway Hydropower Project FERC No. 2503) was also available for use in our analysis. The "new" JPSS information is primarily related to turbine mortality rates at pump back hydropower facilities, therefore, we used the information to re-evaluate the turbine mortality estimates for Fairfield. No new information is currently available to address the density of fish in the forebay or tailrace of Fairfield that could alter the potential magnitude of fish entrainment.

BACKGROUND

As part of a fish community assessment study of the JPSS, Duke Energy (Duke) conducted hydroacoustic sampling to estimate fish entrainment and a desktop analysis to estimate turbine mortality at JPSS (Duke 2013). The mortality analysis was based on primary factors that influence fish mortality during entrainment: turbine type, turbine speed (rpm), pressurized intake tunnel, and fish size. The analysis noted that, after review of Winchell et al. (2000) which summarized turbine passage mortality reported in the EPRI (1997) database, "the data suggest that fish size relative to the volume of the turbine passage way is more important than species *per se* when assessing fish survival potential (Franke et al. 1997, Winchell et al. 2000)." The JPSS analysis used the formula developed by Franke et al. (1997) to predict mortality, i.e. the probability of a fish strike, for fish passing through a Francis turbine. The formula calculated the probability of a blade strike by relating turbine parameters to fish length. Calculations showed that fish from two inches to 24 inches survive entrainment at a rate of approximately 99% to 88% at JPSS. Basically, shorter fish maintain a higher survival percentage than longer fish. The analysis also noted that, after comparison to data at similar projects, mortality related to decompression was expected to be low at JPSS.

METHODS

To update our analysis, we performed two steps. First, calculate the blade strike probabilities for each length class of fish up to 30 inches using the JPSS equation and the Fairfield turbine specifications. Second, generate a breakdown of length classes for each family group we presented in our 2015 report.

The first step for calculating blade strike probability was based on the formula developed by Franke et al. (1997).

$$P = \lambda\left(\frac{N * L}{D}\right)\left[\frac{\sin\alpha_t\left(\frac{B}{D_1}\right)}{2Q_{\omega d}} + \frac{\cos\alpha_t}{\pi}\right]$$

S = 1 – P where,

λ = Blade strike correlation factor

N = Number of buckets

L = Fish length

D = Diameter of runner

α_t = Angle to tangential of absolute flow upstream of runner

B = Runner height at inlet

D1 = Diameter of runner at inlet

$Q_{\omega d}$ = Discharge coefficient = $(Q/\omega D^3)$

Blade strike probabilities were calculated using a blade strike correlation factor of 0.15. This factor was chosen because it gave a higher, more conservative mortality rate. Table 1 contains the turbine parameters at Fairfield assuming the plant is operating at the best efficiency point for both generation and pumping.

TABLE 1. FAIRFIELD FRANCIS TURBINE SPECIFICATIONS

TURBINE CHARACTERISTICS		GENERATION	PUMPING
Turbine Type		Francis reversible pump	
No. of Buckets		9	
Runner Diameter (ft.)	inlet	15.92	15.42
	outlet	15.42	15.92
Runner Height at inlet (ft.)		5.43	
RPM		150	
Head (ft.)		160	163
Hydraulic Capacity (cfs)		6,130	4,920

The second step was the development of a database of seasonal fish length class percentages for the Family groups of fish potentially entrained at the Project presented in our 2015 report. The database developed consisted of seasonally entrained species and length class data found within the EPRI (1997) database. Data from the EPRI database that were not relevant were screened to form a Project specific database. The data selected to form the database consisted of studies conducted at Gaston Shoals, Hollidays Bridge, Ninety-Nine Islands, Richard B. Russell (RBR), and Saluda. These hydroelectric projects were also used in other portions of the 2015 Parr/Fairfield entrainment study. These projects were chosen for the development of the dataset for several reasons. All the projects are located within South Carolina and contain similar fish communities as that found at Parr/Fairfield. Also, combining the data from each of the studies provided the most comprehensive database of seasonal length class data for fish potentially entrained at Fairfield.

The seasonal species and length class data for each of the five projects were combined to form length class percentages for the fish Family groups previously identified for Fairfield. This exercise was similar to the development of "species composition percentages" in our 2015 report. If no data existed for certain family groups or months, surrogates were designated. The fish length classes were separated into two-inch increments with a minimum fish length of two inches and a maximum fish length of 30 inches.

Once seasonal length class percentages for each family group were calculated, the length class percentages were multiplied by the seasonal total entrainment number for each family from our original report. This divided the total estimated fish entrained at Fairfield into length classes for each family.

Once an estimate of fish potentially entrained within each length class was calculated, Fairfield blade strike probabilities (i.e., mortality rate) for each of the length classes were multiplied by the estimated number of fish entrained within that length class. This resulted in a seasonal estimate of fish killed due to entrainment at Fairfield for each family group and length class. The mortality rate for the longest fish within each length class was applied (e.g., the mortality rate for a 6-inch fish was used for all fish within the 4-6” length class).

RESULTS

Turbine mortality rates ranged from 1.7% to 25.8% for fish entrained during conventional generation and from 1.8% to 27.7% for pump back generation (Table 2). This method of estimating fish mortality predicted far fewer fish being killed by turbine blade strikes at Fairfield than the 2015 report. The updated method predicts reduced mortality at the project across all families when compared to estimates from the 2015 report (Table 3).

The database used to develop length class percentages is provided in Appendix A. Seasonal length class percentages are provided in Appendix B. Entrainment estimates from the 2015 Fairfield study are provided in Appendix C. Updated family entrainment and mortality estimates by length class are provided in Appendix D.

TABLE 2. BLADE STRIKE PROBABILITIES

LENGTH (IN)	CONVENTIONAL	PUMPING
2	1.7%	1.8%
4	3.4%	3.7%
6	5.2%	5.5%
8	6.9%	7.4%
10	8.6%	9.2%
15	12.9%	13.8%
20	17.2%	18.5%
25	21.5%	23.1%
30	25.8%	27.7%

TABLE 3. COMPARISON OF FISH MORTALITY BETWEEN 2015 PARR ENTRAINMENT REPORT AND 2017 TURBINE MORTALITY ANALYSIS

	2017 ANALYSIS ANNUAL ESTIMATE		2015 STUDY ANNUAL ESTIMATE	
	CONVENTIONAL	PUMPBACK	CONVENTIONAL	PUMPBACK
Clupeidae	32,048	105,495	74,589	276,777
Moronidae	484	4,081	3,318	27,581
Black Bass	15	633	59	3,485
Panfish	1,006	2,019	8,148	16,399
Ictaluridae	2,714	1,028	15,468	6,073
Percidae	5,681	472	36,865	3,110
Cyprinidae	201	594	597	1,742
Fundulidae	0	16	0	38
Esocidae	0	5	0	8
Catostomidae	10	5	36	20
Lepisosteidae	2	2	4	3
SUB-TOTAL	**42,161**	**114,351**	**139,084**	**335,236**
TOTAL	**156,512**		**474,320**	

DISCUSSION

Based on the new turbine mortality information, the estimated fish mortality presented in the 2015 Report would be reduced by 67% (Table 3). That is a significant reduction in the number of fish that are potentially killed by passing through the turbines.

No new fish density information for the Fairfield forebay or tailrace areas is currently available that could be used to address the magnitude of fish entrainment. During discussions with TWC members, several ideas have been identified for reducing the potential for fish entrainment. Reduction of area lighting along the intake areas, which may attract fish at night, was proposed as a potential way to reduce concentrations of fish adjacent to the intakes, thereby reducing fish entrainment. The effectiveness of this action could be evaluated with mobile acoustic sonar surveys in the intake areas with “lights on” and “lights off”. There was also a discussion of performing additional hydroacoustic collections in the intake areas of Fairfield – forebay and tailrace to determine actual seasonal densities of fish. This would allow for comparison of entrainment estimates with density estimates to increase the accuracy of the 2015 fish entrainment report.

We appreciate the SCDNR bringing this new information to our notice and recommend that the Fisheries TWC consider this reduction in turbine mortality and the two potential *in situ* studies when developing recommendations for protection, mitigation, and enhancement measures for the new operating license.

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APPENDIX A

STUDY DATABASE

STUDY DATABASE

MONTH	SPECIES/GROUP	FAMILY	0-2"	2.1-4"	4.1-6"	6.1-8"	8.1-10"	10.1-15"	15.1-20"	20.1-25"	25.1-30"	>30"	TOTAL
2	Bluegill	Panfishes	7	1	1	1	0	0	0	0	0	0	10
2	Bluehead chub	Cyprinidae	0	1	0	0	0	0	0	0	0	0	1
2	Central stoneroller	Cyprinidae	0	0	0	1	0	0	0	0	0	0	1
2	Channel catfish	Ictaluridae	0	1	2	27	27	4	0	0	0	0	61
2	Creek chubsucker	Catostomidae	0	0	0	0	1	0	0	0	0	0	1
2	Eastern silvery minnow	Cyprinidae	0	1	0	0	0	0	0	0	0	0	1
2	Gizzard shad	Clupeidae	0	3	1	5	1	2	0	0	0	0	12
2	Golden shiner	Cyprinidae	0	1	0	0	0	0	0	0	0	0	1
2	Hybrid sunfish	Panfishes	2	0	0	0	0	0	0	0	0	0	2
2	Largemouth bass	Black Bass	0	1	0	0	0	0	0	0	0	0	1
2	Northern hog sucker	Catostomidae	0	0	0	1	0	1	0	0	0	0	2
2	Redbreast sunfish	Panfishes	1	0	0	0	0	0	0	0	0	0	1
2	Redear sunfish	Panfishes	0	1	0	0	0	0	0	0	0	0	1
2	Sandbar shiner	Cyprinidae	0	1	0	0	0	0	0	0	0	0	1
2	Seagreen darter	Percidae	0	1	0	0	0	0	0	0	0	0	1
2	Shorthead redhorse	Catostomidae	0	0	0	0	0	1	0	0	0	0	1
2	Striped jumprock	Catostomidae	0	0	0	0	1	0	0	0	0	0	1
2	White catfish	Ictaluridae	0	1	10	6	2	1	0	0	0	0	20
2	White sucker	Catostomidae	0	0	0	0	1	1	0	0	0	0	2
3	Blueback herring	Clupeidae	0	0	1	3	0	0	0	0	0	0	4
3	Bluegill	Panfishes	0	1	1	0	0	0	0	0	0	0	2
3	Channel catfish	Ictaluridae	0	0	0	1	0	0	0	0	0	0	1
3	Gizzard shad	Clupeidae	0	1	2	2	1	2	1	0	0	0	9
3	Redbreast sunfish	Panfishes	3	0	1	0	0	0	0	0	0	0	4
3	Snail bullhead	Ictaluridae	0	1	0	0	0	0	0	0	0	0	1
3	Thicklip chub	Cyprinidae	0	1	0	0	0	0	0	0	0	0	1
3	Threadfin shad	Clupeidae	0	1	0	0	0	0	0	0	0	0	1
4	Black crappie	Panfishes	0	72	1	0	1	0	0	0	0	0	74
4	Blueback herring	Clupeidae	0	0	79	21	3	0	0	0	0	0	103
4	Bluegill	Panfishes	13	98	12	3	0	0	0	0	0	0	125
4	Bluehead chub	Cyprinidae	0	0	1	0	0	0	0	0	0	0	1

MONTH	SPECIES/GROUP	FAMILY	0-2"	2.1-4"	4.1-6"	6.1-8"	8.1-10"	10.1-15"	15.1-20"	20.1-25"	25.1-30"	>30"	TOTAL
4	Brown bullhead	Ictaluridae	0	6	3	0	0	2	0	0	0	0	11
4	Channel catfish	Ictaluridae	0	2	1	0	1	0	0	0	0	0	4
4	Flat bullhead	Ictaluridae	0	0	1	1	0	0	0	0	0	0	2
4	Flathead catfish	Ictaluridae	0	0	0	1	0	0	0	0	0	0	1
4	Gizzard shad	Clupeidae	0	0	0	0	0	6	2	0	0	0	8
4	Golden shiner	Cyprinidae	0	1	1	1	0	0	0	0	0	0	3
4	Green sunfish	Panfishes	1	2	1	0	0	0	0	0	0	0	3
4	Hybrid bass	Moronidae	0	0	0	0	0	0	2	0	0	0	2
4	Hybrid sunfish	Panfishes	8	4	0	0	0	0	0	0	0	0	12
4	Largemouth bass	Black Bass	0	1	0	0	0	0	0	0	0	0	1
4	Margined madtom	Ictaluridae	0	0	2	0	0	0	0	0	0	0	2
4	Northern hog sucker	Catostomidae	0	0	0	0	1	0	0	0	0	0	1
4	Piedmont darter	Percidae	0	1	0	0	0	0	0	0	0	0	1
4	Quillback	Catostomidae	0	0	0	0	0	1	1	0	0	0	2
4	Redbreast sunfish	Panfishes	2	6	3	1	0	0	0	0	0	0	11
4	Redear sunfish	Panfishes	0	6	0	1	0	0	0	0	0	0	7
4	Silver redhorse	Catostomidae	0	0	0	0	0	2	1	0	0	0	3
4	Smallfin redhorse	Catostomidae	0	0	0	0	0	3	0	0	0	0	3
4	Snail bullhead	Ictaluridae	0	3	2	1	1	0	1	1	0	0	8
4	Spottail shiner	Cyprinidae	0	11	7	0	0	0	0	0	0	0	18
4	Striped bass	Moronidae	0	0	3	0	0	1	1	0	0	0	5
4	Striped jumprock	Catostomidae	0	0	0	15	11	3	0	0	0	0	29
4	Threadfin shad	Clupeidae	0	1	0	0	0	0	0	0	0	0	1
4	Unid. carp	Cyprinidae	0	0	0	0	0	0	1	0	0	0	1
4	Warmouth	Panfishes	0	2	2	1	0	0	0	0	0	0	4
4	White catfish	Ictaluridae	0	0	2	0	1	1	0	0	0	0	4
4	White crappie	Panfishes	0	73	3	0	0	0	0	0	0	0	76
4	White perch	Moronidae	0	17	85	4	3	0	0	0	0	0	109
4	Whitefin shiner	Cyprinidae	1	1	1	0	0	0	0	0	0	0	3
4	Yellow perch	Percidae	0	12	88	28	0	0	0	0	0	0	128
5	Black crappie	Panfishes	0	175	35	1	1	0	0	0	0	0	212
5	Blueback herring	Clupeidae	0	0	41	21	3	0	0	0	0	0	65

MONTH	SPECIES/GROUP	FAMILY	0-2"	2.1-4"	4.1-6"	6.1-8"	8.1-10"	10.1-15"	15.1-20"	20.1-25"	25.1-30"	>30"	TOTAL
5	Bluegill	Panfishes	7	34	15	6	0	0	0	0	0	0	63
5	Bluehead chub	Cyprinidae	1	0	0	0	0	0	0	0	0	0	1
5	Brown bullhead	Ictaluridae	0	3	0	0	0	0	0	0	0	0	3
5	Central stoneroller	Cyprinidae	0	0	1	0	0	0	0	0	0	0	1
5	Channel catfish	Ictaluridae	1	3	3	0	4	1	0	0	0	0	11
5	Common carp	Cyprinidae	0	0	0	0	0	0	1	2	0	0	3
5	Creek chub	Cyprinidae	0	1	0	0	0	0	0	0	0	0	1
5	Fieryblack shiner	Cyprinidae	1	1	0	0	0	0	0	0	0	0	2
5	Gizzard shad	Clupeidae	0	0	0	1	0	0	0	0	0	0	1
5	Golden shiner	Cyprinidae	0	0	0	1	0	0	0	0	0	0	1
5	Green sunfish	Panfishes	0	2	0	0	0	0	0	0	0	0	2
5	Margined madtom	Ictaluridae	0	0	1	0	0	0	0	0	0	0	1
5	Redbreast sunfish	Panfishes	0	1	3	1	0	0	0	0	0	0	5
5	Redear sunfish	Panfishes	0	1	2	0	0	0	0	0	0	0	3
5	Redeye bass	Black Bass	0	0	0	0	0	1	0	0	0	0	1
5	Silver redhorse	Catostomidae	0	1	0	0	0	0	0	0	0	0	1
5	Smallfin redhorse	Catostomidae	0	1	0	0	0	0	0	0	0	0	1
5	Smallmouth bass	Black Bass	0	0	0	0	1	0	1	0	0	0	2
5	Snail bullhead	Ictaluridae	0	0	7	5	0	0	0	0	0	0	12
5	Spottail shiner	Cyprinidae	0	5	1	0	0	0	0	0	0	0	6
5	Striped jumprock	Catostomidae	0	0	0	2	1	0	0	0	0	0	3
5	Threadfin shad	Clupeidae	0	56	63	0	0	0	0	0	0	0	119
5	Unid. carp	Cyprinidae	0	0	0	0	0	0	2	0	0	0	2
5	White catfish	Ictaluridae	0	0	2	1	0	0	0	0	0	0	3
5	White crappie	Panfishes	0	2	2	0	0	0	0	0	0	0	3
5	White perch	Moronidae	0	14	57	1	1	0	0	0	0	0	73
5	Whitefin shiner	Cyprinidae	0	2	0	0	0	0	0	0	0	0	2
5	Yellow perch	Percidae	0	151	380	48	0	0	0	0	0	0	580
6	Black crappie	Panfishes	0	68	44	0	1	0	0	0	0	0	113
6	Blueback herring	Clupeidae	0	0	318	486	149	0	0	0	0	0	954
6	Bluegill	Panfishes	3	29	48	45	2	1	0	0	0	0	128
6	Bluehead chub	Cyprinidae	0	2	0	0	0	0	0	0	0	0	2

MONTH	SPECIES/GROUP	FAMILY	0-2"	2.1-4"	4.1-6"	6.1-8"	8.1-10"	10.1-15"	15.1-20"	20.1-25"	25.1-30"	>30"	TOTAL
6	Brown bullhead	Ictaluridae	0	0	0	2	1	2	0	0	0	0	5
6	Channel catfish	Ictaluridae	0	1	2	6	9	1	0	1	0	0	20
6	Common carp	Cyprinidae	2	0	0	0	1	0	0	0	0	0	3
6	Fathead minnow	Cyprinidae	1	0	0	0	0	0	0	0	0	0	1
6	Fieryblack shiner	Cyprinidae	0	3	0	0	0	0	0	0	0	0	3
6	Flat bullhead	Ictaluridae	0	0	1	0	0	0	0	0	0	0	1
6	Gizzard shad	Clupeidae	0	2	0	2	1	9	2	0	0	0	16
6	Golden shiner	Cyprinidae	0	1	0	0	0	0	0	0	0	0	1
6	Green sunfish	Panfishes	0	2	2	0	0	0	0	0	0	0	3
6	Largemouth bass	Black Bass	1	0	0	0	0	0	1	0	0	0	2
6	Margined madtom	Ictaluridae	1	0	0	0	0	0	0	0	0	0	1
6	Redbreast sunfish	Panfishes	0	3	9	14	0	0	0	0	0	0	26
6	Redear sunfish	Panfishes	0	1	1	0	1	0	0	0	0	0	3
6	Shorthead redhorse	Catostomidae	0	0	0	0	0	1	0	0	0	0	1
6	Silver redhorse	Catostomidae	0	0	0	0	0	1	0	0	0	0	1
6	Smallfin redhorse	Catostomidae	0	0	0	0	0	1	0	0	0	0	1
6	Smallmouth bass	Black Bass	0	0	0	0	1	0	0	0	0	0	1
6	Snail bullhead	Ictaluridae	0	4	37	5	4	2	0	0	0	0	52
6	Spottail shiner	Cyprinidae	0	6	2	0	0	0	0	0	0	0	8
6	Spotted bass	Black Bass	0	3	0	0	0	0	0	0	0	0	3
6	Striped jumprock	Catostomidae	0	1	0	2	1	0	0	0	0	0	4
6	Threadfin shad	Clupeidae	1	360	149	0	0	0	0	0	0	0	510
6	Unid. carp	Cyprinidae	0	0	0	0	0	2	2	0	0	0	4
6	White catfish	Ictaluridae	0	5	3	4	3	5	0	0	0	0	20
6	White crappie	Panfishes	1	5	1	0	0	0	0	0	0	0	7
6	White perch	Moronidae	0	0	10	2	0	0	0	0	0	0	11
6	Whitefin shiner	Cyprinidae	0	3	0	0	0	0	0	0	0	0	3
6	Yellow perch	Percidae	0	162	276	20	0	0	0	0	0	0	457
7	Black crappie	Panfishes	0	35	19	0	0	0	0	0	0	0	54
7	Blueback herring	Clupeidae	0	3	89	176	22	0	0	0	0	0	290
7	Bluegill	Panfishes	6	78	14	0	0	0	0	0	0	0	98
7	Brown bullhead	Ictaluridae	0	10	8	6	2	9	0	0	0	0	36

MONTH	SPECIES/GROUP	FAMILY	0-2"	2.1-4"	4.1-6"	6.1-8"	8.1-10"	10.1-15"	15.1-20"	20.1-25"	25.1-30"	>30"	TOTAL
7	Channel catfish	Ictaluridae	0	1	0	0	0	0	0	0	0	0	1
7	Gizzard shad	Clupeidae	0	0	0	0	0	14	0	0	0	0	14
7	Green sunfish	Panfishes	0	2	0	0	0	0	0	0	0	0	2
7	Rainbow trout	Salmonidae	0	0	0	0	0	1	1	0	0	0	2
7	Threadfin shad	Clupeidae	13	1628	217	0	0	0	0	0	0	0	1859
7	Unid. carp	Cyprinidae	0	0	0	0	0	0	22	1	0	0	23
7	Warmouth	Panfishes	0	2	2	0	0	0	0	0	0	0	5
7	White catfish	Ictaluridae	0	10	6	3	0	0	0	0	0	0	19
7	White crappie	Panfishes	0	0	2	0	0	0	0	0	0	0	2
7	White perch	Moronidae	0	0	3	0	0	0	0	0	0	0	3
7	Whitefin shiner	Cyprinidae	0	1	1	0	0	0	0	0	0	0	2
7	Yellow bullhead	Ictaluridae	0	0	0	0	0	7	0	0	0	0	7
7	Yellow perch	Percidae	0	144	295	17	0	0	0	0	0	0	455
8	Blueback herring	Clupeidae	0	1242	70	212	45	0	0	0	0	0	1570
8	Bluegill	Panfishes	18	134	9	3	1	0	0	0	0	0	165
8	Brown bullhead	Ictaluridae	0	0	0	0	0	6	0	0	0	0	6
8	Channel catfish	Ictaluridae	0	1	0	0	0	1	0	0	0	0	2
8	Gizzard shad	Clupeidae	0	0	0	0	0	4	0	0	0	0	4
8	Snail bullhead	Ictaluridae	0	0	1	0	0	0	0	0	0	0	1
8	Spottail shiner	Cyprinidae	0	13	0	0	0	0	0	0	0	0	13
8	Threadfin shad	Clupeidae	0	3227	517	0	0	0	0	0	0	0	3744
8	Unid. carp	Cyprinidae	0	0	0	0	0	0	0	0	2	0	2
8	Warmouth	Panfishes	0	2	2	0	0	0	0	0	0	0	3
8	White catfish	Ictaluridae	0	4	19	8	4	1	0	0	0	0	36
8	Yellow perch	Percidae	0	25	127	7	0	2	0	0	0	0	161
9	Black crappie	Panfishes	0	1	0	0	1	0	0	0	0	0	2
9	Bluegill	Panfishes	6	6	32	12	0	0	0	0	0	0	56
9	Channel catfish	Ictaluridae	0	17	5	15	5	1	0	0	0	0	43
9	Common carp	Cyprinidae	0	0	1	0	0	0	0	0	0	0	1
9	Fieryblack shiner	Cyprinidae	0	1	0	0	0	0	0	0	0	0	1
9	Flat bullhead	Ictaluridae	0	0	0	0	0	2	0	0	0	0	2
9	Gizzard shad	Clupeidae	0	0	1	0	1	0	0	0	0	0	2

MONTH	SPECIES/GROUP	FAMILY	0-2"	2.1-4"	4.1-6"	6.1-8"	8.1-10"	10.1-15"	15.1-20"	20.1-25"	25.1-30"	>30"	TOTAL
9	Golden shiner	Cyprinidae	1	5	0	0	0	0	0	0	0	0	6
9	Largemouth bass	Black Bass	0	0	0	0	0	0	3	0	0	0	3
9	Piedmont darter	Percidae	0	1	0	0	0	0	0	0	0	0	1
9	Redbreast sunfish	Panfishes	0	1	5	0	0	0	0	0	0	0	6
9	Redear sunfish	Panfishes	0	0	0	0	1	0	0	0	0	0	1
9	Sandbar shiner	Cyprinidae	0	15	0	0	0	0	0	0	0	0	15
9	Shorthead redhorse	Catostomidae	0	0	0	0	1	1	0	0	0	0	2
9	Snail bullhead	Ictaluridae	0	4	0	3	3	0	0	0	0	0	10
9	Striped jumprock	Catostomidae	0	0	0	0	2	0	0	0	0	0	2
9	Threadfin shad	Clupeidae	0	8	9	0	0	0	0	0	0	0	17
9	White catfish	Ictaluridae	0	5	0	2	0	1	0	0	0	0	8
9	White crappie	Panfishes	0	0	0	1	0	0	0	0	0	0	1
9	Whitefin shiner	Cyprinidae	3	0	0	0	0	0	0	0	0	0	3
10	Black crappie	Panfishes	0	0	1	1	1	0	0	0	0	0	3
10	Blueback herring	Clupeidae	0	0	47	408	68	0	0	0	0	0	523
10	Bluegill	Panfishes	8	27	28	41	2	0	0	0	0	0	106
10	Brown bullhead	Ictaluridae	0	0	3	7	1	0	0	0	0	0	11
10	Channel catfish	Ictaluridae	0	1	2	2	1	0	0	0	0	0	6
10	Fieryblack shiner	Cyprinidae	0	3	0	0	0	0	0	0	0	0	3
10	Flat bullhead	Ictaluridae	0	1	0	1	0	0	0	0	0	0	2
10	Flathead catfish	Ictaluridae	0	0	1	1	0	0	0	0	0	0	1
10	Gizzard shad	Clupeidae	0	0	2	0	0	3	0	0	0	0	5
10	Golden shiner	Cyprinidae	0	0	0	1	0	0	0	0	0	0	1
10	Largemouth bass	Black Bass	0	0	0	0	0	0	1	0	0	0	1
10	Redbreast sunfish	Panfishes	0	0	3	2	0	0	0	0	0	0	5
10	Redear sunfish	Panfishes	0	0	0	3	4	0	0	0	0	0	7
10	Redeye bass	Black Bass	0	0	0	1	0	0	0	0	0	0	1
10	Smallfin redhorse	Catostomidae	0	0	0	0	0	1	0	0	0	0	1
10	Snail bullhead	Ictaluridae	0	1	1	0	0	0	0	0	0	0	2
10	Spottail shiner	Cyprinidae	0	0	1	0	0	0	0	0	0	0	1
10	Striped jumprock	Catostomidae	0	1	0	4	2	0	0	0	0	0	7
10	Threadfin shad	Clupeidae	99	374	37	0	0	0	0	0	0	0	511

MONTH	SPECIES/GROUP	FAMILY	0-2"	2.1-4"	4.1-6"	6.1-8"	8.1-10"	10.1-15"	15.1-20"	20.1-25"	25.1-30"	>30"	TOTAL
10	Unid. carp	Cyprinidae	0	0	0	0	0	0	16	0	0	0	16
10	White bass	Moronidae	0	0	0	0	0	2	0	0	0	0	2
10	White catfish	Ictaluridae	1	72	155	150	40	0	0	0	0	0	418
10	White perch	Moronidae	0	0	0	1	1	0	0	0	0	0	2
10	Whitefin shiner	Cyprinidae	0	6	1	0	0	0	0	0	0	0	7
10	Yellow perch	Percidae	0	13	34	3	0	0	0	0	0	0	50
11	Black crappie	Panfishes	0	1	3	0	6	1	0	0	0	0	11
11	Blueback herring	Clupeidae	0	59	58	288	47	0	0	0	0	0	451
11	Bluegill	Panfishes	10	116	13	7	0	0	0	0	0	0	147
11	Brown bullhead	Ictaluridae	0	29	102	35	10	2	1	0	0	0	179
11	Channel catfish	Ictaluridae	1	6	43	16	4	2	1	0	0	0	74
11	Flat bullhead	Ictaluridae	0	0	0	1	1	0	0	0	0	0	2
11	Flathead catfish	Ictaluridae	0	0	2	3	1	1	0	0	0	0	7
11	Gizzard shad	Clupeidae	0	3	19	3	14	12	1	0	0	0	52
11	Hybrid bass	Moronidae	0	0	0	0	0	0	1	0	0	0	1
11	Largemouth bass	Black Bass	0	0	0	0	0	0	1	0	0	0	1
11	Northern hog sucker	Catostomidae	0	0	0	0	1	0	0	0	0	0	1
11	Redbreast sunfish	Panfishes	0	0	2	4	0	0	0	0	0	0	6
11	Silver redhorse	Catostomidae	0	0	0	1	0	0	0	0	0	0	1
11	Snail bullhead	Ictaluridae	0	0	0	1	0	0	0	0	0	0	1
11	Spotted bass	Black Bass	0	0	0	0	0	1	0	0	0	0	1
11	Striped jumprock	Catostomidae	0	0	0	1	5	2	0	0	0	0	8
11	Threadfin shad	Clupeidae	3192	9962	821	0	0	0	0	0	0	0	13976
11	Unid. carp	Cyprinidae	0	0	0	0	0	0	1	0	3	0	4
11	Warmouth	Panfishes	0	3	0	0	0	0	0	0	0	0	3
11	White catfish	Ictaluridae	3	56	154	114	34	3	0	0	0	0	364
11	White crappie	Panfishes	0	1	0	0	0	0	0	0	0	0	1
11	White perch	Moronidae	0	0	0	3	3	2	0	0	0	0	7
11	White sucker	Catostomidae	0	0	0	0	1	0	0	0	0	0	1
11	Yellow bullhead	Ictaluridae	0	0	0	0	0	2	0	0	0	0	2
11	Yellow perch	Percidae	0	21	100	24	1	0	0	0	0	0	147
12	Black crappie	Panfishes	0	2	0	0	0	1	0	0	0	0	3

MONTH	SPECIES/GROUP	FAMILY	0-2"	2.1-4"	4.1-6"	6.1-8"	8.1-10"	10.1-15"	15.1-20"	20.1-25"	25.1-30"	>30"	TOTAL
12	Bluegill	Panfishes	0	1	3	1	0	0	0	0	0	0	5
12	Channel catfish	Ictaluridae	0	0	0	0	0	1	0	0	0	0	1
12	Gizzard shad	Clupeidae	0	0	45	3	0	0	0	0	0	0	48
12	Piedmont darter	Percidae	0	2	0	0	0	0	0	0	0	0	2
12	Smallfin redhorse	Catostomidae	0	0	0	1	0	2	0	0	0	0	3
12	Snail bullhead	Ictaluridae	0	1	0	1	0	0	0	0	0	0	2
12	Tessellated darter	Percidae	0	1	0	0	0	0	0	0	0	0	1
12	White bass	Moronidae	0	0	0	0	0	2	0	0	0	0	2
12	White catfish	Ictaluridae	0	0	1	0	0	0	0	0	0	0	1
12	Yellow perch	Percidae	0	0	0	3	1	0	0	0	0	0	4
Total[1]	53	8	3,420	18,840	4,966	2,403	580	148	67	5	5	0	30,433

[1] The database contains 53 species from 8 families and a total of 30,433 fish spread across the range of length classes. These totals do not account for the use of surrogates for missing months or family data.

APPENDIX B

FAMILY MONTHLY AND SEASONAL LENGTH CLASS PERCENTAGE

FAMILY MONTHLY AND SEASONAL LENGTH CLASS PERCENTAGE

CATOSTOMIDAE

MONT	0-2"	2.1-	4.1-	6.1-	8.1-	10.1-	15.1-	20.1-	25.1-	>30	TOTA	
1	0.0	0.0%	0.0%	14.3	42.9%	42.9%	0.0%	0.0%	0.0%	0.0	100.0	*sub February data for Jan
2	0.0	0.0%	0.0%	14.3	42.9%	42.9%	0.0%	0.0%	0.0%	0.0	100.0	
3	0.0	0.0%	0.0%	39.5	31.6%	23.7%	5.3%	0.0%	0.0%	0.0	100.0	*sub April data for March
4	0.0	0.0%	0.0%	39.5	31.6%	23.7%	5.3%	0.0%	0.0%	0.0	100.0	
5	0.0	40.0	0.0%	40.0	20.0%	0.0%	0.0%	0.0%	0.0%	0.0	100.0	
6	0.0	14.3	0.0%	28.6	14.3%	42.9%	0.0%	0.0%	0.0%	0.0	100.0	
7	0.0	14.3	0.0%	28.6	14.3%	42.9%	0.0%	0.0%	0.0%	0.0	100.0	*sub June data for July
8	0.0	14.3	0.0%	28.6	14.3%	42.9%	0.0%	0.0%	0.0%	0.0	100.0	*sub June data for August
9	0.0	0.0%	0.0%	0.0%	75.0%	25.0%	0.0%	0.0%	0.0%	0.0	100.0	
10	0.0	12.5	0.0%	50.0	25.0%	12.5%	0.0%	0.0%	0.0%	0.0	100.0	
11	0.0	0.0%	0.0%	18.2	63.6%	18.2%	0.0%	0.0%	0.0%	0.0	100.0	
12	0.0	0.0%	0.0%	33.3	0.0%	66.7%	0.0%	0.0%	0.0%	0.0	100.0	

SEASON	0-2"	2.1-4"	4.1-6"	6.1-8"	8.1-10"	10.1-15"	15.1-20"	20.1-25"	25.1-30"	>30"	TOTAL
WINTER	0.0%	0.0%	0.0%	17.6%	35.3%	47.1%	0.0%	0.0%	0.0%	0.0%	100%
SPRING	0.0%	2.5%	0.0%	39.5%	30.9%	22.2%	4.9%	0.0%	0.0%	0.0%	100%
SUMMER	0.0%	14.3%	0.0%	28.6%	14.3%	42.9%	0.0%	0.0%	0.0%	0.0%	100%
FALL	0.0%	4.3%	0.0%	26.1%	52.2%	17.4%	0.0%	0.0%	0.0%	0.0%	100%
TOTAL	**0.0%**	**4.2%**	**0.0%**	**33.1%**	**32.4%**	**27.5%**	**2.8%**	**0.0%**	**0.0%**	**0.0%**	**100%**

Kleinschmidt

BLACK BASS

MONTH	0-2"	2.1-4"	4.1-6"	6.1-8"	8.1-10"	10.1-15"	15.1-20"	20.1-25"	25.1-30"	>30"	TOTAL	
1	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	*sub February data for January
2	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	
3	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	*sub April data for March
4	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	
5	0.0%	0.0%	0.0%	0.0%	33.3%	33.3%	33.3%	0.0%	0.0%	0.0%	100.0%	
6	17.8%	46.5%	0.0%	0.0%	17.8%	0.0%	17.8%	0.0%	0.0%	0.0%	100.0%	
7	17.8%	46.5%	0.0%	0.0%	17.8%	0.0%	17.8%	0.0%	0.0%	0.0%	100.0%	*sub June data for July
8	17.8%	46.5%	0.0%	0.0%	17.8%	0.0%	17.8%	0.0%	0.0%	0.0%	100.0%	*sub June data for August
9	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	100.0%	
10	0.0%	0.0%	0.0%	50.0%	0.0%	0.0%	50.0%	0.0%	0.0%	0.0%	100.0%	
11	0.0%	0.0%	0.0%	0.0%	0.0%	50.0%	50.0%	0.0%	0.0%	0.0%	100.0%	
12	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	*sub February data for December

SEASON	0-2"	2.1-4"	4.1-6"	6.1-8"	8.1-10"	10.1-15"	15.1-20"	20.1-25"	25.1-30"	>30"	TOTAL
WINTER	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100%
SPRING	0.0%	25.0%	0.0%	0.0%	25.0%	25.0%	25.0%	0.0%	0.0%	0.0%	100%
SUMMER	17.8%	46.5%	0.0%	0.0%	17.8%	0.0%	17.8%	0.0%	0.0%	0.0%	100%
FALL	0.0%	0.0%	0.0%	14.3%	0.0%	14.3%	71.4%	0.0%	0.0%	0.0%	100%
TOTAL	**5.7%**	**26.2%**	**0.0%**	**5.7%**	**11.4%**	**11.4%**	**39.8%**	**0.0%**	**0.0%**	**0.0%**	**100%**

PANFISH

MONT	0-2"	2.1-	4.1-	6.1-	8.1-	10.1-	15.1-	20.1-	25.1-	>30	TOTAL
1	71.4	14.3%	7.1%	7.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0
2	71.4	14.3%	7.1%	7.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0
3	50.0	16.7%	33.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0
4	7.5%	83.5%	6.7%	2.0%	0.3%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0
5	2.5%	74.6%	19.8%	2.8%	0.3%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0
6	1.5%	38.5%	37.2%	21.1%	1.4%	0.4%	0.0%	0.0%	0.0%	0.0%	100.0
7	3.6%	73.5%	23.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0
8	10.8	80.5%	6.3%	1.8%	0.6%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0
9	9.1%	12.1%	56.1%	19.7%	3.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0
10	6.2%	22.7%	26.3%	38.9%	5.8%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0
11	6.2%	72.1%	10.7%	6.7%	3.7%	0.6%	0.0%	0.0%	0.0%	0.0%	100.0
12	0.0%	37.5%	37.5%	12.5%	0.0%	12.5%	0.0%	0.0%	0.0%	0.0%	100.0

*sub February data for

SEASON	0-2"	2.1-4"	4.1-6"	6.1-8"	8.1-10"	10.1-15"	15.1-20"	20.1-25"	25.1-30"	>30"	TOTAL
WINTER	45.5%	22.7%	18.2%	9.1%	0.0%	4.5%	0.0%	0.0%	0.0%	0.0%	100%
SPRING	5.6%	78.6%	13.2%	2.3%	0.3%	0.0%	0.0%	0.0%	0.0%	0.0%	100%
SUMMER	4.6%	59.3%	24.9%	10.2%	0.8%	0.2%	0.0%	0.0%	0.0%	0.0%	100%
FALL	6.7%	44.1%	24.5%	20.1%	4.3%	0.3%	0.0%	0.0%	0.0%	0.0%	100%
TOTAL	**6.0%**	**62.8%**	**20.2%**	**9.4%**	**1.4%**	**0.2%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**100%**

CLUPEIDAE

MONTH	0-2"	2.1-4"	4.1-6"	6.1-8"	8.1-10"	10.1-15"	15.1-20"	20.1-25"	25.1-30"	>30"	TOTAL
1	0.0%	25.0%	8.3%	41.7%	8.3%	16.7%	0.0%	0.0%	0.0%	0.0%	100.0%
2	0.0%	25.0%	8.3%	41.7%	8.3%	16.7%	0.0%	0.0%	0.0%	0.0%	100.0%
3	0.0%	14.3%	21.4%	35.7%	7.1%	14.3%	7.1%	0.0%	0.0%	0.0%	100.0%
4	0.0%	0.9%	70.4%	18.8%	2.8%	5.4%	1.8%	0.0%	0.0%	0.0%	100.0%
5	0.0%	30.1%	56.3%	11.9%	1.7%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
6	0.1%	24.4%	31.6%	33.0%	10.1%	0.6%	0.1%	0.0%	0.0%	0.0%	100.0%
7	0.6%	75.4%	14.2%	8.2%	1.0%	0.6%	0.0%	0.0%	0.0%	0.0%	100.0%
8	0.0%	84.0%	11.0%	4.0%	0.8%	0.1%	0.0%	0.0%	0.0%	0.0%	100.0%
9	0.0%	42.1%	52.6%	0.0%	5.3%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
10	9.6%	36.0%	8.3%	39.2%	6.6%	0.3%	0.0%	0.0%	0.0%	0.0%	100.0%
11	22.0%	69.2%	6.2%	2.0%	0.4%	0.1%	0.0%	0.0%	0.0%	0.0%	100.0%
12	0.0%	0.0%	93.8%	6.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%

*sub February data for January

SEASON	0-2"	2.1-4"	4.1-6"	6.1-8"	8.1-10"	10.1-15"	15.1-20"	20.1-25"	25.1-30"	>30"	TOTAL
WINTER	0.0%	5.0%	76.7%	13.3%	1.7%	3.3%	0.0%	0.0%	0.0%	0.0%	100%
SPRING	0.0%	18.9%	59.8%	15.4%	2.3%	2.6%	1.0%	0.0%	0.0%	0.0%	100%
SUMMER	0.2%	72.1%	15.2%	9.8%	2.4%	0.3%	0.0%	0.0%	0.0%	0.0%	100%
FALL	21.2%	67.0%	6.4%	4.5%	0.8%	0.1%	0.0%	0.0%	0.0%	0.0%	100%
TOTAL	**13.3%**	**68.1%**	**10.4%**	**6.6%**	**1.4%**	**0.2%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**100%**

CYPRINIDAE

MONTH	0-2"	2.1-4"	4.1-6"	6.1-8"	8.1-10"	10.1-15"	15.1-20"	20.1-25"	25.1-30"	>30"	TOTAL	
1	0.0%	80.0%	0.0%	20.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	*sub February data for January
2	0.0%	80.0%	0.0%	20.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	
3	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	
4	3.8%	49.2%	39.4%	3.8%	0.0%	0.0%	3.8%	0.0%	0.0%	0.0%	100.0%	
5	10.5%	47.4%	10.7%	5.2%	0.0%	0.0%	15.7%	10.5%	0.0%	0.0%	100.0%	
6	11.9%	59.9%	8.3%	0.0%	4.0%	7.9%	7.9%	0.0%	0.0%	0.0%	100.0%	
7	0.0%	4.2%	4.2%	0.0%	0.0%	0.0%	87.6%	4.0%	0.0%	0.0%	100.0%	
8	0.0%	86.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	13.3%	0.0%	100.0%	
9	15.4%	80.8%	3.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	
10	0.0%	32.1%	7.1%	3.6%	0.0%	0.0%	57.1%	0.0%	0.0%	0.0%	100.0%	
11	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	25.0%	0.0%	75.0%	0.0%	100.0%	
12	0.0%	80.0%	0.0%	20.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	*sub February data for December

SEASON	0-2"	2.1-4"	4.1-6"	6.1-8"	8.1-10"	10.1-15"	15.1-20"	20.1-25"	25.1-30"	>30"	TOTAL
WINTER	0.0%	80.0%	0.0%	20.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100%
SPRING	6.5%	49.5%	26.8%	4.3%	0.0%	0.0%	8.6%	4.3%	0.0%	0.0%	100%
SUMMER	4.6%	44.6%	4.8%	0.0%	1.5%	3.1%	36.8%	1.5%	3.1%	0.0%	100%
FALL	6.9%	51.7%	5.2%	1.7%	0.0%	0.0%	29.3%	0.0%	5.2%	0.0%	100%
TOTAL	**5.7%**	**49.3%**	**10.6%**	**2.3%**	**0.6%**	**1.1%**	**25.7%**	**1.7%**	**2.9%**	**0.0%**	**100%**

ICTALURIDAE

MONTH	0-2"	2.1-4"	4.1-6"	6.1-8"	8.1-10"	10.1-15"	15.1-20"	20.1-25"	25.1-30"	>30"	TOTAL
1	0.0%	2.5%	14.8%	40.7%	35.8%	6.2%	0.0%	0.0%	0.0%	0.0%	100.0%
2	0.0%	2.5%	14.8%	40.7%	35.8%	6.2%	0.0%	0.0%	0.0%	0.0%	100.0%
3	0.0%	50.0%	0.0%	50.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
4	0.0%	34.5%	33.3%	10.5%	9.3%	9.3%	1.6%	1.6%	0.0%	0.0%	100.0%
5	2.3%	21.1%	42.8%	19.5%	12.0%	2.3%	0.0%	0.0%	0.0%	0.0%	100.0%
6	1.0%	10.3%	43.2%	17.0%	17.4%	10.0%	0.0%	1.0%	0.0%	0.0%	100.0%
7	0.0%	34.9%	21.8%	15.3%	3.3%	24.7%	0.0%	0.0%	0.0%	0.0%	100.0%
8	0.0%	11.6%	44.2%	17.1%	9.3%	17.9%	0.0%	0.0%	0.0%	0.0%	100.0%
9	0.0%	41.3%	7.9%	31.7%	12.7%	6.3%	0.0%	0.0%	0.0%	0.0%	100.0%
10	0.3%	17.0%	36.7%	36.3%	9.7%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
11	0.7%	14.5%	47.8%	27.1%	8.1%	1.6%	0.2%	0.0%	0.0%	0.0%	100.0%
12	0.0%	25.0%	25.0%	25.0%	0.0%	25.0%	0.0%	0.0%	0.0%	0.0%	100.0%

*sub February data for January

SEASON	0-2"	2.1-4"	4.1-6"	6.1-8"	8.1-10"	10.1-15"	15.1-20"	20.1-25"	25.1-30"	>30"	TOTAL
WINTER	0.0%	3.5%	15.3%	40.0%	34.1%	7.1%	0.0%	0.0%	0.0%	0.0%	100%
SPRING	1.1%	28.6%	36.8%	16.0%	10.3%	5.7%	0.8%	0.8%	0.0%	0.0%	100%
SUMMER	0.5%	18.1%	36.9%	16.5%	11.4%	16.2%	0.0%	0.5%	0.0%	0.0%	100%
FALL	0.5%	17.0%	41.3%	30.9%	9.0%	1.3%	0.1%	0.0%	0.0%	0.0%	100%
TOTAL	**0.5%**	**16.9%**	**39.0%**	**28.8%**	**10.8%**	**3.9%**	**0.1%**	**0.1%**	**0.0%**	**0.0%**	**100%**

LEPISOSTEIDAE[2]

MONTH	0-2"	2.1-4"	4.1-6"	6.1-8"	8.1-10"	10.1-15"	15.1-20"	20.1-25"	25.1-30"	>30"	TOTAL	
1	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	*sub February data for January
2	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	
3	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	*sub April data for March
4	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	
5	0.0%	0.0%	0.0%	0.0%	33.3%	33.3%	33.3%	0.0%	0.0%	0.0%	100.0%	
6	17.8%	46.5%	0.0%	0.0%	17.8%	0.0%	17.8%	0.0%	0.0%	0.0%	100.0%	
7	17.8%	46.5%	0.0%	0.0%	17.8%	0.0%	17.8%	0.0%	0.0%	0.0%	100.0%	*sub June data for July
8	17.8%	46.5%	0.0%	0.0%	17.8%	0.0%	17.8%	0.0%	0.0%	0.0%	100.0%	*sub June data for August
9	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	100.0%	
10	0.0%	0.0%	0.0%	50.0%	0.0%	0.0%	50.0%	0.0%	0.0%	0.0%	100.0%	
11	0.0%	0.0%	0.0%	0.0%	0.0%	50.0%	50.0%	0.0%	0.0%	0.0%	100.0%	
12	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	*sub February data for December

SEASON	0-2"	2.1-4"	4.1-6"	6.1-8"	8.1-10"	10.1-15"	15.1-20"	20.1-25"	25.1-30"	>30"	TOTAL
WINTER	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100%
SPRING	0.0%	25.0%	0.0%	0.0%	25.0%	25.0%	25.0%	0.0%	0.0%	0.0%	100%
SUMMER	17.8%	46.5%	0.0%	0.0%	17.8%	0.0%	17.8%	0.0%	0.0%	0.0%	100%
FALL	0.0%	0.0%	0.0%	14.3%	0.0%	14.3%	71.4%	0.0%	0.0%	0.0%	100%
TOTAL	**5.7%**	**26.2%**	**0.0%**	**5.7%**	**11.4%**	**11.4%**	**39.8%**	**0.0%**	**0.0%**	**0.0%**	**100%**

[2] No length class data. Black bass used as surrogate.

Moronidae

Month	0-2"	2.1-4"	4.1-6"	6.1-8"	8.1-10"	10.1-15"	15.1-20"	20.1-25"	25.1-30"	>30"	Total	
1	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	100.0%	*sub December data for January
2	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	100.0%	*sub December data for February
3	0.0%	14.7%	75.8%	3.5%	2.5%	0.9%	2.6%	0.0%	0.0%	0.0%	100.0%	*sub April for March
4	0.0%	14.7%	75.8%	3.5%	2.5%	0.9%	2.6%	0.0%	0.0%	0.0%	100.0%	
5	0.0%	19.7%	77.9%	1.6%	0.8%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	
6	0.0%	0.0%	84.7%	15.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	
7	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	
8	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	*sub July for August
9	0.0%	0.0%	0.0%	25.0%	25.0%	50.0%	0.0%	0.0%	0.0%	0.0%	100.0%	*sub October data for September
10	0.0%	0.0%	0.0%	25.0%	25.0%	50.0%	0.0%	0.0%	0.0%	0.0%	100.0%	
11	0.0%	0.0%	0.0%	32.9%	31.0%	24.1%	12.0%	0.0%	0.0%	0.0%	100.0%	
12	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	100.0%	

Season	0-2"	2.1-4"	4.1-6"	6.1-8"	8.1-10"	10.1-15"	15.1-20"	20.1-25"	25.1-30"	>30"	Total
Winter	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	100%
Spring	0.0%	16.7%	76.6%	2.8%	1.8%	0.5%	1.6%	0.0%	0.0%	0.0%	100%
Summer	0.0%	0.0%	87.6%	12.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100%
Fall	0.0%	0.0%	0.0%	30.3%	29.1%	32.5%	8.1%	0.0%	0.0%	0.0%	100%
Total	**0.0%**	**14.5%**	**72.3%**	**4.9%**	**3.3%**	**3.2%**	**1.8%**	**0.0%**	**0.0%**	**0.0%**	**100%**

PERCIDAE

MONTH	0-2"	2.1-4"	4.1-6"	6.1-8"	8.1-10"	10.1-15"	15.1-20"	20.1-25"	25.1-30"	>30"	TOTAL	
1	0.0%	42.9%	0.0%	42.9%	14.3%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	*sub December for January
2	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	
3	0.0%	9.9%	68.6%	21.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	*sub April for March
4	0.0%	9.9%	68.6%	21.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	
5	0.0%	26.1%	65.6%	8.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	
6	0.0%	35.4%	60.3%	4.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	
7	0.0%	31.5%	64.8%	3.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	
8	0.0%	15.4%	79.0%	4.3%	0.0%	1.2%	0.0%	0.0%	0.0%	0.0%	100.0%	
9	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	
10	0.0%	26.0%	68.2%	5.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	
11	0.0%	14.2%	68.3%	16.7%	0.8%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	
12	0.0%	42.9%	0.0%	42.9%	14.3%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	

SEASON	0-2"	2.1-4"	4.1-6"	6.1-8"	8.1-10"	10.1-15"	15.1-20"	20.1-25"	25.1-30"	>30"	TOTAL
WINTER	0.0%	46.7%	0.0%	40.0%	13.3%	0.0%	0.0%	0.0%	0.0%	0.0%	100%
SPRING	0.0%	21.1%	66.5%	12.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100%
SUMMER	0.0%	30.8%	65.0%	4.0%	0.0%	0.2%	0.0%	0.0%	0.0%	0.0%	100%
FALL	0.0%	17.7%	67.9%	13.8%	0.6%	0.0%	0.0%	0.0%	0.0%	0.0%	100%
TOTAL	**0.0%**	**25.9%**	**65.4%**	**8.5%**	**0.1%**	**0.1%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**100%**

FUNDULIDAE[3]

MONTH	0-2"	2.1-4"	4.1-6"	6.1-8"	8.1-10"	10.1-15"	15.1-20"	20.1-25"	25.1-30"	>30"	TOTAL	Note
1	0.0%	80.0%	0.0%	20.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	*sub February data for January
2	0.0%	80.0%	0.0%	20.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	
3	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	
4	3.8%	49.2%	39.4%	3.8%	0.0%	0.0%	3.8%	0.0%	0.0%	0.0%	100.0%	
5	10.5%	47.4%	10.7%	5.2%	0.0%	0.0%	15.7%	10.5%	0.0%	0.0%	100.0%	
6	11.9%	59.9%	8.3%	0.0%	4.0%	7.9%	7.9%	0.0%	0.0%	0.0%	100.0%	
7	0.0%	4.2%	4.2%	0.0%	0.0%	0.0%	87.6%	4.0%	0.0%	0.0%	100.0%	
8	0.0%	86.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	13.3%	0.0%	100.0%	
9	15.4%	80.8%	3.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	
10	0.0%	32.1%	7.1%	3.6%	0.0%	0.0%	57.1%	0.0%	0.0%	0.0%	100.0%	
11	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	25.0%	0.0%	75.0%	0.0%	100.0%	
12	0.0%	80.0%	0.0%	20.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	*sub February data for December

SEASON	0-2"	2.1-4"	4.1-6"	6.1-8"	8.1-10"	10.1-15"	15.1-20"	20.1-25"	25.1-30"	>30"	TOTAL
WINTER	0.0%	80.0%	0.0%	20.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100%
SPRING	6.5%	49.5%	26.8%	4.3%	0.0%	0.0%	8.6%	4.3%	0.0%	0.0%	100%
SUMMER	4.6%	44.6%	4.8%	0.0%	1.5%	3.1%	36.8%	1.5%	3.1%	0.0%	100%
FALL	6.9%	51.7%	5.2%	1.7%	0.0%	0.0%	29.3%	0.0%	5.2%	0.0%	100%
TOTAL	**5.7%**	**49.3%**	**10.6%**	**2.3%**	**0.6%**	**1.1%**	**25.7%**	**1.7%**	**2.9%**	**0.0%**	**100%**

[3] No length class data. Cyprinidae used as surrogate.

ESOCIDAE[4]

MONTH	0-2"	2.1-4"	4.1-6"	6.1-8"	8.1-10"	10.1-15"	15.1-20"	20.1-25"	25.1-30"	>30"	TOTAL	
1	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	*sub February data for January
2	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	
3	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	*sub April data for March
4	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	
5	0.0%	0.0%	0.0%	0.0%	33.3%	33.3%	33.3%	0.0%	0.0%	0.0%	100.0%	
6	17.8%	46.5%	0.0%	0.0%	17.8%	0.0%	17.8%	0.0%	0.0%	0.0%	100.0%	
7	17.8%	46.5%	0.0%	0.0%	17.8%	0.0%	17.8%	0.0%	0.0%	0.0%	100.0%	*sub June data for July
8	17.8%	46.5%	0.0%	0.0%	17.8%	0.0%	17.8%	0.0%	0.0%	0.0%	100.0%	*sub June data for August
9	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	100.0%	
10	0.0%	0.0%	0.0%	50.0%	0.0%	0.0%	50.0%	0.0%	0.0%	0.0%	100.0%	
11	0.0%	0.0%	0.0%	0.0%	0.0%	50.0%	50.0%	0.0%	0.0%	0.0%	100.0%	*sub October data for November
12	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	*sub February data for December

SEASON	0-2"	2.1-4"	4.1-6"	6.1-8"	8.1-10"	10.1-15"	15.1-20"	20.1-25"	25.1-30"	>30"	TOTAL
WINTER	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100%
SPRING	0.0%	25.0%	0.0%	0.0%	25.0%	25.0%	25.0%	0.0%	0.0%	0.0%	100%
SUMMER	17.8%	46.5%	0.0%	0.0%	17.8%	0.0%	17.8%	0.0%	0.0%	0.0%	100%
FALL	0.0%	0.0%	0.0%	14.3%	0.0%	14.3%	71.4%	0.0%	0.0%	0.0%	100%
TOTAL	**5.7%**	**26.2%**	**0.0%**	**5.7%**	**11.4%**	**11.4%**	**39.8%**	**0.0%**	**0.0%**	**0.0%**	**100%**

[4] No length class data. Black bass used as surrogate.

APPENDIX C

2015 FAIRFIELD ENTRAINMENT ESTIMATES

TOTAL FISH ENTRAINMENT ESTIMATE

		SEASONAL ENTRAINMENT RATE (fish/mcf) CONVENTIONAL GEN	SEASONAL ENTRAINMENT RATE (fish/mcf) PUMPBACK GEN	TOTAL MONTHLY PROJECT FLOWS (mcf)	TOTAL ESTIMATED NUMBER OF FISH ENTRAINED BY MONTH CONVENTIONAL GEN	TOTAL ESTIMATED NUMBER OF FISH ENTRAINED BY MONTH PUMPBACK GEN	TOTAL ESTIMATED NUMBER FISH ENTRAINED BY SEASON CONVENTIONAL GENERATION	TOTAL ESTIMATED NUMBER FISH ENTRAINED BY SEASON PUMPBACK GENERATION
Winter	December	9.2	3.2	14,203	130667.6	45,449.6	374,026	130,096
	January	9.2	3.2	11,969	110114.8	38,300.8		
	February	9.2	3.2	14,483	133243.6	46,345.6		
Spring	March	2.5	6.3	18,237	45592.5	114,893.1	169,495	427,127
	April	2.5	6.3	23,287	58217.5	146,708.1		
	May	2.5	6.3	26,274	65685	165,526.2		
Summer	June	1.7	16.4	28,142	47841.4	461,528.8	137,846	1,329,810
	July	1.7	16.4	29,049	49383.3	476,403.6		
	August	1.7	16.4	23,895	40621.5	391,878		
Fall	September	2.6	11.5	19,622	51017.2	225,653	132,891	587,788
	October	2.6	11.5	16,077	41800.2	184,885.5		
	November	2.6	11.5	15,413	40073.8	177,249.5		
Annual							**814,258**	**2,474,822**

CONVENTIONAL GENERATION FISH ENTRAINMENT ESTIMATE

	WINTER	SPRING	SUMMER	FALL	ANNUAL
Catostomidae	25	44	33	0	103
Black Bass	3	21	69	56	148
Panfish	633	7,830	14,520	1,861	24,843
Clupeidae	350,027	72,192	96,559	102,794	621,573
Cyprinidae	407	815	679	794	2,695
Ictaluridae	12,872	1,224	3,507	24,617	42,220
Lepisosteidae	3	0	31	0	33
Moronidae	15	8,532	465	43	9,056
Percidae	10,028	78,737	21,950	2,725	113,441
TOTAL	**374,014**	**169,393**	**137,846**	**132,891**	**814,144**

PUMPBACK FISH ENTRAINMENT ESTIMATE

	WINTER	SPRING	SUMMER	FALL	ANNUAL
Catostomidae	8	9	3	37	57
Black Bass	62	0	8,385	279	8,727
Panfish	371	41,921	6,032	1,677	50,001
Clupeidae	128,476	316,097	1,281,433	580,469	2,306,475
Cyprinidae	15	4,557	3,234	66	7,872
Ictaluridae	867	7,874	3,916	3,918	16,576
Lepisosteidae	1	0	22	3	26
Moronidae	250	50,188	23,711	1,130	75,279
Percidae	46	6,464	2,851	209	9,570
Fundulidae	0	18	154	0	171
Esocidae	0	0	69	0	69
TOTAL	**130,096**	**427,127**	**1,329,810**	**587,788**	**2,474,822**

APPENDIX D

FAMILY LENGTH CLASS ENTRAINMENT AND MORTALITY ESTIMATES

FAMILY LENGTH CLASS ENTRAINMENT AND MORTALITY ESTIMATES

Catostomidae						
Conventional				Pumpback		
Winter	Ent. Fish/Length Class	Mortality/Length Class		Winter	Ent. Fish/Length Class	Mortality/Length Class
2.0	0	0		2.0	0	0
4.0	0	0		4.0	0	0
6.0	0	0		6.0	0	0
8.0	4	0		8.0	1	0
10.0	9	1		10.0	3	0
15.0	12	2		15.0	4	1
20.0	0	0		20.0	0	0
25.0	0	0		25.0	0	0
30.0	0	0		30.0	0	0
Total	25	3		Total	8	1
Spring	Ent. Fish/Length Class	Mortality/Length Class		Spring	Ent. Fish/Length Class	Mortality/Length Class
2.0	0	0		2.0	0	0
4.0	1	0		4.0	0	0
6.0	0	0		6.0	0	0
8.0	18	1		8.0	4	0
10.0	14	1		10.0	3	0
15.0	10	1		15.0	2	0
20.0	2	0		20.0	0	0
25.0	0	0		25.0	0	0
30.0	0	0		30.0	0	0
Total	44	4		Total	9	1
Summer	Ent. Fish/Length Class	Mortality/Length Class		Summer	Ent. Fish/Length Class	Mortality/Length Class
2.0	0	0		2.0	0	0
4.0	5	0		4.0	0	0
6.0	0	0		6.0	0	0
8.0	10	1		8.0	1	0
10.0	5	0		10.0	0	0
15.0	14	2		15.0	1	0
20.0	0	0		20.0	0	0
25.0	0	0		25.0	0	0
30.0	0	0		30.0	0	0
Total	33	3		Total	3	0
Fall	Ent. Fish/Length Class	Mortality/Length Class		Fall	Ent. Fish/Length Class	Mortality/Length Class
2.0	0	0		2.0	0	0
4.0	0	0		4.0	2	0
6.0	0	0		6.0	0	0
8.0	0	0		8.0	10	1
10.0	0	0		10.0	19	2
15.0	0	0		15.0	6	1
20.0	0	0		20.0	0	0
25.0	0	0		25.0	0	0
30.0	0	0		30.0	0	0
Total	0	0		Total	37	3
Annual Total	103	10		Annual Total	57	5

Black Bass						
Conventional				Pumpback		
Winter	Ent. Fish/Length Class	Mortality/Length Class		Winter	Ent. Fish/Length Class	Mortality/Length Class
2.0	0	0		2.0	0	0
4.0	3	0		4.0	62	2
6.0	0	0		6.0	0	0
8.0	0	0		8.0	0	0
10.0	0	0		10.0	0	0
15.0	0	0		15.0	0	0
20.0	0	0		20.0	0	0
25.0	0	0		25.0	0	0
30.0	0	0		30.0	0	0
Total	3	0		Total	62	2
Spring	Ent. Fish/Length Class	Mortality/Length Class		Spring	Ent. Fish/Length Class	Mortality/Length Class
2.0	0	0		2.0	0	0
4.0	8	0		4.0	0	0
6.0	0	0		6.0	0	0
8.0	0	0		8.0	0	0
10.0	4	0		10.0	0	0
15.0	4	1		15.0	0	0
20.0	4	1		20.0	0	0
25.0	0	0		25.0	0	0
30.0	0	0		30.0	0	0
Total	21	2		Total	0	0
Summer	Ent. Fish/Length Class	Mortality/Length Class		Summer	Ent. Fish/Length Class	Mortality/Length Class
2.0	12	0		2.0	1495	28
4.0	32	1		4.0	3901	144
6.0	0	0		6.0	0	0
8.0	0	0		8.0	0	0
10.0	12	1		10.0	1495	138
15.0	0	0		15.0	0	0
20.0	12	2		20.0	1495	276
25.0	0	0		25.0	0	0
30.0	0	0		30.0	0	0
Total	69	4		Total	8385	585
Fall	Ent. Fish/Length Class	Mortality/Length Class		Fall	Ent. Fish/Length Class	Mortality/Length Class
2.0	0	0		2.0	0	0
4.0	0	0		4.0	0	0
6.0	0	0		6.0	0	0
8.0	8	1		8.0	40	3
10.0	0	0		10.0	0	0
15.0	8	1		15.0	40	6
20.0	40	7		20.0	200	37
25.0	0	0		25.0	0	0
30.0	0	0		30.0	0	0
Total	56	9		Total	279	45
Annual Total	148	15		Annual Total	8727	633

Panfish					
Conventional			Pumpback		
Winter	Ent. Fish/Length Class	Mortality/Length Class	Winter	Ent. Fish/Length Class	Mortality/Length Class
2.0	352	6	2.0	206	4
4.0	123	4	4.0	72	3
6.0	88	5	6.0	52	3
8.0	53	4	8.0	31	2
10.0	0	0	10.0	0	0
15.0	18	2	15.0	10	1
20.0	0	0	20.0	0	0
25.0	0	0	25.0	0	0
30.0	0	0	30.0	0	0
Total	633	21	Total	371	13
Spring	Ent. Fish/Length Class	Mortality/Length Class	Spring	Ent. Fish/Length Class	Mortality/Length Class
2.0	435	7	2.0	2327	43
4.0	6156	212	4.0	32960	1217
6.0	1031	53	6.0	5519	306
8.0	182	13	8.0	977	72
10.0	26	2	10.0	138	13
15.0	0	0	15.0	0	0
20.0	0	0	20.0	0	0
25.0	0	0	25.0	0	0
30.0	0	0	30.0	0	0
Total	7830	288	Total	41921	1650
Summer	Ent. Fish/Length Class	Mortality/Length Class	Summer	Ent. Fish/Length Class	Mortality/Length Class
2.0	669	12	2.0	278	5
4.0	8612	297	4.0	3578	132
6.0	3615	187	6.0	1502	83
8.0	1481	102	8.0	615	45
10.0	119	10	10.0	50	5
15.0	24	3	15.0	10	1
20.0	0	0	20.0	0	0
25.0	0	0	25.0	0	0
30.0	0	0	30.0	0	0
Total	14520	611	Total	6032	272
Fall	Ent. Fish/Length Class	Mortality/Length Class	Fall	Ent. Fish/Length Class	Mortality/Length Class
2.0	125	2	2.0	113	2
4.0	821	28	4.0	740	27
6.0	455	24	6.0	410	23
8.0	374	26	8.0	337	25
10.0	80	7	10.0	72	7
15.0	5	1	15.0	5	1
20.0	0	0	20.0	0	0
25.0	0	0	25.0	0	0
30.0	0	0	30.0	0	0
Total	1861	87	Total	1677	84
Annual Total	24843	1006	Annual Total	50001	2019

Clupeidae					
Conventional			Pumpback		
Winter	Ent. Fish/Length Class	Mortality/Length Class	Winter	Ent. Fish/Length Class	Mortality/Length Class
2.0	0	0	2.0	0	0
4.0	29169	1005	4.0	10706	395
6.0	228490	11811	6.0	83866	4644
8.0	63199	4356	8.0	23197	1713
10.0	9723	838	10.0	3569	329
15.0	19446	2513	15.0	7138	988
20.0	0	0	20.0	0	0
25.0	0	0	25.0	0	0
30.0	0	0	30.0	0	0
Total	350027	20523	Total	128476	8069
Spring	Ent. Fish/Length Class	Mortality/Length Class	Spring	Ent. Fish/Length Class	Mortality/Length Class
2.0	0	0	2.0	0	0
4.0	13611	469	4.0	59595	2200
6.0	43188	2232	6.0	189101	10470
8.0	11146	768	8.0	48802	3603
10.0	1694	146	10.0	7419	685
15.0	1857	240	15.0	8130	1125
20.0	696	120	20.0	3049	563
25.0	0	0	25.0	0	0
30.0	0	0	30.0	0	0
Total	72192	3976	Total	316097	18646
Summer	Ent. Fish/Length Class	Mortality/Length Class	Summer	Ent. Fish/Length Class	Mortality/Length Class
2.0	153	3	2.0	2032	38
4.0	69632	2400	4.0	924082	34111
6.0	14668	758	6.0	194661	10778
8.0	9451	651	8.0	125420	9259
10.0	2343	202	10.0	31090	2869
15.0	291	38	15.0	3861	534
20.0	22	4	20.0	286	53
25.0	0	0	25.0	0	0
30.0	0	0	30.0	0	0
Total	96559	4055	Total	1281433	57642
Fall	Ent. Fish/Length Class	Mortality/Length Class	Fall	Ent. Fish/Length Class	Mortality/Length Class
2.0	21780	375	2.0	122987	2270
4.0	68846	2373	4.0	388769	14351
6.0	6578	340	6.0	37145	2057
8.0	4621	318	8.0	26093	1926
10.0	864	74	10.0	4877	450
15.0	99	13	15.0	560	78
20.0	7	1	20.0	37	7
25.0	0	0	25.0	0	0
30.0	0	0	30.0	0	0
Total	102794	3495	Total	580469	21138
Annual Total	621573	32048	Annual Total	2306475	105495

Cyprinidae						
Conventional				Pumpback		
Winter	Ent. Fish/Length Class	Mortality/Length Class		Winter	Ent. Fish/Length Class	Mortality/Length Class
2.0	0	0		2.0	0	0
4.0	326	11		4.0	12	0
6.0	0	0		6.0	0	0
8.0	81	6		8.0	3	0
10.0	0	0		10.0	0	0
15.0	0	0		15.0	0	0
20.0	0	0		20.0	0	0
25.0	0	0		25.0	0	0
30.0	0	0		30.0	0	0
Total	407	17		Total	15	1
Spring	Ent. Fish/Length Class	Mortality/Length Class		Spring	Ent. Fish/Length Class	Mortality/Length Class
2.0	53	1		2.0	294	5
4.0	404	14		4.0	2258	78
6.0	218	11		6.0	1221	63
8.0	35	2		8.0	196	14
10.0	0	0		10.0	0	0
15.0	0	0		15.0	0	0
20.0	70	12		20.0	392	68
25.0	35	8		25.0	196	42
30.0	0	0		30.0	0	0
Total	815	48		Total	4557	269
Summer	Ent. Fish/Length Class	Mortality/Length Class		Summer	Ent. Fish/Length Class	Mortality/Length Class
2.0	31	1		2.0	149	3
4.0	303	10		4.0	1444	50
6.0	33	2		6.0	156	8
8.0	0	0		8.0	0	0
10.0	10	1		10.0	50	4
15.0	21	3		15.0	99	13
20.0	249	43		20.0	1189	205
25.0	10	2		25.0	50	11
30.0	21	5		30.0	99	26
Total	679	67		Total	3234	319
Fall	Ent. Fish/Length Class	Mortality/Length Class		Fall	Ent. Fish/Length Class	Mortality/Length Class
2.0	55	1		2.0	5	0
4.0	411	14		4.0	34	1
6.0	41	2		6.0	3	0
8.0	14	1		8.0	1	0
10.0	0	0		10.0	0	0
15.0	0	0		15.0	0	0
20.0	233	40		20.0	19	3
25.0	0	0		25.0	0	0
30.0	41	11		30.0	3	1
Total	794	69		Total	66	6
Annual Total	2695	201		Annual Total	7872	594

Ictaluridae						
Conventional				Pumpback		
Winter	Ent. Fish/Length Class	Mortality/Length Class		Winter	Ent. Fish/Length Class	Mortality/Length Class
2.0	0	0		2.0	0	0
4.0	388	13		4.0	26	1
6.0	1939	100		6.0	131	7
8.0	5195	358		8.0	350	24
10.0	4497	387		10.0	303	26
15.0	853	110		15.0	57	7
20.0	0	0		20.0	0	0
25.0	0	0		25.0	0	0
30.0	0	0		30.0	0	0
Total	12872	969		Total	867	65
Spring	Ent. Fish/Length Class	Mortality/Length Class		Spring	Ent. Fish/Length Class	Mortality/Length Class
2.0	13	0		2.0	85	1
4.0	350	12		4.0	2252	78
6.0	450	23		6.0	2895	150
8.0	196	13		8.0	1260	87
10.0	126	11		10.0	813	70
15.0	70	9		15.0	449	58
20.0	9	2		20.0	61	10
25.0	9	2		25.0	61	13
30.0	0	0		30.0	0	0
Total	1224	73		Total	7874	467
Summer	Ent. Fish/Length Class	Mortality/Length Class		Summer	Ent. Fish/Length Class	Mortality/Length Class
2.0	17	0		2.0	19	0
4.0	635	22		4.0	709	24
6.0	1293	67		6.0	1444	75
8.0	579	40		8.0	647	45
10.0	398	34		10.0	445	38
15.0	568	73		15.0	634	82
20.0	0	0		20.0	0	0
25.0	17	4		25.0	19	4
30.0	0	0		30.0	0	0
Total	3507	240		Total	3916	268
Fall	Ent. Fish/Length Class	Mortality/Length Class		Fall	Ent. Fish/Length Class	Mortality/Length Class
2.0	121	2		2.0	19	0
4.0	4174	144		4.0	664	23
6.0	10158	525		6.0	1617	84
8.0	7618	525		8.0	1212	84
10.0	2204	190		10.0	351	30
15.0	309	40		15.0	49	6
20.0	33	6		20.0	5	1
25.0	0	0		25.0	0	0
30.0	0	0		30.0	0	0
Total	24617	1432		Total	3918	228
Annual Total	42220	2714		Annual Total	16576	1028

Lepisosteidae[5]						
Conventional				Pumpback		
Winter	Ent. Fish/Length Class	Mortality/Length Class		Winter	Ent. Fish/Length Class	Mortality/Length Class
2.0	0	0		2.0	0	0
4.0	3	0		4.0	1	0
6.0	0	0		6.0	0	0
8.0	0	0		8.0	0	0
10.0	0	0		10.0	0	0
15.0	0	0		15.0	0	0
20.0	0	0		20.0	0	0
25.0	0	0		25.0	0	0
30.0	0	0		30.0	0	0
Total	3	0		Total	1	0
Spring	Ent. Fish/Length Class	Mortality/Length Class		Spring	Ent. Fish/Length Class	Mortality/Length Class
2.0	0	0		2.0	0	0
4.0	0	0		4.0	0	0
6.0	0	0		6.0	0	0
8.0	0	0		8.0	0	0
10.0	0	0		10.0	0	0
15.0	0	0		15.0	0	0
20.0	0	0		20.0	0	0
25.0	0	0		25.0	0	0
30.0	0	0		30.0	0	0
Total	0	0		Total	0	0
Summer	Ent. Fish/Length Class	Mortality/Length Class		Summer	Ent. Fish/Length Class	Mortality/Length Class
2.0	5	0		2.0	4	0
4.0	14	0		4.0	10	0
6.0	0	0		6.0	0	0
8.0	0	0		8.0	0	0
10.0	5	0		10.0	4	0
15.0	0	0		15.0	0	0
20.0	5	1		20.0	4	1
25.0	0	0		25.0	0	0
30.0	0	0		30.0	0	0
Total	31	2		Total	22	1
Fall	Ent. Fish/Length Class	Mortality/Length Class		Fall	Ent. Fish/Length Class	Mortality/Length Class
2.0	0	0		2.0	0	0
4.0	0	0		4.0	0	0
6.0	0	0		6.0	0	0
8.0	0	0		8.0	0	0
10.0	0	0		10.0	0	0
15.0	0	0		15.0	0	0
20.0	0	0		20.0	2	0
25.0	0	0		25.0	0	0
30.0	0	0		30.0	0	0
Total	0	0		Total	3	0
Annual Total	33	2		Annual Total	26	2

[5] Black Bass used as a surrogate for length class distribution. Likely underestimates fish length.

Moronidae					
Conventional			Pumpback		
Winter	Ent. Fish/Length Class	Mortality/Length Class	Winter	Ent. Fish/Length Class	Mortality/Length Class
2.0	0	0	2.0	0	0
4.0	0	0	4.0	0	0
6.0	0	0	6.0	0	0
8.0	0	0	8.0	0	0
10.0	0	0	10.0	0	0
15.0	15	2	15.0	250	32
20.0	0	0	20.0	0	0
25.0	0	0	25.0	0	0
30.0	0	0	30.0	0	0
Total	15	2	Total	250	32
Spring	Ent. Fish/Length Class	Mortality/Length Class	Spring	Ent. Fish/Length Class	Mortality/Length Class
2.0	0	0	2.0	0	0
4.0	1358	47	4.0	7987	275
6.0	6511	337	6.0	38303	1980
8.0	259	18	8.0	1526	105
10.0	178	15	10.0	1048	90
15.0	56	7	15.0	331	43
20.0	169	29	20.0	992	171
25.0	0	0	25.0	0	0
30.0	0	0	30.0	0	0
Total	8532	453	Total	50188	2664
Summer	Ent. Fish/Length Class	Mortality/Length Class	Summer	Ent. Fish/Length Class	Mortality/Length Class
2.0	0	0	2.0	0	0
4.0	0	0	4.0	0	0
6.0	417	22	6.0	21226	1097
8.0	49	3	8.0	2485	171
10.0	0	0	10.0	0	0
15.0	0	0	15.0	0	0
20.0	0	0	20.0	0	0
25.0	0	0	25.0	0	0
30.0	0	0	30.0	0	0
Total	465	25	Total	23711	1268
Fall	Ent. Fish/Length Class	Mortality/Length Class	Fall	Ent. Fish/Length Class	Mortality/Length Class
2.0	0	0	2.0	0	0
4.0	0	0	4.0	0	0
6.0	0	0	6.0	0	0
8.0	13	1	8.0	328	23
10.0	12	1	10.0	317	27
15.0	16	2	15.0	416	54
20.0	3	0	20.0	69	12
25.0	0	0	25.0	0	0
30.0	0	0	30.0	0	0
Total	43	4	Total	1130	116
Annual Total	9056	484	Annual Total	75279	4081

Percidae						
Conventional				Pumpback		
Winter	Ent. Fish/Length Class	Mortality/Length Class		Winter	Ent. Fish/Length Class	Mortality/Length Class
2.0	0	0		2.0	0	0
4.0	4680	161		4.0	22	1
6.0	0	0		6.0	0	0
8.0	4011	276		8.0	19	1
10.0	1337	115		10.0	6	1
15.0	0	0		15.0	0	0
20.0	0	0		20.0	0	0
25.0	0	0		25.0	0	0
30.0	0	0		30.0	0	0
Total	10028	553		Total	46	3
Spring	Ent. Fish/Length Class	Mortality/Length Class		Spring	Ent. Fish/Length Class	Mortality/Length Class
2.0	0	0		2.0	0	0
4.0	16635	573		4.0	1366	47
6.0	52342	2706		6.0	4297	222
8.0	9759	673		8.0	801	55
10.0	0	0		10.0	0	0
15.0	0	0		15.0	0	0
20.0	0	0		20.0	0	0
25.0	0	0		25.0	0	0
30.0	0	0		30.0	0	0
Total	78737	3952		Total	6464	324
Summer	Ent. Fish/Length Class	Mortality/Length Class		Summer	Ent. Fish/Length Class	Mortality/Length Class
2.0	0	0		2.0	0	0
4.0	6753	233		4.0	877	30
6.0	14272	738		6.0	1853	96
8.0	884	61		8.0	115	8
10.0	0	0		10.0	0	0
15.0	41	5		15.0	5	1
20.0	0	0		20.0	0	0
25.0	0	0		25.0	0	0
30.0	0	0		30.0	0	0
Total	21950	1037		Total	2851	135
Fall	Ent. Fish/Length Class	Mortality/Length Class		Fall	Ent. Fish/Length Class	Mortality/Length Class
2.0	0	0		2.0	0	0
4.0	481	17		4.0	37	1
6.0	1851	96		6.0	142	7
8.0	377	26		8.0	29	2
10.0	16	1		10.0	1	0
15.0	0	0		15.0	0	0
20.0	0	0		20.0	0	0
25.0	0	0		25.0	0	0
30.0	0	0		30.0	0	0
Total	2725	140		Total	209	11
Annual Total	113441	5681		Annual Total	9570	472

Fundulidae[6]					
Conventional			Pumpback		
Winter	Ent. Fish/Length Class	Mortality/Length Class	Winter	Ent. Fish/Length Class	Mortality/Length Class
2.0	0	0	2.0	0	0
4.0	0	0	4.0	0	0
6.0	0	0	6.0	0	0
8.0	0	0	8.0	0	0
10.0	0	0	10.0	0	0
15.0	0	0	15.0	0	0
20.0	0	0	20.0	0	0
25.0	0	0	25.0	0	0
30.0	0	0	30.0	0	0
Total	0	0	Total	0	0
Spring	Ent. Fish/Length Class	Mortality/Length Class	Spring	Ent. Fish/Length Class	Mortality/Length Class
2.0	0	0	2.0	1	0
4.0	0	0	4.0	9	0
6.0	0	0	6.0	5	0
8.0	0	0	8.0	1	0
10.0	0	0	10.0	0	0
15.0	0	0	15.0	0	0
20.0	0	0	20.0	2	0
25.0	0	0	25.0	1	0
30.0	0	0	30.0	0	0
Total	0	0	Total	18	1
Summer	Ent. Fish/Length Class	Mortality/Length Class	Summer	Ent. Fish/Length Class	Mortality/Length Class
2.0	0	0	2.0	7	0
4.0	0	0	4.0	69	2
6.0	0	0	6.0	7	0
8.0	0	0	8.0	0	0
10.0	0	0	10.0	2	0
15.0	0	0	15.0	5	1
20.0	0	0	20.0	56	10
25.0	0	0	25.0	2	1
30.0	0	0	30.0	5	1
Total	0	0	Total	154	15
Fall	Ent. Fish/Length Class	Mortality/Length Class	Fall	Ent. Fish/Length Class	Mortality/Length Class
2.0	0	0	2.0	0	0
4.0	0	0	4.0	0	0
6.0	0	0	6.0	0	0
8.0	0	0	8.0	0	0
10.0	0	0	10.0	0	0
15.0	0	0	15.0	0	0
20.0	0	0	20.0	0	0
25.0	0	0	25.0	0	0
30.0	0	0	30.0	0	0
Total	0	0	Total	0	0
Annual Total	0	0	Annual Total	171	16

[6] The use of Cyprinidae as a surrogate for length class distribution data resulted in some unrealistic fish size estimates. This is due likely to the presence of common carp within the dataset.

Esocidae[7]						
Conventional				Pumpback		
Winter	Ent. Fish/Length Class	Mortality/Length Class		Winter	Ent. Fish/Length Class	Mortality/Length Class
2.0	0	0		2.0	0	0
4.0	0	0		4.0	0	0
6.0	0	0		6.0	0	0
8.0	0	0		8.0	0	0
10.0	0	0		10.0	0	0
15.0	0	0		15.0	0	0
20.0	0	0		20.0	0	0
25.0	0	0		25.0	0	0
30.0	0	0		30.0	0	0
Total	0	0		Total	0	0
Spring	Ent. Fish/Length Class	Mortality/Length Class		Spring	Ent. Fish/Length Class	Mortality/Length Class
2.0	0	0		2.0	0	0
4.0	0	0		4.0	0	0
6.0	0	0		6.0	0	0
8.0	0	0		8.0	0	0
10.0	0	0		10.0	0	0
15.0	0	0		15.0	0	0
20.0	0	0		20.0	0	0
25.0	0	0		25.0	0	0
30.0	0	0		30.0	0	0
Total	0	0		Total	0	0
Summer	Ent. Fish/Length Class	Mortality/Length Class		Summer	Ent. Fish/Length Class	Mortality/Length Class
2.0	0	0		2.0	12	0
4.0	0	0		4.0	32	1
6.0	0	0		6.0	0	0
8.0	0	0		8.0	0	0
10.0	0	0		10.0	12	1
15.0	0	0		15.0	0	0
20.0	0	0		20.0	12	2
25.0	0	0		25.0	0	0
30.0	0	0		30.0	0	0
Total	0	0		Total	69	5
Fall	Ent. Fish/Length Class	Mortality/Length Class		Fall	Ent. Fish/Length Class	Mortality/Length Class
2.0	0	0		2.0	0	0
4.0	0	0		4.0	0	0
6.0	0	0		6.0	0	0
8.0	0	0		8.0	0	0
10.0	0	0		10.0	0	0
15.0	0	0		15.0	0	0
20.0	0	0		20.0	0	0
25.0	0	0		25.0	0	0
30.0	0	0		30.0	0	0
Total	0	0		Total	0	0
Annual Total	0	0		Annual Total	69	5

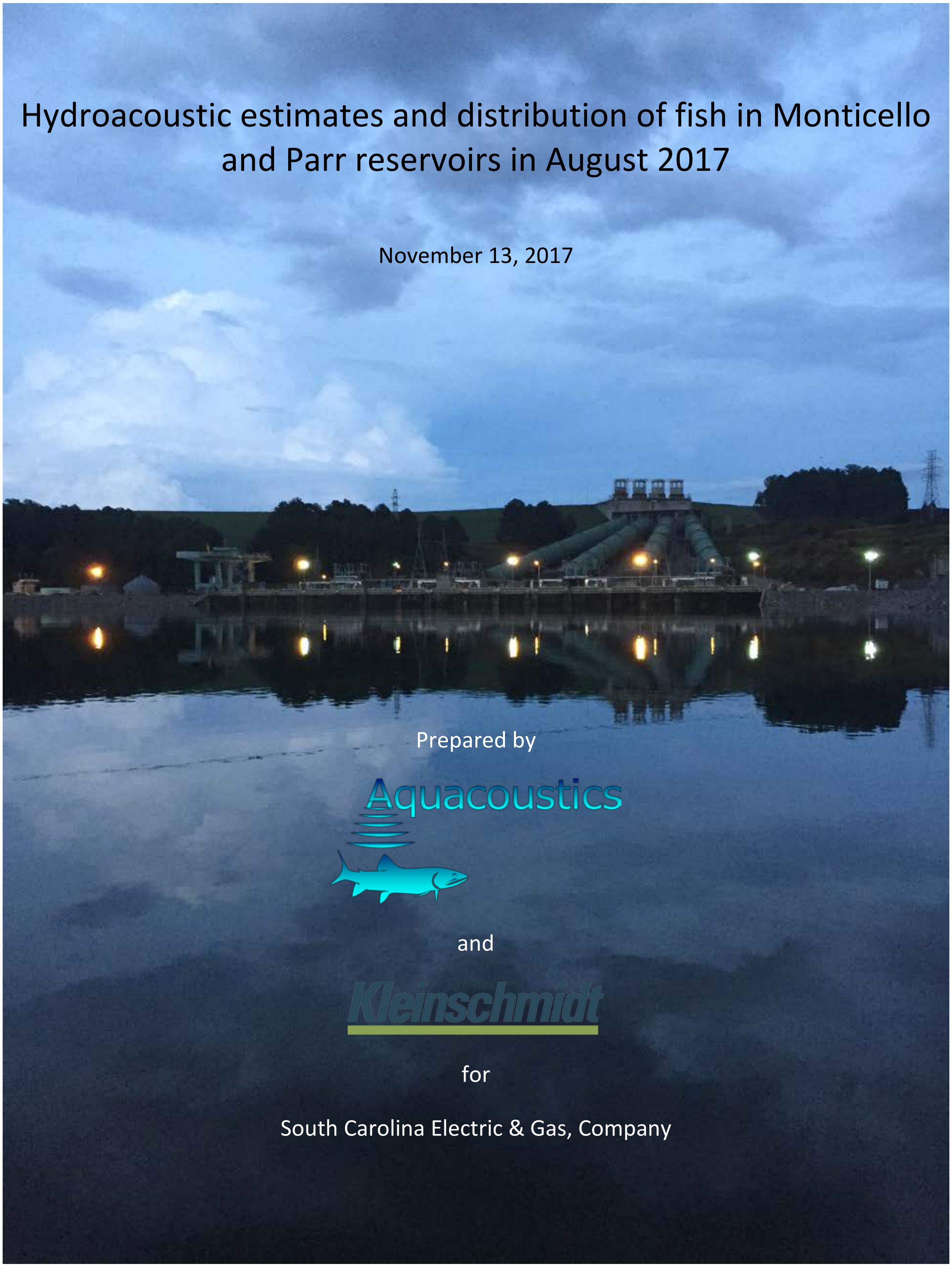
[7] Black Bass used as a surrogate for length class distribution.

Exhibit E-5 Fisheries Resources

Hydroacoustic Estimates and Distribution of Fish in Monticello and Parr Reservoirs in August 2017 - Protection, Mitigation and Enhancement Measure Recommendation

Hydroacoustic estimates and distribution of fish in Monticello and Parr reservoirs in August 2017

November 13, 2017



Prepared by

Aquacoustics

and

Kleinschmidt

for

South Carolina Electric & Gas, Company

Introduction

South Carolina Electric & Gas Company (SCE&G) is the Licensee of the Parr Hydroelectric Project (FERC No. 1894) (Project). The Project consists of the Parr Shoals Development and the Fairfield Pumped Storage Development. Both Developments are located along the Broad River in Fairfield and Newberry Counties, South Carolina.

The Parr Shoals Dam forms the 15-mile-long Parr Reservoir along the Broad River. The Parr Development has 6 vertical-shaft Francis turbines with a combined licensed capacity of 14.9 MW. The maximum hydraulic capacity of each turbine is approximately 1,000 cubic feet per second (cfs), and the minimum unit turndown has an estimated flow of 150 cfs. Parr Development typically operates in a modified run-of-river mode and normally operates continuously to pass Broad River flows.

The Fairfield Development is located directly off of the Broad River and uses the 6,800-acre Monticello Reservoir as its upper pool and Parr Reservoir as the lower pool for pumped storage operations. The Fairfield Development has eight vertical-shaft reversible Francis pump turbines. The turbines have a maximum combined licensed capacity of 511.2 MW. The maximum hydraulic capacity of each pump-turbine in generating mode is 6,300 cfs, and the minimum turndown flow is approximately 2,500 cfs. In pumping mode, the turbines each have an average rated hydraulic capacity of 5,225 cfs across the total dynamic head range of 158 to 173 feet. The Fairfield Development is primarily used for peaking operations, reserve generation, and power usage.

The Project is currently involved in a relicensing process which involves a variety of stakeholders including state and federal resource agencies, state and local government, non-governmental organizations (NGO), and interested individuals. SCE&G established several Technical Working Committees (TWC's) comprised of interested stakeholders with the objective of identifying and addressing environmental issues associated with the Project.

As part of this process, the Fisheries TWC requested a desktop fish entrainment and turbine mortality study be conducted as part of relicensing to determine the potential impacts of operating the two Developments on the fisheries communities in Parr and Monticello reservoirs. That study was performed by Kleinschmidt Associates (2015). A recommendation of the study was to identify potential ways to reduce fish entrainment at the Project. The TWC discussed the reduction of lighting at night in each of the intake areas as a potential way to reduce fish entrainment. To evaluate this measure, SCE&G contracted with Aquacoustics, Inc. to perform hydroacoustic evaluations in each of the Fairfield Development intake areas (conventional and pump-back) at night with lights “on” and lights “off” to determine if reduction of lighting in the intake areas could potentially reduce concentration of fish at the intakes and therefore reduce potential fish entrainment.

This report provides a summary of the hydroacoustic study performed by Aquacoustics.

Methods

Monticello Reservoir and a portion of Parr Reservoir were sampled in August 2017 with a 200-kHz split beam sonar system to estimate the limnetic fish population. The survey goals were:

1. to provide a fish density estimate in Monticello and Parr reservoirs, and
2. to collect fish density data in the Fairfield intake/discharge areas to determine if reduction of lights would reduce fish densities in the intakes.

Sampling for reservoir fish density was conducted in Monticello Reservoir on August 9th after sunset (Figure 1). The Project station did not operate during data collection. Sampling within the Fairfield intake also occurred on August 9th (lights "on") and was concentrated within the intake structure and along the dam on either side of the intake structure (Figure 2). SCE&G originally proposed that data be collected during both lights "on" and lights "off". However, the intake structure was not sampled during a lights "off" condition because there was only a single light in the intake and it did not appear to represent an attraction to fish.

The Fairfield tailwater was sampled on August 10th (lights "on") and 11th (lights "off") after sunset. The Project did not operate during data collection. Sampling in the tailwater included an S-shaped transect from the railroad trestle upstream to the dam face on August 10th, and 3 replicate transects less than 30 meters from the face of the dam from the river-left bank to the river-right bank (Figure 2). Six tailwater lights were lit during the August 10th sampling. The tailwater lights were turned off during sampling on August 11th (Figure 3) when the 3 replicate transects across the face of the dam were re-sampled.

Hydroacoustic data was collected using a Simrad EK60 sonar system with two 7° circular split beam transducers. Sampling and processing parameters are listed in Table 1. The system was calibrated in situ using a standard 36 mm tungsten carbide sphere, and gain corrections were applied to the data during processing to correct the measured sphere acoustic size to the expected value at the water temperature of 30°C. Sampling was conducted after sunset by randomly traversing the limnetic region of the reservoir at a speed of 2.0 - 2.2 meters/sec. The vertically and horizontally aimed transducers were mounted on poles at a depth of 0.5 and 1 meter, respectively. The top 2 meters of the water column was sampled by the horizontally aimed transducer and the remainder of the water column was sampled with the vertically aimed transducer. A Geographic Positioning System (GPS) with Wide Area Augmentation System (WAAS) differential correction fed location information to the system and was written to the acoustic data files.

The data were processed using EchoView software to output total backscatter from fish targets in 1-meter depth strata for each 250-meter longitudinal distance sampled in Monticello Reservoir. For surveys in the vicinity of the Fairfield intake and discharge targets were summed for each 100-meter distance and 1-meter depths , and the Fairfield lights on/lights off survey used 5-meter intervals and 1-meter depths. The echo integration values were scaled using the mean backscatter (TS/Sigma) for an individual fish for each area and transducer sampled. The lakewide survey on Monticello reservoir also used different scalers by depth strata because fish size varied by depth in the reservoir. Echoview single target criteria are presented in Table 1.

Results

The lakewide population estimate for Monticello Reservoir is 81,302,857 (Table 2). The lake was stratified into 3 zones for the population estimate; the Upper Lake, Mid-Lake, and the Exclusion Zone (Figure 1). Densities were over 2 times higher in the Upper and Mid-Lake strata than in the Exclusion Zone (Table 2). Densities in the Fairfield intake (Monticello Reservoir) were less than half the densities found in the nearby Exclusion Zone. Densities in the Fairfield discharge (Parr Reservoir) between the dam and the railroad trestle were slightly higher than in the intake area.

The vertical distribution of fish varied by strata with 97% of the fish in the Upper Lake above 10 meters while the Mid-Lake and Exclusion Zone had only 88.3% and 91.8% above 10 meters, respectively (Figure 4). The 10% of the population below 10 meters in the Mid-Lake and Exclusion Zone were also larger fish. Nearly 85% of fish in the top 10 meters were less than 8-cm, while only 50% of the fish below 15 meters were less than 8-cm (Figure 5).

Fish densities measured in and near the Fairfield intake (Monticello Reservoir) structure during lights "on" were lower than in Monticello Reservoir, but the fish were larger (Figure 6). Only 35% of the fish were less than 10-cm and 43% were greater than 30-cm. These larger fish are likely not as susceptible to entrainment because they likely can escape the water velocities produced by generation, but may be in the area to prey upon smaller fish entrained during pump operations.

Sampling the Fairfield discharge (Parr Reservoir) indicated that lights on the dam face were attracting fish to the structure when the hydro was not pumping. We saw a mean density of 12,946 fish/hectare near the face of the structure when the lights were on, but only 3,980 fish/hectare the following night when the lights were off. Fish were also distributed near surface and the lights (Figure 7).

Conclusions

We can make two general remarks based on these hydroacoustic surveys at the Fairfield Project.

The lake-wide estimates on Monticello Reservoir were performed during the time of year that the highest fish (especially shad) densities are expected to be observed. Estimates in the late fall, winter, and early summer would better define the fish densities susceptible to entrainment during other portions of the year. Monthly surveys at other hydroelectric project (Lake Norman and Thurmond Lake) tailwater areas indicate that shad populations decline through the fall (threadfin shad die-off in December or January with colder water temperatures) and shad recruitment occurs in June, so potential entrainment should oscillate during the year as densities in the reservoir and tailwater change.

Based on our observations, it is reasonable to conclude that lighting reduction in the Fairfield discharge (Parr Reservoir) should reduce the concentration of fish in the immediate intake area. This reduction could reduce the potential of fish entrainment at pump back start up and during some pumping events in that area of the Project.

Protection, Mitigation, Enhancement Measure Recommendation

As a protection and reduction measure for fish entrainment at the Fairfield Development, SCE&G recommends that the Fairfield Development tailrace lights (the lights that are located on the powerhouse intake and shine onto the tailrace intake area) will be turned off under normal operating conditions. The lighting reduction should provide a reduction in future entrainment at the Fairfield Development.

However, should the Department of Homeland Security National Terrorism Advisory System (or an equivalent program) or other law enforcement agency determine that the security threat level should be elevated, these lights may be turned on and may stay on as long as an elevated security threat level is in place. Lights will be turned off again after the threat level is lowered to normal levels.

Table 1. Hydroacoustic data collection and processing parameters.

Sampling Parameter	Setting
Power	60 W
Pulse duration	256 µsec
Ping rate	5/sec
Processing Parameter	
Minimum threshold	-60 dB
Minimum TS threshold	-60 dB
Sound speed	1509 m/sec
Absorption coefficient	0.006622
Single target detection	
TS threshold	-60 dB
Pulse length determination level	6 dB
Min normalized pulse length	0.5
Max normalized pulse length	1.5
Beam compensation	Simrad LOBE
Max beam compensation	12 dB
Max STD minor angle	0.6
Max STD major angle	0.6

Table 2. Fish density estimates by strata with area for each strata and population estimates with 95% confidence limits.

Strata	Area (ha)	Density (#/ha)	Estimate	Lower 95%	Upper 95%
Monticello Lake					
Upper Lake	835	42,347	35,346,124	26,855,930	46,143,995
Mid-Lake	1407	29,296	41,223,193	30,555,188	54,233,970
Exclusion Zone	332	14,254	4,733,540	3,882,570	5,629,847
Total		28,962	81,302,857	61,293,689	106,007,812
Fairfield					
Fairfield intake (Monticello Res.)	1.5	5,835	8,753	5,586	14,242
Fairfield discharge (Parr Res.)	24.55	7,308	179,401	135,433	228,495

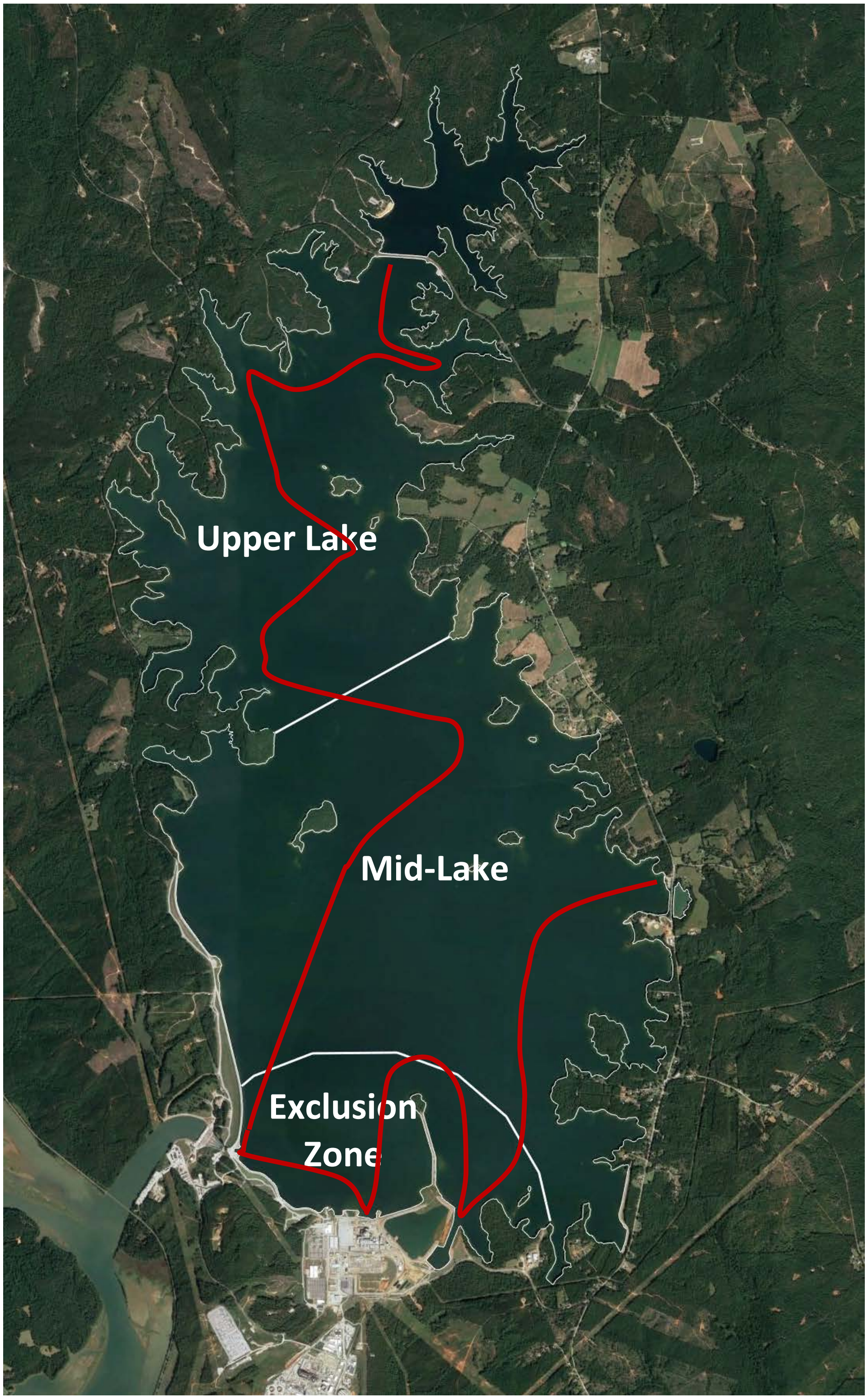


Figure 1. Map of Monticello Reservoir with transect line (red) and zones sampled using hydroacoustics.

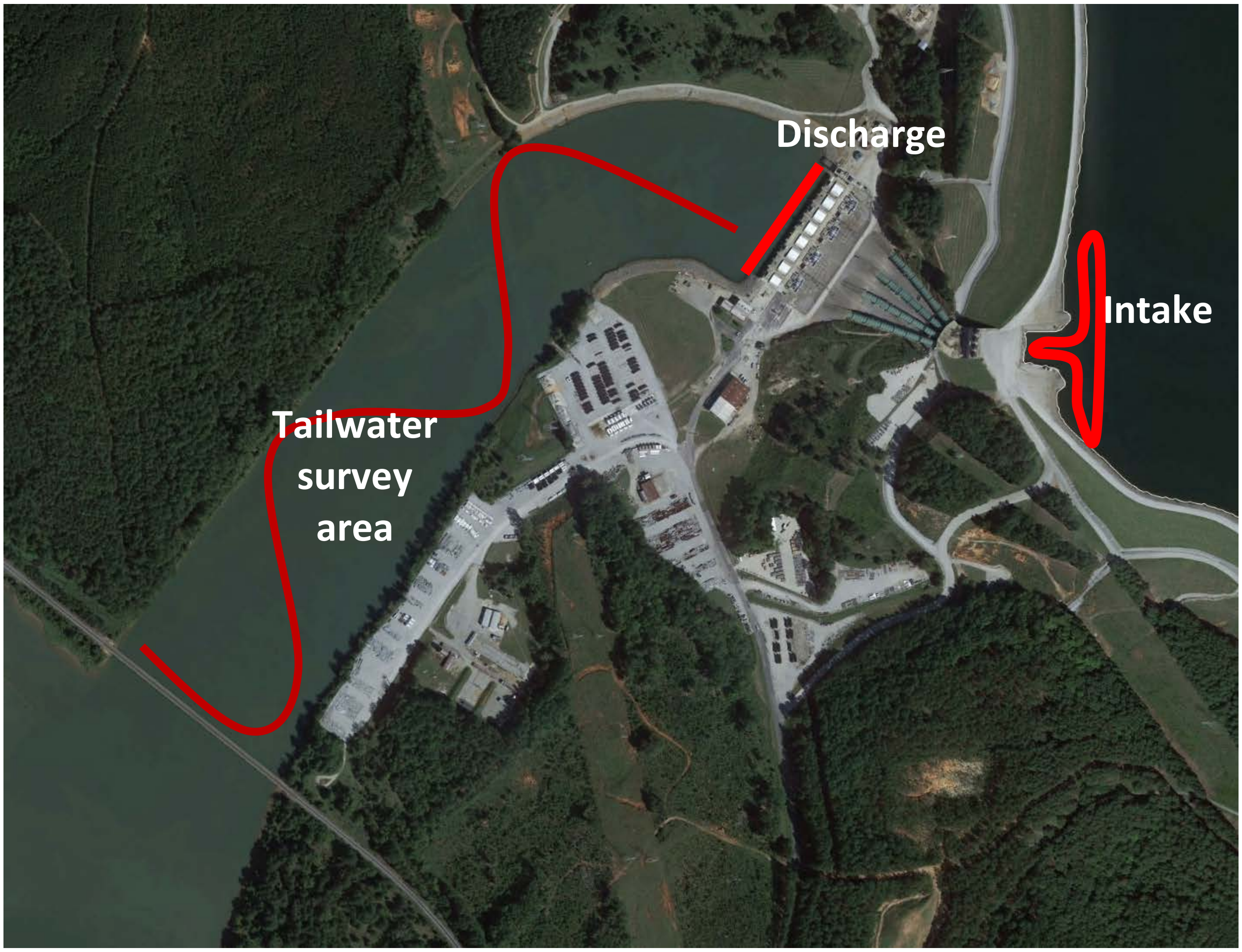


Figure 2. Map of intake, discharge, and tailwater areas sampled with hydroacoustics.

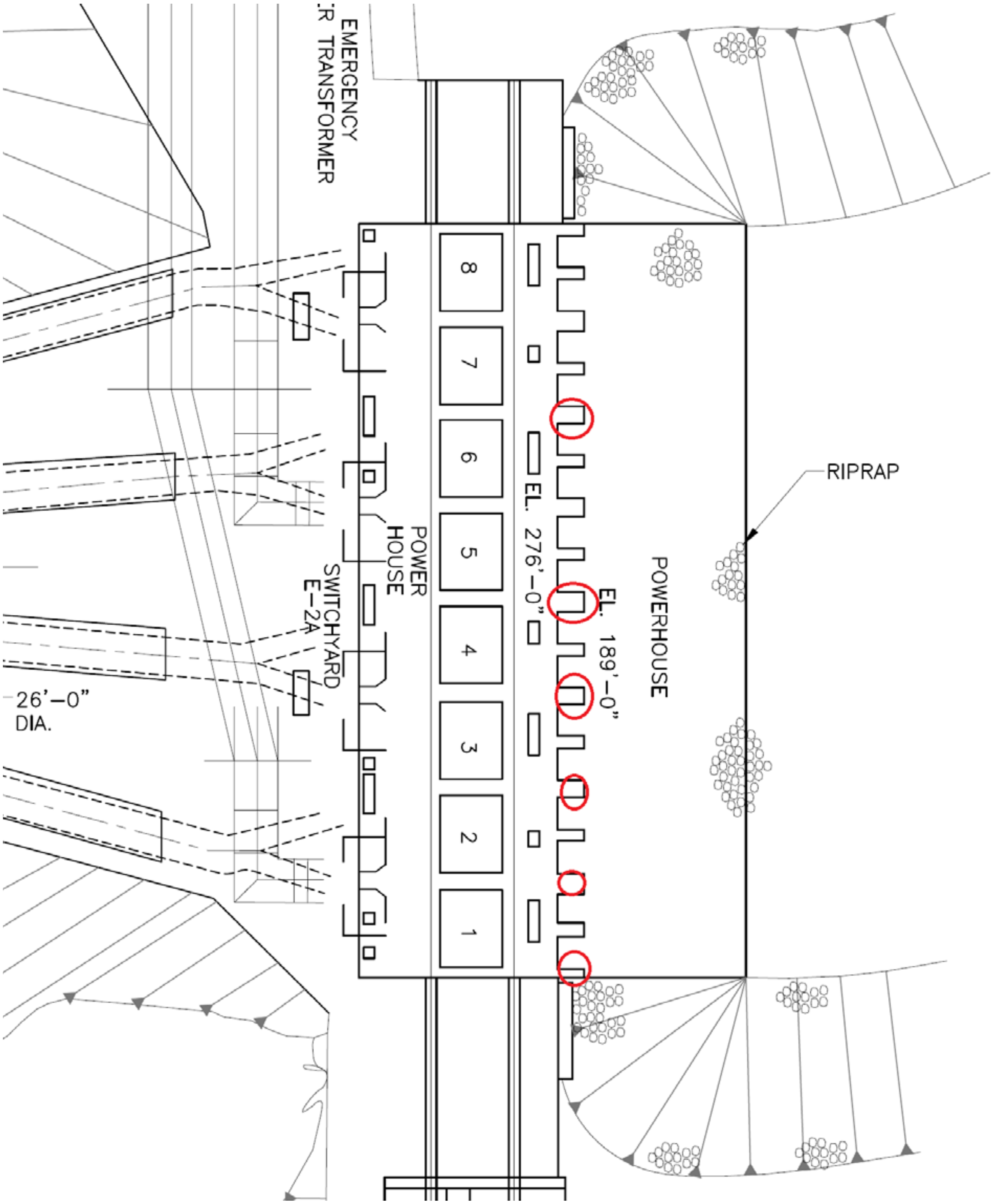


Figure 3. Diagram of Fairfield discharge with locations of lights indicated with red circles.

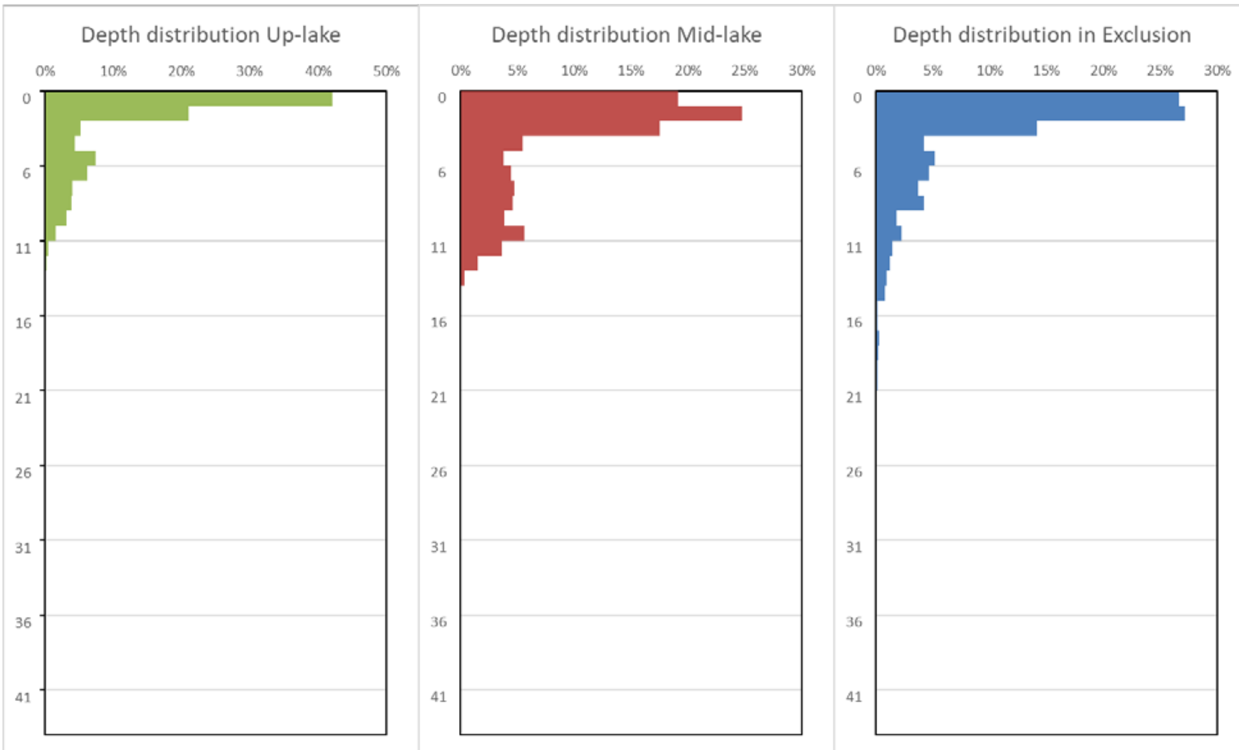


Figure 4. Vertical distribution of fish in the 3 sample strata.

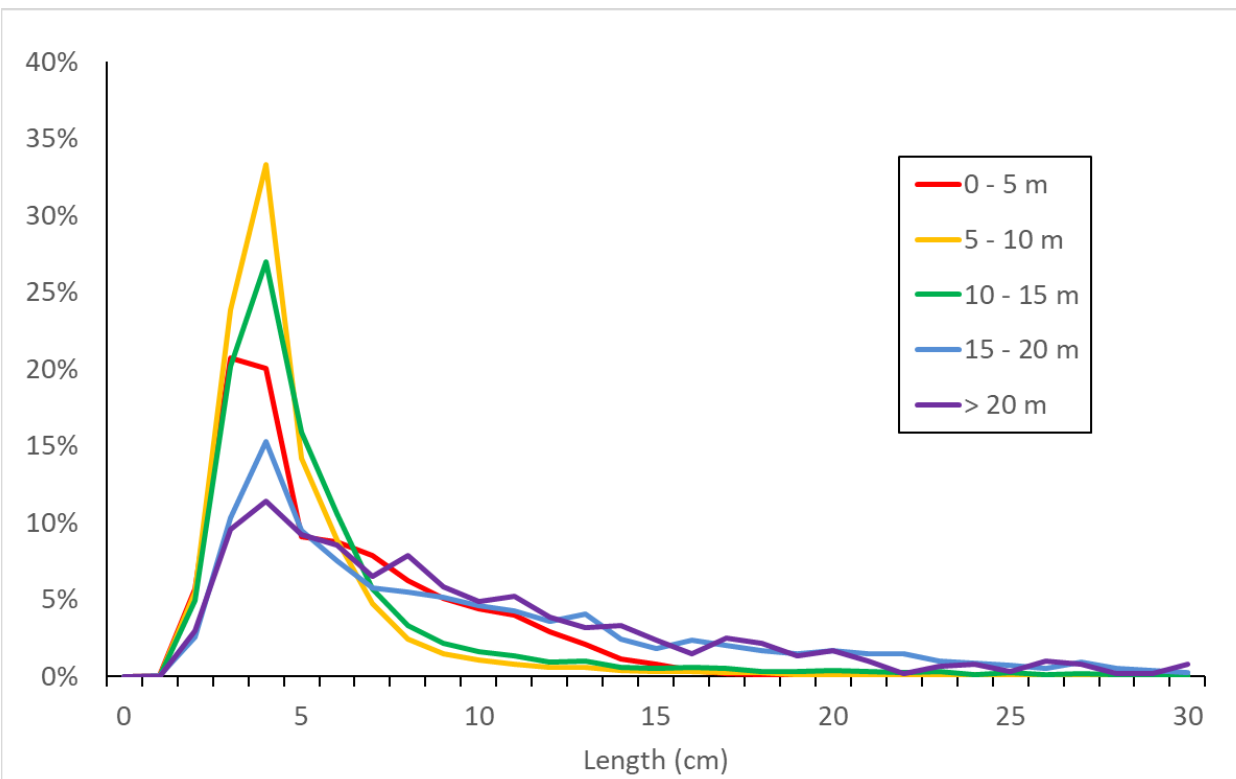


Figure 5. Length frequency of fish targets in Monticello Reservoir by depth strata. Acoustic size converted to fish length using Loves dorsal aspect equation.

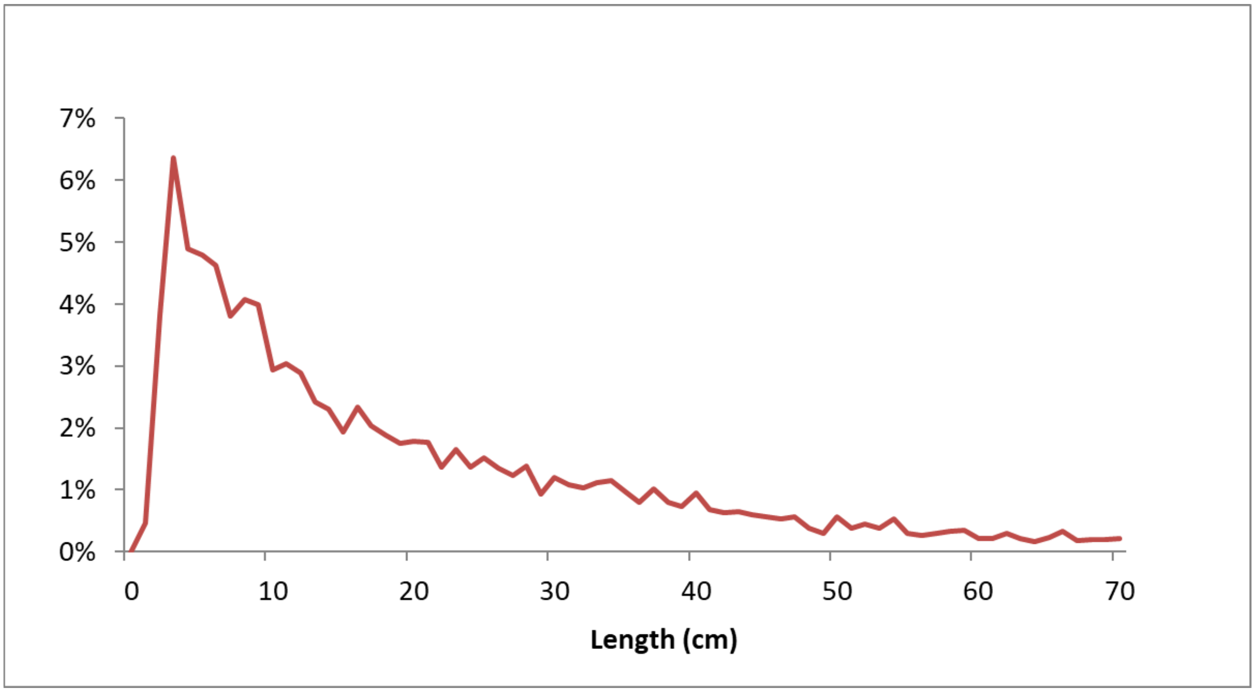


Figure 6. Length frequency distribution of fish in the Fairfield intake. Acoustic size converted to fish length using Loves dorsal aspect equation.

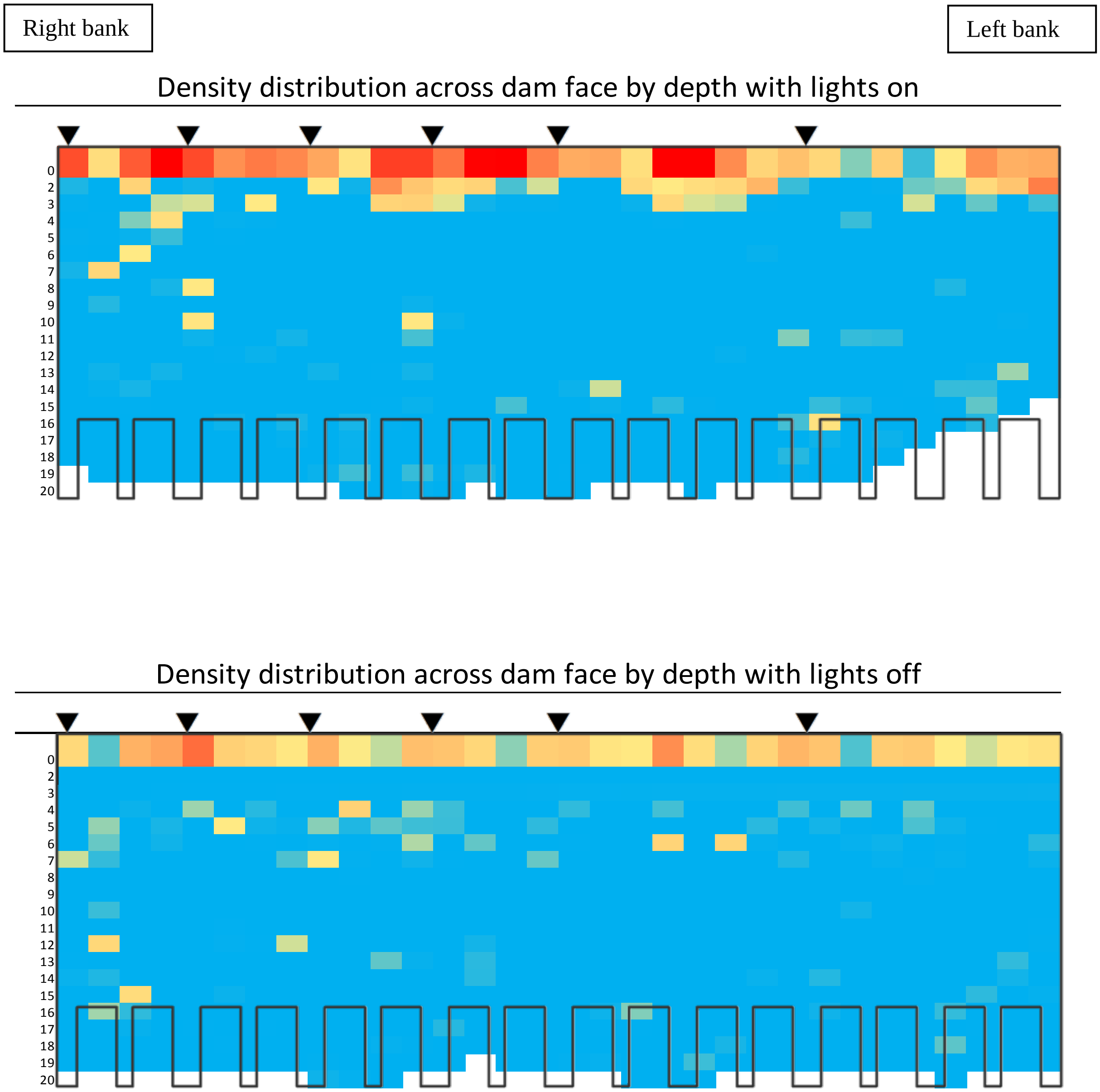


Figure 7. Density distribution of fish in the Fairfield tailrace near the dam on August 10 and 11 when the lights were "on" and "off", respectively. Graphic shows distribution across the face of the dam from top to bottom. Hot colors indicate higher densities and cooler colors show low densities. White indicates no data. Black triangles near surface indicate the location of the lights that were on during sampling, and the intake bays are near bottom at 16 to 20 meters deep.

Exhibit E-5 Fisheries Resources

Baseline Fisheries Resources Report

BASELINE FISHERIES RESOURCES REPORT

PARR HYDROELECTRIC PROJECT
FERC NO. 1894

Prepared for:

South Carolina Electric & Gas Co.
Cayce, South Carolina

Prepared by:

Kleinschmidt

Lexington, South Carolina
www.KleinschmidtUSA.com

November 2013

BASELINE FISHERIES RESOURCES REPORT

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SOUTH CAROLINA ELECTRIC & GAS CO.

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BASELINE FISHERIES RESOURCES REPORT

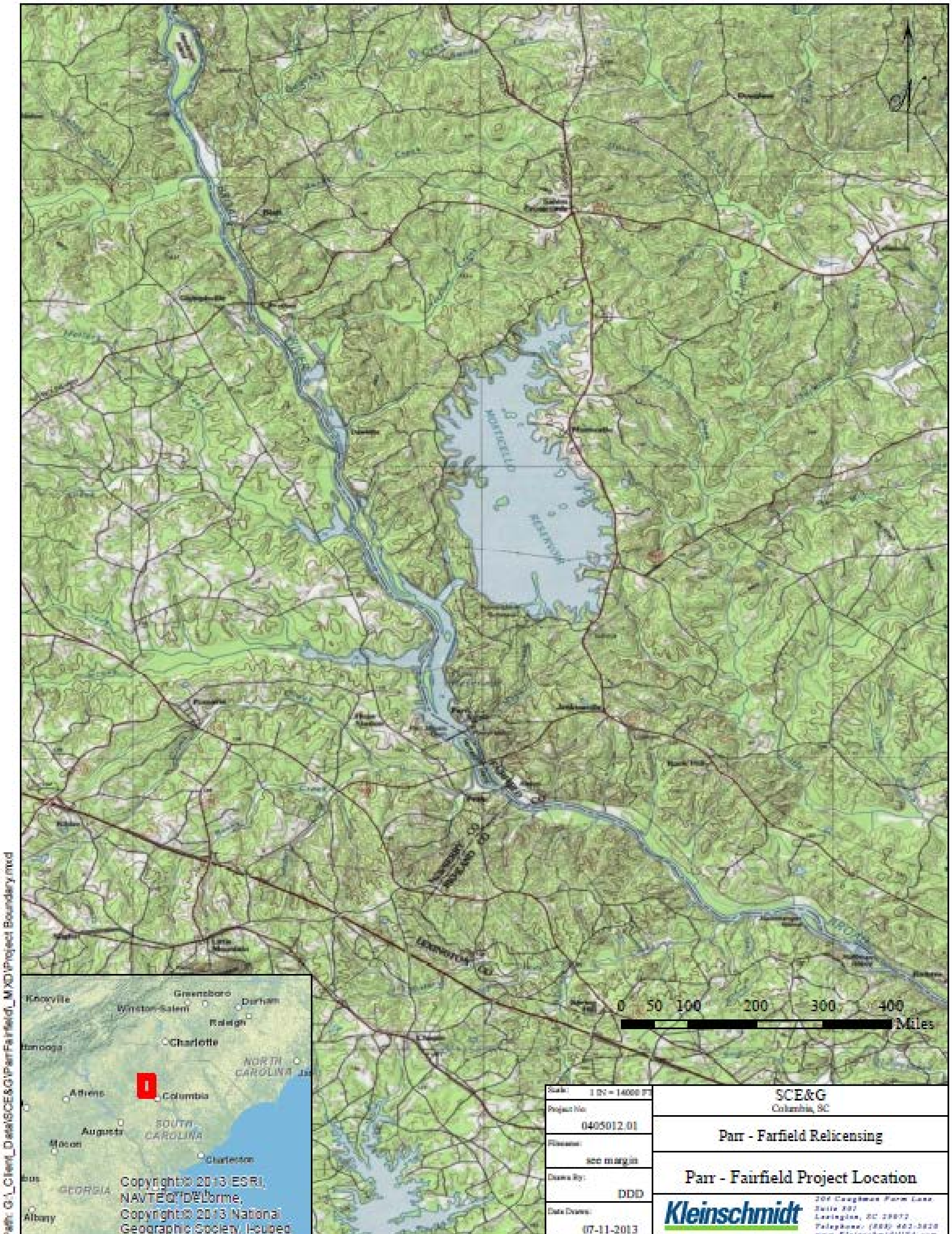
PARR HYDROELECTRIC PROJECT
FERC NO. 1894

SOUTH CAROLINA ELECTRIC & GAS CO.

1.0 INTRODUCTION

The Parr Fairfield Hydroelectric Project (FERC No. 1894) (“Parr Fairfield Project” or “Project”), owned and operated by the South Carolina Electric & Gas Company (“SCE&G” or “Licensee”), is currently licensed by the Federal Energy Regulatory Commission (“FERC” or “the Commission”) through June 2020. The Project consists of the 14.9 megawatt (MW) Parr Hydro Development and the 511.2 MW Fairfield Pumped Storage Facility Development. These Developments are located along the Broad River in Fairfield and Newberry Counties, South Carolina, approximately 31 river miles downstream of Neal Shoals and 24 river miles upstream of Columbia Diversion Dam (Figure 1).

During preliminary relicensing discussions that began in the fall of 2012, the South Carolina Department of Natural Resources (SCDNR), U.S. Fish and Wildlife Service (USFWS), NOAA National Marine Fisheries Service (NMFS), American Rivers and other stakeholders indicated a need for information characterizing the fisheries resources of the Project. The purpose of this request was to provide a baseline for assessing potential impacts of the relicensing and continued operation of the Project. This baseline fisheries report was subsequently prepared utilizing existing fisheries data available for the waters associated with the Parr Fairfield Project including Parr Reservoir, Lake Monticello, and the Lower Broad River, located below the Parr Shoals Dam.



Sources: ESRI, SCE&G, Kleinschmidt

FIGURE 1 LOCATION MAP FOR THE PARR FAIRFIELD HYDROELECTRIC PROJECT

2.0 GOALS AND OBJECTIVES

The goal of this report is to describe the fisheries communities occurring in Parr Reservoir, Lake Monticello, and the reach of the Broad River downstream of the Parr Shoals Dam in order to provide a baseline for assessing potential effects of relicensing and continued operations at the Project.

3.0 EXISTING FISHERY DATA

The Broad River basin supports a diverse fish community representative of Piedmont rivers in South Carolina. A recent basin-wide inventory documenting 51 species from nine families, with Cyprinidae contributing the most species (14), followed by Centrarchidae (10 species) and Catostomidae (10 species) (Bettinger et al. 2003). The Broad River also supports a smallmouth bass (*Micropterus dolomieu*) fishery unique among Piedmont rivers in South Carolina. Smallmouth bass were first introduced to the Broad River in South Carolina by SCDNR in 1984 to enhance sportfishing opportunities (Bettinger et al. 2003); however, stocking has recently been curtailed due to significant natural reproduction (Hal Beard, SCDNR, Personal Communication). Smallmouth growth rates in the Broad River are comparable to other Piedmont systems in the Southeast (Bettinger et al. 2003).

Recent and relevant data describing the fisheries community of the Project vicinity comes primarily from two sources. Specifically, data for Parr and Monticello Reservoirs (areas upstream of Parr Dam) are primarily from surveys conducted by SCANA Corporate Environmental Services and its contractors in support of licensing and compliance activities for the V.C. Summer Nuclear Station (Normandeau 2007, 2008 & 2009; SCANA, 2013). Conversely, data from the reach of the Broad River downstream of the Parr Dam are primarily from an ongoing fish community study being conducted by SCDNR Region 3 Freshwater Fisheries staff (Ron Ahle, SCDNR, unpublished data). These data are discussed in greater detail below.

3.1 RESERVOIR FISHERIES

Available data suggest that the Parr and Monticello reservoirs support warmwater fish communities typical of impounded river reaches in the Piedmont of South Carolina. Recent survey work by SCANA Corporate Environmental Services and their contractors has documented 30 species of fish occurring in Parr Reservoir and 24 in Lake Monticello (Table 1). Although some seasonal variations in community structure have been documented, the fish communities are generally similar between the two reservoirs, with gizzard shad, blue catfish, bluegill, channel catfish and white perch often being the dominant species (Normandeau 2007, 2008, 2009; SCANA 2013). Additional detail regarding the community structure for each of the reservoirs is provided below and detailed relative abundance and catch per unit effort (CPUE) data for the above referenced studies are included in Appendix A.

TABLE 1 FISH SPECIES DOCUMENTED AT PARR AND MONTICELLO RESERVOIRS (SOURCE: NORMANDEAU 2007, 2008, 2009; SCANA 2013)

COMMON NAME	SCIENTIFIC NAME	PARR	MONTICELLO
Black crappie	*Pomoxis nigromaculatus*	x	x
Blue catfish	*Ictalurus furcatus*	x	x
Bluegill	*Lepomis macrochirus*	x	x
Channel catfish	*Ictalurus punctatus*	x	x
Flat bullhead	*Ameiurus platycephalus*	x	x
Flathead catfish	*Pylodictis olivaris*	x	
Gizzard shad	*Dorosoma cepedianum*	x	x
Golden shiner	*Notemigonus chrysoleucas*	x	x
Highfin carpsucker	*Carpiodes velifer*	x	
Largemouth bass	*Micropterus salmoides*	x	x
Longnose gar	*Lepisosteus osseus*	x	
Northern hogsucker	*Hypentelium nigricans*	x	x
Notchlip redhorse	*Moxostoma collapsum*	x	x
Pumpkinseed	*Lepomis gibbosus*	x	x
Quillback	*Carpiodes cyprinus*	x	x
Redbreast sunfish	*Lepomis auritus*	x	x
Redear sunfish	*Lepomis microlophus*	x	x
Robust Redhorse	*Moxostoma robustum*	x	
Sandbar shiner	*Notropis scepticus*	x	
Shorthead redhorse	*Moxostoma macrolepidotum*	x	x
Smallmouth bass	*Micropterus dolomieu*	x	x
Snail bullhead	*Ameiurus brunneus*		x
Spottail shiner	*Notropis hudsonius*	x	x
Threadfin shad	*Dorosoma petenense*	x	x
Warmouth	*Lepomis gulosus*	x	
White bass	*Morone chrysops*	x	
White catfish	*Ameiurus catus*	x	x
White perch	*Morone americana*	x	x
Whitefin shiner	*Cyprinella nivea*	x	x
Yellow bullhead	*Amierus natalis*	x	x
Yellow perch	*Perca flavescens*	x	x

3.1.1 PARR RESERVOIR

SCE&G commissioned Normandeau Associates to conduct surveys of Parr Reservoir fish community in the fall of 2006 and spring of 2007. Fish were collected at three locations in the lower reservoir. Three gear types (electrofishing, gill nets, hoop nets) were employed, but all (476) fish were collected by electrofishing and gill netting (Normandeau 2007). Four groups dominated collections: Ictaluridae (33.8 % of total; 3 species), Moronidae (24.8 %; one species), Centrarchidae (17.6 %; 6 species), and Clupeidae (12.6%; one species) (Figure 2). Seventeen fish species, all relatively common Piedmont species, were collected. Channel catfish (26.1% of the total), white perch (24.8% of the total), gizzard shad (12.6% of the total), largemouth bass (7.8% of the total), blue catfish (7.1% of the total), and bluegill (7.1% of the total) were the species most often collected.

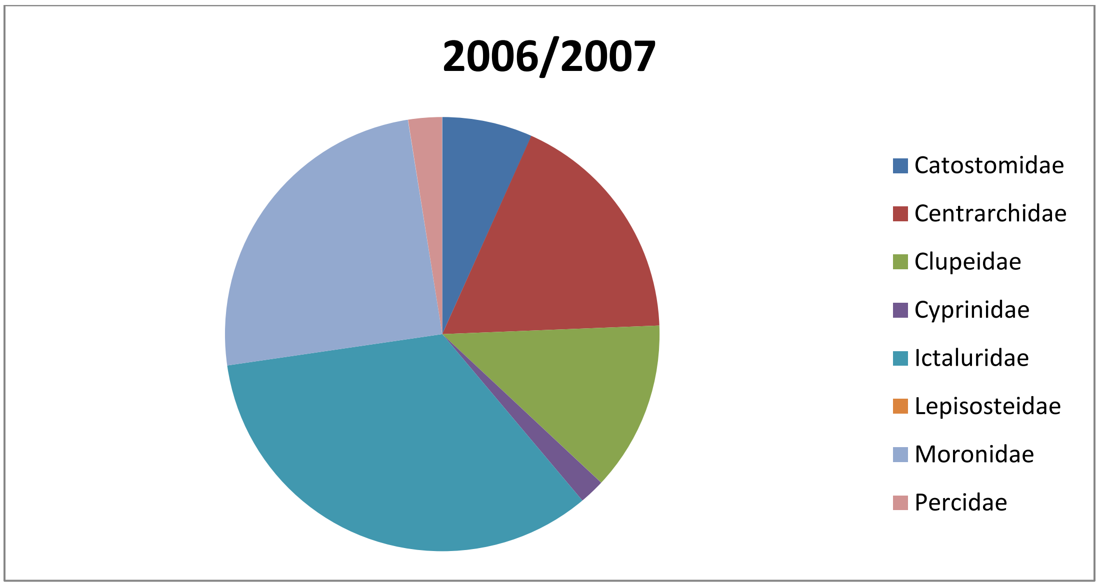


FIGURE 2 RELATIVE ABUNDANCE BY FAMILY OF FISH COLLECTED IN PARR RESERVOIR, FALL 2006 AND SPRING 2007

Normandeau collected additional samples at the same three locations in July 2008 and February 2009 using electrofishing gear and gill nets (Normandeau 2008, 2009). Hoop nets, which were ineffective collecting fish in 2006-2007, were not used in 2008. Collections in July 2008 were dominated by gizzard shad (52.4 % of total), accounting for the dominance of Clupeids in the sample (Figure 3). Substantial numbers of bluegill (14.3 %), white perch (7.6 %), largemouth bass (6.1 %), blue catfish (4.3 %), and channel catfish (3.7 %) were also collected (Normandeau

2008). February 2009 collections were dominated by Centrarchids, which accounted for almost 50% of the catch, followed by Ictalurids, Cyprinids and Clupeids (Figure 4). From a species perspective, bluegill (33.6%), largemouth bass (9.2%), spottail shiner (9.2%), channel catfish (9.2%) and blue catfish (8.4%) were dominant (Normandeau 2009). The numerical dominance of gizzard shad in July 2008 samples reflects the fact that large numbers of small (50-100 mm TL) gizzard shad were present. Gizzard shad young-of-the-year grow rapidly, but are heavily preyed upon by a variety of predatory fish species including largemouth bass, crappies, and catfishes (Michaletz 1997). Thus, large numbers of young shad are typically present in summer (most spawning occurs in April and May), but numbers tend to decline in fall and winter as predation takes its toll. Gizzard shad are also prone to sudden die-offs in late summer (Mettee et al. 1996).

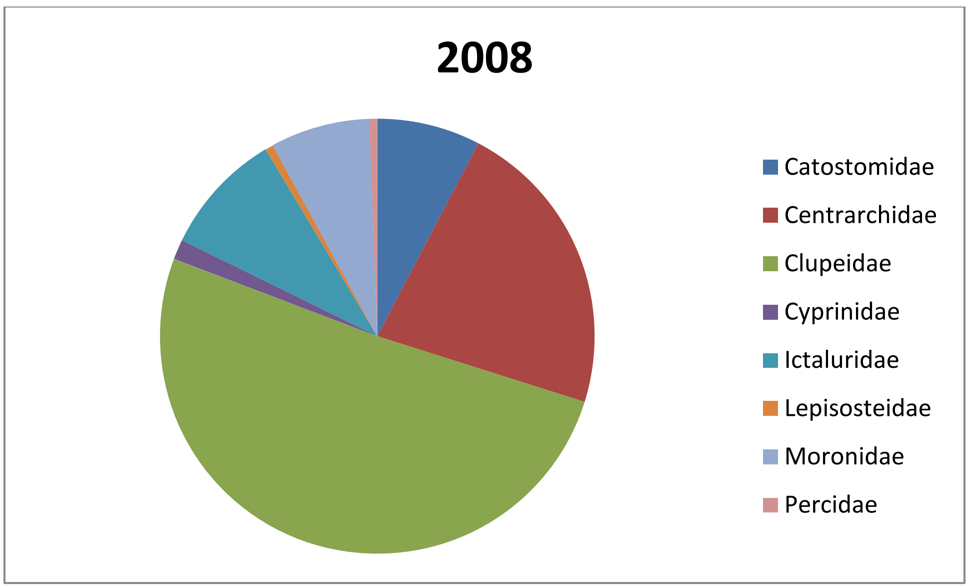


FIGURE 3 RELATIVE ABUNDANCE BY FAMILY OF FISH COLLECTED IN PARR RESERVOIR, SUMMER 2008

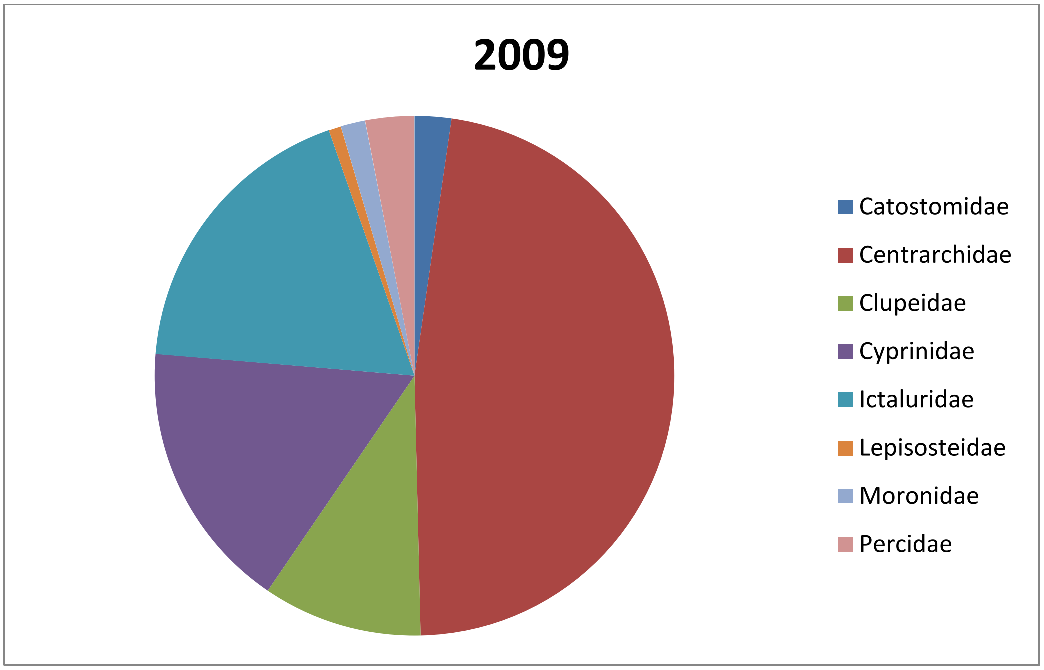


FIGURE 4 RELATIVE ABUNDANCE BY FAMILY OF FISH COLLECTED IN PARR RESERVOIR, WINTER 2009

Additional gillnet and boat electrofishing was conducted during the spring and fall of 2012 by personnel from SCANA Corporate Environmental Services, yielding 20 species (SCANA 2013). Results were very similar to those obtained by Normandeau during the spring of 2006 and fall of 2007 and were dominated by Ictalurids, Morones, Centrarchids and Clupeids (Figure 5). From a species perspective, channel catfish (24.5%), white perch (18.9%), gizzard shad (13.2%), bluegill (12.6%) and blue catfish (10.1%) accounted for 79% of the catch. Only blue catfish, bluegill and channel catfish appeared in both spring and fall samples, supporting the Normandeau assertion of significant seasonal variation among species such as white perch and gizzard shad.

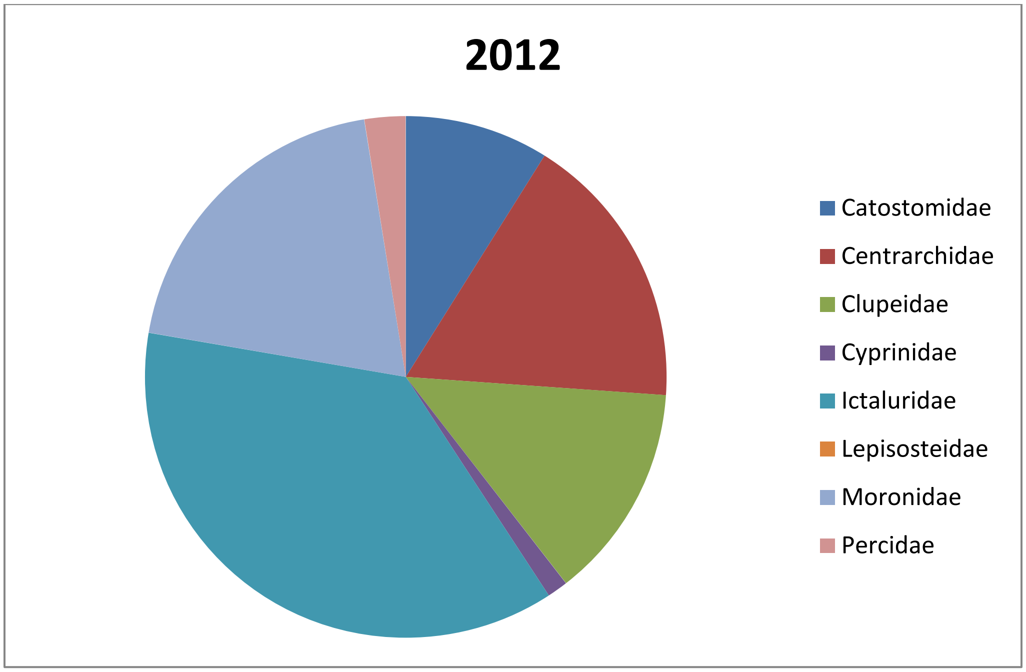


FIGURE 5 RELATIVE ABUNDANCE BY FAMILY OF FISH COLLECTED IN PARR RESERVOIR, SPRING AND FALL 2012

It should be noted that two robust redhorse (*Moxostoma robustum*) have been documented from Parr Reservoir, one during the July 2008 Normandeau sampling and a second in the fall of 2012 by SCANA staff (Normandeau 2009, SCANA 2013). The robust redhorse is a large, long-lived member of the redhorse sucker family. In 1995, a Robust Redhorse Conservation Committee (RRCC) was created to improve the status of the species throughout its former range. The RRCC is a cooperative, voluntary partnership formed under a Memorandum of Understanding (MOU) between state and federal resource agencies, private industry, and the conservation community. From 2004 through 2012, the SCDNR has stocked a total of 25,316 fingerling robust redhorse suckers in the Broad River above the Parr Hydroelectric Facility. Through 2012, a total of seven robust redhorse suckers have been captured in the Broad River drainage above the Parr Hydroelectric Facility by various state and private entities (SCANA 2013).

3.1.2 MONTICELLO RESERVOIR

Sampling of Monticello Reservoir by Normandeau in the fall of 2006 and spring of 2007 yielded results similar to those of Parr Reservoir for the same time period, with the fish community dominated by Centrarchids (48.8 %), Clupeids (19.6 %) and Ictalurids (17.3 %) (Figure 6).

Bluegill (32.6%), gizzard shad (19.6%), blue catfish (11.0%), white perch (9.5%) and largemouth bass (8.7%) were the species most often collected (Normandeau 2007).

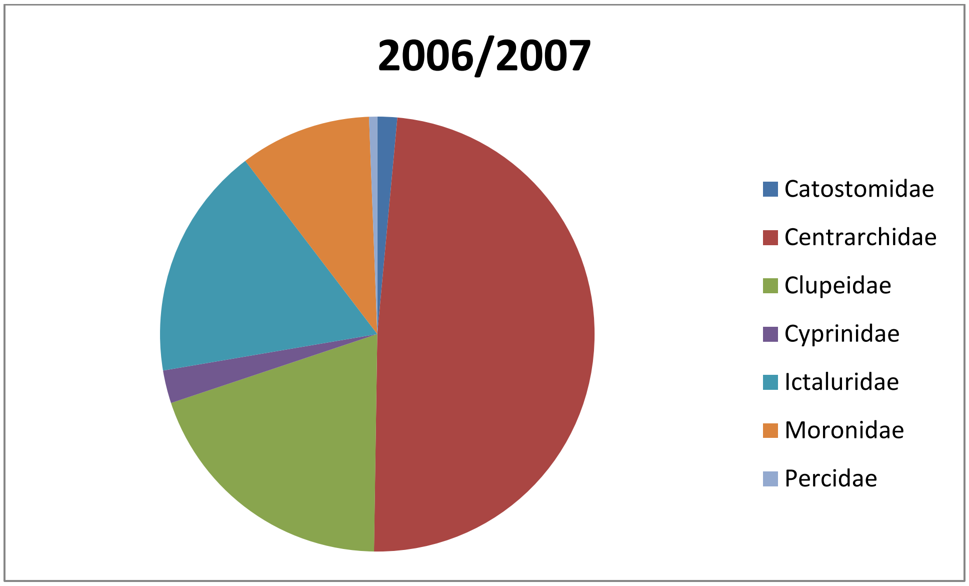


FIGURE 6 RELATIVE ABUNDANCE BY FAMILY OF FISH COLLECTED IN MONTICELLO RESERVOIR, FALL 2006 AND SPRING 2007

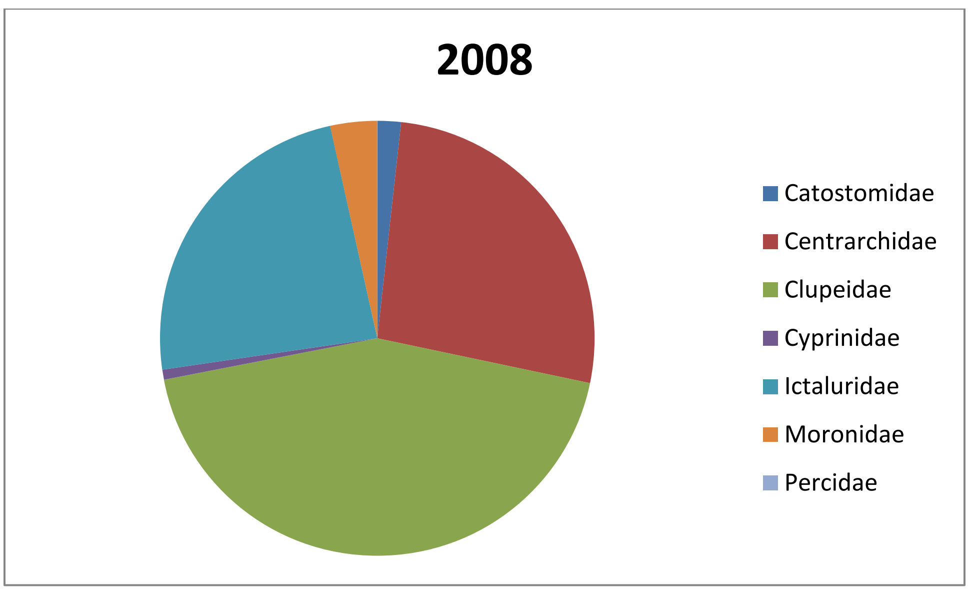


FIGURE 7 RELATIVE ABUNDANCE BY FAMILY OF FISH COLLECTED IN MONTICELLO RESERVOIR, SUMMER 2008

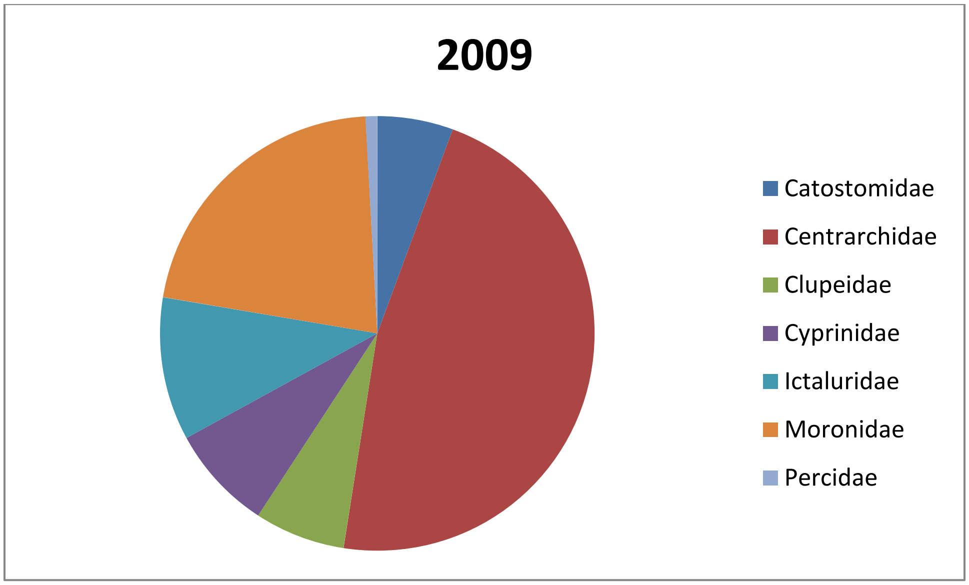


FIGURE 8 RELATIVE ABUNDANCE BY FAMILY OF FISH COLLECTED IN MONTICELLO RESERVOIR, WINTER 2009

Additional sampling of Monticello Reservoir fish was conducted in July 2008 to obtain information on possible seasonal differences in the reservoir's fish populations. Clupeids, Centrarchids and Ictalurids dominated the sample (Figure 7), with three species—gizzard shad (42.2 %), bluegill (23.2 %), and blue catfish (20 %)—accounting for more than 85 % of all fish captured. Smaller numbers of white perch (3.6 %), channel catfish (2.6 %), largemouth bass (1.4 %), and white catfish (1.4 %) were also collected. As previously noted, the same species dominated samples in 2006-2007, only bluegill ranked first in abundance and gizzard shad second. Relatively high numbers of gizzard shad in Parr and Monticello Reservoir collections in July 2008 reflect the fact that large numbers of small (50-100 mm TL) gizzard shad were present. Gizzard shad young-of-the-year grow rapidly, but are subject to high rates of mortality. Thus, it is understandable that large numbers of young are present in summer, but these numbers decline in fall and winter. This is corroborated by sampling conducted during February 2009 (Figure 8), which was dominated by bluegill (33.4%), white perch (21.5%), and largemouth bass (7.6%), with gizzard shad only accounting for 6.7 % of the catch (Normandeau 2009).

Although somewhat less productive than other older reservoirs in the region, Monticello Reservoir continues to provide fishermen in the South Carolina Midlands and Upstate with a variety of fishing opportunities. Roving creel surveys in 1997–1998 and 1998–1999, that included interviews of selected anglers, revealed that roughly half (51% in 1997–98, 42% in

1998–99) of all fishing effort in Monticello Reservoir was directed at catfish (Christie and Stroud 1999). Less effort was expended fishing for black crappie (15% in 1997–98, 5% in 1998–99), largemouth bass (12% in 1997–98, 10% in 1998–99), and other species (bluegill, carp, white bass, white perch). The creel surveys indicated that fishing effort (number of hours fished per annum) had increased substantially since the late 1980s. They also showed that fishing pressure (hours fished per acre) was lower on Monticello Reservoir than on other reservoirs in the region (Christie and Stroud 1999).

3.2 BROAD RIVER DOWNSTREAM OF PARR DAM

An ongoing fish community study being conducted by SCDNR Region 3 fisheries staff provides significant data describing the fish community in the Lower Broad River downstream of the Parr Shoals dam. This study has sampled the Lower Broad River fish community since 2009. For the purposes of this review, data from three sample reaches between the Parr Shoals dam and the impoundment of the downstream Columbia Hydroelectric Project will be reported (Figure 9). Study reach one (1) extents from the Project dam to the Palmetto Trail trestle crossing and is delineated into two sub-reaches: the Project tailrace (delineated as 1t on Table 2) and the "bypass" reach located on the western side of the island immediately below the dam (delineated as 1b on Table 2). The next downstream reach extends from the Palmetto Trail trestle crossing to the downstream terminus of Huffman Island and is delineated as reach 2a on Figure 9. The lowermost reach (2b on Figure 9) extends from the downstream terminus of Huffman Island to the downstream terminus of Boatright Island.

Data from the study suggests significantly higher diversity in the downstream riverine reaches, as compared to the two upstream reservoirs (54 species compared to 24-30 in the Parr and Monticello reservoirs) (Table 2). As expected, diversity appears to increase with increased distance from the dam, although redbreast sunfish, whitefin shiner, bluegill and snail bullhead generally dominate from a relative abundance standpoint at all sites (Table 2). Reach 1b, the "bypass" reach, displays the lowest diversity (13 species) and is dominated by Cetrarchids, with bluegill and redbreast sunfish accounting for more than 85% of the total catch in the reach (Figure 10, Table 2). Conversely, the project tailrace (Reach 1t) supports a much greater diversity of fishes, most notably an abundance of riverine suckers (Catostomidae) (Figure 11). The downstream sites (reaches 2a and 2b) support similar fish communities with Centrarchids, Cyprinids, Ictalurids and Percids (*Etheostoma* spp. and *Percina* spp.) being well represented (Table 2, Figure 12, Figure 13).

Finally, it is noteworthy that robust redhorse have been detected in the Project tailrace (Reach 1t) and consultation with SCDNR suggests that significant spawning habitat may exist in the reach (Ron Ahle, SCDNR, Personal Communication).

Bettinger et al. (2003) also sampled a site downstream of the Parr Shoals Dam (just below Bookman Island) as part of a basin-wide aquatic resource inventory. Results from this effort were generally similar to those of the current SCDNR effort, with a total of 34 species documented. Boat electrofishing samples were dominated by redbreast sunfish, redear sunfish, whitefin shiner and sandbar shiner, while redbreast sunfish, margined madtom, Piedmont darter, whitefin shiner and seagreen darter dominated backpack electrofishing samples (Table 3).

3.2.1 DIADROMOUS FISH

American shad (*Alosa sapidissima*), an anadromous species, were collected at the downstream sampling sites, as well as in the Project tailrace (Reach 1t) (Table 2). The source of these fish is likely a combination of recent stocking efforts by the SCDNR and passage at the Columbia Fishway. The Columbia Fishway was constructed in 2006 at the Columbia Hydroelectric Project (FERC No. 1895), located on the Lower Broad River approximately 23 miles downstream of the Parr Shoals Dam. The fishway was designed to provide safe, timely and effective upstream passage for anadromous American shad and blueback herring (*Alosa aestivalis*) to historical spawning and maturation habitats upstream of the Columbia Diversion Dam, including areas of the Lower Broad River downstream of the Parr Shoals Dam. The most recent monitoring data suggests that an estimated 1,730 American shad were passed upstream during the 2013 migration season, which is the highest estimated passage numbers observed since monitoring began in 2007 (Kleinschmidt 2013).

During review of an earlier draft of this report, TWC members requested information summarizing American shad and American eel (*Anguilla rostrata*) studies conducted on the Lower Broad River and funded by the Santee Basin Cooperative Fish Passage Accord (Accord). The Accord is a cooperative program between USFWS, SCDNR, North Carolina Wildlife Resources Commission, SCE&G and Duke Energy Carolinas aimed at restoring diadromous fish

(American shad, blueback herring, and American eels) in the Santee River Basin. Results of Accord-funded studies of American shad and American eels are summarized in Appendix B.

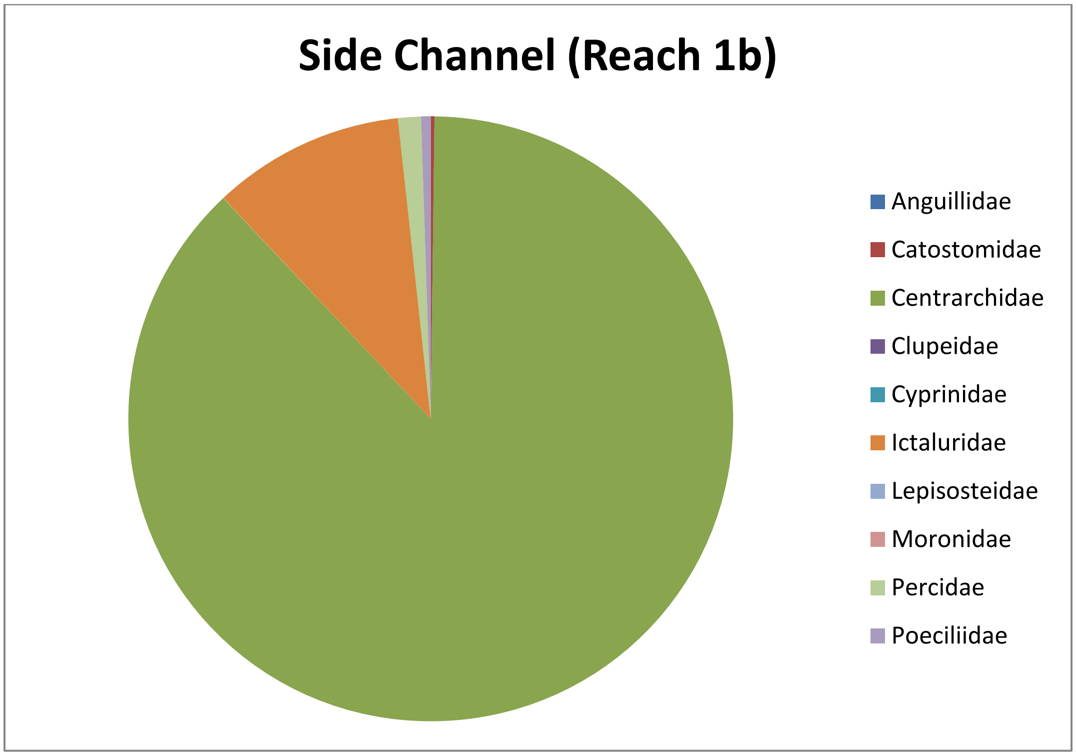


FIGURE 9 RELATIVE ABUNDANCE BY FAMILY OF FISH COLLECTED IN PARR DAM "BYPASS" REACH (SCDNR SAMPLE REACH 1B), FALL 2009 – SPRING 2013

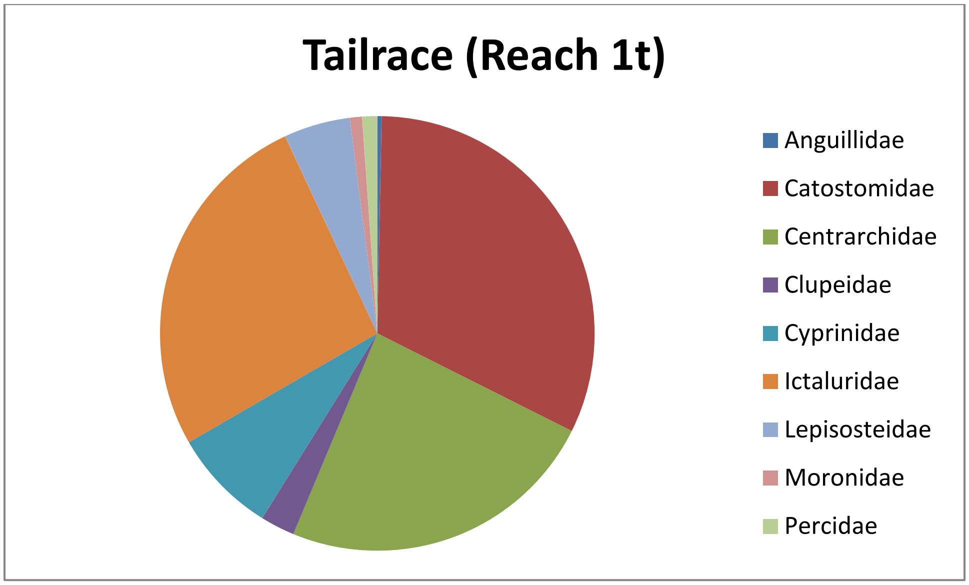


FIGURE 10 RELATIVE ABUNDANCE BY FAMILY OF FISH COLLECTED IN PARR DAM TAILRACE (SCDNR SAMPLE REACH 1T), FALL 2009 – SPRING 2013

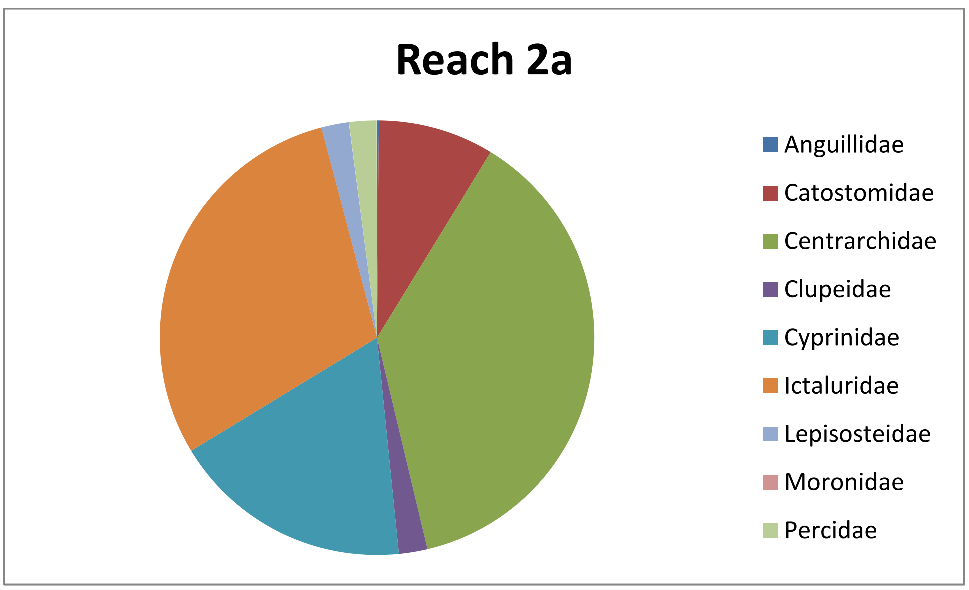


FIGURE 11 RELATIVE ABUNDANCE BY FAMILY OF FISH COLLECTED IN SCDNR SAMPLE REACH 2A, FALL 2009 – SPRING 2013

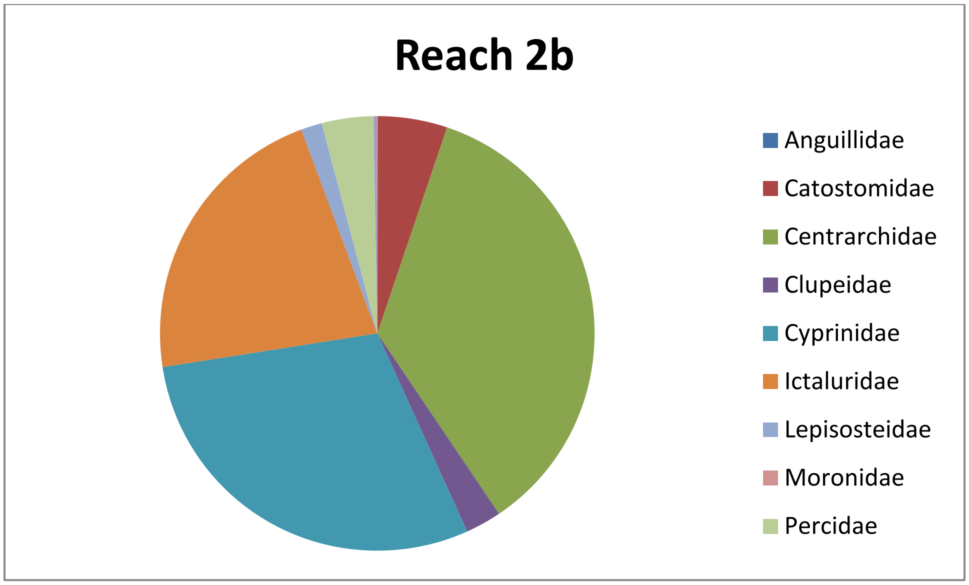


FIGURE 12 RELATIVE ABUNDANCE BY FAMILY OF FISH COLLECTED IN SCDNR SAMPLE REACH 2B, FALL 2009 – SPRING 2013

TABLE 2 PRELIMINARY RESULTS FROM THE LOWER BROAD RIVER FISH COMMUNITY STUDY, FALL 2009 THROUGH SPRING 2013

		TOTAL		PARR BYPASS		PARR TAILRACE		UPPER NATURAL		LOWER NATURAL	
COMMON NAME	SCIENTIFIC NAME	N	RELATIVE ABUNDANCE (RA)	1B	RA	1T	RA	2A	RA	2B	RA
redbreast sunfish	*Lepomis auritus*	5455	30.21%	595	60.59%	505	15.99%	1090	28.65%	1701	28.75%
snail bullhead	*Ameiurus brunneus*	2884	15.97%	81	8.25%	604	19.13%	830	21.81%	1026	17.34%
whitefin shiner	*Cyprinella nivea*	1824	10.10%			134	4.24%	305	8.02%	1042	17.61%
bluegill	*Lepomis macrochirus*	1440	7.97%	253	25.76%	86	2.72%	156	4.10%	138	2.33%
brassy jumprock	*Scartomyzon sp. (1-27-06)*	774	4.29%	1	0.10%	521	16.50%	153	4.02%	90	1.52%
sandbar shiner	*Notropis scepticus*	585	3.24%			18	0.57%	236	6.20%	294	4.97%
largemouth bass	*Micropterus salmoides*	446	2.47%	3	0.31%	93	2.94%	79	2.08%	87	1.47%
margined madtom	*Noturus insignis*	415	2.30%			10	0.32%	208	5.47%	144	2.43%
spottail shiner	*Notropis hudsonius*	414	2.29%			51	1.61%	85	2.23%	181	3.06%
longnose gar	*Lepisosteus osseus*	345	1.91%			156	4.94%	78	2.05%	93	1.57%
notchlip redhorse	*Moxostoma collapsum*	315	1.74%			130	4.12%	78	2.05%	77	1.30%
shorthead redhorse	*Moxostoma macrolepidotum*	294	1.63%			236	7.47%	33	0.87%	16	0.27%
piedmont darter	*Percina crassa*	285	1.58%	3	0.31%	21	0.66%	46	1.21%	180	3.04%
redear sunfish	*Lepomis microlophus*	275	1.52%	9	0.92%	55	1.74%	54	1.42%	47	0.79%
flat bullhead	*Ameiurus platycephalus*	212	1.17%	17	1.73%	19	0.60%	66	1.73%	86	1.45%
channel catfish	*Ictalurus punctatus*	188	1.04%			122	3.86%	16	0.42%	28	0.47%
v-lip redhorse	*Moxostoma pappillosum*	161	0.89%			64	2.03%	41	1.08%	43	0.73%
smallmouth bass	*Micropterus dolomieu*	159	0.88%			11	0.35%	46	1.21%	78	1.32%
bluehead chub	*Nocomis leptocephalus*	145	0.80%					10	0.26%	11	0.19%
threadfin shad	*Dorosoma petenense*	140	0.78%			5	0.16%	7	0.18%	128	2.16%
coastal shiner	*Notropis petersoni*	126	0.70%			23	0.73%	17	0.45%	75	1.27%
gizzard shad	*Dorosoma cepedianum*	114	0.63%			57	1.80%	44	1.16%	5	0.08%
american shad	*Alosa sapidissima*	109	0.60%			19	0.60%	30	0.79%	25	0.42%
northern hogsucker	*Hypentelium nigricans*	102	0.56%			27	0.85%	15	0.39%	50	0.85%
greenfin shiner	*Cyprinella chloristia*	85	0.47%			2	0.06%	18	0.47%	38	0.64%
blue catfish	*Ictalurus furcatus*	67	0.37%			65	2.06%	2	0.05%		
seagreen darter	*Etheostoma thalassinum*	55	0.30%			10	0.32%	31	0.81%	12	0.20%

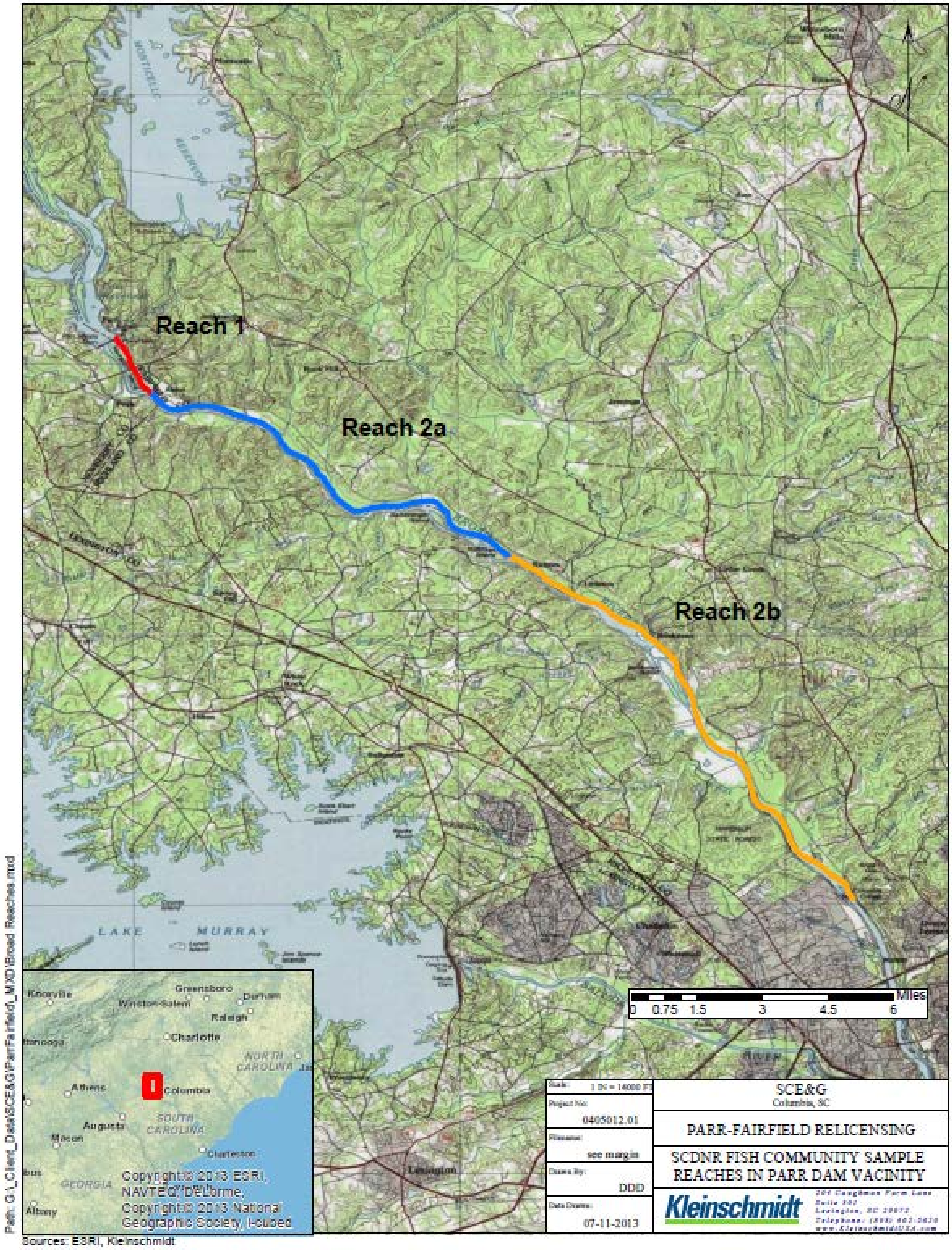
		Total		Parr Bypass		Parr Tailrace		Upper Natural		Lower Natural	
Common Name	**Scientific Name**	**n**	**Relative abundance (RA)**	**1b**	**RA**	**1t**	**RA**	2a	**RA**	**2b**	**RA**
thicklip chub	*Cyprinella labrosa*	51	0.28%							49	0.83%
tessellated darter	*Etheostoma olmstedi*	51	0.28%	9	0.92%	3	0.09%	1	0.03%	34	0.57%
highback chub	*Hybopsis hypsinotus*	46	0.25%					4	0.11%	42	0.71%
mosquitofish	*Gambusia affinis*	43	0.24%	5	0.51%			1	0.03%	17	0.29%
green sunfish	*Lepomis cyanellus*	36	0.20%							33	0.56%
warmouth	*Lepomis gulosus*	32	0.18%	2	0.20%	2	0.06%			4	0.07%
spotted sucker	*Minytrema melanops*	29	0.16%	1	0.10%			1	0.03%	12	0.20%
quillback	*Carpiodes cyprinus*	26	0.14%			22	0.70%			4	0.07%
white perch	*Morone americana*	26	0.14%			26	0.82%				
white catfish	*Ameiurus catus*	19	0.11%	3	0.31%	12	0.38%				
robust redhorse	*Moxostoma robustum ##*	18	0.10%			14	0.44%	4	0.11%		
American eel	*Anguilla rostrata*	17	0.09%			10	0.32%	5	0.13%	2	0.03%
striped jumprock	*Moxostoma rupiscartes*	17	0.09%					2	0.05%	13	0.22%
black crappie	*Pomoxis nigromaculatus*	14	0.08%			3	0.09%	3	0.08%	4	0.07%
swallowtail shiner	*Notropis procne*	14	0.08%			14	0.44%				
carp	*Cyprinus carpio*	11	0.06%			4	0.13%	4	0.11%		
flathead catfish	*Pylodictis olivaris*	9	0.05%			1	0.03%	1	0.03%	5	0.08%
blackbanded darter	*Percina nigrofasciata*	3	0.02%							1	0.02%
grass carp	*Ctenopharyngodon idella*	2	0.01%					2	0.05%		
striped bass	*Morone saxatilis*	2	0.01%			2	0.06%				
tadpole madtom	*Noturus gyrinus*	2	0.01%					2	0.05%		
creek chubsucker	*Erimyzon oblongus*	1	0.01%					1	0.03%		
Santee chub	*Hybopsis zanema*	1	0.01%							1	0.02%
white bass	*Morone chrysops*	1	0.01%			1	0.03%				
yellow perch	*Perca flavescens*	1	0.01%			1	0.03%				

(Source: Ron Ahle, SCDNR Freshwater Fisheries Region 3, data unpublished)

TABLE 3 RELATIVE ABUNDANCE OF FISH SPECIES COLLECTED BY BOAT AND BACKPACK ELECTROFISHING BELOW BOOKMAN ISLAND (SOURCE: BETTINGER ET AL. 2003)

SPECIES	BOAT	BACKPACK
longnose gar	0.8	
gizzard shad	0.1	
threadfin shad	0.4	
greenfin shiner	0.1	0.4
whitefin shiner	6.4	9
common carp	0.1	
eastern silvery minnow	0.1	
thicklip chub		4.3
bluehead chub		1.7
spottail shiner	0.5	0.9
yellowfin shiner	0.2	1.3
sandbar shiner	8.3	3.2
silver redhorse	4.8	
shorthead redhorse	0.1	
striped jumprock	0.2	
brassy jumprock	3.6	
snail bullhead	0.9	7.7
flat bullhead	0.6	1.0
channel catfish	0.2	0.1
margined madtom	0.2	13.6
white perch	0.3	
white bass	0.1	
flier	0.1	
redbreast sunfish	41.8	35.9
pumpkinseed	0.1	
warmouth	0.8	
bluegill	16.2	0.3
redear sunfish	7.5	
largemouth bass	4.2	0.5
black crappie	0.4	
tessellated darter	0.1	1.0
yellow perch	0.8	
seagreen darter		8.3
Piedmont darter	0.1	10.6
	100%	100%

FIGURE 13 SCDNR FISH COMMUNITY SAMPLING SITES IN THE VICINITY OF PARR SHOALS DAM



4.0 SUMMARY

Parr and Monticello reservoirs support warmwater fish communities typical of impounded river reaches in the Piedmont of South Carolina, with recent work having documented 30 species in Parr Reservoir and 24 in Monticello. Although some seasonal variations occur, fish communities are generally similar between the two reservoirs, with gizzard shad, blue catfish, bluegill, channel catfish and white perch often being the dominant species. Both reservoirs appear to support relatively high numbers of gizzard shad during the summer months (often numerically dominating the population); however, existing data suggests that these populations decline rapidly during the fall and winter, presumably due to high levels of predation and/or seasonal die-offs. No species that are state or federally listed as threatened or endangered have been documented in Monticello or Parr reservoirs, although robust redhorse, which is considered a species of highest conservation concern by the SCDNR (2005), has been documented in limited numbers in both reservoirs.

The reach of the Broad River downstream of the Parr Dam appears to support a diverse and robust fishery characteristic of large rivers in the Piedmont of South Carolina, although some influence from the Project is evident primarily in the reach extending from the dam to the Palmetto Trail trestle crossing (SCDNR Study Reach 1). The fish community within Reach 1 differs significantly between the Project tailrace (SCDNR Study Reach 1t) and the “bypass” reach located on the western side of the island immediately below the dam (SCDNR Study Reach 1b). The “bypass” reach is characterized by relatively low diversity and is dominated by sunfishes, with redbreast and bluegill account for more than 85% of the catch during recent sampling. Conversely, the tailrace channel side of Reach 1 supports a much more robust fish community and approached what would be expected in a Piedmont river. Most notably, an abundance of riverine suckers (Catostomids) have been documented in the reach, and it is thought to represent a potential spawning area for robust redhorse. Downstream of the Palmetto Trail trestle crossing, the fish communities appear to stabilize, with the two remaining SCDNR sample reaches upstream of the Columbia Hydro Impoundment (Reaches 2a and 2b) having very similar composition at the family level (See Figures 12 and 13). These reaches support a balanced community primarily consisting of Centrarchids, Cyprinids, Ictalurids and Catostomids, with redbreast sunfish, whitefin shiner, bluegill and snail bullhead as dominant species. The diverse fish community occurring in the reach provides an abundance of fish hosts for native freshwater mussels, as is evidenced by a recent survey by Alderman (2012) which found the highest freshwater mussel diversity in the Broad River Sub-basin in North and South Carolina upriver from the Columbia Diversion Dam occurring immediately downstream of Parr Shoals Dam.

No species that are state or federally listed as threatened or endangered have been documented in Monticello or Parr reservoirs or in the downstream reach of the Broad River between Parr Dam and Columbia Hydro Impoundment; however, 16 species that are considered to be priority species in the SCDNR's Comprehensive Wildlife Conservation Strategy (SCDNR 2005) are found in the Project area (Table 4).

TABLE 4 SOUTH CAROLINA CWCP PRIORITY SPECIES

					SCDNR DOWNSTREAM STUDY REACHES			
COMMON NAME	**SCIENTIFIC NAME**	**PRIORITY STATUS**	**PARR**	**MONTICELLO**	**1B**	**1T**	2A	**2B**
American eel	*Anguilla rostrata*	Highest				X	X	X
American shad	*Alosa sapidissima*	Highest				X	X	X
Flat bullhead	*Ameiurus platycephalus*	Moderate	X	X	X	X	X	X
Greenfin shiner	*Cyprinella chloristia*	Moderate				X	X	X
Highfin carpsucker	*Carpiodes velifer*	Highest	X					
Notchlip redhorse	*Moxostoma collapsum*	Moderate	X	X		X	X	X
Piedmont darter	*Percina crassa*	High			X	X	X	X
Quillback	*Carpiodes cyprinus*	High	X	X		X		X
Robust Redhorse	*Moxostoma robustum*	Highest	X			X	X	
Santee Chub	*Hybopsis zanema*	High						X
Seagreen darter	*Etheostoma thalassinum*	High				X	X	X
Snail bullhead	*Ameiurus brunneus*	Moderate		X	X	X	X	X
Striped bass	*Morone saxatilis*	Moderate				X		
Thicklip chub	*Cyprinella labrosa*	Moderate						X
V-lip redhorse	*Moxostoma pappillosum*	Moderate				X	X	X
White catfish	*Ameiurus catus*	Moderate	X	X	X	X		

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APPENDIX A

RELATIVE ABUNDANCE AND CPUE DATA FOR PARR AND MONTICELLO RESERVOIRS, 2007 - 2013

RELATIVE ABUNDANCE OF FISH COLLECTED ON PARR AND MONTICELLO RESERVOIRS, FALL AND SPRING 2007 (SOURCE: NORMANDEAU 2007)

Species	Monticello		Parr	
	# Individuals	Relative Abundance	# Individuals	Relative Abundance
Quillback	1	0.1	3	0.6
Northern Hogsucker	1	0.1	0	0.0
Shorthead Redhorse	10	1.2	29	8.1
Redbreast	3	0.4	0	0.0
Pumpkinseed	12	1.5	8	1.7
Warmouth	6	0.7	0	0.0
Bluegill	267	32.6	34	7.1
Redear	7	0.9	3	0.6
Smallmouth Bass	2	0.2	1	0.2
Largemouth Bass	71	8.7	37	7.8
White Perch	78	9.5	118	24.8
White Bass	2	0.2	0	0.2
Black Crappie	32	3.9	1	0.2
Gizzard Shad	161	19.6	60	12.6
Whitefin Shiner	15	1.8	2	0.4
Golden Shiner	0	0.0	5	1.1
Spottail Shiner	5	0.6	2	0.4
White Catfish	14	1.7	3	0.6
Flat Bullhead	7	0.9	0	0.0
Blue Catfish	90	11.0	34	7.1
Channel Catfish	31	3.6	124	26.1
Yellow Perch	5	0.6	12	2.5

ELECTROFISHING CPUE FOR PARR AND MONTICELLO RESERVOIRS, FALL AND SPRING 2007 (SOURCE: NORMANDEAU 2007)

Species	Monticello Reservoir		Parr Reservoir	
	Fall2006 CPUE	Spring2007 CPUE	Fall2006 CPUE	Spring2007 CPUE
Quillback	0.00	0.00	0.00	3.99
Northern Hogsucker	0.00	3.99	0.00	0.00
Shorthead Redhorse	0.00	19.96	7.98	19.96
Redbreast	7.99	4.00	0.00	0.00
Pumpkinseed	43.91	3.99	19.94	7.98
Warmouth	23.97	0.00	0.00	0.00
Bluegill	806.20	239.38	59.82	75.84
Redear	7.98	7.98	7.97	3.99
Largemouth Bass	31.92	143.74	39.90	35.93
White Perch	0.00	55.90	0.00	0.00
Black Crappie	0.00	0.00	0.00	3.99
Gizzard Shad	0.00	23.94	119.69	63.86
Whitefin Shiner	55.92	3.99	7.97	0.00
Spottail Shiner	3.99	3.99	0.00	7.98
White Catfish	0.00	51.89	0.00	0.00
Flat Bullhead	15.97	0.00	0.00	0.00
Blue Catfish	0.00	0.00	3.99	0.00
Channel Catfish	0.00	31.95	0.00	3.99
Yellow Perch	19.98	0.00	11.96	23.95

RELATIVE ABUNDANCE OF FISH COLLECTED ON PARR AND MONTICELLO RESERVOIRS, SUMMER 2008 (SOURCE: NORMANDEAU 2008)

Common Name	Parr		Monticello	
	Total	Abundance	Total	Abundance
Quillback	2	0.6	0	0
Northern Hogsucker	0	0	1	0.1
Notchlip Redhorse	2	0.6	9	1.2
Shorthead Redhorse	11	3.4	4	0.5
Robust Redhorse	1	0.3	0	0
Redbreast	0	0	3	0.4
Pumpkinseed	3	0.9	6	0.8
Bluegill	47	14.3	181	23.1
Redear	3	0.9	4	0.5
Smallmouth Bass	1	0.3	1	0.1
Largemouth Bass	20	6.1	11	1.4
White Perch	25	7.6	28	3.6
Black Crappie	1	0.3	7	0.9
Gizzard Shad	172	52.4	330	42.2
Whitefin Shiner	0	0	2	0.3
Spottail Shiner	5	1.5	4	0.5
Snail Bullhead	0	0	1	0.1
White Catfish	5	1.5	11	1.4
Yellow Bullhead	0	0	1	0.1
Flat Bullhead	0	0	2	0.3
Blue Catfish	14	4.3	156	19.9
Channel Catfish	12	3.7	20	2.6
Longnose Gar	2	0.6	0	0
Yellow Perch	2	0.6	0	0

ELECTROFISHING CPUE FOR PARR AND MONTICELLO RESERVOIRS, SUMMER 2008 (SOURCE: NORMANDEAU 2008)

Common Name	Parr	Monticello
Northern Hogsucker		3.99
Notchlip Redhorse	3.97	35.88
Shorthead Redhorse		3.99
Redbreast		5.98
Pumpkinseed	11.97	23.92
Bluegill	89.76	143.99
Redear	11.97	7.95
Smallmouth Bass	3.96	3.99
Largemouth Bass	26.44	13.27
White Perch	7.98	33.92
Gizzard Shad	333.05	182.40
Whitefin Shiner		3.98
Spottail Shiner	9.97	7.98
Snail Bullhead		3.97
White Catfish	3.99	14.58
Yellow Bullhead		3.97
Flat Bullhead		7.94
Blue Catfish		3.97
Channel Catfish	15.95	11.96
Yellow Perch	7.98	

RELATIVE ABUNDANCE OF FISH COLLECTED ON PARR AND MONTICELLO RESERVOIRS, WINTER 2009 (SOURCE: NORMANDEAU 2009)

Common Name	Parr		Monticello	
	Total	Abundance	Total	Abundance
Quillback	1	0.8		
Northern Hogsucker			2	0.4
Notchlip Redhorse			8	1.7
Shorthead Redhorse	2	1.5	16	3.5
Redbreast	1	0.8	6	1.3
Pumpkinseed	2	1.5	10	2.2
Bluegill	44	33.6	154	33.4
Redear	1	0.8	2	0.4
Smallmouth Bass	2	1.5	1	0.2
Largemouth Bass	12	9.2	35	7.6
White Perch	2	1.5	99	21.5
Black Crappie			8	1.7
Gizzard Shad	9	6.9	31	6.7
Threadfin Shad	4	3.1		
Whitefin Shiner			16	3.5
Eastern Silvery Minnow	7	5.3	8	1.7
Golden Shiner	3	2.3		
Spottail Shiner	12	9.2	12	2.6
White Catfish	1	0.8	8	1.7
Flat Bullhead			1	0.2
Blue Catfish	11	8.4	14	3
Channel Catfish	12	9.2	26	5.6
Longnose Gar	1	0.8		
Yellow Perch	4	3.1	4	0.9

ELECTROFISHING CPUE FOR PARR AND MONTICELLO RESERVOIRS, WINTER 2009 (SOURCE: NORMANDEAU 2009)

Common Name	Parr	Monticello
Northern Hogsucker		3.99
Notchlip Redhorse		5.98
Shorthead Redhorse	3.96	3.99
Redbreast	3.97	7.95
Pumpkinseed	3.98	13.29
Bluegill	58.17	121.74
Redear	3.99	7.97
Smallmouth Bass	7.94	3.99
Largemouth Bass	13.25	31.81
White Perch	3.99	56.81
Black Crappie		7.97
Gizzard Shad	11.97	16.9
Threadfin Shad	7.97	
Whitefin Shiner		63.79
Eastern Silvery Minnow	27.72	15.95
Spottail Shiner	23.82	15.96
White Catfish	3.99	9.31
Blue Catfish		3.99
Channel Catfish		35.88
Yellow Perch	3.96	5.32

RELATIVE ABUNDANCE OF FISH COLLECTED ON PARR RESERVOIR, SPRING AND FALL 2012 (SOURCE: SCANA 2013)

Species	# Individuals	Relative Abundance
blue catfish	16	10.06
bluegill	20	12.58
channel catfish	39	24.53
flathead catfish	1	0.63
gizzard shad	21	13.21
highfin carpsucker	10	6.29
largemouth bass	4	2.52
notchlip redhorse	2	1.26
redbreast sunfish	1	0.63
redear sunfish	1	0.63
robust redhorse	1	0.63
sandbar shiner	1	0.63
shorthead redhorse	1	1.89
spottail shiner	1	0.63
warmouth	1	0.63
white bass	1	0.63
white catfish	1	0.63
white perch	30	18.87
yellow bullhead	1	0.63
yellow perch	4	0.63

APPENDIX B

SANTEE RIVER ACCORD

AMERICAN EEL AND AMERICAN SHAD SUMMARIES

Introduction

The following is a summary of information gathered as part of the "*Santee River Basin Accord for Diadromous Fish Protection, Restoration, and Enhancement*" (Accord). The Accord is a collaborative approach among utilities with licensed hydroelectric projects, including South Carolina Electric & Gas (SCE&G) and Duke Energy Carolinas, LLC (Duke), and federal and state resource agencies, including the South Carolina Department of Natural Resources (SCDNR), the North Carolina Wildlife Resources Commission (NCWRC), and the United States Fish and Wildlife Service (USFWS) to address diadromous fish protection, restoration, and enhancement in the Santee River Basin. The Accord supports the *Santee-Cooper Basin Diadromous Fish Passage Restoration Plan* which was developed by the SCDNR, the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) and the USFWS, and was accepted as a Comprehensive Plan by the Federal Energy Regulatory Commission (FERC).

American Eel Summary

The South Carolina Department of Natural Resources studied American eel abundance and distribution along the spillways of the Lake Wateree Dam on the Wateree River and Columbia Dam on the Broad River. The study occurred from January 1, 2010 through December 31, 2012. The objectives of this study were to quantify the migrational timing and abundance of American eels at various locations along the spillways of the Lake Wateree Dam and the Columbia Dam, evaluate factors that effected this distribution, and identify areas where American eel collection rates could be maximized. Eel ramp traps of a standard design were used and consisted of a ramp covered with a textured surface, attraction flow and covered collection container with aeration or flow-through water supply. Traps were set at several locations across the base of the Lake Wateree Dam and the Columbia Dam. Traps were deployed in early January and monitored biweekly until eels were detected, then weekly until April 1, and then every other day through June. Monitoring then reverted to biweekly for the remainder of the year after catch numbers subsided. The presence and abundance of eels in the vicinity of the Wateree Dam was evaluated by monthly electrofishing efforts from March through June, and then bi-monthly for the remainder of the year. Electrofishing was also conducted below Columbia Dam 2-3 times each year. All eels collected were enumerated, measured and released or retained for further study.

Some of the eels collected were tagged or marked as part of a pilot study to evaluate tagging methods and tag retention for future movement studies or population estimates.

The study results showed that American eels were not abundant below Columbia Dam or Wateree Dam during 2010, 2011 and 2012. Only 25 American eels (13 at Columbia and 12 at Wateree) were collected during the three year study, with 16.5 hours of electrofishing and 4,500 trap days of effort. Although too few eels were collected to thoroughly address the objectives listed above, it was found that eels were collected most frequently during the months of April through June. Eels were most frequently collected near the powerhouse at Wateree, and near the fish passage structure at Columbia. The study also suggested that few eels make it above the Santee-Cooper lakes. During 2012, 13 eels were captured at the Columbia and Wateree sites, while 17,500 eels were captured in the two ramp traps below St. Stephen's.

American Shad Summary

Adult

Each year adult American shad pass through the Santee-Cooper lake system via the St. Stephen fish lift. It is assumed that once fish exit the fish lift, they continue their upriver spawning migrations to the upper Santee, Wateree, and Congaree Rivers. In 2009, ultrasonic telemetry was used to gain a better perspective on the distribution and migration range of American Shad beyond the St. Stephen fish lift. Three hundred ninety six American shad were collected and implanted with ultrasonic transmitters and released above the fish lift to resume their journey upriver. Tagging was distributed to account for the early, mid and latter portions of the shad migration, with personnel downloading locations of transmitted fish weekly from the various receivers located throughout the study area (Figure 1). Several manual tracking trips were also conducted, to account for fish that were located between receivers.

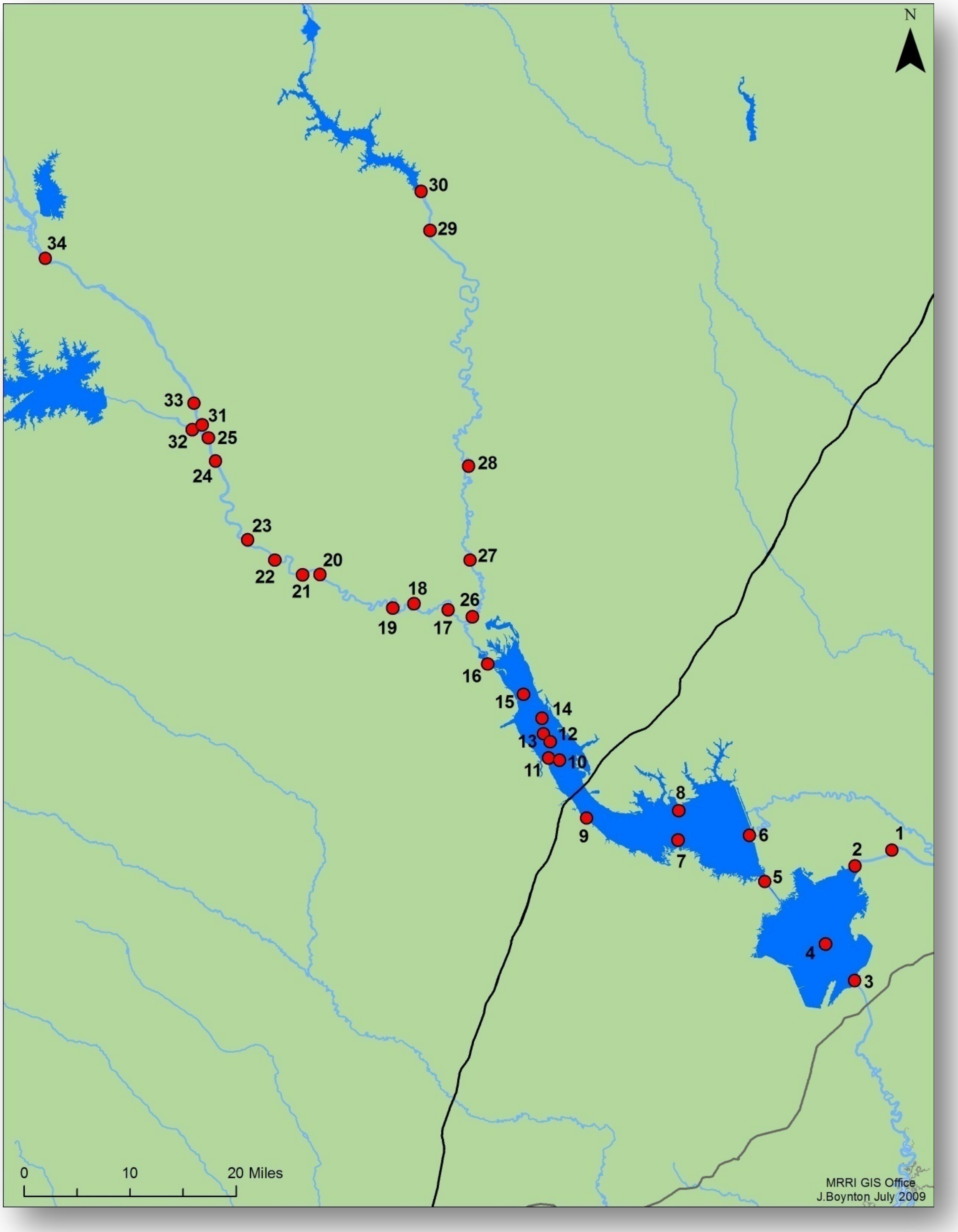

Figure 14 Acoustic Telemetry Receiver Locations in the Santee River Basin, SC

Results from the 2009 Adult American Shad Study indicated that shad were not reaching upper river habitats, but that most shad (67%) were utilizing the area between I-95 and the confluence of the Congaree and Wateree rivers. To determine if this was normal behavior or an anomaly, the study was repeated on a smaller scale in 2010. Two hundred forty seven shad were implanted with transmitters, and identical locations were used for receivers. Tagging was distributed to account for the early, mid and end portions of the shad migration, with personnel downloading locations of transmitted fish weekly from the various receivers. There were also several manual tracking trips conducted to account for fish that were located between receivers.

Of the 247 fish tagged with transmitters, 240 were detected by at least one receiver. 58 American shad were pulled through the turbines or the outmigration bypass system and ended up downstream of the St. Stephen Dam, but two of these fish traveled back upstream through the fish lift and re-entered the lake system. One hundred eighty one fish traveled upstream to Lake Moultrie, with 155 travelling through the Diversion Canal to enter Lake Marion. One hundred nine of the transmitted American shad traveled to the upper portion of Lake Marion, between the I-95 Bridge and Low Falls Landing, on the upper Santee River. This area appears to be where the majority of spawning is taking place. Eighty fish were detected approximately 10 km downstream of the Wateree/Congaree confluence. Fifteen American shad were detected in the lower portion of the Wateree River, and three of these fish continued upstream to the SCE&G Plant. Thirty three American shad were detected in the Congaree River where Hwy 601 crosses the river, and 9 of these fish continued upstream to Congaree National Park. Only two fish traveled far enough upstream to be detected by the receiver in the Congaree River at Rosewood Landing (rkm 77). One tagged American shad successfully traveled through the Columbia Fishway and was detected at the most upstream receiver just below Parr Dam. No American shad were detected in the bypassed reach of the Broad River adjacent to the Columbia Hydro Plant, nor were any American shad detected by receivers in the Saluda River.

Juvenile

As part of the Santee Basin Cooperative Accord, diadromous fish populations in upstream river reaches are being rebuilt through enhancement activities and the construction of permanent passage facilities at dams. Enhancement activities include population augmentation with hatchery-reared American shad fry, as well as re-locations of pre-spawning adults.

As part of an ongoing study, electrofishing is conducted on a weekly basis each year during June through November at several predetermined nursery sites. The study area includes: the Broad River, upstream and downstream of the Columbia Fishway; three sites in the Congaree River between rkm 0-6; four sites in the Upper Santee River between rkm 0-26; three sites in the Wateree River between rkm 39-47; Lake Marion at Harry's Fish Camp, Big Water and Indian Bluff; the Diversion Canal upstream of the Hwy 45 bridge; and Lake Moultrie at Bonneau Beach.

Young-of-year juvenile shad and herring are collected to determine abundance, distribution, growth rates, food habits and out-migration timing. Shad otoliths are also analyzed to determine the relative contribution of naturally produced versus hatchery produced shad juveniles. Each year, American Shad are collected and counted, and the sagittal otoliths are examined to determine if they are from hatchery stock. Results from the study are summarized in Table 1. This study was conducted in 2013 and will continue in 2014 in order to establish trends in abundance and determine overall hatchery contribution to the system.

Table 3 Santee Accord Juvenile American Shad Study Results

YEAR	# AMERICAN SHAD COLLECTED	# AMERICAN SHAD EXAMINED	% HATCHERY STOCK
2010	2,845	2,689	2.8%
2011	3,176	3,167	0.7%
2012	2,277	2198	0.8%

Exhibit E-5 Fisheries Resources

Santee River Basin Accord for

Diadromous Fish Protection,

Restoration and Enhancement

SANTEE RIVER BASIN ACCORD FOR DIADROMOUS FISH PROTECTION, RESTORATION, AND ENHANCEMENT

General

The Santee River Basin Accord ("Accord") is a collaborative approach among utilities with licensed hydroelectric projects, and federal and state resource agencies to address diadromous fish protection, restoration, and enhancement in the Santee River Basin ("Basin"). This Accord supports the *Santee-Cooper Basin Diadromous Fish Passage Restoration Plan* (2001) which was developed by the South Carolina Department of Natural Resources ("SCDNR"), the National Oceanic and Atmospheric Administration's National Marine Fisheries Service ("NMFS"), and the United States Fish and Wildlife Service ("USFWS"), and was accepted as a Comprehensive Plan by the Federal Energy Regulatory Commission ("FERC") as noted in the FERC's letter to the USFWS dated October 3, 2001.

Accord participants and hydroelectric projects (referred to herein singularly as "Project" and together as "Projects") that are the subject of this Accord include South Carolina Electric & Gas Company ("SCE&G"), licensee of the Saluda Hydroelectric Project No. 516, the Parr Hydroelectric Project No. 1894, and the Neal Shoals Hydroelectric Project No. 2315, and Duke Energy Carolinas, LLC ("Duke"), licensee of the Catawba-Wateree Hydroelectric Project No. 2232, the Ninety-Nine Islands Hydroelectric Project No. 2331, and the Gaston Shoals Hydroelectric Project No. 2332 (SCE&G and Duke referred to herein singularly as "Utility" and together as "Utilities") and their successors; and the SCDNR, the North Carolina Wildlife Resources Commission ("NCWRC"), and the USFWS (referred to herein singularly as "Agency" and together as "Agencies") and their successors. Singularly, any Utility or Agency that signs this Accord may be referred to herein as "Party". Collectively, the Utilities and Agencies that sign this Accord constitute the Cooperative Accord Partnership ("CAP" or "Parties"). The NMFS and the South Carolina Department of Health and Environmental Control ("SCDHEC") were also involved in the development of this Accord, but neither are currently signatories to the Accord and are therefore not CAP members. Future CAP members, if any, will be limited to federal and state resource agencies with authority for any diadromous fish species and their habitats in the Basin, and to owners of other FERC-licensed hydroelectric projects in the Basin. Non-governmental organizations and the general public will not be members of the CAP, but may participate via consultation with CAP members and may attend CAP meetings in a non-decision-making role. However, all discussions by non-CAP members in CAP meetings will be limited to a short public comment period (to include submission of written comments, if desired) at the start of a meeting, unless the CAP agrees by consensus on a case-by-case basis to do otherwise.

This Accord constitutes an agreement among the CAP members for the protection, restoration, and enhancement of diadromous fish in the Basin through implementation of a 10-year Action Plan ("Plan") that was initially developed by the USFWS (*Cooperative Accord 10-Year Action Plan For The Restoration and Enhancement of Diadromous Fish In The Santee Basin*—original draft dated January 24, 2007), and that includes no-sooner-than dates and biological triggers for fish passage as specified in this document. Tasks and cost estimates for each activity in the Plan are shown in Appendix A, and no-sooner-than dates, biological triggers, and other agreed-upon actions are noted in Appendix B. The agreements, activities, and biological studies identified in the Accord, and in Appendices A, B, and C which are hereby incorporated by reference, will be used to support the development of fish passage prescriptions that will protect, restore, and enhance diadromous fish species in the Basin and will be filed with the FERC for inclusion in the new licenses for some of the above-referenced Projects. The CAP members have worked to create this Accord to meet the interests of CAP members while still allowing all Agencies and Jurisdictional Bodies to meet their respective statutory obligations for diadromous fish under §7 of the Endangered Species Act ("ESA") and under §4(e), §10(a), §10(j), and §18 of the Federal Power Act ("FPA"), and under §401 of the Clean Water Act ("CWA"), for the above-referenced Projects. The CAP has agreed to implement phased, deliberate, and effective activities that will initiate diadromous fish population enhancements in the near-term while collecting data and monitoring diadromous fisheries over a longer period for optimizing further restoration efforts.

Definitions

Consensus—a vote with no dissenting votes; abstention by a member is not a dissenting vote.

Jurisdictional Body—any governmental body, except Agencies, which has the authority to bind the Utilities by imposing requirements affecting the operation of the Projects that are the subject of the Accord.

Existing Project License—the hydropower license that as of the effective date of this Accord has been issued by the FERC for Projects No. 1894, No. 2315, No. 2331, and No. 2332 but does not include subsequent or renewed licenses, or their terms, even if some or all of the terms of a subsequent or renewed license are identical to terms in an Existing Project License.

Inconsistent Act—(A) any requirement, condition, prescription, or recommendation imposed by a Jurisdictional Body pursuant to §§4(e), 10(a), 10(j), or 18 of the FPA, §7 of the ESA, or §401 of the CWA for operation of a Project that materially varies any obligation concerning the restoration of diadromous fish, reservoir elevation limitations, required flow releases, and low inflow protocols or high inflow protocols from those set forth in the Catawba-Wateree Comprehensive Relicensing Agreement (CRA), as amended on December 29, 2006, or in an Existing Project License; or (B) any requirement, condition, prescription, or recommendation imposed by a Jurisdictional Body pursuant to §§4(e), 10(a), 10(j), or 18 of the FPA, §7 of the ESA, or §401 of the CWA that materially varies any obligation from those set forth in this Accord.

Breach—a failure of a Party to comply with the terms of the Accord in a significant and non-trivial manner and includes, but is not limited to: (A) a requirement, condition, prescription, or recommendation for a Project that is imposed by an Agency pursuant to §§4(e), 10(a), 10(j), or 18 of the FPA, or §7 of the ESA that materially varies any obligation set forth in this Accord; or (B) any CAP member's requesting, promoting, or supporting an Inconsistent Act or other requirements that materially varies any obligation set forth in this Accord.

Materially Vary or Varies—a requirement, condition, prescription, or recommendation materially varies if it imposes additional obligations that in the discretion of the affected Utility are significant and includes, but is not limited to: (A) reservoir elevation limitations; required flow releases; low inflow protocols or high inflow protocols that are significantly different from those in the CRA or in an Existing Project License (whether by changing the actual obligation or by changing the method of implementing the obligation); (B) upstream or downstream passage of diadromous fish at a Project dam on a schedule different from that identified in the Accord; (C) installation of fishway equipment on a Project dam that is in addition to or different from what is required by the Accord; or (D) fish studies, monitoring, or analyses that are in addition to or different from what is required by the Accord.

Fish Passage Facilities, Fishways, and Prescriptions— defined in *Notice of Proposed Interagency Policy on the Prescription of Fishways Under Section 18 of the Federal Power Act,* (Federal Register/Volume 65, No. 247/Friday, December 22, 2000) for existing hydroelectric projects on the Saluda, Broad, and Catawba-Wateree rivers. These terms are used interchangeably throughout this document.

Key Agreements

The CAP members agree as follows:

General Agreements

1. The Utilities will not pursue Trial Type Hearings ("TTH") before an Administrative Law Judge pursuant to FPA §§4(e) or 18 to contest the USFWS's FPA §§4(e) or 18 diadromous fish requirements so long as the USFWS's ESA §7 requirements, FPA §§4(e) conditions, 10(a) and 10(j) recommendations, and 18 prescriptions do not materially vary reservoir elevation limitations, required flow releases, low inflow protocols or the high inflow protocols as set forth in: (A) the CRA; (B) Existing Project Licenses at the Ninety-Nine Islands and Gaston Shoals Projects; (C) a settlement agreement among the SCDNR, the USFWS, and SCE&G for the Saluda Hydroelectric Project; and (D) this Accord.

2. The Plan, which emphasizes research on fish movement (both upstream and downstream), distribution, and habitat use; fish population enhancement and restoration activities; and related funding responsibilities for American eels, American shad, Atlantic sturgeon, blueback herring, and shortnose sturgeon, will be implemented.

3. The Accord's no-sooner-than dates and biological triggers (in Appendix B) will be used to initiate conceptual design and subsequent construction of fish passage facilities for existing hydroelectric Projects on the Broad River and the Catawba-Wateree River.

4. The restoration target numbers for adult anadromous American shad and adult anadromous blueback herring restoration in the Broad River are set in Appendix C.

5. Subject to limitations regarding confidential and proprietary information, the CAP will establish and maintain a publicly accessible electronic archive for all data and documents created as a result of the Accord. When requested by a Utility, the Agencies will treat specific data provided by the Utility as confidential and proprietary, to the extent permitted by law. This may include pre-decisional work products, proprietary information, and sensitive resource data. In the event that any confidential or proprietary information is required by law to be released by an Agency, that Agency shall provide

CAP members affected by such a release with at least a 30-day written notice in advance of such release, unless a shorter notice period is required by law. Nothing herein shall be interpreted to prevent any Agency from complying with the Freedom of Information Act and 43 CFR Part 2, Subpart A and B.

6. If any Utility considers an action or omission to be an Inconsistent Act or a Breach, then that Utility may withdraw from this Accord by giving written notice of its intent to withdraw, pursuant to Paragraph 7; provided, however, that in the case of an Inconsistent Act, such notice of withdrawal may not take place until the time period to initiate administrative appeal of the Inconsistent Act has expired.

7. A withdrawing Utility initiates withdrawal by providing written notice of an Inconsistent Act or Breach and its intent to withdraw to all CAP members. This notice must include a brief statement setting forth: (A) the date and nature of the Inconsistent Act or Breach giving rise to the right to withdraw and (B) how the alleged Inconsistent Act or Breach meets the definition of "Inconsistent Act" or "Breach," as defined herein.

8. In the event of an alleged Accord Breach by any CAP member, the CAP member that is alleged to have breached the Accord shall have thirty (30) days after receipt of the notice of Breach within which to cure the Breach. If it is not reasonably possible to cure such Breach within thirty (30) days, the breaching CAP member shall notify the CAP Board ("Board," see Paragraph 26) of the time reasonably necessary to cure such Breach. If the Board can agree on the time reasonably necessary to cure the Breach, the breaching CAP member shall proceed to cure such Breach within such time as the Board shall agree. If the Board is unable to agree on the time reasonably necessary to cure the Breach, the breaching CAP member shall proceed to cure such Breach as soon as reasonably possible. The breaching CAP member(s) shall keep the Board informed of the progress in curing the Breach. Failure of the breaching CAP member to cure a Breach in accordance with this paragraph shall allow the CAP member that is harmed by the Breach to withdraw from the Accord.

9. In the event of a withdrawal by a Utility or the failure of a Utility to cure a Breach of the Accord, the Agencies have the option to reconsider any prior fish passage prescriptions submitted pursuant to FPA §18 for Projects owned by the withdrawing or breaching Utility. Withdrawal relieves the Utility of its performance obligations under this Accord, but will not result in the return of any funds previously contributed pursuant to Paragraph 37.

10. If the Accord Utility membership changes, the Plan will be adjusted by the remaining CAP members to be compatible with funding being provided by the remaining member Utilities.

11. The Agencies and Utilities agree that extension of the Plan beyond 2017 is optional, and the obligation and agreement to comply with the Accord is not conditioned upon a continuation of the Plan beyond the initial 10-year term.

12. The Agencies and the Utilities agree to use their best efforts to make this Accord a success and to participate in all Accord administrative activities at their own expense.

SCE&G Specific Agreements

13. The reservoir elevation limitations, required flow releases, low inflow protocols or high inflow protocols to be developed in a relicensing agreement for the Saluda Hydroelectric Project among the USFWS, SCDNR, and SCE&G along with the reservation by the USFWS of any fishway prescriptions for this Project will be filed with the FERC for the term of the new Saluda Hydroelectric Project license which is anticipated to be issued in 2010.

14. It is the understanding of the CAP that the diadromous fish study needs below the Parr Shoals Development Dam will be addressed through the Accord. Additional diadromous fish studies downstream of Parr Shoals Development Dam will not be required during the relicensing of the Parr Hydroelectric Project. A Fish Passage Feasibility Assessment (an evaluation of the upstream and downstream passage alternatives and their conceptual designs) will be conducted pursuant to the Accord, by SCE&G, and will commence upon attainment of the biological triggers as set out in Appendix B.

15. The Fish Passage Feasibility Assessment will commence at the Parr Shoals Development Dam within one year following passage of 50% of the adult anadromous American shad or adult anadromous blueback herring target restoration numbers as set out in Appendix B, upstream for any three years in a five-year period at the Columbia Diversion Dam Fish Passage Facility. Construction of a fishway at the Parr Shoals Development Dam will be initiated within one year and completed within three years following passage of 75% of the adult anadromous American shad or adult anadromous blueback herring target restoration numbers as described in Appendix B, upstream for any three years in a five-year period at the Columbia Diversion Dam Fish Passage Facility. In no event shall fish passage feasibility assessment or construction of the fishway commence before 2012. No changes will be required in the Parr Hydroelectric Project's current operations until issuance of the new FERC license for this Project. Any fish passage at this Project will not impact generation and pumping operations at the Fairfield Pumped Storage Facility until relicensing studies support the need for such a change and then only with the issuance of the new license for the Parr Hydroelectric Project (anticipated to be issued by FERC in 2020).

16. The USFWS agrees to reserve its FPA §18 authority to prescribe any type of fish passage facilities for sturgeon species at the Parr Shoals Development Dam until the new FERC license is issued for the Parr Hydroelectric Project, anticipated to be in 2020.

17. In the event that SCE&G applies for an amendment to the Parr Hydroelectric Project's current license for construction of a future power plant, the USFWS will reserve its authority under FPA §4(e) and §18 for this license amendment at that Project.

18. The Fish Passage Feasibility Assessment, including conceptual designs, will begin at the Neal Shoals Hydroelectric Project within one year following 50% of target restoration

numbers for adult anadromous American shad or adult anadromous blueback herring, as described in Appendix B, being passed upstream for any three years out of a five-year period at the Parr Shoals Dam. The construction of fish passage facilities at the Neal Shoals Hydroelectric Project will commence within one year and be completed within three years following passage of 75% of target restoration numbers of adult anadromous American shad or adult anadromous blueback herring being passed upstream three years out of a five-year period at the Parr Shoals Development Dam, but in no event shall the fish passage feasibility assessment or construction commence before 2016.

Duke Specific Agreements

19. For the Catawba-Wateree Hydroelectric Project, the obligation to operate a fishway and associated facilities as set out in the Accord will continue for the term of the new license, and the USFWS agrees that the prescription to be filed with the FERC for the new license will include such a provision. A trap and truck fish passage facility ("T&T facility") for adult anadromous American shad and adult anadromous blueback herring will be designed by Duke, in consultation with the Agencies and with input from the Accord Technical Committee ("TC;" see Paragraph 33), by December 31, 2015, and will commence operation by January 1, 2018, at the Wateree Development of the Catawba-Wateree Hydroelectric Project (see Appendix B). Fish trapped at this T&T facility will be placed in Lake Wateree. The year after the combined annual total catches of adult anadromous American shad and adult anadromous blueback herring equal or exceed 10,000, and in all subsequent years of the term of this Accord, all trapped adult anadromous American shad and adult anadromous blueback herring shall be trucked to upstream areas in the SC portion of the Catawba-Wateree River Basin designated by the TC. If the Accord is not functional, then the USFWS and the SCDNR will designate these upstream reaches in the SC portion of the Catawba-Wateree River Basin by consensus. Effectiveness studies (e.g., usefulness of attraction flows to increase capture of target fish and determination of target fish mortality associated with handling and transportation) for this T&T facility will be conducted by Duke during the first three years of operations, provided sufficient numbers of fish, as determined by the consensus of the Agencies with input from the TC, are available to do so. Information from the effectiveness studies will be used to improve effectiveness of the T&T facility.

20. The Agencies agree that operation of the T&T facility at the Wateree Development, as specified above and as incorporated in the prescription to be filed with the FERC for inclusion in the new license, will fulfill FPA §18 prescriptions and ESA §7 requirements for upstream passage for all adult anadromous fish (including but not limited to American shad, blueback herring, Atlantic sturgeon, and shortnose sturgeon) for all Catawba-Wateree Hydroelectric Project developments for the term of the new license.

21. The SCDNR will issue a scientific collection permit to operate the T&T facility at the Wateree Development pursuant to SC Code §50-11-1180 to ensure that Duke will not be held civilly or criminally responsible for any bycatch mortality, provided Duke is in compliance with its collection permit.

22. The Agencies agree that existing upstream fish passage facilities at the Wateree Development (i.e., partial ramp(s) and manual trap(s) in good repair and similar to that described in David Solomon's 2004 Fish Passage Design for Eels and Elvers) that use manual transport and release of captured American eels into Lake Wateree are sufficient to fulfill FPA §18 upstream prescriptions for catadromous fish (e.g., American eels) at the Wateree Development, when supplemented with additional partial ramp(s)/manual trap(s) determined by the results of partial ramp/manual trapping conducted in all seasons in 2009-2011 in areas adjacent to the spillway (data collected via the Catawba-Wateree River Elver Study in Appendix A). So long as American eels are passed upstream at the Wateree Development in an efficient, safe, and timely manner, Duke, at its sole discretion, may decide to continue operation of the ramp/trap fishway or construct a new passage facility. If Duke chooses to construct a new American eel passage facility at the Wateree Development, Duke will consult with the Agencies and the TC regarding facility design and construction.

23. The Agencies and Duke agree that a series of portable ramp/trap devices will be sufficient for the three-year monitoring studies, and that the studies will be conducted at each development in an orderly upstream sequence of the Catawba-Wateree Hydroelectric Project developments upstream of the Wateree Development. A template for the initial and subsequent studies to ascertain American eel abundance at each tailrace site is set out in the 10-Year Action Plan and is budgeted in Appendix A (location of such studies will occur in an orderly upstream sequence beginning at the Rocky Creek-Cedar Creek Development and ending at the Bridgewater Development at a time to be determined in consultation with the Agencies and with input from the TC). These data will allow effective design and placement of permanent or semi-permanent passage devices for best upstream passage at each development for American eels. Duke will develop a study plan for review and approval by the Agencies with input from the TC prior to commencing any studies at these upstream developments. Information collected from these studies shall include size, seasonality, and location of juvenile American eels in the tailrace areas where these fish may congregate. Captured American eels will be passed into the immediate upstream reservoir. The Agencies and the TC may approve a request for extension of the term of the initial monitoring study in the event few American eels are captured during the study phase.

24. Following the above monitoring for American eels described in Paragraph 23, Duke agrees to design, construct, and operate at each development (in consultation with the Agencies and with input from the TC after a review of the data collected during each three-year study) permanent or semi-permanent upstream passage facilities at each development within two years of completion of the monitoring study at a particular development. So long as American eels are passed upstream at each development in an efficient, safe, and timely manner, Duke, at its sole discretion, may decide to continue operation of the ramp/trap type fishways or construct a new passage facility at each Catawba-Wateree Project development.

25. Duke in cooperation with Agencies and with input from the TC will commence studies in 2024 to address the safe, timely, and effective downstream passage of American eels in the Catawba-Wateree system.

Management and Direction

CAP Board

26. The Accord will be directed by a Board composed of one representative appointed by each CAP member. Each CAP member may designate an alternate who may function as its Board representative in the absence of the appointed Board member. It shall be the responsibility of each CAP member to notify other members in writing within 14 calendar days following any change of the name or contact information for its Board member and/or alternate. On an annual basis, the Board shall elect a chairperson ("Chair") and may elect other officers as deemed necessary. Initial terms for Board members will be staggered so that there is continuity in the operation of the Accord over the long term, with Duke and USFWS Board members serving three-year initial terms and SCE&G and state agency members serving two-year terms. Successive Board members will serve two-year terms. Meetings by the Board will be held in compliance with the Freedom of Information Act in the jurisdiction where the meeting is held.

27. The initial Board shall establish and schedule at least one meeting of the Board per calendar year (Annual Meeting) for the duration of the Accord. The Chair will select the meeting location and will develop an agenda and provide draft minutes of the previous meeting within two weeks following each meeting and require all members to return their comments within two weeks following receipt of the draft minutes. Additional meetings (Called Meetings) of the Board may be called by the Chair or upon the agreement of at least 25 percent of the Board members, but no Called Meeting that is not called by consensus vote by the Board may be held with less than four weeks prior written notice.

28. A quorum is required for the transaction of business (e.g., official votes) at any Board meeting. A quorum is defined as the presence of a representative or alternate of each CAP member participating in the Accord on the date of the meeting. Once a quorum is established, it may not be broken by departure of one or more members' representatives or alternates, and voting may occur once a quorum is established.

29. Failure to comply with terms of the Accord, including the prompt payment of a Utility's annual contributions, will result in the revocation of that member's right to vote until the failure to comply is remedied.

30. The representatives of the members, or their alternates, may participate, which participation includes voting, in meetings by any means of communication by which all participants may simultaneously hear each other during the meeting. A member's representative or its alternate participating in a meeting by this means is deemed to be present in person at the meeting. No proxy voting shall be permitted. A member's alternate shall not vote if that member's regular representative is present.

31. In addition to conducting its affairs at meetings, the Board may also validly exercise its authority in writing. A proposal may be presented, whether in written or electronic format, to each member's representative. Upon the approval, whether in written or electronic format, of each member's representative to that written proposal, the action of

the Board concerning the proposal will constitute a valid exercise of the Board's authority. A complete record of all action taken by the Board without meeting shall be filed with the minutes of the proceedings of the members, whether done before or after the action so taken.

32. Final decisions must be made by consensus of Board members or their alternates.

Technical Committee (TC)

33. A TC comprised of fishery biologists and/or other qualified professionals representing each CAP member will be established by the Board and will advise the Board on technical issues associated with the Accord. The TC will exist for the duration of the Accord.

34. The TC will develop consensus recommendations to the Board and will guide the design and implementation of all Plan tasks for the duration of the Plan. Following the expiration of the term of the Plan, the TC will function as a scientific advisor to the Board regarding all matters related to the restoration of diadromous fish in the Santee Basin.

35. Failure to allocate and disburse funds according to direction of the Board will result in the revocation of that member's right to participate or to vote on matters brought to the TC, until the failure to comply is remedied.

36. For the duration of the Accord, the TC will provide a brief written annual progress report to the Board by February 15 of the following year.

Communications Protocol

The Board will develop a protocol to communicate clearly on all Accord-related resource study, protection, restoration, and enhancement activities occurring in the Basin. All CAP members shall adhere to the Communications Protocol. It is the intent of the Accord to publicly disseminate all technical and scientific findings of its monitoring and study efforts.

Term of the Accord and the 10-year Action Plan

The effective date of this Accord shall be April 15, 2008. The Accord shall terminate for SCE&G at the end of the term of the new FERC license for the Saluda Hydroelectric Project (expected to be issued by the FERC in 2010) and for Duke at the end of the term of the new FERC license for the Catawba-Wateree Hydroelectric Project (expected to be issued in 2009). Each annual extension, if any, of the applicable new licenses by the FERC (commonly referred to as an "annual license") will also extend the term of the Accord for the applicable Utility by one year. Since diadromous fish restoration can be a long-term endeavor, the Board may desire to extend the term of the Plan, or to increase funding during its term. Through a consensus vote of its members, the Board may alter or modify Plan tasks and expenditures within those amounts currently established by the Plan and such Plan modifications do not require new signatures on the Accord from the authorized representative of each CAP member's organization.

The term of the Plan shall be April 15, 2008, through December 31, 2017, unless extended as noted above. The Board shall consider revision or renewal of the Plan in 2015 and shall decide by consensus of its membership if the Plan shall be revised or renewed. A decision not to extend or renew the Plan does not affect the obligations of and agreements among the CAP members contained in the Accord.

Dispute Resolution

Major disputes regarding the Accord, if at all possible, will be resolved by the Board through good-faith negotiations which may be assisted by selecting the services of a neutral mediator (cost of the mediator to be shared as determined by the Board).

Roles and Responsibilities for Implementing the 10-year Action Plan

Utilities

37. Utilities will fund the Plan with SCE&G providing $200,000 per year (unadjusted annual contribution) and Duke providing $500,000 per year (contributions expressed in 2008 dollars and to be adjusted annually using the Consumer Price Index). Additional funding secured through grants or other sources by the CAP may be incorporated into the budget and is encouraged. Funding levels provided by the original Utilities are set at that described above. If the costs of proposed activities and studies under the Plan exceed the funding provided by the Utilities, then later activities and studies under the Plan will be abandoned or reduced appropriately as determined by the Board to accommodate the funding level agreed to in this document, unless the necessary additional funding can be obtained by new utility participants, non-CAP member entities, grants and/or existing Fisheries Enhancement Plans from within the Basin. However, funding by non-CAP members will not render otherwise ineligible entities eligible to guide Accord activities or become members of the CAP.

38. In addition to the funding set forth in Paragraph 37, Utilities will provide technical/scientific input to program development, personnel and in-kind services (as appropriate), while conducting some studies, and will provide assistance in the scheduling and conduct of studies.

State and Federal Agencies

39. Agencies will provide technical/scientific input to program development, assistance in the scheduling of studies, personnel and in-kind services (as appropriate) while conducting some studies, and assistance in reporting study results.

40. Agencies will investigate and solicit any sources of supplemental or matching funds.

41. Agencies will assist, to the extent practicable, with the issuance of all applicable permits.

Fund Management

Funds to be contributed by the Utilities shall be maintained by each Utility and accounted for in a separate CAP Fund Account. The CAP Board will develop and adopt procedures concerning when the Utilities will deposit their contributions to this account and how disbursements from this account are approved. Each Utility shall provide annually, no later than March 31, a report of all fund deposits, disbursements, and balances for the previous calendar year. Any funds obtained by a Utility from other sources that are to be used solely in the execution of the Plan shall be included in that Utility's CAP Fund Account and shall be identified in the annual report as a contribution by others. The annual reports provided by the Utilities to the CAP Board will be provided to all CAP members. All such funds, whether contributed by Utilities or others shall be the exclusive property of the CAP to be disbursed and spent according to the Board.

Disbursements from a Utility's CAP Fund Account shall be made only at the consensus direction of the CAP Board. Each Utility owes a fiduciary duty to manage and account for the funds for the benefit of the CAP and to follow the CAP Board's direction for disbursements.

It is the desire of the Utilities that all monies contributed to the Plan be spent during the term of the Plan. In the event that the Plan is not extended and unspent funds are available at the conclusion of the Plan term, the Board will decide by consensus and direct the Utilities to allocate these monies to other ongoing programs of a similar nature and the Utility CAP Fund Accounts will be closed, after which each Utility shall submit to the CAP Board a final accounting report within 60 days following closing its account.

Reserved Authority

The Utilities recognize that the USFWS will reserve authority to alter its FPA §4(e) conditions and FPA §18 prescriptions for diadromous fish. The Agencies and Utilities agree that the Accord provisions are appropriately based on current knowledge of diadromous fisheries in the Santee River Basin. The USFWS believes it will be able to meet its FPA §§ 4(e) and 18 and ESA §7 obligations consistent with its Accord commitments.

State Commitments

The SCDNR agrees to use its best efforts to make this Accord a success. In the event that the USFWS exercises its reserved authority and issues a FPA §18 prescription or a FPA §4(e) condition, or an ESA §7 requirement, or the SCDHEC issues a CWA §401 certification that is inconsistent with, or would impose obligations in addition to those set forth in the Accord or Project settlement agreement with the SCDNR, the SCDNR may exercise any procedural and substantive rights it may have to contest such a prescription, condition, or requirement.

The NCWRC agrees to use its best efforts to make this Accord a success. In the event that the USFWS exercises its reserved authority and issues a FPA §18 prescription or a FPA §4(e) condition, or an ESA §7 requirement, or the North Carolina Division of Water Quality issues a CWA §401 certification that is inconsistent with, or would impose obligations in addition to those set forth in the Accord or Project settlement agreements with the NCWRC, the NCWRC may exercise any procedural and substantive rights it may have to contest such a prescription, condition, or requirement.

Modification of the Accord

This Accord may be modified; however, except for modifications of the Plan as described above, no modification of the Accord will be effective or valid unless it is signed by the authorized representative of each CAP member's organization.

Miscellaneous Agreements

No Admission of Liability – The Accord is a compromise, balancing many interests. The actions taken hereunder are not intended nor shall be construed as an admission on the part of any CAP member, or its agents, representatives, attorneys or employees that such CAP member was so obligated in any manner independent of this Accord. Except as provided herein, no CAP member shall be prejudiced, prevented, or estopped from advocating in any manner or before any entity, including the FERC or any state agency, any position inconsistent with those contained in this Accord regarding the licensing, permitting and license compliance of these or any other hydropower projects other than those addressed in this Accord.

Accord Terms Contractual/Merger – The terms of the Accord are contractual and not mere recitals. This Accord, which includes and fully incorporates any and all Appendices and the Plan, constitutes the entire agreement among the CAP members with respect to the subject matter hereof. All prior contemporaneous or other oral or written statements, representations or agreements by, between or among any of the CAP members, with respect solely to fish passage and fishway prescriptions of the subject Projects are superseded hereby. Nothing herein shall be construed to affect, negate, or supersede obligations and benefits arising from Duke's Comprehensive Relicensing Agreement and SCE&G's potential settlement agreement for the Saluda Hydroelectric Project regarding reservoir elevation limitations, required flow releases, low inflow protocols or high inflow protocols.

Enforceability – All terms of the Accord not incorporated as FERC License Articles shall be enforced through remedies available under applicable state or federal law.

Compliance with Laws – It is the responsibility of the CAP members to comply with all applicable federal, state and local laws, codes, rules, regulations, and orders of any governmental authority, and, except as otherwise provided herein, each CAP member will obtain, at its own expense all permits and licenses pertaining to its obligations under the Accord. The Accord is not intended and shall not be construed as a defense to or a limitation on civil or criminal liability in any action brought by any governmental entity to enforce any law and shall not limit the assessment or award of any fees, fines, penalties, remediation costs or similar liabilities in any such enforcement action.

Force Majeure – The Parties agree that a CAP member shall not be in breach of the Accord to the extent that any delay or default in performance is due to causes beyond the reasonable control of the delayed or defaulting CAP member; provided, that the delayed or defaulting CAP member notifies the other CAP members as soon as possible of: (A) the event; (B) the expected duration of the event; and (C) the delayed or defaulting CAP member's plan to mitigate the effects of the delay or default. Such causes may include, but are not limited to, natural disasters, labor or civil disruption, acts of terrorism, the inability to secure any legal authorization from another entity (e.g., a permit or license) where such legal authorization is a prerequisite or requirement for complying with the Accord, or breakdown or failure of the affected Project's works, so long as such causes are beyond the reasonable control of the delayed or defaulting CAP member.

Applicable Law and Venue – This Accord shall be governed by the law of the state wherein the subject hydroelectric development is located. Execution of the Accord does not constitute a consent to jurisdiction of any court unless such jurisdiction otherwise exists. Execution of the Accord also does not constitute a waiver of any immunity or privilege except as provided by law.

Waiver Independence – No consent to or waiver of any provision of the Accord shall be deemed either a consent to or waiver of any other provision hereof, whether or not similar, or a continuing consent or waiver unless otherwise specifically provided.

Water Rights Unaffected – Except as between the Parties hereto and as specifically set forth in this Accord, the Accord does not release, deny, grant or affirm any property right, license or privilege in any waters or any right of use in any waters. The Accord does not authorize any person to interfere with the riparian rights, littoral rights or water use rights of any other person. No person shall interpose the Accord as a defense in an action respecting the determination of riparian or littoral rights or other water use rights.

Parties' Own Costs – Except as expressly provided for in the Accord, all CAP members are to bear their own costs of participating in the Accord.

Existing Laws – Unless otherwise noted, any reference to any statute, regulation or other document refers to the statute, regulation or document as it exists on the date of the first signature on the Accord.

No Third-Party Beneficiary – The Accord shall not create any right in any individual or entity that is not a signatory hereto or in the public as a third-party beneficiary. This Accord shall not be construed to authorize any such third party to initiate or to maintain a suit in law or equity or other administrative proceeding.

No Commitment of Funds – Nothing in the Accord shall be construed as obligating any federal, tribal, state, or local agency to expend in any fiscal year any sum in excess of appropriations made by Congress, tribal councils, or state or local legislatures or administratively allocated for the purpose of this Accord for the fiscal year or to involve any federal, tribal, state, or local agency in any contract or obligations for the future expenditure of money in excess of such appropriations or allocations.

No Government Agency Delegation – Nothing in the Accord shall be construed as requiring or involving the delegation by any government agency to any other body of any authority entrusted to it by Congress, tribal council, or by the legislature of any state.

Successors and Assigns – The Accord shall apply to, and be binding on, the CAP members, their successors, transferees and assigns. No change of ownership in a Project or transfer of a license shall in any way modify or otherwise affect any other CAP member's interests, rights, responsibilities, or obligations under the Accord. (See the General section of the Accord for a list of Projects and current licensees.) Unless prohibited by applicable law, the licensee of the affected Project shall provide in any transfer of the existing or new license for the Project, that such new owner shall be bound by, and shall assume the rights and obligations of the Accord upon completion of the change of ownership. In the event applicable law prohibits the new owner from assuming the rights and obligations of the Accord, any CAP member may withdraw from the Accord. The licensee of the affected Project shall provide written notice to the other CAP members at least 90 days prior to completing such transfer of the license.

Caption Headings – The paragraph titles and caption headings in the Accord are for convenience of reference and organization, are not part of the Accord, and shall not be used to modify, explain, interpret, or define any provisions of the Accord or the intention of the CAP members.

Limitation of Applicability – The CAP members have entered into the negotiations and discussions leading to the Accord with the explicit understanding that all discussions relating thereto are to be considered as settlement negotiations, shall not prejudice the position of any CAP member or entity that took part in such discussions and negotiations, and are not to be otherwise used in any manner in connection with these or any other proceedings. The CAP members understand and agree that execution of the Accord establishes no precedents, does not admit or consent to any fact, opinion, approach, methodology, or principle except as expressly provided herein.

Execution in Counterparts – This Accord may be signed in counterparts to expedite signatures, and shall become binding between the Utilities and the Agencies upon the last signature below by an authorized representative of each.

Full Legal Authority – Each signatory Party to the Accord represents that it has the full legal authority to execute this Accord and to bind the principal who it represents, and that by such representative's signature, such principal shall be bound upon full execution of the Accord.

Notices – Notices in connection with matters under the Accord shall be provided in writing and addressed to:

Hugh Barwick
Senior Environmental Resource Manager
Duke Energy Carolinas, LLC
526 South Church Street, P. O. Box 1006 (EC12Y)
Charlotte, NC 28201-1006
704/382-8614 FAX

William Argentieri, PE
Manager—Civil Engineering F/H Technical Services
South Carolina Electric & Gas Company
111 Research Drive
Columbia, SC 29203
803/933-7849 FAX

Bennett Wynne
Anadromous Fish Coordinator
NC Wildlife Resources Commission
901 Laroque Avenue
Kinston, NC 28501
252/522-9736 FAX

Richard Christie
FERC Coordinator
SC Department of Natural Resources
1771-C Highway 521 By-Pass South
Lancaster, SC 29720
803/286-5598 FAX

Tim Hall
USFWS Field Supervisor
176 Croghan Spur Rd., Suite 200
Charleston, SC 29407
843/727-4218 FAX

Brian Cole
USFWS Field Supervisor
160 Zillicoa Street
Asheville, NC 28801
828/258-5330 FAX

AGREED TO BY THE AUTHORIZED REPRESENTATIVES OF THE PARTIES NAMED BELOW ON THE DATES SHOWN BY THEIR SIGNATURES:

SOUTH CAROLINA ELECTRIC & GAS COMPANY

By: ____________________ Date: 4/18/08
James M. Landreth
Vice President, Fossil Hydro Operations
111 Research Drive
Columbia, SC 29203

DUKE ENERGY CAROLINAS, LLC

By: ____________________ Date: 4/10/08
Steven D. Jester
Vice President, Hydro Licensing and Lake Services
526 South Church Street
Charlotte, NC 28202

U.S. FISH & WILDLIFE SERVICE

By: ____________________ Date: 4/25/08
Sam Hamilton
Regional Director, Southeast Region
1875 Century Blvd., Suite 400
Atlanta, GA 30345

S.C. DEPARTMENT OF NATURAL RESOURCES

By: ____________________ Date: 5/14/08
John Frampton
Director
1000 Assembly Street
Columbia, SC 29202

N.C. WILDLIFE RESOURCES COMMISSION

By: ____________________ Date: 4/21/08
Fred Harris
Interim Executive Director
1701 Mail Service Center
Raleigh, NC 27699-1701

Appendix A. Projected annual costs for tasks in the Santee River Basin Cooperative Fish Passage Accord 10-Year Action Plan[1].

	Years										Total for
Task	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	all years
Hatchery Operations	$ 340,000	$ 138,000	$ 142,000	$ 146,000	$ 151,000	$ 155,000	$ 160,000	$ 165,000	$ 170,000	$ 175,000	$ 1,742,000
Adult Shad Transport	$ 77,000	$ 80,000	$ 82,000	$ 84,000	$ 87,000	$ 90,000	$ 92,000	$ 95,000	$ 98,000	$ 101,000	$ 886,000
Elver Studies/Catawba-Wateree River	$ 43,000	$ 64,000	$ 46,000	$ 47,000	$ 75,000	$ 50,000	$ 52,000	$ 82,000	$ 55,000	$ 56,000	$ 570,000
Juvenile Shad Monitoring		$ 106,000	$ 109,000	$ 113,000	$ 116,000	$ 119,000	$ 123,000	$ 127,000	$ 130,000	$ 134,000	$ 1,077,000
Adult Shad Migration		$ 159,000						$ 190,000			$ 349,000
Sturgeon Studies			$ 109,000	$ 113,000	$ 116,000	$ 119,000	$ 123,000				$ 580,000
Elver Studies/Parr									$ 65,000	$ 34,000	$ 99,000
Estimated Annual Costs	$ 460,000	$ 547,000	$ 488,000	$ 503,000	$ 545,000	$ 533,000	$ 550,000	$ 659,000	$ 518,000	$ 500,000	$ 5,303,000
Available Funds	$ 700,000	$ 715,000	$ 730,450	$ 746,364	$ 762,755	$ 779,638	$ 797,027	$ 814,938	$ 833,386	$ 852,388	$ 7,731,946
Fund Balance[2]	$ 240,000	$ 408,000	$ 650,450	$ 893,814	$ 1,111,569	$ 1,358,207	$ 1,605,234	$ 1,761,172	$ 2,076,558	$ 2,428,946	

[1] Assumes an annual 3% inflation rate for all items except contributions by South Carolina Electric and Gas Company.

[2] Fund balance or contengency is the difference between the estimated task costs and available funds for that year, and includes the balance from the previous year.

Appendix B. No-sooner-than dates, total restorational numbers, and biological triggers for construction of fish passage facilities at selected Santee River Basin hydroelectric dams.

Utility	Dam	Date	Total number[1]	50% Trigger[2]	75% Trigger[3]
SCE&G	Saluda	Deferred	NA[4]	NA	NA
	Columbia[5]	2007	92,800 (464,000)	46,400 (185,600)	69,600 (348,000)
	Parr	2012	128,150 (640,750)	64,075 (320,325)	96,112 (480,562)
	Neal Shoals	2016	37,400 (187,000)	18,700 (93,500)	28,050 (140,250)
Duke	Wateree[6]	2018	NA	NA	NA

[1] **Total restoration numbers for adult andaromous American shad (blueback herring) developed by the USFWS from surface acreage** calculations of the river (including available tributaries) from that dam to the next dam upstream.

[2] **50% trigger or when 50% of the total restoration numbers for adult anadromous American shad (blueback herring) for the unblocked** reach upstream of the dam are being passed at that dam. This would initiate a Fish Passage Feasibility Assessment at the upstream dam.

[3] **75% trigger or when 75% of the total restoration numbers for adult anadromous American shad (blueback herring) for the unblocked reach upstream of the dam are being passed at that dam. This would initiate construction of a Fish Passage Facility at the upstream dan**

[4] NA = Not applicable

[5] Volitional Fish Passage Facility is operational and passage is currently being evaluated.

[6] Trap and Truck Fish Passage Facility operational by January 1, 2018.

Appendix C. **River miles, surface acreages of the mainstem river and associated tributaries, and restoration numbers (fish/acre) calculated** for adult anadromous American shad and blueback herring from selected reaches of the Broad River.

Restoration phase and Reach	River miles	Mainstem acres	Tributary acres	Total acres	Shad[1]	Herring[2]
Phase 1						
Columbia Dam to Parr Shoals Development Dam	24	1,758	98	1,856	92,800	464,000
Phase 2						
Parr Shoals Development Dam to Neal Shoals Dam	31	2,106	457	2,563	128,150	640,750

[1] American shad restoration numbers are the product of total acres and 50 fish/acre.

[2] Blueback herring restoration numbers are the product of total acres and 250 fish/acre.