PARR HYDROELECTRIC PROJECT
FERC NO. 1894

FINAL
DESKTOP FISH ENTRAINMENT
STUDY RESULTS

Prepared for:

South Carolina Electric & Gas Company
Cayce, South Carolina

Prepared by:

Kleinschmidt

Lexington, South Carolina
www.KleinschmidtGroup.com

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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				
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 2-2 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
	December	2.97	9,167	**27,226**	
Winter	January	2.97	9,786	**29,065**	**84,590**
	February	2.97	9,528	**28,299**	
	March	3.41	12,131	**41,367**	
Spring	April	3.41	10,481	**35,740**	**105,806**
	May	3.41	8,416	**28,699**	
	June	7.4	6,932	**51,300**	
Summer	July	7.4	6,163	**45,606**	**138,679**
	August	7.4	5,645	**41,773**	
	September	4.17	5,348	**22,302**	
Fall	October	4.17	5,070	**21,141**	**69,322**
	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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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).

<u>Estimation of Fish Entrainment</u>

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.

<u>Species Composition Analysis</u>

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.

<u>Application of Physical or Biological Filters</u>

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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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 species 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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Kleinschmidt. 1996. Lockhart Project Fish Entrainment Analysis FERC No. 2620. An Estimate of the Annual Number of Fish Entrained Through Turbines at the Lockhart Project, Broad River, South Carolina.

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.

[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.

Kleinschmidt

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	

Kleinschmidt

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*

Kleinschmidt

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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**

Kleinschmidt

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

	# released	# recovered	immediate # live	survival recovered
ALCONA				
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%
walleye	92	92	69	75%
white 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%
walleye	115	115	95	83%
white 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%
white 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%
walleye	no data	38	36	95%
white 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, white 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

	# released	# recovered	immediate # live	survival recovered
Bond Falls				
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, white sucker, golden/shorthead redhorse	844	803	520	65%
Colton				
	# released	# recovered	immediate # live	survival recovered
white 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%
walleye	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%
walleye	42	40	31	78%
white 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.

<u>Revised Memo #1</u>

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.

<u>Memo #2</u>

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

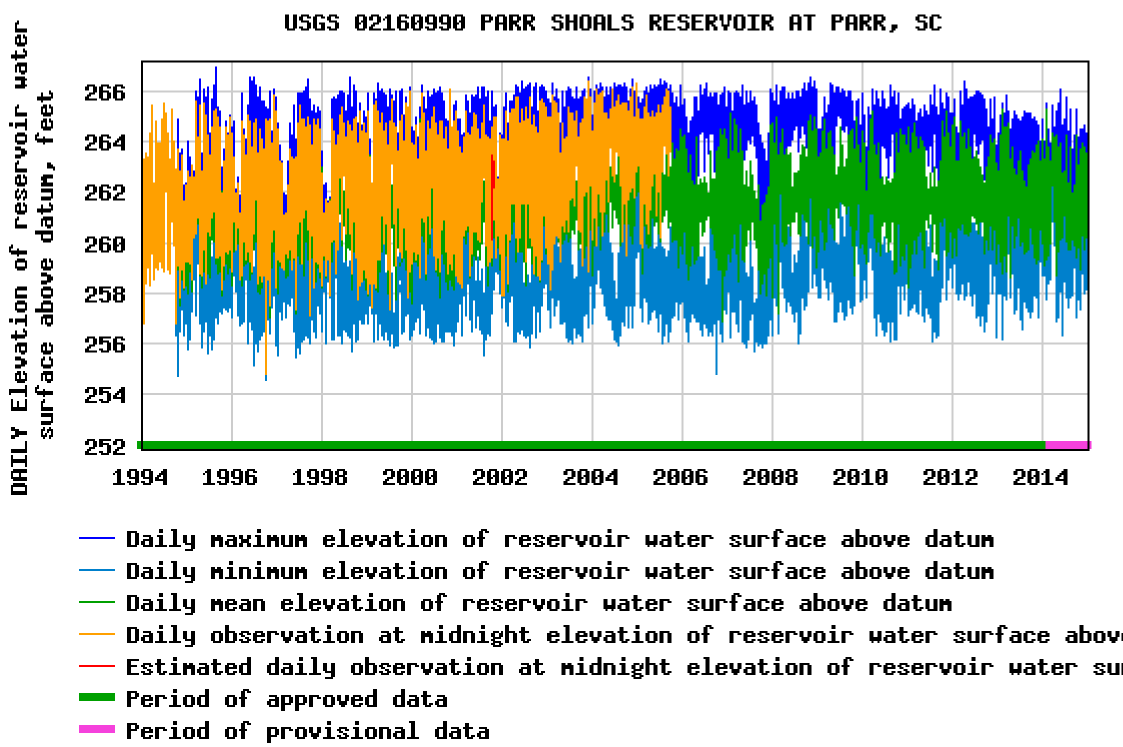
Considering the statistical ranking of the annual average flows, the period 2000 – 2010 includes the two years with the lowest average flow (2001 and 2008), as well as the highest average flow year (2003). The remaining years are at the 50 percent ranking or below, with 6 years in the lowest quartile. 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%

Summary

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)
Brandon Stutts (SCANA)
Hal Beard (SCDNR)
Ron Ahle (SCDNR)
Jordan Johnson (Kleinschmidt)
Shane Boring (Kleinschmidt)
Milton Quattlebaum (SCANA)
Steve Summer (SCANA)
Bill Marshall (SCDNR)
Dick Christie (SCDNR)
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 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.