SOUTH CAROLINA ELECTRIC & GAS COMPANY

COLUMBIA, SOUTH CAROLINA

SALUDA HYDROELECTRIC PROJECT
FISH ENTRAINMENT AND TURBINE MORTALITY ANALYSIS

(FERC No. 516)

AN ESTIMATE OF THE ANNUAL NUMBER OF FISH ENTRAINED AND SUBSEQUENT TURBINE MORTALITY AT THE SALUDA HYDRO PROJECT
LAKE MURRAY, SOUTH CAROLINA

FINAL TECHNICAL WORKING COMMITTEE VERSION

MARCH 2007

Prepared by:

Kleinschmidt

Energy & Water Resource Consultants

SOUTH CAROLINA ELECTRIC & GAS COMPANY
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SALUDA HYDRO PROJECT
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SALUDA FISH ENTRAINMENT AND TURBINE MORTALITY REPORT

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1.0 INTRODUCTION

The Saluda Hydro project (FERC project No. 516) is an existing licensed hydroelectric facility with a rated capacity of 202.6 MW, owned and operated by the South Carolina Electric & Gas Company (SCE&G) (Licensee). The project is located on the Saluda River and lies within the boundaries of Richland, Lexington, Saluda, and Newberry Counties of South Carolina, near the towns of Irmo and Chapin, approximately 10 miles west of the city of Columbia.

1.1 Project Description

Present day components of the project consists of Lake Murray, the Saluda Dam, the new back-up Saluda Berm, Spillway, Saluda powerhouse, intake towers and associated penstocks. The 2,420 square mile watershed area, drained by the Saluda River and it's tributaries above the Saluda Dam, provide water for the project's impoundment, Lake Murray, and the Saluda Hydroelectric plant. The project is currently licensed by the Federal Energy Regulatory Commission (FERC No. 516) and the present license is due to expire in the year 2010.

1.2 Project Background

The Licensee prepared and issued the Initial Consultation Document (ICD) on April 29, 2005, in order to initiate the relicensing process for the Project. The Licensee submitted the document to a number of state and federal resource agencies for their review and comment. As a result, the United States Fish and Wildlife Service (USFWS) and the South Carolina Department of Natural Resources (SCDNR) requested studies to determine the potential impact of project operation on the project's fishery resources, and recommended that the Licensee assess potential fish entrainment effects on the fishery resources due to project operation.

In response to resource agency requests for studies in support of relicensing, SCE&G proposed to develop an entrainment estimate for the project based on the extensive entrainment database that currently exists from previous hydroelectric relicensing studies. Resource agencies agreed with SCE&G's proposal to determine potential fish entrainment effects through a "desktop analysis" (see Fish and Wildlife RCG meeting notes dated February 22, 2006 Appendix A). SCE&G prepared a draft entrainment study plan, which was submitted to the resource agencies on April 17th, 2006 and was approved on May 9th, 2006 (Appendix A).

The goals of this "desktop" Entrainment study were to:

1) Define the entrainment database that could be applied to the Saluda Hydro Project.
2) Calculate a potential estimated fish entrainment rate(s) (with seasonal rates if possible).
3) Characterize the species composition of potential fish entrainment.
4) Estimate the potential total annual entrainment for the Saluda Hydro Project.
5) Estimate potential turbine mortality for fish entrainment based on turbine mortality estimates from similar project studies.

2.0 METHODOLOGY

The study approach utilized in developing potential fish entrainment estimates for the Saluda Hydro Project was based on the successful methodology adopted during the previous relicensing of the Lockhart Power Hydroelectric Project (FERC No. 2620) and the Columbia Hydroelectric Project (FERC No. 1895). Estimated turbine-induced mortality rates (based on mortality studies for similar type turbines) were applied to the fish entrainment estimates to determine potential project related impacts to the local fisheries resources.

The following sections detail the steps taken to calculate the potential annual estimated fish entrainment and potential turbine-induced mortality for the Saluda Hydro Project.

2.1 Entrainment

Fish entrainment is the passage of fish through the trash rack, penstock, and turbines into the tailrace of a hydropower development. Fish entrainment at the Saluda Hydro Project was assessed through a desktop study. The goal of this study was to characterize and provide an order-of-magnitude estimate of potential fish entrainment using existing literature and site specific information. The primary steps in this analysis include:

- Define the entrainment database that can be applied to the Saluda Hydro Project;
- Use the entrainment database to develop potential fish entrainment rates and species composition;
- Determine the average monthly turbine flows for Units 1 through 5; and
- Estimate the number and species composition of fish potentially entrained through the Saluda Hydro Project.

2.2 Define the Entrainment Database

Over sixty (60) 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)(Appendix B, Table B-1). Descriptive information was gathered from each entrainment study and includes:

- Project name and FERC project number;
- Location: state and river;
- Project size: discharge capacity and power production;
- Physical project characteristics: trash rack spacing, intake velocity, etc.;
- Project operation: e.g., peaking run-of-river, etc.;
- Biological factors: fish species composition; and
- Impoundment characteristics: general water quality, impoundment size, flow regime.

This information was assembled into a “screening matrix” of data that could potentially be used for this study. Specific studies were selected from the screening matrix that were the most applicable to the Saluda Hydro Project. Criteria used in selecting specific studies were as follows:

- Similar geographical location, with preference given to projects located in the same basin;
- Similar station hydraulic capacity;
- Similar station operation (peaking, pulsing, run-of-river, etc.);
- Biological similarities: fish species, assemblage and water quality; and
- Availability of entrainment netting data.

Using these criteria, the list of entrainment studies accepted for transfer to the Saluda Hydro project was winnowed to six (6) sites. Summaries of the selected studies are provided in Appendix C of this report. These sites were the Ninety-nine Islands (FERC No. 2331), Gaston Shoals (FERC No. 2332), Neal Shoals (FERC No. 2315), Hollidays Bridge (formerly FERC No. 2465), Saluda Station[1] (formerly FERC No. 2406) and Richard B. Russell (USACOE) projects. Two of these projects, Hollidays Bridge and Saluda Station (FERC No. 2406) are located on the Saluda River. Richard B. Russell project is located along the Georgia/South Carolina boarder. The other three projects, Gaston Shoals, Ninety-nine Islands, and Neal Shoals, are located on the Broad River (adjacent to the Saluda River).

2.3 Fish Entrainment Rates

The entrainment rate information from the six selected entrainment studies was consolidated to reflect potential fish entrainment rates on a seasonal basis. Preference was given to netting entrainment rates over hydroacoustic entrainment rates. In an effort to make each project's entrainment data comparable, entrainment rates were converted to fish per million cubic feet of water passed through the project turbines. This conversion was based on the reported number of fish entrained per hour of netting collections and the respective turbine capacities of the unit that was sampled at each project during monthly entrainment collections. Entrainment rate data was then grouped by season to determine an entrainment rate for each season of the year. The seasonal rates were used to develop an average seasonal entrainment rate for the Saluda Hydro Project.

2.4 Turbine Flows

Water is supplied to the powerhouse through five intake towers upstream of the dam and routed through individual penstocks to the powerhouse turbines (FERC 2002). Units 1 through 4 pull water from near the bottom of the lake at a depth of about 190 feet, while Unit 5 pulls water from a depth of about 80 feet deep from the surface. SCE&G operates Unit 5 as "last on, first off," due to environmental and operational factors. Because long term operational records for each Unit were difficult to access, turbine operations for Units 1 through 4 versus Unit 5 were estimated using the historic flow record for the lower Saluda River (Appendix D, Table D-1). Calculations for this step are based on monthly historic recorded USGS data for the water years of 1978 to 2003.

[1] Saluda Station (FERC No. 2406) is located on the Saluda River in Anderson, Greenville, and Pickens Counties, South Carolina. Mark Sundquist and Co. from North Brook Electric is the current licensee of the Saluda Station.

2.5 Species Composition

Species composition refers to the species of fish typically entrained at hydroelectric projects in the study database. When examining the species composition database, it was observed that there were slight species-level differences between the fisheries data collected from Lake Murray (Saluda Hydro Project) and each of the entrainment study sites. This was especially evident in comparisons with the five smaller projects with small impoundments. Therefore, seasonal family composition data from Richard B. Russell project is proposed as a better estimator for species composition of entrainment for the Saluda Hydro Project. For better accuracy, we subdivided the family Centrarchidae into Sunfish and Micropteran (Bass) components.

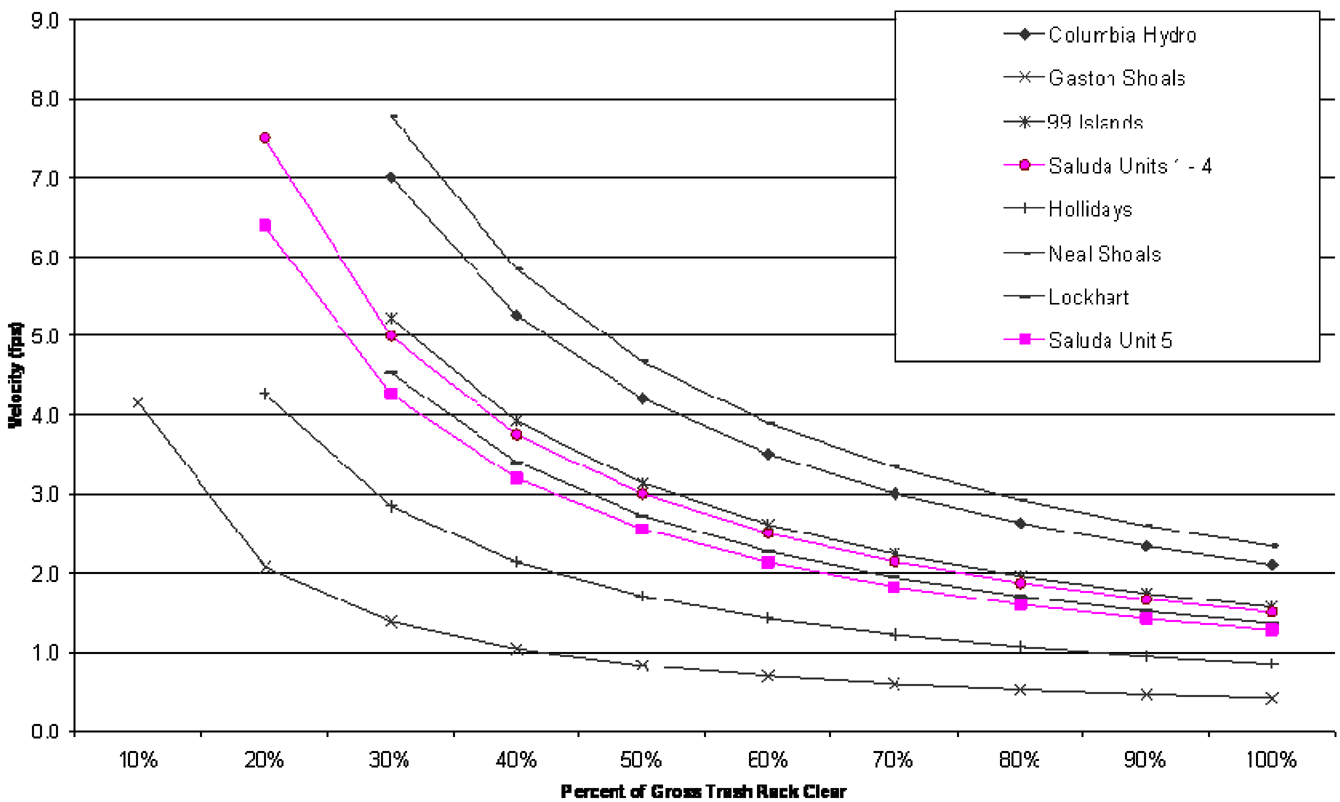
2.6 Entrainment Filters

Physical differences between the studies included in the entrainment database and the Saluda Hydro could potentially affect overall entrainment estimates. Three typical differences considered for this evaluation were average intake velocity, trash-rack spacing, and depth of turbine intake in relation to lake stratification.

When average intake velocities of the Saluda Hydro Project were compared with those of the entrainment database, average intake velocities were within a similar range (Figure 2-1). The average intake velocity for Units 1 – 4 is 2.21 ft/sec and for Unit 5 is 3.83 ft/sec. It is important to note that these intake velocities are based on maximum hydraulic capacity for each unit (3,000 cfs for Units 1-4, and 6,000 cfs for Unit 5), which is not the typical operation of the units.

Trash rack bar spacing can potentially prevent fish over a certain width from becoming entrained but can also result in impingement of the fish on the trash rack. Because the trash rack spacing on each unit at the Saluda project is approximately 4 in. clear space (4 5/8 in. on center), the racks should not reduce entrainment estimates or result in potential impingement. This assumption is based on examining the estimated swimming speed of fish and the average intake velocity of the project. The relationship of fish length (total length) to sustained swimming speed and intake velocity was examined by using the formula developed by the USFWS (1989) for addressing entrainment at power plants. Swimming Speed X Fish Length (ft.) = Intake Velocity (ft/sec) (3 to 7 body lengths/sec)

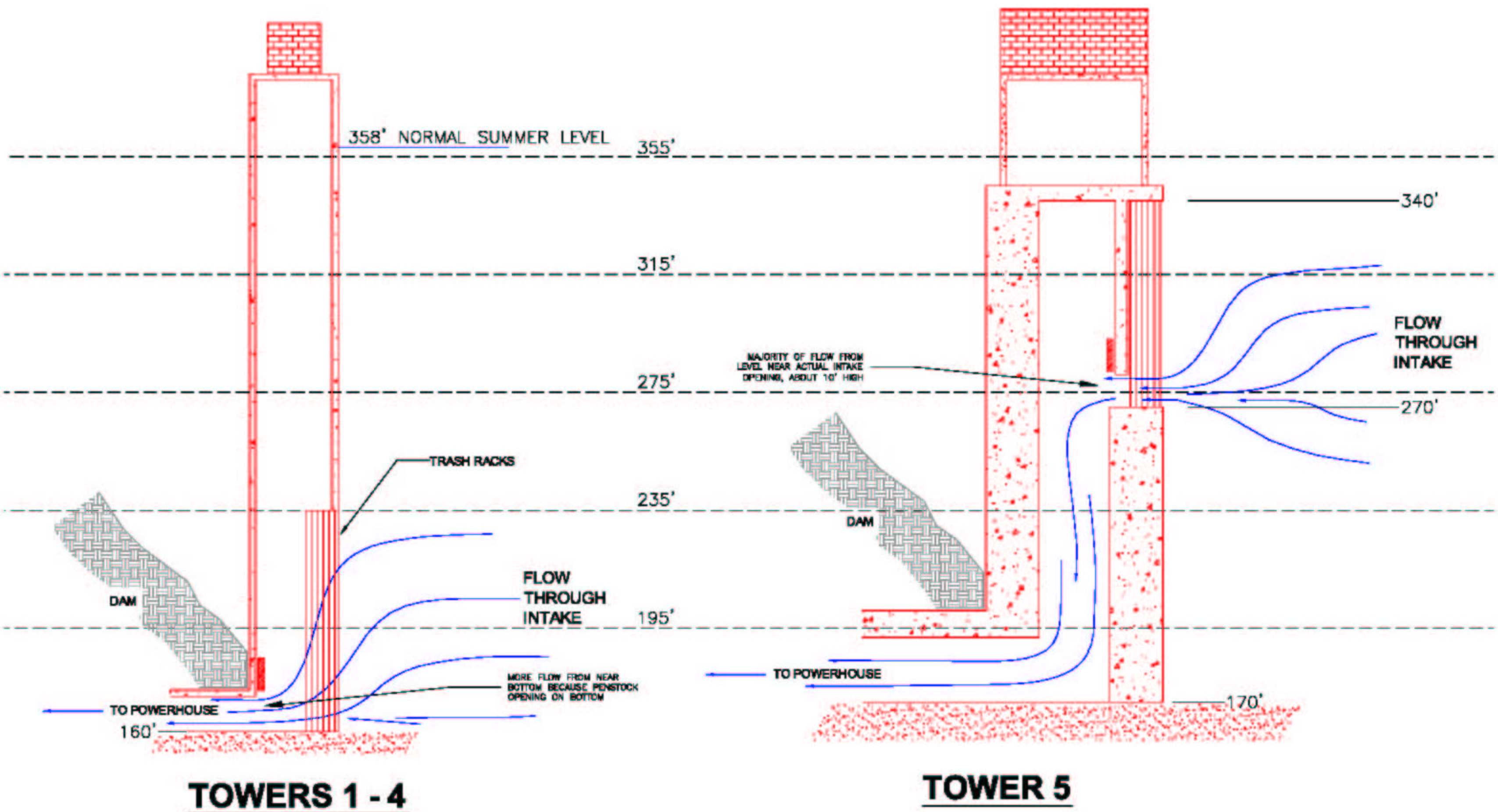
Figure 2-1: Comparison of Estimated Intake Velocities (fps) with Varying Trash Rack Clearance for Several South Carolina Hydroelectric Projects



In this relationship a minimum sustained swimming speed of 3 to 5 body lengths/sec is considered to be conservative and 6 to 7 body lengths is liberal (closer to burst speed). Using a conservative swimming speed of 4 body lengths/sec and the average intake velocity of Units 1-4 (2.21 ft/sec at maximum generation), it is estimated that all fish less than 6 ½ inches (in length) in the vicinity of the intakes could be entrained into the project. It is apparent that the 4 inch wide spacing would not restrict or impinge fish of this size.

However, lake stratification when compared with intake depth could have an influence on entrainment estimates. Since the intakes for Units 1-4 are located approximately 190 ft. deep (from maximum pool) (Figure 2-2) and the lake is typically stratified with very little dissolved oxygen in the hypolimnion from July through November, entrainment rates for Units 1-4 should be adjusted to zero (0) for these months (Kleinschmidt, 2005). Upon consideration of the depth of Unit 5 (80 ft deep at full pool) and the fact that lake stratification doesn’t typically extend this deep during the year, the entrainment rates for Unit 5 should not be adjusted.

Figure 2-2: Intake Towers for Units 1 Through 4 and Unit 5



2.7 Calculation of Entrainment Estimates

The proposed calculation of entrainment estimates for the Saluda Hydro Project 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

The Estimated Number of Fish Entrained by Month (Step #1) is calculated by multiplying the seasonal entrainment rates from the 6-study database by the mean monthly project flow at the Saluda Hydro Project. Step # 2 is calculated by adding the three months of entrainment together for each season. In Step #3, results from #2 are multiplied by seasonal species composition percentages from the Richard B. Russell fish entrainment. Step #4 involves adjusting the entrainment rates to zero for Units 1-4 from June through October.

2.8 Turbine Mortality

Turbine passage survival studies have been performed at numerous hydroelectric projects throughout the country over the past 15 or more years. Characteristics of these identified projects were compared to the characteristic of the Saluda Hydro Project and appropriate studies were selected for the transfer of turbine mortality data.

The Saluda Hydro turbines are Francis-type runners, with an operating head of 180 ft. Units 1 through 4 have a rotational speed of 138.5 rpm and runner diameter of 144 inches. Unit 5 has a rotational speed of 128.6 rpm and a runner diameter of 175 inches. The literature suggest, that for large fish, size of wicket gates, number of blades, and guide vane clearances may be the most important mortality factors, along with operating efficiency. For fish, the most frequently cited significant mortality factors relating to the hydraulic passage environment for Francis runners are runner speed, peripheral runner velocity, head, and cavitations (Semple, 1979, Turbak, et al., 1981, Ruggles and Palmeter, 1989, Cada, 1990, EPRI, 1992).

In a Francis unit (where fish enter the turbine chamber along the periphery of the turbine housing), the runner speed (rpm) influences the probability of a fish encountering a turbine blade (Rochester, et al., 1984). For a given turbine size, the faster the runner is rotating, the opening through which the fish must pass is clear less often. RPM therefore dictates the opening between the turbine and the unit housing through which the fish pass. Head indirectly affects turbine mortality by dictating Francis turbine design and operating characteristics, such as peripheral runner velocity and cavitations, which in turn are believed to more directly affect fish.

2.9 Turbine Mortality Rate

Since the Saluda Hydro Project is equipped with Francis-type turbines, studies from the turbine mortality database were separated based on whether they were performed at sites with propeller or Francis-type turbines. The sites were then sorted based on several characteristics including station head, runner diameter, and runner speed.

Information on each turbine mortality study is provided in Appendix E. The study information contained in Table E-1 includes (where available) species type tested, size class/range tested, number of fish tested (test and control), and survival results. The study information is sorted by species type tested.

2.10 Calculation of the Turbine Mortality Estimate

Estimates of turbine mortality were calculated by applying the mortality rates from the study database to the entrainment estimates of the Saluda Hydro Project. Since turbine parameters for units 1-4 and unit 5 are similar in range, one mortality estimate was calculated for the Saluda Hydro Project.

3.0 RESULTS

As previously described, the calculation of annual estimated fish entrainment for the Saluda Hydro is based on a methodology developed with the USFWS and SCDNR during relicensing of the Lockhart Hydroelectric Project (FERC No. 2620).

3.1 Fish Entrainment Rates

Table 3-1 depicts entrainment rate information from the six selected entrainment studies in fish/million cubic feet of water.

Table 3-1: Entrainment Rates from the Study Database (fish/million cubic feet of water)

SITE NAME	WINTER	SPRING	SUMMER	FALL	ANNUAL AVERAGE
Ninety-nine Islands	2.8	2.5	4.5	3.8	3.4
Gaston Shoals	1.1	2.4	8.7	2.1	3.6
Neal Shoals	3.5	5.0	8.7	4.9	5.5
Hollidays Bridge	2.1	7.3	7.1	2.4	4.7
Saluda Station	5.4	N.A.	8.0	7.6	N.A.
Richard B. Russell	13.8	0.9	0.7	1.2	4.2
Seasonal Average	4.8	3.6	6.3	3.7	4.3

3.2 Turbine Flows

Calculations for these steps are based on monthly historic recorded USGS data for the water years of 1978 to 2003. The Monthly flow duration curves for the lower Saluda River were calculated by using the mean daily flow data from USGS gage Nos. 02169000 (Saluda River Near Columbia, SC) and 02168504 (Saluda River Below LK Murray Dam NR Columbia, SC). The data from these two gages were combined to form flow duration curves shown in Appendix D. The period of record for the data that is depicted in these graphs extends from 1979 through 2003 (Appendix D, Table D-1). Since gage number 02168504, directly downstream from the dam, was not installed until 1988, data from gage 02169000 was also used (pro-rated based on drainage area) to develop this historic operation database.

Units 1 through 4 have a total capacity of approximately 12,000 cfs (3,000 cfs each). Therefore, only Units 1 through 4 were assumed to be operating when flows were less than 12,000 cfs. Total operation time of Unit 5 was determined by examining the percentage of time the USGS gage flows exceeded 12,000 cfs. Using time of operation, total flow was calculated by assuming that Unit 5 was always operating at 6,000 cfs whenever it was on (Table 3-2).

Example: January had 4% flows over 12,000 cfs
*6000 cfs * 3600 sec/hr * 31 days * 24 hr * 0.04 percent over 12,000 cfs =*
642,816,000 cubic feet
million cubic feet = 642.816

The total average flows (cubic ft) for all units combined were calculated for each month, and flow through Units 1 through 4 were determined after subtraction of the estimated flows through Unit 5 (calculated above).

Example: February had total average flow of 3737 cfs for units 1-5
Unit 5 had a average flow of 585,792,00 cubic feet for February
*3737 cfs * 3600 sec/hr * 28.25 days * 24 hr – 585,792,000 cubic feet =*
535,477,600 cubic feet
million cubic feet = 535.4776

Table 3-2: Average Historical Operation of Units 1-4 Based on Flow Duration Records 1979 – 2003 and Estimated Operation of Unit 5

	AVERAGE ANNUAL DAILY FLOW (CFS)	HOURS/ MONTH	TOTAL FLOW (CFS)	ESTIMATED OPERATION OF UNIT 5 (CFS)	TOTAL FLOW THROUGH UNITS 1-4 (CFS)
January	3,369	744	9,022,565,376	642816000	8,379,749,376
February	3,737	678	9,121,269,600	585,792,000	8,535,477,600
March	3,962	744	10,611,177,984	803,520,000	9,807,657,984
April	2,723	720	7,058,119,680	622,080,000	6,436,039,680
May	1,841	744	4,931,362,944	160,704,000	4,770,658,944
June	1,849	720	4,792,608,000	77,760,000	4,714,848,000
July	2,221	744	5,948,512,128	0	5,948,512,128
August	2,368	744	6,342,879,744	160,704,000	6,182,175,744
September	2,308	720	5,982,750,720	0	5,982,750,720
October	2,150	744	5,758,131,456	160,704,000	5,597,427,456
November	2,072	720	5,370,209,280	0	5,370,209,280
December	2,529	744	6,772,602,240	80,352,000	6,692,250,240

*For more information on Unit 5 operations, see Appendix D, Table D-2

These flow estimates were then used in subsequent calculation of potential entrainment of fish through Units 1 through 4 and Unit 5.

3.2.1 Step 1 – Total number of Fish Entrained by Month

The estimated total number of fish entrained monthly by each project is based on two parameters: seasonal fish entrainment rate (fish per million cubic feet (mcf) of water) and project operation (mcf of water passed through the turbines – average flow during normal water years). The estimated fish entrained monthly was calculated by multiplying the appropriate seasonal fish entrainment rate from the 6-study database by the average volume of water passed through the turbines monthly during average generation years for the Saluda Hydro Project. The estimated total number of fish potentially entrained monthly and annually for the Saluda Hydro Project is presented in Table 3-3.

*Example: 5.0 fish/mcf of water * 1,000 mcf = 5,000 fish*

Table 3-3: Estimated Fish Entrainment at the Saluda Hydro Project Based on Project Generation Volume (million cubic feet)

	Month	Seasonal Entrainment Rate (fish/mcf)	Total Monthly Project Flows (mcf)	Total Estimated Number of fish Entrained by Month	Total Estimated Number of fish Entrained by Season
	December	4.8	6,773	32,398	
Winter	January	4.8	9,023	43,160	119,186
	February	4.8	9,121	43,629	
	March	3.6	10,611	38,412	
Spring	April	3.6	7,058	25,550	81,812
	May	3.6	4,931	17,850	
	June	6.3	4,793	30,116	
Summer	July	6.3	5,949	37,380	107,351
	August	6.3	6,343	39,855	
	September	3.7	5,983	21,938	
Fall	October	3.7	5,758	21,113	62,740
	November	3.7	5,370	19,690	

When all monthly entrainment estimates were calculated and summed the estimated annual fish entrainment for the Saluda Hydro Project was 371,089 fish.

3.2.2 Step 2 – Total Number of Fish Entrained by Season

To calculate the total number of fish entrained by season, sum the total number of fish entrained per month (from step 1) for each season according to the following:

Winter:	December, January, February
Spring:	March, April, May
Summer:	June, July, August
Fall:	September, October, November

Refer back to Table 3-3 to view the estimated total number of fish entrained for the Saluda Hydro Project for each season.

3.2.3 Step 3 – Number of Entrained Fish Within Each Family/Genus Grouped by Season

The percentages for each family/genus-group are based on the data collected at the Richard B. Russell field study (Richard B. Russell entrainment data is included in Appendix C) . The composition of entrained fish was represented as a percentage of the total number of fish entrained (e.g., Lepomids = 25%, Micropterans = 10%, Ictalurids = 9%, etc.) for each season. This calculation multiplies the seasonal entrainment estimates (from Step 2) by the Richard B. Russell seasonal family/genus percent composition data (Table 3-4) to produce a seasonal total for each family/genus group. The data are also shown on a seasonal basis to depict the effect of seasonal flow variation on estimated entrainment. Three groups that accounted for a majority of the estimated entrainment were the Lepomid, Ictalurid, and Shad families.

Example: *Total number of fish entrained in Spring = 100,000*
Spring composition percentage of Lepomids for Richard B. Russell = 25%
*100,000 * 0.25 = 25,000 Lepomids entrained in Spring for the Saluda Hydro Project*

The annual and seasonal number (and percent) of fish entrained by family-genus group at the Saluda Hydro Project is presented in Table 3-5.

Table 3-4: Seasonal Number of Fish Entrained, by Family-Genus Group at the Richard B. Russell Project by Percent

FAMILY/GENUS GROUP	SPRING	SUMMER	FALL	WINTER
Anguillidae	0.00	0.00	0.00	0.00
Aphredoderidae	0.00	0.00	0.00	0.00
Atherinidae	0.00	0.00	0.00	0.00
Catastomidae	0.03	0.02	0.00	0.01
Sunfish	2.29	3.25	1.38	0.15
Centrarchidae	2.34	7.34	0.06	0.02
Clupeidae	42.59	70.05	77.35	93.58
Cyprinidae	0.48	0.49	0.60	0.11
Esocidae	0.00	0.06	0.00	0.00
Ictaluridae	0.72	2.54	18.52	3.44
Lepisosteidae	0.00	0.02	0.00	0.00
Moronidae	5.03	0.34	0.03	0.00
Percidae	46.45	15.87	2.05	2.68
Poeciliidae	0.00	0.00	0.00	0.00
Salmonidae	0.00	0.02	0.00	0.00
TOTAL	**99.94**	**100.00**	**100.00**	**100.00**

*Differences in total percent due to rounding

Table 3-5: Annual and Seasonal Number (and percent) of Fish Entrained, by Family/Genus Group at the Saluda Hydro Project by Percent

	Spring		Summer		Fall		Winter		Total
Family/genus group	**Number of Fish**	**Percent of Fish**	**Number of Fish**	**Percent of Fish**	**Number of Fish**	**Percent of Fish**	**Number of Fish**	**Percent of Fish**	**Number of Fish**
Anguillidae	0	0.00	0	0.00	0	0.00	0	0.00	**0**
Aphredoderidae	0	0.00	0	0.00	0	0.00	0	0.00	**0**
Atherinidae	0	0.00	0	0.00	0	0.00	0	0.00	**0**
Catastomidae	21	0.03	26	0.02	0	0.00	8	0.01	**55**
Sunfish	1,873	2.29	3,484	3.25	865	1.38	175	0.15	**6,397**
Centrarchidae	1,916	2.34	7,878	7.34	40	0.06	27	0.02	**9,861**
Clupeidae	34,846	42.59	75,198	70.05	48,531	77.35	111,539	93.58	**270,113**
Cyprinidae	393	0.48	529	0.49	375	0.60	130	0.11	**1,427**
Esocidae	3	0.00	61	0.06	0	0.00	0	0.00	**64**
Ictaluridae	591	0.72	2,732	2.54	11,622	18.52	4,102	3.44	**19,046**
Lepisosteidae	0	0.00	24	0.02	0	0.00	1	0.00	**25**
Moronidae	4,118	5.03	362	0.34	21	0.03	5	0.00	**4,506**
Percidae	38,002	46.45	17,034	15.87	1,287	2.05	3,195	2.68	**59,517**
Poeciliidae	0	0.00	0	0.00	0	0.00	0	0.00	**0**
Salmonidae	0	0.00	25	0.02	0	0.00	0	0.00	**25**
TOTAL	**81,763**	**99.94**	**107,351**	**100.00**	**62,740**	**100.00**	**119,182**	**100.00**	**371,036**

*Differences in total percent due to rounding

3.3 Applying Entrainment Filters

As outlined in Section 2.6, it is recommended that the entrainment filter of lake stratification/water quality be included in the Saluda Hydro Project estimates. Because the intakes for Units 1-4 are located approximately 190 ft. deep (from maximum pool) and the lake is typically stratified with very little dissolved oxygen in the hypolimnion from July through November, entrainment rates for Units 1-4 were adjusted to zero (0) for these months. Upon consideration of the depth of Unit 5 (80 ft deep at full pool) and the fact that lake stratification does not typically extend this deep during the year, the entrainment rates for Unit 5 were not adjusted. The adjusted fish entrainment numbers for the months of July through November represent fish entrainment estimates for Unit 5. Table 3-6 depicts the adjusted flows for Units 1 through 5. Table 3-7 depicts the adjusted entrainment estimates by season, and Table 3-8 depicts adjusted entrainment estimates by family/genus group.

Table 3-6: Monthly Estimated Total Number of Fish Entrained at the Saluda Hydro Project With and Without the Stratification Filter

SITE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
Saluda Hydro (without the stratification filter applied)	43,160	43,629	38,412	25,550	17,850	30,116	37,380	39,855	21,938	21,113	19,690	32,398	371,089
Saluda Hydro (with the stratification filter applied)	43,160	43,629	38,412	25,550	17,850	30,116	0	1,012	0	590	0	32,398	232,716

Table 3-7: Seasonal Estimated Total Number of Fish Entrained at the Saluda Hydro Project With and Without the Stratification Filter

SITE	WINTER	SPRING	SUMMER	FALL	TOTAL
Saluda Hydro (without the stratification filter applied)	119,186	81,812	107,351	62,740	371,089
Saluda Hydro (with the stratification filter applied)	119,186	81,812	31,128	590	232,716

Table 3-8: Entrainment Estimates by Family/Genus Group for the Saluda Hydro Project With Stratification Filter

FAMILY/GENUS GROUP	SPRING	SUMMER	FALL	WINTER	TOTAL
Anguillidae	0	0	0	0	0
Aphredoderidae	0	0	0	0	0
Atherinidae	0	0	0	0	0
Catastomidae	21	8	0	8	37
Sunfish	1,873	1,010	8	175	3,066
Centrarchidae	1,916	2,284	0	27	4,228
Clupeidae	34,846	21,804	457	111,539	168,646
Cyprinidae	393	153	4	130	680
Esocidae	3	18	0	0	21
Ictaluridae	591	792	109	4,102	5,594
Lepisosteidae	0	7	0	1	8
Moronidae	4,118	105	0	5	4,228
Percidae	38,002	4,939	12	3,195	46,148
Poeciliidae	0	0	0	0	0
Salmonidae	0	7	0	0	7
TOTAL	81,763	31,128	590	119,182	232,663

3.4 Turbine Mortality

As noted, information from each of the turbine mortality studies was sorted by turbine type, head, runner speed, and peripheral runner velocity. These data are presented in Tables 3-9 through 3-11. Because mortality test data was unavailable for certain family/genus-groups, the mortality data was averaged to produce a mortality rate for Panfish and Fusiforme fish.

Table 3-9: Francis-Type Turbine Mortality Database, Sorted by Rated Head

SITE CHARACTERISTICS RELEVANT TO TURBINE PASSAGE SURVIVAL																
Site Name	**Unit # Tested**	**Turbine Type**	**Rated Head**		**Rated Power**	**Rated Power**	**Rated Flow**		**Speed**	**Runner Diameter**		**Peripheral Runner Velocity**		**No. of Runner Blades**	**No. of Wicket Gates**	**No. of Stay Vanes**
			(ft)	(m)	(HP)	(MW)	(cfs)	(cms)	(rpm)	(in)	(cm)	(ft/sec)	(m/sec)			
Peshtigo	4	Francis (vert)	13	4.0		0.36	460	13.0	100	80	203	35.0	10.7			
Potato Rapids	1	Francis (vert)	17	5.2		0.5	500	14.2	123	84	213	45.0	13.7			
Potato Rapids	2	Francis (vert)	17	5.2		0.44	440	12.5	135	80	203	47.0	14.3			
Minetto	3/4	Francis (vert)	17.3	5.3		1.6	1500	42.5	72	139	353	43.6	13.3	16	28	
Grand Rapids	1/2	Francis (horiz)	28	8.5		1.2	645	18.3								
Grand Rapids	4	Francis (horiz)	28	8.5		1.7	926	26.2								
Stevens Creek	3	Francis (vert)	28	8.5		2.35	1000	28.3	75	135	343	44.2	13.5	14	20	
White Rapids	1	Francis (vert)	29	8.8	4385	3.27	1540	43.6	100	134	340	58.4	17.8	14	20	
Vernon	4	Francis (vert)	34	10.4		2.5	1280	36.2	133.3	62	158	36.3	11.1	14	16	
Vernon	10	Francis (vert)	34	10.4		4.2	1834	51.9	74	156	396	50.3	15.3	15	20	
Hollidays Bridge	1	Francis (horiz, triple runner)	35	10.7		0.9	370	10.5								
Five Channels	2	Francis (horiz, quad)	36	11.0		3	1500	42.5	150	55	140	36.0	11.0	16	18	
Rogers	2	Francis (vert)	39.2	11.9		1.7	727	41.2	150	60	152	39.3	12.0	15		
Sandstone Rapids	1	Francis (vert)	42	12.8		1.9	650	18.4	150	87	220	57.0	17.4			
Alcona	2	Francis (vert)	43	13.1		4	1600	45.3	90	100	254	39.3	12.0	16	18	
Higley	3	Francis (horiz)	45	13.7	2800	2.1	695	19.7	257	48	121	53.2	16.2	13	16	16
Finch Pruyn	5	Francis (horiz, double)	49	14.9		14	4600	130.3								
Finch Pruyn	4	Francis (horiz, quad)	49	14.9		14	4600	130.3								

SITE CHARACTERISTICS RELEVANT TO TURBINE PASSAGE SURVIVAL

Site Name	Site Name	Turbine Type	Rated Head		Rated Power	Rated Power	Rated Flow		Speed	Runner Diameter		Peripheral Runner Velocity		No. of Runner Blades	No. of Wicket Gates	No. of Stay Vanes
			(ft)	(m)	(hp)	(mw)	(cfs)	(cms)	(rpm)	(in)	(cm)	(ft/sec)	(m/sec)			
Prickett	1	Francis (vert)	54	16.5		1.1	326	9.2	257	53	136	59.9	18.2			
Holtwood	3	Francis (vert, double-runner)	61.5	18.7	19840	14.95	3500	99.1	102.8	112	284	50.2	15.3	17	20	
Holtwood	10	Francis (vert)	62	18.9	20000	14.9			94.7					16		
E. J. West	2	Francis (vert)	63	19.2	17150	12.8	2450	69.4	112.5	131	332	64.1	19.5	15	28	19
Ninety-Nine Islands	3	Francis (horiz, twin runner)	74	22.6	4700	3	584	16.5	225							
Caldron Falls	1	Francis (vert)	80	24.4		3.2	650	18.4	226	72	182	71.0	21.6			
High Falls - Peshtigo R.	5	Francis (horiz)	83	25.3		1.4	275	7.8	359	39	99	61.0	18.6			
Hardy	2	Francis (vert)	100	30.5		10	1500	42.5	163.6	84	213	59.8	18.2	16		
Hoist	3	Francis (vert)	142	43.3	2400	1.8			360							
Schaghticoke	4	Francis (vert)	153	46.6	6300	4.7	410	11.6	300	51	128	66.1	20.1	17	28	8
Saluda Hydro	**1-4**	**Francis (horiz)**	**180**				**3000**			**144**		**87.0**				
Saluda Hydro	**5**	**Francis (horiz)**	**180**				**6000**			**175**		**98.0**				
Bond Falls	1	Francis (vert)	210	64.0	9300	6	450	12.7	300							
Colton	1	Francis (vert)	258	78.6	15080	11.2	450	12.7	360	59	150	92.6	28.2	19	2.8	

Table 3-10: Francis-Type Turbine Mortality Database, Sorted by Runner Speed

SITE CHARACTERISTICS RELEVANT TO TURBINE PASSAGE SURVIVAL

Site Name	Unit # Tested	Turbine Type	Rated Head		Rated Power	Rated Power	Rated Flow		Speed	Runner Diameter		Peripheral Runner Velocity		No. of Runner Blades	No. of Wicket Gates	No. of Stay Vanes
			(ft)	(m)	(HP)	(MW)	(cfs)	(cms)	(rpm)	(in)	(cm)	(ft/sec)	(m/sec)			
Minetto	3/4	Francis (vert)	17.3	5.3		1.6	1500	42.5	72	139	353	43.6	13.3	16	28	
Vernon	10	Francis (vert)	34	10.4		4.2	1834	51.9	74	156	396	50.3	15.3	15	20	
Stevens Creek	3	Francis (vert)	28	8.5		2.35	1000	28.3	75	135	343	44.2	13.5	14	20	
Alcona	2	Francis (vert)	43	13.1		4	1600	45.3	90	100	254	39.3	12.0	16	18	
Holtwood	10	Francis (vert)	62	18.9	20000	14.9			94.7					16		
Peshtigo	4	Francis (vert)	13	4.0		0.36	460	13.0	100	80	203	35.0	10.7			
White Rapids	1	Francis (vert)	29	8.8	4385	3.27	1540	43.6	100	134	340	58.4	17.8	14	20	
Holtwood	3	Francis (vert, double-runner)	61.5	18.7	19840	14.95	3500	99.1	102.8	112	284	50.2	15.3	17	20	
E. J. West	2	Francis (vert)	63	19.2	17150	12.8	2450	69.4	112.5	131	332	64.1	19.5	15	28	19
Potato Rapids	1	Francis (vert)	17	5.2		0.5	500	14.2	123	84	213	45.0	13.7			
Saluda Hydro	**5**	**Francis (horiz)**	**180**				**6000**		**128.6**	**175**		**98.0**				
Vernon	4	Francis (vert)	34	10.4		2.5	1280	36.2	133.3	62	158	36.3	11.1	14	16	
Potato Rapids	2	Francis (vert)	17	5.2		0.44	440	12.5	135	80	203	47.0	14.3			
Saluda Hydro	**1-4**	**Francis (horiz)**	**180**				**3000**		**138.5**	**144**		**87.0**				
Five Channels	2	Francis (horiz, quad)	36	11.0		3	1500	42.5	150	55	140	36.0	11.0	16	18	
Rogers	2	Francis (vert)	39.2	11.9		1.7	727	41.2	150	60	152	39.3	12.0	15		
Sandstone Rapids	1	Francis (vert)	42	12.8		1.9	650	18.4	150	87	220	57.0	17.4			
Hardy	2	Francis (vert)	100	30.5		10	1500	42.5	163.6	84	213	59.8	18.2	16		
Ninety-Nine Islands	3	Francis (horiz, twin runner)	74	22.6	4700	3	584	16.5	225							
Caldron Falls	1	Francis (vert)	80	24.4		3.2	650	18.4	226	72	182	71.0	21.6			
Higley	3	Francis (horiz)	45	13.7	2800	2.1	695	19.7	257	48	121	53.2	16.2	13	16	16
Prickett	1	Francis (vert)	54	16.5		1.1	326	9.2	257	53	136	59.9	18.2			
Schaghticoke	4	Francis (vert)	153	46.6	6300	4.7	410	11.6	300	51	128	66.1	20.1	17	28	8
Bond Falls	1	Francis (vert)	210	64.0	9300	6	450	12.7	300							
High Falls - Peshtigo R.	5	Francis (horiz)	83	25.3		1.4	275	7.8	359	39	99	61.0	18.6			
Hoist	3	Francis (vert)	142	43.3	2400	1.8			360							

SITE CHARACTERISTICS RELEVANT TO TURBINE PASSAGE SURVIVAL

Site Name	Unit # Tested	Turbine Type	Rated Head		Rated Power	Rated Power	Rated Flow		Speed	Runner Diameter		Peripheral Runner Velocity		No. of Runner Blades	No. of Wicket Gates	No. of Stay Vanes
			(ft)	(m)	(HP)	(MW)	(cfs)	(cms)	(rpm)	(in)	(cm)	(ft/sec)	(m/sec)			
Colton	1	Francis (vert)	258	78.6	15080	11.2	450	12.7	360	59	150	92.6	28.2	19	2.8	
Grand Rapids	1/2	Francis (horiz)	28	8.5		1.2	645	18.3								
Grand Rapids	4	Francis (horiz)	28	8.5		1.7	926	26.2								
Hollidays Bridge	1	Francis (horiz, triple runner)	35	10.7		0.9	370	10.5								
Finch Pruyn	5	Francis (horiz, double)	49	14.9		14	4600	130.3								
Finch Pruyn	4	Francis (horiz, quad)	49	14.9		14	4600	130.3								

Table 3-11: Francis-Type Turbine Mortality Database, Sorted by Runner Diameter

SITE CHARACTERISTICS RELEVANT TO TURBINE PASSAGE SURVIVAL

Site Name	Unit # Tested	Turbine Type	Rated Head		Rated Power	Rated Power	Rated Flow		Speed	Runner Diameter		Peripheral Runner Velocity		No. of Runner Blades	No. of Wicket Gates	No. of Stay Vanes
			(ft)	(m)	(HP)	(MW)	(cfs)	(cms)	(rpm)	(in)	(cm)	(ft/sec)	(m/sec)			
High Falls - Peshtigo R.	5	Francis (horiz)	83	25.3		1.4	275	7.8	359	39	99	61.0	18.6			
Higley	3	Francis (horiz)	45	13.7	2800	2.1	695	19.7	257	48	121	53.2	16.2	13	16	16
Schaghticoke	4	Francis (vert)	153	46.6	6300	4.7	410	11.6	300	51	128	66.1	20.1	17	28	8
Prickett	1	Francis (vert)	54	16.5		1.1	326	9.2	257	53	136	59.9	18.2			
Five Channels	2	Francis (horiz, quad)	36	11.0		3	1500	42.5	150	55	140	36.0	11.0	16	18	
Colton	1	Francis (vert)	258	78.6	15080	11.2	450	12.7	360	59	150	92.6	28.2	19	2.8	
Rogers	2	Francis (vert)	39.2	11.9		1.7	727	41.2	150	60	152	39.3	12.0	15		
Vernon	4	Francis (vert)	34	10.4		2.5	1280	36.2	133.3	62	158	36.3	11.1	14	16	
Caldron Falls	1	Francis (vert)	80	24.4		3.2	650	18.4	226	72	182	71.0	21.6			
Peshtigo	4	Francis (vert)	13	4.0		0.36	460	13.0	100	80	203	35.0	10.7			
Potato Rapids	2	Francis (vert)	17	5.2		0.44	440	12.5	135	80	203	47.0	14.3			
Hardy	2	Francis (vert)	100	30.5		10	1500	42.5	163.6	84	213	59.8	18.2	16		
Potato Rapids	1	Francis (vert)	17	5.2		0.5	500	14.2	123	84	213	45.0	13.7			
Sandstone Rapids	1	Francis (vert)	42	12.8		1.9	650	18.4	150	87	220	57.0	17.4			
Alcona	2	Francis (vert)	43	13.1		4	1600	45.3	90	100	254	39.3	12.0	16	18	
Holtwood	3	Francis (vert, double-runner)	61.5	18.7	19840	14.95	3500	99.1	102.8	112	284	50.2	15.3	17	20	
E. J. West	2	Francis (vert)	63	19.2	17150	12.8	2450	69.4	112.5	131	332	64.1	19.5	15	28	19
White Rapids	1	Francis (vert)	29	8.8	4385	3.27	1540	43.6	100	134	340	58.4	17.8	14	20	
Stevens Creek	3	Francis (vert)	28	8.5		2.35	1000	28.3	75	135	343	44.2	13.5	14	20	
Minetto	3/4	Francis (vert)	17.3	5.3		1.6	1500	42.5	72	139	353	43.6	13.3	16	28	
Saluda Hydro	**1-4**	**Francis (horiz)**	**180**				**3000**		**138.5**	**144**		**87.0**				
Vernon	10	Francis (vert)	34	10.4		4.2	1834	51.9	74	156	396	50.3	15.3	15	20	
Saluda Hydro	**5**	**Francis (horiz)**	**180**				**6000**		**128.6**	**175**		**98.0**				
Holtwood	10	Francis (vert)	62	18.9	20000	14.9			94.7					16		
Ninety-Nine Islands	3	Francis (horiz, twin runner)	74	22.6	4700	3	584	16.5	225							
Bond Falls	1	Francis (vert)	210	64.0	9300	6	450	12.7	300							
Hoist	3	Francis (vert)	142	43.3	2400	1.8			360							

SITE CHARACTERISTICS RELEVANT TO TURBINE PASSAGE SURVIVAL

Site Name	Unit # Tested	Turbine Type	Rated Head		Rated Power	Rated Power	Rated Flow		Speed	Runner Diameter		Peripheral Runner Velocity		No. of Runner Blades	No. of Wicket Gates	No. of Stay Vanes
			(ft)	(m)	(HP)	(MW)	(cfs)	(cms)	(rpm)	(in)	(cm)	(ft/sec)	(m/sec)			
Grand Rapids	1/2	Francis (horiz)	28	8.5		1.2	645	18.3								
Grand Rapids	4	Francis (horiz)	28	8.5		1.7	926	26.2								
Hollidays Bridge	1	Francis (horiz, triple runner)	35	10.7		0.9	370	10.5								
Finch Pruyn	5	Francis (horiz, double)	49	14.9		14	4600	130.3								
Finch Pruyn	4	Francis (horiz, quad)	49	14.9		14	4600	130.3								

3.5 Turbine Mortality Calculation

Turbine mortality estimates are based on the 6 studies chosen from the mortality database. In order to compare data, each family/genus group was categorized into either fusiforme or panfish body shape. An average mortality rate was determined for fusiforme and panfish from each of the selected studies (Table 3-12).

Table 3-12: Summary of Type of Fish Tested and Percent Mortality Rates for Each of the Six Studies Chosen from the Mortality Database

SITE	FAMILY GROUP TESTED	BODY SHAPE TYPE	PERCENT MORTALITY
Caldron Falls	Catastomidae	Fusiforme	32
	Sunfish	Panfish	2
Hardy	Catastomidae	Fusiforme	16
	Cyprinidae	Fusiforme	3
	Esocidae	Fusiforme	12
	Centrarchidae	Fusiforme	5
	Percidae	Fusiforme	9
	Salmonidae	Fusiforme	29
	Sunfish	Panfish	4
Hoist	Sunfish	Panfish	53
	Salmonidae	Fusiforme	63
Schaghticoke	Catastomidae	Fusiforme	63
	Cyprinidae	Fusiforme	38
	Percidae	Fusiforme	39
	Centrarchidae	Fusiforme	59
	Salmonidae	Fusiforme	66
	Sunfish	Panfish	55
Bond Falls	Cyprinidae	Fusiforme	26
	Percidae	Fusiforme	20
	Salmonidae	Fusiforme	17
	Sunfish	Panfish	18
Colton	Catastomidae	Fusiforme	38
	Percidae	Fusiforme	53
	Centrarchidae	Fusiforme	64
	Salmonidae	Fusiforme	57
	Sunfish	Panfish	59
	Average Mortality	Fusiforme	35
		Panfish	32

The entrainment estimates for each family/genus group for Lake Murray were multiplied by the average mortality rate of either panfish or fusiforme fish (3-13), by the estimated fish entrained seasonally (refer back to 3-8), for each family/genus group of the Saluda Hydro Project to yield a seasonal mortality estimate.

Table 3-13: Estimated Mortality Rates for the Saluda Hydro Project

FISH TYPE	AVERAGE
Panfish	32
Fusiforme	35

When turbine mortality rates were applied to the estimates of fish entrainment, a total of 82,252 fish are estimated to be killed annually due to turbine mortality at the Saluda Hydro Project (Table 3-14). Table 3-15 depicts the estimated total annual mortality of potentially entrained fish at the Saluda Hydro project, by family/genus group with the stratification filter. Table 3-16 depicts the estimated total annual mortality of potentially entrained fish, by family/genus group without the stratification filter.

Table 3-14: Estimated Annual Total Number of Potentially Entrained Fish Killed Due to Turbine Mortality at the Saluda Hydro Project

SITE	SPRING	SUMMER	FALL	WINTER	ANNUAL
Saluda Hydro Project	28,877	10,983	209	42,184	82,252

Table 3-15: Estimated Total Annual Mortality of Potentially Entrained Fish at the Saluda Hydro Project, by Family/Genus Group With the Stratification Filter

FAMILY/GENUS GROUP	SPRING	SUMMER	FALL	WINTER	SUBSTITUTE SPECIES DATA*
Anguillidae	0	0	0	0	na
Aphredoderidae	0	0	0	0	na
Atherinidae	0	0	0	0	na
Catastomidae	8	3	0	3	Fusiformes
Sunfish	596	321	3	56	Panfish
Centrarchidae	678	809	0	10	Fusiformes
Clupeidae	12,335	7,719	162	39,485	Fusiformes
Cyprinidae	139	54	1	46	Fusiformes
Esocidae	1	6	0	0	Fusiformes
Ictaluridae	209	280	39	1,452	Fusiformes
Lepisosteidae	0	2	0	0	Fusiformes
Moronidae	1,458	37	0	2	Fusiformes
Percidae	13,453	1,748	4	1,131	Fusiformes
Poeciliidae	0	0	0	0	na
Salmonidae	0	3	0	0	Fusiformes
TOTAL	**28,877**	**10,983**	**209**	**42,184**	**82,252**

*indicates which mortality rates were used as substitutes where species-specific data was unavailable

Table 3-16: Estimated Total Annual Mortality of Potentially Entrained Fish at the Saluda Hydro Project, by Family/Genus Group Without the Stratification Filter

FAMILY/GENUS GROUP	SPRING	SUMMER	FALL	WINTER	SUBSTITUTE SPECIES DATA*
Anguillidae	0	0	0	0	na
Aphredoderidae	0	0	0	0	na
Atherinidae	0	0	0	0	na
Catastomidae	8	9	0	3	Fusiforme
Sunfish	596	1,108	275	56	Panfish
Centrarchidae	678	2,789	14	10	Fusiforme
Clupeidae	12,335	26,620	17,180	39,485	Fusiforme
Cyprinidae	139	187	133	46	Fusiforme
Esocidae	1	21	0	0	Fusiforme
Ictaluridae	209	967	4,114	1,452	Fusiforme
Lepisosteidae	0	8	0	0	Fusiforme
Moronidae	1,458	128	7	2	Fusiforme
Percidae	13,453	6,030	455	1,131	Fusiforme
Poeciliidae	0	0	0	0	na
Salmonidae	0	9	0	0	Fusiforme
TOTAL	**28,877**	**37,877**	**22,179**	**42,184**	**131,117**

*indicates which mortality rates were used as substitutes where species-specific data was unavailable

4.0 DISCUSSION

The methodologies and rates presented in this report for estimating annual fish entrainment at the Saluda Hydro Project was based on similar approaches used in other hydro relicensing efforts and incorporated data from numerous FERC-accepted studies. The magnitude of the average annual fish entrainment estimate presented in this report is reasonable when compared with the entrainment estimates from the other six hydropower projects. This reported entrainment estimate was based on USGS historical flow data (prorated for the project) spanning the period of 1979 through 2003. The results of this study will be used in the final assessment of the impacts of the Saluda Hydro Project.

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APPENDIX A

FINAL FISH ENTRAINMENT STUDY PLAN
FISH AND WILDLIFE MEETING NOTES, FEBRUARY 22, 2006

Saluda Hydroelectric Project (FERC No. 516)

Study Plan: Fish Entrainment Desktop Study Plan

Fish Entrainment Technical Working Committee
May 9, 2006

I. Study Objective

The study objective is to characterize and provide an order-of-magnitude estimate of entrainment using existing literature and site-specific information for the Saluda Hydro Dam.

II. Introduction

The Saluda Hydro project is a 202.6 MW licensed hydroelectric facility located in Lexington, Newberry, Richland, and Saluda Counties of South Carolina and is owned and operated by South Carolina Electric & Gas (Licensee). The project consists of Lake Murray, the Saluda Dam, the new back-up Saluda Berm, Spillway, powerhouse, intakes, and penstocks. The project is currently licensed by the Federal Energy Regulatory Commission (FERC No. 516) and the present license is due to expire in the year 2010.

The Licensee prepared and issued the Initial Consultation Document (ICD) on April 29, 2005, in order to initiate the relicensing process for the Project. The Licensee submitted the document to a number of state and federal resource agencies for their review and comment. As a result, the United States Fish and Wildlife Service (USFWS) and the South Carolina Department of Natural Resources (SCDNR) requested studies to determine the potential impact of Project operation on the fishery resource. The resource agencies recommended the Licensee assess potential fish entrainment effects on the fishery resource due to project operation.

In response to resource agency requests for studies in support of relicensing, SCE&G proposed to develop entrainment estimates from the extensive entrainment database that currently exists from recent project relicensing. Resource agencies concurred with SCE&G's proposal to determine potential fish entrainment effects through a desktop analysis (see Fish and Wildlife RCG meeting notes dated February 22, 2006).

III. Methodology

Fish entrainment at the Saluda project will be assessed through a desktop study. The goal of this study is to characterize and provide an order-of-magnitude estimate of entrainment using existing literature and site-specific information. The primary inputs for this analysis will be:

1) Develop an entrainment database that can be applied to the Saluda Hydro Project.
2) Calculate and estimate fish entrainment rate(s) (seasonal if possible).
3) Characterize the species composition of fish entrainment.
4) Apply any physical or biological filters that may affect entrainment.
5) Estimate total annual entrainment for the Saluda Hydro Project.

These inputs will be developed as described in the following sections.

Development of 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 each entrainment study and will include:

1) Location: geographical proximity (preference given to same river basin).
2) Project size: discharge capacity and power production.
3) Mode of operation - e.g., peaking, run-of-river etc.
4) Biological factors: fish species composition.
5) Impoundment characteristics: general water quality, impoundment size, flow regime.
6) 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 Saluda Hydro Project entrainment desktop study. After review and discussion, the Technical Working Committee (TWC) will select specific studies from this “matrix” that are most applicable to the Saluda Hydro Project. Several key criteria to be used in acceptance of candidate studies will be:

1) Similar geographical location, with preference given to projects located on the same river basin.
2) Similar station hydraulic capacity.
3) Similar station operation (peaking, pulsing, run-of-river, etc.).
4) Biological similarities: fish species, assemblage and water quality.
5) Availability of entrainment netting data.

Fish Entrainment Rate

The entrainment rate information from the accepted studies will be consolidated to show fish entrainment rates on a monthly basis (when available). Preference will be given to netting entrainment rates over hydroacoustic entrainment rates. 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 the Saluda Hydro Project.

Species Composition Analysis

Species composition data from the accepted entrainment studies will be analyzed and compiled to determine the general 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:

1) A list of potentially entrained fish species.
2) Expected relative abundance of each species identified as potentially entrained.
3) Prediction of seasonality of potentially entrained fish species.

Estimation of Annual Fish Entrainment

Total fish entrainment for the Saluda Hydro Project 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 projects will be compared to the characteristics of the Saluda Hydro Project and suitable studies will be selected for the transfer of turbine mortality data for each development. Selected turbine survival rate data will be obtained from the literature and used to estimate the number of fish killed due to turbine mortality. The following turbine characteristics are recommended as general criteria in accepting turbine mortality studies for use in this analysis:

1) design type
2) operating head
3) runner speed
4) diameter, and peripheral runner velocity

These characteristics are commonly attributed to turbine passage mortality (Cramer and Oligher, 1963; Bell, 1991; Eicher, 1987; EPRI, 1992).

To the extent possible, turbine mortality rate data available from source studies will be related to the species-family group and size class of fish estimated to be entrained at the Lake Murray Project. Where multiple tests are available for a given species-family group/size class, a mean survival rate will be computed. For species-family groups/size classes where no applicable data can be found or accepted, the survival rate reported for a similar group/size class will be substituted.

Once turbine mortality rates are developed from the study database, the rates will be applied to the entrainment estimates for each development. This will be accomplished by multiplying fish entrainment estimates by the composite mortality rates for each family/genus group (where applicable).

Entrainment Filters

Due to certain site-specific characteristics of Lake Murray, it may be necessary to adjust entrainment estimates. Factors affecting entrainment rates that may warrant investigation for adjustment of estimates include:

1) stratification at the intakes (dissolved oxygen);
2) intake velocities;
3) fish habitat available at the intakes, and/or
4) other site specific factors.

IV. Schedule and Required Conditions

In an attempt to reach consensus during the entrainment desktop study, each step of the process will be discussed with TWC members. 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 state and federal resource agencies 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 all TWC members and will be resubmitted as the Final Report.

V. Use of Study Results

Study results will be used as an information resource during discussion of relicensing issues with the SCDNR, USFWS, Fish Entrainment TWC, and other relicensing stakeholders.

VI. Study Participants

NAME	ORGANIZATION	PHONE	E-MAIL
Fish Entrainment Technical Working Committee			
Tom Bowles	SCE&G	(803)217-9615	tbowles@scana.com
Alan Stuart	Kleinschmidt	(803)822-3177	Alan.stuart@kleinschmidtusa.com
Hal Beard	SCDNR	(803)955-0462	BeardH@dnr.sc.gov
Wade Bales	SCDNR	(803)734-3932	balesw@dnr.sc.gov
Amanda Hill	USFWS	(843)727-4707, x303	Amanda_hill@fws.gov
Jennifer Summerlin	Kleinschmidt	(803)822-3177	Jennifer.Summerlin@kleinschmidtusa.com
Shane Boring	Kleinschmidt	(803)822-3177	shane.boring@kleinschmidtusa.com
Applicant Contacts			
Stephen E. Summer	SCANA Services	(803)217-7357	ssummer@scana.com
William Argentieri	SCE&G	(803)217-9162	bargentieri@scana.com
Randy Mahan	SCANA Services	(803)217-9538	rmahan@scana.com

MEETING NOTES

SOUTH CAROLINA ELECTRIC & GAS COMPANY
SALUDA HYDRO PROJECT RELICENSING
FISH AND WILDLIFE RESOURCE CONSERVATION GROUP

SCE&G Training Center
February 22, 2006

ATTENDEES:

Bill Argentieri, SCE&G
Alison Guth, Kleinschmidt Associates
Shane Boring, Kleinschmidt Associates*
Tom Eppink, SCANA Services
Randy Mahan, SCANA Services
Gerrit Jobsis, SCCCL & Am. Rivers
Dick Christie, SCDNR
Malcolm Leaphart, Trout Unlimited
Amanda Hill, USFWS
George Duke, LMHOC
Tom Bowles, SCE&G
Gina Kirkland, SCDHEC
Alan Stuart, Kleinschmidt Associates
Steve Bell, Lake Watch
Bill East, Lake Murray Assoc.
Jeni Summerlin, Kleinschmidt Associates
Hal Beard, SCDNR
Wade Bales, SCDNR
Joe Logan, Midland Stripers
Bob Seibels, Riverbanks Zoo
Ron Ahle, SCDNR
Brandon Stutts, SCANA Services
Bill Marshall, SCDNR & LSSRAC
Steve Leach, SCDNR

** Facilitator*

ACTION ITEMS:

- Prepare a study plan on fish entrainment and submit to the Fish Entrainment TWC for review
  Alan Stuart, Shane Boring

- Provide raw data and other information for the 1989 Saluda IFIM study
  Ron Ahle

- Compile available studies on resident fish fauna and distribute for review
  Shane Boring, Alan Stuart, Steve Summer

- Schedule next Fish & Wildlife RCG meeting
  Fish and Wildlife TWCs – Shane Boring will coordinate

MEETING NOTES:

These notes summarize the major items discussed during the meeting and are not intended to be a transcript or analysis of the meeting.

Shane Boring opened the meeting at approximately 9:00 am, and meeting attendees introduced themselves. It was noted that the primary purpose of today's meeting would be to form the Technical Working Committees (TWCs) for the Fish and Wildlife Resource Conservation Group (RCG) and assign study request to the TWCs.

Mission Statement

Shane reviewed the following mission statement for the Fish and Wildlife RCG, noting that it had been finalized and placed on the Saluda Relicensing website:

> *The mission of the Fish and Wildlife RCG is to develop a Protection, Mitigation, and Enhancement Agreement (PM&E Agreement) relative to fisheries and wildlife management for inclusion within the Saluda Hydroelectric Project license application. The objective of the PM&E Agreement shall be to assure the development and implementation of a level of integrated management best adapted to serve the public interests. To achieve this mission, the Fish and Wildlife RCG shall identify the need for, define the scope of, and manage or influence as appropriate, data collection and/or studies relative to potentially impacted fish, wildlife, and plant species and ecological communities, ecosystems and/or habitat within the Saluda Hydroelectric Project.*

Gerrit Jobsis asked that "within the Saluda Hydroelectric Project" be changed to "within the project vicinity" since some impacts can be outside of the project boundary. Alan Stuart and Alison Guth noted that it would require some work to change the mission statement as it had already been distributed to stakeholders and posted to the website as final. The group agreed that it was implicit in the mission statement that the project has potential to impact areas outside of the project boundary.

Formation and Membership of TWCs / Assignment of Study Requests

Shane reminded the group that, at the initial RCG meeting, a document was distributed that summarizes the study requests received in response to issuance of the Initial Consultation Document (ICD). He added that the primary purpose of today's meeting would be to review the fish-and-wildlife-related study requests (see attached handout from the meeting), form appropriate TWCs to handle these requests, and solicit (volunteer) membership for the TWCs. It was noted that, while all RCG members are welcome to attend the technical meetings, the TWC membership should consist of individuals with technical expertise in the resource area.

Following a review of the study requests received to date, 6 TWCs were formed; these TWCs, their membership, and their study request assignments are summarized below:

1) <u>Freshwater Mussels/Benthic Macroinvertebrates TWC</u>

Membership:	Shane Boring	Ron Ahle
	Amanda Hill	Jennifer Price
	Gerrit Jobsis	SCDHEC Representative
	Steve Summer	Jeni Summerlin

Study Requests[2] to be Addressed: Mussel Surveys, Benthic Macroinvertebrate Study

[2] Study Requests correspond to the study request summaries included in the attached meeting handout.

2) <u>Terrestrial Resources TWC</u>

Membership:	Shane Boring	Dick Christie
	Amanda Hill	Buddy Baker
	Ron Ahle	Brandon Stutts

Study Requests to be Addressed: Migratory Bird Study (includes wood storks, waterfowl, and bald eagles)

3) <u>Rare Threatened and Endangered Species/Habitat Studies TWC</u>

Membership:	Shane Boring	Gerrit Jobsis
	Ron Ahle	Bob Seibels
	Amanda Hill	Tom Eppink

Study Requests to be Addressed: Rare, Threatened and Endangered Species/Habitat Studies

4) <u>Diadromous Fish TWC</u>

Membership:	Alan Stuart	Amanda Hill
	Gerrit Jobsis	Steve Summers
	Dick Christie	Prescott Brownell
	Steve Leach	Shane Boring
	Jeni Summerlin	

Study Requests to be Addressed: Diadromous Fish Studies

5) <u>Instream Flow / Aquatic Habitat TWC</u>

Membership:	Alan Stuart	Shane Boring
	Steve Summers	Gerrit Jobsis
	Ron Ahle	Amanda Hill
	Hal Beard	Dick Christie
	Brandon Kulik	Wade Bales
	Scott Harden	

Study Requests to be Addressed: Instream Flow Studies, Floodplain Flow Elevations, Ecologically Sustainable Water Management, Comprehensive Habitat Assessment, Sediment Regime and Sediment Transport Studies, Evaluation of Potential for Self-Sustaining Trout Population

6) Fish Entrainment TWC

Membership:	Alan Stuart	Wade Bales
	Amanda Hill	Hal Beard
	Tom Bowles	Jennifer Summerlin
	Shane Boring	

Study Requests to be Addressed: Fish Entrainment Desktop Study

Discussion/Comments on Study Requests

Diadromous Fish Studies

Shane noted that the sampling of diadromous species is among the early studies that SCE&G decided to begin prior to relicensing. He added that sampling is currently being done by Dr. Jeff Isely from Clemson University and that the study plan is available on the Saluda relicensing website. Amanda Hill explained that state and federal agencies, including NMFS, USFWS, and SCDNR, have an interest in restoring diadromous species in the Santee basin, and as such, have cooperatively developed a restoration plan to guide such efforts. She added that the diadromous study was requested to help understand potential impacts operation of Saluda may have on migration and/or spawning of the diadromous species in the Saluda and Congaree.

Shane then provided the group with a brief summary of SCE&G's effort to obtain a scientific research permit from NOAA Fisheries – National Marine Fisheries Service (NMFS) to sample for shortnose sturgeon in the Saluda and Congaree. Specifically it was noted that the application had been submitted since June of 2005 (informally since April 2005), and to date, a permit has still not been issued. Shane noted that he had spoken with Shane Guan at NMFS, and they are expecting to have the permit issued in 9 to 10 weeks.

Amanda Hill enquired as to the status of American eel sampling. Shane provided a quick review of the discussions regarding eel sampling from the January 6, 2006 conference call with the agencies (see meeting notes on the Saluda relicensing website). Specifically, it was noted that USFWS recommended use of an eel ramp to sample for elvers due to the ineffectiveness of the eel pot sampling. He added that the group had agreed to evaluate use of an eel ramp; however, due to time constraints (sampling was slated to begin February 1), it was determined that eel pot sampling should continue in the interim until potential eel ramp sites/design can be evaluated. Amanda reiterated that USFWS still strongly recommends a ramp for sampling elvers.

Freshwater Mussel Surveys

Shane noted that he had talked to Jennifer Price with SCDNR and Lora Zimmerman with USFW, and unfortunately, data on historical distributions of mussels in SC is extremely limited. He added that no mussels are known to occur in the LSR; however, no surveys have been conducted. Amanda Hill reiterated that information on mussels in SC is extremely limited and that recent FERC relicensing efforts have provided a lot of what is known. Amanda noted a similar lack of known mussel populations at the beginning of the Santee-Cooper relicensing; however, a survey by John Alderman indicated presence of several species, includes species with conservation status. The group agreed that a potential mussel survey was deserving of further discussion in the technical committee.

Benthic Macroinvertebrate Studies

The group briefly discussed the status of the crayfish pilot survey that was conducted on the LSR in fall 2005. Alan noted that a significant number were captured, have been IDed, and are currently being verified by Arnie Eversol at Clemson. Hal Beard noted the crayfish populations may fluctuate over time due to the amount of vegetation available along the shoreline, which is directly related to flow regime. Gina Kirkland noted that, since she is likely not going to be on the TCW, she would like to ensure that the crayfish population is properly evaluated due to their importance as prey for trout in the LSR.

Gerrit noted that importance of considering sediment dynamics when evaluating potential impacts to the macroinvertebrate community. Shane noted that the sediment regime study request had been shifted to the Instream Flow/Aquatic Habitat TWC under the Fish and Wildlife RCG to ensure that such factors are taken into account. The group agreed to defer further discussion to the TWC meeting.

Instream Flow Studies

Alan Stuart specifically noted that instream flow evaluations are a standard request for most relicensing efforts. Alan pointed out an important role of the Instream Flow TWC will be to provide input and alternatives to the Operations TWC. Dick Christie clarified, the purpose of this committee would be to use another model to identify flows that will protect and potentially restore habitat on the LSR. Once flows have been identified, the operations group may be able to answer what else happens to the project if these specific flows proceed downstream. Ron Ahle noted that it may be important to examine the habitat needs of specific target species, and from this information, determine which flows are necessary to provide habitat for these particular species. Ron recommended using a Physical Habitat Model (PHABSIM). Ron noted that there was a previous IFIM study done on the LSR, but that it is outdated. Several group members noted the importance of including data from the previous IFIM study into the discussions of the Instream Flow TWC. Ron noted that he has the raw data and summary information on the IFIM study and would share the information with the group. The group decided to propose a date after information has been obtained from Ron.

Fish Community Surveys

Shane noted that numerous studies have been done through the years on the resident fish fauna and that consolidating this information might satisfy the request. Shane referenced specifically Steve Summer's quarterly electrofishing in the LSR, Hal Beard's spring sampling on the LSR, and the Lake Murray Management Reports (SCDNR). Hal noted that, while the management reports provide some valuable information, they are typically species specific and would not cover the full range of potential species. He added that his boat electrofishing in the LSR likely misses some of the smaller species. Dick Christie noted that a compilation of the studies conducted over the last approximately 40 years would likely provide a fairly comprehensive species list. Amanda Hill proposed, and the group agreed, that available studies should be compiled and distributed to the group for review to determine whether any further surveys are needed.

Evaluation of Potential for Self-Sustaining Trout Population in LSR

Malcolm Leaphart noted that USGS did a study of the LSR in 1985 and found that, based on temperature and flow, the LSR has potential to be a coldwater fishery year-round. He noted that, in his opinion, the river has been impaired for decades due to operations at Saluda, and as such, has not been able to function as year-round coldwater habitat. Malcolm requested that the potential for establishing a year-round coldwater fishery be at least considered and discussed in the relicensing and referenced the Smith River trout studies as an example of potential enhancements. Gina Kirkland noted that the LSR's designated use is as a Put-Grow-and-Take trout stream; thus the stream is not impaired for its current designated use. Dick Christie noted that there is obviously strong interest in this issue and proposed that it be discussed further in the technical committees. After some discussion, it was determined that the limiting factors for reproducing trout are primarily habitat-related; thus the study request was assigned to the Instream Flow/Aquatic Habitat TWC. Dick Christie noted that a special meeting, drawing from several TWCs, may be in order.

Rare, Threatened and Endangered (RT & E) Species

Amanda Hill noted that the Ivorybill Woodpecker had recently been rediscovered in Arkansas and that the experts felt that the most likely place for additional Ivory-bills is Congaree Swamp. She added that, since we will be evaluating impacts of project operations on Congaree Swamp, the Ivorybill should be considered in the evaluation of RT &E species. She also noted that the Saluda Crayfish, a terrestrial species known from a single location near Silversreet, SC in Newberry Co., should also be considered.

Fish Entrainment

Shane noted there was a request to conduct a desktop study of potential entrainment using previous studies conducted at other similar facilities. Alan pointed out that this is a typical request for relicensing. He added that there is a fairly standard study plan that is used. The group agreed that Kleinschmidt should distribute the study plan for review, after which, a conference call can be scheduled to discuss how to proceed on this issue.

Migratory Bird Survey

Shane noted that there is a considerable amount of data available for Dreher Island State Park, as well as the Lower Saluda River, from Columbia Audubon and other sources. Bob Seibels added that the zoo has access to considerable amount of data for their site. The group agrees this request should be deferred to the terrestrial TWC for further discussion of existing data and to determine whether a study is needed. It was also proposed that the study request regarding waterfowl usage, habitat, and hunting areas be deferred to the terrestrial group for discussion along with the other migratory bird request.

Striped Bass Evaluations

The group agreed that many of the issue related to impacts to striped bass are water-quality-related and thus are being handled by the Water Quality TWC. Dick Christie noted, and the group acknowledged, that there will undoubtedly be a need for the Water Quality TWC and Fish and Wildlife RCG to interface regarding this issue.

Hydrologic/Hydraulic Operations Model

After some discussion, it was noted that the scope of this request is being handled in the Operations TWC; however, several group members noted the need to ensure that information is shared between the Operations and Instream Flow/Aquatic habitat TWCs.

Low Inflow Protocol Study

The group likewise agreed that the scope of this request is being handled in the Operations TWC; group members also noted the need to ensure that information is shared between the Operations and Instream Flow/Aquatic habitat TWCs.

Other Relevant Studies in the LSR and Congaree River

Wade Bales briefly discussed two future studies that the SCDNR will be conducting downstream of Saluda Hydro. He explained the first study will be to evaluate trout mortality in the river. He noted there is very little historical information on which to base trout stocking strategies, and they would like to establish baseline data to further enhance management strategies. This study will assess estimated annual mortality based on the number of trout released. He added that, after the trout have been stocked in the river, SCDNR will sample by electrofishing methods quarterly. Hal added that they are also hoping to identify any mortality differences between brown and rainbow trout, including the potential for holdovers. He noted they recently stocked trout in the river on January 10th and would start sampling in about one week. He added sampling would also take place in June, September, and possibly December.

Wade also noted SCDNR is developing a striped bass telemetry project. The goal of this study will be to document striped bass spatial and temporal use on the river via receivers deployed as part of Steve Leach's Shortnose Sturgeon study. He noted 30 striped bass, with a size range over ten pounds, will be tagged with transmitters in the Lower Saluda, Congaree, and Wateree Rivers. He explained that SCDNR is interested in movements of mature spawning striped bass, as well as how stocked and reproducing populations intermingle.

Dates and of Upcoming RCG and TWC Meetings

The RCG meeting was closed at approximately 2:00 pm and the group agreed to use the remainder of the afternoon to convene the Diadromous Fish TWC (notes prepared separately). No date was set for the next Fish and Wildlife RCG meeting as the group determined it best that the TWC meet a few times and then propose a date to the RCG for its next meeting. The group also agreed to have the Terrestrial; Rare, Threatened and Endangered Species; and Freshwater Mussel/Benthic macroinvertebrate TWCs meet on March 8, 2006 at 9:00 am at the Lake Murray Training Center.

FISH AND WILDLIFE

Study Requests:

- **Diadromous Fish Studies**: Study requests from the CCL/American Rivers focused on a more in depth analysis of habitat conditions, feasibility of hatchery operations for diadromous fish, impacts analysis of the Project on diad. fish stocks of the Santee-Cooper Basin, the feasibility and costs of fish passage at the Project. SCDNR requests that spawning and nursery habitat for diadromous fish species in the river and lake should be identified and quantified.

Requested by: CCL/American Rivers, SCDNR, LSSRAC, National Marine Fisheries Service, USFWS

- **Mussel Surveys**: It was requested that the present status of mussels in the project area should be evaluated, their habitat needs assessed, and any project impacts on habitat be identified. CCL requests an evaluation of the cumulative impact analysis that the Project has on mussel stocks in the Santee Cooper Basin.

Requested by: CCL/American Rivers, SCDNR, LSSRAC, USFWS

- **Benthic Macroinvertebrate Study**: Requested in order to determine if invertebrate fauna have increased in either number or species diversity as a result of turbine venting. As well as how far downstream they are impacted.

Requested by: SCDNR, LSSRAC, National Marine Fisheries Service, SC Council Trout Unlimited, USFWS

- **Fish Community Surveys:** It was requested that these surveys be performed and include small non-game species in the Saluda River above and below the reservoir as well as in Lake Murray, to supplement existing fish community data and/or replace dated information. Specific sampling focused on determining presence or absence of the rare robust redhorse sucker, Carolina sucker, and the highfin carpsucker should be conducted in the lower Saluda River.

Requested by: USFWS

- **Striped Bass Evaluations:** This study would involve an evaluation of project operations on the reservoir striped bass population, particularly regarding: (1) the effectiveness of current turbine operations, (2) potential additional enhancements in association with the summer thermocline near the powerhouse; and (3) determine if striped bass migrate upstream of the project within the Saluda River during the spring spawning season, and if and where spawning activities occur.

Requested by: USFWS

- **Migratory Bird Surveys**: This survey would evaluate the effects of the project on migratory bird use at Lake Murray and the Saluda River and riparian ecosystems. Surveys of migratory birds and their habitats to provide baseline information on populations. Aerial surveys for potential roosting, nesting, and foraging sites for the federally endangered woodstork should also continue.

Requested by: USFWS

- **Hydrologic/Hydraulic Operations Model**:[3] Requested development of a computer simulation model that incorporates the operating characteristics of the Saluda Hydro Project. The model would be capable of simulating the Project's operations using specific hydraulic relationships based on inflows from all drainages to Lake Murray ending downstream in the Congaree River floodplain. The model would also include water flows in the Broad River above its confluence with the Saluda to accurately model combined flow conditions at the confluence and in the Congaree River.

Requested by: LSSRAC

- **Low Inflow Protocol Study**:[1] Requested study to evaluate the effects of periods of low flow on elements such as reservoir levels, water availability, river flora and fauna habitat, etc. Study leading to the development of a low flow operations plan for the Project. According to the City of Columbia Parks and Recreation, this study should include the development of a "Hydrologic/Hydraulic Operations Model."

Requested by: CCL/American Rivers, City of Columbia Parks and Recreation, LSSRAC

- **Floodplain Flow Evaluations**:[1] A study was requested in order to evaluate the flows necessary for incremental levels of floodplain inundation for the Lower Saluda, Congaree River, and Congaree National Park. It is requested that it include an inventory of floodplain vegetation as well, in order to classify and characterize the vegetative species composition and structure of the floodplain areas within the zone of operational influence of the river reaches.

Requested by: CCL/American Rivers *(requested floodplain inundation study as well as floodplain vegetation component)*, LSSRAC *(requested floodplain vegetation component only)* National Park Service

**In relation to this study, SCDNR requests that the hydrologic record associated with the operation of the project be compared to the unregulated hydrology that would have occurred under a natural flow regime over the life of the project. Including an estimate of the timing, duration and magnitude of flood events that occurred and that would have occurred in absence of the project.*

[3]Not included as part of meeting handout; however, this study request was discussed in the meeting and thus is included in the meeting notes.

Requested by: SCDNR

- **Instream Flow Studies**:[1] Requested for the Saluda River and the Confluence area. An assessment on how Project operations affect stream flows, and which flow regimens would best meet the needs of the biota.

Requested by: CCL/American Rivers, City of Columbia Parks and Recreation, SCDNR*, LSSRAC, National Marine Fisheries Service, SC Council Trout Unlimited, USFWS

**[IFIM requested by SCDNR in lieu of implementing an instantaneous flow of at least 470 cfs needed to support one-way downstream navigation, and flows of 590 cfs (July – November), 1170 cfs (Jan-April), and 880 cfs (May, June and December) to provide seasonal aquatic habitat]*

- **Ecologically Sustainable Water Management (ESWM)**:[1] Described by the National Park Service as a "inclusive, collaborative, and consensus-based process to determine a scientifically based set of river flow prescriptions in order to protect downstream resources while balancing upstream benefits." The NPS notes that they believe this process can be readily adapted to the Saluda Project and have already began gathering information and developing an interactive GIS tool to provide information regarding the effect of various Saluda operational scenarios on the degree of inundation at the Congaree National Park. NPS seeks "partnership" with SCE&G as well as stakeholders in implementing this ESWM process.

Requested by: National Park Service

- **Sediment Regime and Sediment Transport Studies:[1]** A request has been made that a study be performed on the sediment regimen in the Project area as well as the Project effects on the sediment regimen of the lower Saluda River. Should include such things as sediment composition, bedload movement, gravel deposition, sediment storage behind dams, and bedload changes below the dam; and project effects on downstream geomorphometry, sediment availability and streambank erosion, and the possible addition of gravel to mitigate for project impacts. Also, the effects of the Project operations on habitat requirements for spawning fishes.

Requested by: CCL/American Rivers, USFWS

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[1] Not included as part of meeting handout; however, this study request was discussed in the meeting and thus is included in the meeting notes.
[1] Not included as part of meeting handout; however, this study request was discussed in the meeting and thus is included in the meeting notes.

Information Needs:

- **Comprehensive Habitat Assessment**: To provide quantitative and qualitative data in GIS format of available and potential spawning, rearing, and foraging habitats (i.e., riffles, shoals, open water, shallow coves, littoral zones) for diadromous and resident fishes in Lake Murray, the Saluda River and its major tributaries, and the Lower Saluda River below the Project.

  Requested by: National Marine Fisheries Service, USFWS

  - **Fish Entrainment Desktop Study:** This study would include conducting a desktop study of potential entrainment using previous studies conducted at other similar facilities. The objectives of the study should be to (1) quantify the numbers and sizes of fish entrained, by species, (2) estimate mortality rates associated by species, and (3) provide recommendations for project design and operation that can reasonably be made to prevent or minimize fish entrainment and associated injury/mortality.

  Requested by: SCDNR, National Marine Fisheries Service, USFWS

  - **A Study to Determine the Factors Needed for a Self Sustaining Trout Fishery**: The purpose of this study should be to determine the factors needed for a self sustaining trout fishery that can reproduce and thrive year round, and how the operation can be modified to meet the habitat needs. Dissolved oxygen, flows, spawning and rearing habitat, the aquatic food base, especially in the shallow, rocky foraging areas, and actual water chemistry should be key items in such an assessment.

  Requested by: SC Council Trout Unlimited

  - **Rare Threatened and Endangered Species/Habitat Studies**: A study was requested to assess the condition of rare threatened and endangered species in the Project area, as well as how Project operations are affecting these species and how Project operations can be used to protect, restore, or enhance populations. Management plans be developed for species existing in the project area or under the influence of the project. Suggestions include Wood Stork and RSSL Surveys as well as SNS and American eel sampling.

  Requested by: CCL/American Rivers, SCDNR, LSSRAC, National Marine Fisheries Service, USFWS

  - ***SCDNR*** requests a summary of emergency spill gate testing protocol to include the frequency, time of year, and any adaptive measures that are used to reduce fish mortality as a result of spill gate testing.
  - Information on species composition, location, and acreage of aquatic plants in the project is needed to aide in the development of an aquatic plant management plan. ***SCDNR***
  - Information be dispersed to lake users by SCE&G on aquatic weed control measures. ***County of Newberry***

- Please provide copies of the existing environmental studies conducted at the Saluda Hydroelectric Project by SCE&G contractors and the South Carolina Department of Natural Resources that are referenced in the literature cited section of the Initial Consultation Document. These may be provided as hard copies or via CD (preferable). **USFWS**

Requests for Potential Mitigation: None

APPENDIX B

SCREENING MATRIX OF FISH ENTRAINMENT STUDIES FROM VARIOUS HYDROELECTRIC PROJECTS

ENTRAINMENT DATABASE FOR USE WITH THE SALUDA HYDRO PROJECT ENTRAINMENT STUDY

Table B-1: Entrainment Database for Use with the Saluda Hydro Project Entrainment Study

ID	PROJECT	LOCATION		TURBINE CONFIGURATION				INTAKE PARAMETERS			OPERATION	IMPOUNDMENT/POWER CANAL DATA				BIOLOGICAL DATA AVAILABLE					ENTRAINMENT RATE		
	Name FERC NO.	State	River	Capacity (MW) (CFS)	Turbine Type	Number of Turbines	Rated Head (ft)	Intake Velocity (ft/s)	Bar Rack Spacing (in)	Depth of Intake (ft)	Peaking or Run of River	Impoundment / Power Canal	Surface Acres	Volume (acre/ft.)	Ave. Depth (ft)	Baseline Survey	Fishery Type	Entrainment Sampling Netting	Hydroacoustics	Mortality Study	Fish / Hour	Fish / Hour/ 1000 cfs	Fish/mcf
1	Saluda Hydro Project No. 516	SC	Saluda	202.6 MW 18,000 cfs	Vertical Francis	3@32,500 KW 1@42,300 KW 1@67,500 KW	3@180 1@180 1@180		4 in	Bottom oriented Units 1-4 top located 180 ft and unit 5 top located 85 ft below summer pool .	Reserve	Impoundment	48,000	1.5 million	na	YES	Warm/cool	na	na	na			
2	Ninety-nine Islands No. 2331	SC	Broad	18 MW 3992 cfs	Horizontal Francis	6 @ 3000 kW	72	2.3 70% clear		Bottom oriented 11.5 ft. below the water surface	Modified Peaking	Impoundment	433	2300	> 6	YES	Warm	Full Recovery Netting on Unit 4	YES	YES	18.8	4.1	3.4
3	Gaston Shoals No. 2332	SC	Broad	9.1 MW 2800 cfs	Horizontal Francis Vertical Francis	1 @ 2320 kW 3 @ 1440 kW 1 @ 2500 kW	43 . 51	0.7 70% clear	2.5	Bottom oriented 13.5 ft below the water surface	Modified Peaking	Impoundment	300	2500	> 30	YES	Warm	Full Recovery Netting on Unit 6	YES	NO	17.9	6.7	3.6
4	Neals Shoals No. 2315	SC	Broad	4.42 MW 4000 cfs	Horizontal Francis	4 @ 1100 kW	24	3.4 70% clear		Intake pulls from entire water column	Run of River	Impoundment	600	1500		YES	Warm	Full Recovery Netting on Unit 3	YES	YES	17.4		5.5
5	Hollidays Bridge No. 2465	SC	Saluda	3.5 MW 1850 cfs	Horizontal Francis Vertical Francis	3 @ 1250 kW 1 @600 kW	41.5	1.2 70% clear	2	Bottom oriented 18 ft. below the water surface	Modified Peaking	Impoundment Power Canal	466 1.5	6000	> 6	YES	Warm	Full Recovery Netting on Unit 3	YES	YES	12.8	8.0	4.7
6	Saluda Hydro . No. 2406	SC	Saluda	2.4 MW 1280 cfs	Horizontal Francis	4 @ 600 kW	38	2.0 70% clear		Bottom oriented 14 ft. below the water surface	Modified Peaking	Impoundment	556	7228	6	YES	Warm	Full Recovery Netting on Unit 1	YES	NO	8.3	10.4	5.3
7	Richard B. Russell	GA/SC	Savannah	648 MW 60,000 cfs	Francis	4@ 80MW 4@ 82MW	144		8	Mid-depth 100 ft. below normal pool	peaking	Impoundment	26,653	1,026,244		YES	Warm	Full Recovery Netting on 1 unit	YES	YES	894.2	14.9	4.1

Table B-2: Screening Matrix of Fish Entrainment Studies from Various Hydroelectric Projects

PROJECT	LOCATION		TURBINE CONFIGURATION				INTAKE PARAMETERS			OPERATION	IMPOUNDMENT/POWER CANAL DATA				BIOLOGICAL DATA AVAILABLE					ENTRAINMENT RATE		
Name FERC NO.	State	River	Capacity (MW) (CFS)	Turbine Type	Number of Turbines	Rated Head (ft)	Intake Velocity (ft/s)	Bar Rack Spacing (in)	Depth of Intake (ft)	Peaking or Run of River	Impoundment / Power Canal	Surface Acres	Volume (acre/ft.)	Ave. Depth (ft)	Baseline Survey	Fishery Type	Entrainment Sampling Netting	Entrainment Sampling Hydroacoustics	Mortality Study	Fish / Hour	Fish / Hour / 1000 cfs	Fish/mcf
Saluda Hydro (Lake Murray) No. 516	SC	Saluda							Units 1-4 Bottom oriented Unit 5 - XX feet below normal pool	Peaking Reserve	Impoundment				YES SCDNR	Warm						
Ninety-nine Islands No. 2331	SC	Broad	18 MW 3992 cfs	Horizontal Francis	6 @ 3000 kW	72	2.3 70% clear		Bottom oriented 11.5 ft. below the water surface	Modified Peaking	Impoundment	433	2300	> 6	YES	Warm	Full Recovery Netting on Unit 4	YES	YES	18.8	4.1	3.4
Gaston Shoals No. 2332	SC	Broad	9.1 MW 2800 cfs	Horizontal Francis Vertical Francis	1 @ 2320 kW 3 @ 1440 kW 1 @ 2500 kW	43 . 51	0.7 70% clear	2.5	Bottom oriented 13.5 ft below the water surface	Modified Peaking	Impoundment	300	2500	> 30	YES	Warm	Full Recovery Netting on Unit 6	YES	NO	17.9	6.7	3.6
Neals Shoals No. 2315	SC	Broad	4.42 MW 4000 cfs	Horizontal Francis	4 @ 1100 kW	24	3.4 70% clear		Intake pulls from entire water column	Run of River	Impoundment	600	1500		YES	Warm	Full Recovery Netting on Unit 3	YES	YES	17.4		5.5
Hollidays Bridge No. 2465	SC	Saluda	3.5 MW 1850 cfs	Horizontal Francis Vertical Francis	3 @ 1250 kW 1 @ 600 kW	41.5	1.2 70% clear	2	Bottom oriented 18 ft. below the water surface	Modified Peaking	Impoundment Power Canal	466 1.5	6000	> 6	YES	Warm	Full Recovery Netting on Unit 3	YES	YES	12.8	8.0	4.7
Saluda Hydro. No. 2406	SC	Saluda	2.4 MW 1280 cfs	Horizontal Francis	4 @ 600 kW	38	2.0 70% clear		Bottom oriented 14 ft. below the water surface	Modified Peaking	Impoundment	556	7228	6	YES	Warm	Full Recovery Netting on Unit 1	YES	NO	8.3	10.4	5.3
High Falls	NC	Deep	0.66 MW	Francis	3 units	17		2.375			Impoundment				YES	Warm	Partial	NO	NO	3.1		
Richard B. Russell	GA/SC	Savannah	648 MW 60,000 cfs	Francis	4 @ 80MW 4 @ 82MW	144		8	Mid-depth 100 ft. below normal pool	peaking	Impoundment	26,653	1,026,244		YES	Warm	Full Recovery Netting on 1 unit	YES	YES	894.2	14.9	4.1
Steven's Creek No. 2535	GA	Savannah	18.9 MW	Vertical Francis		28				controlled by upstream releases	Impoundment				YES	Warm	Full Recovery	YES	YES			
King Mill No. 9988	GA	Augusta Canal Savannah	2.05 MW 9.50 cfs	Horizontal Francis	1 @ 650 kW 1 @ 1400 kW	30	1.5 ft/s	2	Intake pulls from entire water column	Run of River	Power Canal			7 11	YES	Warm	Partial Recovery Net in tailrace	NO	NO	15.8	15.8	5.1
Four Mile	MI	Thunder Bay	1.8 MW 1,800 cfs	Horizontal	3 @ 600 kW	29	n/a	n/a	n/a	n/a	Impoundment	n/a	n/a	n/a	n/a	Warm/Cool	Full Recovery on Unit 1	NO	YES			

PROJECT	LOCATION		TURBINE CONFIGURATION			INTAKE PARAMETERS				OPERATION	IMPOUNDMENT/POWER CANAL DATA				BIOLOGICAL DATA AVAILABLE					ENTRAINMENT RATE	
Moore's Park	MI	Grand	1.8 MW 1,200 cfs	Horizontal Francis	2 @ 540 kW	15	3.67	1.62	17	Run of river	Impoundment	240	2,000	n/a	YES	Warm/cool	Full recovery	YES	YES	9.8	8.2
Belding	MI	Flat	n/a 416 cfs	Kaplan	2	11	n/a	2	n/a	Run of River	Impoundment	n/a	n/a	n/a	n/a	Cool	Full Recovery	NO	YES		
La Barge	MI	Thornapple	1.6 MW	Horizontal Francis	2 @ 800 kW	15	n/a	n/a	n/a	Run of River	Impoundment	100	n/a	n/a	n/a	Warm	Full Recovery	NO	YES	1.68	
Mio	MI	Au Sable	5 MW 4950 cfs	tbd	n/a	35	23	2.94	20	Run of River	Impoundment	880	12,000	n/a	n/a	Cool	Partial Recovery Net	YES	NO	13.7	5.1
Alcona	MI	Au Sable	8.0 MW 8000 cfs	Vertical Francis	n/a	43	22	3.12	25	Pulsed	Impoundment	1075	25,000	n/a	n/a	Cool	Partial Recovery Net	YES	YES	10.3	3.2
Loud	MI	Au Sable	4.0 MW 4444 cfs	tbd	n/a	40	15	1.69	22.6	Pulsed	Impoundment	780	12,600	n/a	n/a	Cool	Partial Recovery Net	YES	NO	18.6	7.1
Five Channels	MI	Au Sable	6 MW 3,000 cfs	Horizontal Francis	n/a	36	14	1.75	22.2	Pulsed	Impoundment	250	4,000	n/a	n/a	Cool	Partial Recovery Net	YES	YES	48.7	16.2
Cooke	MI	Au Sable	9 MW 3,600 cfs	tbd	n/a	50	17	1.75	28.5	Pulsed	Impoundment	1800	30,000	n/a	n/a	Cool	Partial Recovery Net	YES	NO	25.4	7.0
Foote	MI	Au Sable	9 MW 4,050 cfs	tbd	n/a	40	22	2.87	22	Pulsed	Impoundment	1800	30,000	n/a	n/a	Cool	Partial Recovery Net	YES	NO	17.7	4.4
Rogers	MI	Muskegon	8.8 MW 2,400 cfs	Vertical Francis	n/a	39.2	n/a	1.75	23	Run of River	Impoundment	810	10,000	n/a	n/a	Cool	Full/Partial Recovery Net	YES	YES	6.4	2.7
Hardy	MI	Muskegon	30 MW 37,500 cfs	Vertical Francis	n/a	100.2	n/a	n/a	n/a	Pulsed	Impoundment	3902	134,973	n/a	n/a	Cool	Partial Recovery Net	YES	YES	3	0.7
Croton	MI	Muskegon	8.8 MW 10,510 cfs	tbd	n/a	50	n/a	1.75	21	Run of River	Impoundment	1209	21,932			Cool	Partial Recovery Net	YES	YES	25.1	6.8
Morrow	MI	Kalamazoo	880 cfs	rim-drive	4	13	n/a	n/a	n/a	Run of River	Impoundment	1000	n/a	n/a	n/a	Cool	Full Recovery on one unit	NO	YES		
Kleber	MI	Black	1.2 MW 1,200	Vertical Kaplan	2 @ 600kW	44	1.41	3	15	Run of River	Impoundment	270	3,000	n/a	n/a	Warm/cool	Full Recovery on one Unit	YES	YES	7.2	18
Constantine	MI	St. Josephs	1.2 MW 1,200 cfs	n/a	4	11	13	3	13.74	Run of River	Impoundment	525	n/a	n/a	n/a	Cool	Full Recovery	No	NO	7.6	5.1
Buchanan	MI	St. Josephs	4.1 MW 4,569 cfs	Vertical Francis	10	12.8	0.7	3	13.87	Run of River	Impoundment	525	3,895	n/a	YES	Cool	Partial Recovery Net	NO	Yes	8	2.1
Mc Clure	MI	Dead	460 cfs	Pelton	2	410	tbd	3	tbd	Run of River	Impoundment	tbd	tbd	tbd	Yes	Warm/cool	Full recovery	No	No		
Ninth Street	MI	Thunder Bay	1650 cfs	tbd	3 @ 460 kW	tbd	tbd	1.0	tbd	Run of rier	Impoundment	tbd	tbd	n/a	n/a	Warm	Full recovery	NO	YES		

PROJECT	LOCATION			TURBINE CONFIGURATION		INTAKE PARAMETERS				OPERATION	IMPOUNDMENT/ POWER CANAL DATA				BIOLOGICAL DATA AVAILABLE					ENTRAINMENT RATE	
Hillman	MI	Thunder Bay	550 cfs	tbd	1 @ 460 kW	tbd	tbd	tbd	tbd	Run of River	Impoundment	tbd	tbd	n/a	n/a	Warm	Full recovery 1 Unit	NO	YES		
Hoist	MI	Dead	760 cfs	Francis	2	84	tbd	3	tbd	Run of river	Impoundment	tbd	tbd	tbd	Yes	Warm/cool	Full Recovery	No	Yes		
Prickett	MI	Sturgeon	2.2 MW 2220 cfs	Vertical Francis	2 @ 1100 kW	54	1.6	2	17	Modified ROR	Impoundment	773	13,987	n/a	n/a	Warm/cool	Full Recovery	NO	YES		
Escanaba Dam 3	MI	Escanaba	2.5 MW 3400 cfs	n/a	2	30.5	3	1.62	16.5	Run of River	Impoundment	182	1,100	n/a	n/a	Cool	Full Recovery	NO	Yes	2.5	2.0
Escanaba Dam 1	MI	Escanaba	1.95 MW 1,600 cfs	n/a	3	23.2	3	1.62	18.2	Run of River	Impoundment	75	375	n/a	n/a	Cool	Full Recovery	NO	Yes	5.2	4.4
Stewart's Bridge No. 2047	NY	Sacandaga	36 MW 5,400	Francis	1 @ 5400 cfs		n/a	n/a	n/a		Impoundment	480	18,600	n/a	YES	n/a	n/a	n/a	n/a		
E.J. West No. 2318	NY	Sacandaga	5400	Vertical Francis	2 @ 2700 cfs	63	2.8 fps	4.5		Peaking	Impoundment	25,940	681,000	n/a	YES State Agency	n/a	Full Netting Unit 2	NO	YES		
Sherman Island No. 2482	NY	Hudson	6600 cfs 30 MW	Vertical Francis	4 @ 1650 cfs	69	2.2 fps	3.13		Peaking	Impoundment Power Canal	305	6,960	n/a	YES	n/a	Full Netting Units 2,3, & 5	NO	NO		
Feeder Dam	NY	Hudson	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Impoundment	n/a	n/a	n/a	-------	n/a	Full Netting Units 1,3, & 5	NO	YES		
Minetto	NY	Oswego	7500 cfs	Vertical Francis	5 @ 1500 cfs	17.3	2.6 fps	2		Peaking	Impoundment	350	4,730	n/a	YES	Cool/cold	Full Netting Units 3, 4 , & 5	NO	YES		
Schagticoke	NY	Hoosic	1640 cfs	Vertical Francis	4 @410 cfs	15.3	1.6 fps	2.25		Peaking	Impoundment Power Canal	164	1,150	n/a	YES	Warm/cool	Full Netting Unit 4	NO	YES		
Johnsonville	NY	Hoosic	1288 cfs	Horizontal Francis	2 @644 cfs	38	0.9 fps	2		Peaking	Impoundment	450	6,430	n/a	YES	Warm/cool	Full Netting Units 1 & 2	NO	NO		
Higley	NY	Middle Racquette	2045 cfs	Horizontal Francis	2 @675 cfs 1@ 695 cfs	46 45	1.5 fps	3.63		Peaking	Impoundment Power Canal	742	4,496	n/a	YES	Cool/cold	Full Netting Units 1, 2 , & 3	NO	YES		
Colton	NY	Middle Racquette	1503 cfs	Vertical Francis	2 @497 cfs 1 @509 cfs	28.5 28.5	2.7 fps	2		Peaking	Impoundment	195	620	n/a	YES	Cool/cold	Full Netting Unit 1	NO	YES		
Raymondville	NY	Lower Racquette	1640 cfs	Fixed Propeller	1 @ 1640 cfs	21.5	1.9 fps	3		Peaking	Power Canal	50	264	n/a	YES	Cool/cold	Full Netting Unit 1	NO	YES		
East Norfolk	NY	Lower Racquette	1635 cfs	Fixed Propeller	1 @ 1635 cfs	31.4	4.2 fps	8.75		Peaking	Impoundment Power Canal	135	287.9	n/a		Cool/cold	Full Netting Power Canal	NO	NO		
High Falls	NY	Beaver	900 cfs	Vertical Francis	3 @300 cfs	10.0	0.9 fps	1.81		Peaking	Impoundment	290	1,059	n/a	YES	Cool/cold	Full Netting Unit 1	NO	NO		
Moshier	NY	Beaver	660 cfs	Vertical Francis	2 @330 cfs	19.6	1.3 fps	1.5		Peaking	Impoundment	690	7,339	n/a	YES	Cool/cold	Full Netting Unit 2	NO	NO		
Herrings	NY	Black	3609 cfs	Fixed Propeller	3 @ 1203 cfs	19.5	2.3 fps	3.5		Run-of-River	Impoundment	140	n/a	n/a	YES	Cool	Full Netting Unit 2	NO	YES		

PROJECT	LOCATION			TURBINE CONFIGURATION			INTAKE PARAMETERS			OPERATION	IMPOUNDMENT/ POWER CANAL DATA				BIOLOGICAL DATA AVAILABLE					ENTRAINMENT RATE	
Station 26	NY	Genessee	3.0 MW	n/a	n/a	n/a	n/a	n/a	n/a	N/a	Impoundment	n/a	n/a	n/a	n/a	Cool	n/a	n/a	n/a	30.8	17.1
Little Quinnesec	WI	Menominee	9.1 MW 2,176	Francis Horizontal Vertical	5 1@1,00 hp 2@1,400 hp 1 @ 2600 hp 1 @ 2800 hp 1 @ 3240 hp	65	n/a	2	n/a	Peaking	Impoundment	349	3,000	n/a	n/a	Warm	No	n/a	n/a		
Chalk Hill	WI	Menominee	7.8 MW 3993 cfs	Kaplan	3	28	n/a	4.5	n/a	Peaking	Impoundment	n/a	n/a	n/a	n/a	Warm/cool	No	No	Yes		
Grand Rapids	WI	Menominee	7.02 MW 3870 cfs	Francis	5 3 @1,700 1 @ 2,500 1 @ 2,400	28	n/a	1.75	n/a	Peaking	Canal	n/a	n/a	n/a	n/a	Warm/cool	Partial	n/a	n/a		
White Rapids	WI	Menominee	8.0 MW 3,994	Francis	3 units 2 @ 4,385 1 @ 3,100	29	1.9	2.5	23.9	Run of river	Impoundment	435	5,155	n/a	Yes	Warm/cool	Partial	YES	YES	16.5	3.2
Park Mill	WI	Menominee	4.6 MW 2543 cfs	V. Francis H. Francis		16	2.06	3	16	Run of river	Impoundment Power Canal 2400 ft. long	539	3788		n/a	Cool	Partial Netting of Power Canal for species	YES	YES	5.3	2.1
Brule	WI	Brule	5.3 MW 1500 cfs	Francis	3 @ 1760 kW	63	1	1.375	22 ft.	Run of river	Impoundment	545	8,800		YES	Cool	Full Recovery on Two Units	YES	YES	4.8	3.5
Upper	WI	Flambeau	0.9 MW 720 cfs	n/a	n/a		2	1.75	13.6	Run of River	Impoundment	431	3280	n/a	n/a	n/a	NO	Yes	NO	6.4	8.9
Lower	WI	Flambeau	1.2 MW 930 cfs	n/a	n/a	n/a	1.7	3.5	12.2	Run of River	Impoundment	71	570	570	n/a	n/a	NO	Yes	NO	11.8	12.7
Pixley	WI	Flambeau	.96 MW 675 cfs	n/a	n/a	n/a	2	1.75	16	Run of River	Impoundment	193	1757	n/a	n/a	n/a	NO	Yes	NO	5.6	8.3
Crowley	WI	Flambeau	1.74 MW 1480 cfs	n/a	n/a	n/a	1.4	2.38	20.7	Run of River	Impoundment	422	3539	n/a	YES	Warm	Full Recovery	YES	YES	7.6	5.1
Thornapple	WI	Flambeau	1.4 MW 1400 cfs	Propeller	2 @ 700 kW	15	1.22	1.69	13.1	Run of River	Impoundment	295	1000	n/a	YES	Warm	Full Recovery on One Unit	NO	YES	7.0	5.0
Rothschild	WI	Wisconsin	3.64 MW 3386 cfs	H. Francis Vert. Propeller	6 units 1 unit	n/a	2.15	1.38	15	Run of River	Impoundment	1,604	13,900	n/a	YES	Warm	Full Recovery on Two Units	NO	YES	24.3	7.4
Wis. River Div.	WI	Wisconsin	1.8 MW 5141 cfs	Horizontal Francis Tube Turbine	9 units hydromechanical 1 unit hydroelectric	20 22	n/a	n/a	19	Run of River	Impoundment Mainstem of the Wisconsin River	240	1,120	n/a	n/a	Warm	Full Recovery Netting in Tailrace	NO	YES	80.6	15.7

PROJECT	LOCATION		TURBINE CONFIGURATION				INTAKE PARAMETERS			OPERATION	IMPOUNDMENT/POWER CANAL DATA				BIOLOGICAL DATA AVAILABLE					ENTRAINMENT RATE	
Centralia	WI	Wisconsin	3.2 MW 3900 cfs	Vertical Francis Vertical Propeller	4 @ 400 kW 2 @ 800 kW	15.5 15.5	n/a	3.5	n/a	Run of River	Impoundment Power Canal 200 ft. long	250	n/a	n/a	n/a	Warm/cool	Full Recovery on Unit # 2 Vertical Francis	NO	YES	95.2	26.2
Shawano	WI	Wolf	0.7 MW 835 cfs		1	18.5	1.48	5	16	Run of River	Impoundment	155	1,090	n/a	n/a	n/a	YES	YES	YES	4.6	5.5
Townsend	PA	Beaver	5.0 MW								Impoundment	n/a	n/a	n/a			Full Recovery			34.6	7.8
Youghiogheny	PA	Youghiogheny									Impoundment	n/a	n/a	n/a			Full Recovery			212.4	132.7
Hawks Nest	WV	New	102 MW							Peaking	Impoundment	n/a	n/a	n/a			Partial Recovery Net	YES		5.5	0.1
Dam #4	WV	Potomac	1.0 MW 1082 cfs	Horizontal Francis	2 @ 500 kW	17.3					Impoundment	n/a	n/a	n/a			Full Recovery on Unit # 1	NO	YES	0.6	0.3
Millville	WV	Shenandoah	2.8 MW 1970 cfs	Francis Propeller Kaplan	1 @ 840 kW 1 @ 1000 kW 1 @ 1000 kW	22.4 24 24					Impoundment						Full Recovery on Unit # 1 Francis	NO	NO	3.5	1.6

APPENDIX C

SUMMARY OF SELECTED ENTRAINMENT STUDIES

Ninety-Nine Islands (FERC No. 2331)

Gaston Shoals (FERC No. 2332)

Neal Shoals (FERC No. 2315)

Hollidays Bridge (FERC No. 2315)

Saluda Station (FERC No. 2406)

Richard B. Russell Project (USACOE project)

SUMMARY OF SIX ENTRAINMENT PROJECTS USED IN THE SALUDA HYDRO PROJECT DESKTOP ENTRAINMENT REPORT

1.0 NINETY-NINE ISLANDS

Hydroacoustic and full recovery netting were performed on Unit 4 (a 3 MW horizontal twin-runner Francis-type turbine) of the Ninety-nine Islands project during February - December of 1990.

1.1 Full Recovery Entrainment Netting

Full recovery entrainment netting was performed on Unit 4 of the Ninety-nine Islands project during the daylight hours of 0800 - 1700 hrs. Netting was performed on a monthly basis with a 2 hour sample taken 2 times a day for 2 consecutive days per month yielding a total of 68 sampling hours for the year (Table 1). "Initial and steady-state" sampling was performed, but no apparent trends were observed; therefore all monthly netting data was combined to yield a total number of fish (by species) entrained per hour of sampling. Monthly netting efficiencies were calculated and each monthly data set was corrected for net losses. The total number of fish entrained by month was determined by totaling the number of generation hours for each of the six turbine units at the project and multiplying by the monthly entrainment netting rate. The sum of the estimated monthly entrainment yields a total estimated annual entrainment of 238,447 fish for the project. Investigators indicated that these estimates may be inflated due to suspected net intrusion in the tailrace collections.

1.2 Hydroacoustic Entrainment Sampling

Hydroacoustic sampling was performed on Unit 4 of the Ninety-nine Islands project on a monthly basis during both daytime and nighttime project operation with a total of 2,042 hours of data collected over 101 days (Table 2). Fish entrainment is reported as the number of fish entrained per hour of sampling. Reported monthly rates are the mean of all hourly sampling rates for the collection month. The total number of fish entrained by month was determined by totaling the number of generation hours for each of the six turbine units at the project and multiplying by the monthly hydroacoustic entrainment rate for Unit 4. The sum of the monthly fish entrainment estimates yields a total estimated annual entrainment of 205,585 fish for the project. Based on background noise levels, it was calculated that the smallest fish target "acoustically visible" was 100 mm in length. By comparing simultaneous netting and hydroacoustic samples, it was determined that there was fairly good agreement between the netting and hydroacoustic entrainment estimates for the Ninety-nine Islands Project.

Table C-1: Entrainment Netting Recovery Data Collected at the Ninety-Nine Islands Project During February - December of 1990

MONTH	HOURS SAMPLED	HOURLY ENTRAINMENT RATE	TOTAL HOURS OF TURBINE OPERATION	PROJECTED NUMBER OF FISH ENTRAINED
January	No Data	Ave. of Dec. and Feb. rates = 6.8	3,140	21,352
February	8	13.5	3,656	49,355
March	8	1.9	3,937	7,479
April	8	5.1	3,362	17,145
May	8	10.8	2,862	30,911
June	8	10.9	1,708	18,618
July	No Data	June rate = 10.9	1,655	18,042
August	No Data	June rate = 10.9	1,489	16,233
September	8	6.5	1,357	8,821
October	4	13.2	2,605	34,390
November	8	7.8	2,064	16,101
December	8	0	2,026	0
TOTAL	**68 hrs**	**Mean = 8 fish/hr**	**29,861 hrs**	**238,447 fish**

Table C-2: Fish Entrainment at the Ninety-Nine Islands Project Based on Hydroacoustic Sampling During February - December of 1990

MONTH	DAYS SAMPLED	HOURLY ENTRAINMENT RATE	TOTAL HOURS OF TURBINE OPERATION	PROJECTED NUMBER OF FISH ENTRAINED
January	No Data	Used Feb = 0.4	3,140	1,256
February	13	0.4	3,656	1,487
March	13	4.6	3,937	18,150
April	9	4	3,362	13,474
May	7	12.8	2,862	36,701
June	15	11	1,708	18,722
July	15	5.9	1,655	9,838
August	9	14.8	1,489	22,037
September	12	8	1,357	10,788
October	No Data	Ave. of Sept. and Nov. rates = 13.2	2,605	34,386
November	9	18.4	2,064	37,936
December	No Data	Feb. rate = 0.4	2,026	810
TOTAL	**101 days**	**Mean =6.9 fish/hr**	**29,861 hrs**	**205,585 fish**

2.0 GASTON SHOALS

Hydroacoustic and full recovery netting were performed on Unit 6 (a 2.5 MW vertical Francis-type turbine) of the Gaston Shoals Hydroelectric project during January - December of 1990.

2.1 Full Recovery Entrainment Netting

Full recovery entrainment netting was performed on Unit 6 of the Gaston Shoals project during the daylight (0800 - 1600) and the nighttime hours (2000 - 0400). Netting was performed on a monthly basis with a 2 hour sample taken 4 times a day (one 24 hr period) once per month yielding a total of 64 (32 daytime and 32 nighttime) sampling hours for the year (Table 3). "Initial and steady-state", daytime, and nighttime sampling was performed, but no apparent trends were observed; therefore all monthly netting data was combined to yield a total number of fish (by species) entrained per hour of sampling. Monthly netting efficiencies were calculated and each monthly data set was corrected for net losses. The total number of fish entrained by month was determined by totaling the number of generation hours for each of the three operational turbine units at the project and multiplying by the monthly entrainment netting rate. The sum of the estimated monthly entrainment yields a total estimated annual entrainment of 156,619 fish for the project. Investigators indicated that these estimates may be inflated due to suspected net intrusion in the tailrace collections.

2.2 Hydroacoustic Entrainment Sampling

Hydroacoustic sampling was performed on Unit 6 of the Gaston Shoals on a monthly basis during both daytime and nighttime project operation with a total of 112 days of data collected (Table 4). Fish entrainment is reported as the number of fish entrained per hour of sampling. Reported monthly rates are the mean of all hourly sampling rates for the collection month. The total number of fish entrained by month was determined by totaling the number of generation hours for each of the three turbine units at the project and multiplying by the monthly hydroacoustic entrainment rate for Unit 6. The sum of the monthly fish entrainment estimates yields a total estimated annual entrainment of 91,753 fish for the project. Based on background noise levels, it was calculated that the smallest fish target "acoustically visible" was 100 mm in length. By comparing simultaneous netting and hydroacoustic samples, it was determined that there was no acceptable correlation between the entrainment netting estimates and the hydroacoustic entrainment estimates for the Gaston Shoals project.

Table C-3: Entrainment Netting Recovery Data Collected at the Gaston Shoals Project During February - December of 1990

MONTH	HOURS SAMPLED	HOURLY ENTRAINMENT RATE	TOTAL HOURS OF TURBINE OPERATION	PROJECTED NUMBER OF FISH ENTRAINED
January	No Data	Ave. of Dec. and Feb. rates = 2.9	2,021	5,859
February	8	3.3	2,012	6,639
March	8	1.4	2,224	3,113
April	8	11.5	2,152	24,749
May	8	3.4	2,182	7,418
June	8	20.9	1,568	32,773
July	No Data	June rate = 20.9	1,382	28,882
August	No Data	June rate = 20.9	1,260	26,334
September	8	9.0	1,080	9,720
October	No Data	Ave. of Sep. and Nov. rates = 5.6	1,352	7,569
November	8	1.0	1,253	1,255
December	8	1.3	1,776	2,308
TOTAL	**64 hrs**	**Mean = 7.7 fish/hr**	**20,262 hrs**	**156,619 fish**

Table C-4: Fish Entrainment at the Gaston Shoals Project Based on Hydroacoustic Sampling During February - December of 1990

MONTH	DAYS SAMPLED	HOURLY ENTRAINMENT RATE	PROJECT TURBINE OPERATION	PROJECTED NUMBER OF FISH ENTRAINED
January	8	8.5	2,021	17,199
February	10	2.3	2,012	4,628
March	5	3.6	2,224	7,984
April	8	2.7	2,152	5,875
May	13	0.3	2,182	715
June	15	10.5	1,568	16,495
July	16	2.5	1,382	3,455
August	6	1.4	1,260	1,701
September	9	1.8	1,080	1,948
October	6	5.2	1,352	7,059
November	16	8.0	1,253	10,042
December	No Data	Ave of Nov.& Jan. rates = 8.25	1,776	14,652
TOTAL	**112 days**	**Mean = 4.5 fish/hr**	**20,262 hrs**	**91,753 fish**

3.0 NEAL SHOALS

Hydroacoustic and full recovery netting were performed on Unit 3 (1.1 MW horizontal Francis-type turbine) of the Neal Shoals Hydroelectric project during February 1991 through January 1990.

3.1 Full Recovery Entrainment Netting

Full recovery entrainment netting was performed on Unit 3 of the Neal Shoals project during the daylight hours (0600 - 1200 or 1600 - 2200 hrs). During each netting-month, a 6 hour sample taken once a day for 2 consecutive days per month (12 hrs/month). There were six successful netting events during March, May, June, August, October, and December yielding a total of 45.75 sampling hours for the year (Table 5). Entrainment netting collection efficiencies were determined for fish < 100 mm (96%) and for fish > 100 mm (71%). Reported entrainment rates were not corrected for these net losses but assumed 100% net efficiency. The total number of fish entrained annually was determined by totaling the number of generation hours for each of the four operational turbine units at the project and multiplying by the mean annual entrainment netting rate of 13.7 fish/hr. Based on the annual project operation time of 19,819.3 hours, the estimated annual entrainment for the project was 271,524.4 fish.

Discussions with Gerrit Jöbsis (South Carolina Department of Natural Resources) determined that the netting rates were adjusted for a 73% netting recovery rate which increased the annual entrainment rate to 345,510 fish for the project.

3.2 Hydroacoustic Entrainment Sampling

Hydroacoustic entrainment sampling was performed on Unit 3 of the Neal Shoals project on a monthly basis during both daytime and nighttime project operation. The hydroacoustic data was analyzed through July of 1991 with poor or no correlation with the entrainment netting data. Based on these results, the number of fish entrained at the site was based solely on entrainment netting.

Table C-5: Entrainment Netting Recovery Data Collected at the Neal Shoals Project During March - December of 1991

MONTH	HOURS SAMPLED	NUMBER OF FISH COLLECTED	INITIAL HOURLY ENTRAINMENT RATE	ADJUSTED HOURLY ENTRAINMENT RATE	PROJECTED NUMBER OF FISH ENTRAINED
January	NA	-------	NA	NA	
February	NA	-------	NA	NA	
March	10.25	171	16.7	21.2	
April	NA	-------	NA	NA	
May	11	259	23.5	29.9	
June	3	58	19.3	24.5	Project
July	NA	-------	NA	NA	Operation =
August	10	109	10.9	13.8	19819.3 hrs
September	NA	-------	NA	NA	times the annual
October	0.5	5	10.0	12.7	entrainment rate
November	NA	-------	NA	NA	of 17.4 fish/hr =
December	11	25	2.3	2.9	
TOTAL	**45.75 hrs**	**627 fish**	**Mean = 13.7 fish/hr**	**Mean = 17.4 fish / hr**	**345,510 fish/yr**

4.0 SALUDA STATION

Hydroacoustic and full recovery netting were performed on Unit 1 (a 0.6 MW horizontal twin-runner Francis-type turbine) of the Saluda Station project during January - December of 1990 and January of 1991.

4.1 Full Recovery Entrainment Netting

Full recovery entrainment netting was performed on Unit 1 of the Saluda Station project during the daylight hours of 0800 - 1700 hrs. Netting was performed on a monthly basis with a 2 hour sample taken 2 times a day for 2 consecutive days per month (8 hrs/month) yielding a total of 48 sampling hours for the year (Table 6). "Initial and steady-state" sampling was performed, but no apparent trends were observed; therefore all the monthly netting data was combined to yield a total number of fish (by species) entrained per hour of sampling. Monthly netting efficiencies were calculated and each monthly data set was corrected for net losses. The total number of fish entrained by month was determined by totaling the number of generation hours for each of the four operational turbine units at the project and multiplying by the monthly entrainment netting rate. The sum of the estimated monthly entrainment for 9 months of operation yields a total estimated entrainment of 87,274 fish for the project. Investigators indicated that these estimates may be inflated due to suspected net intrusion in the tailrace collections.

4.2 Hydroacoustic Entrainment Sampling

Hydroacoustic entrainment sampling was performed on both Unit 1 and Unit 2 of the Saluda Station project a monthly basis during both daytime and nighttime project operation with a total of 1587 hours of data collected over 95 days (Table 7). Unit 1 was sampled during January through October 1990 and Unit 2 was sampled during November of 1990 through January of 1991. Fish entrainment is reported as the number of fish entrained per hour of sampling. Reported monthly rates are the mean of all hourly sampling rates for the collection month. The total number of fish entrained by month was determined by totaling the number of generation hours for each of the four turbine units at the project and multiplying by the monthly hydroacoustic entrainment rate for either Unit 1 or Unit 2. The sum of the monthly fish entrainment estimates yields a total estimated annual entrainment of 31,811 fish for the project. Based on background noise levels, it was calculated that the smallest fish target "acoustically visible" was 100 mm in length. By comparing simultaneous netting and hydroacoustic samples, it was determined that there was limited agreement between the entrainment netting estimates and the hydroacoustic entrainment estimates for the Saluda Station project.

Table C-6: Entrainment Netting Recovery Data Collected at the Saluda Hydroelectric Project During January - December of 1990

MONTH	HOURS SAMPLED	HOURLY ENTRAINMENT RATE	TOTAL HOURS OF TURBINE OPERATION	PROJECTED NUMBER OF FISH ENTRAINED
January	No Data	Dec. rate = 6.2	1917	11,885
February	No Data	Dec. rate = 6.2	2244	13,913
March	No Data	No estimate	2238	---------
April	No Data	No estimate	1963	---------
May	No Data	No estimates	1624	---------
June	8	11.6	1097	12,725
July	No Data	Ave. of June & Aug. rates = 9.3	855	7,952
August	8	6.7	780	5,226
September	8	6.3	720	4,536
October	8	14.5	1350	19,575
November	8	5.5	932	5,126
December	8	6.2	1022	6,336
TOTAL	**48 hrs**	**Mean = 5.2 fish/hr**	**16742**	**87,274 fish**
Adjusted for 9 months of sampling		Mean = 8.0 fish/hr	10,917	87,274 fish

Table C-7: Fish Entrainment at the Saluda Hydroelectric Project Based on Hydroacoustic Sampling During January 1990 to January of 1991

MONTH	DAYS SAMPLED	HOURLY ENTRAINMENT RATE	TOTAL HOURS OF TURBINE OPERATION	PROJECTED NUMBER OF FISH ENTRAINED
January	4	1.1	1,917	2,032
February	4	0.0	2,244	0
March	12	0.6	2,238	1,388
April	23	0.8	1,963	1,570
May	1	0.4	1,624	585
June	9	0.8	1,097	823
July	No Data	3.3	855	2,822
August	4	5.8	780	4,547
September	2	2.3	720	1,663
October	9	7.7	1,350	10,449
November	2	5.1	932	4,716
December	11	1.2	1,022	1,216
January	14	3.0	No Data	No Data
TOTAL	**95 days**	**Mean = 2.4 fish/hr**	**16,742**	**31,811 fish**

5.0 HOLLIDAYS BRIDGE

Hydroacoustic and full recovery netting were performed on Unit 3 (a 0.9 MW horizontal triple-runner Francis-type turbine) during January - December of 1990 and on Unit 2 during April - June of 1992 of the Hollidays Bridge Hydroelectric project.

5.1 Full Recovery Entrainment Netting

Full recovery entrainment netting was performed on Unit 3 of the Hollidays Bridge project during the daylight hours of 0800 - 1700 hrs. Netting was performed on a monthly basis with a 2 hour sample taken 2 times a day for 2 consecutive days per month (8 hrs/month) yielding a total of 40 sampling hours for the year (Table 8). "Initial and steady-state" sampling was performed, but no apparent trends were observed; therefore all the monthly netting data was combined to yield a total number of fish (by species) entrained per hour of sampling. Monthly netting efficiencies were calculated and each monthly data set was corrected for net losses. The total number of fish entrained by month was determined by totaling the number of generation hours for each of the four operational turbine units at the project and multiplying by the monthly entrainment netting rate. The sum of the estimated monthly entrainment for 5 months of project operation yields a total estimated entrainment of 28,489 fish for the project.

To satisfy a FERC AIR, additional entrainment net sampling was performed during April - June of 1992 to fill in missing months of project entrainment. Unit 2 was sampled during this period using the same sampling methodology employed during the 1990 studies. The similarities between the configuration of Unit 3 and Unit 2 were deemed appropriate to assume similar entrainment rates. A total of 32 hours of entrainment netting were performed during the 1992 study bringing the total project entrainment netting to 72 hrs. The total estimated annual fish entrainment of 112,345 fish is based on project operation hours during 1992. Investigators indicated that these estimates may be inflated due to suspected net intrusion in the tailrace collections.

5.2 Hydroacoustic Entrainment Sampling

Hydroacoustic entrainment sampling was performed on a monthly basis during January, February, and September - December of 1990 with a total of 720 hours of data collected over 38 days (Table 9). Unit 1 was sampled during January - October 1990 and Unit 2 was sampled during November of 1990 - January of 1991. Fish entrainment is reported as the number of fish entrained per hour of sampling. Reported monthly rates are the mean of all hourly sampling rates for the collection month. The total number of fish entrained by month was determined by totaling the number of generation hours for each of the three turbine units at the project and multiplying by the monthly hydroacoustic entrainment rate for Unit 1 or Unit 2. The sum of the monthly entrainment estimates yields an estimated entrainment of 14,330 fish for 8 months of project operation. Based on background noise, it was calculated that the smallest fish target "acoustically visible" was 100 mm in length. There was no report of additional hydroacoustics sampling performed in 1992. This is probably due to the limited agreement between the entrainment netting estimates and the hydroacoustic entrainment estimates for the Hollidays Bridge project.

Table C-8: Entrainment Netting Recovery Data Collected at the Hollidays Bridge Project During January - December of 1990 and April-June of 1992

MONTH	HOURS SAMPLED	HOURLY ENTRAINMENT RATE	HOURS OF TURBINE OPERATION (1992)	PROJECTED NUMBER OF FISH ENTRAINED
January	NA	Dec. rate = 3.8	1,468	5,578
February	8	1.4	1,419	1,987
March (92)	8	11.1	1,475	16,373
April (92)	8	6.3	1,382	8,707
May (92)	8	19.9	1,290	25,671
June (92)	8	12.1	1,179	14,266
July	NA	June rate = 12.1	1,015	12,282
August	NA	June rate = 12.1	941	11,386
September	8	4.9	751	3,680
October	8	5.3	729	3,864
November	8	2.1	845	1,775
December	8	5.6	1,210	6,776
TOTAL	**72 hrs**	**Mean = 8.2 fish/hr**	**13,704**	**112,345 fish**

Table C-9: Fish Entrainment at the Hollidays Bridge Project Based on Hydroacoustic Sampling During January 1990 to January of 1991

MONTH	DAYS SAMPLED	HOURLY ENTRAINMENT RATE	TOTAL HOURS OF TURBINE OPERATION	PROJECTED NUMBER OF FISH ENTRAINED
January	9	0.3	1,749	507
February	13	0.3	2,102	631
March	No Data	Feb. rate = 0.3	1,179	354
April	No Data	ND	0	0
May	No Data	ND	0	0
June	No Data	ND	0	0
July	No Data	ND	0	0
August	No Data	1.3	475	618
September	4	1.4	782	1,103
October	2	1.2	1,312	1,561
November	6	4.8	852	4,124
December	4	5.3	1,023	5,432
TOTAL	**38 days**	**Mean = 1.5 fish/hr**	**9,474 hrs**	**14,330 fish**

6.0 RICHARD B. RUSSELL

Full recovery netting was performed on Unit 5 (an 80MW Francis-type turbine) at the Richard B. Russell Project.

6.1 Full Recovery Entrainment Netting

Full discharge recovery netting was performed during conventional generation on Unit 5 of the Richard B. Russell Project as part of a mid-1980s study to analyze the effects of pumpback turbines on the fisheries of Lakes Russell and Thurmond. Sampling was conducted over a full 12-month cycle. Entrainment was dominated by threadfin shad (87.3%), blueback herring (6.6%), and yellow perch (4.2%). Entrainment rates from the Richard B. Russell entrainment study were presented by month and species. For the purpose of summarizing this study, Table 10 presents the average entrainment rate by month and Table 11 presents the average annual entrainment rate for each entrained fish species.

Table C-10: Monthly Average Entrainment Rates for the Richard B. Russell Project Conventional Generation Netting Study

MONTH	ENTRAINMENT RATE (FISH/HR)
January	1,458.22
February	7,251.67
March	224.91
April	251.83
May	108.46
June	71.63
July	101.21
August	269.67
September	127.45
October	91.64
November	556.56
December	228.72
AVERAGE	**894.23**

Table C-11: Mean Annual Entrainment Rates of Fish Entrained During Conventional Generation Netting at the Richard B. Russell Project

NAME	MEAN ANNUAL
threadfin shad	781.363
blueback herring	58.397
yellow perch	36.635
white catfish	6.354
bluegill	2.939
white perch	2.080
black crappie	2.010
channel catfish	0.613
spottail shiner	0.379
white crappie	0.378
carp	0.265
gizzard shad	0.159
warmouth	0.085
yellow bullhead	0.084
flathead catfish	0.062
hybrid bass	0.060
black bullhead	0.036
spotted bass	0.026
green sunfish	0.016
striped bass	0.015
snail bullhead	0.014
golden shiner	0.013
largemouth bass	0.012
redbreast sunfish	0.012
silver redhorse	0.012
tesselated darter	0.010
blackbanded darter	0.007
whitefin shiner	0.007
longnose gar	0.007
rainbow trout	0.006
walleye	0.006
smallmouth bass	0.005
northern hogsucker	0.004
white bass	0.004
Coosa bass	0.001

Table C-12: Richard B. Russell Fish Entrainment Species Composition (by Percent)

COMMON NAME	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Northern Hogsucker	0.0000	0.0000	0.0000	0.0000	0.0000	0.0726	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Silver Redhorse	0.0000	0.0000	0.0000	0.0047	0.0739	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0200
Black Crappie	0.0244	0.0023	0.1062	0.3718	5.2876	17.4898	1.8707	0.7093	0.0000	0.0000	0.0635	0.0400
Coosa Bass	0.0000	0.0000	0.0000	0.0000	0.0148	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Largemouth Bass	0.0023	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0215	0.0970	0.0000	0.0000
Smallmouth Bass	0.0000	0.0000	0.0000	0.0216	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Spotted Bass	0.0000	0.0000	0.0000	0.0000	0.0000	0.0693	0.0000	0.0801	0.0000	0.0000	0.0086	0.0000
White Crappie	0.0000	0.0000	0.0000	1.1535	0.0708	1.6104	0.0564	0.1290	0.0000	0.0000	0.0000	0.0000
Blueback Herring	10.0929	3.5211	21.2217	29.5016	41.1762	30.8363	8.5071	24.1845	5.2183	24.1518	0.7930	1.0700
Gizzard Shad	0.0078	0.0009	0.0583	0.0420	0.0000	0.0665	0.4962	0.0701	0.1628	0.3686	0.0225	0.0400
Threadfin Shad	86.7983	95.5201	17.0483	17.0313	1.6977	15.1388	64.4096	66.4364	78.3285	28.0236	94.9874	83.7000
Carp	0.0000	0.0000	0.0000	0.0619	0.0303	0.2377	0.9427	0.0494	0.0861	1.7073	0.0000	0.0300
Golden Shiner	0.0034	0.0000	0.0000	0.0436	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Spottail Shiner	0.0572	0.0060	0.5785	0.4113	0.3082	0.1868	0.0000	0.0000	0.0000	0.0000	0.0000	0.2300
Whitefin Shiner	0.0000	0.0000	0.0000	0.0080	0.0000	0.0000	0.0606	0.0000	0.0000	0.0000	0.0000	0.0000
Walleye	0.0000	0.0009	0.0000	0.0117	0.0000	0.0000	0.1691	0.0000	0.0000	0.0000	0.0000	0.0000
Black Bullhead	0.0000	0.0000	0.0160	0.0963	0.0000	0.2065	0.0000	0.2615	0.0000	0.0000	0.0000	0.0000
Brown Bullhead	0.0000	0.0000	0.0160	0.0000	0.1289	0.0813	2.3746	0.0000	5.8122	0.9271	0.0319	6.1400
Channel Catfish	0.0138	0.0015	0.0000	0.0262	0.5256	0.0813	0.0751	0.2293	0.2066	0.0970	0.8373	0.1100
Flathead Catfish	0.0000	0.0000	0.0000	0.0114	0.0000	0.0000	0.0000	0.0000	0.0000	0.0970	0.0915	0.0500
Snail Bullhead	0.0000	0.0000	0.0000	0.0000	0.0000	0.0707	0.0000	0.0000	0.0000	0.0000	0.0000	0.0500
White Catfish	0.1101	0.0246	0.4023	0.2249	0.7180	1.0050	1.1070	1.4991	5.0192	39.8065	2.6459	3.8000
Yellow Bullhead	0.0244	0.0000	0.0000	0.0000	0.0000	0.0000	0.6421	0.0000	0.0000	0.0000	0.0000	0.0000
Longnose Gar	0.0023	0.0000	0.0000	0.0000	0.0000	0.0665	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Hybrid Bass	0.0033	0.0000	0.1070	0.0808	0.1328	0.0000	0.0000	0.0000	0.0000	0.0000	0.0150	0.0000
Striped Bass	0.0000	0.0000	0.0301	0.0346	0.0271	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
White Bass	0.0000	0.0000	0.0151	0.0058	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
White Perch	0.0000	0.0090	0.8298	4.7006	9.1373	0.9421	0.0706	0.0000	0.0441	0.0000	0.0391	0.0000
Blackbanded Darter	0.0000	0.0018	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tesselated Darter	0.0000	0.0000	0.0000	0.0000	0.1059	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Yellow Perch	2.7780	0.9028	59.0916	41.4511	38.7012	28.7646	15.6773	3.1601	2.6820	3.1278	0.3424	4.3600
Rainbow Trout	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0706	0.0000	0.0000	0.0000	0.0000	0.0000
Bluegill	0.0739	0.0090	0.4791	4.3537	1.7257	2.9677	3.4140	3.1195	2.3575	1.5961	0.1220	0.3200
Green Sunfish	0.0000	0.0000	0.0000	0.0149	0.0210	0.1062	0.0564	0.0000	0.0000	0.0000	0.0000	0.0000
Redbreast Sunfish	0.0000	0.0000	0.0000	0.0232	0.0000	0.0000	0.0000	0.0322	0.0000	0.0000	0.0000	0.0000
Warmouth	0.0080	0.0000	0.0000	0.1334	0.1171	0.0000	0.0000	0.0395	0.0612	0.0000	0.0000	0.0300

APPENDIX D

SALUDA RIVER MEAN ANNUAL DAILY FLOW DATA COLLECTED FROM USGS GAUGE NUMBER 02169000 DOWNSTREAM OF SALUDA HYDRO PROJECT

AVERAGE HISTORICAL OPERATION OF UNIT 5 BASED ON FLOW DURATION RECORDS 1978 – 2003

SALUDA HYDRO PROJECT FLOW DURATION CURVES

Table D-1: Saluda River Mean Annual Daily Flow Data Collected from USGS Gauge Number 02169000 Downstream of Saluda Hydro Project

	1978-1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
October	613	2386	2809	1131	1612	1791	1340	1458	1320	1385	2415	2408	5751	1732	3049	1442	3500	3626	2201	1863	2039	1176	2049	1776	2674
November	993	4110	2495	1061	621	927	1453	6552	927	743	1175	1844	1828	2262	4709	1962	2710	4574	991	3187	2179	435	1217	1296	1545
December	1700	2226	2124	1129	2916	5413	1267	4736	3582	1522	2286	4217	496	731	5826	2375	4000	3953	686	2871	1919	984	1641	621	3994
January	2673	3165	1825	9255	5521	5802	2160	1928	4854	942	462	2752	1281	1299	9053	2674	7089	3500	1175	6935	1553	3786	737	746	3049
February	5025	3013	955	5100	6348	5129	4654	707	4514	1455	795	7441	2794	1167	7346	1740	8416	4814	4444	8999	1390	1818	641	832	3888
March	5410	7807	787	3469	5451	5389	1305	711	5911	1049	4186	6161	4962	3162	7807	1913	1998	6118	4140	6510	1389	1476	686	717	10530
April	5747	5927	504	1039	5905	3484	880	862	2364	321	3199	3089	4202	2281	4385	1281	691	2424	1976	7260	803	981	609	603	7259
May	3304	2166	482	1137	1405	4510	602	575	541	441	2529	747	4121	1067	2270	774	911	2639	2226	5091	596	629	561	894	5811
June	3817	2101	542	2225	1686	1799	373	550	1460	349	1982	1453	2701	2582	1894	3283	2497	2397	2792	3508	626	663	685	848	3412
July	4108	2953	1153	1968	2229	3385	477	863	1991	380	4252	1754	4132	2273	2382	2996	2046	2234	2639	1151	2342	686	1090	1334	4705
August	2329	1039	656	2693	2884	4178	2620	534	1905	635	3192	2234	3933	2424	1813	5682	4377	2213	2657	1854	748	1468	2036	1545	3555
September	2631	1746	1929	1329	1261	2077	1931	1900	1490	558	2033	6390	2796	3009	1191	3423	3349	7642	1845	2513	726	1651	1040	1748	1496

Table D-2: Average Historical Operation of Unit 5 Based on Flow Duration Records 1978 – 2003

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
Cubic Feet/Sec*	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000
Cubic Feet / Hr	21600000	21600000	21600000	21600000	21600000	21600000	21600000	21600000	21600000	21600000	21600000	21600000
Days/Month	31	28.25	31	30	31	30	31	31	30	31	30	31
Hours/Month	744	678	744	720	744	720	744	744	720	744	720	744
Estimated % of time Unit 5 was Operated	0.04	0.04	0.05	0.04	0.01	0.005	0	0.01	0	0.01	0	0.005
Total flow through Unit 5 (cubic feet)	642,816,000	585,792,000	803,520,000	622,080,000	160,704,000	77,760,000	0	160,704,000	0	160,704,000	0	80,352,000

*assumed 6000 cfs through unit 5, operated at flows above 12,000 cfs (capacity of U1-4 combined)

Figure 1.0 Saluda Project FERC No. 516, South Carlina Eectric & Gas Co., Janary Flow Duration Curve

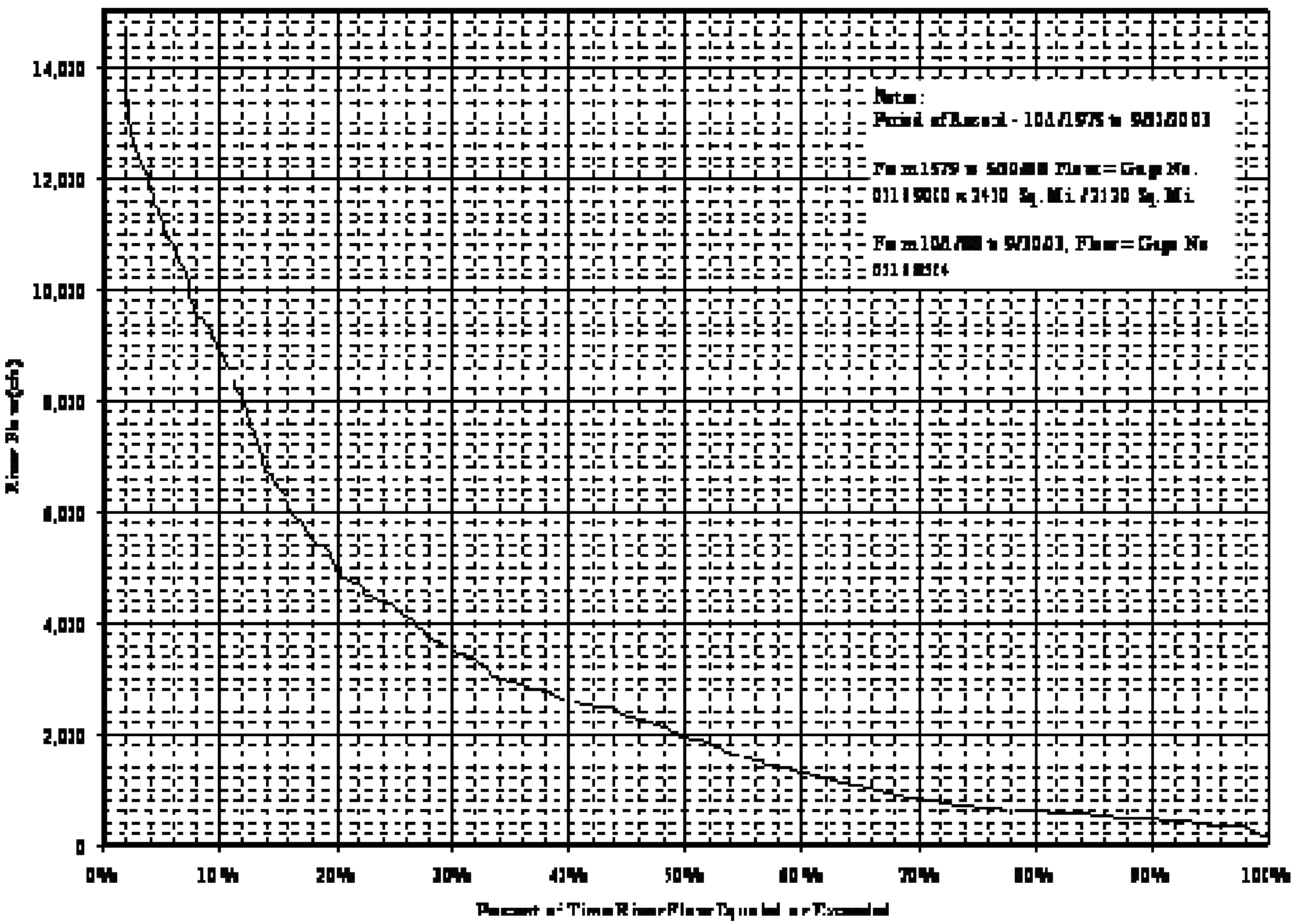


Figure 2.0 Saluda Project FERC No. 516, South Carolina Electric & Gas Co., February Flow Duration Curve

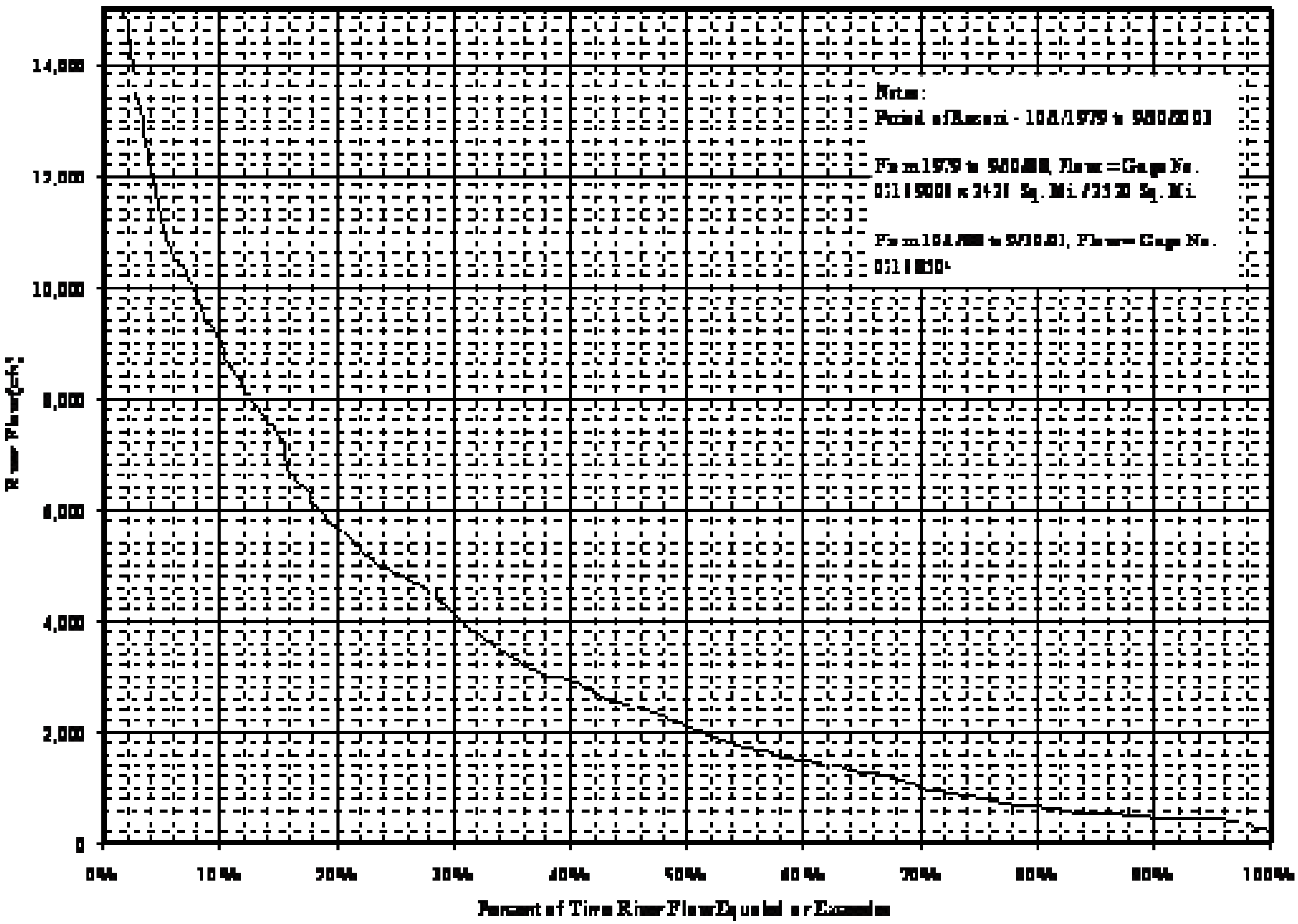


Figure 3.0 Saluda Project FERC No. 516, South Carolina Electric & Gas Co., March Flow Duration Curve

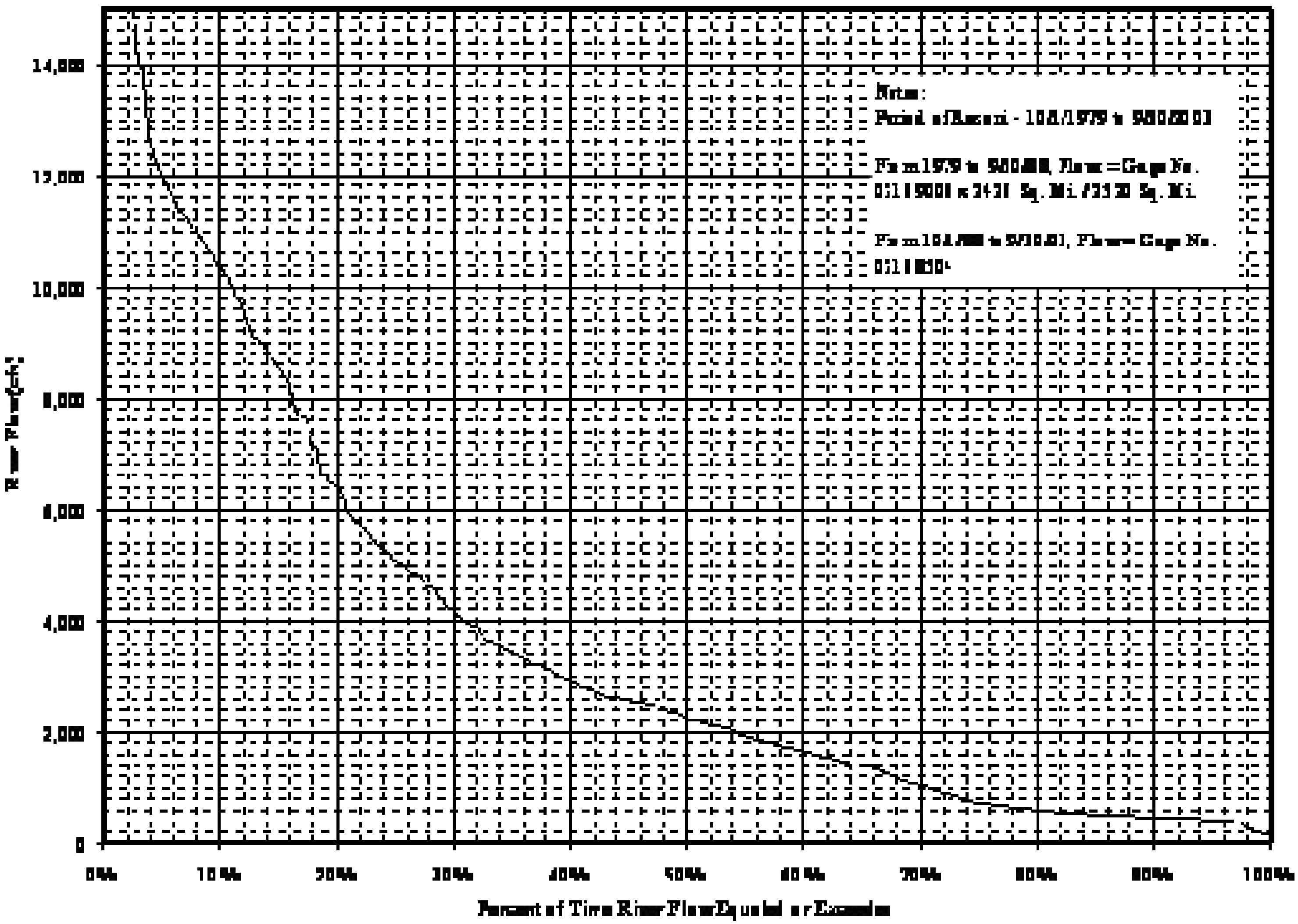


Figure 4.0 Saluda Project FERC No. 516, South Carolina Electric & Gas Co., Apri FlowDuration Curve

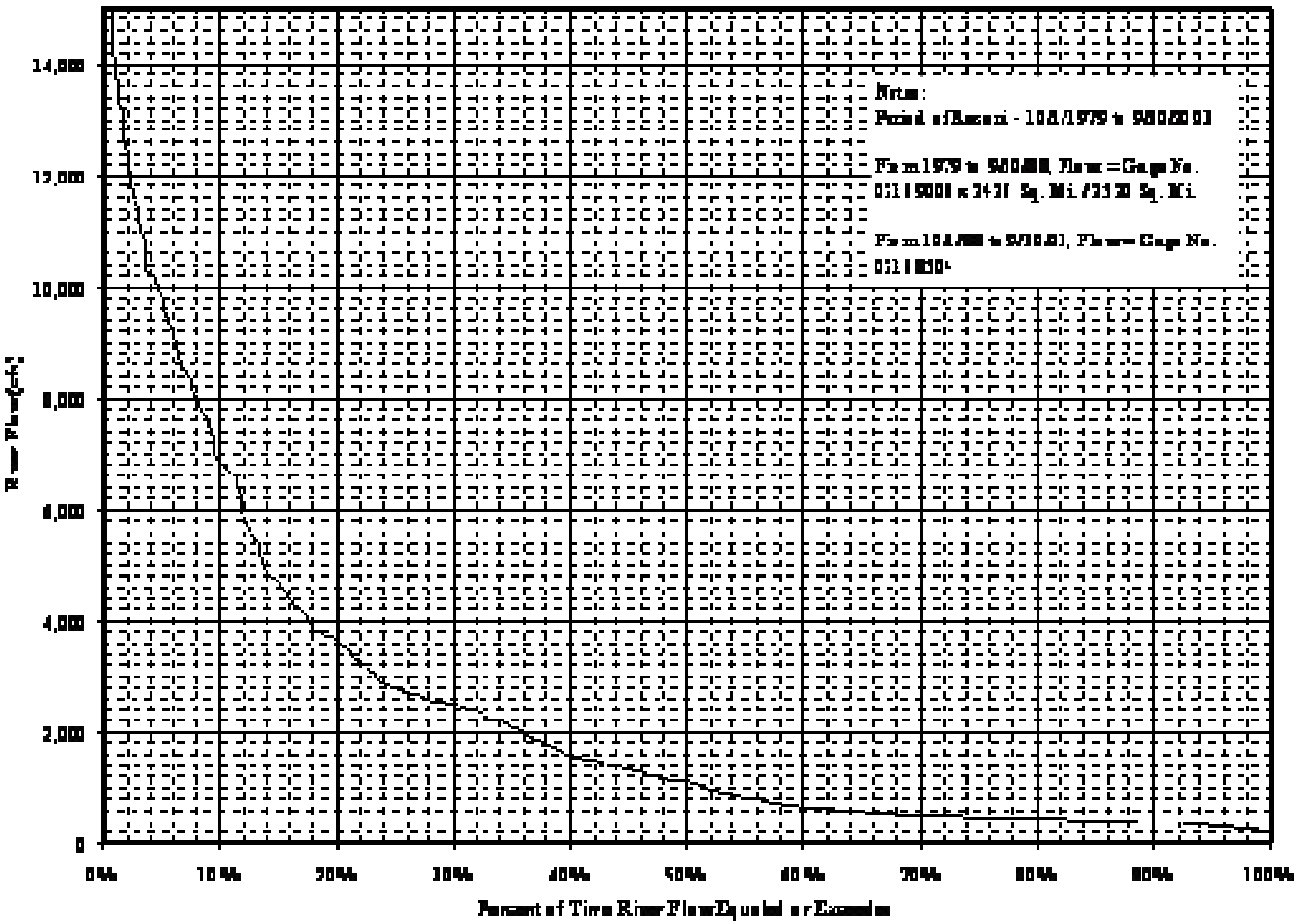


Figure 5.0 Saluda Project FERC No. 516, South Carolina Electric & Gas Co., May Flow Duration Curve

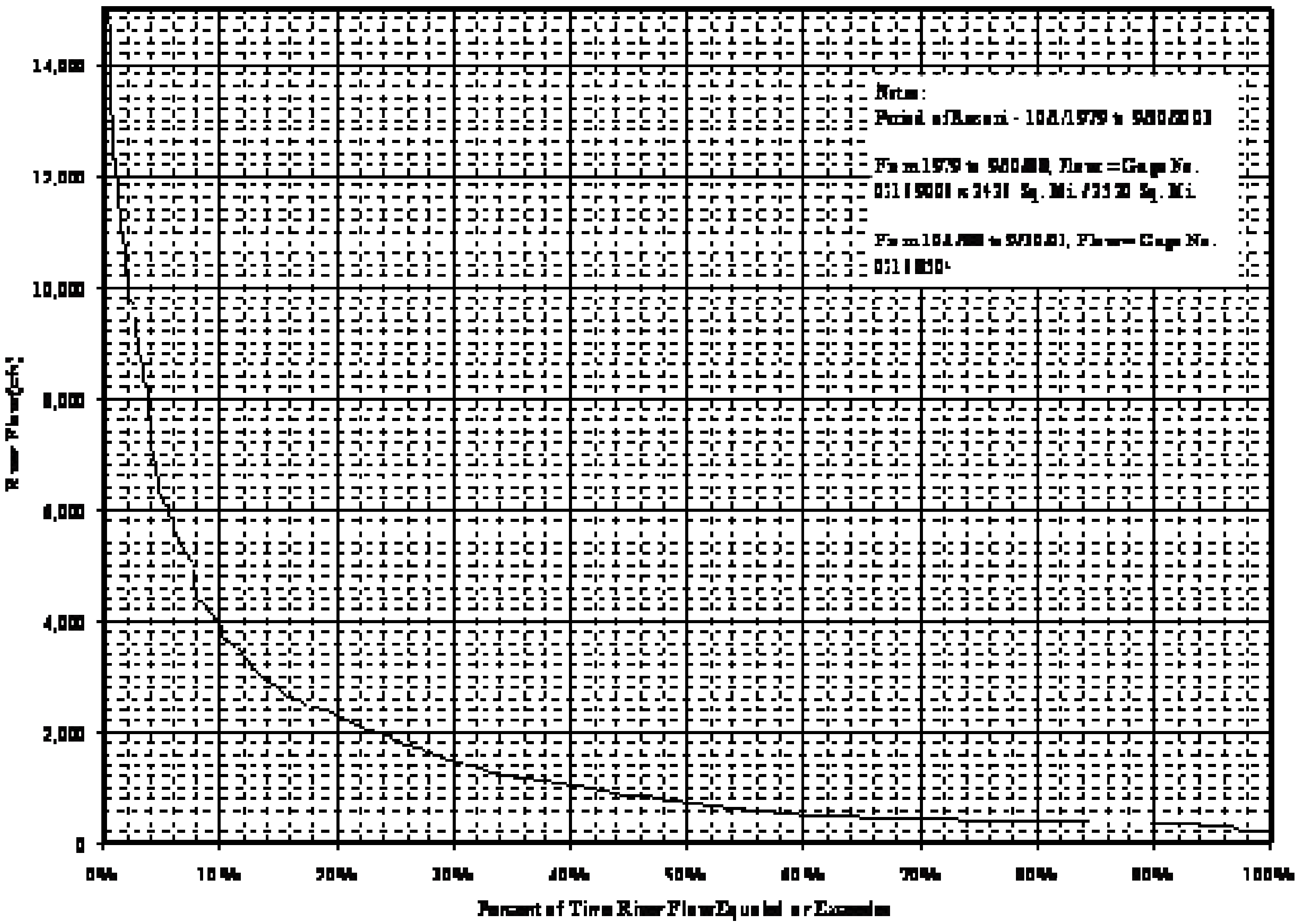


Figure 6.0 Saluda Project FERC No. 516, South Carolina Electric & Gas Co., June Flow Duration Curve

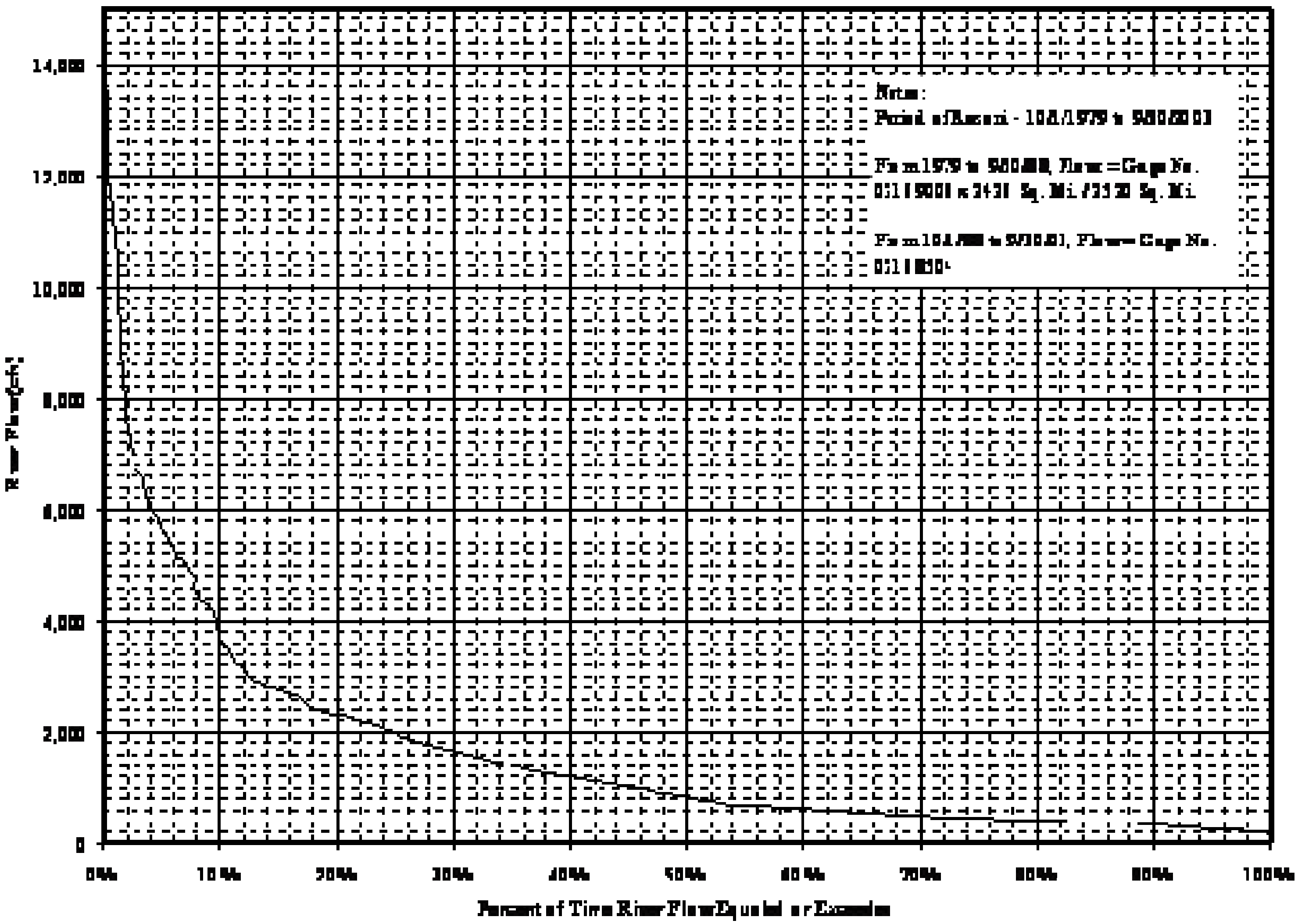


Figure 7.0 Saluda Project FERC No. 516, South Carolina Electric & Gas Co., July Flow Duration Curve

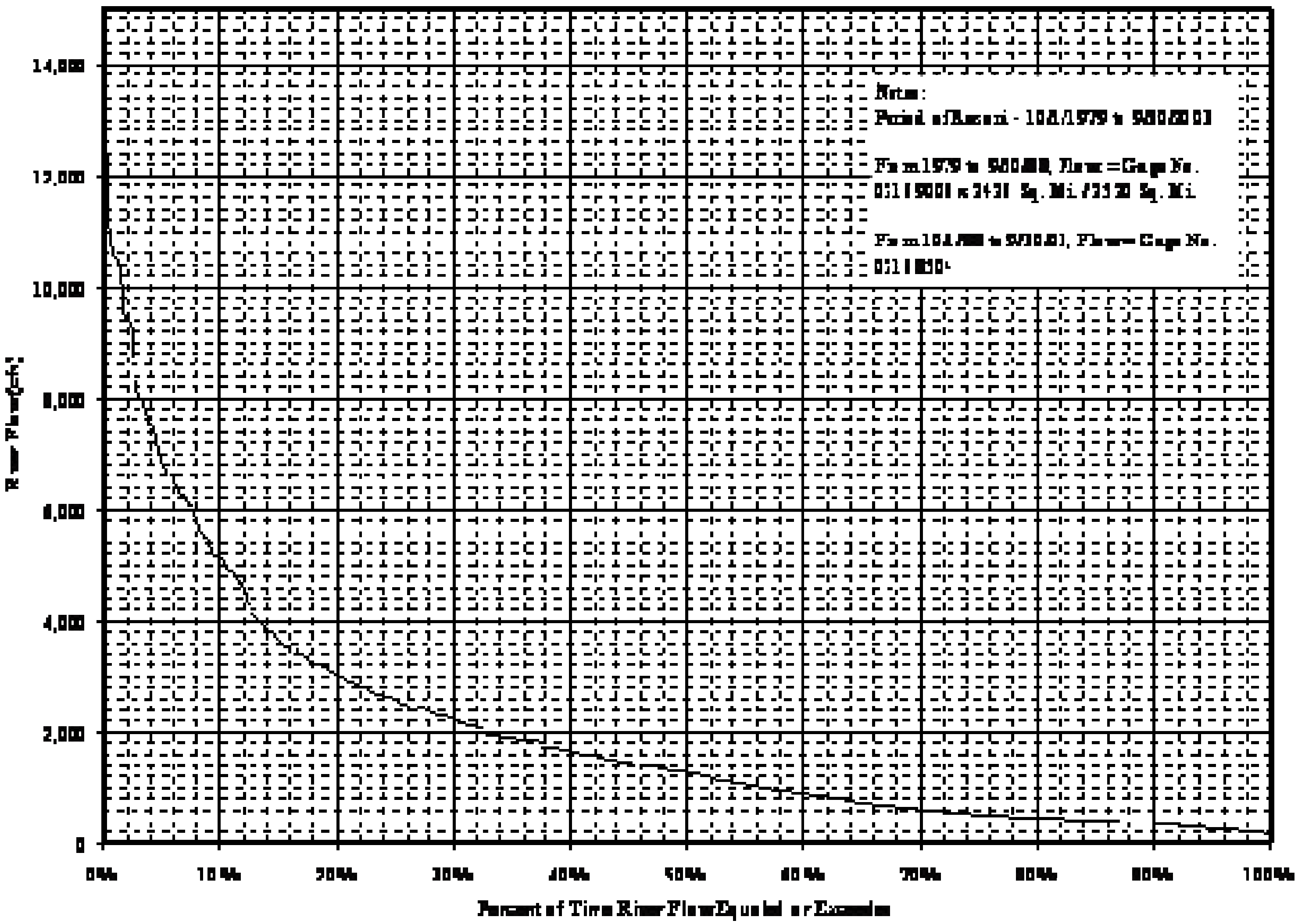


Figure 8.0 Saluda Project FERC No. 516, South Carolina Electric & Gas Co, August Flow Duration Curve

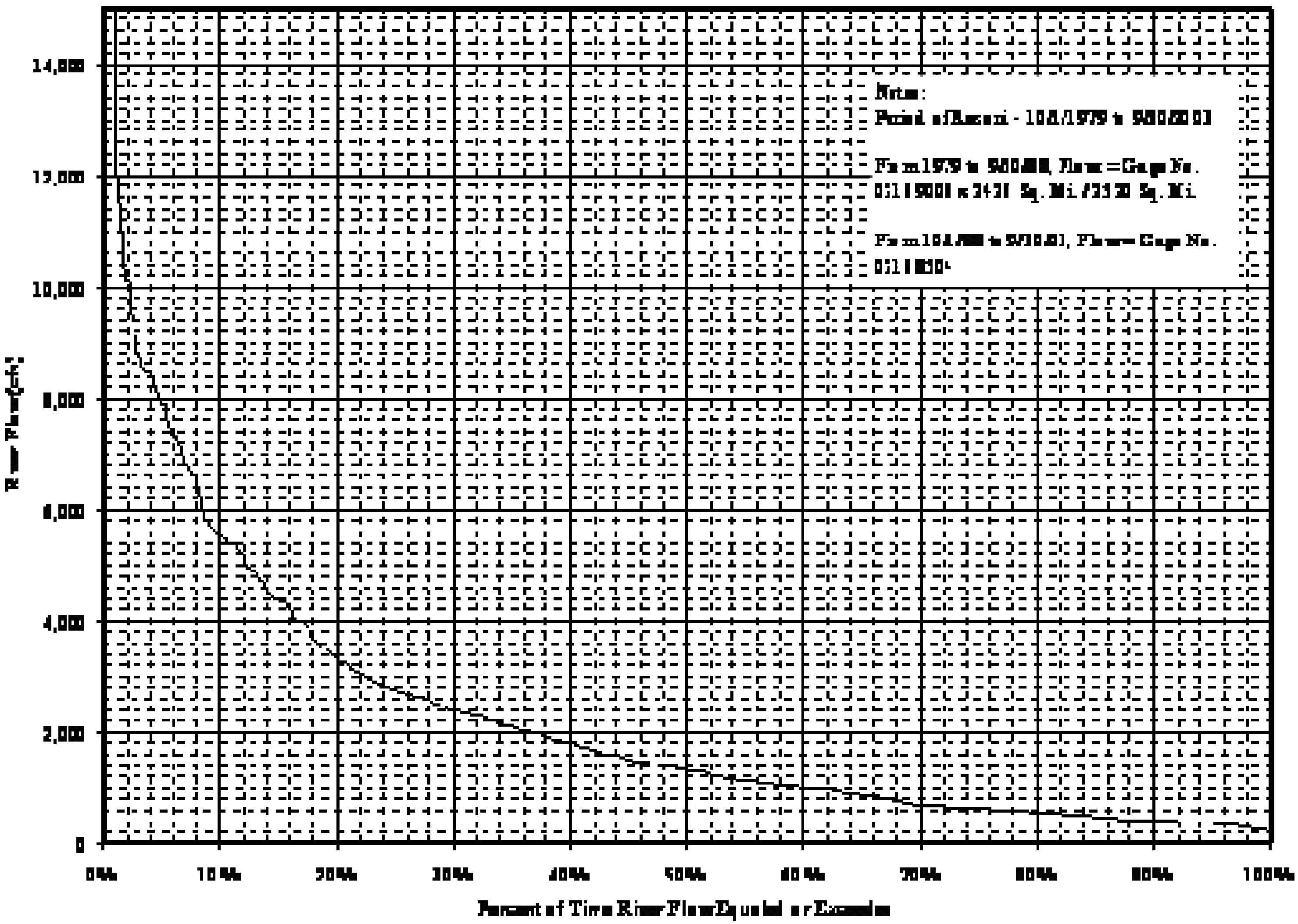


Figure 9.0 Saluda Project FERC No. 516, South Carolina Electric & Gas Co., September Flow Duration Curve

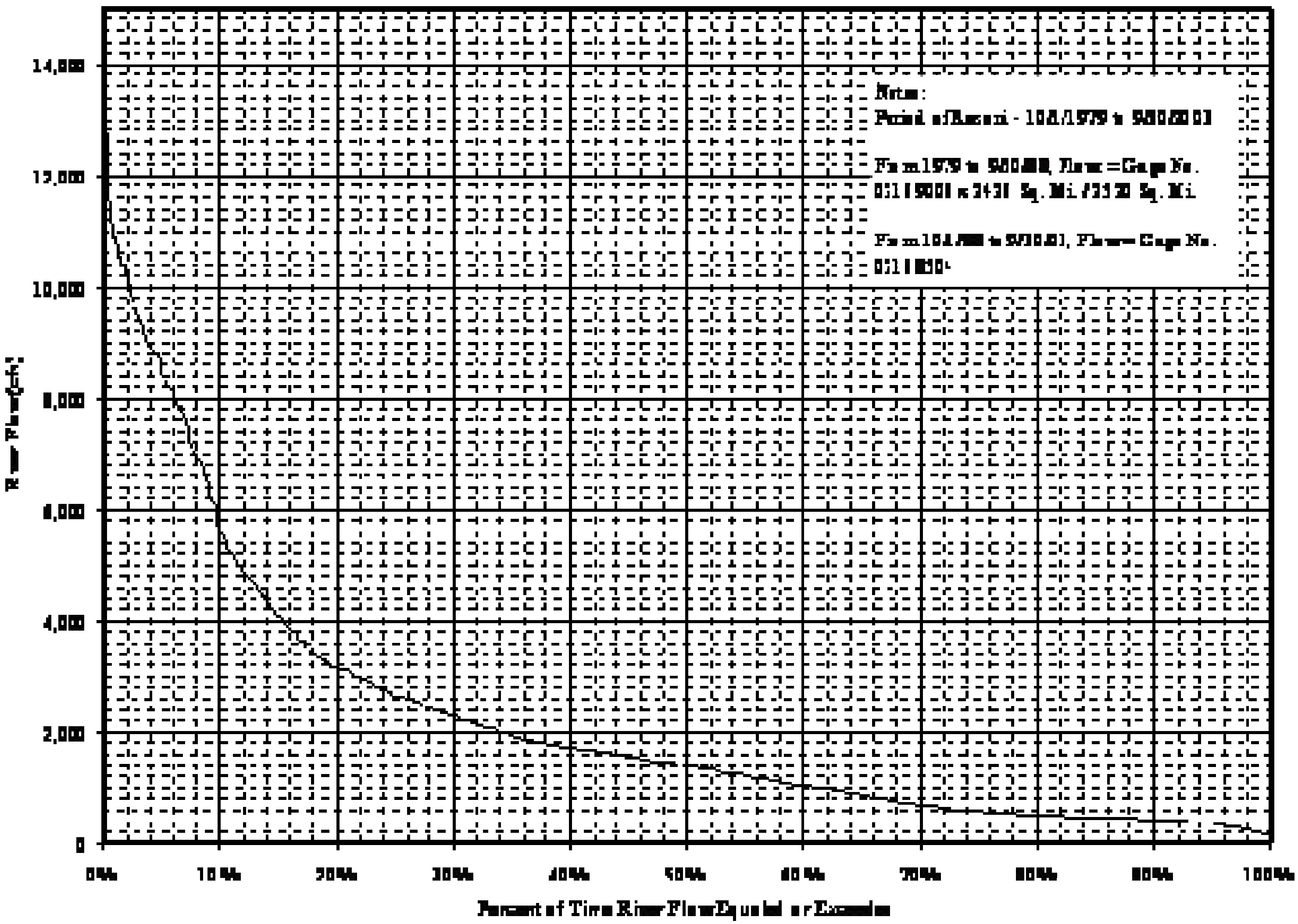


Figure 10.0 Saluda Project FERC No. 516, South Carolina Electric & Gas Co., October Flow Duration Curve

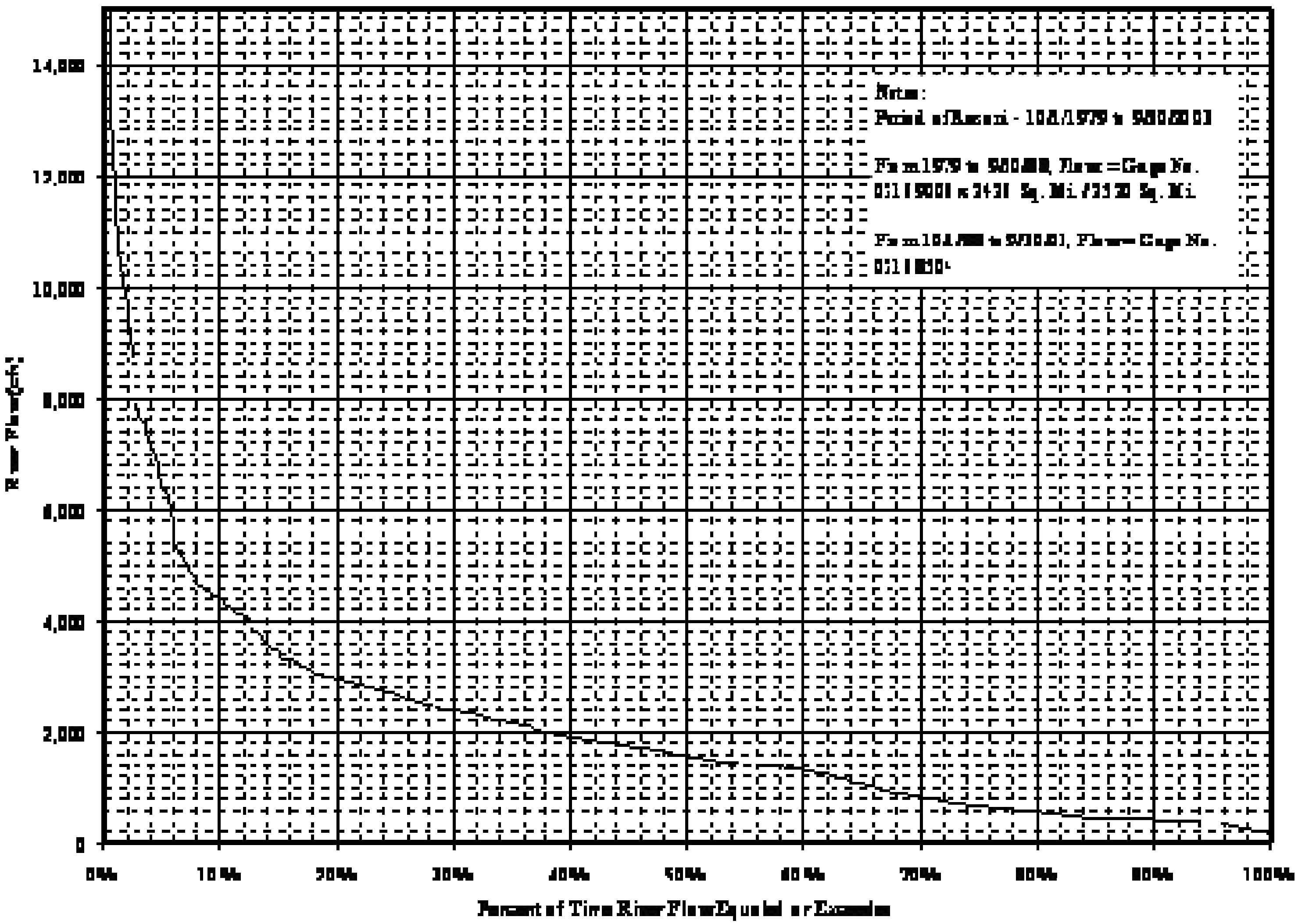


Figure 11.0 Saluda Project FERC No. 516, South Carolina Electric & Gas Co., November Flow Duration Curve

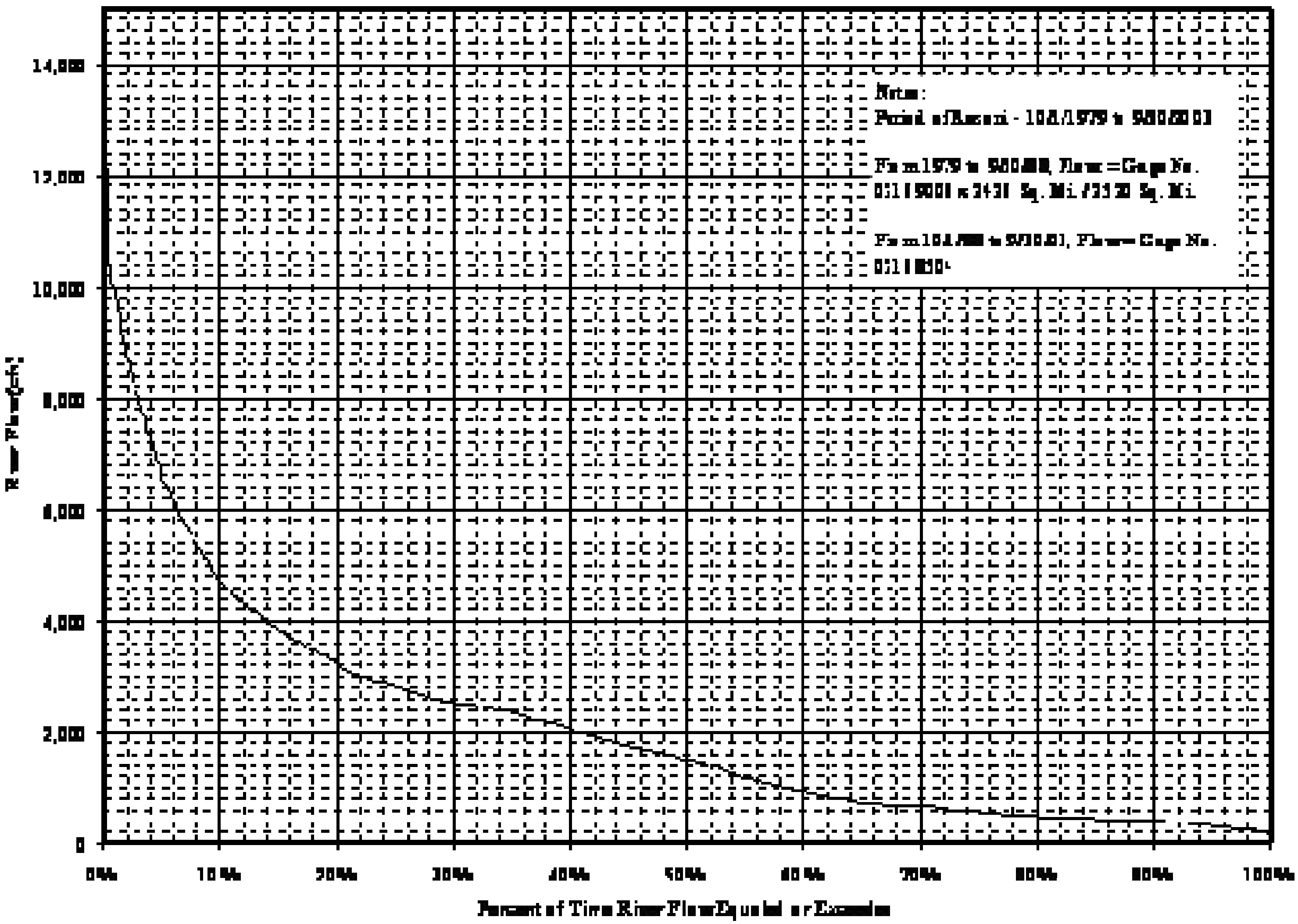
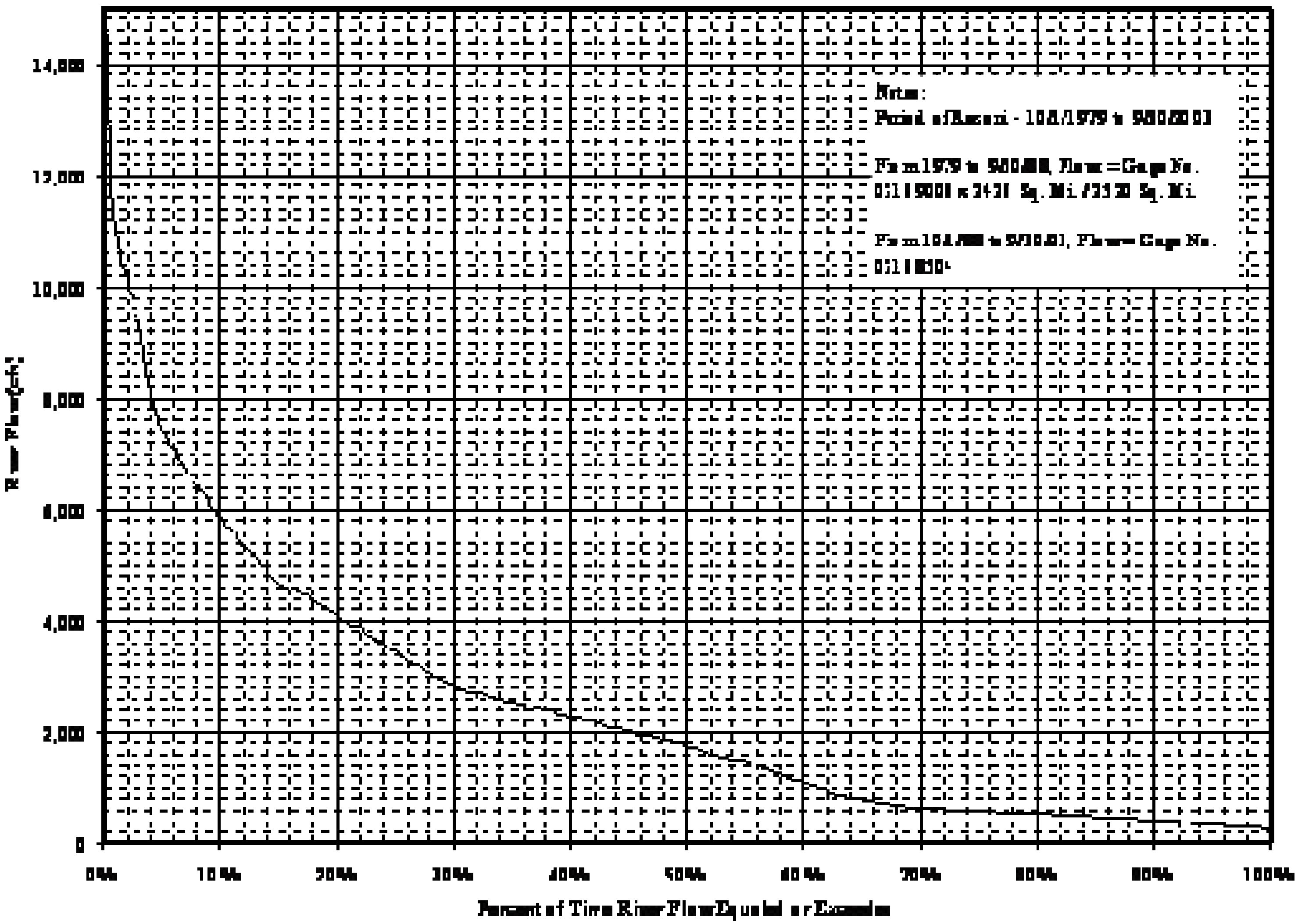


Figure 12.0 Saluda Project FERC No. 516, South Carolina Electric & Gas Co., December Flow Duration Curve



APPENDIX E

PHYSICAL AND HYDRAULIC CHARACTERISTIC OF HYDROELECTRIC DAMS EQUIPPED WITH FRANCIS TYPE TURBINES

TURBINE MORTALITY DATABASE

Table E-1: Physical and Hydraulic Characteristic of Hydroelectric Dams Equipped With Francis Type Turbines

Site Name	Sampling Method	Species Tested	Head (ft)	Runner Speed (RPM)	Runner Diameter (in)	Peripheral Runner Velocity (ft/sec)
Saluda Hydro	**N/A**	**N/A**	**180**	**138.5**	**144**	**87**
Saluda Hydro	**N/A**	**N/A**	**180**	**128.6**	**175**	**98**
Alcona	NETPR	bluegill	43	90	100	39.3
Alcona	NETPR	bluegill	43	90	100	39.3
Alcona	NETPR	rainbow trout	43	90	100	39.3
Alcona	NETPR	rainbow trout	43	90	100	39.3
Alcona	NETPR	spottail shiner	43	90	100	39.3
Alcona	NETPR	yellow perch	43	90	100	39.3
Alcona	NETPR	bluegill	43	90	100	39.3
Alcona	NETPR	bluegill	43	90	100	39.3
Alcona	NETPR	golden shiner	43	90	100	39.3
Alcona	NETPR	golden shiner	43	90	100	39.3
Alcona	NETPR	northern pike	43	90	100	39.3
Alcona	NETPR	grass pickerel	43	90	100	39.3
Alcona	NETPR	walleye	43	90	100	39.3
Alcona	NETPR	walleye	43	90	100	39.3
Alcona	NETPR	white sucker	43	90	100	39.3
Alcona	NETPR	white sucker	43	90	100	39.3
Alcona	NETPR	yellow perch	43	90	100	39.3
Alcona	NETPR	yellow perch	43	90	100	39.3
Bond Falls	NETPR	rainbow trout	210	300		
Bond Falls	NETPR	yellow perch	210	300		
Bond Falls	NETPR	golden shiner	210	300		
Bond Falls	NETPR	bluegill	210	300		
Buzzards Roost	BALT	bluegill	55	240		
Buzzards Roost	BALT	bluegill	55	240		
Buzzards Roost	BALT	bullhead spp	55	240		
Buzzards Roost	BALT	bullhead spp	55	240		
Buzzards Roost	BALT	bluegill	55	240		
Buzzards Roost	BALT	bluegill	55	240		
Buzzards Roost	BALT	white perch	55	240		
Buzzards Roost	BALT	bluegill	55	240		
Buzzards Roost	BALT	bluegill	55	240		
Buzzards Roost	BALT	bullhead spp	55	240		

Site Name	Sampling Method	Species Tested	Head (ft)	Runner Speed (RPM)	Runner Diameter (in)	Peripheral Runner Velocity (ft/sec)
Caldron Falls	NETPR	bluegill, bluegill x green sunfish hybrid	80	226	72	71
Caldron Falls	NETPR	bluegill, bluegill x green sunfish hybrid	80	226	72	71
Caldron Falls	NETPR	bluegill, bluegill x green sunfish hybrid	80	226	72	71
Caldron Falls	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	80	226	72	71
Caldron Falls	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	80	226	72	71
Caldron Falls	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	80	226	72	71
Caldron Falls	NETPR	bluegill, bluegill x green sunfish hybrid	80	226	72	71
Caldron Falls	NETPR	bluegill, bluegill x green sunfish hybrid	80	226	72	71
Caldron Falls	NETPR	bluegill, bluegill x green sunfish hybrid	80	226	72	71
Caldron Falls	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	80	226	72	71
Caldron Falls	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	80	226	72	71

Site Name	Sampling Method	Species Tested	Head (ft)	Runner Speed (RPM)	Runner Diameter (in)	Peripheral Runner Velocity (ft/sec)
Caldron Falls	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	80	226	72	71
Caldron Falls	NETPR	bluegill, bluegill x green sunfish hybrid	80	226	72	71
Caldron Falls	NETPR	bluegill, bluegill x green sunfish hybrid	80	226	72	71
Caldron Falls	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	80	226	72	71
Caldron Falls	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	80	226	72	71
Caldron Falls	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	80	226	72	71
Caldron Falls	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	80	226	72	71
Caldron Falls	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	80	226	72	71

Site Name	Sampling Method	Species Tested	Head (ft)	Runner Speed (RPM)	Runner Diameter (in)	Peripheral Runner Velocity (ft/sec)
Caldron Falls	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	80	226	72	71
Caldron Falls	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	80	226	72	71
Caldron Falls	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	80	226	72	71
Caldron Falls	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	80	226	72	71
Caldron Falls	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	80	226	72	71
Caldron Falls	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	80	226	72	71
Caldron Falls	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	80	226	72	71
Chalk Hill	BALT	bluegill	28	150	102	66.7
Chalk Hill	BALT	bluegill	28	150	102	66.7

Site Name	Sampling Method	Species Tested	Head (ft)	Runner Speed (RPM)	Runner Diameter (in)	Peripheral Runner Velocity (ft/sec)
Chalk Hill	BALT	white sucker/rainbow trout	28	150	102	66.7
Chalk Hill	BALT	white sucker/rainbow trout	28	150	102	66.7
Colton	NETPR	white sucker	258	360	59	92.6
Colton	NETPR	white sucker	258	360	59	92.6
Colton	NETPR	white sucker	258	360	59	92.6
Colton	NETPR	bluegill	258	360	59	92.6
Colton	NETPR	largemouth bass	258	360	59	92.6
Colton	NETPR	largemouth bass	258	360	59	92.6
Colton	NETPR	brook trout	258	360	59	92.6
Colton	NETPR	rainbow trout	258	360	59	92.6
Colton	NETPR	rainbow trout	258	360	59	92.6
Colton	NETPR	white sucker	258	360	59	92.6
Colton	NETPR	white sucker	258	360	59	92.6
Colton	NETPR	white sucker	258	360	59	92.6
Colton	NETPR	bluegill	258	360	59	92.6
Colton	NETPR	largemouth bass	258	360	59	92.6
Colton	NETPR	largemouth bass	258	360	59	92.6
Colton	NETPR	yellow perch	258	360	59	92.6
Colton	NETPR	walleye	258	360	59	92.6
Colton	NETPR	brook trout	258	360	59	92.6
Colton	NETPR	rainbow trout	258	360	59	92.6
Colton	NETPR	rainbow trout	258	360	59	92.6
Colton	NETPR	white sucker	258	360	59	92.6
Colton	NETPR	bluegill	258	360	59	92.6
Colton	NETPR	largemouth bass	258	360	59	92.6
Colton	NETPR	largemouth bass	258	360	59	92.6
Colton	NETPR	yellow perch	258	360	59	92.6
Colton	NETPR	walleye	258	360	59	92.6
Conowingo	BALT	American shad	90	120	225	118
Craggy Dam	BALT	channel catfish	19.7	229	175	174.8
Craggy Dam	BALT	channel catfish	19.7	229	175	174.8
Craggy Dam	BALT	channel catfish	19.7	229	175	174.8
Craggy Dam	BALT	channel catfish	19.7	229	175	174.8
Craggy Dam	BALT	bluegill	19.7	229	175	174.8
Craggy Dam	BALT	bluegill	19.7	229	175	174.8
Crescent	BALT	blueback herring	27	144	108	67.8

Site Name	Sampling Method	Species Tested	Head (ft)	Runner Speed (RPM)	Runner Diameter (in)	Peripheral Runner Velocity (ft/sec)
Crowley	NETPR	white sucker		150	93	60.8
Crowley	NETPR	white sucker		150	93	60.8
Crowley	NETPR	walleye		150	93	60.8
Crowley	NETPR	walleye		150	93	60.8
Crowley	NETPR	largemouth bass		150	93	60.8
E.J. West	NETPR	bluegill	63	112.5	131	64.1
E.J. West	NETPR	yellow perch	63	112.5	131	64.1
E.J. West	NETPR	rainbow trout	63	112.5	131	64.1
E.J. West	NETPR	rainbow trout	63	112.5	131	64.1
E.J. West	NETPR	golden shiner	63	112.5	131	64.1
E.J. West	NETPR	golden shiner	63	112.5	131	64.1
E.J. West	NETPR	rainbow trout	63	112.5	131	64.1
E.J. West	NETPR	largemouth bass	63	112.5	131	64.1
E.J. West	NETPR	largemouth bass	63	112.5	131	64.1
E.J. West	NETPR	bluegill	63	112.5	131	64.1
E.J. West	NETPR	bluegill	63	112.5	131	64.1
E.J. West	NETPR	largemouth bass	63	112.5	131	64.1
E.J. West	NETPR	largemouth bass	63	112.5	131	64.1
E.J. West	NETPR	yellow perch	63	112.5	131	64.1
E.J. West	NETPR	yellow perch	63	112.5	131	64.1
E.J. West	NETPR	rainbow trout	63	112.5	131	64.1
E.J. West	NETPR	rainbow trout	63	112.5	131	64.1
E.J. West	NETPR	rainbow trout	63	112.5	131	64.1
E.J. West	NETPR	rainbow trout	63	112.5	131	64.1
E.J. West	NETPR	white sucker	63	112.5	131	64.1
E.J. West	NETPR	white sucker	63	112.5	131	64.1
E.J. West	NETPR	white sucker	63	112.5	131	64.1
E.J. West	NETPR	white sucker	63	112.5	131	64.1
Finch Pruyn	BALT	smallmouth bass	49	112.5		
Finch Pruyn	BALT	smallmouth bass	49	112.5		
Finch Pruyn	BALT	smallmouth bass	49	112.5		
Finch Pruyn	BALT	smallmouth bass	49	112.5		
Finch Pruyn	BALT	smallmouth bass	49	112.5		
Finch Pruyn	BALT	smallmouth bass	49	112.5		
Five Channels	NETPR	bluegill	36	150	55	36
Five Channels	NETPR	bluegill	36	150	55	36
Five Channels	NETPR	rainbow trout	36	150	55	36
Five Channels	NETPR	rainbow trout	36	150	55	36

Site Name	Sampling Method	Species Tested	Head (ft)	Runner Speed (RPM)	Runner Diameter (in)	Peripheral Runner Velocity (ft/sec)
Five Channels	NETPR	spottail shiner	36	150	55	36
Five Channels	NETPR	yellow perch	36	150	55	36
Five Channels	NETPR	yellow perch	36	150	55	36
Five Channels	NETPR	bluegill	36	150	55	36
Five Channels	NETPR	bluegill	36	150	55	36
Five Channels	NETPR	golden shiner	36	150	55	36
Five Channels	NETPR	golden shiner	36	150	55	36
Five Channels	NETPR	walleye	36	150	55	36
Five Channels	NETPR	walleye	36	150	55	36
Five Channels	NETPR	white sucker	36	150	55	36
Five Channels	NETPR	white sucker	36	150	55	36
Five Channels	NETPR	yellow perch	36	150	55	36
Five Channels	NETPR	northern pike	36	150	55	36
Fourth Lake	NETPR	alewife	75.5	360	65	105.3
Fourth Lake	NETPR	alewife	75.5	360	65	105.3
Fourth Lake	NETPR	alewife	75.5	360	65	105.3
Fourth Lake	NETPR	alewife	75.5	360	65	105.3
Fourth Lake	NETPR	alewife	75.5	360	65	105.3
Fourth Lake	NETPR	alewife	75.5	360	65	105.3
Fourth Lake	NETPR	alewife	75.5	360	65	105.3
Fourth Lake	NETPR	Atlantic salmon	75.5	360	65	105.3
Fourth Lake	NETPR	Atlantic salmon	75.5	360	65	105.3
Fourth Lake	NETPR	Atlantic salmon	75.5	360	65	105.3
Fourth Lake	NETPR	Atlantic salmon	75.5	360	65	105.3
Fourth Lake	NETPR	Atlantic salmon	75.5	360	65	105.3
Fourth Lake	NETPR	Atlantic salmon	75.5	360	65	105.3
Fourth Lake	NETPR	Atlantic salmon	75.5	360	65	105.3
Fourth Lake	NETPR	Atlantic salmon	75.5	360	65	105.3
Fourth Lake	NETPR	Atlantic salmon	75.5	360	65	105.3
Fourth Lake	NETPR	Atlantic salmon	75.5	360	65	105.3
Fourth Lake	NETPR	Atlantic salmon	75.5	360	65	105.3
Grand Rapids	NETPR	bluegill	28	360		
Grand Rapids	NETPR	bluegill	28	360		
Grand Rapids	NETPR	bluegill	28	360		
Grand Rapids	NETPR	white sucker	28	360		
Grand Rapids	NETPR	white sucker	28	360		
Grand Rapids	NETPR	white sucker	28	360		
Grand Rapids	NETPR	white sucker	28	360		

Site Name	Sampling Method	Species Tested	Head (ft)	Runner Speed (RPM)	Runner Diameter (in)	Peripheral Runner Velocity (ft/sec)
Grand Rapids	NETPR	white sucker	28	360		
Grand Rapids	NETPR	white sucker	28	360		
Grand Rapids	NETPR	bluegill	28	360		
Grand Rapids	NETPR	bluegill	28	360		
Grand Rapids	NETPR	white sucker	28	360		
Grand Rapids	NETPR	white sucker	28	360		
Grand Rapids	NETPR	white sucker	28	360		
Grand Rapids	NETPR	white sucker	28	360		
Grand Rapids	NETPR	white sucker	28	360		
Grand Rapids	NETPR	white sucker	28	360		
Grand Rapids	NETPR	bluegill	28	360		
Grand Rapids	NETPR	bluegill	28	360		
Grand Rapids	NETPR	bluegill	28	360		
Grand Rapids	NETPR	white sucker	28	360		
Grand Rapids	NETPR	white sucker	28	360		
Grand Rapids	NETPR	white sucker	28	360		
Grand Rapids	NETPR	white sucker	28	360		
Grand Rapids	NETPR	white sucker	28	360		
Grand Rapids	NETPR	white sucker	28	360		
Grand Rapids	NETPR	bluegill	28	360		
Grand Rapids	NETPR	bluegill	28	360		
Grand Rapids	NETPR	bluegill	28	360		
Grand Rapids	NETPR	white sucker	28	360		
Grand Rapids	NETPR	white sucker	28	360		
Grand Rapids	NETPR	white sucker	28	360		
Grand Rapids	NETPR	white sucker	28	360		
Grand Rapids	NETPR	white sucker	28	360		
Grand Rapids	NETPR	white sucker	28	360		
Grand Rapids	NETPR	bluegill	28	360		
Grand Rapids	NETPR	bluegill	28	360		
Grand Rapids	NETPR	white sucker	28	360		
Grand Rapids	NETPR	white sucker	28	360		
Grand Rapids	NETPR	white sucker	28	360		
Grand Rapids	NETPR	white sucker	28	360		
Grand Rapids	NETPR	white sucker	28	360		
Grand Rapids	NETPR	bluegill	28	360		
Grand Rapids	NETPR	bluegill	28	360		
Grand Rapids	NETPR	bluegill	28	360		

Site Name	Sampling Method	Species Tested	Head (ft)	Runner Speed (RPM)	Runner Diameter (in)	Peripheral Runner Velocity (ft/sec)
Grand Rapids	NETPR	white sucker	28	360		
Grand Rapids	NETPR	white sucker	28	360		
Grand Rapids	NETPR	white sucker	28	360		
Grand Rapids	NETPR	white sucker	28	360		
Grand Rapids	NETPR	white sucker	28	360		
Grand Rapids	NETPR	bluegill	28	360		
Grand Rapids	NETPR	bluegill	28	360		
Grand Rapids	NETPR	bluegill	28	360		
Grand Rapids	NETPR	white sucker	28	360		
Grand Rapids	NETPR	white sucker	28	360		
Grand Rapids	NETPR	white sucker	28	360		
Grand Rapids	NETPR	white sucker	28	360		
Grand Rapids	NETPR	white sucker	28	360		
Grand Rapids	NETPR	white sucker	28	360		
Grand Rapids	NETPR	bluegill	28	360		
Grand Rapids	NETPR	bluegill	28	360		
Grand Rapids	NETPR	bluegill	28	360		
Grand Rapids	NETPR	white sucker	28	360		
Grand Rapids	NETPR	white sucker	28	360		
Grand Rapids	NETPR	white sucker	28	360		
Grand Rapids	NETPR	white sucker	28	360		
Grand Rapids	NETPR	white sucker	28	360		
Grand Rapids	NETPR	white sucker	28	360		
Hadley Falls	BALT	American shad	50	128	170	94.9
Hadley Falls	BALT	American shad	50	128	170	94.9
Hadley Falls	BALT	American shad	50	128	170	94.9
Hardy	NETPR	bluegill	100	163.6	84	59.8
Hardy	NETPR	bluegill	100	163.6	84	59.8
Hardy	NETPR	golden shiner	100	163.6	84	59.8
Hardy	NETPR	golden shiner	100	163.6	84	59.8
Hardy	NETPR	largemouth bass	100	163.6	84	59.8
Hardy	NETPR	northern pike	100	163.6	84	59.8
Hardy	NETPR	rainbow trout	100	163.6	84	59.8
Hardy	NETPR	rainbow trout	100	163.6	84	59.8
Hardy	NETPR	walleye	100	163.6	84	59.8
Hardy	NETPR	white sucker	100	163.6	84	59.8
Hardy	NETPR	white sucker	100	163.6	84	59.8
Hardy	NETPR	yellow perch	100	163.6	84	59.8

Site Name	Sampling Method	Species Tested	Head (ft)	Runner Speed (RPM)	Runner Diameter (in)	Peripheral Runner Velocity (ft/sec)
Hardy	NETPR	yellow perch	100	163.6	84	59.8
Herrings	NETPR	bluegill	19.5	138.5	113	68.3
Herrings	NETPR	largemouth bass	19.5	138.5	113	68.3
Herrings	NETPR	yellow perch	19.5	138.5	113	68.3
Herrings	NETPR	walleye	19.5	138.5	113	68.3
Herrings	NETPR	golden shiner	19.5	138.5	113	68.3
Herrings	NETPR	white sucker	19.5	138.5	113	68.3
Herrings	NETPR	white sucker	19.5	138.5	113	68.3
Herrings	NETPR	rainbow trout	19.5	138.5	113	68.3
Herrings	NETPR	rainbow trout	19.5	138.5	113	68.3
Herrings	NETPR	rainbow trout	19.5	138.5	113	68.3
Herrings	NETPR	bluegill	19.5	138.5	113	68.3
Herrings	NETPR	largemouth bass	19.5	138.5	113	68.3
Herrings	NETPR	largemouth bass	19.5	138.5	113	68.3
Herrings	NETPR	walleye	19.5	138.5	113	68.3
Herrings	NETPR	rainbow trout	19.5	138.5	113	68.3
Herrings	NETPR	rainbow trout	19.5	138.5	113	68.3
Herrings	NETPR	bluegill	19.5	138.5	113	68.3
Herrings	NETPR	largemouth bass	19.5	138.5	113	68.3
Herrings	NETPR	largemouth bass	19.5	138.5	113	68.3
Herrings	NETPR	yellow perch	19.5	138.5	113	68.3
Herrings	NETPR	yellow perch	19.5	138.5	113	68.3
Herrings	NETPR	white sucker	19.5	138.5	113	68.3
Herrings	NETPR	white sucker	19.5	138.5	113	68.3
Herrings	NETPR	white sucker	19.5	138.5	113	68.3
Herrings	NETPR	white sucker	19.5	138.5	113	68.3
Herrings	NETPR	white sucker	19.5	138.5	113	68.3
Herrings	NETPR	white sucker	19.5	138.5	113	68.3
Herrings	NETPR	rainbow trout	19.5	138.5	113	68.3
Herrings	NETPR	rainbow trout	19.5	138.5	113	68.3
Herrings	NETPR	rainbow trout	19.5	138.5	113	68.3
Herrings	NETPR	American eel	19.5	138.5	113	68.3
Herrings	NETPR	bluegill	19.5	138.5	113	68.3
Herrings	NETPR	largemouth bass	19.5	138.5	113	68.3
Herrings	NETPR	largemouth bass	19.5	138.5	113	68.3
Herrings	NETPR	yellow perch	19.5	138.5	113	68.3
Herrings	NETPR	yellow perch	19.5	138.5	113	68.3
Herrings	NETPR	yellow perch	19.5	138.5	113	68.3

Site Name	Sampling Method	Species Tested	Head (ft)	Runner Speed (RPM)	Runner Diameter (in)	Peripheral Runner Velocity (ft/sec)
Herrings	NETPR	yellow perch	19.5	138.5	113	68.3
Herrings	NETPR	yellow perch	19.5	138.5	113	68.3
Herrings	NETPR	white sucker	19.5	138.5	113	68.3
Herrings	NETPR	white sucker	19.5	138.5	113	68.3
Herrings	NETPR	white sucker	19.5	138.5	113	68.3
Herrings	NETPR	white sucker	19.5	138.5	113	68.3
Herrings	NETPR	white sucker	19.5	138.5	113	68.3
Herrings	NETPR	white sucker	19.5	138.5	113	68.3
Herrings	NETPR	rainbow trout	19.5	138.5	113	68.3
Herrings	NETPR	rainbow trout	19.5	138.5	113	68.3
Herrings	NETPR	rainbow trout	19.5	138.5	113	68.3
Herrings	NETPR	alewife	19.5	138.5	113	68.3
Herrings	NETPR	alewife	19.5	138.5	113	68.3
High Falls	NETPR	bluegill, bluegill x green sunfish hybrid	83	359	39	61
High Falls	NETPR	bluegill, bluegill x green sunfish hybrid	83	359	39	
High Falls	NETPR	bluegill, bluegill x green sunfish hybrid	83	359	39	
High Falls	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	83	359	39	
High Falls	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	83	359	39	
High Falls	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	83	359	39	
High Falls	NETPR	bluegill, bluegill x green sunfish hybrid	83	359	39	
High Falls	NETPR	bluegill, bluegill x green sunfish hybrid	83	359	39	

Site Name	Sampling Method	Species Tested	Head (ft)	Runner Speed (RPM)	Runner Diameter (in)	Peripheral Runner Velocity (ft/sec)
High Falls	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	83	359	39	
High Falls	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	83	359	39	
High Falls	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	83	359	39	
High Falls	NETPR	bluegill, bluegill x green sunfish hybrid	83	359	39	
High Falls	NETPR	bluegill, bluegill x green sunfish hybrid	83	359	39	
High Falls	NETPR	bluegill, bluegill x green sunfish hybrid	83	359	39	
High Falls	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	83	359	39	
High Falls	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	83	359	39	
High Falls	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	83	359	39	

Site Name	Sampling Method	Species Tested	Head (ft)	Runner Speed (RPM)	Runner Diameter (in)	Peripheral Runner Velocity (ft/sec)
High Falls	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	83	359	39	
High Falls	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	83	359	39	
High Falls	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	83	359	39	
High Falls	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	83	359	39	
High Falls	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	83	359	39	
High Falls	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	83	359	39	
High Falls	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	83	359	39	

Site Name	Sampling Method	Species Tested	Head (ft)	Runner Speed (RPM)	Runner Diameter (in)	Peripheral Runner Velocity (ft/sec)
High Falls	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	83	359	39	
High Falls	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	83	359	39	
Higley	NETPR	brook trout	45	257		53.2
Higley	NETPR	rainbow trout	45	257		53.2
Higley	NETPR	rainbow trout	45	257		53.2
Higley	NETPR	rainbow trout	45	257		53.2
Higley	NETPR	white sucker	45	257		53.2
Higley	NETPR	yellow perch	45	257		53.2
Higley	NETPR	walleye	45	257		53.2
Higley	NETPR	walleye	45	257		53.2
Higley	NETPR	brook trout	45	257		53.2
Higley	NETPR	rainbow trout	45	257		53.2
Higley	NETPR	white sucker	45	257		53.2
Higley	NETPR	white sucker	45	257		53.2
Higley	NETPR	white sucker	45	257		53.2
Higley	NETPR	bluegill	45	257		53.2
Higley	NETPR	largemouth bass	45	257		53.2
Higley	NETPR	largemouth bass	45	257		53.2
Higley	NETPR	yellow perch	45	257		53.2
Higley	NETPR	golden shiner	45	257		53.2
Higley	NETPR	white sucker	45	257		53.2
Higley	NETPR	white sucker	45	257		53.2
Higley	NETPR	bluegill	45	257		53.2
Higley	NETPR	largemouth bass	45	257		53.2
Higley	NETPR	largemouth bass	45	257		53.2
Higley	NETPR	yellow perch	45	257		53.2
Hoist	NETPR	brown trout	142	360		
Hoist	NETPR	brook trout	142	360		
Hoist	NETPR	brown trout	142	360		
Hoist	NETPR	bluegill	142	360		

Site Name	Sampling Method	Species Tested	Head (ft)	Runner Speed (RPM)	Runner Diameter (in)	Peripheral Runner Velocity (ft/sec)
Hoist	NETPR	bluegill	142	360		
Hollidays Bridge	BALT	bluegill	35	360		
Hollidays Bridge	BALT	bluegill	35	360		
Hollidays Bridge	BALT	catfish spp	35	360		
Hollidays Bridge	BALT	catfish spp	35	360		
Hollidays Bridge	BALT	catfish spp	35	360		
Hollidays Bridge	BALT	catfish spp	35	360		
Holtwood	BALT	American shad	61.5	102.8	112	50.2
Holtwood	BALT	American shad	61.5	102.8	112	50.2
Lower Granite	BALT	chinook salmon	98	90	312	122.5
Lower Granite	BALT	chinook salmon	98	90	312	122.5
Lower Granite	BALT	chinook salmon	98	90	312	122.5
Lower Granite	BALT	chinook salmon	98	90	312	122.5
Lower Granite	BALT	chinook salmon	98	90	312	122.5
Lower Granite	BALT	chinook salmon	98	90	312	122.5
Lower Granite	BALT	chinook salmon	98	90	312	122.5
Minetto	NETPR	bluegill	17.3	72	139	43.6
Minetto	NETPR	largemouth bass	17.3	72	139	43.6
Minetto	NETPR	largemouth bass	17.3	72	139	43.6
Minetto	NETPR	yellow perch	17.3	72	139	43.6
Minetto	NETPR	white sucker	17.3	72	139	43.6
Minetto	NETPR	white sucker	17.3	72	139	43.6
Minetto	NETPR	white sucker	17.3	72	139	43.6
Minetto	NETPR	rainbow trout	17.3	72	139	43.6
Minetto	NETPR	rainbow trout	17.3	72	139	43.6
Minetto	NETPR	rainbow trout	17.3	72	139	43.6
Minetto	NETPR	alewife	17.3	72	139	43.6
Minetto	NETPR	alewife	17.3	72	139	43.6
Minetto	NETPR	alewife	17.3	72	139	43.6
Minetto	NETPR	alewife	17.3	72	139	43.6
Minetto	NETPR	alewife	17.3	72	139	43.6
Minetto	NETPR	bluegill	17.3	72	139	43.6
Minetto	NETPR	largemouth bass	17.3	72	139	43.6
Minetto	NETPR	largemouth bass	17.3	72	139	43.6
Minetto	NETPR	yellow perch	17.3	72	139	43.6
Minetto	NETPR	walleye	17.3	72	139	43.6
Minetto	NETPR	walleye	17.3	72	139	43.6
Minetto	NETPR	white sucker	17.3	72	139	43.6

Site Name	Sampling Method	Species Tested	Head (ft)	Runner Speed (RPM)	Runner Diameter (in)	Peripheral Runner Velocity (ft/sec)
Minetto	NETPR	white sucker	17.3	72	139	43.6
Minetto	NETPR	white sucker	17.3	72	139	43.6
Minetto	NETPR	white sucker	17.3	72	139	43.6
Minetto	NETPR	rainbow trout	17.3	72	139	43.6
Minetto	NETPR	rainbow trout	17.3	72	139	43.6
Minetto	NETPR	rainbow trout	17.3	72	139	43.6
Minetto	NETPR	rainbow trout	17.3	72	139	43.6
Minetto	NETPR	American eel	17.3	72	139	43.6
Ninety-Nine Islands	BALT	bluegill	74	225		
Ninety-Nine Islands	BALT	bluegill	74	225		
Ninety-Nine Islands	BALT	catfish spp	74	225		
Ninety-Nine Islands	BALT	catfish spp	74	225		
Ninety-Nine Islands	BALT	bluegill	74	225		
Ninety-Nine Islands	BALT	bluegill	74	225		
Ninety-Nine Islands	BALT	catfish spp	74	225		
Ninety-Nine Islands	BALT	catfish spp	74	225		
Peshtigo	NETPR	bluegill, bluegill x green sunfish hybrid	13	100	80	35
Peshtigo	NETPR	bluegill, bluegill x green sunfish hybrid	13	100	80	35
Peshtigo	NETPR	bluegill, bluegill x green sunfish hybrid	13	100	80	35
Peshtigo	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	13	100	80	35
Peshtigo	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	13	100	80	35
Peshtigo	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	13	100	80	35

Site Name	Sampling Method	Species Tested	Head (ft)	Runner Speed (RPM)	Runner Diameter (in)	Peripheral Runner Velocity (ft/sec)
Peshtigo	NETPR	bluegill, bluegill x green sunfish hybrid	13	100	80	35
Peshtigo	NETPR	bluegill, bluegill x green sunfish hybrid	13	100	80	35
Peshtigo	NETPR	bluegill, bluegill x green sunfish hybrid	13	100	80	35
Peshtigo	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	13	100	80	35
Peshtigo	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	13	100	80	35
Peshtigo	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	13	100	80	35
Peshtigo	NETPR	bluegill, bluegill x green sunfish hybrid	13	100	80	35
Peshtigo	NETPR	bluegill, bluegill x green sunfish hybrid	13	100	80	35
Peshtigo	NETPR	bluegill, bluegill x green sunfish hybrid	13	100	80	35
Peshtigo	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	13	100	80	35
Peshtigo	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	13	100	80	35

Site Name	Sampling Method	Species Tested	Head (ft)	Runner Speed (RPM)	Runner Diameter (in)	Peripheral Runner Velocity (ft/sec)
Peshtigo	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	13	100	80	35
Peshtigo	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	13	100	80	35
Peshtigo	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	13	100	80	35
Peshtigo	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	13	100	80	35
Peshtigo	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	13	100	80	35
Peshtigo	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	13	100	80	35
Peshtigo	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	13	100	80	35

Site Name	Sampling Method	Species Tested	Head (ft)	Runner Speed (RPM)	Runner Diameter (in)	Peripheral Runner Velocity (ft/sec)
Peshtigo	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	13	100	80	35
Peshtigo	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	13	100	80	35
Peshtigo	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	13	100	80	35
Potato Rapids	NETPR	bluegill, bluegill x green sunfish hybrid	17	123	84	45
Potato Rapids	NETPR	bluegill, bluegill x green sunfish hybrid	17	123	84	45
Potato Rapids	NETPR	bluegill, bluegill x green sunfish hybrid	17	123	84	45
Potato Rapids	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	17	123	84	45
Potato Rapids	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	17	123	84	45
Potato Rapids	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	17	123	84	45
Potato Rapids	NETPR	bluegill, bluegill x green sunfish hybrid	17	123	84	45

Site Name	Sampling Method	Species Tested	Head (ft)	Runner Speed (RPM)	Runner Diameter (in)	Peripheral Runner Velocity (ft/sec)
Potato Rapids	NETPR	bluegill, bluegill x green sunfish hybrid	17	123	84	45
Potato Rapids	NETPR	bluegill, bluegill x green sunfish hybrid	17	123	84	45
Potato Rapids	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	17	123	84	45
Potato Rapids	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	17	123	84	45
Potato Rapids	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	17	123	84	45
Potato Rapids	NETPR	bluegill, bluegill x green sunfish hybrid	17	123	84	45
Potato Rapids	NETPR	bluegill, bluegill x green sunfish hybrid	17	123	84	45
Potato Rapids	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	17	123	84	45
Potato Rapids	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	17	123	84	45
Potato Rapids	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	17	123	84	45

Site Name	Sampling Method	Species Tested	Head (ft)	Runner Speed (RPM)	Runner Diameter (in)	Peripheral Runner Velocity (ft/sec)
Potato Rapids	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	17	123	84	45
Potato Rapids	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	17	123	84	45
Potato Rapids	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	17	123	84	45
Potato Rapids	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	17	123	84	45
Potato Rapids	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	17	123	84	45
Potato Rapids	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	17	123	84	45
Potato Rapids	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	17	123	84	45

Site Name	Sampling Method	Species Tested	Head (ft)	Runner Speed (RPM)	Runner Diameter (in)	Peripheral Runner Velocity (ft/sec)
Potato Rapids	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	17	123	84	45
Potato Rapids	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	17	123	84	45
Potato Rapids	NETPR	bluegill, bluegill x green sunfish hybrid	17	123	84	45
Potato Rapids	NETPR	bluegill, bluegill x green sunfish hybrid	17	123	84	45
Potato Rapids	NETPR	bluegill, bluegill x green sunfish hybrid	17	123	84	45
Potato Rapids	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	17	123	84	45
Potato Rapids	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	17	123	84	45
Potato Rapids	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	17	123	84	45
Potato Rapids	NETPR	bluegill, bluegill x green sunfish hybrid	17	123	84	45
Potato Rapids	NETPR	bluegill, bluegill x green sunfish hybrid	17	123	84	45
Potato Rapids	NETPR	bluegill, bluegill x green sunfish hybrid	17	123	84	45

Site Name	Sampling Method	Species Tested	Head (ft)	Runner Speed (RPM)	Runner Diameter (in)	Peripheral Runner Velocity (ft/sec)
Potato Rapids	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	17	123	84	45
Potato Rapids	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	17	123	84	45
Potato Rapids	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	17	123	84	45
Potato Rapids	NETPR	bluegill, bluegill x green sunfish hybrid	17	123	84	45
Potato Rapids	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	17	123	84	45
Potato Rapids	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	17	123	84	45
Potato Rapids	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	17	123	84	45
Potato Rapids	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	17	123	84	45

Site Name	Sampling Method	Species Tested	Head (ft)	Runner Speed (RPM)	Runner Diameter (in)	Peripheral Runner Velocity (ft/sec)
Potato Rapids	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	17	123	84	45
Potato Rapids	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	17	123	84	45
Potato Rapids	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	17	123	84	45
Potato Rapids	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	17	123	84	45
Potato Rapids	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	17	123	84	45
Potato Rapids	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	17	123	84	45
Potato Rapids	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	17	123	84	45

Site Name	Sampling Method	Species Tested	Head (ft)	Runner Speed (RPM)	Runner Diameter (in)	Peripheral Runner Velocity (ft/sec)
Potato Rapids	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	17	123	84	45
Prickett	NETPR	bluegill	54	257	53	59.9
Prickett	NETPR	bluegill	54	257	53	59.9
Prickett	NETPR	bluegill	54	257	53	59.9
Prickett	NETPR	white sucker	54	257	53	59.9
Prickett	NETPR	white sucker	54	257	53	59.9
Prickett	NETPR	golden shiner	54	257	53	59.9
Rocky Reach	BALT	chinook salmon	92	90	280	110
Rocky Reach	BALT	chinook salmon	92	90	280	110
Rocky Reach	BALT	chinook salmon	92	90	280	110
Rocky Reach	BALT	chinook salmon	92	90	280	110
Rocky Reach	BALT	chinook salmon	92	90	280	110
Rocky Reach	BALT	chinook salmon	92	90	280	110
Rocky Reach	BALT	chinook salmon	92	90	280	110
Rocky Reach	BALT	chinook salmon	92	90	280	110
Rocky Reach	BALT	chinook salmon	92	90	280	110
Rocky Reach	BALT	chinook salmon	92	90	280	110
Rocky Reach	BALT	chinook salmon	92	90	280	110
Rocky Reach	BALT	chinook salmon	92	90	280	110
Rocky Reach	BALT	chinook salmon	92	90	280	110
Rocky Reach	BALT	chinook salmon	92	90	280	110
Rocky Reach	BALT	chinook salmon	92	90	280	110
Rogers	NETPR	bluegill	39.2	150	60	39.3
Rogers	NETPR	bluegill	39.2	150	60	39.3
Rogers	NETPR	rainbow trout	39.2	150	60	39.3
Rogers	NETPR	rainbow trout	39.2	150	60	39.3
Rogers	NETPR	spottail shiner	39.2	150	60	39.3
Rogers	NETPR	yellow perch	39.2	150	60	39.3
Rogers	NETPR	bluegill	39.2	150	60	39.3
Rogers	NETPR	bluegill	39.2	150	60	39.3
Rogers	NETPR	golden shiner	39.2	150	60	39.3
Rogers	NETPR	golden shiner	39.2	150	60	39.3
Rogers	NETPR	largemouth bass	39.2	150	60	39.3
Rogers	NETPR	northern pike	39.2	150	60	39.3

Site Name	Sampling Method	Species Tested	Head (ft)	Runner Speed (RPM)	Runner Diameter (in)	Peripheral Runner Velocity (ft/sec)
Rogers	NETPR	walleye	39.2	150	60	39.3
Rogers	NETPR	white sucker	39.2	150	60	39.3
Rogers	NETPR	white sucker	39.2	150	60	39.3
Rogers	NETPR	yellow perch	39.2	150	60	39.3
Rogers	NETPR	yellow perch	39.2	150	60	39.3
Safe Harbor	BALT	American shad	55	109	220	104.6
Safe Harbor	BALT	American shad	55	109	220	104.6
Safe Harbor	BALT	American shad	55	109	220	104.6
Sandstone Rapids	NETPR	bluegill, bluegill x green sunfish hybrid	42	150	87	57
Sandstone Rapids	NETPR	bluegill, bluegill x green sunfish hybrid	42	150	87	57
Sandstone Rapids	NETPR	bluegill, bluegill x green sunfish hybrid	42	150	87	57
Sandstone Rapids	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	42	150	87	57
Sandstone Rapids	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	42	150	87	57
Sandstone Rapids	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	42	150	87	57
Sandstone Rapids	NETPR	bluegill, bluegill x green sunfish hybrid	42	150	87	57
Sandstone Rapids	NETPR	bluegill, bluegill x green sunfish hybrid	42	150	87	57
Sandstone Rapids	NETPR	bluegill, bluegill x green sunfish hybrid	42	150	87	57

Site Name	Sampling Method	Species Tested	Head (ft)	Runner Speed (RPM)	Runner Diameter (in)	Peripheral Runner Velocity (ft/sec)
Sandstone Rapids	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	42	150	87	57
Sandstone Rapids	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	42	150	87	57
Sandstone Rapids	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	42	150	87	57
Sandstone Rapids	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	42	150	87	57
Sandstone Rapids	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	42	150	87	57
Sandstone Rapids	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	42	150	87	57
Sandstone Rapids	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	42	150	87	57

Site Name	Sampling Method	Species Tested	Head (ft)	Runner Speed (RPM)	Runner Diameter (in)	Peripheral Runner Velocity (ft/sec)
Sandstone Rapids	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	42	150	87	57
Sandstone Rapids	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	42	150	87	57
Sandstone Rapids	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	42	150	87	57
Sandstone Rapids	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	42	150	87	57
Sandstone Rapids	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	42	150	87	57
Sandstone Rapids	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	42	150	87	57
Sandstone Rapids	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	42	150	87	57

Site Name	Sampling Method	Species Tested	Head (ft)	Runner Speed (RPM)	Runner Diameter (in)	Peripheral Runner Velocity (ft/sec)
Sandstone Rapids	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	42	150	87	57
Sandstone Rapids	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	42	150	87	57
Sandstone Rapids	NETPR	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	42	150	87	57
Schaghticoke	NETPR	brook trout	153	300	51	66.1
Schaghticoke	NETPR	brook trout	153	300	51	66.1
Schaghticoke	NETPR	largemouth bass	153	300	51	66.1
Schaghticoke	NETPR	brook trout	153	300	51	66.1
Schaghticoke	NETPR	golden shiner	153	300	51	66.1
Schaghticoke	NETPR	white sucker	153	300	51	66.1
Schaghticoke	NETPR	white sucker	153	300	51	66.1
Schaghticoke	NETPR	bluegill	153	300	51	66.1
Schaghticoke	NETPR	largemouth bass	153	300	51	66.1
Schaghticoke	NETPR	yellow perch	153	300	51	66.1
Schaghticoke	NETPR	brook trout	153	300	51	66.1
Schaghticoke	NETPR	white sucker	153	300	51	66.1
Schaghticoke	NETPR	white sucker	153	300	51	66.1
Schaghticoke	NETPR	largemouth bass	153	300	51	66.1
Schaghticoke	NETPR	largemouth bass	153	300	51	66.1
Schaghticoke	NETPR	brook trout	153	300	51	66.1
Schaghticoke	NETPR	white sucker	153	300	51	66.1
Schaghticoke	NETPR	white sucker	153	300	51	66.1
Schaghticoke	NETPR	largemouth bass	153	300	51	66.1
Schaghticoke	NETPR	walleye	153	300	51	66.1
Schaghticoke	NETPR	brook trout	153	300	51	66.1
Schaghticoke	NETPR	brook trout	153	300	51	66.1
Schaghticoke	NETPR	bluegill	153	300	51	66.1

Site Name	Sampling Method	Species Tested	Head (ft)	Runner Speed (RPM)	Runner Diameter (in)	Peripheral Runner Velocity (ft/sec)
Schaghticoke	NETPR	yellow perch	153	300	51	66.1
Schaghticoke	NETPR	yellow perch	153	300	51	66.1
Stevens Creek	BALT	blueback herring	28	75	135	44.2
Stevens Creek	BALT	sunfish spp	28	75	135	44.2
Stevens Creek	BALT	sunfish spp	28	75	135	44.2
Stevens Creek	BALT	yellow perch/spotted sucker	28	75	135	44.2
Townsend	BALT	largemouth bass	16	152	113	75
Townsend	BALT	largemouth bass	16	152	113	75
Townsend	BALT	rainbow trout	16	152	113	75
Townsend	BALT	rainbow trout	16	152	113	75
Twin Branch	NETPR	bluegill	21.1	152	60	
Twin Branch	NETPR	chinook/channel catfish	21.1	152	60	
Twin Branch	NETPR	chinook/channel catfish	21.1	152	60	
Twin Branch	NETPR	steelhead/channel catfish	21.1	152	60	
Vernon	BALT	Atlantic salmon	34	133.3	62	36.3
Vernon	BALT	Atlantic salmon	34	133.3	62	36.3
Vernon	BALT	Atlantic salmon	34	133.3	62	36.3
Wanapum	BALT	coho salmon	80	85.7	285	106.5
Wanapum	BALT	coho salmon	80	85.7	285	106.5
Wanapum	BALT	coho salmon	80	85.7	285	106.5
Wanapum	BALT	coho salmon	80	85.7	285	106.5
Wanapum	BALT	coho salmon	80	85.7	285	106.5
Wanapum	BALT	coho salmon	80	85.7	285	106.5
Wanapum	BALT	coho salmon	80	85.7	285	106.5
Wanapum	BALT	coho salmon	80	85.7	285	106.5
White Rapids	BALT	bluegill	29	100	134	58.4
White Rapids	BALT	bluegill	29	100	134	58.4
White Rapids	BALT	white sucker	29	100	134	58.4
White Rapids	BALT	white sucker	29	100	134	58.4
Wilder	BALT	Atlantic salmon	51	112.5	108	53

TURBINE PASSAGE SURVIVAL DATABASE
SURVIVAL DATA

TEST ID INFO			SURVIVAL ESTIMATES								
			Based on number released			Based on number recovered			Based on number recovered		
Test ID No.	Site Name	Species Tested	Immediate Survival	24-Hour Survival	48-Hour Survival	Immediate Survival	24-Hour Survival	48-Hour Survival	Control Survival Immediate	24 hour	48 hour
AC-01	Alcona	bluegill	1.028	1.028	1.000	1.000	1.000	0.973	1.000	1.000	1.000
AC-02	Alcona	bluegill	1.000	0.886	0.831	1.000	0.886	0.831	1.000	1.000	0.957
AC-03	Alcona	rainbow trout	1.182	1.182	1.136	0.929	0.929	0.893	1.000	1.000	1.000
AC-04	Alcona	rainbow trout	1.333	1.333	1.333	1.000	1.000	1.000	1.000	1.000	1.000
AC-05	Alcona	spottail shiner	0.825	0.871	0.520	0.943	0.995	0.594	1.000	0.775	0.625
AC-06	Alcona	yellow perch	1.008	1.120	0.968	1.008	1.120	0.968	0.909	0.818	0.818
AC-07	Alcona	bluegill	0.772	0.711	0.631	0.863	0.795	0.705	1.000	0.839	0.806
AC-08	Alcona	bluegill	0.736	0.855	0.842	0.780	0.906	0.893	1.000	0.817	0.717
AC-09	Alcona	golden shiner	0.837	0.805	0.995	0.909	0.874	1.080	0.973	0.946	0.730
AC-10	Alcona	golden shiner	0.902	0.837	0.777	0.939	0.871	0.809	1.000	0.984	0.984
AC-11	Alcona	northern pike	0.545	0.500	0.500	0.558	0.512	0.512	1.000	1.000	1.000
AC-12	Alcona	grass pickerel	0.967	0.900	0.867	0.967	0.900	0.867	1.000	1.000	1.000
AC-13	Alcona	walleye	1.106	0.922	0.447	0.956	0.796	0.386	1.000	0.921	0.921
AC-14	Alcona	walleye	0.951	1.839	1.404	0.899	1.739	1.328	0.615	0.135	0.096
AC-15	Alcona	white sucker	1.037	0.996	0.975	0.963	0.924	0.905	1.000	0.962	0.962
AC-16	Alcona	white sucker	0.883	0.897	0.962	0.883	0.897	0.962	1.000	0.967	0.883
AC-17	Alcona	yellow perch	0.581	0.641	0.513	0.625	0.689	0.551	1.000	0.907	0.907
AC-18	Alcona	yellow perch	0.565	0.484	0.484	0.452	0.387	0.387	1.000	0.083	0.083
BF-01	Bond Falls	rainbow trout				0.829	0.666	0.645	1.000	1.000	1.000
BF-02	Bond Falls	yellow perch				0.798	0.771	0.768	0.995	0.991	0.991
BF-03	Bond Falls	golden shiner				0.744	0.615	0.579	0.967	0.924	0.890
BF-04	Bond Falls	bluegill				0.816	0.752	0.781	0.984	0.959	0.900
BR-01	Buzzards Roost	bluegill				0.931	0.759	0.759	1.000	1.000	1.000
BR-02	Buzzards Roost	bluegill	1.000	0.870	0.870	1.000	0.870	0.870	1.000	1.000	1.000
BR-03	Buzzards Roost	bullhead spp	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
BR-04	Buzzards Roost	bullhead spp	0.774	0.774	0.774	0.774	0.774	0.774	1.000	1.000	1.000
BR-05	Buzzards Roost	bluegill	0.960	1.189	2.704	0.960	1.189	2.704	1.000	0.538	0.192
BR-06	Buzzards Roost	bluegill	0.893	0.771	3.375	0.893	0.771	3.375	1.000	0.741	0.148
BR-07	Buzzards Roost	white perch	0.923	1.615		0.923	1.615		1.000	0.500	
BR-08	Buzzards Roost	bluegill	0.931	3.966	1.970	0.931	3.966	1.970	1.000	0.200	0.280
BR-09	Buzzards Roost	bluegill	0.931	0.828	1.634	0.931	0.828	1.634	1.000	1.000	0.464
BR-10	Buzzards Roost	bullhead spp	0.963	0.963	0.963	0.963	0.963	0.963	1.000	1.000	1.000
CF-01	Caldron Falls	bluegill, bluegill x green sunfish hybrid	1.413	1.386	1.386	0.981	0.962	0.962	1.000	1.000	1.000
CF-02	Caldron Falls	bluegill, bluegill x green sunfish hybrid	0.935	0.947	1.038	0.924	0.936	1.026	0.769	0.731	0.615
CF-03	Caldron Falls	bluegill, bluegill x green sunfish hybrid	1.048	1.048	1.048	1.048	1.048	1.048	0.935	0.935	0.935
CF-04	Caldron Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.820	0.794	0.741	0.883	0.855	0.798	0.900	0.900	0.900
CF-05	Caldron Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.515	0.515	0.515	0.613	0.613	0.613	0.971	0.971	0.971
CF-06	Caldron Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.956	0.956	0.969	0.991	0.991	1.005	0.964	0.964	0.929
CF-07	Caldron Falls	bluegill, bluegill x green sunfish hybrid	1.132	1.153	1.131	0.999	1.018	0.999	0.966	0.931	0.931
CF-08	Caldron Falls	bluegill, bluegill x green sunfish hybrid	0.803	0.843	0.890	0.906	0.951	1.004	1.000	0.920	0.840

TURBINE PASSAGE SURVIVAL DATABASE
SURVIVAL DATA

TEST ID INFO			SURVIVAL ESTIMATES								
			Based on number released			Based on number recovered			Based on number recovered		
Test ID No.	Site Name	Species Tested	Immediate Survival	24-Hour Survival	48-Hour Survival	Immediate Survival	24-Hour Survival	48-Hour Survival	Control Survival Immediate	Control Survival 24 hour	Control Survival 48 hour
CF-09	Caldron Falls	bluegill, bluegill x green sunfish hybrid	0.744	0.744	0.744	0.941	0.941	0.941	1.000	1.000	1.000
CF-10	Caldron Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	1.191	1.191	1.108	0.945	0.945	0.879	0.875	0.875	0.875
CF-11	Caldron Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.555	0.579	0.588	0.572	0.596	0.605	0.926	0.889	0.778
CF-12	Caldron Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.934	0.934	0.912	0.974	0.974	0.951	0.939	0.939	0.939
CF-13	Caldron Falls	bluegill, bluegill x green sunfish hybrid	0.867	0.800	0.800	0.867	0.800	0.800	1.000	1.000	1.000
CF-14	Caldron Falls	bluegill, bluegill x green sunfish hybrid	0.934	0.934	0.885	0.934	0.934	0.885	1.000	1.000	1.000
CF-15	Caldron Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.792	0.771	0.911	0.884	0.860	1.017	1.000	1.000	0.824
CF-16	Caldron Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.320	0.320	0.200	0.333	0.333	0.208	1.000	1.000	1.000
CF-17	Caldron Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.723	0.751	0.729	0.723	0.751	0.729	0.931	0.897	0.897
CF-18	Caldron Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.800	0.783	0.767	0.800	0.783	0.767	1.000	1.000	1.000
CF-19	Caldron Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.494	0.494	0.378	0.465	0.465	0.356	0.938	0.938	0.938
CF-20	Caldron Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.784	0.757	0.730	0.784	0.757	0.730	1.000	1.000	1.000
CF-21	Caldron Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.857	0.829	0.829	0.811	0.784	0.784	1.000	1.000	1.000
CF-22	Caldron Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.675	0.675	0.638	0.450	0.450	0.425	0.909	0.909	0.909
CF-23	Caldron Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.597	0.597	0.597	0.597	0.597	0.597	1.000	1.000	1.000
CF-24	Caldron Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.530	0.507	0.461	0.469	0.449	0.408	1.000	1.000	1.000
CF-25	Caldron Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.367	0.341	0.301	0.259	0.241	0.213	1.000	1.000	0.958
CF-26	Caldron Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.455	0.455	0.455	0.465	0.465	0.465	1.000	1.000	1.000
CH-01	Chalk Hill	bluegill	0.909		0.909	0.969		0.969	0.976		0.976
CH-02	Chalk Hill	bluegill	0.984		1.125	0.974		1.113	0.985		0.862
CH-03	Chalk Hill	white sucker/rainbow trout	0.854		0.864	0.912		0.923	0.985		0.910
CH-04	Chalk Hill	white sucker/rainbow trout	0.974		0.896	0.974		0.896	1.000		0.822
CT-01	Colton	white sucker				1.319			0.158		
CT-02	Colton	white sucker				0.635	0.721	0.641	1.000	0.720	0.540
CT-03	Colton	white sucker				0.567	0.376	0.232	1.000	0.842	0.719
CT-04	Colton	bluegill				0.044	0.000	0.000	0.707	0.244	0.171
CT-05	Colton	largemouth bass				0.956	0.077	0.042	0.981	0.404	0.250
CT-06	Colton	largemouth bass				0.356	0.337	0.000	1.000	0.653	0.286

TURBINE PASSAGE SURVIVAL DATABASE
SURVIVAL DATA

TEST ID INFO			SURVIVAL ESTIMATES								
			Based on number released			Based on number recovered			Based on number recovered		
									Control Survival		
Test ID No.	Site Name	Species Tested	Immediate Survival	24-Hour Survival	48-Hour Survival	Immediate Survival	24-Hour Survival	48-Hour Survival	Immediate	24 hour	48 hour
CT-07	Colton	brook trout				0.670	0.678	0.667	1.000	0.941	0.941
CT-08	Colton	rainbow trout				0.339	0.321	0.250	1.000	1.000	1.000
CT-09	Colton	rainbow trout				0.065	0.059	0.061	0.958	0.792	0.771
CT-10	Colton	white sucker				0.536	0.686	0.802	0.957	0.532	0.404
CT-11	Colton	white sucker				0.284	0.280	0.292	1.000	0.960	0.920
CT-12	Colton	white sucker				0.128	0.118	0.118	1.000	0.980	0.980
CT-13	Colton	bluegill				0.082	0.028	0.000	0.938	0.458	0.438
CT-14	Colton	largemouth bass				0.000	0.000	0.000	1.000	0.900	0.880
CT-15	Colton	largemouth bass				0.000	0.000	0.000	0.960	0.800	0.780
CT-16	Colton	yellow perch				0.499	0.567	0.433	0.882	0.706	0.647
CT-17	Colton	walleye				0.092	0.084	0.099	0.940	0.820	0.700
CT-18	Colton	brook trout				0.735	0.699	0.687	1.000	1.000	1.000
CT-19	Colton	rainbow trout				0.472	0.404	0.363	0.978	0.913	0.804
CT-20	Colton	rainbow trout				0.302	0.180	0.084	1.000	0.971	0.941
CT-21	Colton	white sucker				0.966	1.097	1.185	0.810	0.643	0.595
CT-22	Colton	bluegill				0.296	0.104	0.056	0.980	0.620	0.580
CT-23	Colton	largemouth bass				0.111	0.014	0.014	1.000	1.000	1.000
CT-24	Colton	largemouth bass				0.025	0.025	0.000	1.000	1.000	0.980
CT-25	Colton	yellow perch				0.855	0.899	0.860	0.594	0.406	0.406
CT-26	Colton	walleye				0.323	0.269	0.176	1.000	1.000	0.979
CW-01	Conowingo	American shad	0.949		0.929	0.949		0.929	0.917		0.917
CD-01	Craggy Dam	channel catfish	0.889	0.889	0.873	0.903	0.903	0.887	1.000	1.000	1.000
CD-02	Craggy Dam	channel catfish	0.692	0.692	0.692	0.794	0.794	0.794	1.000	1.000	1.000
CD-03	Craggy Dam	channel catfish	0.860	0.860	0.860	0.925	0.925	0.925	1.000	1.000	1.000
CD-04	Craggy Dam	channel catfish	0.875	0.875	0.875	0.933	0.933	0.933	1.000	1.000	1.000
CD-05	Craggy Dam	bluegill	0.928			0.943			1.000		
CD-06	Craggy Dam	bluegill	0.801			0.864			1.000		
CS-01	Crescent	blueback herring	0.944	0.990	1.000	0.960	1.006	1.017	0.878	0.789	0.707
CL-01	Crowley	white sucker	0.979	1.024	1.100	1.000	1.046	1.124	1.000	0.894	0.638
CL-02	Crowley	white sucker	0.892	0.563	0.300	1.019	0.643	0.343	0.981	0.741	0.556
CL-03	Crowley	walleye	1.200	0.867	2.080	1.200	0.867	2.080	0.750	0.115	0.038
CL-04	Crowley	walleye	0.833	0.639	0.519	1.000	0.767	0.623	1.000	0.575	0.425
CL-05	Crowley	largemouth bass	0.941	0.980	0.980	0.980	1.020	1.020	1.000	0.800	0.380
EJW-01	E.J. West	bluegill	1.261		1.714	1.108		1.506	0.793		0.362
EJW-02	E.J. West	yellow perch	1.098		3.000	1.117		3.051	0.850		0.217
EJW-03	E.J. West	rainbow trout	1.020		1.000	0.945		0.927	1.000		1.000
EJW-04	E.J. West	rainbow trout	1.429		0.818	0.870		0.498	1.000		0.786
EJW-05	E.J. West	golden shiner	0.813		0.667	0.925		0.759	0.970		0.955
EJW-06	E.J. West	golden shiner	1.171		0.630	0.850		0.457	0.946		0.730
EJW-07	E.J. West	rainbow trout	0.746		0.746	0.932		0.932	0.983		0.983
EJW-08	E.J. West	largemouth bass	0.802		0.664	0.870		0.720	1.000		0.986
EJW-09	E.J. West	largemouth bass	0.800		0.750	0.955		0.896	1.000		0.966
EJW-10	E.J. West	bluegill	0.436		0.412	0.696		0.657	0.932		0.576
EJW-11	E.J. West	bluegill	0.209		0.238	0.592		0.675	0.985		0.618
EJW-12	E.J. West	largemouth bass	1.929		1.924	0.816		0.814	1.000		0.952
EJW-13	E.J. West	largemouth bass	0.944		0.427	1.053		0.476	0.950		0.300
EJW-14	E.J. West	yellow perch	0.952		1.261	0.856		1.133	0.792		0.434
EJW-15	E.J. West	yellow perch	1.810		2.000	1.329		1.469	0.583		0.361
EJW-16	E.J. West	rainbow trout	1.517		1.800	0.971		1.152	0.906		0.625
EJW-17	E.J. West	rainbow trout	0.854		1.000	0.874		1.024	0.953		0.721
EJW-18	E.J. West	rainbow trout	1.625		1.581	0.909		0.884	0.970		0.939
EJW-19	E.J. West	rainbow trout	1.526		1.600	0.935		0.981	1.000		0.789
EJW-20	E.J. West	white sucker	0.695		0.162	0.813		0.189	0.738		0.452
EJW-21	E.J. West	white sucker	0.625		0.541	0.773		0.668	0.984		0.689
EJW-22	E.J. West	white sucker	0.684		0.680	0.722		0.718	1.000		0.877

TURBINE PASSAGE SURVIVAL DATABASE
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TEST ID INFO			SURVIVAL ESTIMATES								
			Based on number released			Based on number recovered			Based on number recovered		
Test ID No.	Site Name	Species Tested	Immediate Survival	24-Hour Survival	48-Hour Survival	Immediate Survival	24-Hour Survival	48-Hour Survival	Control Survival Immediate	24 hour	48 hour
EJW-23	E.J. West	white sucker	0.799		1.250	0.767		1.200	1.000		0.528
FPU4-01	Finch Pruyn	smallmouth bass	0.939			0.949			1.000		
FPU4-02	Finch Pruyn	smallmouth bass	0.838			0.909			1.000		
FPU4-03	Finch Pruyn	smallmouth bass	0.954			0.926			1.000		
FPU5-01	Finch Pruyn	smallmouth bass	0.655			0.941			1.000		
FPU5-02	Finch Pruyn	smallmouth bass	0.706			0.815			1.000		
FPU5-03	Finch Pruyn	smallmouth bass	0.720			0.707			1.000		
FC-01	Five Channels	bluegill	0.583	0.530	0.401	0.944	0.859	0.649	1.000	0.971	0.941
FC-02	Five Channels	bluegill	1.762	1.850	1.875	1.000	1.050	1.064	1.000	0.952	0.762
FC-03	Five Channels	rainbow trout	1.775	1.775	1.775	0.700	0.700	0.700	1.000	1.000	1.000
FC-04	Five Channels	rainbow trout	0.852	0.852	0.852	0.958	0.958	0.958	1.000	1.000	1.000
FC-05	Five Channels	spottail shiner	0.411	0.274	0.822	1.030	0.687	2.061	0.971	0.529	0.088
FC-06	Five Channels	yellow perch	0.818	1.058	1.455	0.818	1.058	1.455	1.000	0.688	0.250
FC-07	Five Channels	yellow perch	0.919	4.960	9.920	0.943	5.091	10.182	0.964	0.179	0.071
FC-08	Five Channels	bluegill	1.002	1.002	0.984	0.967	0.967	0.950	1.000	1.000	1.000
FC-09	Five Channels	bluegill	0.964	0.927	0.944	0.930	0.895	0.911	1.000	1.000	0.982
FC-10	Five Channels	golden shiner	0.782	0.778	0.808	0.827	0.823	0.854	1.000	0.982	0.945
FC-11	Five Channels	golden shiner	0.900	0.846	0.752	0.980	0.921	0.818	1.000	0.958	0.958
FC-12	Five Channels	walleye	0.862	0.844	0.809	0.817	0.800	0.767	1.000	1.000	1.000
FC-13	Five Channels	walleye	0.896	0.734	0.764	0.836	0.685	0.713	1.000	0.982	0.893
FC-14	Five Channels	white sucker	0.770	0.770	0.748	0.735	0.735	0.714	1.000	1.000	1.000
FC-15	Five Channels	white sucker	0.791	0.791	0.801	0.875	0.875	0.886	1.000	1.000	0.964
FC-16	Five Channels	yellow perch	0.895	0.942	0.720	0.944	0.994	0.760	1.000	0.950	0.950
FC-17	Five Channels	northern pike	1.258	1.258	1.258	0.941	0.941	0.941	0.952	0.952	0.952
FL-01	Fourth Lake	alewife	1.333			0.873			0.879		
FL-02	Fourth Lake	alewife	0.676			0.897			0.943		
FL-03	Fourth Lake	alewife	0.770			0.845			0.913		
FL-04	Fourth Lake	alewife	0.675			0.802			0.943		
FL-05	Fourth Lake	alewife	0.539			0.707			0.900		
FL-06	Fourth Lake	alewife	0.506			0.851			0.340		
FL-07	Fourth Lake	alewife	0.583			0.875			0.833		

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TEST ID INFO			SURVIVAL ESTIMATES								
			Based on number released			Based on number recovered			Based on number recovered		
Test ID No.	Site Name	Species Tested	Immediate Survival	24-Hour Survival	48-Hour Survival	Immediate Survival	24-Hour Survival	48-Hour Survival	Control Survival Immediate	24 hour	48 hour
FL-08	Fourth Lake	Atlantic salmon	0.758			0.868			0.985		
FL-09	Fourth Lake	Atlantic salmon	0.944			0.849			0.987		
FL-10	Fourth Lake	Atlantic salmon	0.565			0.814			1.000		
FL-11	Fourth Lake	Atlantic salmon	0.669			0.695			0.986		
FL-12	Fourth Lake	Atlantic salmon	0.967			0.777			1.000		
FL-13	Fourth Lake	Atlantic salmon	0.747			0.754			0.943		
FL-14	Fourth Lake	Atlantic salmon	0.753			0.709			0.813		
FL-15	Fourth Lake	Atlantic salmon	0.628			0.691			0.971		
FL-16	Fourth Lake	Atlantic salmon	0.930			0.871			0.963		
FL-17	Fourth Lake	Atlantic salmon	0.691			0.705			0.955		
FL-18	Fourth Lake	Atlantic salmon	1.031			1.407			0.484		
GR-U1-01	Grand Rapids	bluegill				1.000	1.000	0.999	1.000	1.000	0.975
GR-U1-02	Grand Rapids	bluegill				0.982	0.930	0.929	1.000	1.000	0.982
GR-U1-03	Grand Rapids	bluegill				0.905	0.931	0.815	1.000	0.818	0.818
GR-U1-04	Grand Rapids	white sucker				0.980	0.980	0.980	1.000	1.000	1.000
GR-U1-05	Grand Rapids	white sucker				0.976	1.040	1.040	1.000	0.939	0.939
GR-U1-06	Grand Rapids	white sucker				0.978	1.000	1.000	1.000	0.933	0.911
GR-U1-07	Grand Rapids	white sucker				1.000	1.061	1.065	1.000	0.897	0.872
GR-U1-08	Grand Rapids	white sucker				1.000	1.000	0.994	1.000	1.000	0.958
GR-U1-09	Grand Rapids	white sucker				1.000	1.000	1.000	1.000	1.000	1.000
GR-U1-10	Grand Rapids	bluegill				0.980	0.980	0.978	1.000	1.000	0.960
GR-U1-11	Grand Rapids	bluegill				1.000	1.000	1.000	1.000	1.000	1.000
GR-U1-12	Grand Rapids	white sucker				1.000	1.000	0.955	1.000	1.000	1.000
GR-U1-13	Grand Rapids	white sucker				1.000	1.000	1.000	1.000	1.000	1.000
GR-U1-14	Grand Rapids	white sucker				1.000	1.000	1.000	1.000	1.000	1.000
GR-U1-15	Grand Rapids	white sucker				1.000	0.979	0.958	1.000	1.000	1.000
GR-U1-16	Grand Rapids	white sucker				1.000	0.980	0.980	1.000	1.000	1.000
GR-U1-17	Grand Rapids	white sucker				1.000	0.933	0.911	1.000	1.000	1.000
GR-U1-18	Grand Rapids	bluegill				1.133	1.075	1.053	0.653	0.633	0.551
GR-U1-19	Grand Rapids	bluegill				1.343	1.419	1.870	0.686	0.608	0.451

TURBINE PASSAGE SURVIVAL DATABASE
SURVIVAL DATA

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GR-U1-20	Grand Rapids	bluegill				0.929	0.961	0.957	1.000	0.967	0.933
GR-U1-21	Grand Rapids	white sucker				1.121	1.101	1.071	0.737	0.711	0.711
GR-U1-22	Grand Rapids	white sucker				0.999	1.020	1.042	0.980	0.960	0.940
GR-U1-23	Grand Rapids	white sucker				0.980	0.980	0.980	1.000	0.980	0.959
GR-U1-24	Grand Rapids	white sucker				0.907	0.888	0.829	0.980	0.939	0.939
GR-U1-25	Grand Rapids	white sucker				0.846	0.846	0.846	1.000	1.000	1.000
GR-U1-26	Grand Rapids	white sucker				0.913	0.913	0.913	1.000	1.000	1.000
GR-U2-01	Grand Rapids	bluegill				0.974	0.974	0.974	1.000	1.000	1.000
GR-U2-02	Grand Rapids	bluegill				0.981	0.981	0.925	1.000	1.000	1.000
GR-U2-03	Grand Rapids	bluegill				0.950	0.960	0.960	1.000	0.833	0.833
GR-U2-04	Grand Rapids	white sucker				1.000	2.182	2.343	1.000	0.458	0.417
GR-U2-05	Grand Rapids	white sucker				1.026	1.002	1.002	0.975	0.975	0.975
GR-U2-06	Grand Rapids	white sucker				1.029	0.957	0.987	0.971	0.943	0.914
GR-U2-07	Grand Rapids	white sucker				1.000	1.000	0.920	1.000	1.000	1.000
GR-U2-08	Grand Rapids	white sucker				0.974	1.035	1.041	1.000	0.941	0.912
GR-U2-09	Grand Rapids	white sucker				1.000	0.957	0.957	1.000	1.000	1.000
GR-U2-10	Grand Rapids	bluegill				0.978	0.978	0.957	1.000	1.000	1.000
GR-U2-11	Grand Rapids	bluegill				1.000	1.000	1.146	1.000	1.000	0.872
GR-U2-12	Grand Rapids	white sucker				1.000	1.000	0.978	1.000	1.000	0.957
GR-U2-13	Grand Rapids	white sucker				1.000	1.001	0.981	1.000	0.980	0.959
GR-U2-14	Grand Rapids	white sucker				1.000	1.000	1.000	1.000	1.000	1.000
GR-U2-15	Grand Rapids	white sucker				1.000	1.000	1.020	1.000	1.000	0.980
GR-U2-16	Grand Rapids	white sucker				1.000	1.000	1.000	1.000	1.000	1.000
GR-U2-17	Grand Rapids	bluegill				1.071	1.048	1.024	0.894	0.894	0.894
GR-U2-18	Grand Rapids	bluegill				0.980	1.048	0.933	1.000	0.896	0.875
GR-U2-19	Grand Rapids	bluegill				0.978	0.977	0.950	0.979	0.958	0.896
GR-U2-20	Grand Rapids	white sucker				0.974	0.879	0.900	0.918	0.898	0.878
GR-U2-21	Grand Rapids	white sucker				0.956	0.975	0.975	1.000	0.980	0.980
GR-U2-22	Grand Rapids	white sucker				0.957	0.936	0.996	1.000	1.000	0.940
GR-U2-23	Grand Rapids	white sucker				1.000	1.000	0.957	1.000	1.000	1.000

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TEST ID INFO			SURVIVAL ESTIMATES								
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GR-U2-24	Grand Rapids	white sucker				0.689	0.623	0.556	0.978	0.978	0.978
GRU4-01	Grand Rapids	bluegill				0.840	0.758	0.712	0.900	0.880	0.780
GRU4-02	Grand Rapids	bluegill				0.960	0.940	0.940	1.000	1.000	1.000
GRU4-03	Grand Rapids	bluegill				0.884	0.884	0.952	0.980	0.980	0.840
GRU4-04	Grand Rapids	white sucker				1.067	1.091	1.116	0.938	0.917	0.896
GRU4-05	Grand Rapids	white sucker				1.000	1.000	0.980	1.000	1.000	1.000
GRU4-06	Grand Rapids	white sucker				0.979	0.958	0.978	1.000	1.000	0.980
GRU4-07	Grand Rapids	white sucker				0.961	0.960	0.960	1.000	0.980	0.980
GRU4-08	Grand Rapids	white sucker				0.827	0.750	0.731	1.000	1.000	1.000
GRU4-09	Grand Rapids	white sucker				0.783	0.739	0.674	1.000	1.000	1.000
GRU4-10	Grand Rapids	bluegill				1.053	0.994	0.877	0.380	0.380	0.380
GRU4-11	Grand Rapids	bluegill				1.103	0.923	0.789	0.796	0.796	0.776
GRU4-12	Grand Rapids	bluegill				0.938	0.872	0.810	1.000	0.980	0.900
GRU4-13	Grand Rapids	white sucker				1.097	1.059	1.100	0.563	0.563	0.542
GRU4-14	Grand Rapids	white sucker				0.895	0.895	0.895	0.980	0.980	0.980
GRU4-15	Grand Rapids	white sucker				0.848	0.865	0.865	1.000	0.980	0.980
GRU4-16	Grand Rapids	white sucker				0.860	0.816	0.816	1.000	0.980	0.980
GRU4-17	Grand Rapids	white sucker				0.900	0.900	0.900	1.000	1.000	1.000
GRU4-18	Grand Rapids	white sucker				0.880	0.796	0.829	1.000	0.980	0.941
HAFU1-01	Hadley Falls	American shad	1.039	1.333	1.714	1.039	1.333	1.714	0.770	0.390	0.140
HAFU1-02	Hadley Falls	American shad	0.973	0.816	0.286	0.973	0.816	0.286	0.750	0.380	0.140
HAFU2-01	Hadley Falls	American shad	0.890	0.659	0.750	0.890	0.659	0.750	0.833	0.342	0.233
HD-01	Hardy	bluegill	0.979	0.915	0.935	0.958	0.896	0.915	1.000	1.000	0.979
HD-02	Hardy	bluegill	0.769	0.673	0.709	0.971	0.850	0.896	1.000	0.975	0.925
HD-03	Hardy	golden shiner	1.219	1.128	1.128	0.958	0.886	0.886	1.000	0.846	0.846
HD-04	Hardy	golden shiner	1.067	0.909	0.930	0.980	0.835	0.854	1.000	0.978	0.956
HD-05	Hardy	largemouth bass	0.784	0.638	0.629	0.949	0.773	0.762	1.000	0.896	0.875
HD-06	Hardy	northern pike	0.820	0.708	0.708	0.880	0.760	0.760	1.000	1.000	1.000
HD-07	Hardy	rainbow trout	0.667	0.667	0.686	0.667	0.667	0.686	1.000	1.000	0.972
HD-08	Hardy	rainbow trout	0.634	0.654	0.620	0.731	0.754	0.715	1.000	0.969	0.969
HD-09	Hardy	walleye	0.833	0.833	0.806	0.800	0.800	0.773	0.969	0.938	0.938
HD-10	Hardy	white sucker	0.752	0.527	0.527	0.909	0.637	0.637	1.000	0.964	0.964
HD-11	Hardy	white sucker	1.180	1.180	1.180	0.769	0.769	0.769	1.000	1.000	1.000
HD-12	Hardy	yellow perch	0.855	0.852	0.834	0.980	0.976	0.955	1.000	0.983	0.983
HD-13	Hardy	yellow perch	0.900	0.842	0.789	0.947	0.886	0.831	1.000	0.950	0.950
HR-01	Herrings	bluegill	0.502		0.032	1.046		0.066	0.803		0.303
HR-02	Herrings	largemouth bass	0.471		0.333	0.611		0.432	1.000		0.900
HR-03	Herrings	yellow perch	1.751		1.832	1.081		1.130	0.872		0.821
HR-04	Herrings	walleye	0.616		0.556	0.752		0.678	0.903		0.710

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HR-05	Herrings	golden shiner	4.174		4.749	1.381		1.571	0.600		0.200
HR-06	Herrings	white sucker	2.602		3.045	0.922		1.078	1.000		0.818
HR-07	Herrings	white sucker	0.432		0.370	0.610		0.522	0.911		0.821
HR-08	Herrings	rainbow trout	0.789		0.789	1.005		1.005	0.946		0.946
HR-09	Herrings	rainbow trout	0.767		0.743	0.873		0.846	1.000		0.976
HR-10	Herrings	rainbow trout	0.967		1.191	0.809		0.996	0.867		0.600
HR-11	Herrings	bluegill	0.833		1.046	1.017		1.277	0.983		0.712
HR-12	Herrings	largemouth bass	0.935		0.818	0.973		0.851	1.000		0.952
HR-13	Herrings	largemouth bass	1.201		1.096	0.932		0.850	1.000		0.935
HR-14	Herrings	walleye	0.973		1.260	1.013		1.311	0.911		0.489
HR-15	Herrings	rainbow trout	1.273		1.273	0.900		0.900	1.000		1.000
HR-16	Herrings	rainbow trout	17.878		17.878	0.875		0.875	1.000		1.000
HR-17	Herrings	bluegill	0.812		0.769	1.003		0.949	0.982		0.745
HR-18	Herrings	largemouth bass	0.403		0.370	1.000		0.919	1.000		0.961
HR-19	Herrings	largemouth bass	0.705		0.408	0.935		0.541	1.000		0.321
HR-20	Herrings	yellow perch	1.113		0.945	0.818		0.694	1.000		0.917
HR-21	Herrings	yellow perch	2.333		2.400	0.947		0.974	0.964		0.893
HR-22	Herrings	white sucker	0.846		0.517	0.814		0.497	1.000		0.889
HR-23	Herrings	white sucker	2.691		2.258	1.067		0.895	0.900		0.700
HR-24	Herrings	white sucker	0.904		0.672	0.966		0.719	1.000		0.707
HR-25	Herrings	white sucker	1.001		1.072	0.888		0.950	1.000		0.750
HR-26	Herrings	white sucker	0.710		0.583	0.884		0.726	1.000		0.839
HR-27	Herrings	white sucker	0.669		0.643	0.883		0.849	1.000		0.805
HR-28	Herrings	rainbow trout	1.446		1.929	0.783		1.043	1.000		0.625
HR-29	Herrings	rainbow trout	0.429		0.383	0.848		0.758	1.000		0.880
HR-30	Herrings	rainbow trout	0.325		0.233	1.000		0.718	1.000		0.750
HR-31	Herrings	American eel	0.591		0.554	0.821		0.769	1.000		1.000
HR-32	Herrings	bluegill	0.995		1.007	0.981		0.994	0.984		0.613
HR-33	Herrings	largemouth bass	0.915		1.013	0.964		1.067	1.000		0.836
HR-34	Herrings	largemouth bass	0.844		0.753	0.925		0.825	1.000		1.000
HR-35	Herrings	yellow perch	0.902		0.779	0.947		0.817	1.000		0.636
HR-36	Herrings	yellow perch	0.938		0.910	0.976		0.946	1.000		0.881
HR-37	Herrings	yellow perch	0.959		0.850	0.987		0.875	1.000		0.969
HR-38	Herrings	yellow perch	0.874		0.816	0.974		0.910	1.000		0.983
HR-39	Herrings	yellow perch	0.844		0.812	0.962		0.925	1.000		0.986
HR-40	Herrings	white sucker	0.748		0.644	0.982		0.846	1.000		0.912
HR-41	Herrings	white sucker	0.736		0.787	0.969		1.036	1.000		0.742
HR-42	Herrings	white sucker	0.791		0.702	0.900		0.798	1.000		0.710
HR-43	Herrings	white sucker	0.671		0.588	0.933		0.816	1.000		0.551
HR-44	Herrings	white sucker	0.878		0.809	0.878		0.809	1.000		0.783
HR-45	Herrings	white sucker	0.836		0.715	0.909		0.777	1.000		0.953
HR-46	Herrings	rainbow trout	1.220		1.220	0.955		0.955	1.000		1.000
HR-47	Herrings	rainbow trout	1.058		1.058	0.987		0.987	1.000		1.000
HR-48	Herrings	rainbow trout	0.867		0.934	0.986		1.062	1.000		0.929
HR-49	Herrings	alewife	0.966		4.337	0.907		4.070	1.000		0.043
HR-50	Herrings	alewife	0.889		1.136	0.946		1.209	0.988		0.100
HIF-01	High Falls	bluegill, bluegill x green sunfish hybrid	1.044	0.992	0.977	0.967	0.919	0.904	0.880	0.880	0.800
HIF-02	High Falls	bluegill, bluegill x green sunfish hybrid	0.931	0.931	0.931	0.955	0.955	0.955	0.963	0.963	0.963
HIF-03	High Falls	bluegill, bluegill x green sunfish hybrid	0.874	0.874	0.845	0.721	0.721	0.698	1.000	1.000	1.000
HIF-04	High Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.801	0.874	0.736	0.830	0.904	0.762	0.964	0.821	0.750
HIF-05	High Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.637	0.637	0.637	0.861	0.861	0.861	1.000	1.000	1.000
HIF-06	High Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	1.171	1.171	1.230	0.891	0.891	0.936	1.000	1.000	0.952

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HIF-07	High Falls	bluegill, bluegill x green sunfish hybrid	0.735	0.735	0.724	0.745	0.745	0.733	1.000	1.000	0.929
HIF-08	High Falls	bluegill, bluegill x green sunfish hybrid	0.653	0.653	0.653	0.824	0.824	0.824	1.000	1.000	1.000
HIF-09	High Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.708	0.707	0.761	0.665	0.663	0.714	0.967	0.933	0.833
HIF-10	High Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.717	0.717	0.686	0.717	0.717	0.686	0.788	0.758	0.697
HIF-11	High Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.610	0.610	0.610	0.571	0.571	0.571	1.000	1.000	1.000
HIF-12	High Falls	bluegill, bluegill x green sunfish hybrid	1.350	1.250	1.150	0.614	0.568	0.523	1.000	1.000	1.000
HIF-13	High Falls	bluegill, bluegill x green sunfish hybrid	1.120	1.120	1.120	0.622	0.622	0.622	1.000	1.000	1.000
HIF-14	High Falls	bluegill, bluegill x green sunfish hybrid	0.974	0.974	0.974	0.613	0.613	0.613	1.000	1.000	1.000
HIF-15	High Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.429	0.395	0.406	0.481	0.442	0.455	1.000	1.000	0.973
HIF-16	High Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.601	0.578	0.511	0.528	0.508	0.449	1.000	0.966	0.966
HIF-17	High Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.511	0.523	0.535	0.511	0.523	0.535	0.978	0.957	0.935
HIF-18	High Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.473	0.798	0.468	0.585	0.987	0.580	0.964	0.571	0.929
HIF-19	High Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.436	0.410	0.427	0.378	0.356	0.370	1.000	1.000	0.962
HIF-20	High Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.392	0.392	0.403	0.444	0.444	0.457	1.000	1.000	0.972
HIF-21	High Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.175	0.180	0.160	0.160	0.165	0.147	0.970	0.939	0.939
HIF-22	High Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.280	0.280	0.290	0.255	0.255	0.264	1.000	1.000	0.967
HIF-23	High Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.235	0.216	0.196	0.235	0.216	0.196	1.000	1.000	1.000
HIF-24	High Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.029	0.029	0.029	0.026	0.026	0.026	1.000	1.000	1.000
HIF-25	High Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.043	0.043	0.043	0.018	0.018	0.018	1.000	1.000	1.000
HIF-26	High Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.089	0.089	0.089	0.063	0.063	0.063	1.000	1.000	1.000
HL-01	Higley	brook trout				0.915	0.734	0.707	1.000	1.000	0.978
HL-02	Higley	rainbow trout				0.746	1.124	1.124	1.000	0.263	0.263
HL-03	Higley	rainbow trout				0.354	0.927	0.829	1.000	0.250	0.250
HL-04	Higley	rainbow trout				0.386	0.381	0.381	1.000	0.525	0.525
HL-05	Higley	white sucker				0.907	0.630	0.644	1.000	0.979	0.957
HL-06	Higley	yellow perch				0.919	0.410	0.385	0.927	0.561	0.561

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HL-07	Higley	walleye				0.531	0.459	0.448	0.857	0.690	0.619
HL-08	Higley	walleye				0.501	0.403	0.418	0.714	0.592	0.571
HL-09	Higley	brook trout				0.765	0.721	0.691	1.000	0.979	0.894
HL-10	Higley	rainbow trout				0.511	0.444	0.582	1.000	1.000	0.688
HL-11	Higley	white sucker				0.714	0.549	0.549	1.000	0.953	0.953
HL-12	Higley	white sucker				0.690	0.633	0.713	0.980	0.939	0.796
HL-13	Higley	white sucker				0.429	0.446	0.373	1.000	0.960	0.920
HL-14	Higley	bluegill				0.851	0.877	0.828	1.000	0.783	0.739
HL-15	Higley	largemouth bass				0.392	0.342	0.234	1.000	1.000	0.974
HL-16	Higley	largemouth bass				0.375	0.304	0.277	1.000	1.000	0.967
HL-17	Higley	yellow perch				0.966	0.859	0.795	1.000	0.963	0.889
HL-18	Higley	golden shiner				0.416	0.000	0.000	0.233	0.163	0.163
HL-19	Higley	white sucker				0.901	0.709	0.734	0.745	0.723	0.681
HL-20	Higley	white sucker				0.543	0.503	0.430	0.950	0.833	0.800
HL-21	Higley	bluegill				0.697	0.899	0.801	0.763	0.395	0.342
HL-22	Higley	largemouth bass				0.073	0.059	0.045	0.830	0.811	0.811
HL-23	Higley	largemouth bass				0.127	0.116	0.068	0.604	0.264	0.226
HL-24	Higley	yellow perch				0.913	0.000	0.000	0.095	0.048	0.048
HOI-01	Hoist	brown trout	0.255			0.452			1.000		
HOI-02	Hoist	brook trout	0.320			0.436			1.000		
HOI-03	Hoist	brown trout	0.207			0.228			1.000		
HOI-04	Hoist	bluegill	0.075			0.168			0.993		
HOI-05	Hoist	bluegill	0.500			0.765			1.000		
HB-01	Hollidays Bridge	bluegill	1.000	1.007	0.860	1.000	1.007	0.860	1.000	0.840	0.760
HB-02	Hollidays Bridge	bluegill	1.000	0.880	0.840	1.000	0.880	0.840	1.000	1.000	1.000
HB-03	Hollidays Bridge	catfish spp	1.000	1.042	1.087	1.000	1.042	1.087	1.000	0.960	0.920
HB-04	Hollidays Bridge	catfish spp	1.000	1.042	1.087	1.000	1.042	1.087	1.000	0.960	0.920
HB-05	Hollidays Bridge	catfish spp	1.000	0.929	0.929	1.000	0.929	0.929	1.000	1.000	1.000
HB-06	Hollidays Bridge	catfish spp	1.000	0.960	0.960	1.000	0.960	0.960	1.000	1.000	1.000
HWU10-01	Holtwood	American shad	0.875	0.764	0.600	0.894	0.780	0.613	0.926	0.758	0.526
HWU3-01	Holtwood	American shad	0.768	0.629	0.550	0.835	0.683	0.598	0.938	0.875	0.800
LG-01	Lower Granite	chinook salmon	0.946		0.940	0.957		0.951	0.983		0.966
LG-02	Lower Granite	chinook salmon	0.952			0.949			0.994		
LG-03	Lower Granite	chinook salmon	0.956			0.953			0.994		
LG-04	Lower Granite	chinook salmon	0.978			0.978			0.994		
LG-05	Lower Granite	chinook salmon	0.984			0.975			0.994		
LG-06	Lower Granite	chinook salmon	0.968			0.972			0.996		
LG-07	Lower Granite	chinook salmon	0.946			0.946			1.000		
MNU3-01	Minetto	bluegill	0.720		0.680	0.881		0.832	1.000		0.789
MNU3-02	Minetto	largemouth bass	0.864		0.802	0.988		0.918	1.000		0.988
MNU3-03	Minetto	largemouth bass	1.035		0.909	0.965		0.847	1.000		0.889
MNU3-04	Minetto	yellow perch	1.076		0.809	0.944		0.710	1.000		0.821
MNU3-05	Minetto	white sucker	1.857		2.217	1.029		1.229	0.900		0.467
MNU3-06	Minetto	white sucker	0.539		0.590	0.906		0.991	1.000		0.800
MNU3-07	Minetto	white sucker	1.107		0.913	0.988		0.815	1.000		0.767
MNU3-08	Minetto	rainbow trout	0.857		0.840	0.944		0.926	1.000		1.000
MNU3-09	Minetto	rainbow trout	0.868		0.893	0.989		1.018	1.000		0.931
MNU3-10	Minetto	rainbow trout	1.004		0.671	0.895		0.598	1.000		0.323

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MNU3-11	Minetto	alewife	0.722		0.402	0.871		0.485	0.988		0.679
MNU3-12	Minetto	alewife	0.634		0.135	0.728		0.155	0.853		0.293
MNU3-13	Minetto	alewife	0.813		0.498	0.750		0.459	0.667		0.118
MNU3-14	Minetto	alewife	0.809		0.736	0.853		0.775	0.955		0.478
MNU3-15	Minetto	alewife	1.022		0.860	0.972		0.818	0.951		0.617
MNU4-01	Minetto	bluegill	0.623		0.267	0.974		0.417	1.000		0.758
MNU4-02	Minetto	largemouth bass	0.970		0.806	0.887		0.737	0.984		0.969
MNU4-03	Minetto	largemouth bass	0.783		0.653	1.000		0.834	1.000		0.985
MNU4-04	Minetto	yellow perch	0.714		0.668	0.957		0.894	1.000		0.778
MNU4-05	Minetto	walleye	0.620		0.631	1.000		1.018	1.000		0.757
MNU4-06	Minetto	walleye	1.087		1.030	1.000		0.948	1.000		0.851
MNU4-07	Minetto	white sucker	0.638		0.620	0.933		0.907	1.000		0.857
MNU4-08	Minetto	white sucker	0.953		0.802	0.880		0.740	1.000		1.000
MNU4-09	Minetto	white sucker	0.816		0.758	0.961		0.893	0.970		0.924
MNU4-10	Minetto	white sucker	0.856		0.844	0.885		0.874	1.000		1.000
MNU4-11	Minetto	rainbow trout	0.582		0.527	1.000		0.906	1.000		1.000
MNU4-12	Minetto	rainbow trout	0.857		0.780	0.957		0.871	1.000		1.000
MNU4-13	Minetto	rainbow trout	0.898		0.873	0.943		0.917	1.000		0.966
MNU4-14	Minetto	rainbow trout	1.025		0.978	0.961		0.917	0.980		0.980
MNU4-15	Minetto	American eel	0.662		0.620	1.000		0.936	1.000		1.000
NNI-01	Ninety-Nine Islands	bluegill	1.000	0.916	0.759	1.000	0.916	0.759	1.000	0.840	0.760
NNI-02	Ninety-Nine Islands	bluegill	1.000	0.964	0.929	1.000	0.964	0.929	1.000	1.000	1.000
NNI-03	Ninety-Nine Islands	catfish spp	1.000	0.889	0.889	1.000	0.889	0.889	1.000	1.000	1.000
NNI-04	Ninety-Nine Islands	catfish spp	0.962	0.923	0.885	0.962	0.923	0.885	1.000	1.000	1.000
NNI-05	Ninety-Nine Islands	bluegill	1.000	0.962	1.183	1.000	0.962	1.183	1.000	0.680	0.520
NNI-06	Ninety-Nine Islands	bluegill	0.893	0.714	0.643	0.893	0.714	0.643	1.000	1.000	1.000
NNI-07	Ninety-Nine Islands	catfish spp	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
NNI-08	Ninety-Nine Islands	catfish spp	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
PTG-01	Peshtigo	bluegill, bluegill x green sunfish hybrid	0.962	0.962	0.974	0.957	0.957	0.970	1.000	1.000	0.966
PTG-02	Peshtigo	bluegill, bluegill x green sunfish hybrid	0.979	0.979	0.979	1.048	1.048	1.048	0.955	0.955	0.955
PTG-03	Peshtigo	bluegill, bluegill x green sunfish hybrid	0.930	0.930	0.930	1.000	1.000	1.000	1.000	1.000	1.000
PTG-04	Peshtigo	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.767	0.767	0.715	0.862	0.862	0.803	0.897	0.897	0.846
PTG-05	Peshtigo	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	1.001	1.001	1.009	1.036	1.036	1.044	0.944	0.944	0.917
PTG-06	Peshtigo	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.762	0.770	0.779	0.971	0.982	0.994	1.000	0.960	0.920
PTG-07	Peshtigo	bluegill, bluegill x green sunfish hybrid	1.122	1.122	1.122	1.000	1.000	1.000	1.000	1.000	1.000

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PTG-08	Peshtigo	bluegill, bluegill x green sunfish hybrid	0.991	1.027	0.978	0.977	1.013	0.965	1.000	0.964	0.964
PTG-09	Peshtigo	bluegill, bluegill x green sunfish hybrid	0.811	0.811	0.811	1.000	1.000	1.000	1.000	1.000	1.000
PTG-10	Peshtigo	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.848	0.848	0.789	0.915	0.915	0.852	0.939	0.939	0.939
PTG-11	Peshtigo	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.964	0.924	1.094	0.920	0.881	1.043	0.969	0.938	0.750
PTG-12	Peshtigo	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.672	0.672	0.672	0.962	0.962	0.962	1.000	1.000	1.000
PTG-13	Peshtigo	bluegill, bluegill x green sunfish hybrid	1.070	1.044	1.044	1.000	0.976	0.976	1.000	1.000	1.000
PTG-14	Peshtigo	bluegill, bluegill x green sunfish hybrid	0.840	0.907	0.993	0.909	0.982	1.075	1.000	0.895	0.789
PTG-15	Peshtigo	bluegill, bluegill x green sunfish hybrid	1.123	1.123	1.123	1.000	1.000	1.000	1.000	1.000	1.000
PTG-16	Peshtigo	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.940	0.926	0.851	0.940	0.926	0.851	1.000	0.972	0.917
PTG-17	Peshtigo	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.990	0.941	0.933	1.009	0.959	0.951	0.972	0.944	0.833
PTG-18	Peshtigo	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.988	0.988	1.102	0.993	0.993	1.108	0.967	0.967	0.867
PTG-19	Peshtigo	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	1.138	1.138	1.129	1.012	1.012	1.004	0.968	0.968	0.935
PTG-20	Peshtigo	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.981	0.962	0.967	0.981	0.962	0.967	1.000	1.000	0.957
PTG-21	Peshtigo	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.864	0.864	0.864	0.896	0.896	0.896	1.000	1.000	1.000
PTG-22	Peshtigo	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.684	0.703	0.684	0.765	0.785	0.765	0.974	0.949	0.949
PTG-23	Peshtigo	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.996	0.972	1.065	0.894	0.872	0.955	1.000	1.000	0.913
PTG-24	Peshtigo	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.938	0.938	0.938	0.864	0.864	0.864	1.000	1.000	1.000
PTG-25	Peshtigo	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.700	0.700	0.700	0.708	0.708	0.708	1.000	1.000	1.000
PTG-26	Peshtigo	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	1.211	1.339	1.413	0.825	0.912	0.962	0.955	0.864	0.818
PTG-27	Peshtigo	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.604	0.604	0.604	0.806	0.806	0.806	1.000	1.000	1.000
PRU1-01	Potato Rapids	bluegill, bluegill x green sunfish hybrid	1.319	1.477	1.204	1.322	1.480	1.206	0.545	0.424	0.424
PRU1-02	Potato Rapids	bluegill, bluegill x green sunfish hybrid	0.947	0.929	0.924	0.842	0.826	0.821	0.625	0.542	0.417
PRU1-03	Potato Rapids	bluegill, bluegill x green sunfish hybrid	1.031	1.031	1.071	1.123	1.123	1.166	0.871	0.871	0.839

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TEST ID INFO			SURVIVAL ESTIMATES								
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									Control Survival		
Test ID No.	Site Name	Species Tested	Immediate Survival	24-Hour Survival	48-Hour Survival	Immediate Survival	24-Hour Survival	48-Hour Survival	Immediate	24 hour	48 hour
PRU1-04	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.632	0.615	0.631	0.860	0.837	0.859	1.000	1.000	0.975
PRU1-05	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	1.098	1.025	1.001	1.023	0.955	0.932	0.880	0.880	0.880
PRU1-06	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	1.150	1.145	1.049	1.048	1.044	0.957	0.742	0.710	0.677
PRU1-07	Potato Rapids	bluegill, bluegill x green sunfish hybrid	0.727	0.706	0.876	0.728	0.707	0.877	0.865	0.838	0.676
PRU1-08	Potato Rapids	bluegill, bluegill x green sunfish hybrid	0.432	0.432	0.425	0.800	0.800	0.788	1.000	1.000	0.964
PRU1-09	Potato Rapids	bluegill, bluegill x green sunfish hybrid	0.694	0.723	0.680	0.919	0.957	0.901	1.000	0.960	0.960
PRU1-10	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.598	0.598	0.567	0.676	0.676	0.640	0.938	0.938	0.938
PRU1-11	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.713	0.618	0.738	0.713	0.618	0.738	0.957	0.957	0.739
PRU1-12	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.800	0.776	0.822	0.818	0.793	0.841	0.897	0.897	0.793
PRU1-13	Potato Rapids	bluegill, bluegill x green sunfish hybrid	0.475	0.475	0.459	0.853	0.853	0.824	1.000	1.000	1.000
PRU1-14	Potato Rapids	bluegill, bluegill x green sunfish hybrid	0.371	0.371	0.361	0.857	0.857	0.835	1.000	1.000	0.970
PRU1-15	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.621	0.669	0.669	0.611	0.658	0.658	0.966	0.897	0.897
PRU1-16	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.569	0.525	0.554	0.553	0.511	0.538	1.000	1.000	0.909
PRU1-17	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.543	0.598	0.642	0.747	0.822	0.883	0.971	0.882	0.765
PRU1-18	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.498	0.498	0.496	0.591	0.591	0.588	1.000	1.000	0.966
PRU1-19	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.606	0.586	0.587	0.588	0.569	0.569	1.000	1.000	0.964
PRU1-20	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.679	0.743	0.658	0.692	0.757	0.671	1.000	0.889	0.889
PRU1-21	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.563	0.343	0.314	0.788	0.480	0.440	0.889	0.833	0.833
PRU1-22	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.545	0.545	0.583	0.558	0.558	0.597	1.000	1.000	0.897
PRU1-23	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.500	0.500	0.514	0.521	0.521	0.536	1.000	1.000	0.972
PRU1-24	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.383	0.342	0.350	0.362	0.324	0.331	0.902	0.882	0.863
PRU1-25	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.394	0.375	0.357	0.389	0.370	0.352	1.000	1.000	1.000

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PRU1-26	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.234	0.256	0.227	0.333	0.364	0.323	1.000	0.917	0.917
PRU2-01	Potato Rapids	bluegill, bluegill x green sunfish hybrid	0.964	0.964	0.946	0.982	0.982	0.964	1.000	1.000	1.000
PRU2-02	Potato Rapids	bluegill, bluegill x green sunfish hybrid	0.845	0.854	0.808	0.986	0.997	0.943	0.906	0.875	0.813
PRU2-03	Potato Rapids	bluegill, bluegill x green sunfish hybrid	0.871	0.812	0.812	0.947	0.882	0.882	0.941	0.912	0.912
PRU2-04	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.840	0.779	0.553	0.915	0.848	0.603	0.974	0.974	0.974
PRU2-05	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	1.455	1.499	1.548	0.930	0.958	0.990	0.947	0.895	0.842
PRU2-06	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.999	0.999	0.999	1.000	1.000	1.000	1.000	1.000	1.000
PRU2-07	Potato Rapids	bluegill, bluegill x green sunfish hybrid	0.901	0.901	0.735	0.925	0.925	0.755	1.000	1.000	1.000
PRU2-08	Potato Rapids	bluegill, bluegill x green sunfish hybrid	0.395	0.378	0.378	1.030	0.983	0.983	0.971	0.971	0.971
PRU2-09	Potato Rapids	bluegill, bluegill x green sunfish hybrid	0.881	0.857	0.857	0.881	0.857	0.857	1.000	1.000	1.000
PRU2-10	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.590	0.629	0.297	0.697	0.744	0.352	1.000	0.897	0.690
PRU2-11	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.614	0.592	0.310	0.741	0.714	0.374	0.900	0.833	0.700
PRU2-12	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.904	0.888	0.986	0.904	0.888	0.986	0.914	0.857	0.771
PRU2-13	Potato Rapids	bluegill, bluegill x green sunfish hybrid	1.019	0.983	0.948	0.983	0.948	0.914	1.000	1.000	1.000
PRU2-14	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.855	0.912	0.805	0.855	0.912	0.805	0.970	0.909	0.727
PRU2-15	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.734	0.537	0.496	0.780	0.571	0.527	0.885	0.846	0.654
PRU2-16	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.778	0.738	0.747	0.778	0.738	0.747	0.969	0.938	0.906
PRU2-17	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.730	0.730	0.496	0.730	0.730	0.496	0.971	0.971	0.882
PRU2-18	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.640	0.620	0.500	0.769	0.745	0.602	0.929	0.821	0.679
PRU2-19	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.804	0.760	0.738	0.820	0.776	0.753	0.914	0.886	0.857
PRU2-20	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.435	0.435	0.435	0.513	0.513	0.513	1.000	1.000	0.800
PRU2-21	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.681	0.709	0.689	0.762	0.794	0.771	1.000	0.900	0.833

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PRU2-22	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.617	0.467	0.466	0.627	0.475	0.474	1.000	1.000	0.966
PRU2-23	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.287	0.287	0.280	0.280	0.280	0.273	0.893	0.893	0.500
PRU2-24	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.575	0.521	0.461	0.542	0.492	0.435	1.000	1.000	0.935
PRU2-25	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.714	0.595	0.625	0.714	0.595	0.625	1.000	1.000	0.952
PK-01	Prickett	bluegill	0.889	0.919	1.063	0.976	1.010	1.168	0.968	0.691	0.287
PK-02	Prickett	bluegill	0.935	0.818	1.686	0.925	0.809	1.667	1.000	0.583	0.153
PK-03	Prickett	bluegill	0.947	0.529	0.545	0.857	0.479	0.494	1.000	0.895	0.579
PK-04	Prickett	white sucker	0.707	0.653	0.617	0.699	0.645	0.610	0.969	0.917	0.490
PK-05	Prickett	white sucker	0.476	0.267	0.222	0.357	0.200	0.167	1.000	0.714	0.429
PK-06	Prickett	golden shiner	1.471	1.369	1.538	0.929	0.865	0.972	0.867	0.867	0.600
RRU3-01	Rocky Reach	chinook salmon	0.939		0.927	0.939		0.927	0.989		0.977
RRU3-02	Rocky Reach	chinook salmon	0.947		0.951	0.947		0.951	0.988		0.984
RRU5-01	Rocky Reach	chinook salmon	0.973		0.973	0.973		0.973	1.000		1.000
RRU5-02	Rocky Reach	chinook salmon	0.982		0.977	0.986		0.982	1.000		0.991
RRU5-03	Rocky Reach	chinook salmon	0.987		1.009	0.976		0.998	0.989		0.955
RRU5-04	Rocky Reach	chinook salmon	0.915		0.931	0.899		0.913	1.000		0.984
RRU5-05	Rocky Reach	chinook salmon	0.978		0.978	0.976		0.976	0.987		0.987
RRU5-06	Rocky Reach	chinook salmon	0.941		0.929	0.952		0.940	1.000		1.000
RRU6-01	Rocky Reach	chinook salmon	0.912		0.888	0.912		0.888	1.000		1.000
RRU6-02	Rocky Reach	chinook salmon	0.984		0.981	0.976		0.972	1.000		0.991
RRU6-03	Rocky Reach	chinook salmon	0.983		1.010	0.962		0.988	1.000		0.966
RRU6-04	Rocky Reach	chinook salmon	0.965		0.980	0.932		0.948	1.000		0.984
RRU6-05	Rocky Reach	chinook salmon	0.978		0.978	0.965		0.965	0.987		0.987
RRU6-06	Rocky Reach	chinook salmon	0.960		0.960	0.973		0.973	1.000		1.000
RRU8-01	Rocky Reach	chinook salmon	0.962		0.953	0.932		0.924	0.933		0.933
RG-01	Rogers	bluegill	0.906	0.865	1.031	0.906	0.865	1.031	1.000	0.867	0.667
RG-02	Rogers	bluegill	0.870	0.932	0.932	0.932	0.999	0.999	1.034	0.966	0.966
RG-03	Rogers	rainbow trout				0.800		0.720	1.000		1.000
RG-04	Rogers	rainbow trout				0.967		0.900	1.000		1.000
RG-05	Rogers	spottail shiner				0.806		1.262	1.000		0.563
RG-06	Rogers	yellow perch				0.933		0.929	1.000		0.969
RG-07	Rogers	bluegill	0.898	0.847	0.831	0.962	0.908	0.890	0.983	0.983	0.983
RG-08	Rogers	bluegill	1.343	1.377	1.278	0.989	1.014	0.941	0.976	0.952	0.952
RG-09	Rogers	golden shiner	0.583	0.583	0.549	0.984	0.984	0.926	0.960	0.960	0.960
RG-10	Rogers	golden shiner	1.118	0.996	0.643	0.932	0.830	0.536	1.000	0.980	0.980
RG-11	Rogers	largemouth bass	0.813	0.795	0.786	0.800	0.782	0.774	1.000	1.000	0.964
RG-12	Rogers	northern pike	1.049	1.049	0.942	0.929	0.929	0.833	1.000	1.000	1.000
RG-13	Rogers	walleye				0.947		0.862	1.000		0.946

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RG-14	Rogers	white sucker				0.940		0.860	1.000		1.000
RG-15	Rogers	white sucker				0.875		0.812	1.000		0.955
RG-16	Rogers	yellow perch				0.929		0.881	1.000		1.000
RG-17	Rogers	yellow perch				0.956		0.911	1.000		1.000
SHU7-01	Safe Harbor	American shad	0.980	0.980	1.024	0.980	0.980	1.024	1.000	1.000	0.838
SHU9-01	Safe Harbor	American shad	0.978	1.000	1.106	0.978	1.000	1.106	1.000	0.685	0.511
SHU9-02	Safe Harbor	American shad	0.948	0.967	0.667	0.958	0.978	0.674	1.000	0.724	0.541
SS-01	Sandstone Rapids	bluegill, bluegill x green sunfish hybrid	0.759	0.689	0.668	0.886	0.804	0.779	1.000	0.960	0.880
SS-02	Sandstone Rapids	bluegill, bluegill x green sunfish hybrid	0.895	0.895	0.930	0.962	0.962	1.001	1.000	1.000	0.943
SS-03	Sandstone Rapids	bluegill, bluegill x green sunfish hybrid	1.044	1.044	1.044	1.044	1.044	1.044	0.941	0.941	0.941
SS-04	Sandstone Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.676	0.676	0.417	0.818	0.818	0.504	1.000	1.000	0.767
SS-05	Sandstone Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.481	0.401	0.342	0.777	0.647	0.552	0.966	0.966	0.793
SS-06	Sandstone Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.535	0.535	0.515	0.994	0.994	0.958	0.971	0.971	0.971
SS-07	Sandstone Rapids	bluegill, bluegill x green sunfish hybrid	0.877	0.704	0.580	0.896	0.719	0.593	0.808	0.769	0.538
SS-08	Sandstone Rapids	bluegill, bluegill x green sunfish hybrid	0.885	0.885	0.879	0.920	0.920	0.914	1.000	1.000	0.941
SS-09	Sandstone Rapids	bluegill, bluegill x green sunfish hybrid	0.706	0.706	0.706	0.878	0.878	0.878	1.000	1.000	1.000
SS-10	Sandstone Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.936	0.887	0.455	0.959	0.908	0.466	0.967	0.967	0.733
SS-11	Sandstone Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.369	0.403	0.422	0.600	0.655	0.686	0.867	0.733	0.467
SS-12	Sandstone Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.901	0.879	0.879	0.901	0.879	0.879	0.971	0.971	0.971
SS-13	Sandstone Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.833	0.817	0.755	0.833	0.817	0.755	1.000	0.952	0.810
SS-14	Sandstone Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.840	0.840	0.816	0.814	0.814	0.791	1.000	1.000	1.000
SS-15	Sandstone Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.745	0.686	0.504	0.745	0.686	0.504	1.000	1.000	0.778
SS-16	Sandstone Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.753	0.816	0.906	0.842	0.912	1.013	0.839	0.710	0.581
SS-17	Sandstone Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.839	0.843	0.828	0.839	0.843	0.828	1.000	0.974	0.949
SS-18	Sandstone Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.603	0.580	0.538	0.619	0.595	0.552	1.000	1.000	0.862
SS-19	Sandstone Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.864	0.818	0.832	0.905	0.857	0.872	1.000	1.000	0.929

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SS-20	Sandstone Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.743	0.743	0.758	0.717	0.717	0.731	1.000	1.000	0.929
SS-21	Sandstone Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.292	0.243	0.233	0.273	0.227	0.218	1.000	1.000	0.833
SS-22	Sandstone Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.659	0.659	0.659	0.794	0.794	0.794	1.000	1.000	1.000
SS-23	Sandstone Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.519	0.519	0.534	0.583	0.583	0.601	1.000	1.000	0.971
SS-24	Sandstone Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.579	0.521	0.516	0.545	0.491	0.486	1.000	1.000	0.973
SS-25	Sandstone Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.405	0.381	0.357	0.424	0.399	0.374	0.955	0.955	0.955
SS-26	Sandstone Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	0.584	0.584	0.611	0.537	0.537	0.562	0.957	0.957	0.913
STC-01	Schaghticoke	brook trout	0.228		0.245	0.170		0.182	0.983		0.914
STC-02	Schaghticoke	brook trout	0.000		0.000	0.000		0.000	0.905		0.703
STC-03	Schaghticoke	largemouth bass	0.418		0.415	0.314		0.311	0.917		0.883
STC-04	Schaghticoke	brook trout	0.506		0.486	0.433		0.416	0.966		0.862
STC-05	Schaghticoke	golden shiner	0.531		0.483	0.617		0.561	0.985		0.923
STC-06	Schaghticoke	white sucker	0.503		0.405	0.516		0.415	0.928		0.594
STC-07	Schaghticoke	white sucker	0.471		0.492	0.615		0.643	1.000		0.897
STC-08	Schaghticoke	bluegill	0.382		0.294	0.414		0.318	0.984		0.852
STC-09	Schaghticoke	largemouth bass	0.268		0.250	0.254		0.238	0.982		0.912
STC-10	Schaghticoke	yellow perch	0.508		0.540	0.501		0.532	0.913		0.725
STC-11	Schaghticoke	brook trout	0.061		0.063	0.045		0.047	0.846		0.821
STC-12	Schaghticoke	white sucker	0.328		0.309	0.349		0.330	0.906		0.859
STC-13	Schaghticoke	white sucker	0.115		0.118	0.137		0.140	0.936		0.915
STC-14	Schaghticoke	largemouth bass	0.154		0.108	0.189		0.133	0.743		0.529
STC-15	Schaghticoke	largemouth bass	0.000		0.000	0.000		0.000	0.824		0.608
STC-16	Schaghticoke	brook trout	0.209		0.197	0.224		0.211	0.882		0.868
STC-17	Schaghticoke	white sucker	0.319		0.175	0.295		0.161	0.945		0.863
STC-18	Schaghticoke	white sucker	0.265		0.223	0.296		0.249	0.756		0.686
STC-19	Schaghticoke	largemouth bass	0.692		0.900	0.666		0.865	0.520		0.400
STC-20	Schaghticoke	walleye	0.436		0.444	0.382		0.389	0.786		0.257

TURBINE PASSAGE SURVIVAL DATABASE
SURVIVAL DATA

TEST ID INFO			SURVIVAL ESTIMATES								
			Based on number released			Based on number recovered			Based on number recovered		
									Control Survival		
Test ID No.	Site Name	Species Tested	Immediate Survival	24-Hour Survival	48-Hour Survival	Immediate Survival	24-Hour Survival	48-Hour Survival	Immediate	24 hour	48 hour
STC-21	Schaghticoke	brook trout	0.806		0.770	0.737		0.704	0.969		0.953
STC-22	Schaghticoke	brook trout	0.500		0.397	0.427		0.338	0.969		0.906
STC-23	Schaghticoke	bluegill	0.420		0.233	0.491		0.272	0.908		0.566
STC-24	Schaghticoke	yellow perch	0.758		0.751	0.791		0.784	0.900		0.800
STC-25	Schaghticoke	yellow perch	0.585		0.549	0.764		0.717	0.828		0.797
SC-01	Stevens Creek	blueback herring	1.019	1.010	0.993	0.967	0.959	0.943	1.000	1.000	1.000
SC-02	Stevens Creek	sunfish spp	0.974	1.053	1.057	0.974	1.053	1.057	0.981	0.907	0.778
SC-03	Stevens Creek	sunfish spp	0.938	0.909	0.976	0.938	0.909	0.976	1.000	0.964	0.804
SC-04	Stevens Creek	yellow perch/spotted sucker	0.983	0.966	0.972	0.983	0.966	0.972	0.983	0.975	0.883
TS-01	Townsend	largemouth bass	1.000	1.000	1.000	1.000	1.000	1.000	0.980	0.980	0.980
TS-02	Townsend	largemouth bass	0.860	0.860	0.860	0.860	0.860	0.860	1.000	1.000	1.000
TS-03	Townsend	rainbow trout	0.944			0.944			1.000		
TS-04	Townsend	rainbow trout	0.919	0.919	0.919	1.000	1.000	1.000	1.000	1.000	1.000
TBU1-01	Twin Branch	bluegill	1.231		1.202	0.973		0.950	1.000		0.971
TBU5-01	Twin Branch	chinook/channel catfish	0.986		0.963	1.000		0.976	1.000		1.000
TBU5-02	Twin Branch	chinook/channel catfish	0.970		0.815	0.986		0.829	1.000		0.903
TBU5-03	Twin Branch	steelhead/channel catfish	0.703		0.656	0.862		0.804	1.000		0.950
VNU10-01	Vernon	Atlantic salmon	0.959		0.949	1.000		0.989	1.000		1.000
VNU10-02	Vernon	Atlantic salmon	1.013		1.013	1.000		1.000	1.000		1.000
VNU4-01	Vernon	Atlantic salmon	0.851		0.851	0.840		0.840	1.000		1.000
WNP-01	Wanapum	coho salmon	0.897		0.897	0.897		0.897	0.988		0.981
WNP-02	Wanapum	coho salmon	0.949		0.955	0.949		0.955	0.988		0.981
WNP-03	Wanapum	coho salmon	0.935		0.942	0.924		0.930	0.994		0.987
WNP-04	Wanapum	coho salmon	0.981		0.987	0.968		0.975	0.994		0.987
WNP-05	Wanapum	coho salmon	0.942		0.942	0.948		0.948	0.987		0.987
WNP-06	Wanapum	coho salmon	1.006		1.006	1.000		1.000	0.987		0.987
WNP-07	Wanapum	coho salmon	0.868		0.873	0.885		0.890	1.000		0.994
WNP-08	Wanapum	coho salmon	0.962		0.962	0.968		0.968	1.000		0.994
WR-01	White Rapids	bluegill	0.944		1.022	0.945		1.024	1.000		0.852
WR-02	White Rapids	bluegill	0.957		0.967	1.000		1.011	1.000		0.676
WR-03	White Rapids	white sucker	1.018		1.000	1.009		0.992	0.941		0.882
WR-04	White Rapids	white sucker	0.991		1.023	0.930		0.960	1.000		0.932
WD-01	Wilder	Atlantic salmon	0.960	0.943	0.943	0.960	0.943	0.943	1.000	0.984	0.984