CITY OF HASTINGS CITY HALL

101 4th Street East
Hastings, MN 55033-1955
651-480-2350
Fax: 651-437-7082
www.ci.hastings.mn.us
cityhall@ci.hastings.mn.us

Department of
Building Safety
651-480-2342

Engineering/
Planning/HRA/HPC
651-480-2334

Public Works
1225 Progress Drive
651-480-6185

Parks & Recreation
920 10th Street West
651-480-6175

Police
150 3rd Street East
651-480-2300

Fire
115 5th Street West
651-480-6150

Civic Arena
2801 Red Wing Boulevard
651-480-6159

Aquatic Center
901 Maple Street
651-480-2392

April 3, 2009

ELECTRONICALLY FILED

Ms. Kimberly D. Bose
Secretary
Federal Energy Regulatory Commission
888 First Street, NE
Washington, DC 20428

Subject: **Lock and Dam No. 2 Hydroelectric Project**
FERC Project No. 4306
Article 65 – Fish Entrainment and Survival Monitoring Plan

Dear Secretary Bose:

The City of Hastings and Hydro Green Energy, in accordance with License Article 65 of the Order Amending License issued by the Federal Energy Regulatory Commission (FERC or Commission), herein file the Fish Entrainment and Survival Monitoring Plan for the hydrokinetic units at Lock and Dam No. 2 Hydro Project (No. P-4306).

This plan was developed in consultation with the agencies as specified in Article 65 by circulating a draft Fish Entrainment and Survival Monitoring Plan for review and comment on February 17, 2009. Comments on the draft Plan were received from Minnesota Pollution Control Agency (MPCA), National Park Service (NPS), Minnesota Department of Natural Resources (MDNR) and the U.S. Army Corps of Engineers (Corps). Copies of the comments and recommendations and how those are accommodated in the plan and/or the Licensee's reasons for not adopting certain recommendations is attached to this plan.

Prior to circulation of the February 2009 draft, agencies were provided with earlier versions for review and comment. Consultation in the development of this plan has continued from 2007 through the present. Consultation over this plan was first initiated in July 2007 in a conference call, at which time the Licensee's consultant, Normandeau Associates, suggested circulating a draft plan for initial review. That first draft was distributed to all involved parties on July 18, 2007. Initial comments were received and incorporated into a subsequent revision of the draft plan which was included in the Licensee's Draft Application for Amendment of License in October 2007. Comments on that draft Application were incorporated into the final Application for Amendment of License in April 2008.

At the FERC contractor's site visit on June 10, 2008, it was specifically requested that agencies provide substantive comments regarding the fish plan in their responses to the Licensee's Application. The MDNR did not submit comments to either the Licensee's Application or the included draft Fish Evaluation Plan. In addition, License Article 65 again required agency consultation with a minimum 30-day comment period. The Licensee has provided repeated and ample opportunities for consultation and input.

The Licensee is ready to implement this Plan, which meets the requirements of Article 65, immediately upon Commission approval. In fact, had it not been for several regulatory delays the licensing of this project, most notably the 58 day-period that it took the Department of Interior to answer FERC's September 29, 2008 letter regarding the Mississippi National River and Recreation Area (MNRRA), these evaluations could have been

Hastings on the Mississippi

carried out in the fall of 2008 and all stakeholders would now have the data.

Ideally, we will conduct this work in May 2009 and are currently working with local fishermen and fish culturists to identify, obtain and hold test fish, prior to implementation of the plan. As stated above, the Licensee had hoped to conduct these studies last fall. The Licensee would deeply appreciate quick turnaround by the Commission on this plan so that we can conduct the tests and get the results of the environmental studies to regulators and stakeholders as quickly as possible. Planning for development of hydrokinetic resources in other states will also greatly benefit from the environmental impact information from the Hastings project.

We appreciate the opportunity to submit this plan to the Commission for approval, and to gathering important environmental data that we believe will advance the understanding of the nation's hydrokinetic power technologies. We look forward to sharing the data with all stakeholders once collected.

Should you have any questions, please contact Heidi Wahto, Regulatory Advisor at hwahto@hatchacres.com, or (206) 352-5730, Thomas Montgomery at TMontgomery@ci.hastings.mn.us or (651) 480-6188, or Mark Stover, Hydro Green Energy, at mark@hgenergy.com or (877) 556-6566 x711.

Sincerely,

Thomas Montgomery
Public Works Director
City of Hastings, MN

Wayne Krouse
Chairman & CEO
Hydro Green Energy, LLC

Attachments

Hastings on the Mississippi

FISH ENTRAINMENT AND SURVIVAL MONITORING PLAN FOR THE HYDRO GREEN ENERGY HYDROKINETIC SYSTEM AT THE MISSISSIPPI LOCK AND DAM NO. 2 HYDROELECTRIC PROJECT (P-4306) HASTINGS, MINNESOTA

Normandeau Associates Project No. 21104.001

FISH ENTRAINMENT AND SURVIVAL MONITORING PLAN FOR THE HYDRO GREEN ENERGY HYDROKINETIC SYSTEM AT THE MISSISSIPPI LOCK AND DAM NO. 2 HYDROELECTRIC PROJECT (P-4306) HASTINGS, MINNESOTA

PREPARED FOR
HYDRO GREEN ENERGY, LLC
5090 RICHMOND AVENUE, # 390
HOUSTON TX, 77056

PREPARED BY
NORMANDEAU ASSOCIATES, INC.
917 ROUTE 12, #1
WESTMORELAND, NH 03467

April 2009

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1.0 INTRODUCTION

On April 24, 2008, and supplemented on April 30, September 26, November 7, and November 13, 2008, the city of Hastings, Minnesota (City), licensee for the 4.4-megawatt (MW) Mississippi Lock and Dam No. 2 Hydroelectric Project (FERC No. 4306), filed an application with the Federal Energy Regulatory Commission (Commission or FERC) to amend its license to install two 35-killowatt (kW) hydrokinetic turbines (operating capacity) in the project's tailrace. The project is located at the United States Army Corps of Engineers' (USACE) Mississippi Lock & Dam No. 2 on the Mississippi River near the City of Hastings in Dakota County, Minnesota. The Commission issued the Order Amending License on December 13, 2008 and authorized the beginning of installation of the first hydrokinetic turbine on December 23, 2008.

Article 65 of the FERC Order (125 FERC ¶ 61,287) requires the licensee to develop a Fish Entrainment and Survival Monitoring Plan.

<u>License Article 65. Fish Entrainment and Survival Plan</u>

The licensee shall, within 60 days of the issuance of this order, file for Commission approval, a Fish Entrainment and Survival Monitoring Plan. The plan shall be developed in accordance with Condition No. 3 of the state Water Quality Certificate and shall include provisions for: (1) estimating survival/injury for several species; (2) a method for estimating predation; (3) a desktop analysis of possible entrainment rates based on population variability, using data collected in the 1990-1991 entrainment study, the Long Term Resource Monitoring Program database, and results of the current survival study; and (4) a provision to file a final report, describing the results of the monitoring, with the Minnesota Department of Natural Resources, Minnesota Pollution Control Agency, National Park Service, U.S. Fish and Wildlife Service and the Commission. The final report shall include a discussion of the overall effects of the project on the fisheries resources at the Mississippi River Lock and Dam No. 2. If there are any adverse impacts to fisheries resources, the report shall include proposed changes to project operation in order to minimize those impacts. The final report shall be filed with the Commission, after consultation with the agencies.

The plan shall be developed in consultation with the Minnesota Department of Natural Resources, Minnesota Pollution Control Agency, National Park Service, U.S. Fish and Wildlife Service and U.S. Army Corps of Engineers. The licensee shall include with the plan, documentation of consultation, copies of recommendations on the completed plan after it has been provided to the resource agencies, and any specific descriptions of how agency comments are accommodated by the plan. The licensee shall allow a minimum of 30 days for the agencies to comment and make recommendations before filing the plan with the Commission. If the licensee does not adopt a recommendation, the filing shall include the licensee's reasons, based on project-specific information.

The Commission reserves the right to require changes to the plan. Implementation of the plan shall not begin until the plan is approved by the Commission. Upon Commission approval, the licensee shall implement the plan, including any changes required by the Commission.

2.0 FISH ENTRAINMENT AND SURVIVAL MONITORING PLAN

2.1 ESTIMATING SURVIVAL/INJURY

A. Evaluation Objectives and Approach

The objective of estimating the survival/injury of fish passing through the hydrokinetic unit is to reliably estimate the 'fish friendliness' of the Hydro Green Energy hydrokinetic unit. To meet this objective, tagged fish will be inducted through the hydrokinetic unit (treatment group) and their survival and injury rates will be estimated relative to a control group that is released to the tailrace immediately downstream of the hydrokinetic units.

B. Study Design

The HI-Z Turb N' Tag methodology will be used to mark, recapture, and evaluate the direct effects of passage of test fish through the hydrokinetic unit. The methodology uses a controlled experiment approach. Control group fish experience all aspects of the methodology (*e.g.*, handling, tagging, recapture, holding in tanks) that treatment group fish do except for the treatment variable. In this case the treatment is the passage through the hydrokinetic unit. Fish will be tagged with one or more HI-Z tags (also known as balloon tags, see Figure 1). HI-Z tags are attached in the deflated condition. After passage through the hydrokinetic unit, the HI-Z tags inflate and buoy the fish to the surface where they are recaptured by a boat crew. In addition to the balloon tag(s), a miniature radio tag also is attached to the fish to aid in the recapture. The radio tag allows boat crews to locate the tagged fish and typically be nearby the location that they rise to the surface for recapture. This minimizes the time at large. Finally, uniquely numbered visual implant tags (VI tags) or Floy tags are inserted into the fish before the fish is released. This allows for the identification of individual fish or treatment/control groups. Upon recapture of the fish in the tailrace, the biologist quickly removes the balloon and radio tags. Fish are transported to onshore holding tanks for latent mortality evaluation (48 hrs). Because each fish is uniquely identifiable by their VI or Floy tag, mixed treatment and control groups are held in the same tank environment for the 48 hr holding period. After the holding period, or when a fish dies, thorough examinations for injuries are conducted and a photographic record made of those fish with injuries.

C. Sample Size

One of the main considerations in the study design is to release an adequate number of fish such that the resulting survival estimates will be within a pre-specified precision (ε) level. The sample size to estimate survival and injury is a function of the recapture rate (P_A), expected passage survival (τ) or mortality ($1- \tau$), survival of control fish (S), and the desired precision (ε) at a given probability of significance (α). Sample size requirements decrease with an increase in control survival and recapture rates (Heisey *et al*. 1992) (Figure 2 and Table 1). In nearly all previous studies, control group survival has been very high indicating that experimental procedures have little effect on the outcome of the test.

The sample size should be sufficient to provide estimates of survival and injury within the desired level of precision ($\leq \pm$ 5%, 90% of the time, $1 - \alpha = 0.90$). If one or more of the assumptions listed below are violated, the sample size required to meet the desired ϵ and α levels may change. Sample size estimates were based on the following assumptions:

- Control group survival of 98%;
- Treatment (hydrokinetic unit) passage survival of 95% for smaller fish and 90% for larger fish; and
- Treatment recapture rate of 99%.

Based on these assumptions, the estimated total number of fish is approximately 650 to meet the statistical precision desired by Hydro Green Energy. This includes approximately 160 fish of each species/size class used in the analysis.

Normandeau Associates will confer with Hydro Green Energy and professional judgment will be used to adjust sample size, if necessary, during the study. One advantage of the HI-Z tag technology is that near real-time preliminary results are readily available, thus the sample size can be adjusted during the study to meet the statistical precision goals or budget constraints.

D. Fish Species

The December 13, 2008 FERC Order recommends that survival/injury estimates be developed for several species. The FERC EA (page 34) suggested that these species be selected from those that made up over 90% of the species distribution in the 1990/1991 entrainment studies conducted by Barnes-Williams at the Hastings Hydroelectric Project (BWEC, 1991). Table 4 (page 28) of the FERC EA lists these species as: gizzard shad, rosyface shiner, freshwater drum, white bass, and flathead catfish. FERC also recommends that the length range for each species to be tested should be similar to the length ranges observed during the 1990/1991 study.

FERC also states (EA, page 37) that additional information is available on the variability in species abundance and diversity in the long term resource monitoring program (LTRMP) run by the USGS for the upper Mississippi River (Ickes et al. 2005). A synthesis of the long term monitoring program 1993-2002 reported the most abundant species for pool 4 (downstream and adjacent to Pool 3, where the hydrokinetic units will be installed), were emerald shiner, gizzard shad, bluegill, spotfin shiner, and common carp.

The largest fish collected during the Barnes-Williams study (BWEC, 1991) was a 394 mm (15.5 in) freshwater drum; however the lengths of drum (as well as other species) collected from the upper Mississippi River reported by Ickes et al. (2005) were considerably larger. Most importantly, because the hydrokinetic units is suspended in the tailrace of the City's conventional turbines project, large fish may be present and have access to the hydrokinetic turbines. Therefore, we propose that the upper size ranges for fish tested in this study be extended beyond those observed in Barnes-Williams' 1990/1991 study.

Collecting a sufficient number (>150) of each species poses substantial logistical issues including scheduling, fish collection, transportation, and holding. Our recommendation is to work with species that include or represent the most abundant fish in the vicinity and are readily available through commercial fish suppliers to deliver test fish as we need them and in good condition.

We believe that we can meet the intent of the FERC EA with resident surrogate species as identified below. The rationale for this selection is detailed in Table 2.

- Smaller species
    - Bullhead (150 – 200 mm),
    - Yellow perch (150 – 200 mm) or largemouth bass (100 – 150 mm)
- Larger species
    - Freshwater buffalo spp. (200 - 560 mm)
    - Flathead or channel catfish (380 – 610 mm)

E. Fish Collection

Fish will be obtained by Normandeau Associates from one or more of the following sources, as recommended by MDNR:

- Collected from river in the vicinity of the Hastings Project
- Acquired from a local hatchery
- Acquired from a commercial supplier

Fish will be allowed to recover from the stress of capture and/or transport for a minimum of 24 hr prior to tagging. Fish will be separated by species and size class and held in tanks that will be continuously supplied with ambient river water.

F. Tagging and Release of Fish

Tagging techniques will be identical to those previously used in scores of HI-Z tag evaluations. Briefly, while anesthetized in MS-222, or immobilized in a restraint tube, fish will be equipped with a minimum of two-uninflated HI-Z tags and a miniature radio-tag. Tags will be placed in the musculature beneath the dorsal fin. For estimating 48-h survival of each treatment and control fish, a uniquely numbered VI tag or Floy tag will be inserted. Following tagging, fish will be allowed to recover in a covered 20 gal container continually supplied with ambient river water for a minimum of 20 min prior to release.

An induction system will be used to introduce treatment fish at a point of commitment to passage immediately upstream of the entrance to the unit (Figure 3), and control fish will be released into the tailrace. The induction system consists of a pump, induction tank, and 4 to 8-in diameter flexible delivery hose. Control group specimens will be released immediately downstream of the spill area and recaptured using the same techniques as treatment fish. All tagged fish will be recaptured downstream by boat crews stationed in the tailrace.

G. Classification of Recaptured Fish

As in previous investigations, the immediate post passage status of recaptured fish and recovery of inflated tags dislodged from fish will be classified as *alive, dead, subject to predation, inflated tag(s) only*, or *unknown*. The following criteria have been established to make these designations: (1) *alive* – recaptured alive and remained alive for 1h; (2) *alive* – when the fish does not surface but radio signals indicate movement patterns typical of swimming fish; (3) *dead* - recaptured dead or dead within 1h of release; (4) *dead* – when only inflated tag(s) without fish are recovered and telemetric tracking or manner in which inflated balloons surfaced are not indicative of predation; (5) *unknown* – when nothing is recaptured or radio signals are received only briefly and the subsequent status cannot be ascertained; and (6) *predation* – when fish are either actually observed being preyed upon, predator is buoyed to the surface, or subsequent radio telemetric tracking and/or tag indicates predation (*i.e.*, rapid movements of tagged fish in and out of turbulent waters or sudden appearance of fully inflated tags).

Immediately following recapture, the HI-Z tags will be removed and the fish will be examined for injury. Treatment and control fish will be transported from recapture boats to an onshore holding pool where fish will be monitored for 48 h. All fish released during a given testing day will be held in the same holding pool for monitoring. Fish will be distinguished among treatment groups and between treatment and control fish by a series of predetermined fin clips and the VI or Floy tags.

Fish recaptured dead or those that die prior to 1 h following recapture will be designated as 1 h post-passage mortality. Fish that die between 1 h and 48 h after passage will be designated as 48 h post-passage mortality. All fish that die following release will be necropsied to assess the probable cause of death. Additionally, all specimens alive at 48 h will be re-anesthetized and closely examined for injury. Injury and de-scaling will be categorized by type, extent, and area of body. The re-examination of immobilized fish after 48 h should minimize additional handling stress that would occur with thorough examination immediately upon recapture and permit detection of injuries that may be overlooked when initially recaptured. Following examination and recovery from anesthesia, all live fish will be released back into the water, while mortalities will be destroyed, as per permitting requirements.

H. Survival/Injury Estimation Data and Analyses

Prior to tagging, the total length of each fish will be measured to the nearest millimeter, and each fish will be examined for any existing marks or injuries. Information regarding the status of the fish immediately following recapture by the boat crews will be relayed via two-way radio to a data recovery person stationed onshore. The condition of each fish upon recapture and the amount of time between release and recapture will be recorded.

Similar to previous HI-Z tag studies, a likelihood ratio test will be used to estimate whether recapture probabilities were similar for live (P_A) and dead (P_D) fish (RMC and J.R. Skalski 1994). The statistic tests the null hypothesis of the simplified model (H_o:P_A=P_D) versus the alternative of the generalized model (H_o:$P_A \neq P_D$). Depending upon the outcome of the analysis, the parameters and their associated standard errors will be calculated using the appropriate model.

The 90% confidence interval on the estimated survival will be calculated using the profile likelihood method (Hudson 1971). This profile method constructs confidence intervals without assuming normality for passage survival and is generally assumed superior to the normal approximations.

I. Survival Estimation – Logistical and Experimental Assumptions

1. A sufficient number of fish of each desired species and of adequate size and condition to tag will be available for the study.

2. River flows and Project operations are conducive to and safe for completing field efforts in a timely fashion.

3. Adequate access to the tailwater can be provided to the recapture crews, and the boats can operate effectively and safely in the tailwater and for approximately 0.5 – 1 mile downstream.

4. Recapture rates and control groups survival value used to estimate sample size, and which were based on previous experience, are accurate. If actual recapture rates or control groups survival are less than those values used to estimate sample size, the noted precision level of ± 5%, 90% of the time will not be met, and if approved, sample size would need to be increased. Conversely, if recapture rates and control group survival exceed those used in sample size estimation, the precision will be < ±5%. Estimated injury rates within the desired level of precision assume a realized injury rate of up to approximately 5%.

2.2 A METHOD FOR ESTIMATING PREDATION

The FERC order detailing this monitoring requirement refers to the FERC Environmental Assessment (EA) for providing detail as to the expectations for estimating predation. The EA specifies (page 36-37):

The City also states that tailrace hydraulics would be impacted by unit operation. Data presented by the City show that water velocities at the turbine diffuser unit would be at least 50 percent lower than without the turbines in place (City, 2008a). A decrease in water velocity may allow predators to establish feeding stations closer to the face of the dam or downstream of the units in areas with reduced water velocity. These changes have the potential to alter tailrace predation rates. The City proposes to measure direct effects to test fish survival from unit passage, but not indirect effects such as predation.

The City notes that recapture rates of test fish are expected to be 98 percent unless predation is a significant problem. This implies that the City is able to estimate indirect predation effects to fish through the recapture metric. In presenting the results of the survival/injury study, the City should provide estimates of predation rate as implied by the recapture metric, for each test species.

When predation is observed or presumed during the conduct of turbine passage survival evaluations, the proportion of test fish preyed upon is estimated. Predation can be either directly observed or indirectly assumed by the 'behavior' exhibited by the radio tagged test fish. Behavior atypical of test fish and/or typical of a predator is classified as predation. This classification is used when fish are either visually observed being preyed upon, the predator is buoyed to the surface, or subsequent radio telemetric tracking and/or tag dislodgement indicate predation (i.e., rapid movements of tagged fish in and out of turbulent waters or sudden appearance of fully disconnected and inflated tags). Post-passage predation does not necessarily indicate mortality, as not all predation attempts result in mortality to the fish. Additionally, reported predation rates are likely over-estimated due to the restriction the tagging procedure has on the fish's natural predatory avoidance response.

All predation activity during the Survival/Injury study will be reported. These data will include the sizes and species of suspected or confirmed predation targets, and the predator species if known.

2.3 A DESKTOP ANALYSIS AND CHARACTERIZATION OF ENTRAINMENT POTENTIAL

The December 13, 2009 FERC Order detailing this monitoring requirement specifies (page 9):

As stated in the EA, based on the results of the survival study, the licensee can develop an estimate of fish entrainment through the hydrokinetic turbines[23]. Data is available from the 1990-1991 entrainment study conducted by the licensee, and from the Long Term Resource Monitoring Project conducted by the U.S. Geological Survey for the upper Mississippi River System. Data presented in the 1990-1991 entrainment study provides information on the number of fish by species entrained into the existing turbines. The Long Term Resource Monitoring Project data contains information on fish abundance, frequency of occurrence, community composition and species richness. Using the information in these two databases, the number of fish killed or injured passing through the hydrokinetic array can then be estimated, once the survival rate for the array is known. The licensee should prepare a desktop analysis of possible entrainment rates based on population variability.

Hydro Green Energy will use the data collected during the 1990-1991 entrainment study (BWEC 1991), and any additional available and pertinent data, to provide a characterization of the entrainment potential of fish in the near vicinity of the hydrokinetic turbines. The analysis will include a description of the tailrace environment with respect to flow velocities at various operating conditions for the conventional turbine units, turbulence, depth, width, and any other pertinent physical characteristics of the tailrace. For key fish species in the hydrokinetic array vicinity, representing different behavior modes (e.g., pelagic or demersal), swimming capabilities, and general body form types such as fusiform or laterally compressed, the respective characteristics that increase or decrease the likelihood of entrainment for a species will be reviewed. The tailrace environment and fish species characteristics will be used to develop an overall qualitative assessment of entrainment potential for each of these species/groups. The existing entrainment data will be used to establish a context for the entrainment potential and estimated impact of the hydrokinetic units. These results will accompany a general discussion and conclusions relative to potential ecosystem-level effects of the hydrokinetic array.

As the Hydro Green Energy units will not occupy a full cross-section of the Hastings Project tailrace, the entrainment estimates gathered above will represent a "worst-case scenario". Fish entrained through the conventional hydro units or that are otherwise present in the tailrace upstream of the Hydro Green units may go around or under the units and thus avoid entrainment.

3.0 SCHEDULE AND REPORTS

Implementation of the plan shall not begin until the plan is approved by the Commission. Upon Commission approval, the Licensee will immediately begin to implement the plan, including any changes required by the Commission.

The anticipated schedule for performing the survival/injury study is during April or May 2009, and is dependent upon water temperature, safe conditions in the tailwater area, and availability of study fish. The desktop entrainment analysis will be conducted after survival/injury data become available.

Within 6 months after completion of the survival/injury study and the desktop analysis of entrainment potential, the Licensee and Hydro Green Energy will hold a meeting to present results, review the effects of the project, and develop recommendations with the Minnesota Department of Natural Resources, Minnesota Pollution Control Agency, National Park Service, U. S. Fish and Wildlife Service, and U.S. Army Corps of Engineers. Prior to the meeting, a draft report will be provided to the above agencies. The report will include a discussion of the overall effects of the project on the fisheries resources at the Mississippi River Lock and Dam No. 2 Hydro Project. If any adverse impacts to fisheries resources are projected, the final report will include proposed changes to project operation in order to minimize those impacts. The final report will be filed with the Commission, after this consultation with the agencies.

4.0 LITERATURE CITED

BWEC. 1991. Fish entrainment monitoring program, City of Hastings Hydroelectric Project, FERC Project No. 4306-008, Lock and Dam 2, Hastings, Minnesota, June 1990 – May 1991 Report. Report prepared for City of Hastings, Minnesota.

Heisey, P. G., D. Mathur, and T. Rineer. 1992. A reliable tag-recapture technique for estimating turbine passage survival: application to young-of-the-year American shad (*Alosa sapidissima*). Canadian Journal Fisheries and Aquatic Sciences 49:1826-1834.

Hudson, D.J. 1971. Interval estimation from the likelihood function. J. R. Stat. Soc. B. 33:256-262.

Ickes, B. S., M. C. Bowler, A. D. Bartels, D. J. Kirby, S. DeLain, J. H. Chick, V. A. Barko, K. S. Irons, M. A. Pegg. 2005. Multiyear Synthesis of the Fish Component from 1993 to 2002 for the Long Term Resource Monitoring Program. U.S. Geological Survey, Upper Midwest Environmental Services Center, LaCrosse Wisconsin, LTRMP 2005 T005. 60pp. + Appendixes A-E.

RMC and J.R. Skalski. 1994. Survival of yearling fall Chinook salmon smolts (*Oncorhynchus tshawytscha*) in passage through a Kaplan turbine at the Rocky Reach hydroelectric dam, Washington. Report prepared for Public Utility District No. 1 of Chelan County, Wenatchee, WA.

Figure 1. HI-Z Turb N' Tag attached to a juvenile American shad. After passage through a hydraulic control structure, the tag inflates (as shown) and buoys the fish to the surface for recapture by a boat crew.

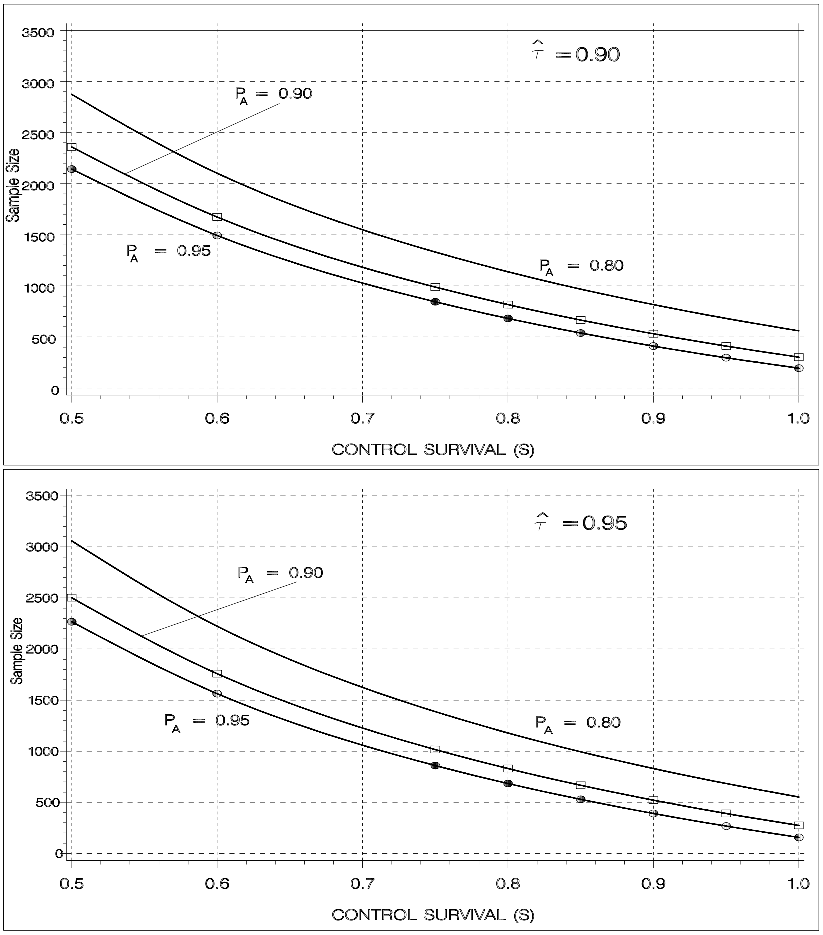

Figure 2. Relationships of sample size relative to various control group survival values and recapture rates for passage survival values**.**

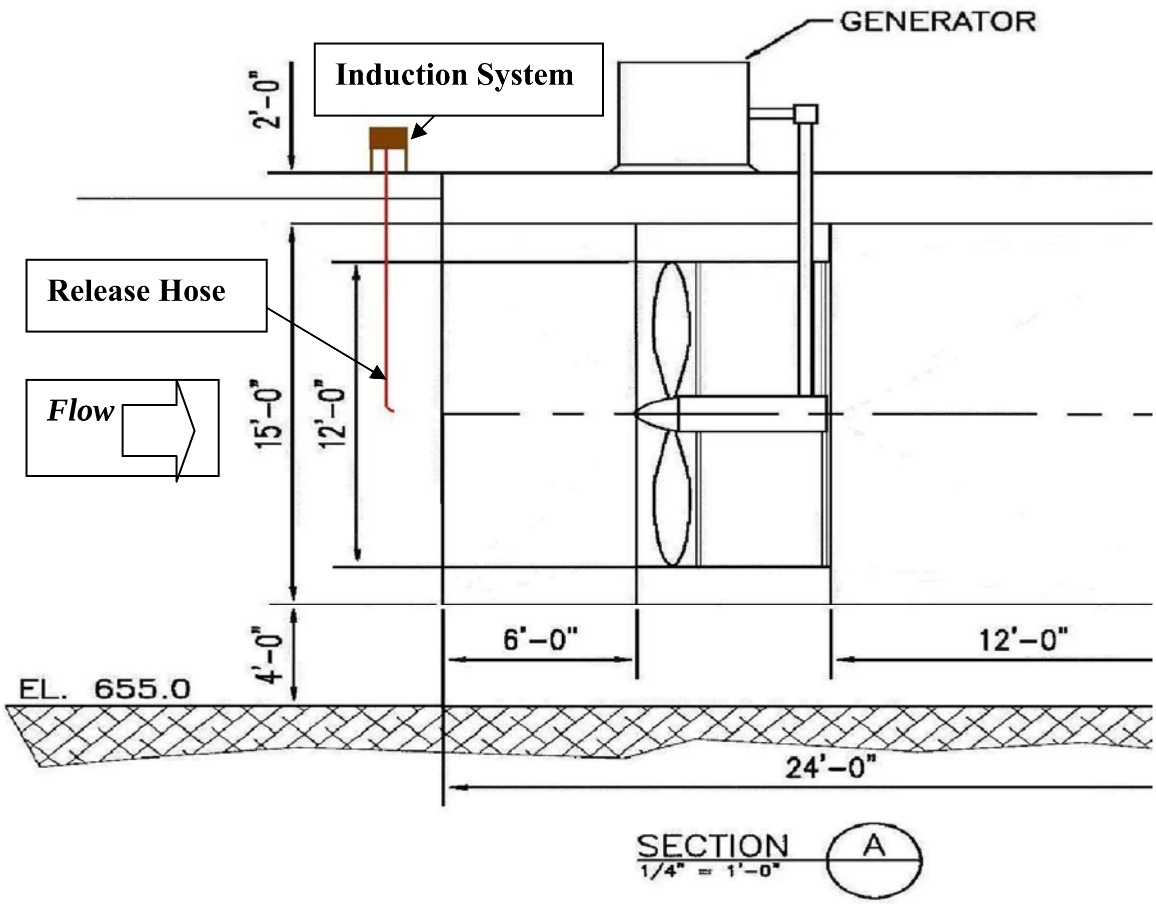

Figure 3. Cross section of Hydro Green Energy unit with induction system schematic. Induction system is used to introduce tagged fish into the unit at a point of commitment to entrainment.

Table 1. Estimated sample sizes for treatment and control releases for various combinations of control survival (S), recapture probability (P), and turbine related survival (τ) to achieve precision level (ε) of ≤±0.05, 90% of the time (1-α=0.90).

Control Survival (S)	Recapture Rate (P)	Turbine Survival (τ)	Number of Fish
1.00	0.99	0.95	72
		0.90	117
		0.85	156
	0.95	0.95	157
		0.90	195
		0.85	228
	0.85	0.95	275
		0.90	304
		0.85	328
0.98	**0.99**	**0.95**	**114**
		0.90	**155**
		0.85	191
	0.95	0.95	201
		0.90	235
		0.85	265
	0.85	0.95	320
		0.90	346
		0.85	366
0.95	0.99	0.95	179
		0.90	215
		0.85	246
	0.95	0.95	269
		0.90	298
		0.85	322
	0.85	0.95	392
		0.90	412
		0.85	427

Table 2. Rationale for selection of study fish species.

Recommended Species in EA (and size ranges)	Suggested Representative/Surrogate	Rationale
Gizzard shad (32 – 337mm)	Freshwater buffalo spp (200 – 560 mm)	• Gizzard shad do not hold well at cooler temperatures and therefore may not provide statistically reliable results
Rosyface shiner (22-97 mm)	Bluegill (100– 150 mm)	• Rosyface shiners are too small (both in length and girth) as adults to test using the balloon tag approach. • We can purchase and test 100 – 150 mm bluegill to be used as a surrogate for this size class. • Ickes et al. 2005 report bluegill being the 3rd most abundant fish in Pool 4. As cited in the EA, “many of the species documented in Pool 4 are also likely to be present in or near the project area”.
Freshwater drum (114-394 mm)	Freshwater buffalo *spp* (200 - 560 mm)	• Freshwater drum do not hold well • Freshwater buffalo have a similar body shape and swimming style to the freshwater drum. Additionally, we’ve confirmed that we can collect a sufficient number of buffalo during the study period. • Using freshwater buffalo will allow us to test survival/injury of larger fish • Freshwater buffalo *spp* would also be a good surrogate for the common carp, which was listed as the 5th most abundant species in the area (Ickes et al. 2005)
White bass (48-331 mm)	Yellow perch (150 – 200 mm) or largemouth bass (100 – 150 mm)	• White bass is an important species to the recreational fishery. • Yellow perch and largemouth bass have a body shape and swimming style that is similar to the white bass. • We have confirmed we can purchase 150 – 200 mm yellow perch or largemouth bass (100 – 150 mm) from a supplier, causing no effect on the native resource.
Flathead catfish (76-358 mm)	Channel catfish (380 – 610 mm) and bullhead (150 – 200 mm)	• Flathead catfish may not be present in sufficient numbers during the study period. If they are, we will use them in place of the 380-610 channel catfish. • Channel catfish and bullhead have a similar body shape and swimming style to the flathead catfish. • We’ve confirmed that we can collect 380 – 610 mm channel catfish and purchase 150 – 200 mm bullhead for the study. • Note: channel catfish were listed as the 6th most abundant species in Barnes-Williams

HI-Z TURB'N TAG LITERATURE

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Paul G. Heisey and Dilip Mathur

RMC Environmental Services, Inc., Utility Consulting Division, Muddy Run Ecological Laboratory, 1921 River Road, P.O. Box 10, Drumore, PA 17518, USA

and Ted Rineer

Safe Harbor Water Power Corporation, 5093 River Road, P.O. Box 97, Conestoga, PA 17516, USA

Heisey, P. G., D. Mathur, and T. Rineer. 1992. A reliable tag–recapture technique for estimating turbine passage survival: application to young-of-the-year American shad (*Alosa sapidissima*). Can. J. Fish. Aquat. Sci. 49: 1826–1834.

A new technique (HI-Z Turb'N Tag, U.S. Patent No. 4,970,988) for estimating turbine passage survival was applied to juvenile American shad (*Alosa sapidissima*) under three operating conditions at a hydroelectric project. Fish are fitted externally with the Turb'N tag and introduced into turbine penstocks. The Turb'N Tag inflates after turbine passage and buoys fish to the surface for recapture and examination; after removal of tags, fish are held to assess long-term effects. Almost all (96%) test (299) and control (300) fish were recovered; average recovery time was less than 9 min. The overall short-term (1 h) survival of test fish, adjusted for control, was 97%; 24- and 48-h survivals were 98 and 94%, respectively. The 48-h survival of test fish was 98–100% for mixed flow and Kaplan turbines and 66.8% for the mixed flow unit in the vented mode. Acute control mortality was negligible (<5%). Our technique offers several significant advantages over traditional net recapture methods: applicable to wide range of species and size; allows predetermination of statistically valid sample size, level of significance, and power of the test to determine need for mitigation measures; and estimation of cumulative effects of multiple turbine exposure.

Une nouvelle technique (étiquette HI-Z Turb'N, brevet américain n° 4,970,988) pour estimer le taux de survie au passage en turbine a été appliquée à de jeunes aloses savoureuses (*Alosa sapidissima*) sous trois régimes de fonctionnement dans une installation hydroélectrique. On fixe sur les poissons, de façon externe, l'étiquette Turb'N, et on les introduit dans les conduites forcées. Après le passage dans la turbine, l'étiquette Turb'N se gonfle et amène le poisson à la surface où on peut le capturer et l'examiner; après prélèvement des étiquettes, on garde les poissons pour évaluer les effets à long terme de l'opération. Presque tous les poissons sujets de l'expérience (299) et témoins (300) ont été récupérés (96 %); le temps moyen de reprise était inférieur à 9 min. Le taux global de survie à court terme (1 h) des poissons soumis à l'expérience, après rajustement en fonction des témoins, était de 97 %; les taux de survie après 24 et 48 h étaient respectivement de 98 et 94 %). Le taux de survie des poissons était de 98 à 100 % pour les turbines mixtes et Kaplan et de 66,8 % pour l'unité mixte avec prise d'air. La mortalité aiguë chez les poissons témoins était négligeable (<5 %). Notre technique offre plusieurs avantages importants par rapport aux méthodes traditionnelles de recapture au filet : elle s'applique à des espèces et des tailles très diverses; elle permet de prédéterminer la taille d'échantillon valide sur le plan statistique, le niveau de signification et la puissance du test pour savoir s'il est nécessaire de prendre des mesures d'atténuation; de plus, elle permet d'estimer les effets cumulatifs de passages multiples en turbine.

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The surge in developing hydro sites combined with a strong impetus to preserve or restore migratory fishes (salmonids and clupeids in particular) has elevated fish mortality by turbine passage to a major concern. Numerous reviews on turbine-related fish mortality (Ruggles 1980; Bell 1981; Turbak et al. 1981; Monten 1985; EPRI 1986; Eicher Associates, Inc. 1987; Ruggles and Palmeter 1989; Ruggles et al. 1990) indicate that most effort has been expended on protection, exclusion devices, and evaluation of mortality of salmonid smolts. Eicher Associates, Inc. (1987) concluded that in spite of decades of research on salmonids, much uncertainty remains in estimating turbine-related mortality. A variety of factors may cause this uncertainty; namely, design of turbine, wicket gate setting, head, species of fish examined, size of fish, rotation of turbine blades, turbine blade angle, and number of blades. These factors in combination with uncertainties associated with conventional tag–recapture techniques make results of turbine-induced mortality studies difficult to interpret. In many cases, however, expensive mitigation measures (spillage, bypass structures, screens, etc.) have been suggested, initiated, or installed prior to actually measuring turbine-passage mortality. An equally important issue is the potential for these mitigation measures to inflict significant mortality or injury relative to passage through hydraulic turbines.

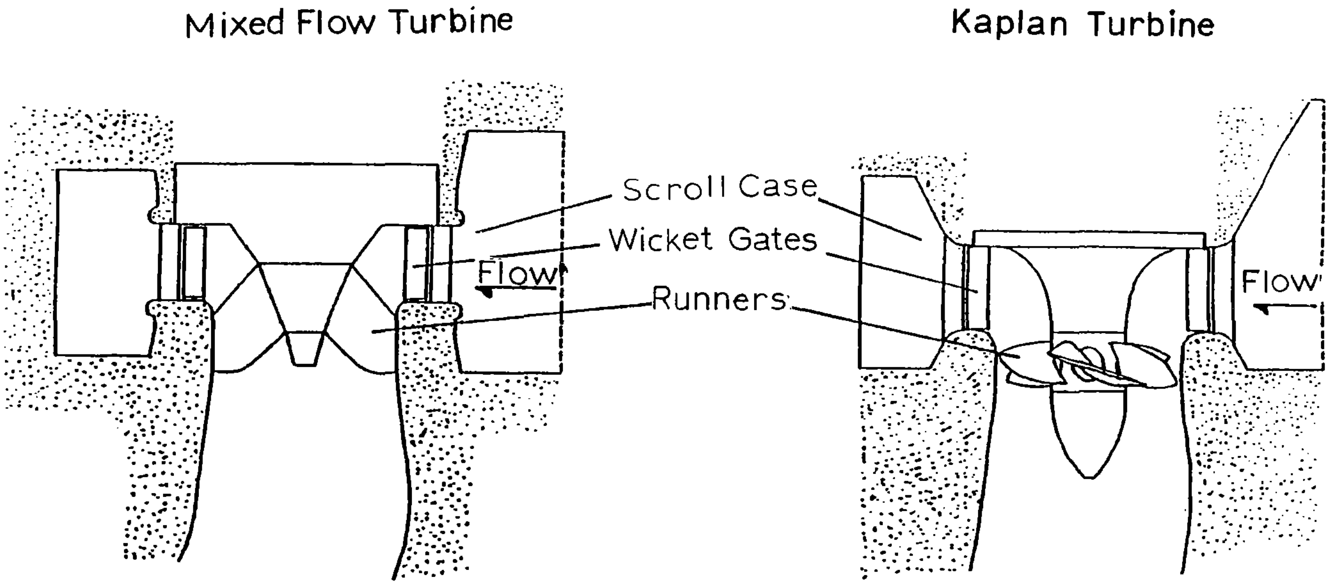

FIG. 1. Schematics of the Kaplan and mixed flow turbines at the Safe Harbor Hydroelectric Station.

Within the last decade, attention has also focused on the need for mitigation of potential losses of alosids during turbine passage (Gloss et al. 1982; Kynard et al. 1982; Davies 1988; Ruggles et al. 1990; Stokesbury and Dadswell 1991). Alosids have been targeted for restoration in many East Coast rivers. Although upstream passages have been provided for alosids at many hydroelectric projects, turbine entrainment mortality of emigrating juveniles remains a serious concern.

Major obstacles block the performance of satisfactory turbine passage mortality studies on juvenile alosids. Alosids are extremely sensitive to handling and tagging; thus, control mortality (in mark–recapture studies) has been high (Ruggles et al. 1990). The inability of investigators to satisfactorily separate the collection mortality from that due to turbine passage and avoid fish extrusion through nets further compounds the problems of reliable mortality estimation. Ruggles and Palmeter (1989) concluded from a netting study of juvenile alewife (*Alosa pseudoharengus*) that total fish recapture after turbine passage is the most effective experimental design to gather unambiguous results quickly. Burnham et al. (1987) also discuss the analytical advantages of high recapture rates of fish in reliably estimating turbine-related mortality of fishes at hydroelectric projects. However, capturing all test and control juvenile alosids has proven difficult.

Our objective is to show the application of the HI-Z Turb'N Tag and recapture method (U.S. Patent No. 4,970,988) in reliably estimating both the short-term (1 h) and long-term (48 h) turbine passage survival rates for juvenile American shad (*Alosa sapidissima*) (90–140 mm fork length (FL)) at the Safe Harbor Hydroelectric Station, a 417-MW peaking hydroelectric project on the lower Susquehanna River (river km 49). The need for rapid recapture of a high proportion of the test and control tagged fish coupled with low handling mortality was inherent in fulfilling the recommendations made by Ruggles and Palmeter (1989).

Methods and Materials

The Safe Harbor Hydroelectric Station consists of a concrete gravity dam 1484 m long and 23 m high, with 12 generating units. The project has seven Kaplan and five mixed flow turbines (Fig. 1) for a total hydraulic capacity of 3143 m^3/s. Each turbine is capable of passing approximately 245 m^3/s. The Kaplan turbines have five blades and are 5.6 m in diameter with a runner speed of 109 rpm. The mixed flow turbines have seven blades, a diameter of 6.1 m, and a runner speed of 77 rpm. Survival of young American shad was estimated at both mixed flow and Kaplan turbines. The mixed flow turbine was tested under vented mode (aeration of flow to increase dissolved oxygen) and unvented operating mode.

Collection and Handling of Specimens

Young-of-the-year American shad were collected by a specially designed lift net from the forebay of the Holtwood Hydroelectric Station, 11 km downstream from the study site. This net minimized handling effects because after lifting, shad were directly transferred in water to transport tanks. Fish were transported to the study site in sealed 75-L circular tanks filled with a 0.5% solution of sodium chloride (NaCl) and river water. The salt solution reduced osmotic and ionic imbalance due to handling stress (Meinz 1978). To the extent possible, shad were not removed from the water during handling. Upon arrival at the study site, fish were transferred to 950-L circular holding tanks positioned at the station headworks and held for 24 h prior to testing. These holding tanks were continuously supplied with river water. The dissolved oxygen of the water remained ≥9 mg/L and water temperature ranged between 10.0 and 23.0°C.

Specimens were removed from the holding tanks in water-filled buckets and placed into a 75-L circular tub prior to tagging and release. Initially, juvenile shad were held in fresh river water, but experience showed that keeping juvenile shad in a 0.5% salt solution for up to 2 h prior to tagging reduced handling stress (see later). Subsequent tagging was, therefore, conducted after shad had been held 0.5–2 h in the salt solution.

Circular net pens for assessment of delayed mortality of recovered test and control fish were located in an eddy 61 m downstream of the powerhouse to minimize the influence of extraneous factors (i.e. net impingement, human disturbance). The net pens were 1.5 m in diameter, 1.2 m deep, and covered on the bottom, sides, and top with 7-mm rigid plastic netting.

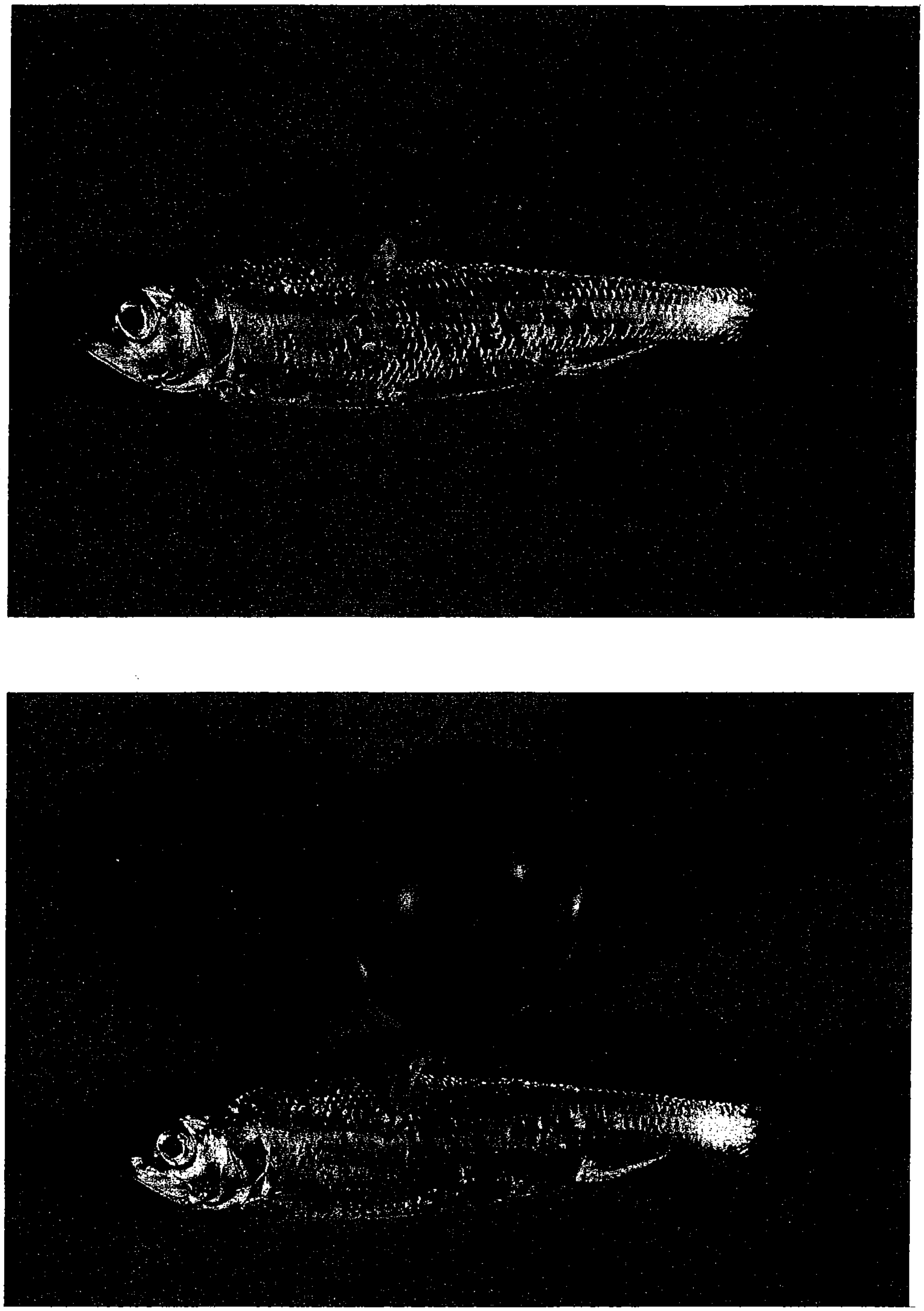

FIG. 2. Uninflated and inflated Turb'N Tag.

Tagging and Induction of Fish

The Turb'N Tag recovery technique (a balloon-type tag) is chemically based and involves external attachment of a small uninflated Turb'N Tag to each fish (Fig. 2). Prior to release of a fish, the tag is activated by injecting 1 mL of water to initiate the chemical reaction. The delayed chemical reaction releases a gas and inflates the tag. Shortly after turbine passage the tag slowly begins to inflate, buoying the fish to the surface for recapture (Fig. 2). The tag inflation time can be adjusted to between 2 to 60 min depending on the water temperature and configuration of the study site. Once recaptured, the inflated tag is removed from the fish with a modified plier or clip (generally within seconds), keeping the fish immersed in water, and the fish's condition can be carefully determined. The fish is then transported in buckets filled with water to a holding pen for assessment of long-term effects. Because of the short duration (few minutes) that the tag remains on the fish, no adverse effects on fish behavior are encountered. Fish tagged and kept in holding pools showed over 80% survival with no apparent effects on swimming ability after tag removal (Mathur and Heisey 1992). Generally, anesthetic is not necessary for tag application on small fish but may be useful on large active fish

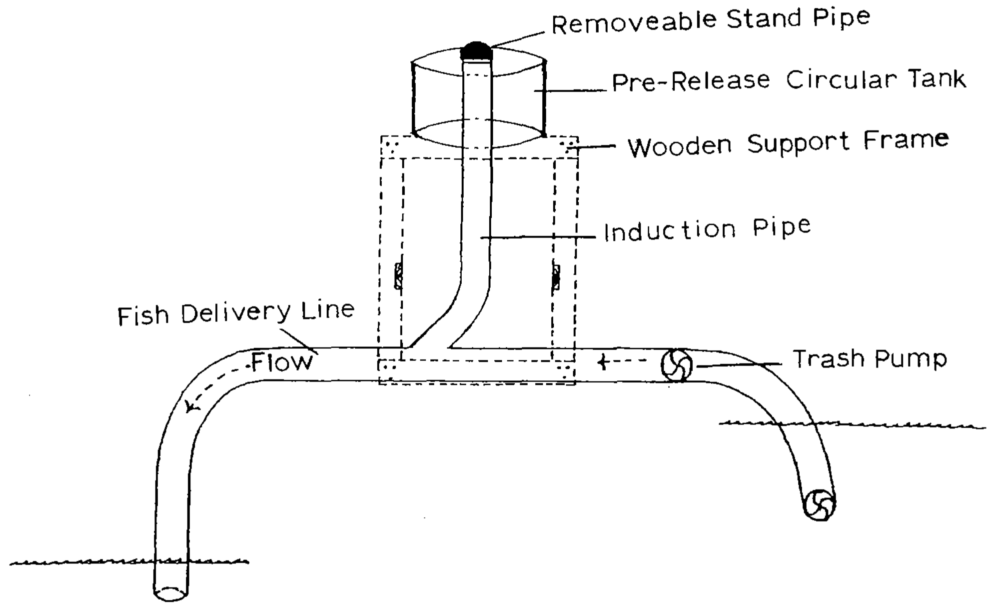

FIG. 3. Schematic of the fish induction system used for the turbine passage survival study of juvenile American shad.

to reduce tagging and handling stress. The tag has been successfully field tested on fishes ranging approximately from 60 to 400 mm in total length (Mathur and Heisey 1992). Larger specimens (>200 mm) may require more than one tag to buoy them.

For this study, each juvenile shad was individually removed from the holding tanks in a water-filled bucket and externally fitted with a Turb'N Tag and a neutrally buoyant miniature radio transmitter. A tag and transmitter were attached by a stainless steel pin (5 or 10 mm long) through the anterior dorsal musculature so that they trailed on either side of the fish. The pin was inserted with a modified ear-piercing gun and secured by a small plastic disc. Attachment of both types of tags increased the probability of recovery if the fish moved rapidly out of the tailrace and could not be located visually. However, it may not be necessary to utilize miniature radio tags for studies at hydroelectric projects with low-volume discharges or if fish size becomes limiting. Clupeids less than 90 mm FL generally do not respond well to attachment of miniature radio tags. Other species more resistant to handling can accept miniature radio tags (Mathur and Heisey 1992). However, if radio tags are needed, they can be reused upon recovery of each fish.

Uninflated Turb'N Tags were made of bright-colored latex, pear-shaped with dimensions of approximately 38 × 13 mm; each weighed 1.5 g. Upon full inflation, the tags measured 75 mm long by 50 mm in diameter. The radio tags weighed 1.7 g, were approximately 10 × 30 mm, and propagated signals through a 27-cm thin wire antenna.

Prior to release of each fish the tag was activated by injecting 1 mL of water to initiate the chemical reaction. Tagged fish were introduced individually into the penstock of an operating turbine at a depth of approximately 10 m by an induction apparatus consisting of a small holding basin attached to a 7.6-cm-diameter reinforced plastic delivery line (Fig. 3). A gasoline-powered trash pump continuously supplied water to the system to ensure rapid transport of fish through the delivery line within a continuous flow of water. Control fish were tagged and released individually through the same induction apparatus directly into the tailrace to separate the effects of tagging/handling from those due to turbine exposure (Fig. 4). Similar sized fish were used for test and control releases.

Fish Recapture

Test and control fish were recaptured by homing on a radio signal or visually spotted by the inflated tag. Each buoyed fish was retrieved by using a 11-L bucket. Fish that failed to surface immediately were monitored via radio signals. Recapture time for each tagged fish was recorded.

The recaptured test and control fish were placed in an onboard holding tank, carefully examined for mechanical injury, tags and attachment pin removed, and tagging site examined. Fish were then transferred to floating net pens for long-term observation (48 h). Net pens were checked for both test and control fish mortalities at 24 and 48 h. Fish were classified into (1) short-term survival or mortality (≤1 h), (2) not recovered and unknown status, and (3) long-term survival or mortality (≤48 h).

Sample Size and Statistical Analysis

Because the analysis of survival experiments based on tag–recapture data is a function of the total number of recaptured fish, statistical significance, and the power of the test, we used the results of a pilot turbine passage survival study conducted at the site in 1989 to calculate the sample size necessary to detect a desired level of statistical difference between survival of control and test fish for this study. To detect a statistical difference in short-term turbine-related mortality of >0.10 at ordinarily accepted levels of alpha ($\alpha = 0.05$) and statistical power ($1 - \beta = 0.8$), we assumed a control survival of 95% and recapture rate of 90%. We estimated that a release of 100 juvenile shad each for test and control was needed for each operating condition. Sample size requirements for other combinations of expected recapture rates, control mortality, and statistical significance were also calculated. However, the present paper deals only with the above-stated statistics.

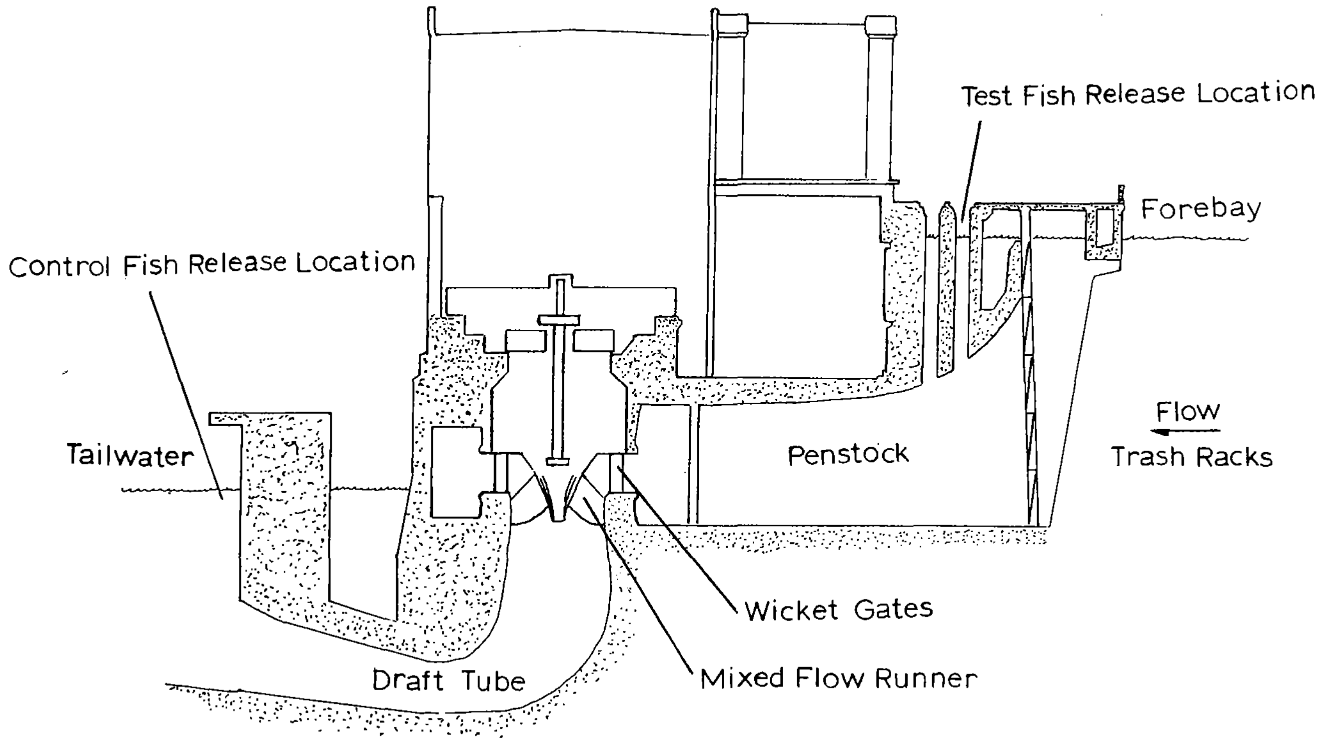

FIG. 4. Release locations of test and control juvenile American shad for the turbine passage survival study.

The short-term (≤1 h) and long-term (24 and 48 h) turbine-related mortality (relative risk) of juvenile American shad was calculated according to the equation given in Fleiss (1981):

$$P_e = \frac{P_2 - P_1}{1 - P_1}$$

where P_e = turbine-related mortality adjusted for control, P_1 = fractional mortality of control fish, and P_2 = fractional mortality of test fish.

The confidence intervals on the estimated turbine-related mortality (P_e) were calculated using the formula for standard error (SE) given in Fleiss (1981):

$$\text{SE of } P_e = \left(\frac{1}{Q_1}\right) \sqrt{\frac{P_2 Q_2}{N_2} + (1 - P_e)^2 \left(\frac{P_1 Q_1}{N_1}\right)}$$

where P_1 = fractional mortality of control fish, P_2 = fractional mortality of turbine-exposed fish, Q_1 = fractional survival of control fish, Q_2 = fractional survival of turbine-exposed fish, N_1 = sample size of control fish, and N_2 = sample size of turbine-exposed fish.

For the purposes of these analyses, fish categorized as "unknown" or "tag and pin" or preyed upon were conservatively considered as dead.

The significance of differences in recapture and survival rates were statistically determined by the Fisher's exact chi-square 2 × 2 contingency test of independence (Sokal and Rohlf 1981). Data were analyzed using the Statistical Analysis System (SAS Institute, Inc. Version 6.03).

Results

Recapture Rates

The recapture of test and control fish was high with an overall rate of 96% (Table 1). Although we recaptured similar ($P > 0.05$) proportions of control and test fish, slight differences (nonsignificant) were observed between test conditions. We recaptured 92% of both the test and control fish from the mixed flow unit in unvented mode and 97–99% from the other test conditions). The seemingly higher proportion (8%) of "unknown" test and control fish for the mixed flow unit in unvented mode appeared to be due to predation by walleye (*Stizostedion vitreum*) on juvenile shad. Predation was confirmed because in one case the tag inflated while the young shad was being swallowed, bringing the walleye to the surface.

The recovery times were short, averaging less than 9 min under all test conditions (Table 1), and similar ($P > 0.05$) both between operating conditions and between control and test fish.

Short-Term Survival

Short-term survival of test fish was high and showed little variation (Table 2). Overall survival was 97%, and differences in survival were not significant ($P > 0.05$) between turbines or between control and test fish.

The high recapture rate of live test and control specimens provided a relatively large sample size for assessment of long-term survival (Table 3). The 24-h survival of juvenile shad at all three operating conditions ranged from 97 to 100%. The 48-h survival of juvenile shad at the mixed flow turbine in unvented mode and Kaplan unit ranged from 98 to 100%. The 48-h survival of juvenile shad at the mixed flow unit in vented

TABLE 1. Comparative statistics on recovery rates and times of test and control young American shad released for the turbine passage survival study under three turbine operating conditions (percentages in parentheses).

	Mixed flow (unvented)		Kaplan		Mixed flow (vented)		Total	
	Control	Test	Control	Test	Control	Test	Control	Test
No. introduced	100	100	100	100	100	99	300	299
No. recovered/	92	92	99	99	98	96	289	287
known status	(92%)	(92%)	(99%)	(99%)	(98%)	(97%)	(96%)	(96%)
Recovery time (min)								
$\bar{X}$	8.9	6.7	4.5	5.4	8.3	8.7	7.2	6.9
SE	1.1	0.4	0.3	0.4	0.8	0.5	0.5	0.3
Min.	1	1	1	1	1	2	1	1
Max.	13	35	78	17	65	25	78	25

TABLE 2. Comparison of short-term (1 h) turbine passage survival of young American shad released under three turbine operating conditions. Test fish survival rate adjusted for control mortality. Fish of unknown status included with dead.

	Mixed flow (unvented)	Kaplan	Mixed flow (vented)	Total
No. introduced	100	100	99	299
No. survived	90	97	92	279
% survival	97.8	98	98.9	96.9
95% CL[a]	93.4–100	94.1–100	94.3–100	93.2–100

[a]Upper limits truncated at 100%.

mode was 67%, with a significantly higher survival of control fish ($P < 0.05$). However, these differences are considered suspect and unreliable due to a high mortality of both test and control fish caused by natural meteorological events. Two weeks of sustained high natural river flows (6000 m^3/s) and falling air temperatures lowered water temperature (from 22.5 to 9.0°C) and created excessive turbidity. Survival of control fish at 24 and 48 h was 72% (71 of 98 held) and 54% (53 of 98), respectively. The respective test fish survival rates unadjusted for control at 24 and 48 h were 74% (68 of 92) and 38% (35 of 92).

Injury

Only 5% of the 283 test fish and 2% of the 289 control fish exhibited external injury marks or scale loss. The primary injury to test fish was small lacerations. Control fish showed minor hemorrhaging or bruises.

Discussion

A combination of high recapture rate and short recapture time indicates that the Turb'N Tag technique worked well and matched the initial expectation. The near 100% survival of control fish, particularly short term, fulfilled the criterion set forth in the experiment and allowed reliable estimation of turbine-related mortality. Burnham et al. (1987) stated that the reliability of turbine passage survival estimation is substantially enhanced when investigators can recover a high proportion of marked fish. Past studies on juvenile alosids have been hampered by generally low recovery rates and high net induced mortality due to abrasion or extrusion through nets. The present recoverable tag overcomes many of the logistical problems associated with sampling in turbulent conditions at hydroelectric projects and was able to provide a more realistic estimate of turbine-related mortality of juvenile shad.

The high rates of recapture of live fish provided an opportunity to assess long-term mortality. However, the tag removal technique on the recovered fish and holding of some fish in freshwater prior to tagging caused high long-term mortality of both control and test fish at the mixed flow unit (unvented mode). On the first day of testing, young shad were held in freshwater and the tags from the recovered fish were removed by needlenose pliers. The 24-h mortality was 56 and 78% for the control and test fish, respectively. At 48 h the mortality was 83% in control and 82% in the test group. Subsequently, young shad were held in 0.5% NaCl solution prior to tagging (see Methods and Materials section). The 24-h mortality decreased substantially, but the condition of the fish at 48 h indicated that the tag removal was still too stressful. Consequently, the tag removal procedure was modified by using two "clips" to pull the plastic disc off the attachment pin that secured the tags to the fish. These modifications resulted in 24-h survival of 100% for control fish. Other studies show that these modifications have improved the procedure considerably and appear to be applicable to a wide range of species and sizes (Mathur and Heisey 1992). The smallest clupeid tagged with the Turb'N Tag was 80 mm total length and the largest fish, a smallmouth bass (*Micropterus dolomieu*), tagged to date measured 305 mm.

There are three principal risks associated with turbine passage: direct strike by the rotating turbine blades, rapid change in water pressure, and hydraulic shear forces. These risks, however, are not universally applicable to all species and their life stages at hydroelectric projects. Unless an individual fish is physically retrieved for careful examination, it may be difficult to estimate these risks quantitatively. Our technique allowed quantification of these risks. The probability of direct contact of fish with the rotating blades is primarily a function of fish morphology and size, turbine runner speed, turbine blade clearance, wicket gate clearances, turbine type and orientation, and hub diameter (Monten 1985). A higher runner speed, larger fish size, and narrower blade clearances increase the probability that an entrained fish will be struck by the turbine blade.

The near absence of mechanical injury to juvenile American shad in the present study indicated that direct contact with the rotating turbine blades was a low probabilistic event under the operating conditions that were tested at Safe Harbor. This may

TABLE 3. Comparison of long-term (24 and 48 h) turbine passage survival of juvenile American shad released under three turbine operating conditions. Fish lost from net pens due to high flow excluded from calculations.

	Mixed flow (unvented)[a]	Kaplan	Mixed flow (vented)[b]	Total
		Test fish		
No. held	90	97	92	279
No. alive (24 h)	63	97	68	228
Adjusted survival (%)[c]	100	100	97	98
No. alive (48 h)	52	85	35	172
Adjusted survival (%)[c]	100	98	67	94.3
		Control fish		
No. held	92	99	98	289
No. alive (24 h)	63	99	71	233
% alive (24 h)	68	100	72	81
No. alive (48 h)	47	83	53	183
% alive (48 h)	53	98	54	67

[a]Twenty test and 20 control fiush held in freshwater prior to testing; tags from 70 test and 70 control fish removed without using the modified "clip."

[b]Five test and five control fish held at a water temperature of 21°C; remaining fish (87 test and 93 control) held at a water temperature of 9–11.0°C.

[c]Test fish survival adjusted for control mortality (see text).

be due to the slow runner speed and wide clearances between turbine runner blades. Cada (1990) suggested that most of the factors that result in mortality at low head hydroelectric projects can be attributed to direct blade contact, and little mortality is caused by turbulence, cavitation, or pressure changes.

Young American shad were subjected to little pressure change (head at Safe Harbor is approximately 18 m) during turbine passage. At low head projects (<30 m), pressure change is usually of no consequence because relatively little change in pressure occurs; fish passage is virtually instantaneous. Another study conducted at a hydroelectric project (net head of 29 m) on the lower Susquehanna River similarly showed no visible effects of pressure on juvenile shad (RMC Environmental Services, Inc., unpubl. data). However, these results are contrary to those of other investigators who have implicated pressure-related injuries to alosids at projects with a net head of even less than 15 m (Gloss et al. 1982; Kynard et al. 1982; Stokesbury and Dadswell 1991). We can only hypothesize on the possible causes of differences. The most likely causative agent for the higher rate of injury appears to be the sampling gear, namely, the recapture netting system. Ruggles et al. (1990) have pointed out several problems with netting studies, one of which is high injury rates. Test fish are frequently impinged on the nets or abraded against the nets resulting in injuries or mortalities resulting in high estimates of turbine-related mortality. Because nearly every tagged fish was recovered individually in the present study, it allowed for the careful examination of each fish for location of mechanical injury and scale loss. Previous studies lacked the capability to unequivocally separate turbine-induced injury/mortality from that due to handling/tagging and netting.

The low estimated mortality of juvenile shad at the Safe Harbor Project is in contrast with that reported in the literature for young alosids exposed to Kaplan and other types of turbines. Previous studies, mostly limited to estimation of acute effects of turbine passage, have been plagued by high control mortality, lack of a true control, methodological problems, inadequate sample size, and low recapture rates (Turbak et al. 1981; Gloss et al. 1982; Kynard et al. 1982; Ruggles et al. 1990). Kynard et al. (1982) reported turbine passage mortality rates of 62–82% for juvenile shad and blueback herring (*Alosa aestivalis*) (60–90 mm) at the Hadley Falls Station (Kaplan turbine) on the Connecticut River. These mortality estimates appear intuitively too high and in conflict with findings on larger fishes. Bell and Kynard (1985) estimated mortality of postspawned adult shad (450–600 mm) to be less than 15% (when adjusted for control mortality). The probability that entrained juveniles will be struck by a turbine blade is much less than for the adults; thus the mortality for larger fish should be higher. Interestingly, mortality of Atlantic salmon smolts (*Salmo salar*) (210–360 mm) was calculated to be less than 7% (when adjusted for control) at the Hadley Falls Station (Kynard et al. 1982); again the salmon smolts were much larger than the juvenile clupeids tested. It is interesting to note that the turbine-related mortality of larger fishes exposed to the Kaplan turbine is somewhat similar to the low mortality reported herein for juvenile American shad. Kynard et al. (1982) used a netting recovery system placed approximately 300 m downstream of the powerhouse for the juvenile clupeid study, while studies on adult shad and salmon smolts utilized radio tags. Recapture rates of marked fish were low (<15%). However, radiotelemetry techniques allowed these investigators to know the status (live or dead) of a high proportion of test fish. Ruggles et al. (1990) noted differences between mortality of naturally entrained young alewife (14%) and those force-fed into the tube turbine (44%). Virtually zero acute control mortality coupled with nearly 100% recovery rates within minutes in our study provided a reliable separation of turbine-related losses from those due to handling stress, rendering interpretation and statistical analysis of the data straightforward.

Evidence is mounting that turbine-induced injury/mortality represents a discriminate stress to the exposed population. Hence, chances of long-term survival for fish that survive passage through turbines at low head projects are as good as those not exposed to turbines (Ruggles 1985). Nearly 100% survival of juvenile shad at 24 and 48 h after turbine passage in most cases of the present study supports this hypothesis. The lower 45-h survival at the mixed flow turbine in vented mode most likely resulted from low water temperature and high turbidity. Chittenden (1971, 1972) reported that young shad are difficult to maintain at low water temperatures and become lethargic. Water temperature was <11.0°C when the test at the mixed flow unit in vented mode was conducted. Many shad held at this temperature appeared more lethargic than those held at higher water temperature. Low water temperatures generally coincide with the end of the juvenile emigration period and many physiological changes, preparatory to the seaward journey, have already taken place. Emigrating young shad may be more susceptible to handling at this time (Howey 1985).

Our data indicate that juvenile American shad may not be as susceptible to injury/mortality during their emigration through turbines as might have been perceived previously and may in fact withstand multiple turbine exposures. All the juvenile shad utilized in our tests had already passed one of the turbines at Safe Harbor Project; these fish were collected for the study from the forebay of the next hydrostation downstream. No spill events occurred during the period when these fish were moving downstream, so they must have passed through turbines. The condition of the recovered shad indicated that they could have been retagged and released again through turbines. Although not part of the present study the ability to recapture live fish may offer opportunities to evaluate the cumulative effects of multiple turbine passage or the physiological and behavioral responses of fishes.

The superiority of complete recapture of tagged fish in release–recapture survival experiments has some significant practical implications. An adequate sample size can be established, correct statistical models applied, and fewer assumptions made. Experience indicates that the importance of appropriate sample size, power of the test, statistical model, and assumptions for quantifying effects on fishes is frequently underestimated (Burnham et al. 1987; Peterman 1990). In the present case, results of a small pilot study provided information on the expected recapture rates and control mortality to calculate a statistically valid sample size to detect a specified magnitude of difference with a given level of significance and power. The resulting small number of fish utilized in our study is in contrast with the need for marking large numbers of fish (several thousands or even millions to ensure a high number of recaptures for valid statistical analyses) in a conventional mark–recapture (i.e. staining, fin clipping, etc.) study using elaborate recapture devices and including many assumptions. The efforts required to collect and recover a large number of specimens substantially increase complexity and cost of a turbine passage survival study. Scarcity of specimens in rivers targeted for fish restoration can virtually eliminate the possibility of conducting a statistically reliable mark–recapture experiment. In the Susquehanna River, the only sources of young American shad are hatchery releases of 18-d-old fry and a small number of fingerlings. Natural reproduction is limited to the progeny of adults transported upstream by a trap and transport program at Conowingo Dam. Historically, adequate numbers of young shad have not been available in the Susquehanna River for conventional mark–recapture turbine passage survival studies.

Unreliable estimates of fish losses or the preconceived notion that turbine-related mortality is nearly 100% have hampered assessments of true effects of hydroelectric turbines on alosids in the northeastern United States and southeastern Canada. If the turbine-related losses are overestimated or perceived to be high, there may be demand for alternative routes (diversion devices, spills, screens, etc.) for fish moving downstream where none may be needed for successful propagation of populations. It is logical to expect that any recommended mitigative measure should achieve a level of protection significantly higher than that afforded by turbines. However, Ruggles et al. (1990) cited a study by Dawley et al. (1989), which reported a 14% greater mortality of chinook salmon (*Oncorhynchus tshawytscha*) fingerlings released into the fish bypass system at the Bonneville Dam Second Powerhouse, Columbia River, than fish passing through the turbines. The Bonneville Dam Fish Bypass System was considered the state-of-the-art fish protection system when constructed in the early 1980's. Apparently, these results suggest that little overall enhancement is afforded to downmigrants by the bypass system.

If the turbine-related losses are underestimated, then protection of the species may be compromised. However, without reliable quantitative data, it is impossible to make a rational decision on this important issue. Because mitigative measures are typically expensive and less than 100% effective in protecting outmigrants, it is necessary to reliably estimate turbine passage survival prior to choosing the course of action.

The new tag–recapture technique shows substantial promise in resolving the above dilemma by providing direct reliable estimates of turbine-related injury/mortality. It is hoped that this in turn will improve the quality of predictions in the assessment of actual effects of turbine passage on fish populations. The potential progress of fish restoration programs can be better gauged by fisheries managers and decision makers.

Acknowledgments

We thank Mr. Marshall Kaiser, President, Safe Harbor Water Power Corporation, and Melissa Weiland, Baltimore Gas and Electric Company, for review of the manuscript and helpful comments. The following consistently assisted in the field: Laura D'Allesandro, Joanne Fulmer, Mark Bush, Robert Haney, Douglas Royer, Julie Woodard, and Eric White. Susan Haney provided assistance with the statistical analysis of the data.

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RE: Federal Energy Regulatory Commission Project No. 4306
Mississippi Lock and Dam No. 2 Hydroelectric Project
Mississippi River, Dakota County, Minnesota
Comments on the Fish Monitoring Plan for the Hydrokinetic Energy System

Dear Mr. Montgomery:

The Minnesota Pollution Control Agency (MPCA) has reviewed the February 2009 Fish Monitoring Plan (Plan) for the Hydrokinetic Energy System at the Mississippi Lock and Dam No. 2 Hydroelectric Project and provides the comments below for your consideration.

Section 2.1 Estimating Survival/Injury
The MPCA is curious as to why the resource agencies are not included in the consultation, in the last paragraph of section C. Sample Size on page 3, if the sample size needs to be adjusted during the study.

Sample sizes are determined prior to conducting the study, and are based on having an adequate number of fish such that the resulting survival estimates will be within a pre-specified precision level. The sample size is a function of the recapture rate, expected passage survival, survival of control fish, and the desired precision level at a given probability of significance. Any adjustments made to the sample size during the study are due to differences between the assumed recapture and survival rates and actual recapture and survival rates so that the pre-specified precision level can be met.

The use of the word consultation is not in the context of the FERC process/license article jargon. We have revised the plan to use a different word to avoid confusion. The point is that Normandeau Associates' methodology permits nearly real time decisions on whether we've met the statistical objectives of the test. If Normandeau is within their budget, and needs to test more fish to meet the statistical objectives, they will do so without conferring with HGE or the agencies. If Normandeau is near the budget limit, they are obligated contractually to confer with HGE prior to exceeding the budget. These are decisions to be made on the spot to keep work moving ahead. If an MPCA representative is on site if and when such decisions need to be made, we will share the information with them.
Location in Plan: Section 2.1 C

While the Licensee references the 1990/1991 fisheries study, in section D. on page 3, for the choice of species to include in the current study, it is not clear why species from the Long-Term Resource Monitoring Plan work in Pool 4 is mentioned in the second paragraph of that section. The Licensee should either clarify the significance of the Pool 4 information or delete that paragraph.

This information was included to provide a larger context for selection of species. As cited in the EA, "many of the species documented in Pool 4 are also likely to be present in or near the project area".
Location in Plan: Section 2.1 D (no changes made)

There is a reference, in the first paragraph of section F. on page 4, to the tagging technique being identical to that used in scores of previous studies. The Licensee should give a more precise number of evaluations the technique was used in.

Attachment 1 to this plan is a list of more than 100 published papers, reports, and presentations of applications and evaluations of the HI-Z Turb'N Tag technique.
Location in Plan: Attachment 1

It is not stated in the Plan how the tag on the control fish will be triggered to allow retrieval if the tag on treatment fish is triggered by the passage through the hydrokinetic turbine array.

Tag inflation is triggered by a chemical reaction inside the balloon that is induced by injecting water into the tag. The reaction is delayed to ensure tag inflation does not occur until after the fish passes through the unit. Attachment 2 to this plan is a journal article entitled: "A reliable tag-recapture technique for estimating turbine passage survival: application to the young-of-the year American shad (*Alosa sapidissima*)," from the Canadian Journal of Fisheries and Aquatic Sciences that describes the method.
Location in Plan: Attachment 2

The Licensee should state specifically, in the last paragraph on page 5, what becomes of the fish that are destroyed following examination.

Fish will be disposed of in accordance with the fish collection permit to be issued by Minnesota Department of Natural Resources (MDNR). All live fish will be released back into the water, mortalities will be incinerated or buried.
Location in Plan: Section 2.1 G

Section 3 Schedule and Reports
While April and May might be the appropriate months for several fish species, the MPCA is concerned whether that is a suitable time frame for all of the species chosen.

The Licensee is working with MDNR, local fishermen and fish culturists who will provide us with those species at the time of the study (April-May). MDNR recommended we use Tim Adams for a commercial in-river supplier and Ronald Rademacher for a hatchery-reared supply.
Location in Plan: Section 2.1 E and Table 2.

The only comment about any affect on the native fisheries resource is made with regards to yellow perch and small-mouth bass. The MPCA believes that an assessment should be done for all of the surrogates considered and that information be included in Table 2. Rationale for selection of study fish species.

The intent of this table is to provide a rationale for using the fish that are either present in the Mississippi River in abundance and recreationally unimportant (buffalo species, catfish), or available by a culturist (bluegill, yellow perch, largemouth bass, bullhead). White bass are a recreationally important species, and are similar in size and body shape to largemouth bass and yellow perch, which can be provided in sufficient numbers and good condition by a MDNR approved hatchery. We will use largemouth bass or yellow perch as a surrogate species for the white bass to avoid impacting the natural resource in the Mississippi River.
Location in Plan: Section 2.1 D and Table 2.

If you have any questions regarding this matter, please feel free to contact me at (651) 757-2544.

Sincerely,

Judy Mader
Minnesota Pollution Control Agency
520 Lafayette Road N.
St. Paul, MN 55155-4194
phone: (651) 757-2544
FAX: (651) 297-8683

The National Park Service has reviewed the Draft Fish Monitoring Plan for the Hydro Green Energy Hydrokinetic System at the Hastings Hydroelectric Project at Lock and Dam No. 2 (FERC Proj. No P-4306). We find the plan inconsistent with the requirements of Article 69 and the requirements under the FERC Order Issuing License Amendment for P-4306 (December 13, 2008), which requires consultation with the National Park Service on the design of the Fish Monitoring Plan, establishment of thresholds for survival, and evaluation of existing conditions prior to development of the draft Fish Monitoring Plan. The following comments represent those of NPS staff at the Mississippi National River and Recreation Area, the NPS Rivers, Trails and Conservation Assistance Program (Hydro Division), and the regional NPS Aquatic Species (Area Fishery Biologist) and Water Resource Divisions.

We recommend the following comments be incorporated into the fish monitoring plan to ensure the plan is designed to address NPS concerns for impacts to Mississippi River fish species, the requirements of Article 69 and Order Issuing License Amendment for FERC Project P-4306.

Section 2.1 A (page 2) - Evaluation Objectives and Approach - The estimate of survival/injury of fish through the hydrokinetic unit should identify the overall impact to fish and related habitat and resources in Pool 2, including impacts to the host species of all mussels (Gizzard shad, Catfish, and Freshwater drum), predators, diving birds, and the impact of fish survival/injury to the river ecosystem.

- The balloon tag study will provide an estimate of survival for a selection of resident fish species as they pass through the HKTA. The fish species used in this study will serve as representatives (both in size and swimming behavior) for many other species found in Pool 2.
- Two potential species selected for this study are host species of the Higgins' eye pearlymussel (e.g., yellow perch and largemouth bass).
- Survival results from the balloon tag study will be used in combination with the desktop entrainment analysis to provide an overall impact analysis of the HKTA to fish species, with a general discussion on potential ecosystem level effects.
- The effects of the HKTA on habitat will not be assessed. The EA found no adverse effects to essential fish habitat (EA, page 14) and that installation of the hydrokinetic turbines would not affect aquatic habitat (EA, page 42).

Section 2.1 C (page 3) - The Long Term Resource Monitoring Program (LTRMP) is not appropriate for showing annual variability of populations of select fish species. We understand the LTRMP's objective was to sample the whole river fish community using a wide variety of gear types. Some of the key fish species likely to be found in the tailwaters of Pool 2 (lake sturgeon, shovelnose sturgeon, paddlefish, etc.) are rarely sampled . . . . and the data is not a good indicator of annual abundance and variability for many species. Fish species in Pool 2 would be very different than Pool 4. We request that variability of fish species be determined based on data available for Pool 2 or that, if unavailable, data for Pool 2 collected.

- FERC found the available data to be sufficient to conduct a desktop analysis of entrainment potential based on population variability. We will do a thorough search for relevant information. Any other data that we find (e.g., MDNR 2008 fish survey in Pool 3) or are brought to our attention, if reasonably available, will be used to better characterize the fishery and entrainment potential. Section 2.3 has been revised to include any additional available and pertinent data.
  Location in Plan: Section 2.3.

Section 2.1 D (page 4) - We strongly disagree that the intent of the FERC EA will be met by studying surrogate fish species similar in size to resident species. In order to adequately determine the impact to fish species present in Pool 2 and in the tailrace of the lock and dam, the overall impact to fish habitat, predation, and the river's ecosystem, it is important, and our preference, to use and acquire resident species from the Mississippi River in the vicinity of the Hastings project or resident species from a reliable, disease-free, commercial source.

- As indicated on page 8 of the study plan, and as approved by the current MDNR permit (number 15405) the species selected for this study are resident species from the Mississippi River in the vicinity of the Hastings project. The larger species (buffalo and catfish) will be collected directly from the Mississippi River in the vicinity of the project area. The smaller species (yellow perch/largemouth bass and bullhead) will be obtained from a reliable, disease-free commercial source on the MDNR approved list of hatchery suppliers.
  Location in Plan: Section 2.1 D and 2.1 E

Section 2.1 F (Page 4) - Tagging and Release of Fish - The study needs to identify the rate of release for test fish and include a fish density analysis (i.e. schooling) that identifies impacts to survival.

- Approximately 10 small fish will be released individually and in succession directly upstream of the turbine and then recaptured just downstream. Approximately five large fish will be released and recaptured in a similar manner. The study will be conducted to evaluate individual survival through the HKTA and will not address schooling behavior.
  Location in Plan: 2.1 F

2.3 (page 7) Desktop Analysis - Please indicate how entrainment estimates will determine if the HTKA's will be a behavioral deterrent and how it will be determined if fish go around or under the hydrokinetic units.

- The study plan stated qualitatively that "It is likely that the Hydro Green Energy units in and of themselves will be a behavioral deterrent…". The entrainment estimates will not determine the behavioral deterrent characteristics of the HKTA. The statement that the HKTA will likely be a behavioral deterrent is simply intuition. If a large (or small) piece of moving equipment is placed near fish, or fish approach such a piece of moving equipment, we believe the reaction will be more a flight response rather than an attraction. This is the basis for the statement. Section 2.3 has been revised accordingly.

Location in Plan: Section 2.3

- The NPS should also be aware that Verdant Power has recently discussed in public that fish are avoiding their hydrokinetic turbines in the East River. Hydro Green Energy is encouraged by Verdant's work on this important subject and has begun to review recent filings at the Commission by Verdant regarding fish issues. We encourage all parties to do the same.

A methodology for continually observing fish behavior in the vicinity of the HKTA's needs to be part of the study. Constant fish entrainment monitoring could be achieved by capturing fish directly at the downstream end of the turbine in addition to the one-time balloon tag recapture technique and is less expensive than multiple balloon tag monitoring efforts. Direct capture of fish would also help validate the desktop analysis effort. Hydro-acoustic monitoring, which assesses the interaction between aquatic species and hydropower technologies, should be considered to monitor fish behavior.

- Entrainment may, or may not be an important aspect of the HKTA's impact on the fisheries. We believe, based on scores of entrainment and survival studies around the country (see attached reference list), that the survival/injury aspect is most important to evaluate initially. If turbine passage results in a significant proportion of fish being killed or seriously injured, then the proportion of the population entrained, or in some cases (e.g., with endangered species) the number of fish entrained becomes very important. If survival is high and injury low, then entrainment is less of a concern, and maybe not a concern at all. Given the specifications of the HKTA, and based on our experience with turbines of a wide range of types, sizes, and speeds, as well as data starting to emerge on other hydrokinetic devices, we believe that overall survival through the HKTA will be high, which is why the approach focuses on survival/injury.
- Hydro Green Energy has met with a large and diverse number of stakeholders throughout the country over the past three years to discuss hydrokinetic power technologies. There is a great interest in its specific technology and approach to generating hydrokinetic power. In its discussions, without question, especially within the environmental community, the key issue raised to Hydro Green when discussing potential impacts is fish mortality. Hydro Green Energy desires to answer these questions as soon as possible.

As FERC indicated in the project's Application for Amendment of License (April 2008), "It is the Applicant's belief that the design and operation of the turbines will have minimal effect on any aquatic resources that may pass downstream through the powerhouse." (Exhibit E, Pg E-4) FERC was relying on the City of Hastings' discussion of slow turbine rotation (21 rpm); three-bladed design; lack of intake structures, gates, vanes, tubes, etc.; and behavioral deterrent by fish species. Research in the field or in the lab needs to be conducted as part of the fish entrainment and mortality studies to support this conclusion. "If turbine survival studies find mortality rates are substantially higher than expected, FERC recommends analysis be expanded to include an assessment of potential long-term population-level consequences for important species and . . . . mitigation occur for higher than expected mortality". Acceptable mortality rates need to be determined by agency consensus, which may vary by species. FERC acknowledged thresholds for survival need to be developed in order to determine when turbine operations should be modified or shut down to protect resources.

- The effect on fish that pass through the HKTA will be assessed through the balloon tag study, and these data will be combined with a desktop entrainment analysis to estimate overall project effects. These data will either support or negate the conclusion referenced above.
- The effect of the HKTA on birds will be monitored through the activities associated with the Bird Monitoring Plan. These data will either support or negate the conclusion referenced above.
- Article 65 requires a Fish Entrainment and Survival Plan that includes a provision to prepare a final report discussing any adverse impacts to fisheries resources and proposed changes to project operation to minimize those impacts. The final report will be developed in consultation with the agencies. Thresholds for survival do not need to be developed prior to the study and acceptable mortality rates and thresholds for survival will be discussed at the completion of the study for inclusion of proposed project changes in the final report.
  Location in Plan: Section 3.0

It should not be assumed that entrainment rates can be estimated from existing data. The results of entrainment and survival studies referenced in the EA, and required under Article 65, were conducted at other projects and hypothesize that the new hydrokinetic turbine impacts to the local fish community would be minimal. The 1991 Fish Entrainment Monitoring Study conducted by Barnes and Williams Environmental for the existing hydropower facility, identified 8 species with entrainment numbers well over 1000, including Freshwater Drum, the host fish for federally endangered Higgins eye pearly mussel. This study, and its assumptions, if valid and accurate, is not necessarily an indication of the entrainment that will occur with the hydrokinetic turbine units. As previously indicated in our EA comments (November 2008), entrainment studies should be conducted several times to capture differences due to season, fish movement, species presence, etc. Additionally, fish monitoring proposed in the Fish Monitoring Plan submitted by Normandeau and Associates (project No. 21104.001) should occur more than one time, to account for differences in flow or turbidity that may occur at different times of year. At a minimum, fisheries monitoring should occur at a low and a high flow period. The entrainment and survival studies need to evaluate project effects on the aquatic community in the project location and provide an adequate level of baseline data regarding fish entrainment and aquatic diversity. The entrainment study needs to be conducted for all species likely to be entrained in Pool 2, not estimated from existing data or surrogate species or from variability data from the Long Term Resource Monitoring Plan (LTRMP) for Pool 4.

- The FERC order states (page 10) "As analyzed in the EA, sufficient data is available to develop estimates of possible fish entrainment". FERC directed that a desktop analysis of entrainment be conducted using the existing baseline data.
- Survival results from the balloon tag study will be used with the available data to characterize entrainment potential and associated impacts, which can be developed separately for "low and high flow" entrainment periods.
  Location in Plan: Section 2.3

As FERC indicated in the EA, the thresholds for survival that will determine if additional studies need to be conducted were to be developed prior to study initiation in order to determine when turbine operations should be modified or shut down to protect fisheries resources. In addition, if the turbine survival study finds that mortality rates are substantially higher than expected, FERC recommended the City expand its analysis to include an assessment of potential long-term population-level consequences for important fish species. The City of Hastings will need to consult with the National Park Service and other agencies to determine if this expanded analysis is needed and what mitigation will occur for higher than expected mortality. "Acceptable" mortality rates need to be determined by agency consensus, which may vary by species. Cumulative, long-term impacts on local fish populations should also be evaluated.

- Article 65 requires a Fish Entrainment and Survival Plan that includes a provision to prepare a final report discussing any adverse impacts to fisheries resources and proposed changes to project operation to minimize those impacts. The report will be developed in consultation with the agencies. Thresholds for survival do not need to be developed prior to the study and acceptable mortality rates and thresholds for survival will be discussed at the completion of the study for inclusion of proposed project changes in the final report.
- The FERC EA stated "…we conclude that the Proposed Action could contribute to cumulative effects on fish populations in the upper Mississippi River through very small increases in entrainment, if any occur. However, the extent of entrainment is not known at this time, and cannot be predicted until the results of entrainment studies." Cumulative long-term impacts will be addressed after the studies have been conducted and the report prepared and reviewed by the agencies.

The HI-Z Turb' N Tag-recapture technique for estimating turbine survival and thresholds for mortality may or may not determine if the level of sampling effort is adequate (i.e. sample size, species that will be tested). The technology appears to have potential for minimizing potential impacts to fish, but thorough monitoring should occur for a period of at least a year to incorporate seasonal changes in flow, turbidity. and fish behavior. The study design appears labor intensive for a one time effort that may not provide adequate information. There should be multiple monitoring efforts. We recommend sampling fish several times with some modification to the actual turbine. For example, there are actually fish capturing devices (usually called a rotary screw trap) used in river systems that are similar in shape and design to the Hydrokinetics turbine. Fish pass through a slow moving turbine and are funneled into a holding tank at the downstream end of the turbine for enumeration. There's debate over how effective they are for population estimates, but they definitely capture fish. Though these fish capturing devices are used near the surface, it would be appropriate for Hydro Green Energy to investigate possible modification of the Hydrokinetics turbine to include a submerged live tank that captures fish entrained in the turbine. A modification that incorporates a live tank at the downstream end of a turbine would allow for constant monitoring of fish entrainment and level of injury at almost any time, and may require much less effort than multiple mark and recapture exercises – although monitoring a control population would still be required so that fish condition prior to entrainment would be known. The live tank can be constructed so that water flow through is similar to inflow at the upstream end of the turbine. However, if this would still compromise function of the turbine, it could be adapted so that the live tank can be easily moved or removed and put in place only when fish movement investigations are required. A live tank could be designed so that it can be lowered into place from the platform and raised to collect fish. This approach is worth investigating for the Hastings' LD 2 facility and for future installations on the Mississippi River. A photo and brief description of the rotary trap used by the USFWS in the Sacramento River is attached for reference.

- The balloon tag study will be conducted in the spring when flows are expected to be high and the conventional turbines may be in full generation mode. This will likely provide a "worst case scenario" for survival.
  Location in Plan: Section 2.3

If is determined that the HI-Z Turb' N Tag technique is not effective or if thresholds for mortality are exceeded, consultation should occur with the National Park Service to determine what study adjustments or mitigation are necessary. A full flow tailrace netting study may need to be conducted to assess the overall effect on the fish community in Pool 2. Entrainment and mortality rates for all large river species (large-mouth bass, freshwater drum, sauger, small-mouth bass, etc.) that serve as host species for threatened or endangered mussel species (e.g., monkeyface, washboard, Higgins eye, etc.) should be included in the study. This also means the behavioral effects of the HKTA units to such host fish species should be studied.

- Article 65 requires a Fish Entrainment and Survival Plan that includes a provision to prepare a final report discussing any adverse impacts to fisheries resources and proposed changes to project operation to minimize those impacts. The final report will be developed in consultation with the agencies. Thresholds for survival do not need to be developed prior to the study and acceptable mortality rates and thresholds for survival will be discussed at the completion of the study for inclusion of proposed project changes in the final report.
- The desktop entrainment analysis will include all species referenced in the entrainment studies. Survival data for these species will be based upon survival data for their "representative" used in the balloon tag study. For example, freshwater drum's representative will be buffalo.

- Two of the potential study fish (yellow perch and largemouth bass) are host fish for the Higgins' eye pearlymussel.

The determination of an estimated 110,000 fish that could be entrained indicates a potential increase in prey availability in the tailrace area for gulls, terns, and bald eagles. The entrainment levels of the existing hydropower units may or may not be applicable. If it is determined that increased foraging does result in impacts to these and other species, mitigation should occur.

- Foraging behavior of birds in the tailrace will be evaluated through the monitoring activities associated with the Bird Monitoring Plan.

Thank you for the opportunity to submit comments on the Draft Fish Monitoring Plan. Please do not hesitate to call me if you have any questions or need to discuss these comments further.

Sincerely,

Susan Overson

Minnesota Department of Natural Resources

500 Lafayette Road

St. Paul, Minnesota 55155-4025

March 20, 2009 **[BY ELECTRONIC MAIL]**

Ms. Heidi Wahto, Regulatory Specialist
Hatch Acres/Hatch Energy
6 Nickerson Street, Suite 101
Seattle, WA 98109

Subject: City of Hastings and Hydro Green Energy, LLC, Hydrokinetic System at Hastings Mississippi River Lock and Dam No. 2 Hydroelectric Project (P-4306) Minnesota Department of Natural Resources Comments on Draft Fish Monitoring Plan

Dear Ms. Wahto:

The Minnesota Department of Natural Resources (MDNR) has reviewed the February, 2009 Draft Fish Monitoring Plan or Draft Fish Entrainment and Survival Monitoring Plan for the Hydro Green Energy and City of Hastings Lock and Dam No. 2 Hydroelectric Project (P-4306). Article 65 of the license issued on December 13, 2008 by the Federal Energy Regulatory Commission (FERC or Commission) requires the preparation of a Fish Entrainment and Survival Monitoring Plan and the license article identifies the required components of such a Plan.

The MDNR has a number of items of concern regarding this Draft Fish Monitoring Plan (i.e., also referred to throughout these comments as Draft Plan). For your information and assistance, these comments include a series of important but general as well as procedural comments followed by more specific comments and recommendations on the proposed Draft Plan.

- The MDNR is concerned about the absence of consultation with the resource agencies, in particular the MDNR, during the development of this Draft Plan. FERC License Article 69 clearly and specifically requires that this Draft Plan be developed <u>in</u> consultation with the MDNR and other resource agencies (emphasis added). However, consultation with the MDNR did not occur until the MDNR received the February, 2009 Draft Plan for review and comment. Appropriate consultation should have occurred during and throughout the preparation of the Draft Plan and should not have been limited to sending the Draft Plan to the MDNR and to other resource agencies for review and comment.

  Consultation in the development of this plan has continued from 2007 through the present. Consultation over this plan was first initiated in July 2007 in a conference call, at which time the Licensee's consultant, Normandeau Associates, suggested circulating a draft plan for initial review. That first draft was distributed to all involved parties on 18 July 2007. Initial comments were received and incorporated into a subsequent revision of the draft plan which was included in the Licensee's Draft Application for Amendment of

License in October 2007. Comments on that draft Application were incorporated into the final Application for Amendment of License in April 2008. At the FERC contractor's site visit on 10 June, 2008, it was specifically requested that agencies provide substantive comments regarding the fish plan in their responses to the Licensee's Application. The MDNR did not submit comments to either the Licensee's Application or the included draft Fish Evaluation Plan. In addition, License Article 65 again required agency consultation with a minimum 30 day comment period. The Licensee has provided repeated and ample opportunities for consultation and input and thus MDNR's comment does not have merit.

- According to FERC License Article 69, the essence of the license article is the development of a Fish Entrainment and Survival Monitoring plan or a Fish Monitoring Plan. Development of such a plan should not be limited to a "study plan" (which might also be interpreted as a plan for study) (i.e., headings on Title Page ii and on each page of the Draft Plan) but should be the Draft Plan for Fish Monitoring being proposed by the licensee.

  The wording has been revised to be consistent with Draft Fish Entrainment and Survival Monitoring Plan.
  Location in Plan: Title pages and header.

- Part of Section 1.0, Introduction, is confusing and should be clarified. The last sentence of the first paragraph on Page 1 refers to the "Commission granted the application on December 13, 2008." The MDNR's understanding is the FERC did not grant the application in December, 2008, but actually issued the Order for the License Amendment on that date. FERC acceptance of the license amendment application occurred well before this date when the licensee submitted its amendment application to the FERC and when the FERC accepted the application for filing. This sentence would be more clear if revised to read, "… Commission issued an order amending the license on December 13, 2008 …."

  The wording has been revised.
  Location in Plan: Section 1.

<u>MDNR general comments and background regarding proposed "study plan" or approach</u>

The MDNR has consistently responded to previous descriptions, approaches for study, or outlines of this Plan, both verbally and in writing, and emphasized that this approach is incomplete and flawed. The Licensee's approach essentially contends that entrainment (i.e., the number and species of fish being pulled through the turbines) is not an important aspect of a hydropower plant's impact on the environment. Rather, the Licensee's approach appears to be that only fish survival is the important aspect, and that if survival is above some value (e.g., 90% as an example), no discernible impact on the fishery of the Mississippi River can be expected. Unfortunately, this approach or view is based on a lack of knowledge, and not on science (i.e., particularly when referring to the Mississippi River system). In a system as unique, complex, and important as the Mississippi River, this limited approach is not an acceptable approach to the agencies responsible for protecting and managing this system for present and future citizens.

MDNR has mischaracterized the approach. Entrainment may or may not be an important aspect of the HKTA's impact on the fisheries. We believe, based on scores of entrainment and survival studies around the country (see reference list at Attachment 1), that the survival/injury aspect is most important to evaluate initially. If turbine passage results in a significant proportion of fish being killed or seriously injured, then the proportion of the population entrained, or in some cases (e.g., with endangered species) the number of fish entrained becomes very important. If survival is high and injury low, then entrainment is less of a concern, and maybe not a concern at all. Given the specifications of the HKTA, and based on our experience with turbines of a wide range of types, sizes, and speeds, as well as emerging data on other hydrokinetic devices, we believe that overall survival through the HKTA will be high. That is why the approach focuses on survival/injury.

Hydro Green Energy has met with a large and diverse number of stakeholders throughout the country over the past three years to discuss hydrokinetic power technologies. There is a great interest in its specific technology and approach to generating hydrokinetic power. In its discussions, without question, especially within the environmental community, the key issue raised to Hydro Green when discussing potential impacts is fish mortality. Hydro Green Energy desires to answer these questions as soon as possible.

Entrainment potential will be characterized based on existing information such data from the entrainment study conducted by Barnes & Williams at the conventional hydro powerhouse, any relevant information reasonably available from the MDNR on species relative abundance and sizes in the vicinity of Lock and Dam No. 2, current velocities in the tailrace, etc. The survival/injury information along with the entrainment characterization will be used to estimate the impact of entrainment at the HKTA.
Location in Plan: Section 2.3.

Referring to the Draft Plan as a Draft Fish Entrainment and Survival Plan is itself not accurate. Entrainment through these hydrokinetic turbine arrays has not been studied or evaluated and is as we know unstudied. The approach of this proposed 'study plan' is to (1) remove the uncertainty of the natural Mississippi River system from the equation; (2) conduct an on-site release and capture study using balloon and radio-tagged hatchery fish; (3) and then bring the results back to the laboratory where one can "re-introduce" the science collected from other studies which were conducted for other reasons, work through the data or numbers, and then "determine" the overall effects of the project on the Mississippi River's fisheries resources. The MDNR cannot agree to this approach, given the potential for expansion of this type of project, and given a river of this size and importance to the region, the State of Minnesota, and to the nation. The MDNR has described and outlined in previous comments, a study method preferable to this proposed approach.

The stated intent and design of this Fish Entrainment and Survival Monitoring Plan is to 1) estimate the survival and injury rates of fish passing through the Hydro Green Energy hydrokinetic unit using the HI-Z Turb'N Tag (balloon tag) method, 2) estimate predation, and 3) provide a characterization of the entrainment potential through a desktop entrainment analysis upon completion of the balloon tag test. The results of the entrainment evaluation will be part of the basis for a general discussion on potential ecosystem-level effects in the report.
Location in Plan: Section 2.3.

Turbines do kill fish. The MDNR experience and expertise is that the numbers and species of entrained fish are highly variable, in space (from one spot in the river to the next) and over time. Correlations among entrainment and mortality rates related to biological conditions (species, size, and class), environmental conditions (temperature and flow levels), and plant design and operational conditions (turbine type and gate settings) have not been established. The Hydro Green Energy design configuration represents a new turbine array and technology. In addition, the exact implications of turbine-caused fish mortalities to the fish populations and the ecology of rivers are both unknown and contested or disputed**.** The MDNR has found the underlying considerations regarding turbines, entrainment, and mortality to be often distinguished into two areas:

- Hydropower proponents or proposers may agree that turbines do kill fish, but contend that: (1) a relatively small amount is actually killed; (2) those that are killed are not important or desirable or valuable or ecologically meaningful; and (3) even if fish are killed, their death is compensated for by other mechanisms such that it actually helps the remaining fish in the system.

- The resource agencies as well as those with concerns regarding hydropower effects and impacts on natural resources, contend that: (1) the single estimate demonstrates only part of the story; (2) variability (temporally and spatially) is important and the numbers are and can be substantial; and (3) the fish killed are an integral part of the system, and compensatory mechanisms are sometimes suggested for convenience. For resource agencies, it is a matter of risk; can our river systems, already some of the most ecologically imperiled systems, sustain additional drains on their resources? There is general consensus that risk (i.e., the probability of something undesirable happening), however it is defined, arises from uncertainty. Uncertainty can be defined in this context as 'the incompleteness of knowledge about the state or processes of nature.' Thus, it follows that it is a lack of knowledge that causes risk.

  Some turbines may kill a significant number of fish, but it is incorrect to say that all do, which is implied in the comments above. That is an oversimplification of how a wide variety of hydropower turbines interact with fish species. The low rotational speed, few blades, and large diameter of this unit make it unlike any other turbine in the world or turbines that MDNR may or may not have come to know in the past. We also reject the definition of risk proposed by MDNR. After this study is completed, we will have information to assess the risk of entrainment.

  When faced with this reality, the resource agencies often resort to the basics and suggest that killing fish through entrainment is a taking of a public resource from a public system. State laws or rules often address compensation for these types of 'takings.'

<u>MDNR specific responses, comments, and recommendations to provisions in the Draft Plan</u>

As part of the MDNR's review of the Draft Plan, the MDNR referred specifically to the provisions in FERC License Article 65, regarding this Draft Plan. FERC License Article 65 requires:

- The plan is to include provisions for (1) estimating survival/injury for several species, (2) having a method for estimating predation, and using (3) a desktop analysis of possible entrainment rates based on population variability, using data collected in the 1990-1991 entrainment study (i.e., the study that was never finalized and that the MDNR did not concur with regarding conclusions or findings), data in the Long-Term Resource Monitoring Program database, and the results of the current survival study.

  We will do a thorough search for relevant information. Any other data that we find (e.g., MDNR 2008 fish survey in Pool 3) or is brought to our attention, if reasonably available,

will be used to better characterize the fishery and entrainment potential.
Location in Plan: Section 2.3.

- The ultimate final report or plan is to include a discussion of the overall effects of the project on the fisheries resources at the Mississippi River Lock and Dam No. 2.

- If there are any adverse impacts to fisheries resources, the report or plan shall include proposed changes to project operation in order to minimize those impacts.

Section 2.1.A., Estimating Survival/Injury, Evaluation Objectives and Approach

This section of the Draft Plan states that "[t]he objective of estimating the survival/injury of fish passing through the hydrokinetic unit is to reliably estimate the 'fish friendliness' of the Hydro Green Energy hydrokinetic unit. To meet this objective, tagged fish will be inducted through the hydrokinetic unit (treatment group) and their survival and injury rates will be estimated relative to a control group that is released to the tailrace immediately downstream of the hydrokinetic units." (Emphasis added.)

As stated in the above general and background comments, impingement and entrainment rates are known to vary. The MDNR's experience is these variations occur: (1) during different hours of the day, (2) seasonally, (3) intra-annually, (4) from river to river, (5) from site to site on the same river, (5) from turbine unit to turbine unit at the same site, and (6) from one species to the next. Relationships between physical characteristics of the hydroelectric projects and fish entrainment has been examined for: turbine type(s), number of units, rated head, draft tube pressure, flow, flow acceleration (increase in flow), runner diameter, runner speeds, number of blades, inlet angle, gate opening, turbine operating efficiency, tailwater elevation, plant hydraulic capacity, reservoir area, reservoir storage, reservoir volume, reservoir flushing rate, trash rack spacing, and average seasonal water temperatures (Bell 1981, Coutant and Whitney 2001). The following biological factors are also thought to be important: size of fish, species (e.g., for general behavior related to water column position), age class (e.g., swimming ability), body orientation (relative to bulk flow in the forebay area, relative to surface, and relative to flow entering the turbines), distribution in intakes, fish condition, and reaction time. There is variability among individual fish that may be important as well (Cada et al. 1997).

The MDNR's recommendation is that "reliably estimating the 'fish friendliness' of the" hydrokinetic barge in the Mississippi River can only begin to be approximated by a study which involves more than a one-time release and capture exercise with four species of fish.

The MDNR correctly characterizes the variability related to entrainment (impingement is not an issue because there are no trash racks). In fact, one of the reasons that FERC moved away from requiring full discharge netting studies over the past 10-15 years is that the variability in those studies was so great that the value of the typically expensive studies was exceptionally low. The proposed methodology contains not nearly as much variability with respect to passage survival and injury. We believe we have taken a reasonable approach to address the factors that result in acceptable variability in survival and injury estimation.

- Multiple species and sizes of fish.
- Approximately 10 small fish will be released individually and in succession directly upstream of the turbine and then recaptured just downstream. Approximately five large fish will be released

and recaptured in a similar manner. The study will be conducted to evaluate individual survival through the HKTA.

Location in Plan: 2.1 F.

- Survival results from the balloon tag study will be used with the available data to characterize entrainment potential and associated impacts, which can be developed separately for "low and high flow" entrainment periods.

  Location in Plan: Section 2.3.
- The balloon tag study will be conducted in the spring when flows are expected to be high and the conventional turbines may be in full generation mode. This will likely provide a "worst case scenario" for survival.

  Location in Plan: Section 2.3.

Section 2.1.B., Estimating Survival/Injury, Study Design

This section of the Draft Plan states that "[t]he HI-Z Turb N' Tag methodology will be used to mark, recapture, and evaluate the direct effects of passage of test fish through the hydrokinetic unit .... "Fish will be tagged with one or more HI-Z tags (also known as balloon tags, see Figure 1). HI-Z tags are attached in the deflated condition. After passage through the hydrokinetic unit, the HI-Z tags inflate and buoy the fish to the surface where they are recaptured by a boat crew. In addition to the balloon tag(s), a miniature radio tag also is attached to the fish to aid in the recapture .... Finally, uniquely numbered visual implant tags (VI tags) or Floy tags are inserted into the fish before the fish is released. This allows for the identification of individual fish or treatment/control groups. Upon recapture of the fish in the tailrace, the biologist quickly removes the balloon and radio tags. Fish are transported to onshore holding tanks for latent mortality evaluation (48 hrs)."

Primary suppositions of this release and capture study are that:

- The fish selected for release and capture represent the species in the river;
- The fish that are tagged with balloons and radio transmitters behave as fish that do not have them; and
- That fish released at 'the point of no-return' enter the turbine as would fish naturally arriving to the area enter the turbines.

The MDNR recommends that the licensee outline its plans for representation for all the species in the river, and document these decisions and the rationale. That is, which fish in the release and capture study represent which fish actually found in the Mississippi River when the numbers are expanded to the 150+ species? Do bullheads represent gar? Who and what size fish represents flathead catfish, channel catfish, or bullheads? Who is representing paddlefish, or lake sturgeon? Who is representing Gizzard shad?

Based on extensive data, survival and injury of fish passing through a turbine appears to be much more a function of fish size than of species. However we have selected four species in order to include species (and swimming characteristics (e.g., swimming speed, form of locomotion)) as a variable. The species originally chosen for inclusion in this study will represent two general size classes of fish: small (150-200mm) and large (200-610mm). They will also represent fishes having different swimming characteristics (bottom-oriented slow swimmers such as catfish, and pelagic oriented fast swimmers such as buffalo, and largemouth bass or yellow perch). See below for a more detailed description on our process for selecting species for the study. Currently, we do not have a test species that will directly represent extra-large adult paddlefish and lake sturgeon. If the results for the large test species (e.g.,

large catfish and large buffalo species) indicate a survival/injury issue, additional methods for evaluating these extra-large species will be considered.
Location in Plan: Section 2.1 B.

The Licensee is currently working with MDNR, local fisherman and fish culturists to identify these fish species that are either present in the Mississippi River in abundance and recreationally unimportant (buffalo species, catfish), or available by a culturist (bluegill, yellow perch, largemouth bass, bullhead).
Location in Plan: Table 2, which summarizes the species selected as recommended in the FERC's EA, the suggested representative or surrogate species, and the supporting rationale.

The MDNR would also benefit from video showing fish with no tags and fish balloon and radio-tags, as a comparison of their differences or similarities in behavior.

For a behavioral study, it is very important to understand, and ideally, quantify the effects, or lack thereof, of tags. However, this is not a behavioral study. In fact, the whole premise of the balloon tag is to affect behavior by buoying fish to the surface so they can be recaptured promptly.

Attachment 1 to this plan is a list of more than 100 published papers, reports, and presentations of applications and evaluations of the HI-Z Turb'N Tag technique.
Location in Plan: Attachment 1.

The MDNR requests documentation regarding the representiveness of the release such as: do fish living the river enter the turbine area the same way? What is the influence of entering from deeper in the water column or off the bottom? How are certain type or species of fish (e.g., larger predators that inhabit the outflows of Lock and Dam No. 2) being represented by this release study?

Both large and small test fish will be inducted into the turbine at a location close to the perimeter of the blade assembly, where the blades are spinning the fastest, providing the highest probability of blade strike. This location will therefore represent the worst case scenario for all potential entrances into the turbine.

Section 2.1.C., Estimating Survival/Injury, Sample Size

This section of the Draft Plan states that "[b]ased on these assumptions, the estimated total number of fish is approximately 650 to meet the statistical precision desired by Hydro Green Energy. This includes approximately 160 fish of each species/size class used in the analysis." This section further states that "<u>[c]onsultation with Hydro Green Energy and professional judgment will be used to adjust sample size</u>, if necessary, during the study. One advantage of the HI-Z tag technology is that near real-time preliminary results are readily available, thus the sample size can be adjusted during the study to meet the statistical precision goals or <u>budget constraints</u>." (Emphasis added.)

The FERC license article specifically identifies that the Plan is to be developed in consultation with and after consultation with the resource agencies. The Draft Plan appears to limit consultation to consultation with its client. The MDNR is concerned with the premise that sample size can be adjusted to meet statistical precision or budget constraints. Altering or adjusting the sample size to achieve budgetary constraints should not be the sole purpose or rationale for the adjustment.

The use of the word consultation is not in the context of the FERC process/license article jargon. We have revised the plan to use a different word to avoid confusion. The point is that Normandeau Associates' methodology permits nearly real time decisions on whether we've met the statistical objectives of the test. If Normandeau is within their budget, and needs to test more fish to meet the

statistical objectives, they will do so without conferring with HGE or the agencies. If Normandeau is near the budget limit, they are obligated contractually to confer with HGE prior to exceeding the budget. These are decisions to be made on the spot to keep work moving ahead. If MDNR is on site if and when such decisions need to be made, we will be happy to share the information with them. While MDNR may not need to consider the project budget, Normandeau Associates and HGE do.
Location in Plan: Section 2.1 C.

Section 2.1.D., Estimating Survival/Injury, Fish Species

A total of 156 species of fish have been collected and identified from the Upper Mississippi River since record keeping began late in the 19th century (Pitlo et al. 1995). Roughly 51 of these species are considered to be abundant or common in a pool within the Upper Mississippi River. Three species, gizzard shad, common carp, and emerald shiner, are considered abundant throughout the entire river. Forty species are considered occasional in abundance; fifteen species are considered to be uncommon in most parts of the river; thirteen species are found only rarely in the river; four species are considered historic; and thirty-three species previously documented are considered to be strays.

Based in part on this information, the FERC-prepared Environmental Assessment (EA) recommends that survival/injury estimates be developed for a minimum of five species. It is suggested that these five species be those that made up over 90% of the species distribution in the 1990/1991 entrainment studies conducted by Barnes-Williams at the Hastings Hydroelectric Project (BWEC 1991) for that project. The FERC-prepared EA lists these species as gizzard shad, rosyface shiner, freshwater drum, white bass, and flathead catfish. At the time, the MDNR recommended five species be selected, not for their numeric importance, but to represent the range in body forms and drift/swimming behaviors. Using this rationale, Ictalurids then, are seen as different from centrachids, and separate from shad, drum, and sturgeon.

Our selection of species considered the guidance by both the FERC EA and MDNR. Rosyface shiner is simply too small to use in this application and that is why that species is not included. The other four were selected based on a combination of the guidance given and the availability of fish from MDNR approved commercial sources.

Based on this information and recommendations, the proposed study plan proposes to float four species through the turbine with tags. These four species are bullhead, yellow perch or largemouth bass, and freshwater buffalo spp., and channel catfish.

As this release and capture study is the only on-site science being proposed, the MDNR recommends that the licensee provide additional scientific rationale for selection of these species and sizes, as well as the licensee's plans for extrapolation of the data (refer to discussion in Section 2.1.B., Estimating Survival/Injury, Study Design).

Based on extensive data, survival and injury of fish passing through a turbine appears to be much more a function of fish size than of species. However we have included four species to include species (and swimming characteristics (e.g., swimming speed, form of locomotion)) as a variable. In selecting the species to be included in this study, we began with the top five most abundant species, as they were listed in Table 4 of the FERC EA. That list included gizzard shad, rosyface shiner, freshwater drum, white bass, and flathead catfish. We then contacted MDNR research staff to obtain a list of approved commercial suppliers. Our commercial suppliers indicated that gizzard shad and freshwater drum do

not hold well, and therefore would be difficult to provide to us in good condition in the numbers required for the study. Buffalo species, a fish very similar in size and swimming characteristics to gizzard shad and freshwater drum, do hold well and would be able to be provided in good condition and in the numbers required for the study. We confirmed with MDNR research staff that using buffalo species in this study would not be of concern. Rosyface shiner is too small to use in this study. It would be possible to use bluegill as a surrogate for the rosyface shiner. White bass are a recreationally important species, and are similar in size and body shape to largemouth bass and yellow perch, which can be provided in sufficient numbers and good condition by a MDNR approved hatchery. We opted to use largemouth bass or yellow perch as a surrogate species for the white bass to avoid impacting the natural resource in the Mississippi River. Finally, we have modified Table 2 to include using large flathead catfish, if suitable test fish are available in sufficient numbers at the time of the study. If they are not available, we will use channel catfish as a surrogate. To test smaller catfish that might not be captured by the commercial fisherman's gear, we opted to use bullheads provided by a MDNR approved hatchery. We have obtained prior approval from MDNR research staff to use small bullhead, yellow perch or largemouth bass, large buffalo, and large channel catfish. Table 2 has been revised.
Location in Plan: Table 2.

Section 2.1.E., Estimating Survival/Injury, Fish Collection

This section of the Draft Plan indicates that fish will be obtained from one or more of the following sources: (1) the Mississippi river in the vicinity of the project, (2) acquired from a local hatchery, and/or (3) acquired from a commercial supplier.

Fish used in this study must come from a certified disease-free source. The MDNR's recommendation is for fish from the Mississippi River system in the vicinity of the Hastings project. The MDNR is prepared to provide you with the names of appropriate MDNR staff that can discuss or give you additional information about obtaining fish from certified disease-free source or sources.

Our initial selections of fish species to be used in the study were either going to be provided by a commercial fisherman from the Mississippi River system in the vicinity of the Hastings project (buffalo spp. and channel catfish) or from a MDNR approved certified disease-free source (yellow perch or bass and bullhead). MDNR recommended that we use Tim Adams for a commercial in-river supplier and Ronald Rademacher for a hatchery-reared supply.

Section 2.3., A Desktop Analysis of Possible Entrainment Rates

This section of the Draft Plan addresses and discusses a desktop analysis of possible entrainment rates. The MDNR has, for a number of years and on a number of hydroelectric projects throughout Minnesota not supported or concurred with the use of a desktop analysis. This section on a proposed desktop analysis states that "Hydro Green Energy will use the data collected during the 1990-1991 entrainment study (BWEC 1991) to provide entrainment estimates for the upstream conventional turbines. These entrainment estimates, as well as several more probable estimates, will be scaled down to be representative of the flow passing through the hydrokinetic turbine, and will be used along with the results of the Survival/Injury study to provide an estimate of the total number of fish killed or injured passing through the hydrokinetic turbines. The data collected during the Long Term Resource Monitoring Project will allow for this calculation to be made allowing for population variability (i.e., seasonal variability of fish presence/abundance)."

Although the MDNR is cognizant that FERC License Article 65 included the reference to data collected during the Long-Term Resource Monitoring Project and data that is part of the Long-Term Resource Monitoring database, the MDNR's supervisor of the MDNR's Long Term Resource Monitoring Program (LTRMP) at the Lake City Field Station questions the extent to whether the LTRMP fish database is appropriate for showing annual variability of populations of select fish species. The objective of the LTRMP is to sample the whole river fish community using a wide variety of gear types. Some of the key fish species likely to be found in the tailwaters of Pool 2 (i.e., lake sturgeon, shovelnose sturgeon, paddlefish, etc.) are rarely sampled. Since the MDNR and the MDNR's LTRMP does not specifically target certain species like Fish Management, the MDNR's LTRMP data is not a good indicator of annual abundance and variability for many species. In addition, since the MDNR's LTRMP has dropped certain gears and reduced annual effort over the years, the fish abundance and variability data can be very misleading. Mississippi River Pool 2 is very different than Mississippi River Pool 4, as would also be the fish populations. This is due to Lake Pepin (i.e., a large natural lake within the Mississippi River proper).

We will do a thorough search for relevant information. Any other data that we find (e.g., MDNR 2008 fish survey in Pool 3) or are brought to our attention, if reasonably available, will be used to better characterize the fishery and entrainment potential. Section 2.3 has been revised.
Location in Plan: Section 2.3

This section of the Draft Plan also states that "[a]s the Hydro Green Energy units will not occupy a full cross-section of the Hastings Project tailrace, the entrainment estimates gathered above will represent a "worst-case scenario." Fish entrained through the conventional hydro units or that are otherwise present in the tailrace upstream of the Hydro Green units may go around or under the units and thus avoid entrainment. It is likely that the Hydro Green Energy units in and of themselves will be a behavioral deterrent and thus fish will tend to go around or under the hydrokinetic units."

The Hydro Green Energy configuration (i.e., a bank of turbines deployed beneath a raft in the tailwater of a dam/hydroelectric facility) is a new engineering development. Fish entrainment and mortality on the Mississippi River through this array has never been studies or evaluated or analyzed. Suppositions as to what fish will or will not do in the tailwater of Lock and Dam #2 and in and around the unit are conjecture at this time. Proposing a Draft Plan with an unsubstantiated likelihood for a fish's reaction to the units and then suggesting conclusions based on such suppositions are neither accurate nor logical.

The Draft Plan stated qualitatively that "It is likely that the Hydro Green Energy units in and of themselves will be a behavioral deterrent…". The entrainment estimates will not determine behavioral deterrent characteristics of the HKTA. The statement that the HKTA will likely be a behavioral deterrent is simply intuition. If a large (or small) piece of moving equipment is placed near fish, or fish approach such a piece of moving equipment, we believe the reaction will be more a flight response rather than an attraction. That is the basis for the statement.

MDNR should also be aware that Verdant Power has recently discussed in public that fish are avoiding their hydrokinetic turbines in the East River. Hydro Green Energy is encouraged by Verdant's work on this important subject and has begun to review recent filings at the Commission by Verdant regarding fish issues. We encourage all parties to do the same.

Unfortunately, much of the important information on the frequency, species, sizes, and seasonal nature of entrainment is not addressed by the Draft Plan. The MDNR is concerned that results or conclusions from this type of study as being proposed, with little applicable on-site information, and a study plan which is both constrained by logistics and not focused on the particular natural system being studied, is likely to be inconclusive.

The MDNR is aware of and also directs the licensee's attention to the substantive comments submitted by the National Park Service, the U.S. Army Corps of Engineers, and potentially the U.S. Fish and Wildlife Service.

The MDNR both recommends and encourages the licensee and the licensee's agent to contact the MDNR's East Metro Fisheries staff and identify the specific dates when release and recovery of fish through the turbine system is planned or proposed. I can separately give you contact names and information regarding this MDNR staff. In addition and at the appropriate future time, the MDNR would appreciate the opportunity to observe the process, both on the current structure and downstream of the turbine array units. I can also separately provide you contact names and information regarding various MDNR staff who may wish to observe the process or be informed about it.

As previously stated, assuming no liability issues, MDNR representatives and others may observe the work. Our field schedule will be driven by several factors, and so must be provisional; however, we will provide the likely range of dates that we will be in the field, and then when definite, MDNR will be contacted with specifics. The invitation by HGE to observe does not preclude the MDNR or other observers from any and all of the U.S. Army Corps of Engineers' and City of Hastings' requirements for access to the project site. The initial invitation will be made to Charlotte Cohn.

In addition and as you know, in the MDNR's Division of Waters Public Waters Work Permit amendment letter issued in December, 2008, there is specific language regarding review and written approval of the Fisheries Entrainment Plan by others in the MDNR. We have evaluated this situation as part of the MDNR's review and comment on this Draft Plan and our view is that this Draft Plan is not the most effective time for this more formal review. It is certainly likely that the Draft Plan may change or be revised and the MDNR feels that this more formal review and approval should occur at a time closer to potential submittal to or FERC approval of the Fish Monitoring Plan required by FERC License Article 65.

In accordance with Amended DNR Permit # 1985-6098, the final Fish Entrainment and Survival Monitoring Plan will also be provided to the Director of the DNR, Division of Ecological Resources.

The MDNR may also be interested in engaging in further meetings or discussions with you and representatives of the licensee regarding compensation or mitigation plans or opportunities to limit effects on fisheries and natural resources. Please contact me if you would like to start a consultation or interative process regarding these types of plans and opportunities.

Thank you for the opportunity to review and to submit comments on the February, 2009 Draft Fish Monitoring Plan for the City of Hastings and Hydro Green Energy, LLC's hydrokinetic hydroelectric project at the Mississippi Lock and Dam No. 2 hydroelectric facility.

Please contact me at the above address, at 651-259-5072, or by e-mail to charlotte.cohn@dnr.state.mn.us if you have further questions.

Sincerely,
Charlotte W. Cohn
Environmental Planner
Division of Ecological Resources
Minnesota Department of Natural Resources

c: Judy Boudreau
Erik Wrede
Wayne Barstad
Nick Rowse, USFWS
Judy Mader, MPCA
Tom Montgomery, City of Hastings
Mark Stover, Hydro Green Energy
Ian Chisholm
Molly Shodeen
Gerald Johnson
Susan Overson, NPS/MNRRA
Nanette Bischoff, USACE

Wahto, Heidi

From: Bischoff, Nanette M MVP [nanette.m.bischoff@usace.army.mil]
Sent: Tuesday, March 24, 2009 11:42 AM
To: Wahto, Heidi
Subject: RE: FERC Amendment for P-4306: Article 65 Fish Monitoring Plan

Heidi, the St. Paul District does not have any comments on the Fish Monitoring Plan.

Nanette M. Bischoff, P.E.
Project Manager
FERC Coordinator

-----Original Message-----
From: Wahto, Heidi [mailto:hwahto@hatchenergy.com]
Sent: Tuesday, February 17, 2009 5:45 PM
To: Charlotte Cohn; Mader, Judy; Susan_Overson@nps.gov; Nick_Rowse@fws.gov; Bischoff, Nanette M MVP
Cc: Mark Stover; Jennifer Stone; Tim Brush; Thomas Montgomery
Subject: FERC Amendment for P-4306: Article 65 Fish Monitoring Plan

Good Afternoon-
The City of Hastings and Hydro Green Energy, in accordance with Article 69 of the Order Amendment License issued by the FERC on Dec 13, 2008, herein submit for your review and comment the DRAFT Fish Entrainment and Survival Monitoring Plan for the hydrokinetic array at the Lock and Dam No. 2 Hydro Project (P-4306).

As required, we are consulting with the MN Dept of Natural Resources, MN Pollution Control Agency, National Park Service, U.S. Fish and Wildlife Service, and U.S. Army Corps of Engineers to develop a final Fish Entrainment and Survival Monitoring Plan.

Please review the attached draft Fish Monitoring Plan and respond with your comments or recommendations within 30 days. Article 65 is reproduced in the attached draft Plan for your review of the FERC's requirements. Transmittal of this draft Fish Monitoring Plan initiates consultation under the requirements of Article 65.

Should you have any questions, please contact me at hwahto@hatchacres.com or (206) 352-5730, Thomas Montgomery at TMontgomery@ci.hastings.mn.us or (651) 480-6188, or Mark Stover at mark@hgenergy.com or (877) 556-6566.

Thanks everyone for your continued participation.

Sincerely,
Heidi Wahto

Heidi Wahto, M.P.A. | Regulatory Specialist Hatch Acres | Water and Wind Power
6 Nickerson Street, Suite 101 | Seattle, WA 98109 | USA T (206) 352-5730 | C (206) 755-4867 hwahto@hatchacres.com <blocked::mailto:hwahto@hatchacres.com>
| www.hatchenergy.com <blocked::http://www.hatchenergy.com/>
