Roanoke Rapids and Gaston Hydropower Project
FERC No. 2009

Implementation of Article 414

Study Plan:

# Effects of Within-Day Peaking on Fish and Benthic Macroinvertebrates

APPENDIX 4

September 18, 2006

## Introduction

Concerns were raised during the relicensing of the Roanoke Rapids/Gaston Project about the effects of within-day peaking operations on fish and benthic macroinvertebrates in the lower Roanoke River downstream of Roanoke Rapids Dam. During the course of relicensing the Project, Dominion conducted studies of fish in the Roanoke River to help assess the impacts of peaking operations (Fogarty 2001). The general conclusion from these studies was that the species richness and diversity of the Roanoke River's fish assemblage were similar to other nearby rivers not subject to peaking operations. However, studies of other southeastern rivers had documented adverse effects from hydroelectric power peaking, and indicated that similar adverse effects should be expected to occur in the lower Roanoke River, given the magnitude and frequency of flow fluctuations attributable to peaking operations. Any adverse effects were hypothesized by the relicensing participants to be most pronounced in the upper reaches of the river nearest the dam.

As a result of settlement negotiations, the Order of Settlement issued by the Federal Energy Regulatory Commission (Commission) for the Project March 4, 2005 addressed the concerns with effects of within-day peaking on fish and benthic macroinvertebrates in the lower Roanoke River (Article 414). This plan describes how studies to address these concerns will be conducted.

## Background

During the 1980s a number of studies were conducted that investigated the effects of hydropower peaking on stream organisms. As early as the mid-1980s, it was noted that fishes in productive riffle areas were often affected by variations in flow attributable to hydropower peaking (Cushman 1985). For less mobile organisms such as benthic macroinvertebrates, it was documented that extreme hydraulic forces accompanying high discharge events can displace animals from the stream bed (Lancaster and Hildrew 1993). Bain and Boltz (1989) reviewed the literature and developed a conceptual model for how regulated stream flows may affect fish habitat, and thereby the fish assemblage. Their

model predicted three generalized impacts on fishes that varied with how much the stream hydrology was changed, and the distance downstream from the dam. These were: 1) fluctuating streamflows would reduce the diversity and abundance of habitat-specialist fishes living near shore or in shallow waters, 2) fluctuating streamflows would not have a great effect on the abundance of habitat-generalist fishes living in midstream, and 3) there would be a longitudinal gradient of fish species and abundance as the effects of regulation diminish downstream.

During the late 1980s and 1990s studies were conducted in southeastern warmwater streams that investigated the model of Bain and Boltz (1989), and generally supported it (Bain and Travnichek 2000). However, with study other effects became apparent. Studies by Bowen et al. (1998) examined the importance of key habitats to both habitat specialists and generalists, the importance of within-year habitat persistence, and the importance of inter-annual variation. Freeman et al. (2001) also examined how altered flow regimes could affect the availability and persistence of fish habitats, and demonstrated an association between young-of-year (YOY) fish abundance and shallow-water habitat persistence. Orth (2000) found differences in potential spawning habitat in the form of substrates near and distant from a hydropower dam operated in peaking mode, and that YOY brown trout appeared to be displaced from areas near the dam to areas farther downstream.

Two recurring themes that have emerged from studies examining the effects of flow regulation associated with hydropower in warmwater systems are the importance of shallow-water habitats, and decreased effects of flow regulation with increased distance from dams. Shallow-water habitats are often areas that are important to YOY fishes and very productive in terms of invertebrate biomass. Shallow riffles and runs generally yield the highest levels of primary production that many invertebrates are dependent on, provide refuge from larger fish predators, and may exhibit warmer water temperatures conducive to growth. Additionally, habitat-specialist species tend to be more abundant in shallow-water habitats due to greater diversity in micro-habitats. The current study will concentrate on shallow-water habitats because of their importance, and because measurable effects of hydropower peaking have been consistently found in these areas. However, the study will also address longitudinal changes in the fish assemblage as distance from the Roanoke Rapids Dam increases. There is a major change in stream gradient and habitat between the river reach bordered by the Roanoke Rapids Dam and Weldon, and from Weldon on downstream. Therefore different sampling approaches will be employed upstream and downstream from Weldon, as described below.

## Methods

### *Fish*

Upstream of Weldon boat electrofishing will be used to sample most habitats during a peaking and a non-peaking period each year. In addition electric seine, backpack electofisher, or fixed-position grid sampling will be employed in shallow-water habitats

to collect fishes in a standardized manner (details to be developed, but approach to follow those of related studies). Hydropower peaking operations are curtailed during the period March 1 to June 15, except for up to 5 days in March. Therefore, sampling above Weldon will occur during the first two weeks of June following a prolonged period of uniform weekly flow releases, and be repeated during the last two weeks of June or the first two weeks of July when peaking will occur (given sufficient water availability). Restricting sampling to the period June – early July may help minimize effects of greatly varying water temperatures, a factor that often confounds studies of aquatic organisms.

It is recognized that physical differences between the Piedmont and Coastal Plain sections of the river upstream and downstream of Weldon make it very difficult to effectively sample shallow-water habitats downstream of Weldon. Therefore, only boat electrofishing will be employed to sample the fish assemblage downstream of Weldon, with a focus on detecting longitudinal changes in the fish assemblage from Weldon to near Oak City. Sampling will likely involve 2 electrofishing boats, will occur in the late June –early July time frame, and coincide with the peaking period sampling for fish upstream of Weldon.

The amount of effort to be devoted to sampling will be determined by the Cooperative Management Team (CMT) after reviewing results of electrofishing surveys conducted by Dominion during the 1990s (Knutzen 1997), and consulting with the consultant contracted to conduct the study. Analysis will include comparisons of species richness, species diversity, and proportion of habitat specialists in samples collected upstream of Weldon during non-peaking and peaking periods. Trends in species richness, species diversity and proportion of YOY collected near Weldon in comparison to sites farther downstream will be examined for longitudinal effects during peaking periods.

*Benthic Macroinvertebrates*

Studies of benthic macroinvertebrates to be conducted upstream of Weldon will investigate the general health of the benthic community. .

Expectations of what the benthic community in a unregulated river with similar physical characteristics to the Roanoke River upstream of Weldon and good water quality would look like will be developed based on existing literature and data analysis conducted by the Environmental Protection Agency. This "expected" community will be compared with the "existing" community, as determined by annual sampling. Benthic macroinvertebrates will be collected using protocol consistent with large river sampling procedures developed by the North Carolina Division of Water Quality (DENR 2003). Sampling will be conducted during late June or early July, and at the lowest water levels possible.
In addition, the benthic community in the Cape Fear River – near Erwin/Lillington and/or an area near the old Buckhorn dam boulder field - will be sampled and examined in comparison to the Roanoke River upstream of Weldon.. The CMT acknowledges the difficulties associated with using a reference river approach. However, a reference river comparison will be beneficial in terms of assessing how well the “expected” community

to be developed from existing literature reflects local conditions, and identifying effects of factors other than peaking (e.g., major floods or droughts) that may influence the benthic communities of both rivers over time. The possibility of using the James River, Virginia, as a reference river will also be explored. The James River fall zone is physically similar and in relatively close proximity to the fall zone of the Roanoke River upstream of Weldon. Further, the James and Roanoke watersheds are adjacent to each other, and there are only minor (10-15% of flow) peaking effects on the lower James River. A comparison of parameters calculated by the Index of Hydrologic Alteration will be made using the Roanoke River Basin Operations Model and USGS gage data as part of assessing the value of this approach.

The decreased habitat complexity and increased uniformity downstream of Weldon should lend itself to a standardized sampling approach that will enable longitudinal changes in the rivers benthic communities to be examined. Sampling stations will be established, at a minimum, near Weldon, near Oak City, and about midway in between. A reach of the Neuse River at or near Fort Barnwell or the Tar River at or near Greenville will also be sampled for reference. A standardized sampling approach will be used to characterize the benthic macroinvertebrate communities at each sampling site. Within the Roanoke River, longitudinal differences in benthic macroinvertebrate communities among sites will be examined in relation to differences in hydrologic indices, using USGS gage data. Roanoke River community attributes will be compared with those of the reference river. As with sampling upstream of Weldon, sampling will be conducted during late June – early July at the lowest water levels possible. Quantitative data will be collected using protocol consistent with procedures developed by the North Carolina Division of Water Quality (DENR 2003). During sampling, notes will be made as to habitats sampled so the relative values of different types of habitat, especially woody debris, can be addressed in later analysis or future years. Woody debris in the Roanoke River may be key habitat component that is affected by peaking operations.
The amount of effort to be devoted to sampling and appropriate statistical analyses will be determined in consultation with the contractor that will conduct the studies. The contractor will possess certification from the North Carolina Division of Water Quality (NCDWQ) in acceptable benthic macroinvertebrate sampling and sample processing techniques, have equivalent certification, or develop a quality control/quality assurance plan that meets NCDWQ approval.

For collections made both upstream and downstream of Weldon, and in any reference rivers, appropriate indices of water quality and/or community health (e.g., presence/absence, relative abundance, density, community similarity indices) will be calculated and compared following consultation with the contractor and CMT.

Synopsis of Sampling Programs

- Upstream of Weldon
  - Fish – Sampling prior to peaking (early June) and after peaking (late June – early July). Before and after peaking comparisons.

    - Benthos – Sampling after peaking. Comparisons with reference reach without peaking in Cape Fear River, James River, or literature-derived expectation.

- Downstream of Weldon
    - Fish – Sampling after peaking. Longitudinal comparisons.
    - Benthos - Sampling after peaking. Longitudinal comparisons. Possible comparison with reference reach in Neuse River, Tar River, or literature-derived expectation.

Schedule

The first year of sampling will be 2007. Results of annual sampling in 2007, 2008 and 2009 will be used to assess the effects of unmodified peaking operations at Roanoke Rapids Power Station. A report detailing findings of this baseline period will be submitted to the Commission by February 28, 2010.

Literature Cited

Bain, M.B., and J.M. Boltz. 1989. Regulated streamflow and warmwater stream fish: a general hypothesis and research agenda. U.S. Fish and Wildlife Service Biological Report 89 (18).

Bain, M.B., and V.T. Travnichek. 2000. Assessing impacts and predicting restoration benefits of flow alterations in rivers developed for hydroelectric power production. M. Leclerc, H. Capra and S. Valentine (editors), Proceedings of the 2nd International Symposium on Habitat Hydraulics, Volume B. Institut national de la recherche scientifique, Eau, Quebec.

Bowen, Z.H., M.C. Freeman, and K.D. Bovee. 1998. Evaluation of generalized habitat criteria for assessing impacts of altered flow regimes on warmwater fishes. Transactions of the American Fisheries Society 127: 455-468.

Cushman, R.M. 1985. Review of ecological effects of varying flows downstream of hydroelectric facilities. North American Journal of Fisheries Management 5 (3A): 300-339.

DENR. 2003. Standard operating procedures for benthic macroinvertebrates. North Carolina Department of Environment and Natural Resources, Raleigh, North Carolina.

Fogarty, L. 2001. Comparison of the health and status of resident fishes of the lower Roanoke, Neuse and James rivers. Dominion, Richmond, Virginia.

Freeman, M.C., Z.H. Bowen, K.D. Bovee, and E.R. Irwin. 2001. Flow and habitat effects on juvenile fish abundance in natural and altered flow regimes. Ecological Applications 11 (1): 179-190.

Lancaster, J., and A.G. Hildrew. 1993. Characterizing in-stream flow refugia. Canadian Journal of Fisheries and Aquatic Science 50:1663-1675.

Knutzen, J.. 1997. Aquatic resources of the lower Roanoke River: updated version of 1996 year-end report. Prepared for North Carolina Power by Foster Wheeler Environmental Corporation.

Orth, D.J. 2000. Influences of fluctuating releases on stream habitats for brown trout in the Smith River below Philpott Dam. Annual Report to Virginia Department of Game and Inland Fisheries, Contract No. 08220203.

Travnichek, V.H., and M.J. Maceina. 1994. Comparison of flow regulation effects on fish assemblages in shallow and deep water habitats in the Tallapoosa River, Alabama. Journal of Freshwater Ecology, 9 (3): 207-216.