APPALACHIAN POWER COMPANY

ROANOKE, VIRGINIA

SMITH MOUNTAIN HYDROELECTRIC PROJECT

FERC NO. 2210

LEESVILLE DEVELOPMENT DISCHARGE STUDY PLAN

Draft

~~February 2009~~February 2010

Prepared by:

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1.0 INTRODUCTION

The Smith Mountain Hydroelectric Project (FERC No. 2210) consists of two developments located on the headwaters of the Roanoke River in Bedford, Campbell, Franklin, and Pittsylvania counties in Virginia. The Leesville Development is the downstream of the two developments, and is a conventional hydroelectric development. The Leesville Dam has a maximum height of 94 feet above the streambed, while the powerhouse has two generating units, with a combined generating capacity of 50 MW. The reservoir surface area is 3,260 acres at an operating pool elevation of 613.0 NGVD.

2.0 BACKGROUND

As part of the Virginia Water Protection Permit issued October 31, 2008 by the Commonwealth of Virginia Department of Environmental Quality pursuant to the State Water Control Law and Section 401 of the Clean Water Act, water will be released from Leesville Dam to achieve target flows downstream at Brookneal. These target flows vary by month and consider water inputs from the contributing watershed. Further, for the period November 1st through February 29th, average hourly discharge from the dam will not be less than 375 cfs. For the period from March 1st through October 31st, the average hourly discharge will not be less than 400 cfs. Flows will be released by hourly autocycle where one unit at the Dam will be operated in a pulsed manner. If neither of the two units is available for operation, water will be discharged through the spill gates or by whatever means is available.

3.0 PURPOSE AND OBJECTIVES

In accordance with Instream Flow Condition D.3 of the 401 Certificate, the objective of this study will be to determine the relative impact of providing streamflows downstream of Leesville Dam through hourly autocycling compared to continuous releases. More specifically, the study will investigate the relative difference in potential effects between these two operating conditions on bank erosion, recreation, public safety, water quality, and fishery and benthic habitat. The following tasks will be completed to achieve this objective:

1. Contact and interview landowners with property along the river between Leesville Dam and the confluence of Goose Creek. Identify concerns pertaining to the current hourly autocycle operations;
2. Determine the magnitude of water level changes, as well as rates of rise and fall, occurring downstream of Leesville Dam as a result of hourly autocycling operations;
3. Evaluate effects on public safety and recreation resulting from water level and velocity changes associated with autocycling;
4. Assess changes in aquatic habitat associated with hourly autocycling compared to continuous flow;
5. Evaluate erosion potential and sediment inputs resulting from hourly autocycling as compared to continuous flow releases;
6. Determine effects of autocycling operations on dissolved oxygen (DO) levels;
7. Evaluate the effectiveness of re-vegetating shorelines as a bank stabilization measure at selected active erosion sites downstream of Leesville Dam; and
8. Conduct a feasibility evaluation on the ability to add a minimum flow unit to Leesville Dam.

4.0 METHODS AND GEOGRAPHIC SCOPE

The geographic scope of the study includes the Roanoke (Staunton) River beginning at the base of the Leesville Dam and extending to the confluence with Goose Creek a distance of approximately 3.5 miles. The study of the effect of autocycling on erosion will extend further downstream to Altavista, a distance of approximately 11 miles from the Leesville Dam. *(Article 401 (a) and FEIS Appendix D – p. D26.)*

Methods to be employed are summarized below according to the eight (8) tasks identified in Section 3.0:

Task 1 – Contact and interview landowners with property along the river between Leesville Dam and the confluence of Goose Creek. Identify concerns pertaining to the current hourly autocycle operations.

A letter explaining this study will be sent to all property owners along the study reach. The letter will provide contact information for the researchers conducting the study along with a contact at Appalachian. It will also inform the property owners that the researchers will be contacting them in order to document any concerns they may have regarding the current autocycling operation. When feasible and at the landowners discretion, interviews should be conducted on-site. Any survey mechanism (questionnaire) developed to facilitate the interviews will be reviewed by the stakeholder group (VDGIF, VDEQ, CPR, and TCRC) prior to being implemented in the field.

The result of these interviews will be collated into a summary report that includes information on the property owners (*e.g.*, property location, river frontage, property size, land use, and other pertinent information), names of individuals interviewed, and concerns regarding the recently implemented hourly autocycling mode. The report will be distributed to the stakeholder group as part of Task 3 below. After review and comment, it may be necessary to adjust subsequent tasks to more accurately address the concerns of property owners.

Task 2 – Determine the magnitude of water level changes, as well as rates of rise and fall, occurring downstream of Leesville Dam as a result of hourly autocycling operations.

To accurately assess the effect of project autocycling on water levels in the Roanoke River, water level data loggers (or comparable instruments) will be deployed at locations downstream of Leesville Dam. Water level loggers will record barometric pressure and water depth once per minute or less. Approximate locations to characterize the study reach within the mainstem Staunton River will be: at the cable barrier in the Project tailrace; 0.5 miles downstream of the cable barrier; 1.0 mi downstream of the cable barrier; 2.0 mi downstream of the cable barrier; just upstream of the mouth of Goose Creek. Level logger data will also be collected on the lower reach of Goose Creek to quantify the effects of flow fluctuations related to Leesville releases on aquatic habitat in the creek (including Roanoke Logperch habitat). *(Article 401(d))* The above listed locations are approximate and one of them will be adjusted to include the anticipated location of the proposed canoe launch area. Stage data will also be obtained from the USGS gage (#2060500) at Altavista, located approximately 12 miles downstream of the dam and also from the Leesville Dam which monitors tailwater elevation.

Due to the fact that normal target flows downstream of Leesville vary by month and include flow contributed from the watershed downstream of the Dam, the hourly autocycle will also vary. Therefore it is necessary data over the range of normal expected operations be collected. In addition to the water level data, water velocity data will be collected at each monitor location over the range of operations. Due to the dynamic nature of autocycling, this data will be representative of what is occurring but will not be definitively correlated to a given flow at an exact point in time. Velocities data will then serve as a component for Task 3. Further, it will serve to ground truth water velocity output from the two-dimensional hydrodynamic model developed as part of Task 5.

Conduct water level tests over a one to two week period. After installation of the instruments, autocycle operations can be conducted to achieve the range of target flows. Releases providing a specific target flow would have to be conducted for sufficient period to allow conditions to stabilize which may take a one or more days to occur. However, the data needed would be collected over a relatively short period, accurately depict the magnitude and rate of change in water levels, and minimize the potential for lost or vandalized equipment. The disadvantage of this scenario is that there needs to be sufficient water available to release from Leesville and agency approval would be required if releases below a given months target flow is required.

Task 3 – Evaluate effects on public safety and recreation resulting from water level and velocity changes associated with autocycling.

This task will consist of collecting additional on-site information plus utilizing the results of Tasks 1 and 2. For this task, it is assumed that while flow changes would occur during continuous flow operation, changes would be relatively infrequent and generally in small increments that mimic the natural hydrograph. Therefore, the continuous flow scenario is considered to provide stable conditions for this evaluation.

Data collection will consist of qualitative observations on the ability to hear the warning system signifying plant start-up throughout the study reach. These observations will be made at least three times during the course of the study and represent times of the year when the highest recreation levels are expected and also when terrestrial vegetation is in full foliage due to its sound attenuation ability. Researchers will determine the approximate downstream extent where the warning siren can be heard and also where it appears to be effective. Investigators will also qualitatively assess the adequacy of existing signage notifying river users of the water level fluctuations and the significance of the warning siren.

A report will be produced that provides the information collected in Tasks 1, 2 and 3. Water level data (both magnitude of fluctuation and rate of change) will be presented in a manner that considers the timing of the warning siren relative to changes that occur at locations throughout the study reach. Data will be presented in a matrix that displays distance from the dam, ability to hear the warning siren, amount of time between initiation of the siren and the onset of water level changes, the magnitude of water level fluctuation, the range of water velocities observed, and the rate of change from low to high and also from high to low. Existing information on standardized criteria regarding water depth and velocity and its potential effect on safety for river-based recreation will also be presented to the extent that such information is readily available. Concerns expressed by property owners will be presented. Those concerns related to safety and recreation will then be evaluated relative to the data collected.

The summary report will be provided to the stakeholder group in order to assess the adequacy of the existing warning system. Additionally, the group will then assess the magnitude and rate of water level and water velocity changes to determine what portion of the study reach may represent an impediment to recreation or a public safety hazard. If it is determined that additional water velocity information is required for this evaluation, output from the two-dimensional hydrodynamic model developed as part of Task 5 will include velocity estimates.

Task 4 – Assess changes in aquatic habitat associated with hourly autocycling compared to continuous flow.

The first step of characterizing the effects of hourly autocycling on aquatic habitat would be to consider the habitat present. For example, a reach comprised predominantly of pool and/or run habitats with few riffles is unlikely to result in substantial impacts to usable habitat for pool dwelling species due to the addition of moderate increases in flow. Numerous instream flow studies have shown that additional flow in pools and runs increases depth and surface velocities, but has relatively little effect on mid-column velocities and on overall habitat. Conversely, riffle habitat would see more dramatic effects with increases in flow.

As part of the Instream Flows Needs Study conducted as part of the relicensing effort, habitat mapping for the study reach is already available. Results of this effort indicate that more than 80 percent of the study reach consists of pools, runs, and glides. Additionally, while study transects were not located in the area between the Dam and Goose Creek, the study report states that "*downstream study areas should be adequate to represent habitat conditions in this section*".

Therefore, the model developed as part of the Instream Flow Needs study can be used to assess changes in habitat availability over a range of flow scenarios. This would consist of modeling flows that represent continuous releases required to meet target flows and also a range of flows that would be expect to occur throughout the study reach during an hourly autocycle. The results of this effort would yield estimates in Weighted Useable Area for the target species present in the study reach over a range of conditions. Following review of this evaluation by the stakeholders, a determination will be made regarding whether additional study of aquatic habitat is warranted.

Habitat Types Present between Leesville Dam and the Mouth of Goose Creek

Habitat Type	Percent Comp.
Fast Riffle	2.2
Glide	22.2
Lateral Riffle	2.6
Pool	39.5
Run	21.4
Run w/boulders	3.1
Slow Riffle	8.9

Task 5 – Evaluate erosion potential and sediment inputs resulting from hourly autocycling as compared to continuous flow releases.

Erosion in the approximate 3.5 mile long river reach extending from directly downstream of Leesville Dam to the mouth of Goose Creek will be assessed through a combination of field observations and the development of a two-dimensional hydrodynamic model. Several methods for assessing the erosion potential of the two conditions (hourly autocycle and continuous flow) were considered, and this combined approach was identified as the most likely to meet the study objectives. The development of the hydrodynamic model includes measurement of river cross-sectional profiles and gathering empirical data on water level fluctuation and substrate composition. While comparing erosion rates within the study reach to areas unaffected by hourly autocycling may be feasible, it would be difficult to achieve reliable results due to the high spatial and temporal variability in bed and bank erosion rates. This approach would require a long-term study with numerous replicates of cross sections to characterize the period of river morphological and vegetation adjustments and develop meaningful results. This is because it is impossible to only look at a few years of cross-section data and differentiate between erosion that is occurring due to current conditions verses erosion that has resulted from the past 20 years of autocycling on a 2-hour basis, and prior flood regimes.

Fieldwork will consist of a number of steps repeated at specific locations along the study reach. These include a geo-referenced photo and video log of the study reach, establishing reference locations for monitoring bank erosion, and collecting data to quantify existing bank stability and develop and calibrate the hydrodynamic model.

A field survey will evaluate bank stability and erosion mechanisms using methods similar to those employed on the New River (*e.g.* as per Stone, *et al.*, 2009; Riedel, *et al.*, 2006). These methods are reproducible, efficient, and are understandable to a wide user group. Shifts in stability will be plotted and mapped to illustrate trends along the study reach. Soils and geology data for the area will be reviewed along with the field observations to assess the erosion potential along the stretch of the river evaluated. An index of existing bank erosion severity and future bank erosion potential will be created for the riverbanks for the study reach.

Cross-sectional transects will be surveyed at the study sections along the reach. It is estimated that approximately 24 transects will be needed to adequately characterize the range of bank variability. For each transect, data will be collected in the form of the profile shape, surficial sediment conditions, sand/silt/clay fraction of the eroding material, height of the eroding bank above water and other relevant data describing the resisting characteristics of the eroding material and the volume of sediment being eroded.

Erosion pins will be installed at each cross-section location to allow for monitoring of future bank recession rates. Up to 300 geo-referenced bank pins throughout the 3.5-mile study reach will be necessary in order to characterize bank erosion. These pins will largely be associated with transect locations but some pins will also be located in areas between transects. Pin measurements will provide a baseline condition that can be reevaluated at future intervals if needed. The relatively large number of pins will minimize the potential effects of lost pins and erosions variation within a given location. After completion of the fieldwork, a manual will be created to allow for duplication of the measurements of the bank pins and cross-sectional transects along with the photo and video log. Prior to the field surveys, the results of landowner interviews will be reviewed to identify specific sites that have been documented as areas of concern.

Data collected from the field survey along with the water level data collected in Task 2 will be used to develop a two-dimensional hydrodynamic model. Several models will be considered in order to determine which is most appropriate to meet the study objective. Selection of the most appropriate model is vital to an appropriate outcome of this exercise, and selection will be undertaken by an experienced numerical modeler. The model will be used to evaluate three hourly autocycle conditions (a high, medium, and low target flow) and the continuous flow condition. Model output will provide the erosion potential of each discharge condition for the study reach as a whole and for specific erosion areas.

Visual monitoring of bank erosion as identified in Appalachian Power's July 15, 2008 proposed Erosion Monitoring Plan will extend to Altavista, Virginia. Photographic documentation of river bank conditions downstream from Goose Creek in areas where the change to 1-hour auto-cycling eliminates operations-related fluctuations would provide a basis for estimating how much riverbank erosion may occur in the reach above Goose Creek in the absence of operations-related fluctuations. The reach between Goose Creek and Altavista will service as a reference reach. *(FEIS Appendix D - p. D-26)* Limited quantitative measurements of riverbank erosion using bank pins will be conducted between Goose Creek and Altavista. *(Article 401 (c))*

Sediment contributions from the study reach to downstream areas due to autocycling compared to continuous flows is difficult to assess. Based on other studies that have been conducted, Smith Mountain and Leesville dams prevent the sediment load from entering the Roanoke River downstream from Leesville. As a result, the amount of sediment inputs to the Roanoke River from upstream is greatly reduced. Therefore, further evaluation of sedimentation should be contingent on the results of the hydrodynamic model and the difference between erosion potential for each condition. If that analysis indicates a substantial difference in erosion potential, monitoring of the bank pins could continue at regular intervals. This data could then be used to estimate sediment inputs due to bank instability.

Task 6 – <u>Determine effects of autocycling operations on dissolved oxygen (DO) levels</u>.

Concerns have been expressed that marginal water quality may exist at the downstream portion of the study reach and ultimately be present near Altavista. In turn, marginal water quality, specifically DO could then hinder industrial development in the region and result in economic impacts. Evaluation of the effects of hourly autocycling compared to continuous flow releases is not easily accomplished.

The withdrawal zone within the water column for water passing through a given intake will vary based on the location, size, and flow through that intake. Due to the fact that the size and location of the Leesville intakes are fixed, flow is the only variable. As flow volumes change, the withdrawal zone would change. Therefore releasing water through autocycling (large volumes for short periods) compared to continuous flow (small volumes for long periods) would likely affect the withdrawal zone and the resulting downstream water quality. In other words, it is likely that higher intake flows withdraw water from a larger portion of the water column. Conversely, lower flows likely withdraw water from a limited portion of the water column.

However, differences in water quality as the water continues to flow to downstream areas such as Altavista, is influenced by additional factors. An array of biological and mechanical actions occur which can substantially alter water quality. For example, mechanical aeration that occurs as water passes through riffles can increase DO levels while inputs from tributary streams and non-point sources can add nutrients and actually decrease DO levels. Therefore, while any potential enhancements to water quality in the study reach would be a positive effect, it does not necessarily mean that these benefits would be directly evident at Altavista which is approximately 12 miles downstream of the study reach.

Therefore, in order to assess the difference between hourly autocycling and continuous flow releases on DO levels, data will be collected in both the Staunton River and Leesville Dam forebay. First, a continuous water quality monitor will be deployed just upstream of the mouth of Goose Creek. The monitor will measure water temperature, DO, and pH at 10-minute intervals. Data collection will occur for approximately a two-month period during late summer (mid-July through mid-September) when conditions typically represent the worse case scenario (*i.e.,* high temperatures and low flow). Data will be retrieved and maintenance performed on a weekly basis. In addition, data will be collected via a calibrated hand held instrument at the time of deployment and retrieval. Data will be evaluated relative to state standards. Data will indicate if the water quality standards are consistently being achieved through hourly autocycling

Additional data collection efforts would consist of collecting weekly profile data (DO and temperature) in the project forebay and temperature data from the project discharge concurrent with the downstream data collection effort. A withdrawal zone model would be developed based on water temperature profiles in the forebay and discharge temperatures to determine the differences in withdrawal zone depending on discharge rate. Essentially this would be a mass balance model. Any differences in the withdrawal zone could then be used to assess differences in DO between the two operating conditions. This information will also provide information regarding intake locations or constraints relative to assessing the feasibility of a minimum flow turbine (Task 8).

Task 7 – Evaluate the effectiveness of re-vegetating shorelines as a bank stabilization measure at selected active erosion sites downstream of Leesville Dam.

This task should be considered pending the results of Task 1, interviews with property owners. Active erosion sites in areas suitable for re-vegetation could be considered as test plots for establishing natural buffers.

This task would include a literature search to identify projects conducted elsewhere (preferably in a similar geographic region), methodologies that have been successful, and native plant species likely to provide the necessary benefits. The literature search would also provide information on additional techniques used on similar river systems to mitigate for identified effects of pulsed flow releases.

Task 8 – <u>Conduct Minimum Flow Turbine Feasibility Study for the Leesville Development</u>.

Due to the size of the existing turbines and their operational limitations the current facilities at the Leesville Development are not able to provide a continuous flow release at the discharge levels required to meet downstream target flows. In order to meet these continuous flow targets a much smaller minimum flow turbine could be added which would be capable of operating over the required flow range. Conceivably, target flows could also be achieved by releasing water through a spill gate. However, spilling water to reliably achieve target flows is complicated by the 13 ft. water level fluctuations which occur in Leesville Lake. As such, the current spill gates can not provide the continuous flows needed and installation of a new spilling mechanism would be required. Of these two options, a minimum flow turbine is preferable because the released water would still be used to generate electricity and provide increased project capacity which could be utilized under high flow conditions. Installation of such a unit would represent a substantial undertaking at the Dam. However, because it will generate revenue through the production of electricity, any incremental increase in generation between the current and upgraded condition would be considered in the economic feasibility of such an installation.

Completing this task would involve an engineering feasibility study to determine if the installation of a minimum flow turbine is technically and economically feasible at Leesville. The study would result in an opinion of probable construction costs and an estimate of annual generation. These two factors could then serve as components in a cost benefit analysis should other tasks indicate that continuous flows within the study reach represent fewer effects on environmental and social resources.

Should Task 6 above indicate that hourly autocycling results in dissolved oxygen (DO) levels below the state water quality standard, the need to install a minimum flow turbine with DO enhancement capabilities will be also be evaluated as part of Task 8. Additionally, the incremental difference in generation between the current hourly autocycling operation and installation of a minimum flow unit to provide continuous flows will also be estimated.

5.0 REPORTING

~~A~~ Ddraft reports summarizing each study year's findings will be issued to ~~state agencies and other stakeholders~~Virginia Department of Environmental Quality, Virginia Department of Game and Inland Fisheries, Tri-County Relicensing Committee and the Citizens for the Preservation of the River for review and comment within 90 days of completion of field data collection. The above listed stakeholders will be provided 45 days to review and comment on the draft reports. Final reports will be provided to the Federal Energy Regulatory Commission within 60 days following the end of the stakeholder review period. Final reports will contain documentation of stakeholder consultation. Reports as described above will be provided following Study Years 1, 2, 3 and 4 as described in Section 6.0 - Schedule.

Final reports will be filed with the Commission for approval. *(Article 401 (e))*

If Appalachian can demonstrate that the results of its proposed study during Study Years 1 and 2 provide the information needed to adequately assess the Project's effect on aquatic habitat in the Roanoke River downstream from Leesville (including lower Goose Creek), it may seek relief from the remainder of the license requirement for Study Years 3 and 4 of the monitoring. *(FEIS Pg. 280).* If Appalachian seeks relief as described above, documentation of stakeholder consultation will be provided with the report filed with the Commission following Study Year 2.

6.0 SCHEDULE

The study schedule is a phased approach. Due to the fact that hourly autocycling has just been recently implemented (October, 2008), it is unknown exactly how much conditions are different from the previous 2-hour autocycle operation. In addition, downstream property owners may not even be aware of the change. Phase I is proposed to consist of Tasks 1, 2, 3, and 8 and be conducted in study year 1. This will allow for more beneficial input from property owners after they have observed hourly autocycling for a period of time (Task 1). Tasks 2, 3, and 8 largely rely on empirical data which can also be collected in Study Yyear 1.

Following review of Phase I results, stakeholders can review Tasks 4, 5, 6, and 7 (Phase II) to determine if modifications are needed and then proceed as necessary. Field work in Phase II will collect realtime, empirical data on bank erosion, water quality, aquatic habitat, fish populations/communities, recreation (including angling), and public safety. *(Article 401(b))*

Study Year	**Phase**	**Tasks**
Study Year 1 (2010)	Phase I	Tasks 1, 2, 3 and 8
Study Year 2 (2011)	Phase II	Tasks 4, 5, 6, and 7
Study Year 3 (2012)	Phase II	Tasks 4, 5, 6, and 7
Study Year 4 (2013)	Phase II	Tasks 4, 5, 6, and 7

7.0 ESTIMATED COSTS

The following table provides a cost estimate by Task , to conduct this study.

Estimated Costs to Conduct Leesville Study Tasks	
Task 1	**$10,000**
Task 2	**$12,000**
Task 3	**$20,000**
Task 4	**$8,000**
Task 5	**$125,000**
Task 6	**$30,000**
Task 7	**Unknown**
Task 8	**$18,000**
Total Estimated Cost Years 1 and 2	**$223,000**
Additional costs for Years 3 and 4	**$125,000**
Total Estimated Costs	**$348,000***
*Note: Estimated Costs doesn't include cost associated with Appalachian staff, potential generation impacts or costs associated with Task 7.	

8.0 REFERENCES

Riedel, M.S., Brooks, K.N., and Verry, E.S. 2006. *Stream bank stability assessment in grazed riparian areas*, Proc. Joint 8th Federal Interagency Sedimentation and 3rd Hydrologic Modeling Conferences, Reno, NV, April 2-6:1B-4, 9p.

Stone, A.G., Riedel, M.S., Dahl, T.A., and Selegean, J.P. 2009. A GIS Based Streambank Stability Tool for the Great Lakes Region. J. of Great Lakes Research. 35(2).