Date: March 31, 2008

Scope of Work for Philpott Dam 216 Feasibility Study Natural and Cultural Resources Restoration of Endangered Species Description of Existing And Future Without Project Conditions

1. Introduction: The U.S Army Corps of Engineers, Wilmington District (Wilmington District) in partnership with the Commonwealth of Virginia are sponsoring a feasibility study under the authority of Section 216 of the River and Harbor and Flood Control Act of 1970 (Public Law 91-611). Section 216 authorizes the review of the operation of the Philpott Dam and Lake and report recommendations to Congress on the advisability of modifying the structures or the structures' operation and for improving the quality of the environment in the overall public interest. Approval of participation in this feasibility study by the US Army Corps of Engineers, Wilmington District, was based on the report entitled 905(b) Reconnaissance Report, Philpott Dam and Lake, Virginia, (Section 216) Study, Smith River dated August 2004, approved 7 January 2005. Public, stakeholder, and local, State, and Federal agency input received during the early stages of this study indicated there is a public interest in reviewing the following areas: natural resources; downstream fisheries management related to the brown trout fishery, water quality, the Philpott guide curve and its effects on various resources, and upstream fisheries related to the largemouth bass fishery in Philpott Lake. Hydropower and upstream recreation were topics addressed in several comment letters. Downstream water supply, recreation, erosion and siltation, drought management, fish and wildlife, endangered species, cultural resources, and shoreline management are of concern; however; very few comments were submitted regarding these concerns. US Army Corps of Engineers Regulation (ER) 1105-2-100, Planning Guidance Notebook, provides full guidance regarding conduct of the study. Technical Work Groups were formed in the following areas: Natural and Cultural Resources; Operation Policies and Administrative Procedures; Shoreline Management and Erosion; Water Quality; Water Supply; and, Aesthetics and Recreation. Each of the Work Groups is to develop a Scope of Work to assess existing conditions and to forecast the future conditions that would exist if no modifications are made to operating procedures at the Philpott Dam. This analysis is being done in accordance with U.S. Water Resources Council's *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* as implemented by the U.S. Army Corps of Engineers' Planning Guidance Note Book (Engineering Regulation 1105-2-100). A summary of the progress made thus far on the Philpott 216 Study can be found in the November 2006 *Project Management Plan for Philpott Lake, Virginia (Section 216) Feasibility Study*. This management plan and other materials regarding the Philpott 216 study are available at the following website:

http://www.saw.usace.army.mil/Authorized_Projects/Main.htm.

5. Purpose: The objective of the proposed study is to evaluate potential changes in reservoir operations including flow and temperature management options for Philpott Dam and channel restoration activities below the dam to specifically address restoration of the federally listed endangered Roanoke logperch (*Percina rex*) in the Smith River. Specific issues identified by the Natural Resources Work Group are:

- What is the status of the mainstem Smith River Roanoke logperch population below Philpott Dam to the North Carolina state line or confluence with the Dan River in Eden, NC?
- What is the status of the Towne Creek Roanoke logperch population and is it the source of all logperch in the mainstem Smith River below Philpott Dam?
- How can habitat be improved to improve Roanoke logperch reproduction and recovery in the mainstem Smith River below Philpott Dam?
- What is the appropriate discharge protocol from Philpott Dam for the Roanoke logperch in the mainstem Smith River below Philpott Dam?

Information gathered during the course of this contract, will be used along with information gathered for the other identified areas of interest, to evaluate the impacts and feasibility of implementation of various modifications to the operation and/or structure at Philpott Dam on the restoration of the Roanoke logperch population in the Smith River below Philpott Dam. The Dan River basin which incorporates the Smith River basin is shown below in Figure 1.

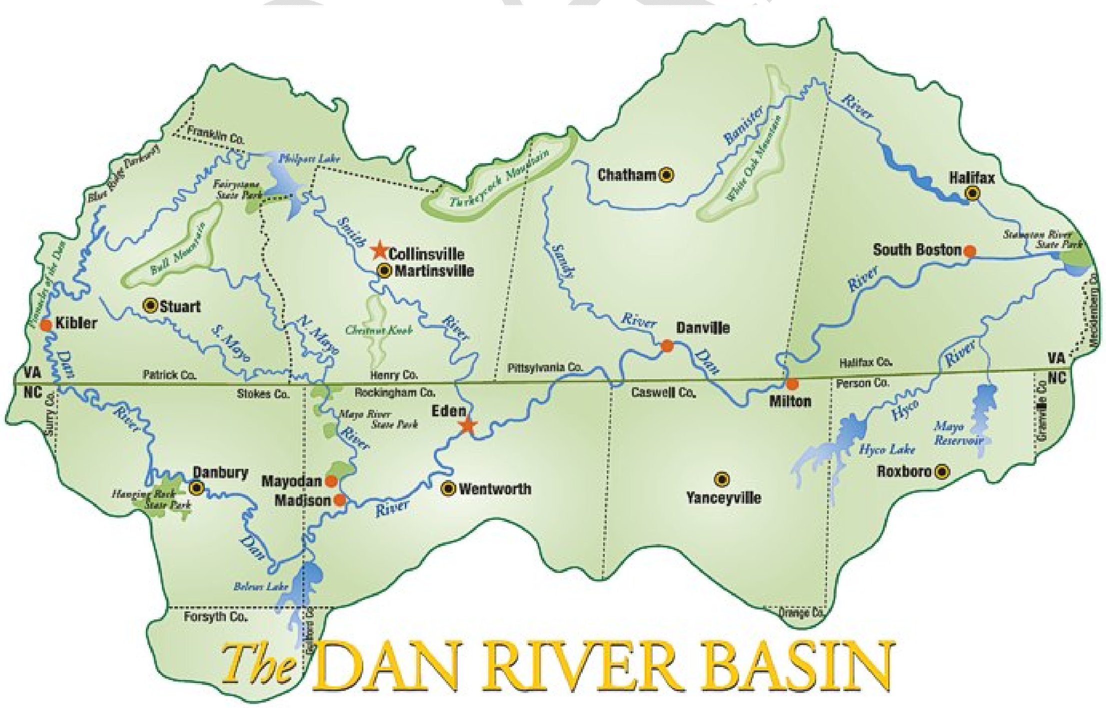

Figure 1. Dan River basin in Virginia and North Carolina.

6. Background: Considerable fisheries research has been conducted on the Smith River during the past 25 years by the Virginia Department of Game and Inland Fisheries (VDGIF) and Virginia Polytechnic Institute and State University (Virginia Tech). VDGIF and Virginia Tech cooperated on a five year study of the fisheries resources of the Smith River from September 1999 to June 2004. The study was entitled *"Influences of Fluctuating Releases on Stream Fishes and Habitat in the Smith River, below Philpott Dam"*. The primary purpose of the research (Orth et al. 2004) was to validate and discover new fish-population and habitat relationships and provide defensible fish-habitat relationships to be used for developing specific management actions to improve the fisheries resources of the Smith River tailwater. More specific objectives of the study are listed below:

- To characterize the instream habitat conditions in areas where successful spawning and juvenile rearing of brown trout occurs.
- To collect biological data to quantify abundance of trout and nongame fishes in the Smith River from Philpott Dam to Martinsville, quantify temperature limits of fish occurrence and monitor annual variation in brown trout recruitment success.
- To evaluate the bioenergetic constraints on growth under existing temperature regimes.
- To design a field survey and modeling protocol to measure effects pf varying flows on the shear stress, mobilization of streambed gravels, and relate discharge to the amount of redd scouring or brown trout fry displacement that would occur at sites in the tailwater.

The Natural Resources Work Group has determined that that this study did an excellent job of characterizing the management needs of the majority of the fisheries resources of the Smith River including the brown trout population and most nongame fishes. As such, no additional research has been recommended for these resources in the Philpott 216 Study. The Executive Summary of the Virginia Tech/VDGIF Study is inserted below to provide general insight to the results of the study.

Influences of Fluctuating Releases on Stream Fishes and Habitat in the Smith River, below Philpott Dam.

EXECUTIVE SUMMARY

Operations of Philpott dam for flood control and peak power generation since 1953 have substantially altered downstream ecosystem conditions in the Smith River from the dam to Martinsville. We have described in intensive detail aspects of habitat and fish populations in the tailwater over the past four years (2000 to 2004), analyzed the limited historical information available to develop a better understanding of the mechanisms behind observed changes in the tailwater, and recommend appropriate actions to improve depressed fish populations and environmental conditions. Our research emphasizes that there are no "silver bullet" solutions and the most successful path toward improving the tailwater will reflect numerous tradeoffs to balance environmental, economic, and recreational goals. However, it is clear that enhancing conditions in the Smith River hinge on mitigating the effects of fluctuating releases from Philpott Dam through a combination of flow management (e.g. characteristics of dam operations during baseflow and peak flow periods) and habitat improvement (e.g. channel restoration, temperature management, enhanced biological productivity). In addition, removal or modification of Martinsville Dam to enhance flow, habitat, and fish and sediment passage would benefit fish populations and environmental conditions in the lower tailwater. Current fishery management strategies which are ineffective for enhancing brown trout should be re-evaluated after habitat and flow changes are instituted. Management actions for improving flow and habitat also should be assessed in light of the presence of the Federally Endangered Roanoke logperch *Percina rex* that also appear to be limited by degraded environmental conditions in the tailwater.

This report is organized into distinct jobs, which were initiated at different schedules. Job 1 is “Characteristics of spawning and rearing habitats for brown trout.” Job 2 has two parts: Part A is “Determinants of brown trout growth and abundance;” Part B is “Longitudinal patterns of community structure for stream fishes in a Virginia tailwater. Job 3 is “Hydraulic model stream development and application to Smith River tailwater.” The final management recommendations are drawn from all job findings.

Coldwater release provides habitat that is now conducive for non-native trout including a wild brown trout population and stocked rainbow trout. These species are the dominant component of the fish fauna. The wild brown trout population has followed a boom and bust cycle since natural reproduction first occurred approximately 30 years ago and special regulations were imposed to sustain the boom 20 years ago. Reservoir productivity has also followed a boom and bust cycle characteristic of new reservoirs. A once plentiful alewife population, which routinely supplemented the food base in Smith River through turbine passage, no longer provides an external source of food to brown trout in the Smith River.

Consequently, the brown trout population now subsists on instream production of depressed populations of aquatic insects. Fish contribute little to the annual diet and subsequent growth of brown trout and only in the downstream portions of the tailwater where the relative abundance of nongame fishes exceeds 100 fish per 100 meters. Alkalinity (19 mg/L) and phosphorous (0.08 mg/L) concentrations are low and place additional constraints on biological productivity in the Smith River.

Recruitment of brown trout to the fishable size classes is constrained by the daily hydropower peaking operations. The number of young brown trout produced each year was strongly related to the average magnitude of the peak flow and the duration of generation flows. Further, number of young brown trout was unrelated to temperature. Therefore, flow management has the potential to influence the recruitment of brown trout in the Smith River tailwater.

Growth of juvenile brown trout is positively related to water temperature, which indicates that adequate prey exists for small trout. However, growth of yearling and older brown trout is less related to temperature and is depressed by limited prey availability in most seasons and stream reaches.

The section of the Smith River between 3 and 10 river kilometers from the dam is the critical reach for supporting the wild brown trout population and popular wild trout fishery. Here we found the highest redd densities, juvenile abundance, and spawner biomass. Other reaches provide suboptimal habitat for brown trout and lower populations. In the reach nearest the dam, brown trout are limited by cold temperatures and lack of spawning, nursery, and productive feeding habitats. In the lower reach, brown trout are limited by the heavily sedimented streambed and a lack of deep pools and rich prey base. The brown trout do actively remove fine sediment via redd construction and spawning, thereby increasing gravel permeability. However, the fine sediments from tributaries and bank erosion are transported by daily peaking flows and rapidly intrude into the spawning gravel in downstream reaches of the river.

Opportunities for enhancing the environmental conditions via changes in the operating conditions of Philpott dam were evaluated as well as other management actions to enhance the quality of the habitat and fishery and native fish populations. Conditions throughout the tailwater are consistent with the patterns expected after 50 years of dam operation with daily peaking, no ramping restrictions, loss of upstream gravel addition, and the rapid warming of cold water as it travels and equilibrates with the prevailing air and tributary inflows.

Operation of the dam for daily peak power generation has created a wider, rectangular-shaped channel, with steeper banks. Also the base channel elevation in the reach nearest the dam has decreased and caused steepening [headcutting] of tributary channels and bank erosion near the mainstem. Bottom substrate in the dam reach is dominated by bedrock and boulder and cobbles, gravel and sand are limited. As a consequence, spawning and nursery habitat for brown trout is limited and rooted aquatic vegetation is sparse. No native fish are present in the dam reach. Temperatures in the dam reach are too cold to permit adequate growth for a productive wild trout fishery.

In the middle reach, there are sufficient concentrations of cobbles, gravels, and islands to create a riffle-and-pool channel morphology. This middle reach supports the vast majority of the successful brown trout spawning and nursery habitat for juvenile survival and growth. Temperature in the middle reach is more conducive to acceptable brown trout growth and production. A few species of native fish exist at low densities in this reach. Populations of native fish appear to be enhanced by a tributary influence on temperature, nutrients, and nursery or spawning habitat.

The stream channel in the lower reach is characterized by a high width-to-depth ratio, which is not conducive to bedload transport. Consequently, excessive aggradation of the channel bed is apparent from river kilometer 10 and further downstream. Temperature in the lower reach is warmer and a population of native fish is present, but production appears to be limited by cool temperature, shallow depth, and fine sediment deposition.

Environmental improvements that could mitigate for the effects of dam operations should be evaluated during the U. S. Army Corps of Engineers Section 216 Feasibility Study. The following would be appropriate actions that could be funded by the U.S. Army Corps of Engineers Section 1135 Funding Authority.

Temperature Management -- Temperature is an important driver for many biological processes in the Smith River. During this study we confirmed a number of important processes that were strongly tied to temperature. Brown trout initiate spawning in November or December when water temperatures first fall below 9 C and timing of spawning depends on distance from Philpott dam. Growth of age-0 brown trout was strongly positively influenced by degree-day accumulation between May and October. Therefore, age-0 brown trout grew faster at downstream reaches and in years with lower volume of cold water releases during this time period. Species richness and abundance of native fish were closely tied to distance from the dam and tributaries, both of which affect water temperature. Densities of Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) were different among stream reaches of the river and significantly depressed below expectations in the dam reach. Although temperature regime could be improved to increase the length of tailwater with suitable temperature for brown trout and native fishes and invertebrates, we were unable to test our predictions of the increased growth rate due to unknown effects of temperature management on future prey availability. The direction of the response is, however, clearly positive if prey populations also increase.

Dynamic flow and water temperature models were used to predict thermal habitat under alternative flow scenarios. Model output and species thermal criteria enabled assessment of potential benefit or detriment to brown trout and warmwater species. Currently the average release temperature (8°C) is below the optimal brown trout growth range (12-19°C). A 12°C outflow scenario predicted the greatest increase of optimal growth temperatures. Warmer temperatures also increase the area of suitable thermal habitat for warmwater species, including the Roanoke logperch. With changes in flow management we found it is possible to improve the trout fishery without detrimental effects to the warmwater community. However, the trout fishery improvement is dependent on concomitant increases in productivity of the trout prey base and appropriate temperature management. Temperature management actions will have to be closely monitored in order to determine the level of increased growth that is realized by a new thermal regime.

Flow Management -- Hydraulic models were used in predicting physical habitat for brown trout spawning under alternative flow scenarios. Results from the habitat simulation indicates a significantly positive relationship between redd density and habitat quality predicated by the model. Based on our regression analysis, current base flow appears to be below the optimal reservoir release range (9-15 m^3/s), while the peak flow is too high to support suitable brown trout spawning environment. A 12 m^3/s reservoir release scenario predicted the best suitable habitat availability in our study site. However, because the highly fluctuating flow causes temporal changes in the locations of suitable habitat, an adaptive monitoring program is needed to correctly evaluate the fish habitat under such a flow scenario. Because brown trout spawning predictable based on daily temperatures, we recommend that peaking flows be restricted during the time of peak spawning. Furthermore, we identified a significant response of brown trout to frequency and magnitude of peaking flows during the incubation and emergence, which indicates that peaking operations could be restricted during these times, especially in dry years, in order to enhance brown trout recruitment success.

The rapid increase in flows during generation causes substantial increase in the shear stresses on the channel bed. Our analysis from hydraulic models shows that gravels, which are important to redd construction, may be moved within the initial release period. This fluctuating flow also causes a higher stress to fish, may displace young brown trout, and prohibits successful spawning by minnows. Our recommendation is to use a two-step flow release scenario. It is better to use one turbine to release flow for half an hour and then add another turbine to release additional flow if necessary. Study illustrates the shear stress acting on gravel and drag force exerted on fish may be greatly reduced under such a hypothetic reservoir release scenario, and hence a healthier stream can be maintained without affecting power generation requirement.

Endangered Species Restoration -- The middle and lower reaches of the Smith River support a population of the Federally listed, endangered Roanoke logperch *Percina rex.* Logperch were present at low abundance but we cannot establish normative population abundance levels from other Roanoke logperch populations. The Roanoke logperch population is disconnected from a population in Town Creek and the main channel population is likely depressed by cold summer temperatures, flow fluctuation during spawning time, and excessive silt and sand in pool habitats. Consequently, the management actions to improve the habitat in the Smith River via channel restoration and flow and temperature management are required and will require Section 7 consultation between the U. S. Fish and Wildlife Service, Department of Game and Inland Fisheries, and the U. S. Army Corps of Engineers.

Habitat Management -- The current stream channel in the lower reach does not adequately function to transport the heavy sediment load under current operations. Flood management has eliminated flood flows in the Smith River such that the highest flow is the peak generation flow, which can occur daily. As a consequence, much of the water surface is shallow and slow moving between generation releases; this causes more rapid warming of the water. We recommend that channel restoration, using natural channel design principles, be implemented in the lower reaches of the Smith River in order to enhance bedload transport, stabilize banks and floodplains, increase habitat suitability, and reduce flood risk. Channel design in the lower reaches should include narrowing and deepening the channel, boulder addition, restoring floodplain contours, increased sinuosity, and adding nearstream woody vegetation to shade the channel and protect streambanks from erosion.

Channel design in the dam reach should include addition of gravel and cobble materials to improve the conditions for invertebrate production if peaking flows were reduced. The amount of material to be added to mitigate for 50 years of channel degradation will be substantial. The use of limestone materials is recommended to enhance the alkalinity and biological productivity. Special attention needs to be made to address the many steep and eroding stream banks in the main channel and the tributary streams (especially Town Creek) which have down cut due to lowered base elevation of Smith River in dam and middle reaches. Design and implementation of the channel restoration will require modifications in the timing and magnitude of the releases from Philpott dam and cannot be successfully implemented without some change in peaking flows.

Daily peaking will continue to destabilize steep banks, thereby adding fine sediment to the channel. This fine sediment rapidly intrudes into the channel bed further depressing the aquatic life processes in the intergravel habitats. Combination of shallow depth, fine sediment, and mobile fine bed deposits provide very poor habitat for production of insects and plants, and for spawning and feeding habitats for native fish and trout.

Our analysis with two- and three-dimensional hydrodynamic models documents the potential mitigating effect that large boulders have in creating stable downstream wakes behind boulders, even during generation flows. These models can be adapted for use in a newly designed channel to create appropriate boulder placements to increase refuges for fish during generation flows and still permit the transport of bedload.

The Martinsville Dam creates a long backwater effect that traps substantial fine sediment, warms water temperatures, thereby further decreasing the amount and quality of suitable fish habitat in the Smith River. Furthermore, the dam creates a barrier to fish movements and prevents recolonization by native fish downstream from the dam. Species, such as the Roanoke Darter *Percina roanoka* and Roanoke Bass *Ambloplites cavifrons*, could benefit from reconnection with a restored Smith River. Native mussels are also extirpated from the mainstem Smith River between Philpott Dam and Martinsville Dam due to cold temperatures and barrier effect of Martinsville Dam. We recommend that the City of Martinsville and the Virginia Department of Game and Inland Fisheries evaluate the costs and benefits of barrier mitigation options at Martinsville Dam.

Harvest Management -- The current management strategies for the trout fishery include a special regulations section with 16 inch minimum size limit and general trout regulations elsewhere. Trophy regulations are not warranted in this population as the brown trout growth is slow and ceases soon after fish are mature enough to spawn. Trout from 8 to 12 inches are in fair to poor condition and nonfishing mortality is very high. Changes in the harvest regulations in the Smith River should be re-evaluated after major changes in dam operations are in place to alter the habitat and potential for enhanced prey production. We further recommend that separate regulations be established for brown trout and stocked rainbow trout in the Smith River in order to emphasize the distinction between wild and stocked trout among the fishing public. There is no compelling biological reason to protect brown trout less than 16 inches since fewer than 1 in 1,000 of the brown trout sampled during this study exceeded 16 inches. However, the population is unlikely to respond to any regulation change at current limited growth rates.

Timing of implementation -- The recommended actions provide a template for future management actions to be considered by the U.S. Army Corps of Engineers and the Department of Game and Inland Fisheries. Clearly, some of these actions will be more expensive and require more time to implement, whereas others can and should be implemented earlier. We recommend guidelines for the timely implementation of changes.

1. Flow changes
2. Channel restoration and habitat management
3. Temperature management
4. Endangered species restoration
5. Fishing regulation changes

In addition to the VDGIF/VA Tech Study, additional fisheries studies were conducted in 2005 (Lahey and Angermeier 2006) and 2006 (Roberts and Angermeier 2007) by VA Tech and the USGS to determine habitat suitability for the Roanoke logperch near Philpott Reservoir and to monitor the Roanoke logperch in the Smith River upstream of Philpott Reservoir, on U. S. Army Corps of Engineers property. The results of these studies indicate that there is considerable Roanoke logperch habitat in the Smith River above Philpott Reservoir and that the species is relatively abundant at least up to White Falls.

7.0 Technical Services: This scope of work requests services related to objectives described in Section 6 (Background).

7.1 Roanoke Logperch Population Status Determination (Task 1): The Contractor will develop a sampling strategy to determine the status of the Roanoke logperch population in the Smith River from Philpott Dam to the North Carolina state line and also in Towne Creek. The population data produced shall include species distribution, size distribution, and relative abundance and/or population estimates and trends.

7.2 Source of the Roanoke Logperch in the Smith River (Task 2): The Contractor will develop a study to determine if Roanoke logperch are spawning in the mainstem of the Smith River and/or the tributaries of the Smith River below Philpott Dam to the VA/NC state line. Tributaries to be included in the study are Towne Creek, Reed Creek, Jordan Creek, Beaver Creek, Marrowbone Creek, and Leatherwood Creek. This work should include genetic (microsatellite DNA) analysis of all logperch collected to identify the source(s) of these fish.

7.3 Roanoke Logperch Habitat Requirements in the Smith River (Task 3): The Contractor will determine the preferred habitat requirements of the Roanoke logperch in the Smith River below Philpott Dam to the VA/NC state line. Habitat requirements should include depth, velocity, flow, temperature and substrate types. It is possible that this requirement of the study may be determined through a literature review and summary. Once the habitat requirements have been determined, an estimate of available habitat for the Roanoke logperch in the Smith River shall be quantified for the current operating protocol and for other potential operating protocols possible within the limits of the current generating equipment in Philpott Dam. It should be mentioned that some habitat data may be available from the Upper Smith River Study conducted by Lahey and Angermeier (2006).

7.4 Roanoke Logperch Population Viability Model (Task 4): The Contractor shall develop a Roanoke logperch population viability model for the Smith River from Philpott Dam to the VA/NC state line. This model should be able to predict population viability (persistence) into the future. The model should take into account population parameters such as recruitment and survival rates, and population density. The Contractor shall work with the U. S. Fish and Wildlife Service initially to determine if a surrogate species such as the bluehead chub, fantail darters, etc. could be used in the model if there is not sufficient data available for the Roanoke logperch. In addition, the Contractor shall determine if the Roanoke logperch population data collected from the Roanoke River by Dr. Paul Angermeier of Virginia Tech would be of use in this modeling study. Should insufficient population data be available to develop a viability model, then researchers should provide an assessment of population viability based on the collective findings of the other tasks being investigated in this scope of work.

8. Timeline: The timeline **indicated** for each task of this project is ***based on timing of previous similar projects. However as indicated in Section 13, proposals that provide justification for an accelerated schedule by using adaptive management or other techniques will be given a higher ranking.***

FUNDING, SCHEDULE AND METHOD OF ACCOMPLISHMENT

Task	Schedule	Estimated Costs	Method of Accomplishment
Task 1. Roanoke Logperch Population Status determination	12 months after contract awarded	$75,000	USACE Contract (VA Tech)
Task 2. Source of the Roanoke Logperch	12 months after contract awarded	$70,000	USACE Contract (VA Tech)
Task 3. Roanoke Logperch habitat requirements	18 months after contract awarded	$75,000	USACE Contract (VA Tech)
Task 4. Roanoke Logperch Population Viability Model	6 months after completion of Tasks 1-3	$25,000 Total = $245,000	USACE Contract (VA Tech)

Funding needs for the various tasks are outlined in the table below. Costs are task completion estimates and fiscal year costs will need to be adjusted depending on when the projects are initiated.

Literature Cited

Lahey, A. M. and P. L. Angermeier. 2006 Habitat suitability for Roanoke logperch near Philpott Reservoir. Final report to U. S. Army Corps of Engineers, Wilmington District, Wilmington, NC.

Orth, D. J., T. J. Newcomb, P. Diplas, and C. A. Dolloff. 2004. Influences of fluctuating releases on stream habitats for brown trout in the Smith River below Philpott Dam. Final report, Federal Aid for Sport Fish Restoration. Contract 08220203. Virginia Department of Game and Inland Fisheries, Richmond, VA . 284 pp.

Roberts, J. H. and P. L. Angermeier. 2007. Monitoring of endangered Roanoke logperch (*Percina rex*) in Smith River upstream of Philpott Reservoir, on U. S. Army Corps of Engineers property. Final report to U. S. Army Corps of Engineers, Wilmington District, Wilmington, NC.