** DRAFT BIOLOGICAL OPINION - COLUMBIA DAM **

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Mr. M. Paul Schmierbach, Manager
Environmental Quality
Tennessee Valley Authority
Knoxville, Tennessee 37902

RE: Log Number 4-2-79-F-97

Dear Mr Schmierbach:

A. Introduction

This letter represents the U.S. Fish and Wildlife Service's (Service) biological opinion regarding the impacts of the Tennessee Valley Authority's (Authority) Columbia Dam project alternatives (Duck River, Maury and Marshall Counties, Tennessee) on federally listed or proposed species. Three federally listed species (all endangered)--the birdwing pearly mussel (Conradilla caelata), the Cumberland monkeyface pearly mussel (Quadrula intermedia), and the tan riffle shell (Epioblasma walkeri)--occur in the project area. This letter is in response to your July 24, 1987, letter requesting reinitiation of Section 7 consultation under the 1973 Endangered Species Act, as

amended (Act), and your November 29, 1988, letter which forwarded a biological assessment on Columbia Dam project alternatives. This letter addresses only the consultation requirements under Section 7(a)(2) of the Act and does not address the requirements of other environmental statutes such as the National Environmental Policy Act or the Fish and Wildlife Coordination Act.

B. Project Description

The Tennessee State Legislature created the Upper Duck River Development Agency (Development Agency) in 1965 and gave it broad authority to formulate and carry out plans for improving the economy in Bedford, Coffee, Marshall, and Maury Counties, Tennessee. The Development Agency, in 1966, proposed a water supply grid system to serve the above four-county area, and they requested that the Authority study the area's water resource development needs. In 1968 the Authority, in cooperation with the Development Agency, issued a planning report that called for a Duck River project involving two reservoirs--Normandy Reservoir, a 3,230-acre impoundment at Duck River mile (river mile) 248, and Columbia Reservoir, a 12,600-acre impoundment at river mile 136.9. Normandy Reservoir was begun first and was completed in 1976. Columbia Dam construction began in 1973, but all work in the project area ceased in 1983 because of the Service's jeopardy biological opinion and to await success of the Authority's mussel conservation program. As originally proposed, the Columbia Dam Reservoir would impound about 54 miles of the Duck River

in Maury and Marshall Counties, Tennessee, and was justified on the basis of enhanced employment, recreation, water supply, flood control, and downstream water quality control. The dam, which is partially (45 percent) complete, will consist of two rolled, earth-filled embankments totaling 2,075 feet in length and 80 feet in height above the floodplain and a concrete weir controlled by five 40-foot-high and 40-foot-wide radial gates.

You proposed alternatives to your original reservoir project in a 1979 "Report to OMB [Office of Management and Budget] on Columbia Dam Alternatives" and in your 1988 "Biological Assessment of Columbia Dam Alternatives, Duck River, Tennessee." A summary description of the 1979 alternatives is contained in the "Consultation History" section of this letter, and a summary description of the 1988 alternatives is contained in the "The Authority's 1988 Project Alternatives" section of this letter.

C. Consultation History

On June 14, 1976 (41 FR 24064), several species of mussels, some of which were reported to have occurred in the upper Duck River, were listed as endangered species. As a result of this rulemaking, you were advised on June 22, 1976, that the Columbia Dam project would impact four of these species, and you were requested to initiate consultation. On August 13, 1976, you requested consultation specifically for one species, Conradilla caelata, and requested information on the

occurrence of other mussel species in the Duck River. A biological opinion was rendered on February 16, 1977, stating that the project as planned was likely to jeopardize the continued existence of the birdwing pearly mussel (Conradilla caelata) and the Cumberland monkeyface pearly mussel (Quadrula intermedia). On April 19, 1978, the U.S. Army Corps of Engineers (Corps) requested consultation on a Section 404 permit application for the project, and a biological opinion was rendered on May 26, 1978, stating that project completion was likely to jeopardize the two species referenced in the previous opinion to the Authority as well as another species, the tan riffle shell (Epioblasma walkeri) (listed on August 23, 1977, 42 FR 42353).

On January 11, 1979, we received your request to reinitiate consultation on the basis of new information and project alternatives that had been developed at the request of the Office of Management and Budget. These project alternatives were:

1. Columbia Dam full-pool level (elevation 630 feet - 54 river miles inundated) as originally planned but with a mussel conservation program.

2. Low-pool level (elevation 600 feet - 36 river miles inundated) and relocation and protection of flood-prone residences and businesses. (You stated that problems associated with operating the low-pool level to avoid impacting endangered

mussel habitat coupled with the uncertainties of water quality ruled out this alternative.)

3. No impoundment with relocation and protection of flood-prone residences and businesses. This third alternative also included recreational development along the river corridor.

On March 6, 1979, Service personnel met with representatives of your agency for a ground and helicopter tour of the dam site and again on March 7, 1979, to discuss alternatives to the original project as proposed by your agency and the possible effects on the referenced mussel species. On April 25, 1979, Service personnel met with Authority personnel in Knoxville, Tennessee, to discuss and clarify the project alternatives and your proposed mussel conservation program as they appear in your "Report to OMB [Office of Management and Budget] on Columbia Dam Alternatives" of April 1979.

The mussel conservation program you proposed in the "Report to OMB [the Office of Management and Budget] on Columbia Dam Alternatives" was intended to improve the status of the birdwing pearly mussel and the Cumberland monkeyface pearly mussel to the point that the loss of these species' Duck River populations by completion of Columbia Dam would not likely jeopardize their continued existence. Your conservation program was to be a major undertaking, including such actions as:
(1) renovating old mill dams and construction of new low-level dams to create mussel habitat, (2) protecting natural mussel shoals from

dredging and other adverse impacts, (3) transplanting mussels, (4) developing special programs to abate existing environmental problems, and (5) promoting additional regulations to protect mussels. The extent of this conservation program and its expected outcome were emphasized in the "Summary" section of your April 1979 report to the Office of Management and Budget. The following four statements were made in that report:

1. "This program [conservation program] would include the operation of Columbia Dam to provide a better habitat for endangered and other mussels as well as steps to improve their habitat elsewhere in the Duck River and in the Clinch and Powell Rivers where the endangered mussel [sic] exists in limited numbers."

2. "In addition some kind of conservation program would have to be implemented to stop the declining population of endangered species."

3. "The option involving completion of the project as planned along with implementation of conservation measures to assure a habitat for the mussel population including the listed species in the Duck River should result in the long-term survival and growth of mussel species. In addition, measures would be implemented on the Clinch and Powell Rivers, where the endangered mussels are still found in small numbers to provide additional opportunities for their survival and growth."

4. "These conservation measures, the cost of which have [sic] not been determined, would have to be designed to create a suitable habitat in the streams to conserve the species and enhance its [sic] ability to survive and thus carry out the purpose of the Endangered Species Act in the most positive manner possible."

We reviewed information contained in the following: "Final Environmental Statement Duck River Project," April 28, 1972; the "Supplement to Final Environmental Statement Duck River Project," June 1974; the "Report on Preliminary Studies of Columbia Dam Alternatives," April 1979; "An Evaluation of Mussel Populations in the Powell River, Tennessee and Virginia," June 1979; and "An Evaluation of Mussel Populations in the Clinch River, Tennessee and Virginia," 1960-1978. Based on the above information, and other information provided by you and academic and private sources, we issued a revised biological opinion on September 28, 1979. That opinion addressed the three Columbia Dam alternatives you presented in your 1979 report to the Office of Management and Budget and judged that the two reservoir alternatives would likely jeopardize the continued existence of the birdwing pearly mussel and the Cumberland monkeyface pearly mussel and that the non-reservoir alternative would not likely jeopardize the continued existence of any mussel species. The tan riffle shell was believed to no longer exist in the area so it was not included in the jeopardy determination.

Because of the major mussel conservation effort you envisioned and the significant positive outcome you forecasted, we accepted your proposal to conduct a mussel conservation program as a reasonable and prudent alternative that would avoid jeopardy for both reservoir projects. Our reasonable and prudent alternative went somewhat further than your proposal in that we stipulated that you could only complete the dam if, prior to project completion and inundation, you were to assure us that the mussel conservation program had been completed with "proven success." We were convinced that the conservation effort was to be substantive and concluded in the 1979 biological opinion that if your conservation program were successful, the results could be the establishment of mussel populations in a superior condition to what existed at the time the opinion was issued.

You, with receipt of the September 28, 1979, biological opinion, accepted our modification to your reasonable and prudent alternatives and began implementation of your mussel conservation program toward completion of the full-pool level (elevation 630 feet) option. The conservation program was to include mussel transplants and was also to emphasize, as did your 1979 report to the Office of Management and Budget, the need for habitat protection and improvement. This commitment to habitat improvement by you, and our belief that you were fully committed to habitat improvement as a part of the conservation program, was emphasized by the Chairman of the Authority's Board (S. David Freeman) and the Service's Director (Lynn Greenwalt) in their 1980 testimony before a Congressional Subcommittee on

Environment, Energy, and Natural Resources (Subcommittee), which was investigating the Columbia Dam project.

Chairman Freeman stated before the Subcommittee:

> "In addition to work on the Duck River, measures will be implemented on the Clinch and Powell Rivers, where the endangered mussels are still found in small numbers, to provide additional opportunities for their survival and growth."

He further stated: "Here is a chance to take a project and turn it into an environmental cleanup of these rivers."

Director Greenwalt testified before the same Subcommittee and stated:

> "Let me point out that in addition to cleaning up the waters, I am sure the Chairman knows that TVA [the Authority] is committed to habitat improvements, the construction of artificial riffles, and this sort of thing, all of which are positive."

In late 1979 the Columbia Dam Coordinating Committee (Committee), cochaired by an Authority and Service biologist, was formed. The Committee was comprised of personnel from the Authority; Service; Environmental Protection Agency; and the Tennessee, Virginia, and

Alabama wildlife resource agencies. The Committee's primary mission was to: (1) review the progress of your conservation program and (2) develop specific criteria to be used by both of us to measure the "proven success" of your mussel conservation program.

On February 15, 1980, we issued a revised biological opinion to the Corps (Nashville District) regarding the issuance of a 404 permit for Columbia Dam. This opinion restated our no-jeopardy position regarding your full-pool project if a mussel conservation program were completed with "proven success" prior to project completion. The opinion to the Corps further stated that jeopardy would not occur to the two mussel species if Columbia Dam were operated as a self-regulating structure (elevation 571 feet), assuming that water would not be backed up above river mile 156.

The Assistant Secretary of the Interior for Fish, Wildlife, and Parks, on April 3, 1980, in a letter to the Corps, provided clarification to the February 15, 1980, biological opinion. The Assistant Secretary stated that issuance of the 404 permit for the self-regulating structure was moot because the Authority did not intend to operate Columbia Dam in that manner. The Assistant Secretary's letter emphasized his perceived scope of the Authority's environmental program, and he stated:

> "Specific river stretches will be identified for habitat improvement, including the placement of instream

structures, as needed, and the modification of substrate. These areas will be the principal sites where both endangered and related species and their host fish will be restored. In addition, working with States and other agencies, sanctuaries will be expanded and established to strengthen these endangered and other cumberlandian fauna. Cooperative work will also seek to correct specific sources of degradation and pollution as they affect existing populations of mussels, restored habitat and reestablished populations.

"This unique conservation program is a significant demonstration of the positive application of the Endangered Species Act. The resources and level of effort which TVA [the Authority] is willing to commit to this effort are considered by knowledgeable biologists to be the type of actions which are most likely to broaden the existing range and habitat and facilitate the recovery of these species. The net effect of the successful implementation of the conservation program will be to improve substantially the likelihood of the survival and conservation of these species."

The Columbia Dam Coordinating Committee, through deliberations in 1980, 1981, and 1982, reviewed your progress and developed and supplied to us specific criteria for evaluating the success of your mussel

conservation program. On May 25, 1982, we communicated the criteria to you. The criteria provided specific conservation program objectives and, at your request, presented a means to evaluate the program's success in two stages--"likely success" of the conservation program, which would allow you to complete dam construction to the preinundation stage, and "proven success" of the conservation program, which would allow you to complete the project and inundate the mussel habitat.

During and after development of the criteria, you conducted work on the conservation program. You transplanted 4,000 birdwing pearly mussels to four sites in four rivers (1,000 mussels per river), conducted mussel surveys, determined host fish for the birdwing pearly mussel and Cumberland monkeyface pearly mussel, evaluated mussel habitat needs, and conducted other related work. However, the conservation program activities concentrated primarily on the transplantation of birdwing pearly mussels, and little was done regarding improvement of the species' habitat or status elsewhere throughout their ranges.

"Likely success" of your conservation program was expected to occur in late spring or early summer of 1983. However, by letter of June 4, 1984, the Committee informed us that "likely success" had not been achieved. The Committee found that you failed to meet the criteria in the following areas:

1. "...only in the North Fork Holston River did transplants of Conradilla caelata [birdwing pearly mussel] exceed the 50 percent [survival] standard established by the committee."

2. "Results of TVA [Authority] activities concerning Quadrula intermedia [Cumberland monkeyface pearly mussel] have failed to meet the stated criteria for additional populations in the Elk River, Clinch River, or other rivers."

3. "With regard to stability of the Powell River population [Cumberland monkeyface pearly mussel], a 1983 die-off is known to have included specimens of Q. intermedia [Cumberland monkeyface pearly mussel]."

4. "The habitat improvement criteria have not been met for either species. No activity directly associated with the Columbia Dam Project has been implemented which has the goal of improving mussel habitat."

We notified you (July 5, 1984) that "likely success" had not been met because of the failure to fulfill several key criteria. Our July 5, 1984, letter also requested that you inform us of the future of the conservation program and Columbia Dam. You responded on August 1, 1984, and stated:

"...the habitat improvement would cost more than eight million dollars and several years to complete. Even if we were to spend this additional time and money, there is no assurance that "proven success" necessary for impoundment would be achieved. In any event, the TVA [Authority] budget for fiscal year 1985 contains insufficient funds for the habitat program. We do, however, plan to continue monitoring the four transplant populations because of programmatic interests in the ultimate success of transplants. Obviously the extent and duration of this future monitoring is subject to the availability of funds.

"In light of these facts, the TVA [Authority] Board sees no basis upon which it could prudently proceed with this comprehensive conservation program, which is the predicate for future construction activities."

You requested a meeting, which was held on July 8, 1985, between Authority and Service biologists and administrators to review conservation program progress and discuss remaining obstacles impeding completion of your conservation program. As a result of these discussions, we called a Columbia Dam Coordinating Committee meeting (held on September 19-20, 1985) to discuss these issues. The Committee restated its position that "likely success" had not been attained but that "proven success" could still be met. The Committee also presented us with revised criteria to judge the success of the conservation

program. These criteria, although they could likely take longer to achieve, provided you greater flexibility in the type of conservation programs that could be pursued in achieving "proven success." These revised criteria were included in a 1985 "Draft Report to OMB [Office of Management and Budget] on Columbia Dam Benefit Cost Analysis" and were officially transmitted by us to you on January 2, 1987.

On July 24, 1987, you requested that we reiniatiate Section 7 consultation on the Columbia Dam project in order to discuss the current status of the listed mussels and review possible alternative pool levels below the full-pool option. We responded on September 11, 1987, and stated our willingness to reiniatiate Section 7 consultation but informed you of the requirement that a biological assessment be prepared on the proposed project alternatives. Representatives of our agencies met December 4, 1987, to discuss the desired contents of your biological assessment, and on January 25, 1988, we (by letter) further defined four specific areas that were to be addressed in your biological assessment. See the "Review of the Authority's Biological Assessment" section of this letter for our evaluation of the assessment.

On July 6, 1988, we received from the Upper Duck River Development Agency a proposed modification of your Cumberlandian Mollusk Conservation Program to resolve the jeopardy situation regarding completion of Columbia Dam. The Service responded on October 3, 1988, to the Development Agency and indicated that as Section 7 consultation

was being actively pursued between the Service and the Authority, the Development Agency should coordinate any conservation programs they wish to pursue with the Authority. We also concluded, after review of the Development Agency's proposal, that although the draft plan could contribute to the conservation of endangered mussels affected by the Duck River project, it appeared to be essentially just a set of research objectives addressing predominately the birdwing pearly mussel. Also, the Development Agency did not present a plan of action with any expected end products. Thus, without clear objectives, the plan would not offset the likelihood of jeopardy for the species prior to completion of Columbia Dam.

You provided us with a biological assessment on the Columbia Dam alternatives on November 29, 1988, and formal Section 7 consultation began on that date.

D. Review of the Authority's Biological Assessment

Your biological assessment is sufficiently complete to allow us to develop a biological opinion on most project alternatives presented. However, it is lacking some specific data and analyses that we requested in our September 11, 1987, and January 25, 1988, letters which outlined what the biological assessment should address.

The following items compare our request for biological assessment information with the actual biological assessment you supplied:

1. A detailed review of project alternatives the Authority wishes the Service to address in their biological opinion. We had asked that the assessment address the economic and engineering feasibility of each alternative. The biological assessment contained only limited discussions of the feasibility of some alternatives; no feasibility analysis was provided on others. Because of the lack of feasibility data and some stated problems with low-pool alternatives (i.e., required dam modifications, water taste and odor problems, and objections by project proponents), we question whether the low-pool alternatives are really feasible projects.

2. An assessment of potential impacts, both direct and indirect, that are expected to occur from each of the proposed project alternatives. We defined direct effects as those impacts that occur on or immediately adjacent to the project site. Indirect effects were defined as impacts that are reasonably expected to occur as a result of the project (i.e., increased development in the watershed) but were later in time.

Direct effects are discussed in the biological assessment for all but Alternatives 6 and 10. These alternatives consisted of a series of potential alternatives which are not described in detail. Indirect effects were not discussed for any alternative. Thus, no information on any of the alternatives was provided on potential

watershed development and the subsequent impacts it could have on the mussel species.

3. An evaluation of the current status and anticipated future progress of the Authority's mussel conservation program. This evaluation was to include a complete review of progress to date of all phases of the Authority's Cumberlandian Mollusk Conservation Program and what your anticipated future progress would be toward completing the present conservation program. We also asked you to describe any new conservation measures you were willing to pursue to accomplish the conservation program's overall goals.

   The biological assessment provided an overview of the conservation program. However, this section concentrated on the mussel transplants and only minimally discussed the status of other phases of your conservation program. No information was supplied on future plans for a conservation program nor was there any discussion of any new or alternative conservation measures that you might pursue as part of any project alternative.

4. Any other available, relevant biological data on the mussel species under consideration. This section was to include an up-to-date synthesis of information on the status of the mussel species throughout their range, including updated information on current threats to all populations.

You conducted extensive mussel surveys and thoroughly addressed the current status of the populations in the Duck, Powell, and Clinch Rivers. However, you did not survey all known populations or identify current threats to all populations.

E. The Authority's 1988 Project Alternatives

Since we have already rendered biological opinions on the project as originally planned (February 16, 1977) and on three project alternatives (see "Consultation History" section) (September 28, 1979), the reinitiation of consultation leading to this biological opinion was based on a series of alternatives which constitute a modification of the project as originally planned. Ten project alternatives are presented in your November 1988 "Biological Assessment of Columbia Dam Alternatives, Duck River, Tennessee." The following is a summary of these 10 alternatives:

1. Project as Planned. This is the original project proposed by the Authority, the alternative the Upper Duck River Development Agency recommends, and the only alternative Congress has directed the Authority to complete. This project would utilize the dam presently at river mile 136.9 and create a 12,600-acre impoundment at maximum-pool elevation of 630 feet. The impoundment would extend upstream 54 miles to approximately river mile 191. The project would provide flood control, water supply, recreation, and land enhancement. This is the only alternative for which a

benefit-cost ratio has been developed. In the Authority's 1986 final report to the Office of Management and Budget, you stated that this alternative is 45 percent complete and has a benefit-cost ratio of 0.5 to 1.

Note: All subsequent mainstream Duck River impoundment alternatives (Alternatives 2, 3, 4, 7, 8 and 9) would use the same dam site at river mile 136.9, but Alternatives 2-4 would require structural modification to the present dam. All of the Duck River impoundment alternatives differ from Alternative 1 above in final- or interim-pool elevations and in the length and size of the impoundment. Also, because of the shallow nature of these smaller reservoirs, water taste and odor problems would likely be greater than under Alternative 1.

2. Reservoir at Elevation 600 Feet. This would create a 3,700-acre, 35-mile-long impoundment extending upstream to river mile 172. This project would provide water supply and some recreational benefit but no flood control.

3. Reservoir at Elevation 585 Feet. At this elevation the reservoir would cover 1,800 acres and extend upstream 28 miles to river mile 165. According to the biological assessment, this alterative has not been evaluated in much detail, but its only benefit would be water supply and some recreation. No flood control would be possible.

4. Reservoir at Elevation 571 Feet. The impoundment under this alternative would be 500 acres and extend upstream 18 miles to river mile 155. Water supply and flood control benefits would be minimal.

5. River Development. Under this alternative the present dam structure at river mile 136.9 would be partially or wholly removed. Recreational development would occur along the river corridor between Columbia, Tennessee, and Henry Horton State Park. Recreation would be the sole benefit.

6. Other Alternatives. This includes a list of possible alternatives intended, according to the biological assessment, to encourage discussion of potential solutions to the area's expressed water needs. They include:

   a. Construction of a water supply reservoir on a Duck River tributary.

   b. Operational modifications at Normandy Dam to augment river flow.

   c. Installation of tertiary waste treatment at one or more municipalities on the Duck River.

   d. Augmentation of water supplies from other sources.

Note: Alternatives 7-9 below are interim Duck River reservoir projects that would be completed to full-pool level (Alternative 1 above) after completion of any required conservation activity.

7. Interim Reservoir at Elevation 600 Feet. This reservoir, described in Alternative 2, would be constructed as an interim measure.

8. Interim Reservoir at Elevation 585 Feet. This reservoir, described in Alternative 3, would be constructed as an interim measure.

9. Interim Reservoir at Elevation 571 Feet. This reservoir, described in Alternative 4, would be constructed as an interim measure.

10. Other Interim Alternatives. Alternatives outlined in Alternative 6 above would be pursued, but the full-pool reservoir (Alternative 1) would be the ultimate goal.

F. Biological Information

Mussel populations throughout the Southeastern United States have been in general decline since modern civilization began to significantly alter aquatic environments. Historically, the Ohio River drainage,

which includes the Tennessee and Cumberland River drainages, contained about 127 distinct species and subspecies of freshwater mussels. Presently, 11 species (9 percent) are believed extinct, 17 species (13 percent) are federally protected as endangered, and 22 species (17 percent) are under Federal review for possible addition to the Federal List of Endangered and Threatened Wildlife and Plants. In less than 100 years, over one-third of the mussel fauna (39 percent) in the Ohio River system has been extirpated, recognized as endangered, or decimated to the point that Federal protection is being considered.

The mussel fauna in most streams of the Tennessee and Cumberland River basins has been directly impacted by impoundments, siltation, channelization, and water pollution. Reservoir construction is the most obvious cause of the loss of mussel diversity (Bates 1962). The Authority has constructed 36 impoundments in the Tennessee River system, and these impoundments have eliminated long sections of riverine habitat (Service 1984a). As most native mussels evolved in riverine environments, impoundment of this habitat directly impacted mussels. The inundation also caused a change in the fish fauna (Ruhr 1956, Starnes and Etnier 1980, Ramsey 1986). This likely affected mussel assemblages by eliminating or altering the abundance of some of the fish species necessary as hosts for mussels to complete their reproductive cycle.

Mussel faunal changes have also been noted upstream of reservoirs (Steven Ahlstedt, Tennessee Valley Authority; James Sharber, U.S. Army

Corps of Engineers; David Stansbery, Ohio State University; personal communications, 1989; Isom and Yokley 1968). In the Powell and Clinch Rivers, mussel diversity and density are lower for some distance upstream of Norris Reservoir than would normally be expected (Ahlstedt, personal communication, 1989). Ahlstedt (1986) reported mussel density and diversity data for the Clinch River above Norris Reservoir. These data appear to indicate that mussel populations do not approach expected density or diversity for the Clinch River until about 9 miles above the normal high-water pool level. Noel Burkhead (U.S. Fish and Wildlife Service, personal communication, 1989) reported that the fish faunal diversity and density in the Clinch River is also below expected levels for several miles above Norris Reservoir. James Sharber (personal communication, 1989) reported that mussel diversity declined in both branches of the Stones River upstream of Percy Priest Reservoir after it was impounded.

Silt deposition during flood events, when reservoirs back up beyond normal-pool level, may cause the loss of selected mussel species in normally unimpounded river reaches. Stansbery (personal communication, 1989) reports that a normally open dam gate on an Ohio River tributary was closed during a flood event. Silt deposition upstream was apparently the cause of the loss of mussels from a significant river reach. Accumulation on the substratum of as little as 0.6 to 2.5 centimeters of silt has been shown to kill mussels (Ellis 1936). The silt apparently interferes with the mussels' feeding and respiration.

Conservation biologists and ecologists identify three major risks to populations when they become restricted either by isolation or fragmentation of habitat (Wilcox and Murphy 1985):

1. Demographic units may be lost outright, reduced in size, or subdivided (i.e., an increased rate of extinction).

2. Potential sources of immigrants to sustain populations may be lost.

3. Immigration routes may be impeded or blocked by habitat alterations.

These risks become a factor for aquatic species when reservoirs are constructed. Dams and reservoirs permanently prevent immigration from downstream, and they fragment the riverine habitat. The populations become isolated, reduced in size, and more vulnerable to anthropogenic impacts such as toxic spills. The theory and experiences with habitat loss and fragmentation indicate that extinctions and extirpations are inevitable when these events occur (Sheldon 1988).

Because of their evolution and adaptation to riverine environments, most mussel species do not survive impoundment (Bates 1962). Studies have shown that the amount of habitable area is the best predictor of mussel species diversity in rivers, more than any other single variable (Sepkoski and Rex 1974). The analysis of mussel diversity in Atlantic drainage rivers supports the hypothesis that species numbers are in

equilibrium in a river maintained by a balance of continual, long-term immigration and extirpation. Elimination of the immigration pathway (upstream and downstream) will result in decreased diversity.

Analogous studies of fish faunas have shown that species diversity is significantly correlated with drainage area, as well as river length and habitable area (Eadie et al. 1986). Species-area relationships imply that extinctions will follow after the fragmentation of a drainage basin, and these drainage alterations can be expected to reduce diversity even in streams removed from the source of fragmentation, such as a dam and reservoir (Sheldon 1988). For example, Ruhr (1956) reported that collections of native stream species in Tennessee were larger in streams in which species derived from reservoirs were rare or absent. Impoundment of the Tennessee River ostensibly caused the extirpation of the central silvery minnow (Hybognathus nuchalis) from the Tennessee drainage, to include tributaries not directly affected by reservoirs (Etnier et al. 1979). Other species also may have been lost from some tributaries in the post-construction period, but these cannot be fully confirmed (Sheldon 1988). Changes in the fish fauna both within and upstream of new reservoirs are therefore well documented (Erman 1973, Baxter and Glaude 1980, Moyle et al. 1986).

An insightful analysis of projected changes in fish fauna due to barriers was conducted by Sheldon (1987). He discussed the potential consequences of isolation by barriers such as reservoirs on fishes and

cited the Duck River as an example of a river with high fish diversity that was likely maintained by immigration. Construction of Kentucky Lake and separation of the Duck River from parental stocks in the Tennessee River have set the stage for likely extirpations of some lower Duck River species; an additional barrier at Columbia will only promote mid-river extirpations. Since mussels are dependent on particular fish species during the parasitic stage of their life cycle, the loss of mussel diversity upstream of reservoirs may also be caused by the altered composition of the fish fauna in the unimpounded river reach above a reservoir (Isom and Yokley 1968).

Some mussel populations have become so reduced in certain rivers that they may have fallen below the number of individuals required to maintain genetic viability. Although studies specifically on mussels have not been conducted, the Service, in its recovery plans for the species under review here (Service 1984a, 1984b, 1984c), stated that:

> "Theoretical considerations by Franklin (1980) and Soul (1980) indicate that 500 [breeding] individuals represent a minimum theoretical population level (effective population size) which would contain sufficient genetic variation to enable that population to evolve and respond to natural habitat changes. The actual population size in a natural ecosystem corresponding to this theoretical population size can be expected to be larger, possibly by as much as 10 times."

The following is a summary of specific biological data and information (primarily from the Authority's 1988 biological assessment and the Service's recovery plans for the three mussel species [Service 1984a, 1984b, 1984c]) considered during this consultation:

BIRDWING PEARLY MUSSEL

The birdwing pearly mussel (Conradilla caelata) was determined to be endangered on June 14, 1976 (41 FR 14064). Critical habitat has not been determined for the species. The birdwing pearly mussel was originally described by Conrad (1834). The historical range has been reported to include the Cumberland, Tennessee, Powell, Clinch, Holston, North Fork Holston, Nolichucky, Paint Rock, Flint, Elk, and Duck Rivers (Service 1984a). Presently, the species is known to survive in only four rivers--the Duck, Powell, Clinch, and Elk Rivers. The Authority (1981) estimated that the Duck River population numbered from 20,000 to 40,000 individuals. The other three existing populations are small, comprising a cumulative total of from 500 to 1,000 individuals.

The Authority, in 1982, as part of their mussel conservation program, introduced 4,000 birdwing pearly mussels (1,000 per river) to the Nolichucky River, North Fork Holston River, Duck River (upstream of the proposed Columbia Dam project site), and Buffalo River. Approximately 20 percent (200) are estimated to survive in each of these rivers. However, in spite of your significant collection efforts at the

introduction sites, no reproduction of the species has been documented at any of these sites.

Based on 1988 data, the Duck River population is by far the best population of the species still in existence. Quantitative samples of the Duck River between river mile 147.4 and 179.2 produced 0.33 individuals per square meter (m^2) in 1979 and 0.62 per m^2 in 1988 (Authority 1988). The birdwing pearly mussel population is most dense from Lillard Mill downstream about 4 miles (river mile 179 to 175). In this reach, samples indicated a density of 1.21 per m^2. Below river mile 147, they averaged 0.14 per m^2.

The populations of this species in the Powell and Clinch Rivers were also evaluated by you in the 1988 biological assessment, and the species was again found in both rivers. Although the samples of birdwing pearly mussels were too small to determine density trends in these populations, you did find that the overall density of mussels in both rivers had declined substantially since 1979. The overall Powell River mussel densities declined from 7.25 per m^2 in 1979 to 2.41 per m^2 in 1988. Overall mussel density declined in the Clinch River from 12.10 per m^2 to 6.01 per m^2. Thus, although no density estimates of birdwing pearly mussels were possible in 1988, it seems reasonable to assume that both populations are extremely small and have declined.

You did not sample the Elk River as part of the 1988 biological assessment. The Elk River population was last evaluated in 1980

(Ahlstedt 1986), when two fresh-dead specimens were collected. This population was believed to be small at that time (Authority 1981). Based on recent observations of the Elk River (Richard Biggins, U.S. Fish and Wildlife Service, personal observation, 1988) there does not appear to be any recovery of the river's mussel fauna. This population is likely still quite small.

In summary, the birdwing pearly mussel appears to be thriving in the Duck River, and this population may in fact be expanding, especially in the river reach from river mile 147.9 to 175. Current data from the Powell and Clinch Rivers indicate that these populations are very small and are likely declining. Recent Elk River data are lacking, but that population was very small in the early 1980s, and there is no information that would indicate the Elk River's mussel fauna has begun to recover. The transplants to the Duck, Buffalo, North Fork Holston, and Nolichucky Rivers have not yet proven to be successful.

CUMBERLAND MONKEYFACE PEARLY MUSSEL

The Cumberland monkeyface pearly mussel (Quadrula intermedia) was determined to be endangered on August 23, 1977 (42 FR 42353). Critical habitat has not been determined. The species was originally described by Conrad (1836). The historic range has been reported (Service 1984b) to include the Tennessee, Powell, Clinch, Holston, North Fork Holston, South Fork Holston, Nolichucky, French Broad, Tellico, Elk, and Duck Rivers. Presently, the species is known to survive only in the Duck,

Powell, and Elk Rivers. The Authority (1981) estimated that the Duck and Elk River populations might each contain perhaps 100 individuals and that the Powell River contained about 1,000 individuals.

The Powell River contains the best surviving population. Your 1988 biological assessment shows that this species was found at one Powell River site in 1988 and at two sites in 1979. The Cumberland monkeyface pearly mussel data from both years are similar. However, significant declines in overall mussel density (down from 7.25 per m^2 in 1979 to 2.41 per m^2 in 1988) indicate that the Cumberland monkeyface pearly mussel population in the Powell River has probably declined.

Three specimens of the Cumberland monkeyface pearly mussel were found in the Duck River at river mile 176.8 in 1988, three were found near river mile 179 in 1980 and 1981, and six were found in 1979 between river mile 162.8 and 173.2. Although these numbers do not show any trend in abundance of the species, the general increase in mussel densities in the Duck River from 3.89 per m^2 in 1979 to 9.33 per m^2 in 1988 indicates that the status of this species in the Duck River may have improved. Also, because of the rarity of this species and thus the difficulty to locate specimens, it is believed that this species likely still exists throughout the river reach (river mile 162.8 to 179) where it has been found over the last 9 years.

The Elk River was not revisited as part of the 1988 biological assessment. Thus, no current data exist on this population. In 1980,

10 specimens were collected. Based on recent observations of the Elk River (Richard Biggins, personal observation, 1988), there does not appear to be any recovery of the mussel fauna. It should be noted, however, that (based on the age of specimens) no Cumberland monkeyface pearly mussel reproduction is evident in the Elk River since the construction of Tims Ford Dam upstream of this population.

In summary, the Cumberland monkeyface pearly mussel's overall status appears to have deteriorated since we issued our 1979 biological opinion. According to the 1988 data provided in your biological assessment, the status of the Cumberland monkeyface pearly mussel appears to be about the same or may have improved in the Duck River since 1979. Increases in overall mussel density would indicate that the future outlook for this species may have improved in the Duck River. The 1988 Powell River data (Authority 1988) on this species in 1988 were similar to 1979, but the significant declines shown for mussel densities in general reveal that the Powell River mussel assemblage, and probably the Cumberland monkeyface pearly mussel, appears to be in decline. Elk River data on the species are lacking since the 1980 survey; however, no information exists to indicate that this river's mussel fauna has improved.

TAN RIFFLE SHELL

The tan riffle shell (Epioblasma walkeri) was determined to be an endangered species on August 23, 1977 (42 FR 42353). Critical habitat

has not been determined. This species was originally described by Wilson and Clark (1914). The species' historic range was reported to include the South Fork Holston River, Middle Fork Holston River, Clinch River, Flint River, Hurricane Creek, Limestone Creek, Duck River, Buffalo River, Cumberland River, Big South Fork Cumberland River, Beaver Creek, East Fork Stones River, Stones River, Harpeth River, and Red River (Service 1984c). Presently, the species is known to survive in only the Duck River, Middle Fork Holston River, and Clinch River. The species may also still exist in the Big South Fork Cumberland River.

A specimen thought possibly to be the tan riffle shell was collected at Duck River mile 179 in 1978, but sampling in 1979 failed to uncover this species, and it was assumed to no longer occur in the Duck River when our September 28, 1979, biological opinion was issued. However, in 1988 (Authority 1988), a fresh-dead 3-year-old specimen was found in the Duck River at river mile 151.6. This specimen was found in an area of the Duck River where mussel densities increased substantially between 1979 and 1988. This area also has a relatively high percentage of juvenile mussels (Richard Biggins, personal observation, 1988). These two factors, plus the fact the tan riffle shell found was young, indicate that although the species may be present only in low numbers, it appears to be reproducing in the Duck River.

Other tan riffle shell populations were not sampled in preparing the 1988 biological assessment. However, based on current information, the

species is still known to survive in the Middle Fork Holston River in Virginia. This population probably contains fewer than 200 individuals (Richard Neves, Virginia Cooperative Fish and Wildlife Research Unit, personal communication, 1988). The species has also been collected in the Upper Clinch River in Virginia (David Stansbery, personal communication, 1989) in the early to mid-1980s. According to Stansbery (personal communication, 1989), this population, if it still exists, likely contains no more than 100 individuals.

Reports have been circulated (Steve Bakaletz, Big South Fork National Recreation Area, personal communication, 1988) that a population of the species may exist in the Big South Fork Cumberland River in Kentucky. These animals have been examined by Stansbery (personal communication, 1989), a noted expert on mussel taxonomy, but he was unable to determine if this population is the tan riffle shell or some other related species. Thus, at this time this population cannot be considered to be the tan riffle shell.

The tan riffle shell is the most seriously endangered of the three species under consideration. All three of its populations are at extremely low levels and are vulnerable to extinction. Presently, the Duck River population may be one of the best hopes for this species' survival, as judged by evidence of recent reproduction and the general improved status of the Duck River's mussels.

G. Biological Opinion

Based on our review of the above information and other information available to us, following is the Service's biological opinion on the alternatives proposed in the Authority's 1988 biological assessment:

Alternative 1 - Reservoir at Elevation 630 Feet

This alternative is likely to jeopardize the continued existence of the birdwing pearly mussel (Conradilla caelata), the Cumberland monkeyface pearly mussel (Quadrula intermedia), and the tan riffle shell (Epioblasma walkeri).

This alternative would flood the Duck River from river mile 137 to river mile 191 and inundate the entire 42-mile river reach (river mile 137 to 179) inhabited by endangered mussels. The physical character of this river reach would change from a series of clean gravel and bedrock riffles and pools to a 54-mile-long impoundment. Silt would settle on the substrate, oxygen levels would decrease in the deeper reservoir sections, and the water temperature regime would be altered. Changes in these and other parameters, caused by the impoundment, would permanently alter the reaches's species composition, including the fish community. The changes would be so dramatic that the impounded reach would bear little ecological resemblance to the former river.

As all three endangered mussels have evolved in and are narrowly and specifically adapted to flowing water in gravel substrate on riffles associated with specific fish species as parasitic hosts for their larvae, these mussels would be extirpated from this river reach. A loss of these populations would mean a loss of about 95 percent of the known birdwing pearly mussels in existence, and it would reduce the number of populations for the other two nearly extinct mussels--Cumberland monkeyface pearly mussel and tan riffle shell--from three populations to only two.

Alternative 2 - Reservoir at Elevation 600 Feet

This alternative is likely to jeopardize the continued existence of the birdwing pearly mussel (Conradilla caelata), the Cumberland monkeyface pearly mussel (Quadrula intermedia), and the tan riffle shell (Epioblasma walkeri).

This alternative would inundate the Duck River each summer from river mile 137 to 172 (35 miles of mussel habitat lost; 7 miles remain). In this impounded river reach, physical, chemical, and biological changes would occur as described under Alternative 1 above. Changes in the river can also be expected to occur upstream of river mile 172. Although the extent of periodic flooding upstream of river mile 172 is unknown (the extent of flooding will depend on flood intensity and design of the dam at river mile 136.9), some inundation of the area will occur (John Jenkinson, Tennessee Valley Authority, personal

communication, 1989). As flood events generally carry large amounts of silt, silt will be deposited on the clean gravel shoals above the normal 600-foot pool elevation during floods. Upstream changes in mussel fauna, possibly as the result of the invasion of reservoir fish, may also occur (Isom and Yokley 1968).

This alternative would cause the direct loss of about 40 percent (between 8,000 and 16,000) of the birdwing pearly mussels, about half of the river's known Cumberland monkeyface pearly mussel habitat would be lost, and all of the tan riffle shell habitat would be flooded. Because of periodic inundation above the normal 600-foot pool elevation during flood events and resultant silt deposition and other flood-related changes in habitat above the reservoir, the remnant populations some distance above river mile 172 likely will eventually be lost. This alternative, although not likely to result in the direct or immediate loss of all birdwing pearly mussels and Cumberland monkeyface pearly mussels, would restrict the remaining populations to less than 7 river miles. With a highway bridge just upstream of this short river reach, the remaining population would be extremely vulnerable to extirpation from a toxic chemical spill.

Our knowledge of the life histories of the birdwing pearly mussel and the Cumberland monkeyface pearly mussel is regrettably incomplete. In particular, only a few of the likely fish hosts for these species have been identified (Authority 1986a). Expected changes and declines in fish faunal diversity upstream of the proposed Columbia Reservoir,

because of river length and drainage area restrictions and immigration of reservoir species, may affect fish species presently serving as hosts for the endangered mussels. The reproductive success of these remnant populations would likely be significantly altered by changes in the fish assemblage induced by the reservoir.

Alternative 3 - Reservoir at Elevation 585 Feet

This alternative is likely to jeopardize the continued existence of the birdwing pearly mussel (Conradilla caelata), the Cumberland monkeyface pearly mussel (Quadrula intermedia), and the tan riffle shell (Epioblasma walkeri).

This project would inundate the Duck River each summer from river mile 137 to 165 (28 miles of mussel habitat lost; 14 miles remain). In this river reach, physical, chemical, and biological changes would occur within the reservoir as described under Alternative 1. Changes upstream of the reservoir would occur as outlined in Alternative 2, but because about 14 river miles of mussel habitat would remain instead of 7, these upstream impacts would be somewhat reduced.

This alternative would cause the direct loss of about 29 percent (6,000 to 12,000 of the birdwing pearly mussels), would inundate about 12 percent of the Cumberland monkeyface pearly mussel's habitat, and would inundate all of the tan riffle shell's habitat. This alternative would not result in the direct loss of all birdwing pearly mussels or

Cumberland monkeyface pearly mussels. However, upstream reservoir effects and the potential for a toxic spill or other catastrophic event destroying the mussels in part of or all the remaining 14 miles of habitat would make these Duck River populations highly vulnerable to extirpation. Of particular concern is the reduction (although only 12 percent) of available Cumberland monkeyface pearly mussel habitat. This species' population was estimated at only about 100 individuals in 1981 (Authority 1981). Any reduction in habitat would drop the population even further below the minimum number thought necessary to maintain a viable population. Additionally, most conservation biologists agree that habitat fragmentation is the most serious threat to biological diversity and is the major cause of extinctions today (Wilcox and Murphy 1985).

Alternative 4 - Reservoir at Elevation 571 Feet

This alternative would likely jeopardize the continued existence of the tan riffle shell (Epioblasma walkeri). However, this alternative is not likely to jeopardize the continued existence of the birdwing pearly mussel (Conradilla caelata) or the Cumberland monkeyface pearly mussel (Quadrula intermedia). This alternative was reviewed in our February 15, 1980, biological opinion to the U.S. Army Corps of Engineers on Columbia Dam. At that time it was considered unlikely to jeopardize any mussel species. However, when the biological opinion was issued, the tan riffle shell was thought to have been extirpated from the Duck River.

This project would inundate the Duck River during the summer between river mile 137 and 155 (18 miles of mussel habitat lost; 24 miles remain). In this river reach, physical, chemical, and biological changes would occur within the reservoir as described under Alternative 1. Changes upstream of the reservoir would occur as outlined under Alternatives 2 and 3, but because of the longer reach of river to remain above the reservoir, these impacts would be reduced.

This alternative would cause the direct loss of about 13 percent (2,600 to 5,200) of the birdwing pearly mussel population. None of the known Cumberland monkeyface pearly mussel habitat would be inundated, and the closest known occurrence of this species is about 8 miles upstream of the normal reservoir elevation. However, the reservoir would flood the reach where the tan riffle shell was found and extend to about 3 miles above that point. The loss of this river reach would likely eliminate the tan riffle shell from the Duck River. The birdwing pearly mussels that remain above the reservoir would number from 17,000 to 35,000 individuals, and all of the known Cumberland monkeyface pearly mussel habitat would be maintained. As 28 miles of riverine habitat for the Cumberland monkeyface and birdwing pearly mussels would be maintained by this alternative, it is likely that both populations would survive.

Alternative 5 - River Development

This alternative is not likely to jeopardize the continued existence of the birdwing pearly mussel (Conradilla caelata), the Cumberland monkeyface pearly mussel (Quadrula intermedia), or the tan riffle shell (Epioblasma walkeri).

This option would develop the Duck River in the area of the proposed impoundment for recreation. No water supply benefits would be provided. This alternative was reviewed by us in our September 28, 1979, biological opinion, and a no-jeopardy opinion was issued for the birdwing pearly mussel and Cumberland monkeyface pearly mussel. This project, although not completely described in your 1988 biological assessment, would appear to have minimal impacts on the three listed mussels. Further discussions would need to be conducted between our agencies to safeguard the mussels during the development and use of this river reach for recreation.

Alternative 6 - Other Alternatives

This alternative contains a list of projects that could meet the area's stated water supply needs while not pursuing development of a reservoir on the main stem Duck River. These alternatives have not been evaluated by you for engineering or economic feasibility, and insufficient data on these projects are supplied in the biological assessment to evaluate their potential impacts on mussels. However,

some of these projects would appear to substantially reduce or eliminate impacts to the species and should be evaluated further by you as a means of meeting the Upper Duck River Development Agency's stated water supply needs while avoiding jeopardy to the mussels.

Alternative 7 - Interim Reservoir at Elevation 600 Feet

This alternative is likely to jeopardize the continued existence of the birdwing pearly mussel (Conradilla caelata), the Cumberland monkeyface pearly mussel (Quadrula intermedia), and the tan riffle shell (Epioblasma walkeri).

The Duck River would be impounded from river mile 137 to 172 as an interim measure and completed to full-pool level (600-foot elevation) after completion of any required mussel conservation program. This project, even as an interim measure, would result in the loss of the Duck River populations of all three mussel species as described under Alternative 2 above.

Alternative 8 - Interim Reservoir at Elevation 585 Feet

This alternative is likely to jeopardize the continued existence of the birdwing pearly mussel (Conradilla caelata), the Cumberland monkeyface pearly mussel (Quadrula intermedia), and the tan riffle shell (Epioblasma walkeri).

This project, as an interim measure, would impound the Duck River from river mile 137 to 165 and be completed to full-pool level after completion of any required mussel conservation program. This project, even as an interim measure, would directly impact all three mussel species and would likely lead to the eventual loss of all three species from the Duck River as described in Alternative 3 above.

Alternative 9 - Interim Reservoir at Elevation 571 Feet

This project alternative would likely jeopardize the continued existence of the tan riffle shell (Epioblasma walkeri). This alternative, as an interim project, is not likely to jeopardize the continued existence of the birdwing pearly mussel (Conradilla caelata) or the Cumberland monkeyface pearly mussel (Quadrula intermedia). However, as no data on the extent of any conservation plan are provided in the biological assessment, a jeopardy/no-jeopardy call for these two species from completion to full-pool level cannot be made.

This project, as an interim measure, would flood the Duck River from river mile 137 to 155 and would be completed to full-pool level after completion of any required mussel conservation program. This project would impact the mussel species as described in Alternative 4 above.

Alternative 10 - Other Alternatives

This alternative would complete some or all of the projects outlined in Alternative 6 above. Then, after completion of a successful mussel conservation program, the project would proceed to full-pool level. This alternative, as described under Alternative 6 above, has not been developed to the point that evaluation of impacts to listed mussels can be made. However, some of the projects described would appear to avoid or reduce impacts to mussels to the point that jeopardy could be avoided.

Summary of Biological Opinion

Because Alternatives 1, 2, 3, 7, and 8 result in the immediate or eventual extirpation of the Duck River populations of the birdwing pearly mussel, Cumberland monkeyface pearly mussel, and tan riffle shell, and as these species' populations outside the Duck River are extremely small and threatened with extinction, the loss of these populations from the Duck River by these alternatives will likely jeopardize the continued existence of all three species.

Because Alternatives 4 and 9 will result in the extirpation of the Duck River population of the tan riffle shell, and as populations of this species outside the Duck River are extremely small and threatened with extinction, the loss of the Duck River population of the tan riffle shell will likely jeopardize its continued existence. Because impacts

to the populations of the birdwing pearly mussel and the Cumberland monkeyface pearly mussel are sufficiently reduced by these project alternatives, these alternatives are not likely to jeopardize the continued existence of these two species.

Although the entire scope of Alternative 5 is not fully developed, this project, when considerations for the species' welfare are included, likely would not jeopardize the continued existence of any of the three mussel species.

Insufficient data are available to fully evaluate the impacts of the list of project options in Alternatives 6 and 10, but it is likely that one or more of these options could be pursued and avoid the likelihood of jeopardy to these three species.

H. Reasonable and Prudent Alternatives

Provided below are three reasonable and prudent alternatives that, if implemented, would not violate Section 7(a)(2) of the Act. Reasonable and prudent Alternatives 1 and 2 were provided as project options in your 1988 biological assessment. Alternative 3 utilizes your mussel conservation program concept which was first presented in your 1979 report to the Office of Management and Budget.

1. The present dam structure could be partially or wholly removed and the section of the Duck River to be impounded would be developed

for recreation. Discussions and further Section 7 consultation between our agencies would be needed to safeguard the mussels during and after development of the river reach for recreation.

2. The area's stated water needs could be met by development of water supply projects other than construction of Columbia Dam. This could include such actions as: (a) construction of a water supply reservoir on a Duck River tributary, (b) operational modifications at Normandy Reservoir to augment river flows in the Duck River, and (c) installation of tertiary waste treatment at one or more municipalities on the Duck River. Discussions and further Section 7 consultation between our agencies would be needed to ensure protection of the mussels during development and operation of one or a combination of these options.

3. Columbia Dam could be completed to full-pool level or to some lower pool level after the Authority had committed to and successfully completed a major mussel conservation program. That program would need to completely compensate for the loss of the three endangered mussels from the Duck River in order to avoid the likelihood of jeopardy from Columbia Dam completion. Additionally, because of the small population size, apparent decline of these species elsewhere, and the great importance of the Duck River to the continued existence of these species, the mussel conservation program would need to be proven successful before the Duck River could be impounded.

We realize that a major commitment of your resources would be required both within and outside the Duck River watershed for any such conservation program to be successful. However, in light of the current significant decline in the status of mussels in the Clinch and Powell Rivers, a conservation effort in these and other rivers is even more critical than it was when you first proposed this type of conservation program in 1979.

We believe the revised criteria (developed by the Columbia Dam Coordinating Committee and provided to you by us January 2, 1987) for judging the "proven success" of your original conservation program should serve as a basis to develop appropriate goals for any new conservation initiative. Some revisions to these criteria have been made to reflect the improved status of mussels in the Duck River and the decline in mussel densities in the Clinch and Powell Rivers. The specific goals that you must achieve before any new mussel conservation program can be proven successful are presented as follows:

Birdwing Pearly Mussel

(Conradilla caelata)

a. Viable birdwing pearly mussel populations must be established in at least three rivers where the species presently does not

exist. The populations will, for the purposes of the Authority's conservation program, be assumed viable when:

(1) Two distinct birdwing pearly mussel year classes, produced in the river, are found in all three rivers. One of the year classes must have been produced within 5 years of the date "proven success" is determined. Within 1 year of the date of "proven success," gravid females of the species must have been present in each population.

(2) Reintroduced birdwing pearly mussel populations are at a viable population level at least 1 1/2 years prior to the date of "proven success." A total of 500 breeding individuals was presented in the Service's mussel recovery plans [Service 1984a, 1984b, and 1984c] as the minimum population level (effective population size) needed to provide for a viable population with sufficient genetic variation to enable the species to evolve and respond to natural habitat changes. The actual population size in a natural ecosystem necessary to produce an effective population of this size can be expected to be larger, possibly by as much as ten times (Steve Chambers, U.S. Fish and Wildlife Service, personal communication, 1989). The number of mussels needed in each population to maintain viability will need to be developed through future research and/or the recommendations of a committee

of population geneticists and demographers that could be formed to address this issue.

These viable populations can be comprised of initial transplants, new transplants that have survived at least 4 years (with a greater than 25 percent survival rate over the 4 years), individuals naturally spawned in the river, or a combination of the above.

b. Naturally reproducing birdwing pearly mussel populations must exist in the Powell and Clinch Rivers. These populations must inhabit approximately the same length of river and be approximately as large as was present in these rivers in the late 1970s and early 1980s. These populations will be assumed to be reproducing when at least 2 distinct year classes, reproduced in the rivers, are found. Both year classes must have been produced within 10 years and 1 year class within 5 years of the date "proven success" is determined. Within 1 year of the date of "proven success," gravid females of the species must have been present in each population. If these populations fall below the levels present in the late 1970s and early 1980s (which may already have occurred), the populations could be supplemented with artificially propagated young to restore the adult (5+ years old) segment of the population to these levels.

c. Mussel conservation activities in the Powell and Clinch Rivers must be successful to the point where the overall density within the mussel communities returns to the levels of the late 1970s and early 1980s. Concurrently, conservation activities must have resulted in natural increases in mussel density in the other three rivers where viable populations have been reestablished.

d. An analysis of threats, including an analysis of the potential for a catastrophic event, must indicate that no continuing or foreseeable threats to the continued existence of the birdwing pearly mussel remain in the Powell and Clinch Rivers or in any of the three reestablished viable populations.

Cumberland Monkeyface Pearly Mussel

(Quadrula intermedia)

a. A naturally reproducing Cumberland monkeyface pearly mussel population at least as large as the Duck River population (in number of individuals and distribution over a similar size river reach) must be established in one river within the historic range where the species presently is not known to exist. This criterion can be met by establishing a population with laboratory-reared young. This population will be assumed to be reproducing when at least 2 distinct year classes, reproduced in the river, are found. One of the year classes

must have been produced within 5 years of the date "proven success" is determined. Within 1 year of the date of "proven success," gravid females of the species must have been present in the population.

b. A naturally reproducing Cumberland monkeyface pearly mussel population must exist in the Powell River. This population must inhabit approximately the same length of river and be approximately as large as was present in the late 1970s and early 1980s. This population will be assumed to be reproducing when at least 2 distinct year classes, reproduced in the river, are found. Both year classes must have been produced within 10 years and 1 year class within 5 years of the date "proven success" is determined. Within 1 year of the date of "proven success," gravid females of the species must have been present in each population. If this population falls below the levels of the late 1970s and early 1980s (which may already have occurred), the population can be supplemented with artificially propagated young to restore the adult (5+ years old) segment of the population to these levels.

c. Mussel conservation activities in the Powell River must be successful to the point that overall mussel densities return to the level of the late 1970s and early 1980s. Concurrently, conservation activities must have resulted in natural increases

in mussel density in the other river where a population has been reestablished.

d. An analysis of threats, including an analysis of the potential for a catastrophic event, must indicate that no continuing or foreseeable threats to the continued existence of the Cumberland monkeyface pearly mussel remain in the Powell River or to the reestablished population.

Tan Riffle Shell

(Epioblasma walkeri)

a. A naturally reproducing tan riffle shell population to replace the Duck River population must be reestablished in one river where the species presently does not exist. This criterion can be met by establishing a population with laboratory-reared young. This population will be assumed to be reproducing when at least 2 distinct year classes, reproduced in the river, are found. One of the year classes must have been produced within 5 years of the date "proven success" is determined. Within 1 year of the date of "proven success," gravid females of the species must have been present in the population.

b. Naturally reproducing tan riffle shell populations must exist in the Clinch and Middle Fork Holston Rivers, and these populations are to be at least as large as the levels that are

determined to be present in 1989. These populations will be assumed to be reproducing when at least 2 distinct naturally reproduced year classes are found in each river. Both year classes must have been produced within 10 years and 1 year class within 5 years of the date "proven success" is determined. Within 1 year of the date of "proven success," gravid females of the species must have been present in each population. If these populations fall below the 1989 levels, the populations could be supplemented with artificially propagated young to restore the adult (5+ years old) segment of the populations to 1989 levels.

c. Mussel conservation activities in the Clinch and Middle Fork Holston Rivers must have been successful to the point that overall mussel densities have returned to the levels present in the Clinch River in the late 1970s and early 1980s and to the point where no decrease below 1989 levels has occurred in the Middle Fork Holston River. Concurrently, conservation activities must have resulted in natural increases in mussel densities in the other river where a population was reestablished.

d. An analysis of threats, including an analysis of the potential for a catastrophic event, must reveal that no continuing or foreseeable threats to the continued existence of the tan

riffle shell remain in the Clinch and Middle Fork Holston Rivers or to the reestablished population.

I. Conclusion

If any modifications or changes are made to this project which were not part of this consultation, or if other information reveals impacts of this action which may affect listed species or critical habitat in a manner not previously considered, Section 7 consultation must be reiniatiated.

We appreciate your efforts to meet your responsibilities under the Endangered Species Act of 1973. Should you desire clarification of items in this opinion, wish to pursue other project alternatives that might avoid jeopardy, or feel a mussel conservation program could be successfully completed as a reasonable and prudent alternative, we would be happy to assist you further.

Sincerely,

Enclosure (References and Literature Cited)

cc:

Director, FWS, Washington, DC (EHC)

Field Supervisor, FWS, Cookeville Field Office, Cookeville, TN

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