PARKER

Dam at DRm 136.7
Lillard Mill at DRm 179

Report to OMB on Columbia Dam Alternatives

Tennessee Valley Authority

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FINAL

REPORT TO OMB
ON COLUMBIA DAM ALTERNATIVES

Prepared by

Tennessee Valley Authority

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FOREWORD

TVA was requested by the Office of Management and Budget (OMB) to study possible alternatives to the completion of the Columbia Dam and Reservoir as originally designed which might provide essential project benefits such as water supply and flood control needs of the Columbia area and be consistent with applicable laws such as the Endangered Species Act. This report summarizes TVA's study. It is not intended to be an exhaustive study but one that would identify possible alternatives to the project as planned and analyze pertinent factors as necessary to determine the reasonableness of these alternatives.

OMB requested TVA to evaluate alternatives and thus the report does not attempt to reanalyze the Columbia project as planned. The project as planned is discussed from a historical perspective and legal constraints are explained. In addition, conservation measures which may be undertaken to preserve endangered mussels are discussed. Details concerning the overall Duck River Project including the anticipated environmental impacts were addressed in TVA's final environmental statement and supplement. These issues have been further discussed in several public hearings regarding the Duck River Project.

The draft of this report was given wide dissemination. TVA submitted it to OMB on February 23, 1979. On the same day copies were distributed for review to Congress; the news media in Knoxville, Nashville, and the Duck River area; state and local agencies and organizations; and a representative of various interested environmental organizations. Copies have been sent to many other interested persons and organizations upon request. On March 12 TVA announced that public comment on the report would be accepted through March 31. Several comments were received and have been considered in developing this final report. Comments received are included in Appendix E together with TVA's responses.

The report has been reviewed by the TVA Board of Directors.

SUMMARY

This report summarizes a study by TVA of alternatives to the completion of Columbia Dam and Reservoir now under construction on the upper Duck River in Maury and Marshall Counties, Tennessee (figures 1 and 2). (Columbia Dam and Reservoir, along with the completed Normandy Dam and Reservoir, make up TVA's Duck River Project.) The report is prepared at the request of the Office of Management and Budget. The study investigated alternatives to the project as planned that would satisfy the needs in the Columbia area and at the same time not jeopardize the habitat for certain endangered species. At the same time it considered an option which would involve completion of the dam and reservoir as planned coupled with a conservation program to preserve the molluskan and other fauna in the area. This 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 exists in limited numbers.

Two alternatives were identified in the study. Both would require substantial changes in the project as planned. The first consists of modifications to the dam as planned to maintain a reservoir at a lower level (figure 4). The second alternative encompasses removal of the earth portion of Columbia Dam and developing the river in a planned fashion (figures 7a, b, c). Both alternatives would include a voluntary downstream relocation program in the Duck River floodplain through the city of Columbia to obtain some of the project benefits associated with flood damage prevention. In addition some kind of conservation program would have to be implemented to stop the declining population of endangered species.

The evaluation encompasses the completed Normandy unit to the extent that modifications would be made in the operation of Normandy Reservoir to enable releases to be made from the dam to meet projected water supply needs in the Columbia area.

The Endangered Species Act of 1973, as amended, provides in part, that no Federal action be undertaken which would jeopardize the continued existence of any endangered or threatened species or

result in the destruction or adverse modification of habitat judged the Department of the Interior to be critical. The mussel populat in the Duck River has been declining for the period of record, a quite probably before, presumably due to the deteriorating phys conditions and quality of the water. There are seven species mussels listed as endangered which could be expected to inhabit Duck River but a viable population of only one of these, Conrad caelata, has been documented. It has been listed as endangered its critical habitat has not been specifically designated. Conrad is found in the area of Duck River downstream from Lillard Mill da

This last remaining population of Conradilla in the Du River basin survives only downstream from an existing dam wh serves as a retention basin and creates an area with necess physical conditions including sufficient quality for the survival the species. It is also relevant that this dam is over 50 years and could be removed or destroyed by some natural occurance.

The Lillard Mill mussel population is located within presently planned impoundment area (figure 2) and thus would adversely affected by the completion of the project as planned. T and the Department of the Interior formally reinitiated consultati in January of this year concerning the project and endangered spec pursuant to Section 7 of the Endangered Species Act. Meetings w held in March to review the project's status, the most recent biologi information, and the alternatives under study. Under this proced the Secretary will provide TVA with a written statement setting fo the Secretary's opinion and a summary of the information on which opinion is based, detailing how the agency action affects the spec or its critical habitat.

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

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

The two alternatives identified were designed in an attempt to avoid the adverse impact to the mussel population at Lillard Mill Dam. An analysis of potential impacts to this and other endangered species in provided in more detail in Appendix A.

The low pool-downstream relocation alternative is designed to preserve the status quo with respect to the mussel. It would cost $55 million to complete or $41 million less than the project as originally planned but the recreation, flood control, and water supply benefits would be appreciably diminished. The reservoir would provide some recreation opportunities for the people of the area and could supplement and regulate flows from Normandy Reservoir. The downstream relocation component of the low pool alternative would capture a part of the flood damage prevention benefit; but the cost would greatly exceed the benefit. The low pool alternative would also require complicated operations of the dam and reservoir to protect endangered species and the water quality of the releases. These operational problems are so severe that TVA does not believe the low pool is a practical alternative. Finally, without some kind of conservation program this alternative would not stop the declining population of the endangered species.

The no impoundment-downstream relocation alternative would cost from $15 to $25 million to implement. The unimpounded river corridor could be developed in a variety of ways. In this report three levels of recreational development are presented. With the change in operation of Normandy Reservoir and the downstream relocation program, this alternative would be designed to preserve the habitat of the endangered mussel. It would provide the same water supply and flood control needs in the Columbia area as the low pool alternative. There are no recreational benefits associated with this alternative that are not otherwise available on the 150 miles of the Duck River which would remain if the reservoir option is adopted. As in the low pool alternative, without some kind of conservation program this alternative would not stop the declining population of endangered species.

HISTORY OF THE DUCK RIVER PROJECT

Early studies on development of the main stem of the Duck River, made as part of the general survey of the Tennessee River and its tributaries, were reported in House Document 328, 2d Session, 71st Congress (1930). In this document, six dam sites were identified on the Duck River from about mile 15 to mile 188. A brief study by TVA in 1951 considered sites at miles 147.7 and 191.3 as offering possibilities for development. However, the projects were not at that time found economically attractive.

In 1964 the leaders in Maury, Marshall, Bedford, and Coffee Counties (figure 1) organized the Upper Duck River Development Association to request assistance under TVA's tributary area development program. This program called for comprehensive unified resource development for the purpose of advancing economic growth through full use and development of all available resources. It focused on smaller areas with the same comprehensive approach that TVA has utilized in the whole Tennessee Valley. The leaders also saw the need to develop an organization with broad legal powers which had official recognition in the governmental structure of the area. In response to that need, the Tennessee Legislature created the Tennessee Upper Duck River Development Agency in March 1965 and gave it broad responsibilities for formulating and carrying out plans and programs for improving the economy of the area. In 1966 the Tennessee State Planning Commission designated the four Upper Duck River counties as a planning region and created the Upper Duck Regional Planning Commission to assist in the development effort. Thus, three different organizations, each performing a separate but vital task, were created to plan, guide, and support an overall development effort in the Upper Duck River Valley. Effective coordination was and still is achieved through a deliberate overlapping of membership on the board of directors of the three organizations and through the use of a common staff.

An inventory of the area's resources to identify its needs and opportunities was carried out through the Upper Duck River Development Association with TVA assistance. A report summarizing this effort

was published in July 1965. This inventory served as a platform from which to survey the region's assets and liabilities, to chart a course of action, and to make decisions regarding desired actions. Based upon the inventory findings, an analysis was made of the economy and future growth patterns in the four-county area, and several important needs were identified to help solve existing and future physical, economic, and social problems. Included were (1) an improved physical and cultural environment, (2) additional high-wage industrial job opportunities, (3) adequate and dependable water supply and waste treatment facilities, and (4) improved educational and vocational training. The Duck River was the focus of this comprehensive development plan.

In 1966 the Upper Duck River Development Agency proposed the development of a water supply grid system to serve the four-county area. It included plans for interconnecting the area's five major cities--Columbia, Lewisburg, Shelbyville, Tullahoma, and Manchester--for greater economy, to aid industries requiring treated water, and to supply water to small communities and rural areas of the four counties. Federal grants, supplemented by municipal bonds, were obtained to construct the grid system which is now largely completed. Branch lines from the grid system will ultimately be constructed to serve virtually everyone in the four-county area. The Upper Duck River Development Association and Agency received national recognition for this major accomplishment. With the local organizations concentrating on the water grid system and other concerns, TVA was requested to investigate water resource development.

TVA first determined that multipurpose reservoir development on the main stem of the Duck River offered the best potential. A reconnaissance study in 1965 identified three dam sites on the Duck River which, if developed, could control the river and provide new opportunities for recreation and lakeshore development. These sites were the Columbia site at Duck River mile 136.7, the County Line site at mile 191.3, and the Normandy site at mile 248.6. Feasibility appraisals indicated that the Columbia and Normandy sites should be considered in more detail. The County Line site was less attractive because of apparent foundation problems and was eliminated from further

consideration. Extremely tight scheduling of investigations on the Upper Duck River precluded a detailed overall appraisal of the water resource development as a system at that time. Therefore, on the basis of the information then available, it was decided to concentrate first on the planning studies for the Columbia site and then to focus attention on the Normandy site. A planning report issued in August 1967 recommended building a dam at Columbia. Further studies proved the feasibility of a dam and reservoir at the Normandy site. The two dam and reservoir projects were then presented as units of the Upper Duck River Project in a 1968 planning report. In that report the project was largely justified on the basis of enhanced employment (29 percent), recreation (25 percent), water supply (16 percent), flood control (7 percent), and water quality control (7 percent).

Streamflow regulation for water quality control was included in the Duck River Project in accordance with the requirements of public law 87-88 which required Federal agencies in planning and development of water resource projects to study the need to include water control storage. The results of TVA's studies concerning the need for streamflow regulation in the Duck River for water quality control were reviewed and concurred in by the proper reviewing agencies in 1967, 1968, and 1969. (At the time of original planning, consultation was with the Department of Health, Education, and Welfare; but it has since shifted to the Department of Interior and then to the Environmental Protection Agency.) The TVA water quality studies were summarized in an October 1969 report entitled "The Potential Impact on Water Quality of the Duck River Project." The final State of Tennessee Duck River Basin Plan based on the water quality control streamflow to be provided by the planned project was adopted by the Tennessee Water Quality Board in October 1974, approved by EPA Region IV, and distributed by the State in May 1975 (see Appendix B).

The project construction cost was estimated at $73.5 million of which $50 million was for the Columbia Dam and Reservoir. The benefit-cost ratio for the two-unit project was estimated at 1.2 to 1. For the Columbia unit the benefit-cost ratio was 1 to 1. The engineering studies and economic analysis for the planned project were summarized

in TVA planning report No. 65-100-1 entitled "The Duck River Project - Normandy and Columbia Reservoirs," issued in September 1968. The planning report was supplemented in October 1969 at the request of the Office of Management and Budget. The first appropriation came in December 1969.

Following the enactment of the National Environmental Policy Act of 1969, TVA prepared a draft environmental impact statement (EIS) which was published in June 1971. A public hearing on the project was held in August and a final EIS published in April 1972. The Environmental Defense Fund, Inc., filed suit in July 1972 challenging the adequacy of the final EIS. The case was tried in United States District Court in 1974, and the Court found the final EIS was deficient. A supplement to the final EIS was issued in June 1974 and court approval followed. Construction of Normandy Dam began in June 1972 and was completed in 1976 at a cost of $37.4 million. Construction at Columbia Dam was begun in August 1973, and completion as originally planned is now projected for 1985. Estimated construction cost now run $140 million. Construction of the Columbia Dam and Reservoir is about 30 percent complete ($44 million expenditures or commitments through FY 1978) however, certain activities have been curtailed pending approval of TVA's application to the Nashville District of the Corps of Engineers for a permit to place fill material below normal high water. Concurrent with the application to the Corps of Engineers, the Tennessee Division of Water Control was requested to review the application and to issue a certification in accordance with the requirement of the Federal Water Pollution Control Act (FWPCA). The State has issued a letter of intent to certify.

The Duck River Project (Columbia and Normandy Dams and Reservoirs) has had the overwhelming support of the local citizens of the area. It also enjoys the overwhelming support of local, state, and Federal elected officials. Indicative of local support, literally hundreds have appeared and testified at public hearings on the Duck River

Project. For example, in April of this year over 350 local citizens went to Washington at their own expense to appear before House and Senate Subcommittees on Public Works Appropriations. As further evidence of their support, the city and county governments, chambers of commerces, civic clubs and other organizations have passed numerous resolutions in support of the project. However, probably the greatest indication of support by the people is their willingness to underwrite the water supply portion of the construction of the project.

TVA entered into an agreement in 1971 with the Upper Duck River Development Agency covering local participation in the overall project. This agreement, in part, recognized TVA's commitment to include in the project design provisions for certain projected water supply needs in the area. The agency in turn committed to repay to the Federal Treasury a portion of the costs of the project. This payment would be from proceeds from the sale by the agency of specified quantities of water to the cities of Manchester, Tullahoma, Shelbyville, Lewisburg, and Columbia for a period of 50 years. This amount is being accumulated by a five cent per thousand gallon surcharge for water use beginning in January 1972. The agency's total repayment obligation is $16.2 million, with $5.7 million due ten years after completion of Normandy Dam and $2 million due ten years after completion of Columbia Dam, plus 3-1/2 percent interest on the unpaid balance. The remaining principal is to be paid in annual installments based on water supply withdrawals by the municipalities. Funds from the sale of water are being accumulated in an interest-bearing trust fund to meet these payment schedules. Under any of the plans being considered, sufficient water can be made available from operation of Normandy Reservoir to fulfill the agency's existing water supply commitments to each municipality.

Normandy Dam and Reservoir serves mainly Coffee and Bedford Counties. Since closure in January 1976 the dam has been operated to reduce a number of downstream floods on agricultural land and at Shelbyville, Tennessee, and to supplement low flows as necessary to satisfy Shelbyville's needs for water supply and water quality control. Tullahoma and Manchester are also making plans to supply future water

supply needs of Coffee County from an intake pumping plant constructed on Normandy Reservoir. In addition, Normandy operation fulfills water quality control requirements for waste assimilation at Columbia, Tennessee, and provides some additional flow for water supply. Normandy Reservoir has completed its third summer of operation and recreation activity is increasing annually.

Original plans for Columbia Dam called for a multipurpose reservoir to serve Maury and Marshall Counties with a summer pool at elevation 630 and a winter drawdown to elevation 603. The drawdown would allow sufficient flood detention capacity in the reservoir area to reduce the flood of record at the city of Columbia to essentially a nondamaging stage. The reservoir would also serve as an ample source of water supply for Maury County including the industrial complex downstream from the city. Water released from Normandy Reservoir for water quality control requirements, together with additional water from storage in Columbia Reservoir, would be released as required to meet future water quality control and water supply needs in Maury County. Columbia Reservoir, with four times the surface area of Normandy Reservoir during the summer months, would be expected to attract a diversity of recreational activity.

LEGAL CONSIDERATIONS

There are several major Federal laws or policies which could affect the completion of the Columbia Dam portion of the Duck River project. These are the Endangered Species Act of 1973; the National Environmental Policy Act of 1969; the Historic Preservation Act of 1966 and the related Executive Order No. 11593; Executive Order No. 11988, "Floodplain Management," which discourages unwise use and development of floodplains; Executive Order No. 11990, "Protection of Wetlands," which discourages new development in wetlands; the Water Resource Planning Act of 1965; the Federal Water Pollution Act; and the President's National Water Policy. As discussed below, the effect of many of these requirements would be different depending on whether the project is completed as presently designed or under an alternative design.

Endangered Species Act of 1973--The crucial provision of this act (Section 7) prohibits Federal agencies from undertaking any activity which would jeopardize the continued existence of an endangered or threatened species or which would destroy or adversely modify such species' critical habitat. Once an agency learns that its project or activity may have such an adverse effect on listed species, it is required to consult with the Department of the Interior in order to assure that the final action complies with the requirements of the act. At the conclusion of the consultations the Secretary of Interior suggests any reasonable and prudent alternatives he believes would resolve the conflict with the listed species. If the species problem cannot be resolved by consultation, the agency or the governor of the affected state may seek an exemption for the project, utilizing a two-stage review process under the act. Pending completion of this process or a delisting of the species or its critical habitat the agency cannot make any irreversible or irretrievable commitment of resources which would have the effect of foreclosing the formulation or implementation of any reasonable and prudent alternative measures which would avoid jeopardizing the continued existence of any endangered or threatened species or adversely modifying or destroying the critical habitat of any such species.

TVA and Interior are consulting concerning the Columbia project. This consultation began in mid-1976, after the listing by the Fish and Wildlife Service of six (now seven) species of freshwater mussels as endangered, designated as having occurred in the Duck River.

The consultation process, under Section 7 of the Endangered Species Act as recently amended was officially reinitiated in January of this year. TVA staff met again with the Interior staff in March to review the project's status, the most recent biological information, and the alternatives under study. In addition, the TVA Chairman has consulted with the Secretary and his Executive Assistant on several occasions. TVA and the Department of Interior have agreed to a 30-day extension of the consultation period. This extension will begin on the date that Interior receives a copy of this final alternative report. At the conclusion of the consultation period the Secretary will issue his final opinion as to the project's effect on endangered species and his suggestions as to alternatives.

National Environmental Policy Act of 1969--TVA filed a final environmental impact statement for the originally proposed Duck River Project in 1972. It was supplemented in 1974. Completion and impoundment and operation of the reservoir as now designed would not require additional NEPA review. In the event the scope of the project or substantial design or operating changes were made in the reservoir resulting in significantly different environmental impacts, a supplemental environmental evaluation would be required to document such changes.

National Historic Preservation Act of 1966 and Related Executive Order No. 11593--The Secretary of the Interior maintains a National Register of Historic Places (Register), and Federal agencies must consider the impacts of their projects upon such values and must consult with the Advisory Council on Historic Preservation on properties included in the Register or eligible therefor. TVA has not yet completed this process for the present project, but the final steps leading to compliance are underway at this time. TVA will be preparing a memorandum of agreement (MOA) pursuant to section 106 of the

National Historic Preservation Act to be entered into by TVA, the State of Tennessee Historic Preservation Officer and the Advisory Council on Historic Preservation. This MOA should be broad enough to cover all project alternatives.

Executive Order No. 11988, "Floodplain Management"--This order was issued May 24, 1977, and generally directs all Federal agencies to avoid taking action within the floodplain unless it is the only practicable alternative. If the floodplain cannot be avoided, agencies are instructed to adjust to the floodplain by reducing the risk of flood loss; minimizing the impact of floods on human safety, health, and welfare; and restoring and preserving the natural and beneficial floodplain values. TVA will implement the policies of the order and the procedures which it is developing [43 Fed. Reg. 24,228 (1978)] in TVA's continuing consideration of alternatives.

Executive Order No. 11990, "Protection of Wetlands"--This Order was issued May 24, 1977, and generally directs all Federal agencies to avoid supporting new development in wetland areas wherever practicable alternatives exist. If wetlands cannot be avoided, agencies are instructed to take all practicable measures to minimize harm to wetlands that may result. TVA will implement the policies of the order and procedures it is developing (43 Fed. Reg. 24,228 (1978)) in its continuing consideration of alternatives.

Water Resources Planning Act of 1965--Any alternatives that are examined for completion of the Duck River Project, including completing the dam under an alternative design, would be evaluated using the Water Resources Council's Principles and Standards. This would be done in the context of the planning and the overall review of the proposal.

Federal Water Pollution Control Act (FWPCA)--To the extent applicable to TVA-built structures in the Tennessee River System, section 404 of this act requires that discharges of dredged or fill material into waters of the United States be permitted by the Secretary of the Army, acting through the Corps of Engineers. The placement of soil, sand, rock, rubble, or similar materials in the waters of the Duck River to stabilize channel banks, emplace structures, divert flows, or

for other purposes constitutes a discharge subject to the requirements of section 404, and to the standards for evaluating such discharges, as specified in the section 404(b) guidelines of the U.S. Environmental Protection Agency. Certain features that might be considered for improvement of endangered species habitat would also require a 404 permit if they involved these types of materials discharges. If an alternative other than the project as planned is selected, TVA would apply for section 404 permit or permits required in conjunction with construction of further development features of the project. Corps of Engineers NEPA procedures require a review of the impacts from the whole project, not just the aspects of the project for which a permit is sought. The Corps can rely wholly or partially on an adequate EIS prepared by another Federal agency or they may hold additional hearings of their own. At present National Pollutant Discharge Elimination System (NPDES) permits are not required for reservoir discharges other than minor miscellaneous discharges; however, it is possible that such permits might be required prior to impoundment of the project. In connection with the obtaining of a 404 or NPDES permit, TVA must also receive from the State of Tennessee certification under Section 401 that the completion of the activities sought to be permitted will not violate Tennessee water quality standards.

President's Water Policy--The President's water policy message, delivered to the Congress on June 6, 1978, is an important directive to reform existing water resources development practices. On July 12, 1978, the President signed a series of documents outlining action to be taken by Federal agencies in implementing his initiatives. In the area of water conservation, the President directed all Federal agencies to incorporate water conservation requirements in all applicable programs. Water conservation practiced by the municipal and industrial users in the upper Duck River area could reduce the long-term average demand and thereby conserve related resources. TVA will promote water conservation as an integral part of the Duck River Project.

DEVELOPMENT OF ALTERNATIVES

The Office of Management and Budget, by letter requested that TVA investigate alternatives to the Columbia Dam and Reservoir, that would "satisfy the essential water supply and flood control needs of the area in a most cost effective manner and not violate the Endangered Species Act or any other existing statutes."

Early in the investigation it was determined that modifications might be made in the operation of Normandy Reservoir so that releases could be made from the dam to meet earlier TVA estimates of projected water supply needs in the Columbia area. (These projections are considered by many who oppose the project as being too high and by the local people as being too low.) However, the Board of Public Utilities for the city of Columbia believes that the water grid system, which they developed for Maury County, will require more than three times the water that TVA has projected. In addition, Williamson County officials have shown an interest in receiving water from the Duck River. Under those circumstances Normandy Reservoir would not be able to meet the future needs in the Columbia area without reservoir levels being adversely affected.

The specific modifications in the Normandy operation would include raising the winter level from the present 859 elevation on January 1 to elevation 866.5. The guide curve would also be further modified to allow filling of the reservoir to its normal maximum level, elevation 875, by the first of May instead of May 15 (figure 5). The modified operation would result in improved summer reservoir levels in many years especially during the early summer months and lower levels in dry years during August and September. During the dry years in particular there would be a problem in meeting flow objectives at Columbia on a timely basis because of the distance involved (115 stream miles).

As the study progressed it became apparent that consideration should be given to another option that might allow the project to be completed as planned. This would include the implementation of conservation measures to assure a habitat for the mussel population in the Duck

River superior to what presently exists. 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.

The first alternative considered in this study is the operation of the project at a lower level (figure 4) so that the reservoir would stop short of Lillard Mill Dam where the habitat of the endangered mussel is located. This low pool could serve as an alternate to Normandy Reservoir as a source of water supply but it would more than likely be operated to supplement and regulate flows from Normandy Reservoir to serve the water needs in the Columbia area in a timely manner. The low pool would also be a water base for recreation, wildlife management, and other development on a similar but substantially reduced scale to the project as planned. The dam could not, however, be operated for flood control; a downstream relocation program would be required to provide for this.

The second alternative would be to remove the earth portion of Columbia Dam and not impound water. The Duck River corridor in the area could then be developed in a planned manner. Development could vary from a full range of developmental opportunities to minimal facilities. The downstream relocation program to provide flood damage prevention could also be included as a part of this alternative.

The option involving completion of the project as planned and the two alternatives are described in the following sections of the report. Estimates of remaining costs are compared in table 1. These estimates do not include the conservation measures described on pages 18 through 21. The cost estimates for the reservoir options have a greater degree of accuracy than the river development options.

PROJECT AS PLANNED--WITH CONSERVATION

Description

If the Columbia unit of the Duck River Project were to be completed as originally planned, the dam would create a 12,600-acre multiple-purpose impoundment at normal maximum pool, elevation 630, which would extend some 54 miles up the Duck River in Maury and Marshall Counties (figure 2). The reservoir would be drawn down after October 15 each year in order to provide winter flood detention capacity. This drawdown would also effectively control potential excessive growth of aquatic weeds. Except during flood conditions, the reservoir level would then be at elevation 603 until February 1, after which time the pool level would be raised gradually along a guide curve with the objective of reaching and maintaining recreational pool levels within about 5 feet of normal maximum pool throughout the summer months.

An estimated 27,500 acres of land would be acquired for the reservoir area. The project would affect about 45 miles of highways, most of which are secondary. It would also require the rebuilding at a higher elevation two bridges of Interstate 65 that span the Duck River and about 3 miles of the interstate.

The dam as originally designed includes a concrete gravity nonoverflow section on each side of a 5-bay concrete spillway and a main embankment of rolled earthfill. The top of dam would be at elevation 648. Discharge facilities would inclue 4 large spillway gates with crest at elevation 594, a large water quality spillway gate with crest at elevation 615, an intermediate level sluice at elevation 613, and two regulating sleeve valves at elevation 584 (figure 3). These features were incorporated in the dam to provide operating flexibility to protect downstream water quality and to provide temperature regimes to enhance the downstream warm water fishery. To further improve operations for water quality, it is now proposed to replace the intermediate level sluice with an additional high-capacity regulating sleeve valve. A multiple-level gating structure would then be added to the face of the dam enclosing the three regulating sleeve valves. Several gated openings

would be provided between elevations 570 and 610. With these gate openings at various levels, withdrawals could be selected from a reservoir stratum having good water quality.

If the Secretary of Interior approves the following conservation plan and TVA obtains the required Section 404 permit from the Corps of Engineers full construction could resume. This would include diverting the river (third stage diversion) through the two spillway bays that have been left open to elevation 568 (figure 3) and completing the dam; completing highway and other relocation work; and acquiring the remaining land. River diversion would continue through the two spillway openings until the Department of Interior determines that the conservation program has been carried out. During this period, Columbia Dam would operate as a self-regulating structure. At extreme low flows in the Duck River the restricted openings would provide some reregulation of the releases from Normandy Dam. During normal flows backwater would extend from elevation 571 at the dam upstream horizontally to about Duck River mile 156 (just downstream from Sowell Mill Pike bridge at Leftwich) where it would intersect normal flows within the streambanks. At flood flows of 5, 10, and 20 year frequencies the backwater affect upstream from mile 156 would be minor.

Conservation Measures

The freshwater mussel fauna of the Duck River has been the subject of at least six surveys during this century. The earliest of these (1921-23) produced 48 species and considering some scattered earlier records identified a total of 55 species thought to occur in the Duck River system. An extensive survey in 1965 located 47 species while recent surveys (1972, 1976, and 1978) showed a further decrease to 30, 26, and 26 species, respectively. Additionally, the 1976 and 1978 investigations showed that most of the species still present occurred only at a few sites downstream from Lillard Mill Dam and the old Columbia Dam. The cause or causes of this rapid and widespread decline in mussel diversity and numbers cannot be scientifically established. Periodic water quality studies conducted since the late 1930's indicate stable water quality conditions in general. However,

these studies do not provide full documentation of any deviations in water quality which may have occurred during the interim periods between the studies which may have contributed to the decline in mussel diversity. Thus, for whatever reason, a threat to the continued existence of the remaining forms must be considered a probability based on the apparently continuing decline. Unless conservation measures are initiated there is every reason to suspect that the general decline will continue.

The prior existence of diverse assemblages of freshwater mussels immediately downstream from low dams has indicated the possible importance of such a physical structure to these communities. The obliteration of these communities by the failure of low dams, e.g., Wilhoite Mill and Hardison Mill, during the period 1955-1965; and the remaining community below Lillard Mill Dam, which continues to exist, serve as evidence that conditions are improved for survival of mussels by the existence of such structures. These low dams probably serve as habitat stabilizing features which modify flow and quality characteristics, improve dissolved oxygen levels and substrata, decrease turbidity and enhance nutrient cycling, all of which presumably create a microhabitat conducive for enhanced productivity and survival of the mollusk community.

Water Quality and Habitat Improvements - The central reach of the Duck River presently receives run-off from farmland, and effluents from several municipalities, and some separate industrial complexes. In order to restore the natural biota of the river, it would be necessary to reproduce, as much as possible, the natural water quality and habitat conditions of centuries ago. The Columbia Dam would be operated to ensure the release of high quality water. Additionally, dischargers of effluents to the river would be expected to provide waste water treatment of levels necessary to maintain the stream use classifications of the river as designated by the Tennessee Water Quality Control Board. These conditions are predicted to produce an improved environment for mollusk, fish and other aquatic organisms.

To accomplish this objective, it is recognized that anticipated impoundment phenomena, such as the occurrence of low dissolved oxygen levels, high concentrations of soluble forms of iron and

manganese, and blooms of nuisance algae would have to be mitigated. To overcome these conditions provisions have been included in the dam structure to provide operating flexibility, to ensure that all releases have dissolved oxygen concentrations of at least 5 mg/1, and that all releases are free of the influence of any nuisance level algal blooms which may occur in the reservoir. However, during the initial few years of lake aging, soluble forms of iron and manganese would be expected to occur in the releases which could impact downstream water uses as well as biota in the downstream reach. Also, if river diversion through the two spillway bays has to be continued for an extended period of time there will be little flexibility to prevent the releases from reflecting the impacts of any nuisance level algal blooms which may occur in the temporary impoundment. For these reasons the transplants mentioned below would not be made downstream from Columbia Reservoir at least until after the initial aging period.

Following the initial period of lake aging, the criteria under which Columbia would be operated and the other downstream point source discharges controlled would be based on the designated stream use classifications of the downstream reaches.

Low Dams - Tailwater reaches downstream from the existing low-level dams on the Duck River at the old Columbia (Duck River mile 130) and Lillard Mill (Duck River mile 179) contain the greatest known concentrations of mussels in the Duck River. This would suggest that certain environmental conditions exist below these two dams, which are essential for the survival of these mussel populations. Reconstruction and renovation of old mill dams at historic sites and construction of new low-level dams or similar structures would create habitats more likely to be colonized by freshwater mussels.

Shoal Areas - Natural shoals in the river would be protected from gravel dredging and other adverse impacts. Recolonization of molluscs should occur by natural processes or may be augmented by transplants.

Transplants - Transplanting all of the freshwater mussels from the section of the river to be impounded to locations, either in the Duck River (e.g., downstream from the Shelbyville Dam) or elsewhere, may be desirable to ensure the continued existence of these species. Reaches of the Clinch, Powell, and North Fork Holston Rivers

Downstream surveys of T & E species?

are good candidate sites for locating these specimens outside of the Duck River system. No transplants are planned downstream from the existing old dam at Columbia at least until after the initial period of lake aging in the new reservoir.

To provide additional conservation, measures would be undertaken to protect existing mussel populations elsewhere. Viable populations of Cumberlandian species also exist in the Clinch, Powell, North Fork Holston, and in other areas in the Valley. It would be proposed to appropriate state agencies that sanctuaries be created in some of these rivers and enforcement of protective measures would be supported. Recognizing that the creation of sanctuaries alone may not provide all the protection these species require, special programs would be developed to abate existing environmental problems on these rivers to include actual reclamation of disturbed land areas, upgrading of municipal waste treatment systems, consistent with stream use classifications, and improving soil erosion control practices in the Clinch-Powell watersheds.

Who will do this and how?

Regulatory Measures - Working through appropriate state agencies, additional regulatory measures would be promoted (including financial assistance to state enforcement programs if necessary) to control the protection, taking, or disturbance of certain freshwater mussel species in some areas. Live specimens should be taken from designated sanctuaries by permit only. Appropriate state agencies would be encouraged to restrict gravel dredging and the taking of freshwater mussels for bait in sanctuary areas and in other sensitive parts of the ranges of some species.

Benefits

The project was planned to provide flood control benefits to urban and agriculture land downstream from the dam; to improve the quality and quantity of water available for municipal and industrial use in Maury County; to create recreational opportunities, including fishing and hunting in and around the reservoir; to provide a setting for shoreland development; and to provide higher wage employment for the subemployed in the area. Figure 2 shows a land use plan for the project as planned.

What is in Duck River downstream from Columbia Dam ?

Operating Columbia Dam to assure desirable water quality and controlling point source discharges into the river should restore the ecology of a major portion of the Duck River downstream from Columbia, Tennessee. This restoration would include the revival and maintenance of the fish and other fauna in the full reach of the river. If the project were to achieve its goals, enhanced resident populations of sport fish would exist throughout the river as would numerous species of molluscs and other animals and plants characteristic of a flowing stream. In addition, large numbers of many fish species would migrate annually from the Kentucky Lake impoundment of the Tennessee River into the Duck River and its tributaries to spawn. This self-sustaining system could harbor an especially wide variety of many types of species, which could be used to recolonize newly reclaimed streams throughout the Tennessee and lower Ohio drainage basins.

Should the conservation measures produce appropriate habitat in the Duck River, the molluscan and other fauna of the river can be expected to regain much of its original diversity and abundance. Reaches of the river which presently contain none or only a few individuals or species of freshwater mussels could be expected to support diverse mussel populations. Such areas could serve as laboratories for the study of life history and ecology questions and as sources of specimens for other scientific and transplant purposes.

If both the area between Normandy and Columbia impoundments and the stream reach immediately downstream from the existing old Columbia Dam are restored, elements of the upper Tennessee (Cumberlandian) and the interior basin (Ohioan) freshwater mussel faunas might be reestablished and protected in the river. These species would represent a fair proportion of the diversity of freshwater mussels present in the entire Tennessee drainage basin.

LOW POOL-DOWNSTREAM RELOCATION ALTERNATIVE

Description

This alternative proposes that Columbia Dam be completed and operated at a low pool that would not impound the reach of the Duck River just downstream from Lillard Mill Dam (mile 179) known to be the habitat for the remaining endangered mussel. In addition the alternative includes a downstream relocation program in the Duck River floodplain through the city of Columbia.

The low pool would normally impound water to elevation 600 extending some 36 miles up the Duck River to about mile 173 (figure 4). It could be operated in conjunction with Normandy Reservoir to provide the Columbia area a water supply and would be very useful in regulating flows to meet the total water needs of the area on a timely basis. It would also serve some recreational needs in the Columbia area. The low pool would have no detention capacity for flood control. In its place this study proposes that TVA support a downstream relocation program that would enable residents and businesses in the most vulnerable areas along the Duck River floodplain in the city of Columbia to relocate to flood-free locations. This program would only partially replace the local flood control benefits of the project as planned; but it would benefit those most directly impacted by the frequent flooding of the Duck River.

The low pool alternative assumes that Columbia Dam would be completed essentially as described in the section on Project as Planned, with the exception of the two spillway bays which have been left down for diversion purposes. Spillway crests in these two bays would be constructed to elevation 585 for one and elevation 600 for the other instead of elevation 594 as now designed (figure 3). This modification would increase flexibility for water quality control and flood operations and would still allow impounding at a higher elevation in the future should that option prove to be desirable.

The low pool would be operated at normal maximum elevation 600 during ten months of the year. It would fluctuate between elevations 600 and 605 as required to handle moderate flows that might be

expected during those months. An occasional rise to around elevation 610 at the dam might be required during moderate to high flows. This would be especially true should potential nuisance level eutrophic conditions occur in the reservoir that would require making downstream releases from lower levels in the reservoir through the limited capacity regulating sleeve valves. Reservoir operations during these times could be delicate. The longer the reservoir would have to be held at the higher elevation the greater the chances of predator fish preying upon the smaller host fish in the Lillard Mill area. Conversely, if flows should become so great that downstream releases would have to be made by opening spillway gates, downstream water users could be adversely impacted. The success of this operation would depend on intensive water quality monitoring.

During a minimum six weeks period in January and February the reservoir would be drawn down to elevation 590 to control the potential growth of excessive quantities of aquatic weeds. This drawdown would dewater the colonized areas allowing the weeds to dry up and die. During these winter months nuisance level eutorphic conditions would not be a problem so all discharge facilities could be operated to handle the larger flood flows that have historically occurred during those months. Even so, the reservoir might be expected to rise from the elevation 590 drawdown to elevation 608 at the dam during a flood of ten-year frequency and to about elevation 613 at the dam during a 100-year frequency. In the Lillard Mill Dam vicinity these elevations would be 641 and 645, respectively, the same as under existing conditions. At the Interstate 65 crossing of the Duck River (mile 151.5) the flood of 100-year frequency would pass at elevation 617, about one foot below low steel on the existing bridges. These infrequent rises during flooding would last for a few days. Although there is concern about predator fish from the reservoir preying upon the smaller host fish at times when the reservoir would be above elevation 600, the high stream velocities during flooding would tend to restrict the upstream migration of these fish.

Sediment accumulation could also be a problem in operating the low pool. Estimates, based on observed data, show that sediment could be expected to fill the low pool to normal maximum elevation 600

in about 100 years. There has been a downward trend in sediment loads over the past 45 years as erosion control measures and improved agricultural practices have been put into more general use. To the extent that this trend continues into the future, the 100-year estimated time for accumulation of sediment would be increased. If this sediment accumulation occurs it would adversely affect recreation activities in and around the reservoir. It would also reduce the water supply storage capability of the reservoir.

An estimated 18,500 acres of land would be included in the purchase boundary for this alternative (table 2). Included in this land are areas which would be developed for recreation, wildlife management, and agriculture demonstration (figure 4). This land includes all of the approximately 11,100 acres already acquired for the project as of September 30, 1978, and an additional 7,400 acres that would have to be purchased.

The low pool alternative would affect some 25 miles of highways, most of which are secondary. Some of these roads have been or are being constructed at this time. The two bridges of Interstate 65 spanning the Duck River would not have to be rebuilt as they would with the project as planned.

The voluntary downstream relocation program, proposed as a part of this alternative, would be carried out by the city of Columbia with financial and technical assistance from TVA. As now envisioned it would include the relocation of twenty-six residences and businesses from the floodplain in the Riverside community, protection of the school in the same area, and relocation of some 17 structures in the Helms Branch area east of the main business district (figure 4). The cleared areas could be utilized for park, recreational, or other uses compatible with the flood hazard and the city of Columbia floodplain regulations. This program would partially compensate for the loss of flood detention capacity that was included in the planned project but the cost would greatly exceed the benefits. Further studies are required before a final plan could be developed for this program.

The cost to complete the combined low pool-downstream relocation alternative would be an estimated $55 million. An additional $700,000 in public money would be required for recreation facilities.

The cost of the downstream relocation program alone would be some $7 million (table 1). Annual costs, including interest and amortization charges for capital over the project economic life and annualized operation, maintenance, and replacements are estimated at $4.4 million. The current discount rate of 6-7/8 percent and a 50 year evaluation period was used.

Benefits

The low pool - downstream relocation alternative would provide similar types of benefits to those provided by the project as planned but at a substantially reduced scale. The benefits of the low pool alternative are described in the following paragraphs. (A river development plan outside the impoundment area is discussed in Appendix C.)

Flood Damage Prevention--The downstream removal program would provide an opportunity for residents and occupants of the flood hazard area of the city of Columbia to locate to flood free locations, thereby reducing the perpetual threat from destructive flooding. The annual benefit would be an estimated $12,000.

Recreation, Cultural, Fish and Wildlife--At elevation 600 the surface area of the low pool would cover some 3,700 acres. In comparison with Columbia Reservoir as planned, this pool would be about one-fourth the size, would be some 18 miles shorter in length and have considerably less shoreline. It would lack much of the wide and deep expanse of the high pool and would have the characteristics of a winding river over most of its length as compared to the upper reaches of the high pool. Based on an analysis of land-to-water relationships, lake configuration, and potential of other lakes in the vicinity, the recreation potential of this project would be limited. However, the presence of a relatively more stable pool would be a positive attribute that would help to offset some of these limitations. Recreation activities along the lower ten miles having a lake setting would be supported by a moderate size public recreation area including a marina. A public park would also be envisioned and six boat launching ramps would be sited at various locations to provide an even distribution of the lake access opportunities. A demonstration regional recreation/environmental education center (figure 6) would be located at Cheek Bend (mile 155) with

an associated educational outpost at Lillard Mill. Additional access sites would also be located upstream from Lillard Mill Dam and in the vicinity of Henry Horton State Park. This would provide easy access to some 12 miles of stream for river recreation (figure 4).

This low pool with its reduced surface acreage would of course offer reduced opportunities for boat and bank fishing. Artificial fish attractors would be installed to replace cover removed from the reservoir and one fishing pier and shoreline fishing facility would be developed. The ability to develop the downstream warm water fishery as planned for the original project would be questionable.

A viable wildlife management program would be developed in the Fountain Creek arm of the reservoir and in the Cheek Bend area on some 6,000 acres of land already largely in TVA ownership (figure 4). Agricultural land would be farmed under arrangements with local farmers and the Tennessee Wildlife Resources Agency. Management options, especially hunting, might be limited by the anticipated Columbia urban expansion along State Route 50, particularly in the Fountain Creek area. Management in the Cheek Bend area would complement public recreation development plans for that area. The wildlife management program would be expected to complete TVA's mitigation of impacts to fish and wildlife from the entire Duck River Project.

TVA proposes to develop a historic community of structures which are representative of the settlement and growth of this area through the 19th century. This proposal is outlined in Appendix D. TVA also plans to create an inventory of logs and related construction materials from among the 50 or more non-Register eligible log structures that have been acquired as a part of this project. These include houses, sheds, cribs, and barns. Such materials are in short supply for historic restorative projects. They would be stored for future public or quasi-public agency use.

Since the low pool would cover only one-fourth of the land impounded by the project as planned the number of archaeological sites inundated would be reduced. Any land to be sold or transferred would be handled according to established procedures concerning the protection of archaeological resources. If significant archaeological sites

are found some of them might also contribute to the interpretation of the history of the area. The annual recreation benefit for the low pool is estimated at $1.8 million. This estimate is based on the travel cost measure of willingness to pay methodology.

Agriculture--Some 1000 acres of agricultural land in the project area above low pool has been tentatively identified to be farmed under arrangements with local farmers and the Tennessee Wildlife Resources Agency. In some locations the lease may provide for a percentage of the crop harvest to be left in the field for wildlife. Land could be leased for crop production, livestock or dairy farming. Dairy and livestock units would involve a long-term lease designed to facilitate private capital development, demonstrate improved management and farming systems for the area, and to insure that appropriate practices are utilized to prevent soil loss. Technical assistance will be provided and operators will agree to set goals, keep adequate farm records, and make investments similar to particpants in the TVA Land Grant University Resource Management Farm Program. This demonstration program would have an annual benefit estimated at $76,000.

Adverse or Irreversible Impacts

Endangered Species--If this option was otherwise feasible the conservation measures described under the project as planned could be implemented.

Aquatic Ecology--Compositional shifts within the phytoplankton community may at times involve excessive numbers of nuisance algal taxa including blooms of blue-green algal cells such as Anabena, Aphanizomenon, and Microcystis. These are capable of producing obnoxious tastes and odors and have been reported to cause toxicity to both agricultural and public water supplies. Other phytoplankton cells such as Synedra may be produced in sufficient numbers to cause filter clogging problems in municipal water treatment facilities. It is not possible to completely predict the trophic status of Columbia Reservoir due mainly to the lack of a sufficient understanding of all factors involved (Appendix B). However, the potential for adverse impacts associated with nuisance-level phytoplankton production in the low pool would be greater than in the project as planned.

A number of undesirable and weedy species of aquatic plants may colonize some of the 1,400 acres that would be available for rooted aquatic plants (macrophyte growth). The potential for adverse impacts would be greater than for the project as planned but the acreage available would be less than half. Excessive growths of weedy species would enhance mosquito production, reduce recreational potential, and create problems relating to water quality. Impoundment would destroy riverine and existing wetland habitats in addition to eliminating beds of a submersed plant (a river weed - Podostemon), which supports a large and diverse aquatic insect community (Appendix B).

Water Quality--It is not possible to predict with certainty the frequency of adverse eutrophic conditions in the low pool; however, operating flexibility would be provided to minimize the chances of tastes and odors associated with blue-green algal blooms in the reservoir, occurring in the releases and adversely impacting downstream water supplies. The reduced volume of water available in the hypolimnion of the low pool as compared with the project as planned decreases the ability for operation during extended periods of algal related problems in the epiliminion. However, these extended periods should be rare. The use of selective withdrawal of water from the lower level of the pool may adversely impact the ability to develop the warmwater fishery downstream of the dam as included in the project as planned. Releases through the regulating sleeve valves would effectively result in oxidation of the soluble forms of iron and partial oxidation of the soluble manganese concentrations. (See Appendix B.)

Historical and Cultural Sites--While the review of cultural properties has not yet been completed with the State and the Advisory Council on Historic Preservation, only one house currently judged eligible for inclusion in the National Register, the Rieves House, would be affected by the low pool. An undetermined number of archaeological sites would be inundated. Mitigation of impact would be undertaken in accordance with established procedures if there are sites among these which are judged eligible for addition to the National Register of Historic Places.

Recreation--Thirty-six miles of stream now receiving some use for canoeing, floating, fishing, and other river-oriented recreation activities in the Columbia area would be impounded and lost for canoeing and floating. Sediment accumulation in the reservoir might adversely affect some recreation activities, especially in later years. The ten foot drawdown would expose some 1,400 acres of previously inundated portions of the shoreline during the winter months when water-oriented recreation would be limited. This impact would largely involve the appearance of the reservoir.

Agriculture--Some 18,500 acres of land would be lost to private ownership as compared with 27,500 acres for the project as planned. This land is used primarily for agricultural production including farm woodland. Major crops in the area are corn, soy beans, wheat, tobacco, and hay. There are 1,400 acres of prime farmland[1] that would be inundated and another 5,000 acres around the reservoir within the purchase boundary. In addition, there are about 600 acres of farmland of state-wide importance that would be inundated and another 900 acres around the reservoir. No unique farmland has been delineated in the reservoir area.

The estimated farm sales for the low pool project area is 50 percent of that for the project as planned ($1 million in 1977 dollars). The gross value of the decline in farm related business activity in 1977 dollars is estimated to be $2.5 million.

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1. Prime farmland is land best suited for producing food, feed, forage, fiber, and seed crops. It has the soil quality, growing seasons and moisture supply needed to produce high yields of crops economically when treated and managed according to modern farming methods. It does not have a serious erosion hazard.

   Unique farmland is land other than prime farmland that is used for the production of specific high value food and fiber crops. It has the special combination of soil quality, location, growing season, and moisture supply needed to economically produce sustained high quality and/or high yields of a specific crop when treated and managed according to acceptable farming methods.

   Additional of Statewide Importance is, in addition to prime and unique farmlands, significant for the production of crops as determined by the appropriate state agencies.

Conclusion

Without some kind of mussel conservation program being implemented this alternative would only preserve the status quo. Indications are that unless steps are taken the mussels would probably eventually become extinct. The value of the low pool to the Columbia area is limited. While it could serve as a source of water supply this source could be depleted over time by sediment accumulation. The only significant purpose of the low pool would be to serve recreational, cultural, fish and wildlife needs. The annual value of these activities would be substantially less than that estimated for the project as planned. The downstream relocation program for flood damage prevention is an independent action which costs many times more than the benefits claimed. In TVA's judgment the problems of operating the low pool to avoid impacting the habitat of the endangered mussel coupled with the uncertainties of water quality rule out this alternative.

NO IMPOUNDMENT - DOWNSTREAM RELOCATION ALTERNATIVE

Description

This alternative is in three separate parts. First, the earth portion of Columbia Dam would be removed and no water would be impounded. Second, the 54 mile reach of the Duck River from the dam site to mile 191, above Henry Horton State Park, would be developed in a planned manner. Three levels of river related development are proposed for this reach, varying all the way from full recreation, cultural resources development, and a wildlife management program with agricultural production and demonstration to a limited wildlife management-agricultural program and a few camping areas providing access points for river recreation. (figures 7a, 7b, and 7c) Any land purchased in the area which could not be utilized under the level of development implemented would be returned to the private sector. Third, the downstream relocation program described under the Low Pool - Downstream Relocation Alternative would be utilized.

The cost to complete the three parts would vary from an estimated $15 to $25 million depending on which river development plan is selected (table 1). The cost to complete the downstream relocation program alone would be some $7 million. Annual costs, including interest and amortization charges for capital over the project economic life and annualized operation, maintenance, and replacements are estimated to range from $1 million to $2.2 million. The current discount rate of 6-7/8 percent and a 50 year evaluation period were used in this calculation.

That portion of the earth fill at Columbia Dam already in place would be removed to reduce floodplain impacts and hazards. Studies show that the concrete spillway and nonoverflow section could be left in place without adversely affecting flood conditions in the area. (Removal of this concrete would increase the costs by about $1.7 million.) This alternative assumes that the concrete portion would be left in place and isolated by fencing, leaving to a later time the final decision on its removal.

The following subsections address the three levels of river development in the 54 mile reach under study and describe the benefits and adverse impacts associated with them. (Appendix C discusses additional Duck River development opportunities outside the scope of this study.)

Maximum Development Level (figure 7a)

Components and Benefits--The following represent the scope of activities proposed for this level of development. Annual benefits for this level of development include $1.4 million for recreation activities as described in the following items and $152,000 for the agricultural demonstration program described under item I.

A. A minimum 50-foot "greenbelt" easement on either side of the stream from the dam site (mile 136.9) to Henry Horton State Park would be maintained for bank stabilization, erosion control, flood plain management and enhancement of wildlife. The "greenbelt" easement will also maintain the pastoral beauty of the river. The easement would be obtained at the rate of 12 acres per river mile.

B. Eight river access sites each consisting of a parking lot, boat/canoe launching ramp, and bank fishing facilities comprising an average of two acres each, would be developed for boating, fishing and consumptive-non-consumptive wildlife uses.

C. A total of 12 informal, primitive camping areas (accessible by river only) would be developed. Each site would average two acres in size. Adirondack-type shelters would be constructed.

D. A main hiking trail approximately 54 miles in length, paralleling the river within the "greenbelt" and linking significant natural history features would be constructed. This trail would facilitate other river oriented recreation use.

E. Sites containing significant natural, historical, cultural, and/or archaeological resources which have been identified, would be proposed for management and development for interpretive and environmental education use. These areas will be joined by an interlocking system of additional hiking trails.

F. A demonstration regional recreation/environmental education center (figure 6) would be built at Cheek Bend (mile 155) with an associated educational outpost constructed at Lillard Mill (mile 179).

Approximately 100 acres of additional land should be purchased to eliminate inholdings in the Cheek Bend area and to acquire land at Lillard Mill.

G. Improvements would be undertaken at suitable sites throughout this stretch of the river to provide improved fishery habitat and improved conditions for water based recreation.

H. Catchable size fish such as channel cat would be stocked on a put and take basis to accommodate increased fishing demand.

I. The central theme for the Columbia unit of the Duck River Project would shift from reservoir oriented recreation-wildlife management to a riverine system. If this occurred, the lands already acquired from the dam site upstream to and including the Fountain Creek area and the Cheek Bend area upstream from the interstate lend themselves well for development as a National demonstration of wildlife management-agriculture-outdoor recreation. Wildlife enhancement would be instituted on some 9,600 acres acquired to date and an additional 3,200 acres within the original purchase boundary which have not yet been purchased. The additional acreage would eliminate inholdings. Some 2000 acres of agricultural land would be farmed under arrangements with local farmers and the Tennessee Wildlife Resources Agency. In some locations the lease may provide for a percentage of the crop harvest to be left in the field for wildlife. Land could be leased for crop production, livestock or dairy farming. Dairy and livestock units will involve a long term lease designed to facilitate private capital development, demonstrate improved management and farming systems for the area, and to insure that appropriate practices are utilized to prevent soil loss. Technical assistance will be provided and operators will agree to set goals, keep adequate farm records, and make investments similar to participants in the TVA Land Grant University Resource Management Farm Program. Consequently, agricultural lands, particularly prime lands, would be kept productive.

J. Additional wildlife management practices such as constructing nesting structures would be utilized along the river greenbelt corridor.

K. TVA could relocate and restore certain houses already owned by TVA in an appropriate setting near Milltown (Lillard Mill). These houses are examples of the progress of this area as portrayed through architectural style from earliest settlement through the pioneer period. They would form a record of the history within the watershed, and also of the westward movement in Tennessee. A plan, for this and other elements concerning cultural resources is set forth in Appendix D.

L. Some 1,500 acres of land purchased to date would be returned to the private sector.

Adverse or Irreversible Impacts--The following represent the range of impacts which can be expected for this level of development.

A. Short-term impacts to recreation areas during the construction of facilities in the nature of siltation and habitat disturbance will occur.

B. Some 13,200 acres will be lost to private ownership (table 2). This impact, however, will be offset by the managed recreational, wildlife and agricultural areas under this option. The decline in farm sales from this reduced farm acreage would be about $700,000 per year in 1977 dollars compared with $2 million per year for the original project. This amounts to $1.8 million in reduced farm-related business per year.

C. Increased fishing pressure could deplete certain native game species. This impact may be mitigated if stocking of catchable size fish proves feasible. Similarly competition and predation by stocked fish may adversely affect native species. This effect may be offset by the improvement of fishery habitat.

D. Uncontrolled access and river use at Lillard Mill could disturb the endangered mussel habitat, including the increased opportunity for illegal collection. These impacts should be avoided by controlling access and area development planning. TVA is studying ways to avoid such adverse effects.

E. Increased public use of the natural resource must be expected. Facility and access planning will help to lessen impacts from public use.

Medium Development Level (figure 7b)

Components and Benefits--The following represent the scope of activities proposed for this level of development. Annual benefits for this level of development include $1.1 million for recreation activities described below and $152,000 for the agricultural demonstration program mentioned in item F.

A. A minimum 50-foot "greenbelt" easement on either side of the stream from the Interstate 65 crossing of the Duck River (mile 151) to Lillard Mill Dam (mile 179). This easement would be maintained for bank stabilization, erosion control, and floodplain mangement.

B. Four river access sites each consisting of a parking lot, boat/canoe launching ramp, and bank fishing facilities comprising an average of two acres each, would be developed on the 30-mile stretch. Additional sites downstream from I-65 will be developed for boat access only.

C. A total of seven informal, primitive camping areas (accessible by river only) would be utilized.

D. A hiking trail of 30 miles in length would be developed in conjunction with the greenbelt.

E. The demonstration regional recreation/environmental education center (figure 6) at Cheek Bend (mile 155) would be constructed as previously described.

F. Wildlife enhancement would be instituted on some 7,000 acres purchased to date and on some 2,000 acres within the original purchase boundary which have not yet been purchased. Development including the agricultural demonstration program on some 2000 acres would be similar to that described under the maximum level except that the Cheek Bend area would not be utilized.

G. Wildlife management practices would be utilized along the river greenbelt corridor.

H. The historic resources program would be the same as described in Appendix D.

I. Improvements would be undertaken at suitable sites to provide improved fishery habitat and improved conditions for water based recreation.

J. Some 4,000 acres of land already purchased would be returned to the private sector.

Adverse or Irreversible Impacts--The following represent the range of impacts which can be anticipated for this level of development.

A. Short-term impacts will be as previously described.

B. About 9,400 acres will be lost to private ownership (table 2). The decline in farm sales from this acreage taken out of farm production would amount to $0.5 million per year in 1977 dollars. The reduction in farm-related business would be about $1.3 million per year.

C. Increased fishing pressure would not be expected to be a serious problem at this level of development.

D. Adverse impacts could occur at Lillard Mill access as previously described.

E. Decreased public use would be expected under this option, requiring less extensive planning to avoid undue stress.

Minimum Development Level (figure 7c)

Components and Benefits--The following represent the scope of activities proposed for this level of development. Annual benefits for this level of development include $700,000 for the recreation activities described below and $76,000 for the agricultural demonstration program mentioned under item C.

A. Eight river access sites each consisting of a parking lot and boat/canoe launching ramp, and comprising an average of two acres each, would be developed.

B. A total of four informal, primitive camping areas (accessible by river only) would be developed.

C. Wildlife enhancement would be instituted on some 5,000 acres of land largely in TVA ownership in the Fountain Creek area for development in the manner previously described. The agricultural demonstration program would be carried out on some 1000 acres of land.

D. The historic resources program would consist of the following:

1. Measure, draw, and photograph structures judged to be representative of the historic and architectural growth of the area.

2. Construct a scale model of these structures for display and interpretation in the area.
3. Collect and store log materials from other acquired structures for use in restoration and preservation projects.
4. Take appropriate mitigative action on archaeological sites impacted.

E. Some 6,600 acres of land already purchased would be returned to the private sector (table 2).

Adverse or Irreversible Impacts--The following represent the range of impacts which can be anticipated.

A. Short-term impacts will be as previously described.
B. About 5,100 acres will be lost to private ownership. The decline in farm sales from this acreage withdrawn from farm production would be about $276,000 per year in 1977 dollars. The decline in farm-related business would be about $0.7 million.
C. Adverse impacts could occur at Lillard Mill access as previously described.
D. Decreased public use would be expected.

Conclusion

The river development alternative provides an opportunity to maintain and enhance the pastoral beauty of the Duck River and to provide for significant recreation, cultural, fish, and wildlife activities in the Columbia area. But even if Columbia Reservoir is impounded as originally planned, there remains some 57 miles of the Duck River between it and Normandy Dam and over 100 miles downstream from Columbia, much of which is similar in characteristics and could be developed in a similar manner.

In summary, unless some kind of mussel conservation program is implemented this alternative would only preserve the status quo. Indications are that unless steps are taken they would probably become extinct. It would not provide any of the benefits of the project as planned except for significantly reduced recreation, cultural, fish and wildlife benefits not unique to that stretch of the river. The relocations for flood damage prevention would not be justified on the basis of the costs involved, and significantly less water would be available for industrial development and jobs.

TABLES

TABLE 1
ESTIMATE OF COST TO COMPLETE
(THOUSANDS OF DOLLARS)

ITEM	PROJECT AS PLANNED	LOW POOL Downstream Removal	NO IMPOUNDMENT-DOWNSTREAM REMOVAL		
			Maximum River Development	Medium River Development	Minimum River Development
Land and Land Rights					
Land Purchase and Acquisition Expense	$20,000	$ 9,150	$ 4,000	$ 2,750	$ 650
Land Sales Less Sales Expense	-	-	- 625	-1,640	-2,970
Net Total Land and Land Rights	20,000	9,150	3,375	1,110	-2,320
Relocations and Protections					
Highways and Bridges	19,733	8,547	7,313	7,313	7,313
Railroads	38	-	-	-	-
Other Structures	5,564	3,137	570	570	570
Total Relocations and Protections	25,335	11,684	7,883	7,883	7,883
General Yard Improvements	637	637	-	-	-
Reservoir	3,972	2,981	-	-	-
Concrete Dam and Spillway	2,682	2,682	-	-	-
Earth Main Dam	1,551	1,551	-	-	-
Sluiceways	1,010	1,010	-	-	-
Access Roads for Permanent Use	397	397	-	-	-
Vectir Control Facilities	416	380	-	-	-
Recreation Facilities and Cultural	1,727	3,079	2,152	2,060	64
Radio Gaging and Control Facilities	5	5	-	-	-
Removal and Restoration					
Riverbank and Main Dam Riprap	-	-	50	50	50
Earth Main Dam and Diversion Dike	-	-	750	750	750
Construction Plant	-	-	80	80	80
Revegetate Cleared Reservoir	-	-	110	110	110

TABLE 1 CONTINUED

ESTIMATE OF COST TO COMPLETE

(THOUSANDS OF DOLLARS)

ITEM	PROJECT AS PLANNED	LOW POOL Downstream Removal	NO IMPOUNDMENT-DOWNSTREAM REMOVAL Maximum River Development	Medium River Development	Minimum River Development
Removal and Restoration (continued)					
Erect Security Fence	-	-	30	30	30
Conclude Miscellaneous Contracts	-	-	970	970	970
Total Removals and Restorations	-	-	1,990	1,990	1,990
Construction Plant, Equipment, and Inventories	-664	-664	-664	-664	-664
Construction Supervision and Services	9,138	5,993	2,972	2,947	2,424
General Engineering and Design	1,417	594	594	594	594
Administrative and General Expense	4,616	3,019	1,481	1,467	1,208
Project Contingency	6,565	4,306	2,021	2,417	1,625
Total Expenditures(1978 dollars)	78,804	46,804	21,804	19,804	12,804
Change in Commitments	-6,804	-6,804	-6,804	-6,804	-6,804
Total Obligations(1978 dollars)	72,000	40,000	15,000	13,000	6,000
Escalation	24,000	8,000	3,000	3,000	2,000
Total Obligation(based on construction schedule)	96,000	48,000	18,000	16,000	8,000
Downstream Removals	-	6,000	6,000	6,000	6,000
Downstream Removals(based on consturction schedule)	-	7,000	7,000	7,000	7,000
TOTAL COST TO COMPLETE (1978 DOLLARS)	$72,000	$46,000	$21,000	$19,000	$12,000
TOTAL COST TO COMPLETE(based on const. schedule)	$96,000	$55,000	$25,000	$23,000	$15,000
Construction Start	10/1/78	10/1/78	10/1/78	10/1/78	10/1/78
Construction Complete	6/85	6/81	6/81	6/81	6/81

TABLE 2

LAND REQUIREMENTS

	ACRES - (APPROXIMATE)			
	REQUIRED	ACQUIRED LAND[1] TO BE RETAINED	ADDITIONAL TO BE ACQUIRED	EXCESS TO BE SOLD
RESERVOIR AS PLANNED	27,500	11,100	16,400	-
LOW POOL	18,500	11,100	7,400	-
NO IMPOUNDMENT-RIVER DEVELOPMENT				
MAXIMUM	13,200	9,600	3,600	1,500
MEDIUM	9,400	7,100	2,300	4,000
MINIMUM	5,100	4,500	600	6,600

1/ The study is based on 11,100 acres of land acquired through September 30, 1978. Since that date some 1,000 additional acres have been acquired.

FIGURES

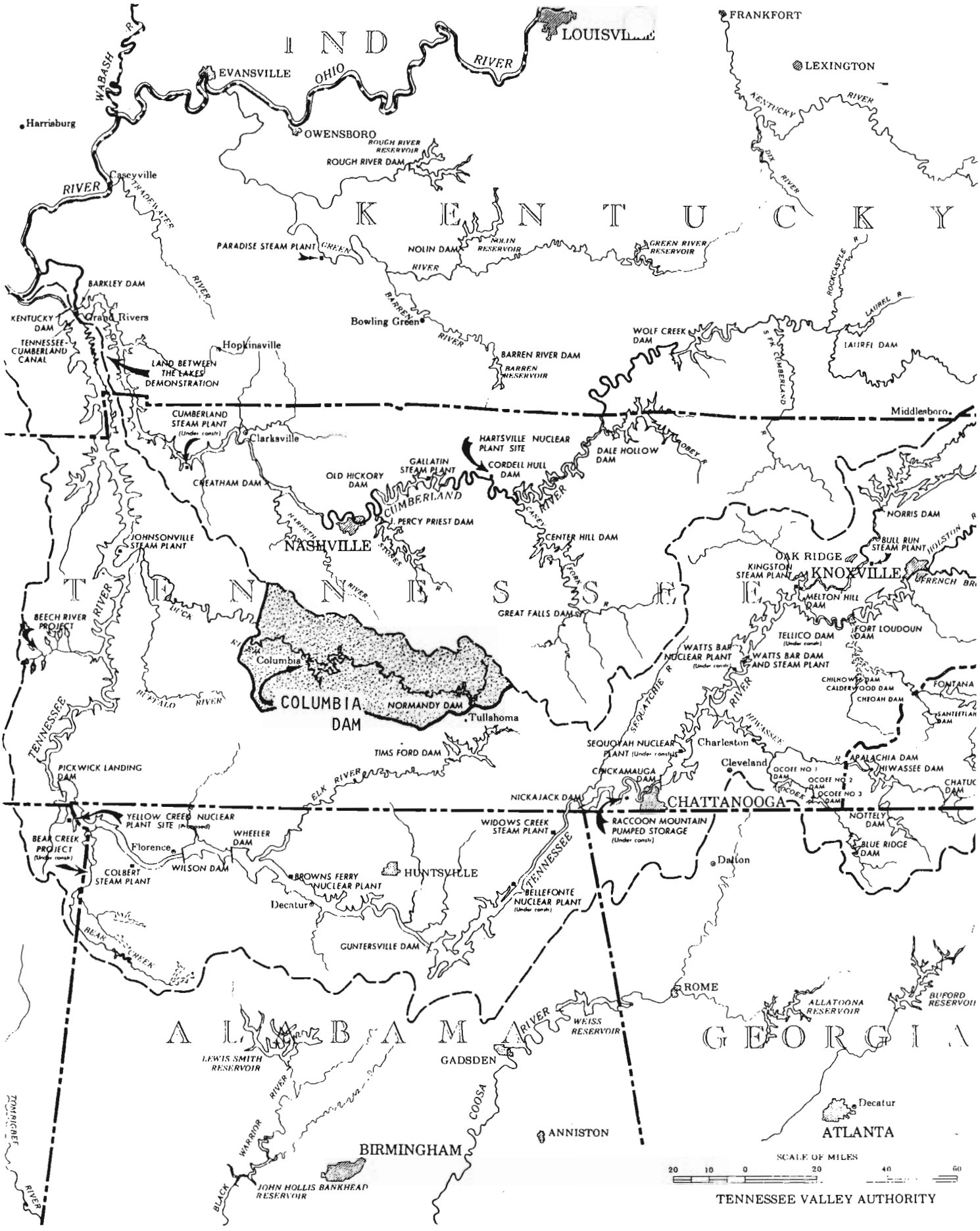


FIGURE 1 - LOCATION MAP

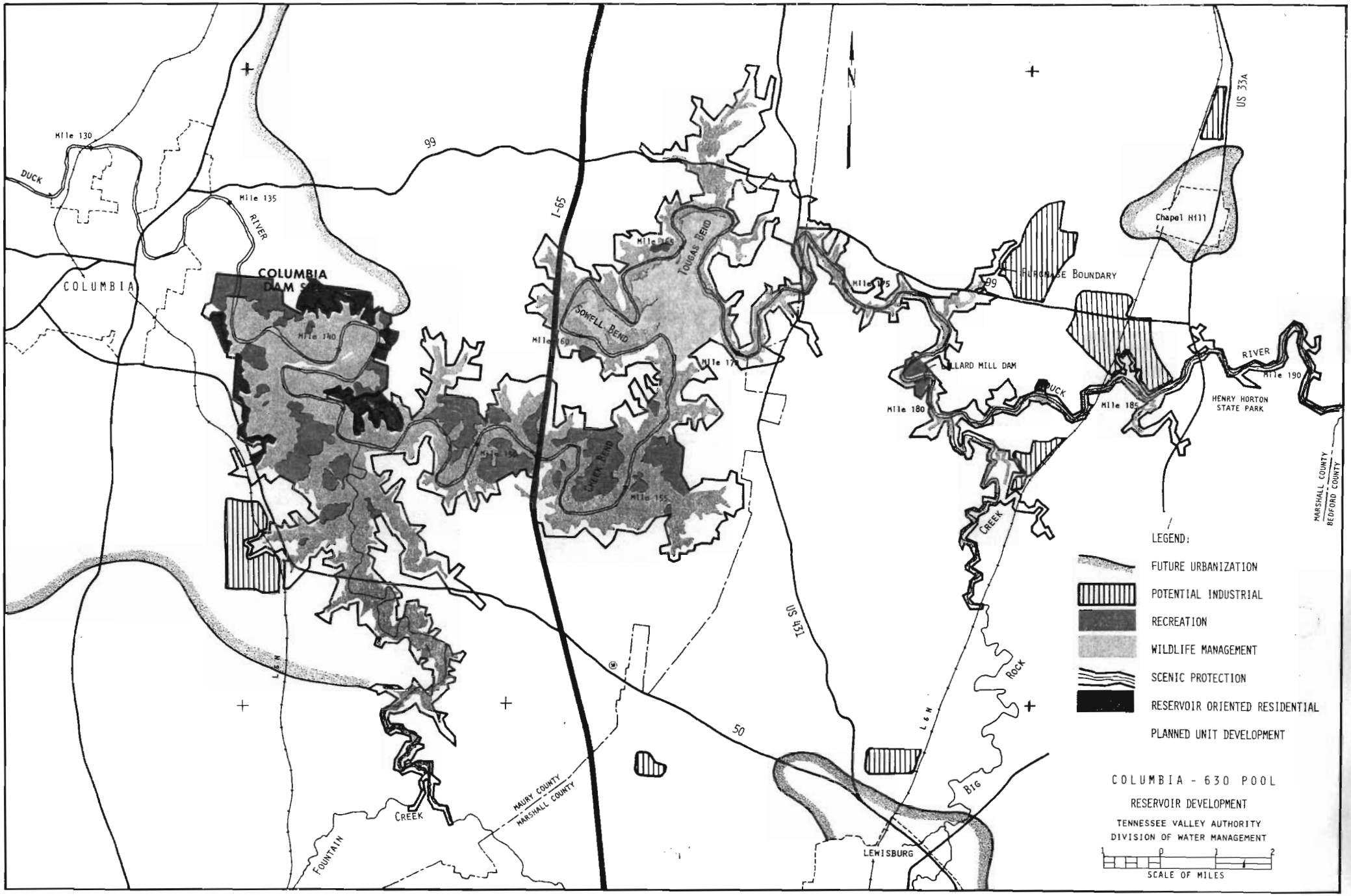
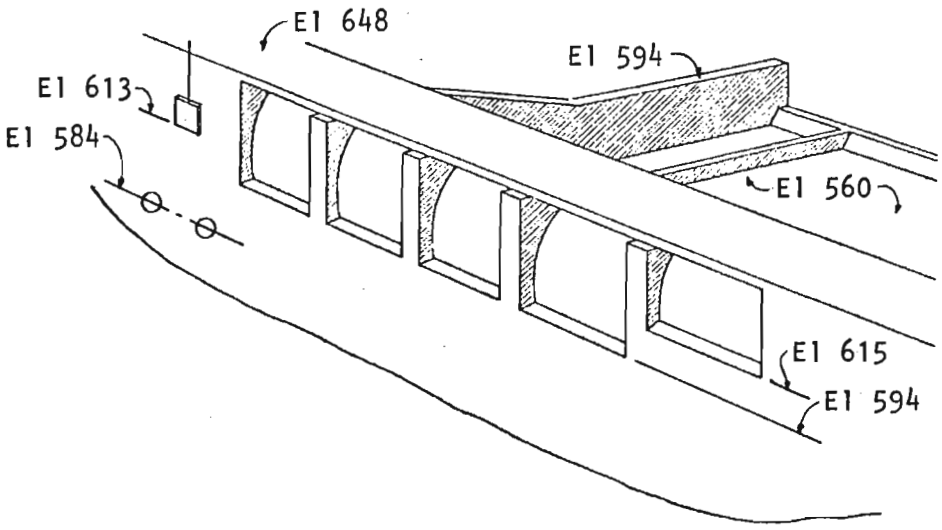
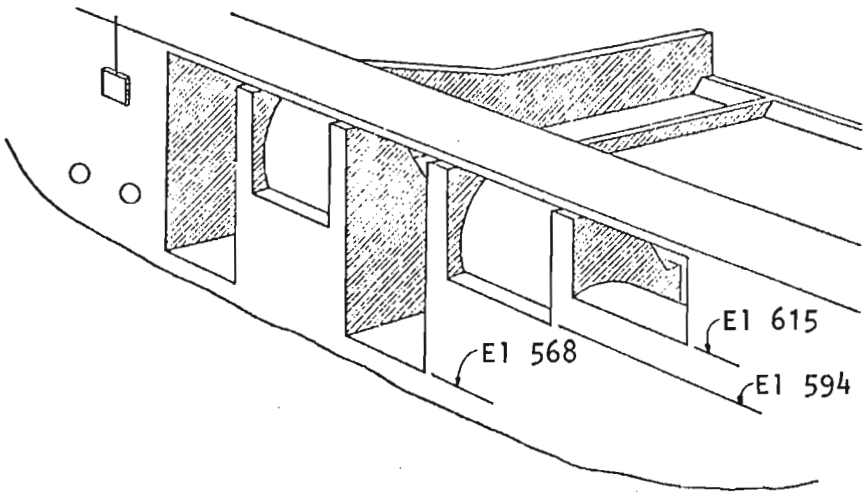


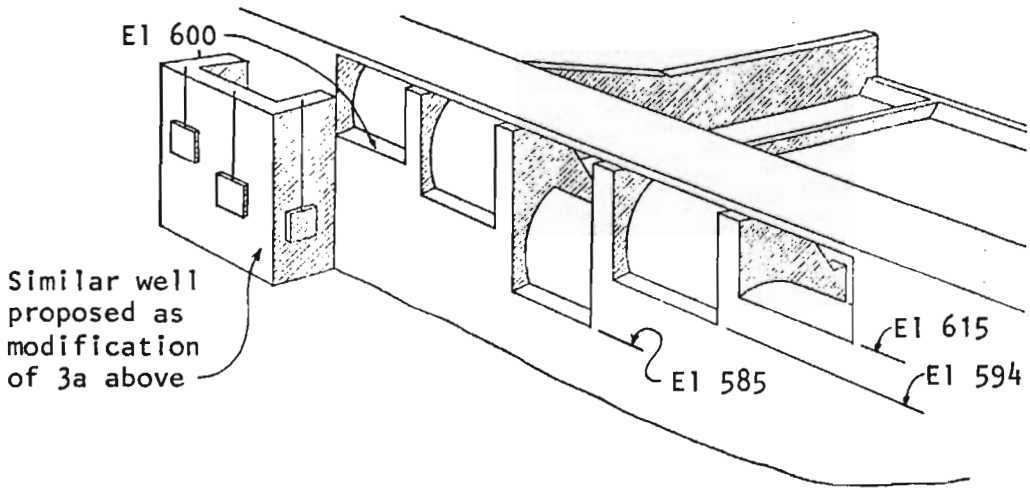
FIGURE 2 - COLUMBIA - 630 POOL - RESERVOIR DEVELOPMENT



3a - Spillway as planned



3b - Spillway as presently constructed



3c - Spillway for low pool alternative

FIGURE 3 - COLUMBIA SPILLWAY

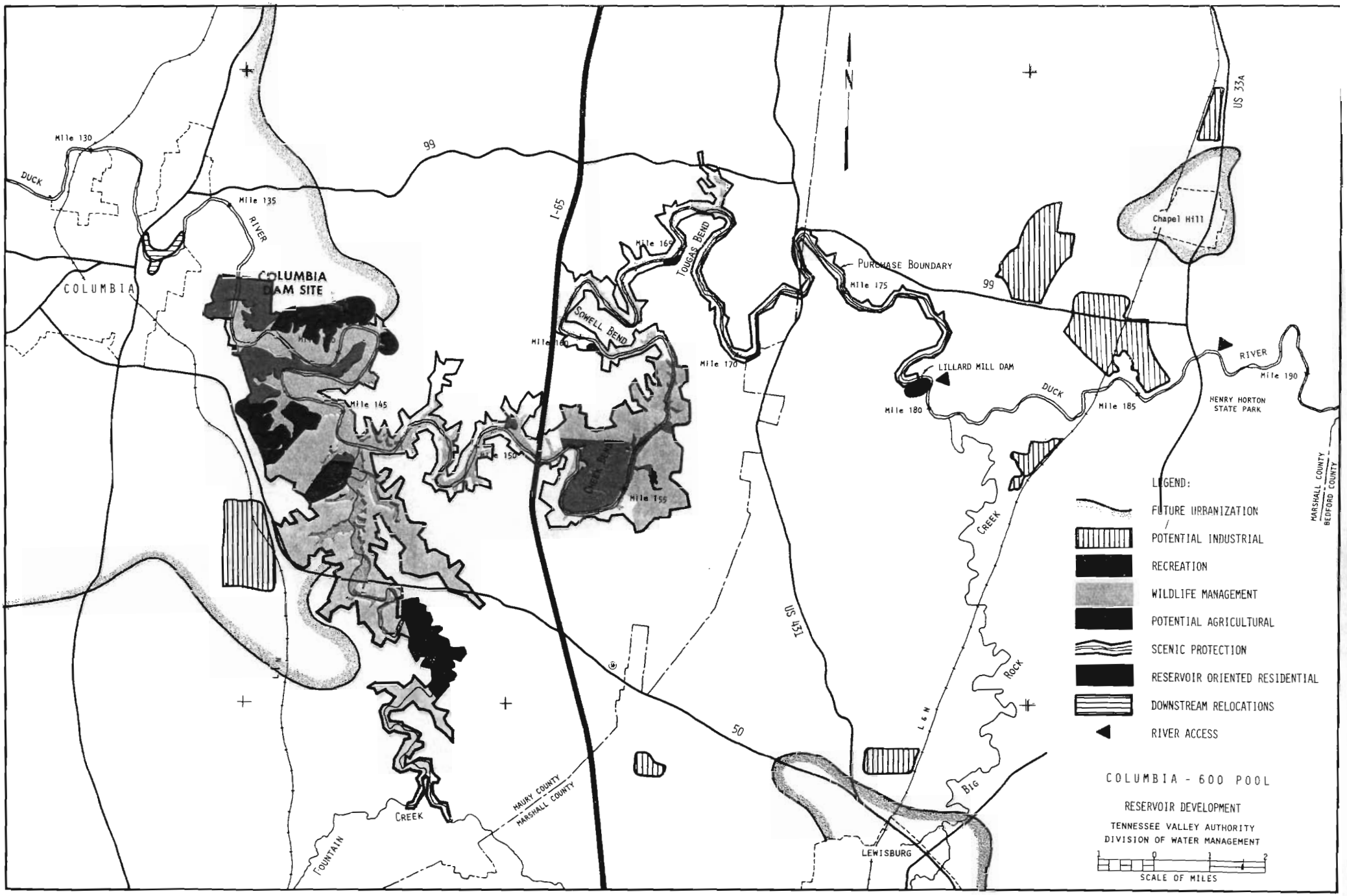
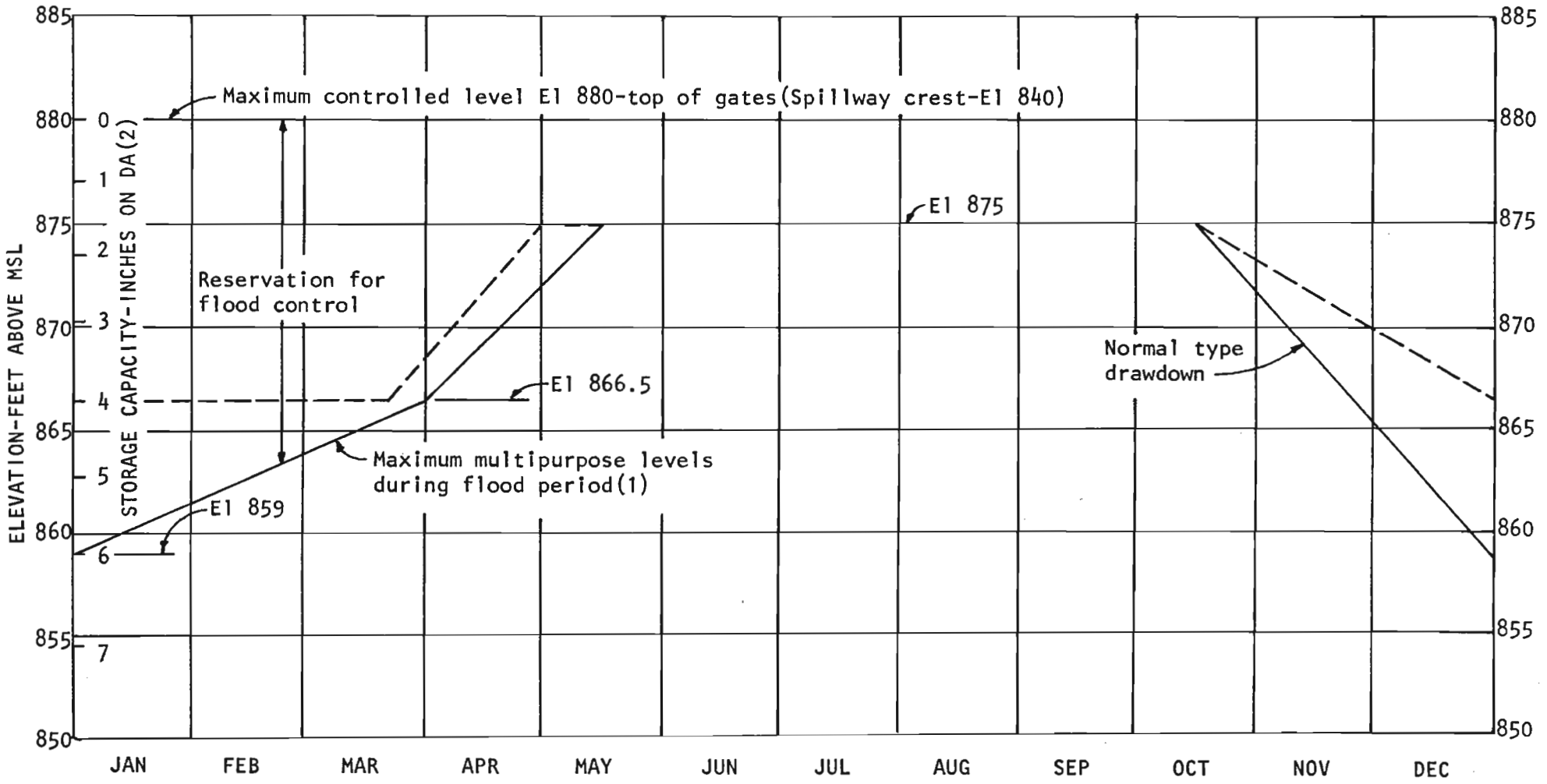


FIGURE 4 - COLUMBIA - 600 POOL - RESERVOIR DEVELOPMENT



NOTES:
(1) To be exceeded only during flood control operations.
(2) Based upon drainage area, 195 square miles.

LEGEND:
——— Normal Operation
– – – – – Modified Operation- Columbia Low Pool and No Impoundment

FIGURE 5 - MODIFIED NORMANDY OPERATION

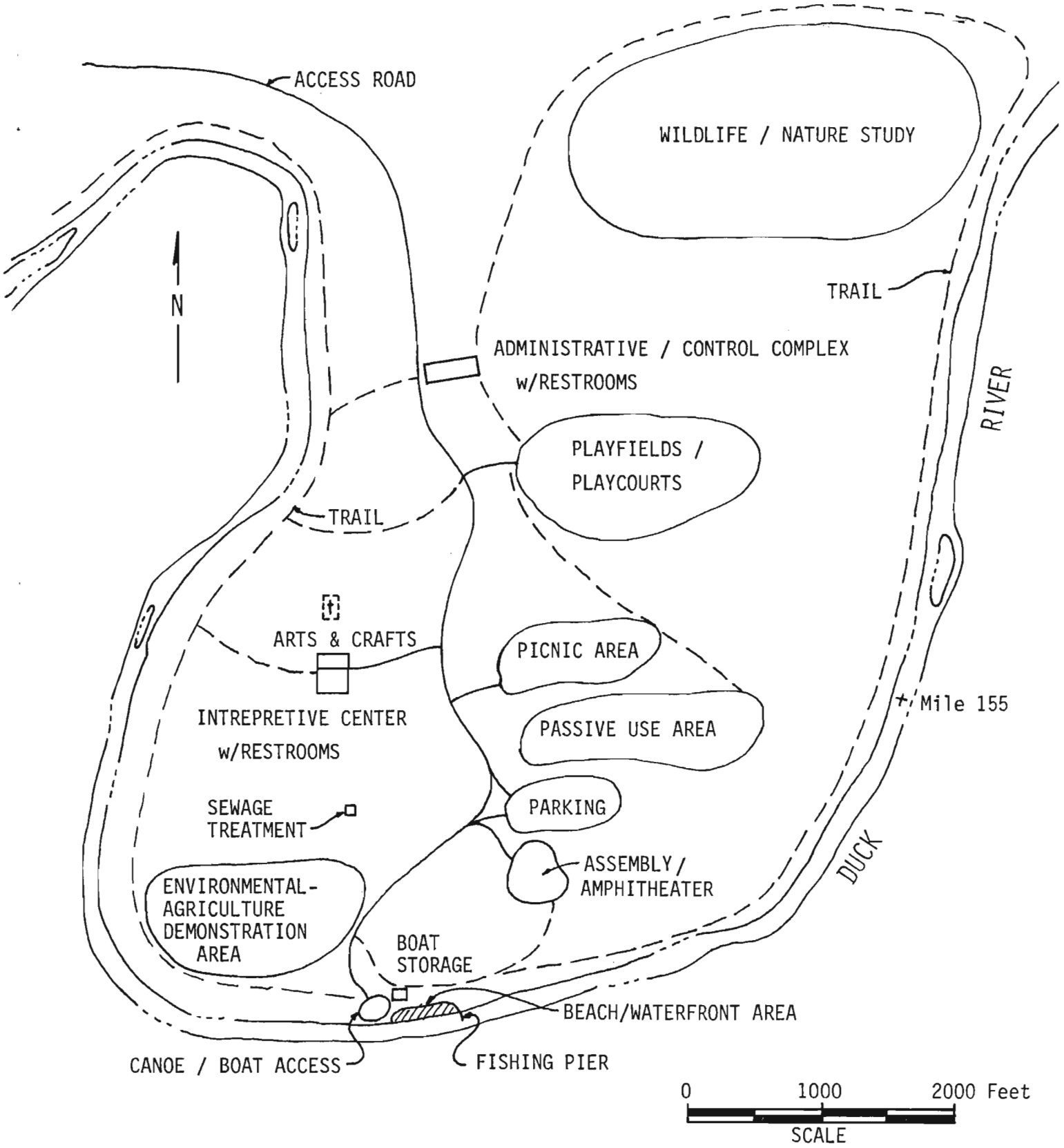


FIGURE 6 - PROPOSED CHEEK BEND DEVELOPMENT

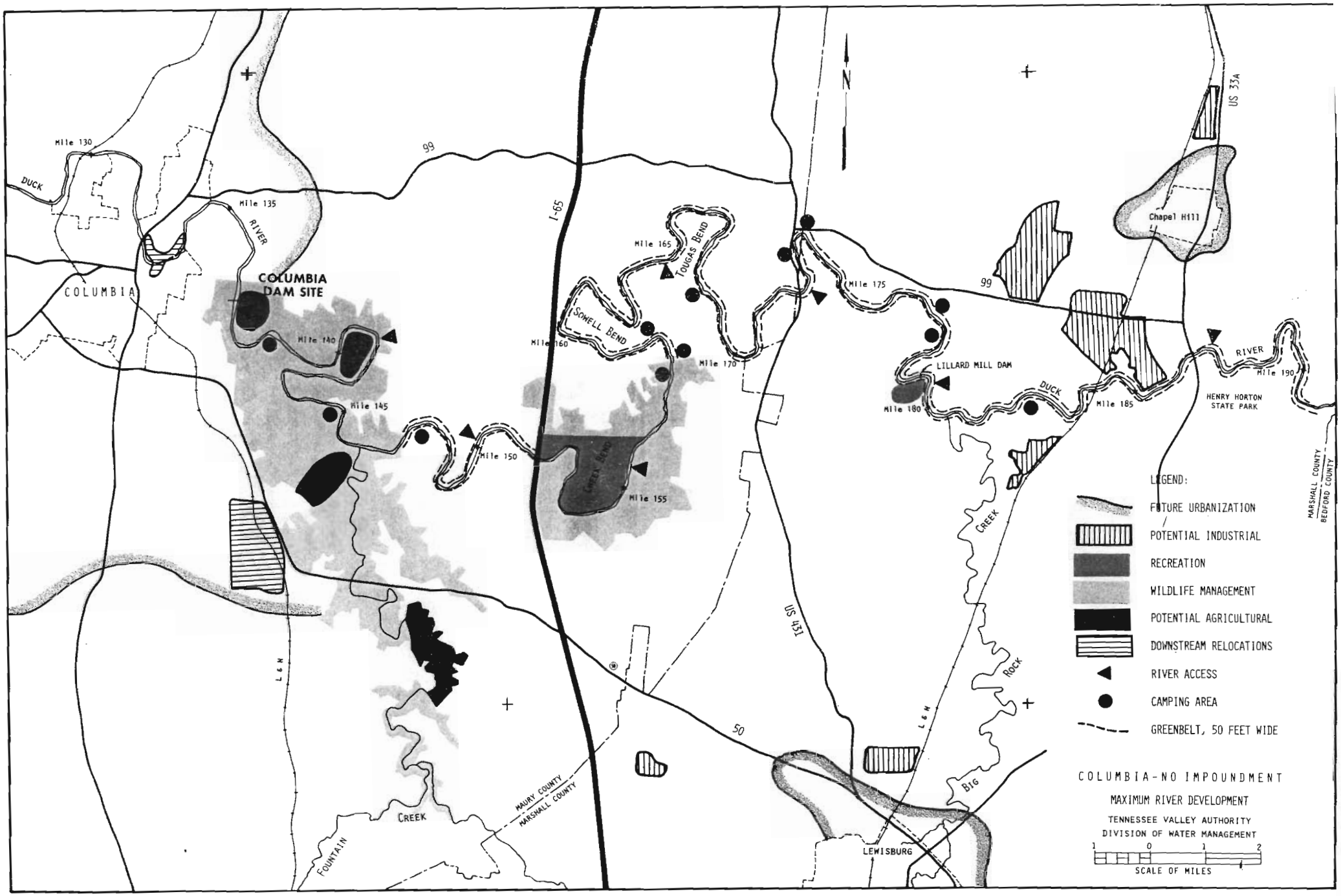


FIGURE 7A - COLUMBIA - NO IMPOUNDMENT - MAXIMUM RIVER DEVELOPMENT

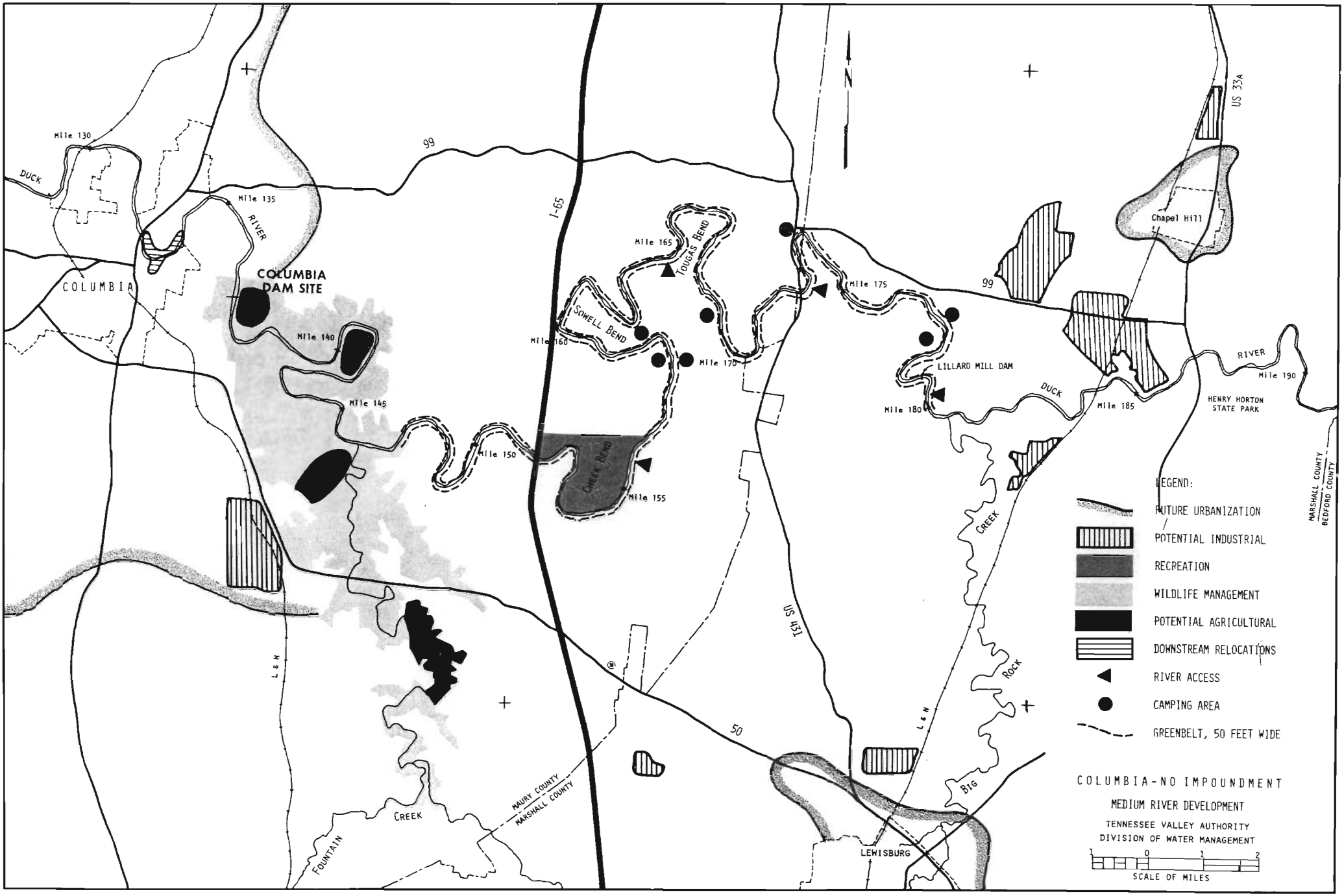


FIGURE 7B - COLUMBIA - NO IMPOUNDMENT - MEDIUM RIVER DEVELOPMENT

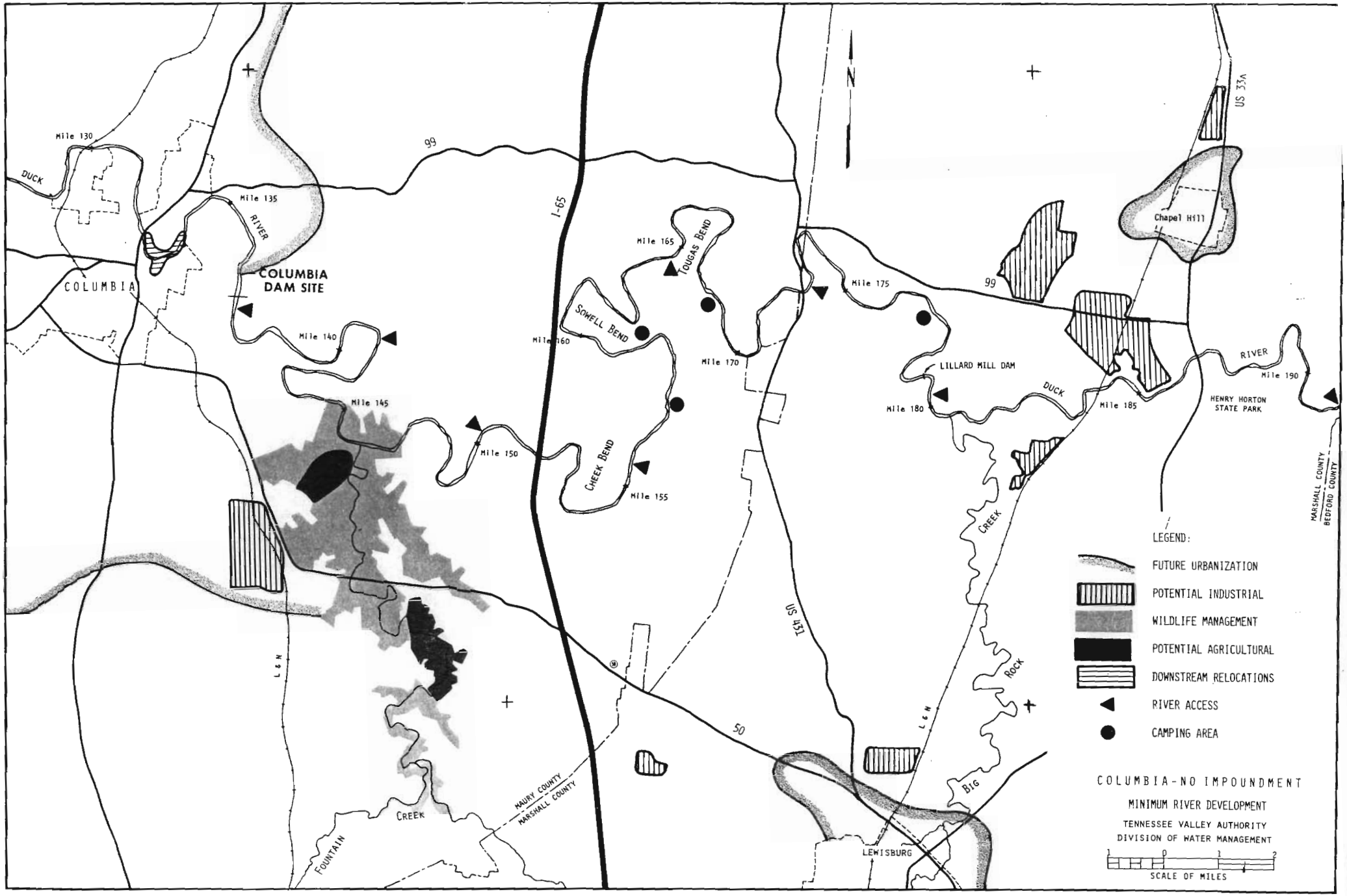


FIGURE 7C - COLUMBIA - NO IMPOUNDMENT - MINIMUM RIVER DEVELOPMENT

APPENDICES

APPENDIX A
ENDANGERED SPECIES

Seven species of endangered mussels have been listed as occurring in the Duck River. The names used to refer to these species are those of the Federal Register and do not necessarily reflect a consensus of scientific opinion in every case. The present status of these species in the Duck River based on intensive surveys by TVA and other sources is as follows:

1. Epioblasma (=Dysnomia) turgidula - presumed extinct by Stansbery in 1971.
2. Epioblasma (=Dysnomia) florentina florentina - presumed extinct by Stansbery in 1971 [1]
3. Epioblasma (=Dysnomia) walkeri - was last collected (alive) in 1964 at DRM 187.0 (Ohio State University Museum specimen). [1]
4. Quadrula intermedia - was last collected (dead) at DRM 179.5 by Yokley in 1973.
5. Toxolasma (=Carunculina) cylindrella - was last collected (above the Normandy Dam site) in 1965 (Ohio State University Museum specimen).
6. Plethobasus cooperianus - listing has been based upon specimens collected alive at DRM 134.0 by Isom and Yokley in 1965 No specimens have since been found.
7. Conradilla caelata - has been found alive in the Duck River and is relatively abundant immediately downstream from Lillard's Mill Dam where it occurs with 18 other species of mussels. This bed extends approximately 0.8 mile downstream from the mill dam (DRM 179.4-178.6). Two freshly dead specimens of C. caelata were recently collected (October 1978) at Creek Island (DRM 178.2). Earlier surveys of the Duck River by Ortmann (1924), Isom and Yokley (1968), and van der Schalie (1973) reported C. caelata to be more widely distributed in the Duck River. However, recent surveys by

[1] In October 1978 a specimen tentatively identified as belonging to the E. walkeri - E. florentina complex was collected alive from downstream of Lillard's Mill Dam, photographed, and returned to the river. Verification of this identification has not been possible due to a photographic malfunction and inability to retrieve the specimen.

TVA (1976 and 1978) have failed to document live C. caelata specimens at any other Duck River location except downstream from the old dam in the town of Columbia where it was transplanted in 1975 by Yokley. At this site, of the 49 specimens that had been introduced, 18 were observed in 1976 and one was found in 1978. C. caelata was transplanted downstream from the Shelbyville Dam in 1974, but all efforts to find these specimens since then have failed. A similar transplant had also been made to Little Cypress Creek in northern Alabama, however, no specimens of this species were found at the transplant site in a November 1978 survey. Outside the Duck River known populations of C. caelata occur in the Powell River and two specimens have been found in the Clinch River.

Additionally, six species of snails listed as occurring in the Duck River have been proposed for threatened and/or endangered status by the Department of the Interior. Intensive surveys by TVA in 1972, 1977 and 1978 have documented the following distribution information for these snail species:

1. Io geniculata geniculata - documented in the Duck River system (including the Buffalo River) and intermittently in the Tennessee River from TRM 8.2-206.1.
2. Io armigera duttoniana - documented in the Duck River. Not known to occur outside the Duck River system.
3. Leptoxis praerosa - documented in the Duck River Other documented locations include the Buffalo, Elk, Little Tennessee, and Nolichucky Rivers, Big Nance Creek, Cedar Creek, and intermittently in the Tennessee River from TRM 4.5-205.4.
4. Io salebrosa - not documented in the Duck River. Present at various sites in the Tennessee River from TRM 5.3-258.0.
5. Io geniculata pinguis - not documented in the Duck River or in the lower Tennessee River.

6. Io armigera jayana - tentatively reported from five sites in the Duck River (DRM 131.0, 160.0, 187.0, 239.8, 245.0) based upon a few specimens collected in October 1978. These identifications will be verified by specialists.

Of these snail species only Io geniculata geniculata, Io armigera duttoniana, Leptoxis praerosa, and possibly Io armigera jayana occur within the Columbia area. These species also occur both above and below the Columbia area in the Duck River.

The State of Tennessee (TWRA) has two species of fish listed on their State list as threatened, Percina macrocephala (longhead darter) and Etheostoma aquali (coppercheek darter). The coppercheek darter has been found by TVA throughout the project area. The longhead darter has not been found within the project area, but may exist there.

Two species of plants known to occur in Maury and Marshall Counties have been proposed for the Federal list of [threatened and/or] endangered plants. They are Leavenworthia exigua lutea, and Lesquerella densipila. Although only limited field surveys have been completed, neither of these are known to occur within the Columbia Project area.

APPENDIX B
WATER QUALITY RELATED CONSIDERATIONS
BACKGROUND

Low stream flows in the Duck River at Columbia, Tennessee, have historically been a reoccurring problem. In these situations, the streamflow has been insufficient to meet either the water supply requirements or the streamflow requirements to assimilate the treated organic waste discharges to protect downstream water quality. These two water uses are not mutually exclusive. For example, provisions to provide for water supply needs would be of little or no value if there were inadequate streamflows available to assimilate the resulting waste discharges with reasonable levels of waste treatment. Likewise, provisions to provide adequate streamflows to assimilate treated waste discharges are of no value if adequate streamflows are not available to meet the corresponding water supply requirements associated with the waste discharge. Consequently, there must be a balance between the streamflow provided by any project alternative to ensure that adequate flows are provided to achieve both of these purposes simultaneously.

The simultaneous satisfaction of both the water quality control and the water supply needs at Columbia, Tennessee, was one of the primary objectives at the Duck River project as initially planned. The achievement of both of these needs is also a primary objective of the low pool and no impoundment alternatives.

Existing Conditions

Water Quality

In general, water quality in the vicinity of Columbia, Tennessee, is good and is suitable for all uses. Soluble iron and manganese concentrations are low, and no undesirable effects have been reported at the Columbia, Tennessee, water treatment plant. Minor water quality problems associated with nonpoint source pollution have been identified within the Columbia area, primarily resulting from the extensive agricultural activity occurring in the Duck River Basin upstream of Columbia, Tennessee. These problems occur during periods of rainfall and are mainly related to increased concentrations of coliform bacteria, turbidity, and suspended solids.

The organic wasteload discharged to the Duck River in the Columbia, Tennessee, area has been documented to depress dissolved oxygen concentrations below an acceptable level (5 mg/l) during periods of low flow. With the closure of Normandy Dam in January 1976 minimum flow at Columbia, Tennessee, was increased and the low dissolved oxygen conditions have improved. Improved waste treatment planned in the Columbia-Mount Pleasant area should result in the elimination of the occurrence of low dissolved oxygen in the Duck River downstream of Columbia, Tennessee, provided streamflows of at least 155 cfs as maintained at DRM 132.8.

Aquatic Ecology (Nonfish)

Phytoplankton--The phytoplankton community in the Duck River reflects changes brought about by the presence of Normandy Reservoir and several small mill dams. The phytoplankton standing crop is greater than for comparable nonimpounded rivers and is typified by a diverse algal assemblage. Because of the impoundments upstream of the Columbia Project area the species composition is more representative of a phytoplankton rather than a potamoplankton (i.e., planktonic organisms living and reproducing in impounded waters rather than in flowing waters) community.

The geologic formations of the Duck River Basin are rich in phosphorus and therefore can be expected to supply a constant amount of nutrient material into impoundments on the Duck River. In addition, discharges from Normandy Dam will consist of one or both of the following: (1) waters from the epilimnion which have the potential of being rich in phytoplankton and (2) hypolimnetic waters which may be rich in nutrients. Any one or combination of these discharges, when combined with tributary drainage into Columbia Reservoir, will most likely increase the probability of Columbia Reservoir being highly eutrophic.

Aquatic Macroinvertebrates--The aquatic macroinvertebrate community of the Duck River represents a diverse well-balanced fauna. However, one notable exception has become evident through the mussel surveys conducted in recent years, especially 1976. The data indicate that the only remaining "mussel bed" within the project area occurs downstream of Lillard's Mill Dam (DRM 179.0). Conradilla caelata Conrad occurs within this bed. The other two extant populations of C. caelata occur in the Powell and Clinch Rivers in Virginia and Tennessee. In 1974 Paul Yokley, working under TVA contract, transplanted three populations of C. caelata outside the project area, all of which have essentially failed. (One live specimen was collected below Columbia City Dam in 1978.)

Three snail species which appear on the Department of Interior's proposed list of threatened or endangered species have been confirmed in the project area. However, each of these species occur outside the project area where they will not be affected.

The Duck River, the tributary streams which would be impacted by the impoundment alternatives support a diverse well-balanced macroinvertebrate fauna.

Aquatic Macrophytes--The Duck River from DRM 146 to DRM 172.1 consists of an alternating series of pools and riffles. Submerged species such as Heteranthera dubia (Jacquin) MacM., Potamogeton nodosus Poiret, and Podostemon ceratophyllum Michx. inhabit most riffles with Justicia americana being the dominant emergent species in both riffle areas and pools. Occasional colonies of duckweed (Lemna, Spirodela, Wolffia) cover the surface in a few sloughs adjacent to the main river channel.

The low gravel bars associated with the riffle areas are dominated by such woody taxa as Salix nigra Marsh., S. caroliniana Michx., Platanus occidentalis L., and Acer saccharinum L. with an occasional Cephalanthus occidentalis L. The herbaceous vegetation on these bars is rather sparse due to frequent inundation associated with fluctuations in water level following periods of rainfall. Also present along the mainstream are islands which are several feet above the summer water level of the Duck River. These islands are similar in composition to the flood plain forests adjacent to the river and are dominated by Acer saccharinum, A. negundo L., and Fraxinus pennsylvanica Marsh. with the herbaceous understory consisting primarily of several species of Polygonum, Boehmeria cylindrica (L.) Swartz, Pilea pumila (L.) Gray, Impatiens capensis Meerb., and Verbesina alternifolia (L.) Kearney. Original riparian vegetation is typically restricted to narrow bands along the river bank.

Areas which could be classified as wetlands are primarily confined to the adjacent flood plain of the Duck River and tributary streams. A few remnants of bottomland hardwood forests dominated by Acer saccharinum, A. negundo, Fraxinus pennsylvanica, and Platanus occidentalis remain, but most have been destroyed by drainage and clearing associated with agricultural practices and reservoir preparation.

No aquatic or wetland species were observed that are on the Tennessee rare plant list (Committee for Tennessee Rare Plants, 1978) or the Federal list of endangered and threatened plant species.

Wastewater Treatment (Organic Wastes)

In the Columbia-Mount Pleasant area there are 12 wastewater discharges. Two of these are municipal waste discharges from the cities of Columbia and Mount Pleasant. The remainder are industrial process, cooling, and sanitary waste discharges. Only two of the industrial discharges contain carbonaceous oxygen demanding materials. The other wastes contain mainly inorganic solids associated with phosphate mining or processing. Several of the phosphate industries have essentially complete wastewater recirculation systems and seldom, if ever, discharge to a stream. These inorganic discharges do not affect the

assimilative capacity of the Duck River for oxygen demanding materials and because of this are not considered in determining streamflows required for water quality control needs at Columbia, Tennessee. The discharge of organic materials would not impact the acceptability of the stream water quality for water supply withdrawals for these industries, provided the withdrawals were located downstream from the point of organic discharges. Similarly, industrial water supply withdrawals would not impact the assimilative capacity of the river for organic wastes provided the withdrawals were made downstream from the point of discharge of the organic wastes.

Municipal Wastewater Treatment--Columbia, Tennessee, has just completed construction of a 7-million gallon per day wastewater treatment facility, when placed into operation, the plant should achieve an 85 percent reduction of organic wasteload. The facility is a secondary type (best practicable) which has the capability of reducing ammonia nitrogen of the effluent to 5 mg/l. The discharge will be at DRM 127.9.

Until the new plant becomes operational, the city is using the old secondary plant which has a design capacity of 2.5 mgd and discharges at DRM 132.2.

Mount Pleasant, Tennessee, operates a secondary type waste treatment plant with a design capacity of 350,000 gallons per day. The effluent point for this plant is Sugar Creek mile 0.9, a tributary stream of the Duck River. The plant presently is overloaded and achieves only a 68 percent BOD removal. A new 710,000 gal/day tertiary treatment plant is under construction with planned completion in 1979. This facility is designed to accomplish a 95 percent reduction in organic wasteload. The new facility will discharge to Sugar Fork, a small tributary stream of the Duck River, thus the need for a high degree of treatment.

Industrial Wastewater Treatment--The two industries having carbonaceous BOD discharges are E. I. Dupont and Union Carbide with waste discharges at DRM 129.9 and DRM 129.3, respectively. The Union Carbide treatment facility achieves over 90 percent BOD removal. However, the Tennessee Division of Water Quality Control has reported

that treatment provided by E. I. Dupont waste treatment plant is inadequate to protect water quality in the Duck River. Corrective actions are being taken by the company to improve this deficiency.

WATER QUALITY CONTROL

The water quality control streamflow provisions incorporated into the original project plan were based on providing sufficient streamflow to increase the stream assimilative capacity for organic wastes in the critical reaches of the Duck River so that dischargers would not have to go beyond secondary treatment. It should be emphasized that providing these streamflows did not relieve the various dischargers of their responsibilities for providing the minimum level of treatment required. Within the nomenclature of the current regulations, this increased streamflow is necessary to allow the critical stream segments to be designated as "effluent limited segments" rather than "water quality limited segments."

Eutrophication

Eutrophication refers to natural or artificial addition of nutrients to bodies of water and to the effects of added nutrients. Eutrophication of lakes is a natural process that can be greatly accelerated by man. The abundance and species composition of plankton, bacterial, benthic, and fish populations change as eutrophication progresses, and changes of this nature may be used an an indicator of eutrophication as well as the rate of eutrophication. When these changes result in dense populations of planktonic algae dominated by a few species of bluegreen algae, then the eutrophication process is undesirable. The increase in undesirable aquatic organisms can preclude recreational use, cause aesthetically unpleasing situations, and result in adverse water quality conditions which can further impair various water uses.

TVA has been aware of the potential problem of eutrophication in the streams and reservoirs of the Tennessee Valley. Although the specific triggering mechanisms for nuisance-level biological responses in a given water body are not fully understood, the potential for the occurrence of such responses have been traditionally associated with high concentrations of the primary nutrients, nitrogen, and/or phosphorus. However, there are other substances other than nitrogen and phosphorus that have been documented as contributing to the eutrophication process (i.e., carbon, vitamins, growth hormones, amino acids, trace elements, etc.). There is little agreement among the experts as to which of the primary nutrients (nitrogen or phosphorus) and what concentrations is the threshold level that if exceeded will result in nuisance-level algal growths. This is also true for the other substances and conforms to Liebig's Law of the Minimum which states:

> "To occur and thrive in a given situation, an organism must have essential materials which are necessary for growth and reproduction. These basic requirements vary with the species and with the situation. The essential material available in amounts most closely approaching the critical minimum needed will tend to be the limiting one." (Odum, 1964)

With respect to eutrophication of reservoirs, physical properties (e.g., hydraulic flow-through pattern, depth of light penetration, depth, shape, geogrphical location, etc.) should be considered as essential materials in Liebig's Law of the Minimum. Nuisance levels of aquatic organisms do not always result from an abundance of chemical nutrients, because some physical factor(s) may be restricting such growth.

TVA has observed nitrogen and phosphorus levels in most of its reservoirs well above the threshold concentrations reported to have caused nuisance-level growths in natural lakes. However, few such growths have been encountered in the TVA system. This lack of such growths is attributed to the difference in the physical and hydraulic flow-through characteristics of man-made reservoirs, such as those in the TVA system when compared with natural lakes.

All of TVA's reservoirs could be considered as biologically productive in terms of the total plankton standing crop. The presence of a large plankton standing crop is important to the maintenance of a healthy fishery resource, since these organisms are the primary links in the food chain. If standing crop were used as the criteria for classifying a lake as eutrophic then all TVA reservoirs would be considered eutrophic. The "key" to water quality problems associated with eutrophication is not the occurrence of large standing crops, but rather is related to the composition of the standing crop. Water quality problems would not be encountered unless the dominant algal taxa were the nuisance forms of blue-green algae which as mentioned earlier are indicative of undesirable eutrophication. Dominance of these blue-green algal species has not occurred, with the exception of Cherokee Reservoir, in the TVA tributary reservoirs although sporadic blooms have and are expected to periodically occur in these reservoirs.

The phosphorus concentrations of the Duck River upstream from the City of Columbia are elevated in comparison to most streams in the Tennessee Valley. The primary sources of these elevated phosphorus concentrations are surface water runoff from agricultural lands and surface runoff and groundwater from the phosphorus rich geologic

conditions of the Duck River Basin. Because of the physical characteristics of the Columbia project as initially planned (detention time measured in months and an annual reservoir drawdown of 27 feet at Columbia), it is expected that the reservoir would respond similar to TVA's headwater reservoirs. The potential for nutrient recycling resulting from mixing of the bottom and surface water and the resolubilization of deposited nutrients from the reservoir bottom would be minimized due to the planned reservoir drawdown. The season when the recycling potential could occur corresponds with (1) the period of minimum reservoir volume, (2) the period of lowest water temperatures which would tend to limit biological production, and (3) the period when homogeneous dissolved oxygen concentrations would occur in the reservoirs.

TVA recognized the potential for eutrophication and related water quality problems when the project was designed and incorporated features in the dam which could preclude or minimize problems downstream of the reservoir. Although the operation was planned to release primarily warmer surface waters so the downstream warm water fishery could be enhanced, the dam has outlets at several different levels so that water could be selected from a stratum having good water quality. The low level outlets are equipped with a regulating sleeve valve which would reaerate releases during periods when water at that level would be low in dissolved oxygen. The installation of an additional high capacity regulating sleeve valve and a multiple level gating structure for the valves will greatly increase the operating flexibility. In addition, the planned annual drawdown of 27 feet would effectively control extensive colonization by rooted aquatic plants. Minor fluctuations in water level during the summer season may be required to prevent mosquito problems. With the expanded operating flexibility built into the Columbia Dam the potential problems associated with the occurrence of nuisance-level blue-green algae blooms in the reservoir could be avoided in the releases.

It is anticipated that Columbia Reservoir, like other storage reservoirs in the TVA system, will undergo strong thermal stratification during the period between early spring (May) and late fall (November).

During this period, the dissolved oxygen in the hypolimnion will become depleted. Provisions have been built into the structure to provide the operating flexibility to ensure that the releases are well oxygenated. All release points from the hypolimnion have been equipped with regulating sleeve valves which are efficient aeration (reoxygenation) devices. Studies have shown that the reoxygenation efficiencies of these valves will satisfy 85 percent of the oxygen deficits of the water entering the valve. Thus, under even the worst case conditions (assuming inflow DO was zero) the dissolved oxygen concentration of the releases through the valves would be at least 85 percent of the saturation value.

Within the reservoir the dissolved oxygen concentration as measured at the five foot level would reflect high dissolved oxygen concentration since water at this depth is within the epilimnion of the reservoir. Thus there should be no problems associated with meeting the 5 mg/l dissolved oxygen standard in the releases from the reservoir or at the applicable measuring point within the reservoir.

The occurrence of the low DO concentrations in the hypolimnion is a natural phenomenon and would not adversely impact the water quality of the reservoir or the ability to maintain a warm water fishery in the reservoir. However, these low DO could have an adverse impact on the fisheries resource if species of fish having thermal preferences associated with the cooler hypolimnetic waters are introduced into the reservoir. The introduction of such species to Columbia Reservoir would not reflect sound fisheries management and would be discouraged.

The low pool alternative will affect the water quality of the dam releases as a result of the expected eutrophic condition of the Columbia Reservoir unless modifications are incorporated into the existing structure which would permit selective withdrawal and reservoir drawdown capabilities.

Structural modifications required would be the installation of an additional large capacity regulating sleeve valve and an upstream multilevel gating structure to provide greater flexibility for selective withdrawal of water from the impoundment. To achieve the needed flexibility, multilevel gate openings for discharges through the regulating sleeve valves would have to be provided between elevations 570 and 600.

Annual reservoir drawdown of 10 feet (with capabilities of increases to 15 feet) during a minimum of a 6-week period between October 1 and March 1 would be required to control the development of excessive quantities of aquatic weeds.

Minor fluctuations in pool elevation of about one foot on a 7-day cycle may be required during the period from May 15 to September 30 for the control of mosquito production.

The structural modifications and operating constraints identified above would provide sufficient operating flexibility to (1) preclude or mitigate to acceptable levels the downstream impact of the reservoir releases on downstream water users in the event a blue-green algal bloom did occur in the reservoir, (2) preclude or control the development of weedy aquatic macrophytes in the reservoir, and (3) control mosquito production in the reservoir. With respect to the impoundment itself it is not feasible (based on the state of the art) to predict with any certainty the occurrance or lack of adverse plankton production (blue-green algae) in the pool. Actual monitoring would be required to document the lack of or presence of such conditions.

Any subsequent mitigative actions needed would have to be based on the monitoring results.

The ability to adjust operations to operate around the occurrence of blue-green algal blooms if structural operating flexibility is provided has been demonstrated at Normandy Reservoir. An extensive blue-green algae bloom did occur in Normandy Reservoir in May 1977 during a period of surface water releases from the reservoir. However, upon notification of resulting taste and odor problems at the downstream water supplies, the releases were switched to lower level outlets and the downstream problems were corrected. This change in operation isolated the bloom in the reservoir until natural die-away occurred.

Although the water depths at Columbia would be much less for the low pool alternative, strong thermal stratification would still be expected to occur in the reservoir. Provisions have been incorporated in the dam structure to ensure selective withdrawal capabilities, with all releases from below the surface elevation being passed through regulating sleeve valves. The incorporation of this operating flexibility will

ensure that (1) all releases have high concentrations of dissolved oxygen, and (2) potential taste and odor problems associated with blue-green algal blooms in the epilimnion of the pool could be avoided in the releases for brief periods of time.

There would be no problems with meeting the minimum dissolved oxygen standard of 5 mg/l in the releases or in the reservoir at the point where the standard is applicable (5 foot depth). However, low dissolved oxygen concentration would be expected to occur in the hypolimnion of the reservoir. As with the project as planned alternative, these low dissolved oxygen concentrations in the reservoir are not of environmental significance provided the introduction of fish species having thermal preference for the hypolimnetic waters does not occur. The volume of the hypolimnetic waters having low dissolved oxygen concentration would be much less than for the project as planned alternative.

APPENDIX C
REGIONAL RIVER DEVELOPMENT

A concept plan has been developed to enhance the recreation, wildlife and fishery opportunities for the Duck River between Columbia Dam at river mile 137 and Normandy Dam upstream at mile 248. This river development plan would include all of the 111 mile reach under the no impoundment alternative or, if either impoundment option is implemented, the reach upstream from the impoundment. The major theme would be to promote the river in the four county Duck River Project area for intensive public river based recreation opportunities. Adjacent lands, where suitable, will be used for wildlife development. Facilities would also be developed which complement the river and add to the visitors enjoyment of the rich natural history to be found in the region. Three levels of development were investigated varying from a full range of opportunities in recreation, fishing and wildlife development down to minimal recreational facilities.

The river development proposed for the reach from Columbia Dam to mile 191 has been included in the main body of the report as an integral part of the no impoundment alternative. This appendix outlines potential development of the remaining 57 miles of the Duck River from mile 191 upstream to Normandy Dam which is beyond the scope of the alternatives study. However, this portion of the Duck River could be developed in conjunction with the project as originally planned or with either alternative to bring additional benefits to the region.

The three levels of development for the 57 mile reach are outlined in the following section.

MAXIMUM DEVELOPMENT LEVEL:

A. A minimum 50-foot "greenbelt" easement of either side of the stream would be maintained for bank stabilization, erosion control, and flood plain management and enhancement for wildlife. The greenbelt would also help in maintaining the pastoral beauty of the river.

B. Ten river access sites each consisting of a parking lot, boat/canoe launching ramp, and bank fishing facilities comprising an average of two acres each, would be developed for boating, fishing and consumptive-non-consumptive wildlife uses.

C. A total of 18 informal, primitive camping areas (accessible by river only) would be developed. Each site would average two acres in size. Adirondack-type shelters would be constructed.

D. A main hiking trail approximately 57 miles in length would be constructed. This trail would parallel the river, within the greenbelt link significant natural history features and facilitate other river oriented recreation.

E. Sites containing significant natural, historical, cultural and/or archaeological resources which have been identified, would be proposed for management and development for interpretive and environmental education use.

F. Improvements would be undertaken at suitable sites throughout this stretech of the river to provide improved fishery habitat and improved conditions for water-based recreation.

G. Opportunities for fish stocking would be examined along the lines of the no impoundment alternative.

H. Wildlife management would be practiced selectively and to complement other recreation development.

MEDIUM DEVELOPMENT LEVEL:

A. A minimum 50-foot "greenbelt" easement on either side of the stream would be maintained for bank stabilization, erosion control, and flood plain management and enhancement for wildlife on the 27 mile stretch from Shelbyville to Normandy Dam. The greenbelt would also help in maintaining the pastoral beauty of the river.

B. Seven river access sites each consisting of a parking lot, boat/canoe launching ramp, and river bank fishing facilities comprising an average of two acres each, would be developed. Three sites will be developed for boating access only.

C. A total of eight informal, primitive camping areas (accessible by river only) would be developed.

D. A hiking trail approximately 27 miles in length would be constructed. This trail would parallel the river within the greenbelt and link significant natural history features.

E. Wildlife management, historical and cultural opportunities would be as described.

F. Improvements would be undertaken at some suitable sites throughout this stretch of the river to provide improved fishery habitat and improved conditions for water-based recreation.

MINIMUM DEVELOPMENT LEVEL:

A. Ten river access sites each consisting of a parking lot and boat/canoe launching ramp, and comprising an average of two acres each, would be developed.

B. A total of three informal, primitive camping areas (accessible by river only) would be developed.

APPENDIX D
DEVELOPMENT PLAN FOR HISTORICAL RESOURCES

A complete survey of the area involved in the project as planned has been made, and the structures with historical significance have been identified. Most of these structures have already been acquired in activity to date. The use and disposition of these structures can be considered in each alternative plan.

The basics of the proposed development plan for historical resources are applicable to all project alternatives. Because of land acquisition already completed, TVA has acquired most of the structures which would allow the development plan to be implemented with a minimum of further acquisition. Among the structures acquired are good examples of the historical growth and development not only of this watershed area, but of the entire westward movement in Tennessee.

The proposed development plan for historical resources is to relocate in an appropriate setting and restore the structures identified below to show the development of architecture, habitation, and economic growth in this area. This portrayal will be an authentic, vivid picture of the lifestyle in this area from earliest settlement to the end of the pioneer period. What is true of this area, with minor variations, will also be true of the westard movement in Tennessee.

The structures fall into two generations with several varieties of style in each. The examples listed below are recommended for relocation and restoration. The first generation of structural styles is as follows:

1. Single crib log houses
   a. Rectangle - Rieves Log House (COLR-801)
   b. Square - Box House (COLR-1611)
   c. Square with frame - Davidson House (COLR-1319)
2. Single crib log houses with additions - Derryberry Log House (COLR-1705) with breezeway and kitchen and the addition of a single room.
3. Double crib log houses with breezeway.
   a. Lovett Log House (COLR-334)
   b. Tyree House (COLR-1903) is a frame house built on this log pattern.

The second generation of structural styles is as follows:

1. Central hall Classical "I" block house.
   a. One-story type - Cheek House (COLR-1511)
   b. Two-story type - Harris House (COLR-511)
2. Central hall Gothic "I" house - Hight House (COLR-1211).

The recommended area for relocating, restoring, and exhibiting these structures is the vicinity of Milltown and Lillard Mill. This vicinity is recommended because it allows some additional complementary development that increases the benefits of this plan. Specifically, the community of Milltown should be the subject of preservation and restoration activity based on the furniture industry that was once located here. Also, the now-abandoned Leonard House (COLR-3501), which TVA will not acquire, could be restored in place and exhibited as a good example of the manor house design. Also the community of Caney Springs, a potential historic district, is just three miles north of this vicinity, and the proximity would be beneficial to both communities.

Visitation to such a developed area should grow gradually over a five-year period to an annual level of 100,000 people. With some promotion and coordination with visitor facilities in the Nashville area, the potential visitation could be greatly increased to a level of 250,000 visits annually.

In addition to the relocation and restoration of the nine structures identified above, TVA has acquired a number of other structures which are significant enough that they need to be measured, drawn, and photographed before being removed. These structures are listed below:

1. Briarwood (COLR-210)
2. York House (COLR-1708)
3. Hardison House (COLR-1706)
4. Vaughn House (COLR-333)
5. Billington House (COLR-2906)

The lime kiln on COLR-901 and the foundation of Fountain Heights Mill on COLR-6-121 need to be measured, drawn, and photographed. Disposition of the lime kiln will depend on the project alternative selected.

A number of log structures having no historical significance have already been acquired in the project area. These structures need to be taken down and the useable logs brought to a central storage point for future use as log material.

Archeological sites on lands already acquired are still being evaluated for significance. Other lands that will be acquired will be reviewed and evaluated. Significant sites may be nominated to the National Register. In any event a mitigation plan for the area will be coordinated with the State Historic Preservation Office (SHPO) and Advisory Council on Historic Preservation (ACHP). A selection of significant archaeological sites will be identified, made accessible to the public, and properly protected and interpreted as part of this plan.

APPENDIX E
SUMMARY OF COMMENTS

General

Comments

Several of the comments received raised questions about various aspects of the project as planned, including economic feasibility, environmental impacts, need for another reservoir, inundation of farmland, etc.

Response

As stated in the Foreword, the purpose of this study was to determine if there are any reasonable alternatives to the completion of the Columbia Dam and Reservoir as originally designed. The report does not attempt to reanalyze the project as planned.

The Duck River Project was planned in the late 1960's. The project was planned, evaluated, and proposed to Congress as an integrated project containing two dams and two reservoirs--Columbia and Normandy. The project was approved and funded by the Congress on this basis. The Congress has continued to appropriate funds for the Duck River project and has directed that the project be completed. Thus in the absence of any legal constraint such as the Endangered Species Act, TVA is obligated to complete the project as planned. Since our report shows that if Interior approves the conservation measures the project can be made compatible with the Act, a reexamination of the cost-benefit analysis is not relevant.

Congress appropriated $26 million for the Duck River project for fiscal year 1979. The project has strong local support as evidenced in testimony in a public hearing held in March 1977 as part of the President's review procedure. Also, local governments have pledged to repay more than $16 million of the water supply portion of the construction of the project.

Water Supply

Comment

The report states that "local people believe" industrial development will take place "at a greater pace than projected." No one evidently consulted others, who believe that just the opposite will be true because phosphate supplies in the area will soon be gone.

Response

The sentence referred to (page 4 of the report) makes the point that Normandy Reservoir might not be able to supply the future water supply needs of the Columbia area if industrial development takes place at a greater pace than TVA projected. The Columbia area industrial development is not predicated primarily on phosphate supplies. Obviously, if TVA's water supply projections are high, as the Tennessee Citizens for Wilderness Planning and others believe, Normandy Reservoir could adequately supply the area.

This point has been clarified on page 15 of the report in the second paragraph under Development of Alternatives.

Comment

On page 9, the last sentence of the second paragraph contains the sentence "Under any of the options being considered, sufficient water can be made available from operation of Normandy Reservoir to fulfill the agency's existing water supply commitments to each municipality." We believe that this statement in the draft does not fully consider growth that is occurring in Maury and Marshall Counties.

Response

This sentence refers only to the contractural commitment between TVA and the Upper Duck River Development Agency which commits TVA to a fixed upper limit of water availability for the five municipalities in the four county area.

Water Quality

Comment

The Tennessee Division of Water Quality Control raised several questions related to potential eutrophic conditions in Columbia Reservoir.

Response

Appendix B of the report responds to the State's concern relating to the occurrence of nuisance level blue-green algae within the Columbia Reservoir. Although TVA does not foresee the extreme conditions forecast by the State, provisions as described in Appendix B, have been incorporated into the project to provide operating flexibility to ensure that the effects of any nuisance level algal blooms which may occur in the reservoir can be isolated in the reservoir without impacting the quality of the releases. Such provisions are not provided to control any blooms which may occur in the reservoir, but are to ensure that downstream uses are not impacted by the releases from the reservoirs during periods of a bloom.

The extent to which the downstream fishery would be impacted by changes in project operation would depend entirely upon the frequency and duration of the occurrence of any nuisance level algal blooms within the reservoir. Although such impacts could occur, it is TVA's opinion that they would not be of a frequency sufficient to significantly restrict or preclude the development of a downstream warm water fishery.

It is TVA's opinion that the State's comparison of Columbia Reservoir with J. Percy Priest Reservoir is not valid. Other limiting conditions exist, including the differences in the operation of the projects which have a significant impact on the conditions which may occur within the reservoirs.

With respect to the reference to water quality problems downstream from Tims Ford Reservoir, that problem results from the occurrence of high concentrations of soluble manganese in the releases resulting from lake aging during the initial few years of

project impoundment and operation and not eutrophication. Such conditions were expected at Tims Ford and are expected at Columbia during the first few years of project operation. As at Tims Ford, TVA has been providing, and will continue to provide, assistance to the water systems along the Duck River in the resolution of water quality related problems associated with the initial lake aging of Normandy Reservoir and Columbia Reservoir when impounded.

Endangered Species

Comment

It appears to us that the endangered-species question may not have been adequately addressed in the study and should be looked into by independent experts. For example, the summary statement (page 1-2) does not reflect the uncertainty conveyed in Appendix A. At least a second species of endangered mussel (from the E. Walkeri-E. florentina complex) is likely to be present, and others have perhaps not been searched for extensively enough. Possibly two of the listed snail species may have the Duck River as their critical habitat; and information on the fish and plant species appears incomplete at best.

Response

The summary statement has been revised to reflect the status of the endangered mussels. TVA biologists and others have spent a considerable amount of time examining the Mollusk populations in the Duck River and the conclusions of these studies are presented in Appendix A, largely without interpretation. There are seven species of freshwater mussels listed as endangered which could be expected to inhabit the Duck River but a viable population of only one of these, Conradilla caelata, has been documented.

No comment about proposed critical habitat for any of the proposed threatened and endangered snail species is made in Appendix A or elsewhere in this report largely because a great deal of distribution and other information has been accumulated by TVA and others

about each of these species since they and their critical habitat areas were proposed in 1977. While the proposed critical habitat of six of the seven snails discussed in Appendix A includes portions of the Duck River, the final boundaries of these critical habitats will almost certainly be much different when and if these species are listed.

Numerous surveys have been conducted in the Duck River to assess the fish population. Through these investigations it has been determined that there are no federally listed species within the area of the project. This information has been discussed with the FWS during formal consultation with no disagreement. One species of fish (coppercheek darter) listed as threatened by the State does occur in the project area but is distributed throughout the Duck River and thus is not in jeopardy.

Comment

We suggest that it might be pointed out as an additional reason that the mussels are disappearing from the Duck River is the fact that the Asiatic Mussel or clam (Corbicula Manilensis) has since the early 1960's, or probably sooner, taken over the Duck River with the result that other mussels and snails are likely to be forced out through this competition.

Response

The Asiatic clam, Corbicula, has been said to be able to outcompete the native mussels once the species is introduced. This hypothesis, which does appear to have some basis in fact so far as the fingernail clams (Family Sphaeriidae) are concerned, has not been subjected to experimental testing. In many areas Corbicula appears to be co-existing with native freshwater mussels without obvious effect.

Comment

The Tennessee Department of Conservation questions the adequacy of the assessment of impacts of the project on "endangered and threatened plant species on page A-3" of the draft report.

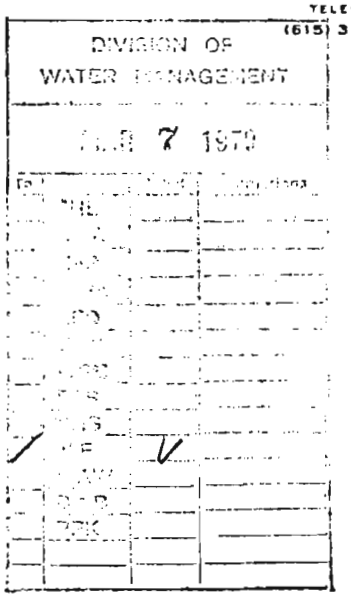
Response

The nine species included in the Department's March 28, 1979, letter are not listed as endangered or threatened on Federal lists. Four are proposed and the other five are being reviewed. "Listed" is a specific term in this context signifying that the species are provided legal protection, which is not the case.

Botanists of the U.S. Office of Endangered Species, Tennessee Heritage Program and TVA are scheduled to spend the weekend of April 28 at the project area to identify areas of mutual concern. It is hoped that this will do much to clarify points of disagreement. The information supplied by the Tennessee Heritage Program is very helpful in this effort and is gratefully acknowledged.

LON P. MACFARLAND, P.C.
ATTORNEY AT LAW
MIDDLE TENNESSEE BANK BUILDING
COLUMBIA, TENNESSEE 38401
TELEPHONE
(615) 388-3215

March 1, 1979



Hon. S. David Freeman
Chairman
Tennessee Valley Authority
TVA Towers
Knoxville, Tennessee

Hon. Richard Freeman
Director
Tennessee Valley Authority
TVA Towers
Knoxville, Tennessee

Re: Report on Preliminary Studies
of Columbia Dam Alternatives

Dear Dave and Dick:

We appreciate your sending copies of this report to us, and we are generally pleased with the report. We note that the report concludes that the Columbia Dam alternatives are not feasible.

On Page 9, the last sentence of the second paragraph, contains the sentence "Under any of the options being considered, sufficient water can be made available from operation of Normandy Reservoir to fulfill the agency's existing water supply commitments to each municipality." We have question as to this statement. We enclose a Future Water Supply Requirement on the Duck River from J. P. Woodruff dated February 7, 1979, on this subject. In addition, we believe that this statement in the draft does not fully consider growth occurring in Maury and Marshall Counties, and especially does not consider the fact that a substantial part of Williamson County will need to get its water supply from the Columbia Dam Reservoir. Williamson is the fastest growing County in the State of Tennessee. It has a very great need for additional water supply, particularly in the southern half and we feel that this should be considered. In addition, the grid system which has been established in Maury and Marshall Counties to provide water throughout the Counties is dependent on the Columbia reservoir for its supply. A great increase in water users will result from further expansion of the grid system.

In addition to the comments in regard to the mussels in connection with the Endangered Species Act, pages 2, 3 and 4, we suggest that it might be pointed out as an additional reason that the mussels are disappearing from the Duck River area is the fact that the Asiatic Mussel or clam (Corbicula Manillenisis) has since the early 1960's, or probably sooner, taken over the Duck River with the result that other mussels and snails are likely to be forced out through this competition. We enclose a statement pointing this out.

We appreciate your effort to complete the Columbia Dam, and look forward to working with you further. We would like to receive copies of the final report and to be kept advised.

Very truly yours,

Lon P. MacFarland
Attorney for the Upper Duck
River Development Agency

LPM:ds

Encl

cc: Mr. Jack Ferguson
Tennessee Valley Authority
Evans Building
Knoxville, Tennessee

Dr. Thomas Ripley
Manager of Natural Resources
Tennessee Valley Authority
TVA Towers
Knoxville, Tennessee

FUTURE WATER SUPPLY REQUIREMENTS ON THE DUCK RIVER

TVA Planning Report No. 65-100-1 projects the future potable and process water requirements as follows in the Upper Duck River Area:

COUNTY	TOWNS	YR 2025	YR 2075
Coffee	Manchester; Tullahoma (combined)	10 MGD	20 MGD
Bedford	Shelbyville	5 MGD	7.5 MGD
Marshall	Lewisburg	4 MGD	7.0 MGD
Maury	Columbia	17 MGD	28 MGD
Subtotal Potable Water -		36 MGD	62.5 MGD
Self-supplying industries, process water		29 MGD	29 MGD
Subtotal		65 MGD	91.5 MGD
Estimate of future Williamson County requirements		10 MGD	15 MGD
Totals		75 MGD	106.5 MGD
Cubic feet per second		116 CFS	164 CFS

TVA DUCK RIVER EIS:

The report states that 20 CFS is lost between Shelbyville and Columbia during prolonged drouth periods by evaporation and transpiration losses when all the streams dry up. This is an observed loss when the natural stream flow was below 30 CFS. With augmented flow by releases from Normandy Dam, these losses would probably increase to 30 CFS. In addition, we calculate that over

21 CFS will be lost from Normandy Lake by evaporation and transpiration in drouth periods.

The planning report also states that 155 CFS will be required to maintain water quality downstream from Columbia.

Inflow to the river above Shelbyville during prolonged drouths has been less than 30 CFS.

The following is a summary of the projected future water requirements of the area during prolonged extreme drouth periods:

	YR 2025	YR 2075
Total water supply requirement	116 CFS	164 CFS
Evaporation and transpiration losses in river	30	30
Evaporation and transpiration on Normandy Lake	21	21
Flow required to maintain water quality below Columbia	155	155
Total requirements	322	370
Less Inflow	(30)	(30)
Water that must be supplied from storage	292 CFS	340 CFS

If Normandy Reservoir is the only storage facility provided on the river, the summer pool at Normandy Reservoir will be lowered drastically during extreme drouths. Many recreation benefits would be lost to the public by operation as the sole water supply reservoir on the river. Normandy Reservoir was lowered about five feet below normal summer pool in 1977 during a drouth which was not extreme.

Columbia Dam is needed to meet the water supply requirements of the Upper Duck River Area. Elimination of Columbia Dam will necessitate compromises on water supply and water quality as well as the loss of most of the flood control benefits in the Columbia Area.

cc: Lon McFarland
Clayborne Ross
David Freeman
Richard Freeman

J. P. Woodruff
2-7-79

SUPPLEMENT TO FUTURE WATER SUPPLY REQUIREMENTS ON THE DUCK RIVER

The City of Lewisburg is in the position of having to make substantial expenditures on their intake structure at the Lillard Mill Dam impoundment. If the Columbia Dam is built as planned, the design will require facilities that can operate with a variation of a summer and winter pool. If Columbia Dam is not built, a different design will be required.

Lewisburg has experienced difficulty during the summer months in maintaining prime on their pumps. They have a problem obtaining sufficient water with their present facilities. They also have to supplement the supply of water from Duck River with water of inferior quality from the city lake.

An early decision on the completion of the Columbia Dam is needed for Lewisburg to make the necessary capital improvements on their water intake on Duck River.

The life of Lillard Mill Dam is doubtful because of erosion around the dam on the north bank of the river.

Studies for construction of a water filtration plant to serve Lewisburg and Marshall County are being made. The site for this new facility is at U. S. Highway 431 and State Highway 99 near the river crossing. The studies and this facility are based on completion of the Columbia Dam as originally designed. The filtration plant can be designed with capacity to supply Franklin and a portion of Williamson County.

27 February 79

ASIATIC MUSSEL OR CLAM (CORBICULA MANILLENSIS)

The asiatic clam has become so numerous in Duck River that it has become a nusiance to municipalities and industry which depend on this source to furnish water for drinking or cooling purposes. This intruder first appeared in the river in the early 60s and in a few years became so prevalent that they began to plug the filters at the Monsanto Plant, twelve miles down river from the City of Columbia.

The build up in the intake pipes caused from the mussels attaching themselves to the sidewalls of the pipes so reduces the volume of water which can be pumped through these pipe has caused a problem in the water systems at Columbia, Lewisburg, and Shelbyville. These cities have been forced to add chlorine to the river water as it enters the system to kill the mussel which then are removed on the primary filter.

Mr. Billy G. Isom and Dr. Paul Yokley, Jr. in their report (THE MUSSEL FAUNA OF DUCK RIVER IN TENNESSEE, 1965) stated that they had found the Corbicula Manillensis at ten stations surveyed between river mile 71 and 242.5. Sinclair and Isom in 1963 reported the Asiatic Clam found in the downstream impounded reaches of Duck River and in the Buffalo River. They stated that they did not know if this introduced specie has contributed to the decline of the native river mussels through competition, but the population densities in some areas were in the hundreds per square meter.

Dr. Henry van der Schalie reports in his paper (THE MULLUSKS OF THE DUCK RIVER DRAINAGE IN CENTRAL TENNESSEE, 1973) on the virtual disappearance of the native mussel from the Duck and Buffalo Rivers. The Buffalo River enters the Duck River near its mouth and has no kown source of pollution and is listed in the wild rivers systems. Dr. van der Schalie states that the serious inroads made by the Asiatic Clam in the Duck and Buffalo Rivers may crowd out the native mussels where they still remain.

It can be seen that even without the dam the native mussel will probable disappear due to other causes. Pollution within the Duck River System has been practically eleminated by the efforts of the TENNESSEE STREAM POLLUTION CONTROL and only the Asiatic Clam is ever increasing.