DOE/EIS-0121

FINAL
ENVIRONMENTAL IMPACT STATEMENT

Alternative Cooling Water Systems
Savannah River Plant
Aiken, South Carolina

October 1987

U.S. Department of Energy

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COVER SHEET

RESPONSIBLE AGENCY: U. S. Department of Energy

ACTIVITY: Final Environmental Impact Statement, Alternative Cooling Water Systems at the Savannah River Plant, Aiken, South Carolina.

CONTACT: Additional information concerning this statement can be obtained from:

Mr. S. R. Wright
Director, Environmental Division,
U. S. Department of Energy
Savannah River Operations Office
P. O. Box A
Aiken, South Carolina 29802
(803) 725-3093

For general information on the Department of Energy's EIS process contact:

Office of the Assistant Secretary for Environment,
Safety, and Health
U.S. Department of Energy
ATTN: Ms. Carol Borgstrom (EH-25)
Acting Director, Office of NEPA Project Assistance
Room 3E-080, Forrestal Building
1000 Independence Avenue, SW
Washington, D. C. 20585
(202) 586-4600

ABSTRACT: The purpose of this Environmental Impact Statement (EIS) is to provide environmental input into the selection and implementation of cooling water systems for thermal discharges from the K- and C-Reactors and from a coal-fired powerhouse at the Savannah River Plant. The Savannah River Plant is a major U.S. Department of Energy (DOE) installation for the production of nuclear materials for national defense. This EIS addresses the potential environmental consequences of constructing and operating once-through and recirculating cooling towers for the K- and C-Reactors; increased pumping to a raw water basin and direct discharge to the Savannah River for a coal-fired powerhouse; and no action. The potential environmental consequences assessed include effects on air and water quality, ecological systems, archaeological resources, endangered species, and wetlands.

PREFACE

The purpose of this Environmental Impact Statement (EIS) is to provide environmental input into the selection and implementation of cooling water systems for thermal discharges from K- and C-Reactors and from a coal-fired powerhouse in the D-Area at the Savannah River Plant (SRP); the Plant is a major U.S. Department of Energy (DOE) installation for the production of nuclear materials. Implementation of cooling water systems for these facilities is needed for compliance with the State of South Carolina Class B Water Classification Standards and Consent Order (84-4-W), dated January 3, 1984, and amended August 27, 1985, and August 31, 1987, between DOE and the South Carolina Department of Health and Environmental Control (SCDHEC).

K- and C-Reactors, which are operating production reactors, discharge their cooling water directly to Pen Branch and Four Mile Creek, respectively. The onsite coal-fired powerhouse in D-Area discharges cooling water from cooling-system condensers into an excavated canal prior to discharge to Beaver Dam Creek. These facilities have been in operation since their construction in the 1950s.

On January 1, 1984, SCDHEC issued a National Pollutant Discharge Elimination System (NPDES) permit (Number SC0000175) for the Savannah River Plant. In this permit, the cooling water discharge limitations included a temperature limitation in onsite streams (i.e., onsite streams are not to exceed 32.2°C; in addition, the effluent must not raise the temperature of the stream more than 2.8°C above its ambient temperature) rather than in the Savannah River as previously permitted by EPA. To achieve compliance with these limitations, DOE and SCDHEC entered into a Consent Order (84-4-W) on January 3, 1984, that temporarily superseded the temperature requirements in the NPDES permit and identified a process for attaining compliance. Major elements of this process included a DOE agreement to complete a comprehensive study of the thermal effects of major SRP thermal discharges, the submittal of a thermal mitigation study, and the selection and implementation of cooling water systems.

On October 3, 1984, DOE submitted its Thermal Mitigation Study to SCDHEC. This study describes the cooling water systems that could be implemented for K- and C-Reactors and the D-Area coal-fired powerhouse to achieve compliance with Federal and State water quality standards.

A Notice of Intent to prepare this EIS was published in the Federal Register on July 29, 1985 (50 FR 30728). That notice solicited comments and suggestions from interested agencies, organizations, and the general public for consideration in preparing the EIS. The preliminary scope was included in the Notice of Intent.

Comments were received by mail and at the scoping meeting held in Aiken, South Carolina on August 19, 1985. Written comments were received until August 31, 1985.

In response to the Notice of Intent, 12 individuals, organizations, and governmental representatives provided comments to assist in the preparation of this EIS. Appendix H includes the issues raised during the scoping process and cross-references to the appropriate Draft EIS chapter or appendix.

As part of the scoping process, DOE invited interested parties to comment on its preliminary determination of reasonable alternatives to be considered in the environmental impact statement (i.e., once-through and recirculating cooling towers for K- and C-Reactors, and increased pumping to the raw water basin for the D-Area powerhouse). Because DOE received no comments on this preliminary determination, it has identified these, in addition to direct discharge of D-Area cooling water to the Savannah River and "no action" (required by the Council on Environmental Quality for implementing the National Environmental Policy Act), as the reasonable alternatives that it will consider in detail in this environmental impact statement.

On March 28, 1986, DOE began the public distribution of the Draft EIS to all interested individuals, agencies, and groups for review. Also on March 28, 1986, a notice in the Federal Register (51 FR 10652) announced the availability of the Draft EIS and a 45-day review/comment period on the document from March 28 to May 19, 1986. DOE conducted public hearings in Aiken, South Carolina, on April 30, 1986.

During the 45-day comment period, DOE received 27 statements and comment letters on the Draft EIS. DOE also received three comment letters after May 19, 1986.

Many of these comments have led to revisions in this Final EIS. Appendix J contains the comments received during the public comment period and DOE's responses to these comments.

In this Final EIS, changes from the draft are indicated by vertical lines in the margin of each affected page. Minor typographical and editorial corrections are not identified. Changes that are the result of public comments are identified by the specific comment numbers that appear in Appendix J. A change that is the result of an error (typing error, etc.) in the draft is identified with the letters "TE," and one made to clarify or expand on the draft statement is identified with the letters "TC." Those changes in this Final EIS that are the result of a public comment are identified by an alphanumeric marginal notation (e.g., AA-1); these notations refer to comments in Appendix J. The responses to these comments in Appendix J also provide additional information and clarification.

In this Final EIS, Chapters 2 and 4 and Appendixes B, C, D, and G have the most changes. Appendix I has been added to provide a detailed discussion of the feasibility of using cooling water discharges from K- and C-Reactors for agricultural and aquacultural uses, industrial applications, direct power generation, and ethanol production. In addition to these changes, the order in which the alternatives and subsequent actions/impacts for each reactor are presented have been revised (i.e., discussions of K-Reactor alternatives now precede those of C-Reactor) because the construction of an alternative for K-Reactor would precede the construction of a C-Reactor alternative. No change bars are used for the new Appendix I, the preface, the summary, and for the reordering of the K- and C-Reactor alternatives.

Since the completion of the Thermal Mitigation Study and the Draft EIS, further design evaluations and studies have been performed to determine optimal performance parameters and to achieve lower costs. These evaluations and studies have indicated that, in several areas, optimization of performance and cost savings can be realized in the construction and operation of once-through towers without introducing major changes in the nature or magnitude of the environmental impacts. These areas include the consideration of gravity-feed versus pumped-feed towers, natural-draft versus mechanical-draft towers, and a chemical injection system for either dissipation or neutralization of chlorine biocide versus holding ponds (and their sizing). Similarly, these evaluations and studies have also led to the development of thermal performance criteria that, when incorporated in the final design of a once-through cooling-tower system, would reduce the potential for cold shock (i.e., reduce the difference between ambient stream temperatures and stream temperatures when the cooling water is being discharged) to fish. In addition, substantive information regarding the biological effects of cooling tower operations has been included in Chapter 4 of this Final EIS.

Since the publication of the Draft EIS, the U.S. Fish and Wildlife Service (FWS) has reclassified the American alligator from "endangered" to "threatened due to similarity of appearance" because the species is no longer biologically endangered or threatened throughout its range (52 FR 107: 21059-21064). The "threatened due to similarity of appearance" status ensures against excessive taking of the alligator and continues necessary protection for the American crocodile, a morphologically similar species. References to the American alligator and impacts to it have been deleted from the summary; references have been retained in the other sections, but without mention of its FWS status (see Appendix C for more details on this reclassification).

This EIS was prepared in accordance with the Council on Environmental Quality NEPA regulations (40 CFR 1500-1508) and DOE's NEPA guidelines (45 FR 20694, March 28, 1980 as amended), by DOE and by DOE's contractors under the direction of DOE. Methodologies used and sources of information relied upon for analysis are identified in this EIS. In addition, available results of ongoing studies have been used.

Referenced material in the EIS is available for review in the U.S. Department of Energy's Public Reading Room, located at the University of South Carolina's Aiken Campus, Aiken, South Carolina, and the Freedom of Information Reading Room, Room 1E-190, Forrestal Building, 1000 Independence Avenue, S.W., Washington, D.C.

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SUMMARY

PURPOSE

The U.S. Department of Energy (DOE) has prepared this final environmental impact statement (EIS) to address the environmental consequences of the proposed construction and operation of modified cooling water systems for K- and C-Reactors and the D-Area coal-fired powerhouse at its Savannah River Plant (SRP) in accordance with Section 102(2)(C) of the National Environmental Policy Act (NEPA) of 1969, as amended, and to provide input into the selection and implementation of such systems. On March 28, 1986, a Federal Register notice (51 FR 10652) announced the availability of the draft EIS and established a 45-day review/comment period on the document, from March 28 to May 19, 1986. On April 30, 1986, DOE conducted public hearings in Aiken, South Carolina. In its preparation of this final EIS, DOE has considered the comments that were submitted by government agencies, private organizations, and individuals during the public hearing and review/comment period. This final EIS incorporates the comments on the draft EIS, DOE's responses, and modifications made as a result of these comments. The major comments received at the public hearings and during the comment period fell into the following categories:

- Alternative uses of cooling water for various agricultural, aquacultural, and power production
- More detailed design analysis and thermal performance data for cooling towers
- Present-worth cost analysis of cooling towers
- Inclusion of predictive biological information similar to that required by Section 316(a) of the Clean Water Act, along with a Habitat Evaluation Procedure (HEP) analysis
- Impact of chlorination/dechlorination and corrosion-inhibiting compounds on the aquatic environment

NEED

The major sources of thermal effluents at the Savannah River Plant are the cooling water discharges from production reactors and the D-Area coal-fired powerhouse. Two of the production reactors, K- and C-Reactors, discharge their cooling water directly to Pen Branch and Four Mile Creek, respectively. The coal-fired powerhouse in D-Area normally discharges cooling water from cooling-system condensers into an excavated canal that flows into Beaver Dam Creek. At present, the discharges from these three facilities do not meet the temperature limits specified in the State of South Carolina's Class B water classification standards.

DOE must implement cooling water systems for the thermal discharges from K- and C-Reactors and the D-Area coal-fired powerhouse to comply with both the South Carolina Class B water classification standards [as contained in the renewed NPDES permit (Number SC0000175)] and a Consent Order (84-4-W), dated January 3, 1984, and amended on August 27, 1985, and August 31, 1987, between DOE and the State of South Carolina Department of Health and Environmental Control (SCDHEC). The Consent Order contains a compliance schedule for the completion of NEPA documentation and the construction and operation of cooling water systems to attain the Class B water classification standards, subject to the appropriation of funds by Congress. As stated in the NPDES permit, cooling water discharge temperature limits for K- and C-Reactors and the D-Area powerhouse are not to exceed an instream temperature of 32.2°C and the effluent must not raise the temperature of the stream more than 2.8°C above its ambient temperature unless the existence of a balanced biological community can be maintained through evidence provided by a Section 316(a) Demonstration study.

PROPOSED ACTION

The proposed action considered in this environmental impact statement is the construction and operation of cooling water systems for K- and C-Reactors and the D-Area powerhouse to attain compliance with the State of South Carolina's Class B water classification standards. DOE's preferred alternatives are to construct and operate once-through cooling towers for K- and C-Reactors, and to implement increased flow with mixing for the D-Area coal-fired powerhouse. Because the discharge temperatures of cooling water from these preferred alternatives will at times raise the ambient stream temperatures by more than 2.8°C, DOE will conduct Section 316(a) demonstration studies to determine whether a balanced biological community can be maintained.

ALTERNATIVES

DOE initially identified 22 possible alternative cooling water systems that could be implemented for K- and C-Reactors and four alternatives for the D-Area powerhouse. Using a structured screening process, DOE then identified those alternatives that would be reasonable to implement; the screening process and alternatives were documented in a Thermal Mitigation Study, which was submitted to SCDHEC on October 3, 1984. Based on the information contained in its Notice of Intent to prepare this EIS and the comments received during the public scoping period, DOE identified the cooling water alternatives that are considered in detail in this EIS.

Since the completion of the Thermal Mitigation Study and the Draft EIS, further design evaluations and studies have been performed to determine optimal performance parameters and to achieve lower costs. These evaluations and studies have identified several areas in which optimization of performance and cost savings can be realized in the construction and operation of cooling towers without introducing major changes in the nature or magnitude of the environmental impacts. These areas include the consideration of gravity-feed versus pumped-feed towers, natural-draft versus mechanical-draft towers, and a chemical injection system for either dissipation or neutralization of chlorine biocide versus holding ponds (and their sizing). Similarly, these evaluations and studies have also led to the development of thermal performance criteria that, when incorporated in the final design and operation of a cooling-tower system, would reduce the potential for cold shock (i.e., reduce the difference between ambient stream temperature and stream temperature when the cooling water is being discharged) to aquatic organisms.

The alternatives considered in this EIS for K- and C-Reactors are the construction and operation of once-through cooling towers, the construction and operation of recirculating cooling towers, and the continuation of direct discharge - or no action [as required by the Council on Environmental Quality for implementing the procedural provision of the National Environmental Policy Act (40 CFR 1502.14)]. The alternatives considered for the D-Area coal-fired powerhouse are to increase the inlet water flow with mixing to the D-Area raw-water basin, and mix raw-water basin overflow with the cooling water discharge; to construct a new pipeline to enable a direct discharge to the Savannah River; and to continue the present operation - or no action. None of the three alternatives considered for the K- and C-Reactors would comply with all temperature limits of the South Carolina Class B water classification standards, as contained in the renewed NPDES permit ΔT (e.g., at the point of discharge). However, DOE believes that Section 316(a) studies will indicate that balanced biological communities can be maintained in the receiving stream systems under either the once-through cooling tower or recirculating cooling tower alternative. If the preferred cooling system alternative for K- and C-Reactors (i.e., once-through cooling towers) is judged not acceptable by the South Carolina Department of Health and Environmental Control, DOE may select the recirculating cooling tower alternative in order to meet the conditions of the NPDES permit.

AFFECTED ENVIRONMENT

The Savannah River Plant is a 780-square-kilometer (192,741-acre), controlled-access area near Aiken, South Carolina. This major DOE installation was established in the early 1950s for the production of nuclear materials for national defense. Six principal tributaries to the Savannah River are located on the Plant. Five of these streams have received thermal discharges from SRP cooling water operations. At present, Beaver Dam Creek, Four Mile Creek, and Pen Branch receive direct thermal discharges from the D-Area coal-fired powerhouse, C-Reactor, and K-Reactor, respectively.

The Plant is bordered on the southwest by the Savannah River, which it parallels for about 16 kilometers. About 10,000 acres of the Savannah River swamp forest lie on the Plant from Upper Three Runs Creek to Steel Creek. Three breaches in a natural levee between the swamp system and the Savannah River allow water from Steel Creek, Four Mile Creek, and Beaver Dam Creek to flow to the river. The combined discharges of Steel Creek and Pen Branch enter the river near the southeastern corner of the Plant. During periods of flooding, the Savannah River overflows the levee and floods the entire swamp area, leaving only isolated islands.

The Savannah River downstream of Augusta, Georgia, is classified by the State of South Carolina as a Class B waterway, suitable for agricultural and industrial use, the propagation of fish, and, after treatment, domestic use.

The Savannah River Plant currently withdraws a maximum of 37 cubic meters per second, primarily for cooling production reactors and the D-Area coal-fired powerhouse. Almost all of this water returns to the river via SRP streams. The temperature of water discharged from the reactors normally ranges between 45° and 65°C above ambient.

The thermal discharges from K- and C-Reactors have changed Pen Branch and Four Mile Creek from single-channel, meandering streams to wide, multichannel, braided systems flowing within partially vegetated floodplains. Where the streams enter the swamp, eroded material has been deposited, and deltas have formed and continue to increase in size. An estimated 1817 acres of wetlands have been adversely affected by the K- and C-Reactor thermal discharges. The estimated average annual loss of wetlands between 1975 and 1985 was about 54 acres.

Few aquatic organisms are found in the thermal areas of Pen Branch and Four Mile Creek. The thermal discharges prevent aquatic species from inhabiting the streams while the reactors are operating. Fish spawning in the streams and deltas is restricted.

Water intake withdrawal from the Savannah River for K- and C-Reactors causes annual estimated entrainment losses of about 26.9×10^6 fish eggs and larvae. These losses represent approximately 11 percent of the fish eggs and larvae passing the intake canals during the spawning season. In addition, estimated impingement losses of about 5885 fish occur annually.

Low fish densities and high water levels in portions of Four Mile Creek, Pen Branch, and the Savannah River swamp limit the value of these areas for foraging by the endangered wood stork. No other threatened or endangered species or critical habitat would be affected by the proposed alternatives for K- and C-Reactors.

The operation of the D-Area coal-fired powerhouse results in a withdrawal of about 2.6 cubic meters of water per second from the Savannah River and thermal discharges to Beaver Dam Creek. These discharges meet the State of South Carolina's Class B water classification standard of a maximum instream temperature of 32.2°C except during occasional periods from May through September, when water temperatures can be as high as 34°C under extreme conditions. The discharges from the D-Area powerhouse also fail to meet the Class B water classification standard of a maximum stream temperature rise over ambient of 2.8°C.

The endangered wood stork uses areas of Beaver Dam Creek and its delta for foraging during the summer.

Water withdrawal from the river for the D-Area powerhouse causes estimated entrainment losses of about 2.0×10^6 fish eggs and larvae and estimated impingement losses of about 1718 fish annually.

ENVIRONMENTAL CONSEQUENCES

No action - the once-through direct discharge of cooling water from K- and C-Reactors and the continuation of the thermal discharges from the D-Area powerhouse - would result in discharges that would not meet the State of South Carolina Class B thermal standards. No action would also result in a continuation of the environmental conditions described above as the affected environment. The following sections summarize the environmental consequences of constructing and operating new cooling water systems for K- and C-Reactors and the D-Area coal-fired powerhouse.

K- AND C-REACTOR ONCE-THROUGH COOLING TOWERS (PREFERRED ALTERNATIVES)

The construction and operation of once-through, natural-draft, gravity-feed cooling towers is the preferred alternative for both K- and C-Reactors. Cooling water discharges from the once-through cooling towers would comply with the State of South Carolina Class B water classification standard of a maximum instream temperature of 32.2°C. However, because the effluent discharge would occasionally raise the ambient stream temperatures by more than the maximum allowable change in temperature of 2.8°C, Section 316(a) Demonstration studies would be performed to determine whether balanced biological communities are being maintained. The reduction in the temperature of cooling water discharges as a result of once-through cooling-tower operation and the continued discharge of approximately the same volume of cooling water would increase the available aquatic habitat for fishes and other organisms. Wetland losses, which are currently about 54 acres per year in the delta/swamp, would decrease as a result of reduced discharge temperatures; some revegetation would occur as a result of natural plant succession.

Construction of natural-draft, once-through, gravity-feed towers for K- and C-Areas would adversely affect approximately 60 acres of uplands, less than 1 acre of which is considered to be wetland. Balanced communities containing all biotic categories should develop and remain in the Pen Branch and Four Mile Creek ecosystems. Conditions for all biotic categories would be greatly enhanced in comparison to present conditions. Recolonization of areas that are presently uninhabitable because of excessive temperatures would be expected to occur rapidly.

Zooplankton would become established which would provide food for the development of balanced indigenous macroinvertebrate and fish communities. The maximum predicted summer temperatures in the Pen Branch and Four Mile Creek systems would be within the range tolerated by most, if not all, indigenous zooplankton species. The standing crop, species composition, community structure, and seasonal periodicity should be similar to those of the Pen Branch and Four Mile Creek systems before Plant operation and to those of other natural streams in the region. Cooling-tower discharge flow would not constitute a lethal barrier to the free movement (drift) of zooplankton.

The habitat-formers community would improve with the addition of once-through cooling towers. However, the pattern of recovery is difficult to predict. High flows probably would impede the types of vegetative communities that could develop. Macrophyte development in Pen Branch and Four Mile Creek probably would be restricted to the edges of the islands throughout the lower stream reaches.

The reduced temperature regimes would permit the invasion of some species of aquatic macrophytes and periphyton in parts of the systems that are presently too hot to support plant life. However, rapid water velocities and scoured stream substrates are expected to retard the development of macrophyte communities in the center of the stream channels. In contrast, development of aquatic macrophyte and riparian communities is expected along the stream margins, as well as in the delta areas, where the stream channels are braided and water velocities are reduced.

The combination of above-ambient temperatures and the nutrient-rich river water that is used for reactor cooling should result in higher levels of primary production than would occur without reactor discharge. In addition, much more aquatic habitat would exist with once-through cooling towers than would exist without the reactor discharges, because of the higher water levels. Flow fluctuations during reactor cycling would result in the dewatering and subsequent dessication of large areas of stream bottom during reactor outages. The flow fluctuations probably would result in macrophyte communities dominated primarily by emergent species that could withstand dewatering, although some submerged macrophyte species probably would become established in pools and backwater areas. The dewatering also would impact periphyton communities, causing die-offs during reactor outages. Thus, although conditions with the cooling towers would be improved over existing conditions due to reductions in stream temperatures, flow fluctuations would perturb the ecosystems of the stream corridors and delta areas to some extent and would influence the types of communities that would develop in these areas.

Reduced stream water temperatures in comparison to present conditions would provide a thermal regime in the Pen Branch and Four Mile Creek systems conducive to the establishment of reasonably diverse macroinvertebrate communities. However, elevated temperature regimes and fluctuations in water level could preclude the establishment of some of the more sensitive macro-invertebrate taxa in the streams. The dominant taxa would be expected to shift, with the more thermally-tolerant species being replaced by other species that are less thermally tolerant. Although above-ambient temperatures might produce earlier emergence of many species of aquatic insects, no major adverse impacts should occur. The slightly elevated temperatures could permit multivoltine species of insects (those that complete more than one life cycle per year) to produce one or more additional generations per year, thereby increasing the net annual production of the macroinvertebrate communities. Organisms that can migrate quickly would be favored in Pen Branch and Four Mile Creek, while sessile organisms, as well as taxa that pupate in the water, could experience high rates of mortality during reactor outages. Increased drift would occur during rising and receding water levels, which could result in increased predation and possibly temporary reductions in standing crop. Species that inhabit the stream substrate might not be greatly impacted, except during extended reactor outages, when discharges could be reduced long enough to dry out portions of the stream substrate completely. If large periphyton die-offs are caused by dewatering, secondary production could be reduced temporarily due to the reduced availability of food. However, the standing crop of macroinvertebrates should be sufficient to ensure a good supply of food for higher trophic levels.

The cooling-tower discharge flows should not interfere with the drift or upstream movement of macroinvertebrates, because the predicted maximum temper-atures of the plumes would be less than the upper thermal limits of most macroinvertebrate species indigenous to the southeast. No significant farfield impacts should occur, because the water would be near ambient temperature by the time it reaches the Savannah River.

Once-through cooling towers would improve conditions for the fish communities in the Pen Branch and Four Mile Creek systems. The communities in the upper reaches above the reactors are not expected to change substantially from present conditions, because the fish communities in the upper reaches of SRP tributary streams appear to be stable and not significantly affected by reactor operations. Reproductive activities of all indigenous fish species should be improved over present conditions by implementation of this alternative; growth should be enhanced by the increased productivity resulting from the slight temperature elevation and nutrient loading from Savannah River water pumped through the systems. Final design and operation of the cooling-tower systems would comply with the temperature shock limits proposed by the U.S. Environmental Protection Agency (EPA) for the protection of all warm-water fishes that could occur during a winter shutdown in Pen Branch or Four Mile Creek. Maximal absolute temperatures and fluctuations therein should not block fish migration. Accordingly, the entire Pen Branch and Four Mile Creek systems should be available for fish habitation and reproduction; the free movement of fishes between the stream headwaters and the Savannah River should not be inhibited by reactor operations at any time during the year. The thermal discharge flows should not block fish migration or exclude fish from any part of the ecosystems. Annual entrainment (26.9×10^6 fish eggs and larvae) and impingement (5885 fish) losses are estimated to be about the same as those estimated for current operations.

The implementation of once-through cooling towers with their associated high flow rates, water depths, and lengthy reactor cycles would minimize the availability of preferred foraging habitat of the endangered wood stork.

Air quality impacts, including fogging and icing, elevated visible plumes, and total-solids (drift) deposition would be negligible. The construction of the towers would disturb one known prehistoric archaeological site that has been determined to be "not significant" by the State Historic Preservation Officer.

Current radiological releases, which would continue with the implementation of the once-through cooling-tower alternatives, consist of remobilized radionuclides in the Pen Branch and Four Mile Creek streambed systems, and radionuclides (principally tritium) from small process-water leaks into the cooling water of the reactors' heat exchangers and releases into process sewers. The operation of once-through cooling towers would not produce any significant changes in the remobilization of radionuclides in streambeds because the rate of cooling water discharged from the towers would remain essentially the same as that for current operations. The operation of once-through cooling towers would result in an annual release of about 100 additional curies of tritium to the atmosphere because of cooling water evaporation, and a corresponding reduction of about 100 curies that had been released to the streams. The operation of once-through cooling towers would result in a total reduction in the maximum individual effective whole-body dose of about 2.3×10^{-4} millirem per year, and a decrease in the total collective effective whole-body dose to the 80-kilometer regional population and downstream water consumers of about 5.5×10^{-2} person-rem per year. These radiological dose changes are extremely small when compared to existing operations and to year-to-year variations in natural background radiation; doses would remain within all applicable requirements and standards.

The estimated present worth for the once-through natural-draft cooling tower at K-Reactor with gravity feed would be approximately $43 million, including production losses ($41.4 million without production losses). Estimated annual operating costs would be $6.4 million. Preliminary design studies suggest a 0.2-percent annual average loss of reactor power attributable to the operation of a once-through tower system in comparison to the No-Action alternative. In addition to construction and operation costs, the estimated cost to conduct a Section 316(a) Demonstration study would be $1.25 million. Construction would require about 36 months, after a 9-month lead design period.

The estimated present worth for the once-through, natural-draft, gravity-feed cooling tower at C-Reactor would be approximately $44 million, including production losses ($42.4 million without production losses). The estimated annual operating cost would be $6.4 million. The construction would require 36 months following a 9-month design phase. Reactor power could be expected to drop by 0.2 percent due to the operation of the once-through system in comparison to the No-Action alternative. As with K-Reactor, C-Reactor would require an additional $1.25 million dollars for a Section 316(a) Demonstration study.

K- AND C-REACTOR RECIRCULATING COOLING TOWERS

The construction and operation of recirculating cooling towers for K- and C-Reactors would reduce thermal effects to Pen Branch and Four Mile Creek while reducing the current discharge (flow) rates by about 90 percent. Wetland losses, estimated to be about 54 acres per year as a result of delta expansion, would essentially cease, and the process of natural plant succession would occur in the area currently affected by thermal discharges. An estimated 1500 acres could be reestablished under this alternative. An estimated 110 acres of uplands would be adversely affected by construction of recirculating cooling towers for K- and C-Reactors. No wetlands would be affected by construction.

Balanced communities containing all indigenous species in all biotic categories should develop and remain in all natural portions of the Pen Branch and Four Mile Creek ecosystems following the implementation of recirculating cooling-tower systems for K- and C-Reactors. Predicted maximum water temperatures in the immediate discharge area would not exceed 30°C and, therefore, would be below the maximum of 32.2°C required for Class B waters of the State. However, the other temperature criterion for Class B waters (maximum temperature increment of 2.8°C above ambient) would be exceeded occasionally by a small margin in the immediate discharge area and to a decreasing extent as far downstream as the Pen Branch delta. Accordingly, a Section 316(a) Demonstration study would be conducted to determine if balanced biological communities would be maintained. In addition to temperature mitigation, flow in the creek system would be reduced to levels typical of small streams in the SRP region; these levels should be conducive to recolonization by habitat formers, macroinvertebrates, and fish.

Conditions for all biotic categories should be greatly enhanced following implementation of this alternative in comparison to present conditions. Recolonization of areas within the Pen Branch and Four Mile Creek systems that are presently uninhabitable because of excessive temperatures and flows would occur rapidly. Furthermore, an analysis of the temperature and flow requirements of the representative and important species indigenous to the creek systems has determined that these species should not be affected adversely by the slightly higher-than-ambient temperatures and lower flows resulting from reactor operations.

Following implementation of recirculating cooling-tower systems, a zooplankton community should become established in the study area, which would provide food for the establishment of balanced macroinvertebrate and fish communities. The maximum predicted temperatures in the Pen Branch and Four Mile Creek systems would be within the range tolerated by most, if not all, indigenous zooplankton species; accordingly, the heated discharge should cause no appreciable harm to the zooplankton community. The standing crop of zooplankton should be enhanced by the relatively slight temperature elevation and standing crop, species composition, community structure, and seasonal periodicity should be similar to those present before SRP operation and to those of other natural streams in the region. Cooling-tower blowdown flow would not constitute a lethal barrier to the free movement (drift) of zooplankton.

The habitat-formers community should improve significantly with the implementation of recirculating cooling-tower systems at K- and C-Reactors. Following the implementation of the systems, reactor discharges would be reduced from approximately 11.3 cubic meters per second to about 1 cubic meter per second. The reduced discharge would result in substantial reductions in stream width, depth, and water velocity in comparison to present conditions. Reduced water velocities would decrease the erosion rate of the stream channels in the upper and mid-stream reaches and would be more conducive to the retention of logs and other organic debris in the stream channels, providing structure for aquatic macroinvertebrates. Lower stream temperatures, coupled with reduced stream velocities, would permit the invasion of aquatic macrophytes into the stream channels, and would also permit the establishment of riparian vegetation in what are presently the high water channels of Pen Branch and Four Mile Creek. Aquatic habitat in the delta areas should differ somewhat from that upstream. At present, water flows through the deltas in a series of shallow braided channels. With reduced discharge, most of the flow should follow the paths of the original stream channels, but some water could flow through one or two of the deeper side channels that have been cut through the deltas. This, coupled with the more gradual stream gradient of the deltas, would probably result in lower velocities than would exist upstream. The delta areas should provide prime habitat for many species of aquatic and semiaquatic macrophytes, which in turn would provide habitat for species of macroinvertebrates that prefer slow-moving streams and dense stands of macrophytes.

Following implementation of the recirculating alternative, diverse and productive macroinvertebrate communities should develop in Pen Branch and Four Mile Creek. The newly established communities would, in turn, provide food necessary for the establishment of balanced indigenous fish communities. The species composition of the stream corridors should be somewhat similar to that of the unimpacted headwater portions, although differences would exist due to a more open canopy and to greater stream discharge volumes from reactor operations. Increased light availability would result in systems that are more autochthonous. Thus, macroinvertebrate species that utilize periphyton or macrophytes as food should be expected to be more abundant. As macrophyte beds become established, macroinvertebrate species that are commonly associated with these beds should increase in abundance. The dominant taxa would be expected to shift, with the more thermally-tolerant species presently occurring being replaced by other species that are less thermally tolerant.

A recirculating cooling-tower system would improve the thermal regimes of Pen Branch and Four Mile Creek over existing conditions to within the range of temperatures tolerated by most, if not all, indigenous macroinvertebrate species. Although the relatively slight increases in temperatures over ambient could result in the earlier emergence of some species, no significant adverse impacts should occur, and the potential for cold shock would not exist during reactor outages in the winter. Thus, the cooling-tower blowdown should cause no appreciable harm to the macroinvertebrate communities. Indeed, the standing crop of macroinvertebrates in the streams should be enhanced by the relatively slight elevations in temperature, due in part to an expected increase in the standing crop of periphyton and heterotrophs, which would provide more food for many species of macroinvertebrates. In addition, the slightly elevated temperatures could permit multivoltine species of insects (those that complete more than one life cycle per year) to produce one or more additional generations per year, thereby increasing the net annual production of the macroinvertebrate community.

The cooling-tower blowdown flow should not interfere with the drift or upstream movement of macroinvertebrates, because the predicted maximum temperature of the flow is less than the upper thermal limits of most macroinvertebrate species indigenous to the area.

Following implementation of the recirculating cooling-tower alternative, a temperature-restricted zone of passage in the upper stream reaches would no longer exist. Reduced flow should allow fish to reinvade these sections of the stream systems, and should provide spawning and nursery areas for many species.

Reduced temperature and flow conditions should allow indigenous fish species to inhabit the mid- and lower reaches of Pen Branch and Four Mile Creek. The addition of slightly heated and relatively nutrient-rich Savannah River water to the streams via the cooling-tower blowdown could increase primary and secondary production in these areas. Reproductive success of indigenous fish species would be improved over present conditions; growth may be possibly enhanced by the increased productivity resulting from the slight temperature elevation and nutrient loading from Savannah River water pumped through the systems.

Final design and operation of the cooling-tower systems would comply with the limits, which are proposed by EPA for the protection of warm-water fishes, of temperature shock that could occur during a winter shutdown in Pen Branch or Four Mile Creek. The entire Pen Branch and Four Mile Creek systems would be available for fish habitation and reproduction; the free movement of fishes between the stream headwaters and the Savannah River should not be inhibited by reactor operations at any time during the year. The thermal discharge flows would not block fish migration or exclude fish from any part of the ecosystems. The areal extent of aquatic habitat would be expected to be reduced from present conditions because of reduced flows, resembling ambient conditions. Annual estimated entrainment (eggs and larvae) losses would be reduced from 26.9×10^6 to 3.9×10^6, while estimated annual impingement losses would be reduced from approximately 5885 to 853 fish. The implementation of recirculating cooling towers would stop existing high flow rates and elevated water temperatures, thus markedly improving habitat conditions for the endangered wood stork.

Maximum annual total-solids deposition from the recirculating towers would be far below levels that cause reduced vegetation productivity. The same prehistoric archaeological site - which has been determined to be not significant - that would be disturbed by the construction of the once-through towers would be affected by the construction of recirculating towers.

The operation of recirculating cooling towers would result in a calculated decrease of about 0.33 curie of cesium released to the Savannah River each year. For both reactors, the operation of recirculating towers would result in an annual release of about 850 additional curies of tritium to the atmosphere because of cooling-tower evaporation and a corresponding reduction of about 850 curies released to the streams. The reduction in radiocesium that would be remobilized, together with the changes in releases of tritium, would produce a total reduction in the maximum individual effective whole-body dose of about 0.19 millirem per year, and a decrease in the collective effective whole-body dose to the 80-kilometer regional population and downstream water consumers of about 1.1 person-rem per year. These radiological dose changes are extremely small in comparison to existing operations and year-to-year variations in natural background radiation, and doses would remain within all applicable requirements and standards.

The estimated present worth for recirculating cooling towers for K-Reactor is about $90 million including production losses ($58 million without production losses); this alternative would require about 42 months to construct after a 9-month design period. Estimated annual operating costs would be $4.4 million. Reactor power could be expected to drop by 3.7 percent due to the operation of the recirculating system in comparison to the No-Action alternative. In addition, the cost to conduct Section 316(a) Demonstration studies would be approximately $1.25 million.

For C-Reactor, the estimated present worth, annual operating cost, construction and design period, amount of reactor power lost, and cost to conduct a Section 316(a) Demonstration study for the recirculating system would be the same as those for K-Reactor.

D-AREA INCREASED FLOW WITH MIXING (PREFERRED ALTERNATIVE)

The implementation of increased flow with mixing for the D-Area powerhouse would reduce the thermal effects in Beaver Dam Creek during critical periods (May-September) by temporarily increasing the flow at these times. Balanced communities in all biotic categories presently exist in Beaver Dam Creek and should remain after implementation of this alternative. Predicted maximum water temperatures would comply with the maximum of 32.2°C required for Class B waters of South Carolina. However, the other temperature criterion for Class B waters (maximum change in temperature of 2.8°C above ambient) would be exceeded throughout the stream. Accordingly, a Section 316(a) Demonstration study would be conducted to determine whether a balanced biological community would be maintained.

Increased flow during the summer should increase aquatic habitat and the abundance and diversity of aquatic biota. However, terrestrial wildlife habitat would be reduced and associated wildlife would be displaced temporarily during periods of increased pumping. An estimated 4 acres each of uplands and wetlands would be inundated temporarily because of intermittent flooding from increased flow.

The increase in pumping probably would cause a temporary increase in the erosion of the stream channel, which could result in reduced primary productivity and reduced populations of some benthic invertebrates. However, the expected erosion and the resulting siltation would equilibrate rapidly under an increased flow regime and biota would be expected to recolonize after the disturbance has ceased.

Following implementation of this alternative, a diverse zooplankton community should remain in Beaver Dam Creek and should not be affected adversely by D-Area powerhouse operation. Rather, increased flow with mixing should enhance the zooplankton communities in the immediate discharge area by eliminating potential exposures to lethal temperatures. The heated discharge should not alter the standing crop, community structure, or seasonal periodicity of zooplankton from those values typical of the receiving water-body segment prior to SRP operation and the thermal plume is not expected to constitute a lethal barrier to the free movement (drift) of zooplankton.

The increased flows and reduced temperatures associated with this alternative should improve the habitat-formers community in Beaver Dam Creek. Scouring due to the increased flow would adversely affect primarily the upper reaches of the stream where, at present, macrophytes do not occur because of high water velocity and turbidity. The habitat-formers community in the delta and swamp areas should not be impacted significantly by increased flows because fluctuations of flow and increases in current velocity through these areas would not be as rapid or severe as those upstream.

Implementation of this alternative should not result in significant changes to the structure and function of the existing macroinvertebrate community, although some minor shifts in the relative abundance of some taxa probably would occur as a result of increased water flows. The increased water velocity could result in temporary increases in the drift rate of some species of macroinvertebrates; however, the macroinvertebrate community should be able to sustain the slightly higher rates of drift and would not be adversely affected. Increased rates of macroinvertebrate drift would provide additional food for higher trophic levels. The rise in water level would inundate the edges of the stream and could result in some increases in the overall amount of aquatic habitat available for colonization. When increased pumping stopped, the water levels should recede gradually and not result in significant stranding of macroinvertebrates.

Increased pumping should not alter the present emergence patterns of insects. The cooler water temperatures that would exist in Beaver Dam Creek during the summer months could result in the addition of a few species of macroinvertebrates that cannot tolerate the present summer temperatures. The macroinvertebrate community should provide the food necessary for the maintenance of a balanced indigenous fish community.

The thermal plume resulting from the D-Area cooling water discharge would not interfere with the drift or upstream movement of macroinvertebrates, if such movement were possible. However, because Beaver Dam is an intermittent stream above the outfall, little, if any, drift or upstream movement is possible.

The temperatures of the thermal plume would not constitute a barrier to either the drift or the upstream movement of macroinvertebrates.

The fish community of Beaver Dam Creek should not suffer appreciable harm from the operation of the D-Area powerhouse following increased flow with mixing. There should be no direct or indirect mortality from excess heat or cold shock. Reproductive success and growth of indigenous species of fish should be similar to present conditions with the implementation of this alternative; growth may be enhanced because the slight warming from the powerhouse discharge results in optimal growth temperatures occurring for more of the year than with ambient conditions. Stream temperature is not expected to block fish migration. Thus, the entire Beaver Dam Creek system would be available for fish habitation; the free movement of fishes between the headwaters of Beaver Dam Creek and the Savannah River would not be inhibited by powerhouse operations at any time during the year.

The increased-flow alternative should not cause significant changes to spawning activities in Beaver Dam Creek. Cooler summer temperatures caused by increased flow and mixing could enhance summer spawning. However, this could be offset by the increased variability of flow and temperature resulting from implementation of this alternative.

Annual estimated entrainment of fish eggs and larvae would increase by about 3 percent (from 2.0×10^6 to 2.06×10^6), while estimated impingement losses would increase from 1718 to about 1831 fish. Estimated temporary wetland disturbances would be about 4 acres during periods when pumping was necessary. The increased flow would probably reduce the availability of foraging sites for the endangered wood stork. There would be no impacts to air quality, noise, release of radionuclides, or archaeological resources due to the implementation of this alternative.

This alternative could be initiated without any capital costs. Annual operating costs would increase by about $30,000. In addition, the estimated cost to conduct a Section 316(a) Demonstration study is about $1.25 million.

D-AREA DIRECT DISCHARGE TO THE SAVANNAH RIVER

Discharging effluent directly to the Savannah River would lower water temperatures to ambient levels in Beaver Dam Creek. The removal of the discharge flow would lower water levels greatly in the creek, thereby reducing available spawning and foraging habitat for aquatic organisms. An estimated 1 acre of wetlands and 5 acres of uplands would be adversely affected by the construction of the direct-discharge pipeline to the Savannah River. Small increases in water temperatures would occur within a mixing zone in the Savannah River and the discharge would meet State of South Carolina Class B water temperature classification standards outside the mixing zone.

Entrainment and impingement effects would be the same as those experienced during present operations. The removal of the discharge from the D-Area powerhouse to the creek would greatly degrade the habitat of the endangered wood stork. There would be no impacts on air quality, noise, radiological releases, or archaeological resources.

The construction of the discharge pipeline would require a capital cost of approximately $14 million and about 22 months to complete. Its operation would increase annual operating costs by about $50,000 per year.

CUMULATIVE ENVIRONMENTAL CONSEQUENCES

The major cumulative impacts associated with the construction and operation of the cooling water alternatives include surface-water usage, ecological impacts, radiological releases, and air quality impacts.

SURFACE-WATER USAGE

The Savannah River Plant currently withdraws approximately 37 cubic meters per second of water from the Savannah River. Approximately 2.4 cubic meters per second of this withdrawal is consumed, and the remainder is returned to the Savannah River via discharges to onsite streams. Total withdrawal from the Savannah River is currently about 24 percent of the 7-day, 10-year low flow (7Q10), or about 13 percent of the average Savannah River flow.

Construction and operation of once-through cooling towers for K- and C-Reactor would not alter the amount of water currently withdrawn from the Savannah River; however, an additional 1.6 cubic meters of water per second would be consumed as a result of evaporative losses from cooling-tower operation. Construction and operation of recirculating cooling towers would reduce the amount of water withdrawn from the river by about 16.3 cubic meters per second and would result in 1.6 cubic meters of water per second consumed as a result of cooling-tower evaporative losses.

Construction of the direct-discharge system for the D-Area powerhouse would not alter the existing amounts of water withdrawal or discharge. Implementation of the increased-flow-with-mixing alternative, which would require additional withdrawals to meet the 32.2°C State Class B water classification standard, would not result in any additional consumptive water losses because the increased withdrawals associated with this alternative would be returned to the Savannah River via Beaver Dam Creek.

ECOLOGY

The principal cumulative impact of the implementation of alternative cooling water systems for K- and C-Reactors and the D-Area powerhouse would be a reduction in the temperatures of Pen Branch, Four Mile Creek, and Beaver Dam Creek. This temperature reduction would allow successional revegetation of thermally affected areas, improvement in wildlife habitats in comparison to existing conditions, and recolonization of thermally affected streams by fish and other lower trophic levels.

Construction and operation of once-through cooling towers for K- and C-Reactors would maintain approximately the same rates of flow and flow variability (i.e., when the reactors are operating as opposed to when they are not operating) in Pen Branch and Four Mile Creek. Construction and operation of recirculating cooling towers would significantly reduce the rates of flow in these streams, and also reduce the variations in flow. For the once-through cooling towers, the combined effect of reduced stream temperatures and maintenance of approximately the same flow rates would result in the establishment of a greater amount of aquatic habitat than for the recirculating towers; however, because of the larger flow rates and flow variability associated with the once-through cooling towers, operation of recirculating cooling towers would result in the successional recovery of a greater amount of wetlands.

Because of the difference in the rates of withdrawal of Savannah River water between the once-through and recirculating cooling towers, the estimated cumulative Savannah River Plant annual entrainment and impingement losses resulting from cooling water withdrawal would remain about the same with operation of the once-through cooling towers, and would be reduced to 22.9×10^6 fish eggs and larvae and 5030 impinged fish annually with the operation of recirculating cooling towers. Implementation of the increased-flow-with-mixing alternative for the D-Area powerhouse would result in a slightly greater annual estimated cumulative rate of entrainment and impingement (6.0×10^4 fish eggs and larvae and 113 fish).

The implementation of the cooling water alternatives (i.e., once-through or recirculating cooling towers for K- and C-Reactors, and increased flow with mixing for the D-Area powerhouse) including the direct-discharge alternative for the D-Area powerhouse would affect the endangered wood stork in varying degrees. The implementation of the direct-discharge alternative would result in a loss of foraging habitat for the wood stork due to the removal of discharge flows from Beaver Dam Creek to the Savannah River.

RADIOLOGICAL RELEASES

Radiological doses associated with current SRP operations are within applicable limits and account for less than 0.1 percent of the total annual dose to an average individual within 80 kilometers of the Savannah River Plant. Construction and operation of either once-through or recirculating cooling towers would result in a small decrease in the cumulative radiological doses associated with existing and planned SRP operations and other nuclear facilities within the vicinity of the plant. The reduction in cumulative radiological doses would be greater with the operation of recirculating cooling towers than with the operation of once-through cooling towers because of reduced remobilization of cesium-137.

AIR QUALITY

The operation of either once-through or recirculating cooling towers would increase cumulative solids deposition from drift. Maximum annual total solids deposition would be greater for recirculating cooling towers than for once-through towers, and would be far below levels that cause reduced vegetative productivity.

The operation of either once-through or recirculating cooling towers would also cause minor and temporary reductions in ground-level visibility and infrequent visible plumes and ice accumulations within 0.4 kilometer of the towers.

COMPARISON OF ALTERNATIVES

For K- and C-Reactors, the principal environmental benefits of recirculating cooling towers in comparison to once-through towers would be the reestablishment of a greater amount of wetlands, the reduction in entrainment and impingement losses, and the establishment of a potentially greater amount of wood stork foraging habitat. Recirculating towers for both reactors would cost about $4.0 million less annually to operate than once-through towers. The principal environmental benefit of the once-through cooling towers comparison to recirculating towers would be the maintenance of existing flow levels in the creeks and deltas, thereby providing more potential aquatic habitat for fish and other aquatic organisms. The present worth cost of the once-through cooling-tower system for both reactors would be approximately $93 million less than that for recirculating cooling towers.

For the various cooling water alternatives for K- and C-Reactors, the following relative rankings of potential wildlife effects were determined from the Habitat Evaluation Procedures Analysis. Effects to terrestrial wildlife from construction of the once-through and recirculation cooling towers are essentially equal. Small stream fish species benefit more from the recirculation alternative in the upper reaches of the creeks. In the middle and lower stream reaches, species such as the catfish and sunfish benefit more from the once-through alternative. In the deep swamp environment, those fish which are more likely to use the swamp during the spawning period benefit more from the recirculation alternative. In the swamp, wading birds benefit more from the recirculation alternative. Overwintering waterfowl such as the mallard benefit more either from the present SRP operations or from the once-through cooling tower.

For the D-Area powerhouse, the principal environmental benefit of the increased-flow-with-mixing alternative over the direct-discharge alternative would be the maintenance of existing water levels in Beaver Dam Creek, thereby maintaining habitat for the endangered wood stork and other aquatic organisms. It would also avoid adverse impacts to about 1 acre of wetlands and 5 acres of uplands that would result from the construction of the direct-discharge pipeline. There would also be a capital cost savings of about $14 million initially and about $20,000 per year thereafter.

Table S-1 summarizes and compares the environmental consequences of once-through cooling towers (i.e., DOE's preferred cooling water alternative), recirculating cooling towers, and the no-action alternative for K- and C-Reactors. In addition, Tables S-2, S-3, and S-4 compare these alternatives, along with the expected natural state of Pen Branch within 15 years if reactor operations cease, for Reaches 1, 2, and 3, respectively, of that stream. The division of the Pen Branch watershed into these reaches was based on the presence of distinct stream gradients. These comparisons were made to assess the potential impacts of the alternatives on discrete reaches and the ability of the entire Pen Branch system to exhibit and maintain a balanced biological community. The following paragraphs describe potential effects of the alternatives on the Pen Branch system. (Similar effects should occur on Four Mile Creek for C-Reactor.)

Table S-1. Comparison of the Impacts of the No-Action Alternative to the Combined Impacts of the Once-Through Cooling Towers (Preferred Alternative) and Recirculating Cooling Towers for K- and C-Reactors (page 1 of 5)

Impacts	No Action[a]	Once-Through Cooling Towers (Preferred Alternative[b])	Recirculating Cooling Towers[c]
SCHEDULE FOR IMPLEMENTATION	Current	Construction of the system would require 36 months after a 9-month design period.	Construction of the system would require 42 months after a 9-month design period.
PRELIMINARY PRESENT - WORTH (MILLION $)			
- including production loss	$0	$87.0 - $43.0 K-Reactor - $44.0 C-Reactor	$180 - $90 K-Reactor - $90 C-Reactor
- excluding production loss	$0	$83.8 - $41.4 K-Reactor - $42.4 C-Reactor	$116 - $58 K-Reactor - $58 C-Reactor
ESTIMATED OPERATING COST (MILLION $ PER YEAR)	$12.4 - $6.2 K-Reactor - $6.2 C-Reactor	$12.8 - $6.4 K-Reactor - $6.4 C-Reactor	$8.8 - $4.4 K-Reactor - $4.4 C-Reactor
SOCIOECONOMICS	No additional workforce required.	Peak construction workforce of 400 persons and 8 persons for operation.	Peak construction workforce of 600 persons and 12 persons for operation.
WATER WITHDRAWAL AND DISCHARGE RATES	About 22.6 cubic meters per second withdrawn from the Savannah River and discharged to the creeks.	Withdrawal the same as for no action; discharge to the creeks would be about 93% of that for no action or 21 cubic meters per second.	Withdrawal of river water would be about 14% of that for no action or 3.3 cubic meters per second. Discharge to the creeks would be about 10% of that for no action or 2.2 cubic meters per second.
WATER QUALITY	Dissolved oxygen concentrations would continue to be below	State Class B water classification standards for dissolved oxygen concentra-	State Class B water classification standards for

Table S-1. Comparison of the Impacts of the No-Action Alternative to the Combined Impacts of the Once-Through Cooling Towers (Preferred Alternative) and Recirculating Cooling Towers for K- and C-Reactors (page 2 of 5)

Impacts	No Action[a]	Once-Through Cooling Towers (Preferred Alternative[b])	Recirculating Cooling Towers[c]
	standards intermittently during the summer and suspended solids would be slightly higher than ambient stream levels.	tions would be met. There would be some reduction in suspended solids.	dissolved oxygen concentrations would be met. Dissolved solids concentrations in discharge would be higher than no action or once-through cooling towers because of cycles of concentrations; however, total suspended solids discharged would be greatly reduced.
TEMPERATURE AND FLOW EFFECTS	Water temperature in the creeks would exceed State Class B water classification standards.	State Class B water classification standards for temperature (32.2°C) would be met; Section 316(a) Demonstration studies will be performed for exceedances of 2.8°C rise in ambient stream temperatures.	State Class B water classification standards for temperature (32.2°C) would be met; Section 316(a) Demonstration studies will be performed for exceedances of 2.8°C rise in ambient stream temperatures.
	There would continue to be few aquatic organisms in the thermal areas of the creeks and deltas. A thermal barrier will prevent aquatic movement in both creeks. Fish spawning in both creeks and deltas would remain reduced.	Reestablishment of aquatic fauna and floral communities, spawning, and foraging in presently uninhabited areas. Water levels would continue to fluctuate, causing some stress to aquatic organisms. Thermal barriers eliminated; free movement of aquatic organisms between all parts of streams and river. There would be no potential for cold shock as the	Additional reduction of thermal effects over what would occur with once-through towers except that flooded habitat area for aquatic organisms would be smaller. Most aquatic communities would benefit from reduced flow and decreased magnitude of water level fluctuations. There

Table S-1. Comparison of the Impacts of the No-Action Alternative to the Combined Impacts of the Once-Through Cooling Towers (Preferred Alternative) and Recirculating Cooling Towers for K- and C-Reactors (page 3 of 5)

Impacts	No Action[a]	Once-Through Cooling Towers (Preferred Alternative[b])	Recirculating Cooling Towers[c]
		Maximum Weekly Average Temperature criteria for winter shutdowns would be met.	would be no potential for cold shock as the Maximum Weekly Average Temperature criteria for winter shutdowns would be met.
ENTRAINMENT/ IMPINGEMENT	Water withdrawal would continue to cause entrainment losses of about 26.9 $\times 10^6$ fish eggs and larvae and the loss of about 5885 fish to impingement annually.	Effects would be about the same as for no action.	Annual entrainment and impingement losses would be reduced to about 3.9 $\times 10^6$ and 854, respectively.
TERRESTRIAL/WETLAND HABITAT	Annual losses of about 54 acres of wetlands due to discharge temperatures and flows would continue.	Wetland losses would decrease; some revegetation of these areas would occur. 60 acres of uplands would be affected by construction.	Wetland losses would essentially cease and about 1500 acres of wetlands would successively revegetate; about 110 acres of uplands would be affected by construction.
SOLIDS DEPOSITION	None.	Maximum annual total solids deposition rates for each tower would be below levels that cause reduced vegetative productivity.	Maximum annual total solids deposition rates would be higher than for once-through towers but would still be far below levels that cause reduced vegetative productivity.
ENDANGERED SPECIES	Thermally affected areas of Four Mile Creek and Pen Branch	Foraging habitat of the wood stork would be restricted due to	Potential of enhancement of wood stork habitat would be

Table S-1. Comparison of the Impacts of the No-Action Alternative to the Combined Impacts of the Once-Through Cooling Towers (Preferred Alternative) and Recirculating Cooling Towers for K- and C-Reactors (page 4 of 5)

Impacts	No Action[a]	Once-Through Cooling Towers (Preferred Alternative[b])	Recirculating Cooling Towers[c]
	would remain too hot for fish production and thus of limited forage value for wood stork; no impacts to other threatened or endangered species.	water depth and flow rates. No impacts on other species.	increased due to lower water levels in the creeks and deltas. No impacts on other species.
AIR QUALITY	No impacts.	Temporary small increases in air pollution and dust during construction.	Construction impacts would be similar to those for the once-through towers.
		Ice accumulation, visible plumes, and reduced ground-level visibility impacts from cooling tower operation would be small.	Total frequency of ice accumulation would be higher than once-through cooling tower. Visible plume occurrence would be only slightly more frequent than that of once-through towers. Reduction in ground-level visibility would be less than for once-through towers and would occur over a somewhat wider area.
NOISE	No impacts.	Same as for recirculating towers during construction. Noise levels from operation would be less than for recirculating towers.	Temporary increases in noise levels during construction. Noise from operation less than 70 decibels about 150 meters from towers.

Table S-1. Comparison of the Impacts of the No-Action Alternative to the Combined Impacts of the Once-Through Cooling Towers (Preferred Alternative) and Recirculating Cooling Towers for K- and C-Reactors (page 5 of 5)

Impacts	No Action[a]	Once-Through Cooling Towers (Preferred Alternative[b])	Recirculating Cooling Towers[c]
ARCHAEOLOGICAL AND HISTORIC SITES	No impacts.	One small nonsignificant prehistoric site near Four Mile Creek would be disturbed during construction.	Same site would be disturbed near Four Mile Creek as with the once-through towers.
RADIOLOGICAL	The cumulative maximum individual effective whole-body dose from SRP and planned facilities would continue at about 3.3 millirem per year. The total collective effective whole-body dose to the regional population and downstream water users would be about 81 person-rem per year; about 0.074 percent of natural background.	Annually, about 100 additional Ci of tritium would be released to the atmosphere and about 100 less Ci of tritium would be discharged to the streams. The maximum individual effective whole-body dose would decrease by 2.3×10^{-4} millirem per year. The total collective effective whole-body dose to the regional population and downstream water users would decrease by 0.055 person-rem per year. The dose changes are very small compared with existing operations and natural background radiation.	Annually, about 850 additional Ci of tritium would be released to the atmosphere and about 850 less Ci of tritium would be discharged to the streams. In addition, a calculated decrease of about 0.33 curie of cesium per year would result from reduced flows. The maximum individual effective whole-body dose would decrease by 0.19 millirem per year. The total collective effective whole-body dose to the regional population and downstream water users would decrease by 1.1 person-rem per year. The dose changes are very small compared with existing operations and natural background radiation.

a. No action is defined as the continuation of existing operations of K- and C-Reactors.
b. The preferred alternative is to construct and operate once-through gravity feed, natural draft cooling towers) for K- and C-Reactors.
c. The alternative is to construct and operate recirculating cooling towers for K- and C-Reactors.

Table S-2. Comparison of Potential Environmental Impacts in Reach 1[a] of Pen Branch System (page 1 of 2)

	Alternative cooling water system			
Parameter	No action	Once-through cooling tower	Recirculating cooling towers	Natural stream[b]
Flow (variation), m^3/sec	11.3 (1-11.3)	10.5 (1-10.5)	1 (0.2-1)	0.03 (natural)
Temperature (°C) Maximum/ T	75/48	32/11	30/6	27/0
Vegetation				
Aquatic	Thermally tolerant algae only.	Limited macrophyte development due to high flows.	Increased macrophyte development, but less available habitat compared to once-through system due to lower flows.	Less available habitat, greater macrophyte species diversity, than recirculating system due to low natural flows.
Riparian	Not present due to high temperatures.	Limited development and distribution due to high flows.	Major increase in available habitats; shrub/herb community; greater species diversity than once-through system.	Highest species diversity; invasion by some nonwetland species.
Macroinvertebrates	Not present due to high temperatures.	Limited abundance and diversity due to flows; early emergence due to T greater than 5°C; stranding could occur due to changing flow rates from reactor operations.	Less available habitat than once-through system, comparable or higher density; greater diversity, reduced potential for early emergence, little chance of stranding due to more stable flows.	Least available habitat due to reduced water volume compared to recirculating system. Highest species diversity, no potential for early emergence.

Table S-2. Comparison of Potential Environmental Impacts in Reach 1[a] of Pen Branch System (page 2 of 2)

Parameter	No action	Once-through cooling tower	Recirculating cooling towers	Natural stream[b]
	Alternative cooling water systems			
Fish	Limited utilization by heat-tolerant mosquitofish during reactor outages; no spawning by any species due to excessive water temperatures; however, limited spawning could occur during long shutdowns; not utilized by anadromous and/or riverine species.	Presence of species with high flow tolerance (i.e., minnows, suckers, darters); limited spawning due to fast flow, high gradient, and channelized banks. Limited utilization by anadromous or riverine species.	Maximum development of limited fish habitat and communities; highest fish biomass potential for this reach; higher spawning per unit area than once-through system due to reduced flows. However, access to this reach by fish from downstream reaches 2 or 3 is unlikely due to reduced flows, shallow water depth, and development of dense stands of aquatic vegetation in these reaches.	Less available habitat due to reduced water volume and less spawning success than recirculating system. Access to this reach from downstream reaches 2 or 3 would also be limited due to reduced flows, shallow water depth, and development of dense stands of aquatic vegetation within these lower reaches.
Endangered species (wood stork)	No utilization - lack of suitable habitat.	No utilization - lack of suitable habitat.	No utilization - lack of suitable habitat.	No utilization - lack of suitable habitat.
Waterfowl	No utilization - lack of suitable habitat.	Very low utilization - lack of suitable habitat.	Very low utilization - lack of suitable habitat.	Very low utilization - lack of suitable habitat.

a. Reach 1 comprises approximately 1 percent of the Pen Branch system that is influenced by reactor operation.
b. Stream system expected within a 15-year period after reactor operations cease.

Table S-3. Comparison of Potential Environmental Impacts in Reach 2[a] of the Pen Branch System (page 1 of 2)

Parameter	Alternative cooling water system: No action	Once-through cooling tower	Recirculating cooling towers	Natural stream[b]
Flow (variation), m^3/sec	11.5 (1.17–11.5)	10.7 (1.17–10.7)	1.17 (0.2–1.17)	0.17 (natural)
Temperature (°C), Maximum/ T	63/30	32/6	29/3	26/0
Vegetation				
Aquatic	Thermally tolerant algae only.	Limited macrophyte development due to high flows; more available habitat than in Reach 1.	Increased macrophyte development over once-through system, but less available habitat due to reduced flows.	Less available habitat due to reduced flow volume, greater diversity than once-through system.
Riparian	Isolated communities limited to sandbars and stumps due to high flows and temperatures.	Isolated communities limited to sandbars and stumps due to high flow.	Major increase in available habitats; shrub/herb community development; greater species diversity due to reduced flows.	Highest species diversity; invasion by some nonwetland species.
Macroinvertebrates	Minimal use by thermally tolerant species (e.g., oligochaetes and nematodes).	Greater abundance and diversity than in Reach 1; moderate potential for early emergence due to T; stranding possible due to variable flow rates from reactor operations.	Moderate improvement in available habitat over those in Reach 1 due to downstream reductions in flow and temperature. Some potential for early emergence. Little chance of stranding due to more stable flows.	Least amount of available habitat due to reduced water volume; highest species density; no potential for early emergence or stranding.

Table S-3. Comparison of Potential Environmental Impacts in Reach 2[a] of the Pen Branch System (page 2 of 2)

		Alternative cooling water systems		
Parameter	No action	Once-through cooling tower	Recirculating cooling towers	Natural stream[b]
Fish	Limited habitat improvement over Reach 1; brief utilization by fish during reactor shutdowns; no spawning during reactor operations; some spawning could occur during long shutdowns.	Moderate improvement in habitat conditions (i.e., reduced temperatures and flows) compared to Reach 1; presence of flow-tolerant species; increased spawning; limited utilization by anadromous species.	Moderate improvement in habitat conditions over those in Reach 1 and once-through systems due to reduced temperatures and flows in upper reach. Reduced utilization and spawning near delta due to reduced flows in shallow depths and development of dense vegetation, which would limit potential access by anadromous and/or riverine species to upper part of Reach 2 and to Reach 1.	Less available habitat and spawning success than recirculating system, limiting access by anadromous and/or riverine species to upper reaches due to reduced flows and dense vegetation.
Endangered species (wood stork)	No utilization due to excessive temperatures and flow.	No utilization due to flows and excessive water depth.	Very low utilization.	Very low utilization due to reduced flows and dense vegetation.
Waterfowl	No utilization.	Moderate utilization in backwater areas.	Moderate utilization.	Moderate utilization.

a. Reach 2 comprises approximately 10 percent of the Pen Branch system that is influenced by reactor operations.
b. Stream system expected within a 15-year period after reactor operations cease.

Table S-4. Comparison of Potential Environmental Impacts in Reach 3[a] of the Pen Branch System (page 1 of 2)

Parameter	No action	Once-through cooling tower	Recirculating cooling towers	Natural stream[b]
	Alternative cooling water system			
Flow (variation), m^3/sec	Highly variable; strongly influenced by Savannah River flows below delta.	Highly variable; strongly influenced by Savannah River flows below delta.	Highly variable; strongly influenced by Savannah River flows below delta.	Highly variable; strongly influenced by Savannah River flows below delta.
Temperature (°C) Maximum/ T	51/14	31/1	29/0	30/0
Vegetation				
Aquatic	Thermally tolerant algae and bacteria only.	Submerged macrophytes limited to edge of delta and lower braided stream area; extensive where present.	Less available habitat than with once-through system; greater abundance due to reduced flow and stable water depth.	Less available habitat than with recirculating system; dense concentrations.
Riparian	Delta - Thermally tolerant herbaceous flora.	Delta - Herbaceous marsh present; should extend into the cypress/tupelo die-off area.	Delta - Herbaceous marsh present but less extensive than once-through system; some shrub species present; old-field species would occur in drier areas.	Delta - Greater development of old-field community; less marsh and shrub vegetation than recirculating system; development of nonwetland species.
	Swamp - Cypress/ tupelo community.	Swamp - Cypress/ tupelo community.	Swamp - Cypress/ tupelo community.	Swamp - Cypress/ tupelo community.
Macroinvertebrates	Greater community diversity than in Reach 2; dominated by thermally tolerant species (e.g., oligochaetes and nematodes).	Great increase in diversity and abundance over no action due to temperature reduction; stranding due to variable flows limited to delta area (swamp	Less available habitat but higher quality than with once-through system due to reduced flows; great increase in diversity and abundance over no action; little chance	Less available habitat than recirculating system; similar in abundance and diversity; little chance of stranding due to more stable flows.

Table S-4. Comparison of Potential Environmental Impacts in Reach 3[a] of the Pen Branch System (page 2 of 2)

Parameter	No action	Once-through cooling tower	Recirculating cooling towers	Natural stream[b]
	Alternative cooling water system			
		flow is regulated by Savannah River); no early emergence expected.	of stranding due to more stable flows.	
Fish	Only thermally tolerant species near delta; brief utilization by fish during reactor shut-downs; limited utilization and spawning by anadromous species in upper swamp due to high temperatures.	Habitat greatly improved over Reach 2; increased spawning success, utilization, and access by anadromous and riverine species due to reduced temperatures.	Reduced utilization and spawning in delta area due to reduced flows, shallow water depth, and development of dense vegetation, which would limit potential access to upper reaches. Habitat for spawning and nursery areas in swamp depends on periodic flooding by Savannah River.	Less available habitat and spawning success than recirculating system due to reduced flow and extensive vegetation in delta area. Swamp utilization similar to that for recirculating system.
Endangered species (Wood Stork)	Very low utilization due to excessive temperatures and flow.	Very low utilization in delta area due to flows.	Increased utilization for feeding due to reduced flows in delta area; this would decrease as vegetation invades.	Limited utilization due to reduced flows in delta area. Decreased use due to vegetation invasion, which would be more rapid than for recirculating system.
Waterfowl	High to moderate utilization, particularly below the delta.	High to moderate utilization of all alternatives due to reduced temperatures near delta.	Moderate utilization; less than with once-through system due to less available habitat from flow reduction near delta and extensive vegetation.	Moderate to low utilization due to less available habitat and less use than with once-through system due to extensive vegetation.

a. Reach 3 comprises approximately 89 percent of the Pen Branch system as utilized for the HEP analysis (Mackey et al., 1987).
b. Stream system expected within a 15-year period after reactor operations cease.

Impacts On Reach 1

Reach 1 extends from the K-Reactor outfall down Indian Grave Branch to its confluence with Pen Branch and on to SRP Road A; it encompasses approximately 1 percent (11 of 1100 acres) of the portion of the Pen Branch system that is influenced by K-Reactor Cooling Water discharges, as utilized for HEP analysis (Mackey et al., 1987). In this reach, the stream is highly channelized and has its highest gradient, water temperatures, and flows.

With the no-action alternative, highly thermally tolerant species of algae would be the only biota to occur, in limited areas. No spawning activity would occur during reactor outages; limited spawning could occur during long reactor shutdowns, but the success of the spawn would be unsure.

With the once-through cooling tower alternative, communities of aquatic and riparian vegetation should develop, but the areal extent, abundance, and species diversity would be limited due to the presence of high and variable cooling water flows. The early emergence of some macroinvertebrate species could occur because of the elevated water temperature; stranding of some macroinvertebrate communities could occur as a result of reactor-induced variations in flow. The fishery community would be limited in size and dominated by species with high flow tolerance (i.e., minnows, suckers, and darters). Spawning by fish would be extremely limited due to fast flow, high stream gradient, and channelized banks. The utilization of Reach 1 by anadromous and riverine species would be limited due to its distance (6 to 8 kilometers) from the Savannah River.

With the recirculating cooling-tower alternative, an increase in the areal extent and diversity of riparian vegetation would occur in comparison with those for the once-through system. An increase in the areal extent of aquatic macrophytes also would occur, but, because of the reduced water flows to be experienced with this alternative, the total available habitat would be reduced. Less habitat would be available for macroinvertebrate communities, but the abundance per unit area would be comparable to that for the once-through system. Species diversity would be greater and the potential for early emergence of macroinvertebrate species would be reduced over that for the once-through system because of reduced temperatures. The more stable water flows would produce little chance of stranding of macroinvertebrates. The reduced flow associated with this system would limit the areal extent of available habitat for fish; however, this habitat would be of higher quality than that for any of the alternatives. This alternative would provide the highest potential standing crop of fish of the alternatives; higher spawning per unit area should occur than with the once-through system. However, access to this region by anadromous or riverine fish species from Reaches 2 and 3 is unlikely due to reduced flows, shallow water depth, and development of dense stands of aquatic vegetation.

The complete cessation of reactor operations (i.e., a return to natural stream conditions) would provide less available habitat for aquatic vegetation and macroinvertebrates than the recirculating cooling-tower alternative due to a further reduction in water flows. Riparian areas would be colonized by some nonwetland vegetation. However, the species diversity of these communities would be the highest of all identified alternatives. No potential would exist for the early emergence of any macroinvertebrate species. Less habitat would be available for fish, and spawning success would be less than that for the recirculating system due to lower flows. In addition, access to this region by fish from downstream Reaches 2 and 3 would be unlikely due to reduced flows, shallow water depths, and the expected development of dense stands of aquatic vegetation.

The stream gradient and flows of Reach 1 would not provide suitable habitat for the endangered wood stork or for waterfowl with any alternative.

Impacts On Reach 2

Reach 2 extends from SRP Road A to the Pen Branch delta. This reach encompasses approximately 10 percent (110 of 1100 acres) of the Pen Branch system that is influenced by reactor cooling water discharges, as utilized for the HEP analysis (Mackey et al., 1987). In this reach, the stream is wider and less channelized, and has less gradient than in Reach 1; shallow backwaters occur in some areas.

The high flows and temperatures expected in Reach 2 (Table S-3) with the selection of the no-action alternative would allow the occurrence only of isolated communities of riparian vegetation (limited to sandbars and stumps); aquatic vegetation would be limited to thermally tolerant algae. Thermally tolerant macroinvertebrate species would make minimal use of the reach. Only limited improvement in the quality of fish habitat would be expected over the conditions described for Reach 1. Utilization by fish would be limited to brief reactor shutdown periods. No spawning would occur during reactor operations; however, limited spawning could occur during long shutdowns. The high flows and temperatures would preclude the use of this reach by the endangered wood stork and waterfowl.

The once-through cooling-tower alternative would reduce water temperatures below those for no action, but flows would remain high and variable (Table S-3). The high flows would limit riparian vegetation to isolated communities on sandbars and stumps. Limited macrophyte development would occur in backwater areas of reduced flow; more total habitat would be available than in Reach 1. The macroinvertebrate community would have greater species diversity and abundance in comparison to Reach 1. Some early emergence should occur with some macroinvertebrate species, due to elevated temperature; some stranding of portions of the macroinvertebrate community could occur due to reactor-influenced flow variations. A moderate improvement in fish habitat conditions over those in Reach 1 would occur due to downstream reductions in temperature, gradient, depth, and flows; this should provide the greatest occurrence of flow-tolerant species and more moderate spawning activity within the reach. Use of this reach by anadromous species would be limited. The endangered wood stork would not use Reach 2, but limited habitat would probably be available for waterfowl in backwater areas.

With the recirculating cooling-tower alternative, reduced flow and temperature would provide an increase in riparian habitat (i.e., development of a shrub/herb community) and greater species diversity in Reach 2. Reduced flows would also enable greater aquatic macrophyte development to occur in comparison to the once-through alternative; however, less total habitat area would be available. A moderate improvement would occur in habitat available for the macroinvertebrate community, in comparison to that expected in Reach 1 with this alternative and to the once-through alternative, as a result of reductions in temperature and flow. Early emergence of macroinvertebrate species would not occur. The reduced flows and temperatures would also provide moderate improvement of fish habitat in the upper portions of Reach 2; however, the reduced water flows and the increased development of vegetation in the lower portions of the reach probably would cause reduced use and spawning in the shallow areas of the delta. Access by fish to the upper portion of Reach 2 and to Reach 1 could become limited due to reduced flows and dense vegetation development. Limited use of this reach by the endangered wood stork and waterfowl would occur.

With a complete cessation of reactor cooling water flows (natural stream conditions), the reduced water volumes in the stream would cause further reductions in available habitat for aquatic vegetation, macroinvertebrates, and fish in comparison to the recirculating cooling-tower alternative (Table S-3). However, species diversity of the aquatic and riparian vegetation and macroinvertebrate communities would be greater in areas where habitat is available. There would be no potential for early emergence of any macroinvertebrate species, and reactor-influenced stranding would not occur. The reduced water volumes would cause the present riparian habitat to be colonized by nonwetland species. The reduced flows and increased density of vegetation would limit fish access to the upper reaches of the stream and, thus, limit overall use and spawning. The endangered wood stork would not use Reach 2, but limited use by waterfowl would occur.

Impacts On Reach 3

Reach 3 of the Pen Branch system, as utilized for the HEP analysis (Mackey et al, 1987) extends from the Pen Branch delta approximately 2 kilometers into the Savannah River swamp; it encompasses approximately 89 percent (988 of 1100 acres) of the Pen Branch system. However, approximately 40 percent of this reach is considered to be part of the Savannah River Swamp and, therefore, is not influenced by reactor operations (Mackey et al., 1987). In Reach 3 the stream is highly braided; the gradient is the lowest of all the reaches; sheet flow is prevalent; and water flows are extremely variable, influenced primarily by periodic Savannah River flooding. The following discussion for each alternative considers only the portion of Reach 3 that potentially is influenced by reactor operations.

With the no-action alternative, aquatic vegetation would be limited to thermally tolerant algae and bacteria (Table S-4). Riparian vegetation in the delta probably would consist of thermally tolerant herbaceous flora; in the swamp, the cypress-tupelo community would predominate. The macroinvertebrate community would be more diverse than that in Reach 2, but it would be dominated by thermally tolerant species (e.g., Oligochaetes and Nematodes). Only thermally tolerant fish species would occur in the delta area. Brief use by some species would occur during reactor shutdowns. In the swamp, high temperatures would limit use and spawning by anadromous species. The endangered wood stork would not use Reach 3 with this alternative; however, extensive use by waterfowl should occur, particularly below the delta.

With the once-through cooling-tower alternative, submerged macrophytes should develop, but their distribution would be limited to the edge of the delta and the lower sections of the braided-stream area; in this area, high abundance would occur. Herbaceous marsh should develop in the riparian areas of the delta, while the cypress-tupelo community would predominate in the swamp. As a result of the large reduction in water temperatures, a substantial increase in macroinvertebrate community diversity and abundance would occur in comparison to the no-action alternative. No early emergence of any species should occur, and stranding due to variable flows would be limited to the delta area because flow in the swamp is influenced strongly by Savannah River flows. Because of lower flows and temperatures, fish habitat should be greatly improved over that present upstream; much greater use and spawning success would occur. Some access to Reach 2 would be available for anadromous and other species. Because of high flows, the endangered wood stork probably would not use this reach for foraging; however, because of lower water temperatures, waterfowl should use the delta area to a greater extent than they would for the no-action alternative.

Less aquatic vegetation habitat would be available with the recirculating cooling-tower system than with the once-through alternative (Table S-4). However, the reduction in flow and the resultant decrease in water depths would provide greater vegetation abundance in the areas of occurrence. In the delta area, herbaceous marsh should occur but in less abundance than with the once-through alternative; shrub species would also be present and old-field species would occur in the drier areas. In the swamp, the cypress-tupelo community would predominate. Less macroinvertebrate habitat would be available than with the once-through system, but the habitat would be of higher quality because of reduced, stable flows. A substantial increase in macroinvertebrate community diversity and abundance would occur, and there would be little chance of stranding due to the more stable flows. Fish use and spawning would be reduced in the delta area as a result of the reduced flow, shallow water depths, and increased densities of vegetation, all of which could also limit access to the upper stream reaches. In the swamp, a high-quality habitat for spawning and nursery functions would occur as a result of the influence of the Savannah River on water levels. Use of the delta area by the endangered wood stork would increase as a result of reduced flows; however, this eventually would decrease as revegetation of the area proceeds. Less habitat would be available in the delta for waterfowl in comparison to the once-through alternative because of flow reduction and the related revegetation of the area.

With a complete cessation of reactor cooling water discharge (natural stream conditions), less habitat would be available for aquatic vegetation than with the recirculating cooling-tower alternative. However, in the available areas, dense concentrations should occur. In the riparian areas of the delta, there would be greater development of an old-field community, with less marsh and shrub vegetation than with the recirculating alternative. In the swamp, the cypress-tupelo community would predominate. Less macroinvertebrate habitat would be available, but community diversity and abundance should be similar to those for the recirculating alternative. There should be little chance of macroinvertebrate stranding due to more stable flows. In the delta area, less fish habitat would be available and spawning success should be less because of reduced flow and revegetation effects that reduce aquatic habitat. However, in the swamp, fish use should be similar to that with the recirculating system. Limited use of the delta area by the endangered wood stork should occur; this would decrease at a more rapid rate than with the recirculating alternative due to revegetation. There would be less use by waterfowl because revegetation would cause less available habitat.

Table S-5 summarizes and compares the environmental consequences of DOE's preferred cooling water alternative (i.e., increased flow with mixing), direct discharge to the Savannah River, and the no-action alternative for the D-Area powerhouse.

FEDERAL AND STATE REQUIREMENTS

Table S-6 lists the permits and other environmental approvals required for the implementation of cooling water alternatives for K- and C-Reactors and the D-Area powerhouse and the current status of each requirement.

Table S-5. Comparison of the No Impact Alternative to the Impacts of the Increased Flow with Mixing (Preferred Alternative) and Direct Discharge Alternative for the D-Area Coal-Fired Powerhouse (page 1 of 3)

Impacts	No action[a]	Increased flow with mixing (Preferred Alternative)	Direct discharge to Savannah River
SCHEDULE FOR IMPLEMENTATION	Current	Current	Construction of this alternative would require about 22 months.
PRELIMINARY COST CAPITAL (MILLION $)	$0	$0	$14
ESTIMATED OPERATING COST INCREASE (MILLION $ PER YEAR)	$0	$0.03	$0.05
SOCIOECONOMICS	No additional work-force required.	No additional work-force required.	Peak construction work force of 40 persons.
WATER WITHDRAWAL AND DISCHARGE RATES	About 2.7 cubic meters per second would continue to be withdrawn from the Savannah River and discharged to Beaver Dam Creek.	Withdrawal and discharge rates would be the same as for no action except when withdrawal and discharge rates each could be as high as 4.0 cubic meters per second to meet the 32.2°C Class B water classification standard.	Withdrawal and discharge rates would be the same as for no action; however, thermal discharge would be directly to the Savannah River. All powerhouse thermal discharges would be removed from Beaver Dam Creek.
TEMPERATURE AND FLOW EFFECTS	Water temperatures in Beaver Dam Creek would continue to exceed the 32.2°C State Class B water classification standard during periods from May through	Water temperatures in the stream would meet the 32.2°C State Class B water classification standard; a Section 316(a) demonstration study will be performed for exceed-	In Beaver Dam Creek, water temperatures would be at ambient levels year-round. In the Savannah River, water temperatures beyond a mixing zone at the discharge point

Table S-5. Comparison of the No Impact Alternative to the Impacts of the Increased Flow with Mixing (Preferred Alternative) and Direct Discharge Alternative for the D-Area Coal-Fired Powerhouse (page 2 of 3)

Impacts	No action[a]	Increased flow with mixing (Preferred Alternative)	Direct discharge to Savannah River
	September; water temperatures would also exceed the maximum ambient stream temperature rise standard of 2.8°C. Concentrations of suspended solids would remain slightly higher than in ambient streams. There would continue to be reduced numbers of aquatic organisms and spawning in the thermally affected areas of Beaver Dam Creek during the warmer months.	ances of 2.8°C rise in ambient stream temperature. Slight increases in suspended solids concentrations would occur during periods of increased flow. No major changes in aquatic fauna or floral communities would be expected to occur except that habitat area would increase during periods of increased flow.	would meet the State Class B water quality classification standard of 32.2°C. Low water levels in Beaver Dam Creek would greatly reduce existing aquatic habitat; however, the absence of thermal stress would allow full use of this habitat by aquatic organisms. Fish spawning would be limited because of reduced habitat. An adequate zone of passage would be present in the river.
ENTRAINMENT/ IMPINGEMENT	Water withdrawal would continue to cause annual entrainment losses of about 2.0 x 10^6 fish eggs and larvae and the loss of about 1718 fish due to impingement annually.	Increased water withdrawal over that for no action would increase annual entrainment losses by about 6.0 x10^4 fish eggs and larvae and the loss of an additional 113 fish due to impingement annually.	Effects would be about the same as for no action.

Table S-5. Comparison of the No Impact Alternative to the Impacts of the Increased Flow with Mixing (Preferred Alternative) and Direct Discharge Alternative for the D-Area Coal-Fired Powerhouse (page 3 of 3)

Impacts	No action[a]	Increased flow with mixing (Preferred Alternative)	Direct discharge to Savannah River
TERRESTRIAL/WETLAND HABITAT	No impacts.	Operation would result in an estimated loss of about 4 acres of wetlands and about 4 acres of uplands.	Construction would result in an estimated loss of about 1 acre of wetlands and 5 acres of uplands.
AIR QUALITY	No impact.	No impact.	No impact.
ENDANGERED SPECIES	The adjacent swamp area would continue to be used by wood storks for foraging. No impact on other endangered species.	Some decrease in wood stork foraging habitat during increased flow periods. No impacts on other species.	Loss of much of the wood stork foraging habitat due to lowered water levels in Beaver Dam Creek. No impacts on other species.
ARCHAEOLOGICAL AND HISTORICAL SITES	No impacts.	One site will be recommended for eligibility for nomination to the National Register of Historic Places. A "no effect" determination issued by the SHPO.	Survey of pipeline area revealed no historic sites.
RADIOLOGICAL RELEASES	No impacts.	No impacts.	No impacts.

a. No action is defined as the continuation of existing operations of the D-Area coal-fired powerhouse.

Table S-6. Required Regulatory Permits and Notifications (page 1 of 2)

Activity/facility	Requirement(s)	Agency	Status
Water			
Cooling water systems construction	Construction permits	South Carolina Department of Health and Environmental Control, Industrial and Agricultural Wastewater Division	To be submitted by September 30, 1988, subject to the appropriation of funds by Congress
	Section 404 permit[a]	U.S. Army Corps of Engineers (COE)	To be submitted prior to construction
	Section 401 certification[a]	South Carolina Department of Health and Environmental Control, Division of Water Quality	Requested by COE as part of the dredge-and-fill permit process
	Section 10 permit for structures in navigable waters[a]	U.S. Army Corps of Engineers	To be submitted prior to construction
	Permit for structures in in navigable waters[a]	South Carolina Budget and Control Board	To be submitted prior to construction
Cooling water discharges	NPDES permit	South Carolina Department of Health and Environmental Control, Industrial and Agricultural Wastewater Division	Issued; modification to permit conditions to be made prior to operation of selected cooling water system
Compliance with delta 2.8°C temperature requirement[b]	Section 316(a) (thermal impact) Demonstration	South Carolina Department of Health and Environmental Control, Industrial and Agricultural Wastewater Division	Plans for conducting studies to be submitted within 2 months following project completion
Water withdrawal/water use	Quarterly reporting	South Carolina Water Resources Commission	Routine reports will continue to be submitted
Endangered species	Consultation/biological assessment	U.S. Fish and Wildlife Service	Consultations with FWS completed

Table S-6. Required Regulatory Permits and Notifications (page 2 of 2)

Activity/facility	Requirement(s)	Agency	Status
Fish and Wildlife Coordination Act	Consultation/ consideration of fish and wild-life resources	U.S. Fish and Wildlife Service	Consultations with FWS completed
Migratory Bird Treaty Act	Consultation with FWS	U.S. Fish and Wildlife Service	Consultation with FWS completed
Anadromous Fish Conservation Act	Consultation with FWS	U.S. Fish and Wildlife Service	Consultation with FWS completed
Historic preservation	Archaeological survey and assessment	South Carolina Historic Preservation Officer	Surveys and assess-ments completed; consultation with SHPO completed
Floodplains/wetlands[c]	Assessment and determination	U.S. Department of Energy	Notice published in Federal Register (51 FR 10654) con-currently with notice of avail-ability of the draft EIS on March 28, 1986; determination pub-lished after com-pletion of FEIS

a. Applicable to the D-Area coal-fired powerhouse direct discharge alternative.
b. Applicable to once-through cooling-tower alternatives for K- and C-Reactors and the increased pumping alternative for the D-Area coal-fired powerhouse.
c. Refer to Appendix F.

CHAPTER 1

NEED FOR COOLING WATER SYSTEMS AND PURPOSE OF THIS ENVIRONMENTAL IMPACT STATEMENT

The implementation of cooling water systems for major sources of thermal effluents at the Savannah River Plant (SRP) is needed for compliance with the Clean Water Act and a Consent Order (84-4-W), dated January 3, 1984, and amended August 27, 1985, and August 31, 1987, between the U.S. Department of Energy (DOE) and the South Carolina Department of Health and Environmental Control (SCDHEC). The purpose of this environmental impact statement is to address the potential environmental consequences of constructing and operating alternative cooling water systems for thermal discharges from K- and C-Reactors and from a coal-fired powerhouse in D-Area as input to the selection and implementation of such systems. TC

1.1 NEED

The Savannah River Plant is a controlled-access area of approximately 780 square kilometers (192,700 acres) near Aiken, South Carolina. It is a major DOE installation established in the early 1950s for the production of nuclear materials for national defense. Plant facilities, which can be characterized as heavy industry, consist of five production reactors (four operational and one in standby status), electrical and steam generating plants, two chemical separations facilities, fuel and target fabrication facilities, research laboratories, and support and administrative facilities.

The major sources of thermal effluents at the Savannah River Plant are the cooling water discharges from the production reactors and an onsite coal-fired powerhouse. Two of the currently operating production reactors, K- and C-Reactors, discharge their cooling water directly to Pen Branch and Four Mile Creek, respectively. The coal-fired powerhouse in D-Area normally discharges cooling water from cooling-system condensers into an excavated canal that flows into Beaver Dam Creek.

The thermal effluent from P-Reactor is cooled by an onsite 2700-acre cooling lake, Par Pond. DOE conducted Section 316(a) and 316(b) studies, as required by the Federal Water Pollution Control Act, as amended (33 USC 1326), and submitted the results of these studies to SCDHEC. On May 14, 1987, SCDHEC concurred with DOE's conclusions that balanced indigenous populations of fish, shellfish, and wildlife presently exist in Par Pond and that the present operations of P-Reactor pose no threat to the continued existence of a balanced indigenous biological community. L-Reactor discharges its cooling water to a 1000-acre cooling lake. Predictive Section 316(a) studies indicating the probable existence of balanced biological communities within and below the cooling lake have been submitted to, and approved by, SCDHEC. The restart of L-Reactor and the cooling lake are discussed extensively in the <u>Environmental Impact Statement, L-Reactor Operation, Savannah River Plant</u> (DOE, 1984a). More detailed discussions of P- and L-Reactors are not within the scope of this EIS. AJ-1

A renewed NPDES permit (Number SC0000175) issued by SCDHEC became effective on January 1, 1984, for SRP operations. The purpose of this permit was to regulate the Plant's discharges of wastewater - including cooling water - to surface streams and other water bodies. As stated in the permit, cooling water discharge temperature limits for K- and C-Reactors and the D-Area powerhouse are not to exceed an instream temperature after mixing of 32.2°C; in addition, the effluent must not raise the temperature of the stream more than 2.8°C above its ambient temperature unless the maintenance of a balanced biological community can be determined by a Section 316(a) demonstration study.

To achieve compliance with these temperature limitations, DOE and SCDHEC entered into a mutually agreed-on Consent Order (84-4-W). This order temporarily superseded the temperature requirements in the NPDES permit and established a process for attaining compliance. Key elements of this process required DOE to:

- Complete a "Comprehensive Cooling-Water Study" of the thermal effects of operations at the Savannah River Plant

- Complete and submit a Thermal Mitigation Study to SCDHEC

- Submit and actively support funding requests to accomplish any actions resulting from the Thermal Mitigation Study

- Undertake work on the alternatives approved by SCDHEC, under a schedule to be established in an amendment to the Consent Order, subject to the appropriation of funds by Congress

In compliance with the Consent Order, DOE submitted a Thermal Mitigation Study (DOE, 1984b) to SCDHEC on October 3, 1984; the Comprehensive Cooling-Water Study, Annual Report (Du Pont, 1985) was submitted in July 1985.

On August 27, 1985, DOE and SCDHEC mutually agreed on an amendment to Consent Order 84-4-W of January 3, 1984, that established a compliance schedule for the completion of National Environmental Policy Act (NEPA) documentation by December 31, 1986. This amendment also established an implementation schedule for the start of construction of a selected cooling water system for C-Reactor on or before September 30, 1987, and completion of construction on or before March 31, 1989. The amendment established the date for the start of construction of a system for K-Reactor on or before September 30, 1987, and completion of construction on or before July 31, 1989. The Consent Order also established March 31, 1987, as the date by which DOE must submit a plan of study and an approvable schedule for the implementation of a cooling water system for the D-Area powerhouse. In compliance with the Amended Consent
TC Order, DOE published a Notice of Availability (51 FR 10652) and submitted a copy of the draft environmental impact statement (EIS) to SCDHEC on March 28, 1986.

On October 29, 1986, DOE and SCDHEC mutually agreed that it would be necessary
TC to change the schedule in the Amended Consent Order. DOE requested this change to respond to comments received from SCDHEC and the U.S. Environmental Protection Agency on the draft EIS. On August 31, 1987, DOE and SCDHEC

mutually agreed on a second amendment to the Consent Order, which established a compliance schedule for the completion of NEPA documentation by October 31, 1987. The second amendment also specified that on or before September 30, 1988, DOE must submit plans and specifications to SCDHEC for the K-Reactor mitigation alternative subject to the authorization of and appropriation of funds by Congress. In addition, this amendment established an implementation schedule for the start of construction of a selected cooling water system for K-Reactor on or before February 28, 1990, and completion of construction on or before December 31, 1992. The amended Consent Order also established March 31, 1988, as the date by which DOE must submit a plan for a Section 316(a) demonstration study and an approvable schedule for the implementation of a cooling water system for the D-Area powerhouse. In addition, the amended Consent Order stated that DOE shall notify SCDHEC immediately upon determination that C-Reactor is to restart and propose a timely schedule for construction of its thermal mitigation alternative. TC

Implementation of cooling water system alternatives at K- and C-Reactors and the D-Area coal-fired powerhouse is needed for compliance with South Carolina water classification standards [as contained in the NPDES permit (Number SC0000175)], and Consent Order 84-4-W between DOE and SCDHEC.

1.2 PURPOSE

The purpose of this environmental impact statement is to address the potential environmental consequences of constructing and operating cooling water systems for thermal discharges from K- and C-Reactors and from the coal-fired powerhouse in D-Area in compliance with Section 102(2)(C) of the National Environmental Policy Act of 1969, as amended, and to provide input into the selection and implementation of such systems.

The proposed action is to construct and operate cooling water systems for K- and C-Reactors and the D-Area powerhouse to attain compliance with the State of South Carolina's Class B water classification standards. DOE's preferred alternatives are to construct and operate once-through cooling towers for the K- and C-Reactors, and to implement increased flow with mixing for the D-Area powerhouse.

This EIS considers three cooling water alternatives each for K- and C-Reactors and three alternatives for the D-Area powerhouse. The alternatives for K- and C-Reactors are the construction and operation of once-through cooling towers; the construction and operation of recirculating cooling towers; and the continuation of direct discharge - or no action [as required by the Council on Environmental Quality for Implementing the National Environmental Policy Act (40 CFR 1502.14)]. The three alternatives for the D-Area powerhouse are to increase the inlet water flow to the D-Area raw-water basin; to implement direct discharge to the Savannah River; and to continue the present operation - or no action.

This EIS describes the cooling water alternatives (Chapter 2) and the affected Savannah River Plant environment (Chapter 3), and assesses the potential environmental consequences of construction and operation of alternative cooling water systems, including cumulative and unavoidable and irreversible impacts (Chapter 4). Chapter 5 discusses Federal and State of South Carolina regulatory requirements/permits and studies and monitoring programs that are applicable to the construction and operation of the cooling water systems.

BB-1 BD-5 Eight documents published in the last 3 years are relevant to an understanding of the potential environmental effects of the construction and operation of alternative cooling water systems:

- Environmental Impact Statement, L-Reactor Operation, Savannah River Plant, Aiken, South Carolina (DOE, 1984a) describes alternative cooling water systems for L-Reactor and the potential environmental effects of these systems on the Savannah River and the onsite swamp system.

- Thermal Mitigation Study - Compliance with the Federal and South Carolina Water Quality Standards, Savannah River Plant, Aiken, South Carolina (DOE, 1984b) discusses and evaluates 22 possible cooling water alternatives for K- and C-Reactors and the D-Area powerhouse.

- The Comprehensive Cooling-Water Study Annual Report and Final Report, Savannah River Plant, Aiken, South Carolina (Du Pont, 1985; 1987) evaluates the environmental effects of the intake and release of cooling water on the structures and functions of aquatic ecosystems at the Savannah River Plant, including water quality, radionuclide and heavy metal transport, wetlands ecology, aquatic ecology, and endangered species.

TC
- Draft Environmental Impact Statement, Alternative Cooling Water Systems, Savannah River Plant, Aiken, South Carolina (DOE, 1986) describes alternative cooling water systems for K- and C-Reactors and the D-Area powerhouse and the potential environmental effects of these systems on the Savannah River and the onsite streams.

BB-1 BD-5
- Impingement and Entrainment at the River Water Intakes of the Savannah River Plant (DOE, 1987) summarizes the impact of withdrawing Savannah River water for secondary cooling of SRP nuclear reactors and a large, coal-fired, stream generation facility on the Savannah River fisheries.

- Chlorination/Dechlorination Studies Relating to Proposed Cooling Towers for K- and C-Reactors (Wilde, 1986) provides information on the chlorination and dechlorination of SRP reactor cooling water pumped from the Savannah River.

BC-2
- Habitat Evaluation Procedure (HEP) Assessment for Thermal Mitigation Alternatives for C- and K-Reactors (Mackey et al., 1987) identifies the value of habitat to be gained or lost with the implementation of once-through or recirculating cooling towers.

REFERENCES

DOE (U.S. Department of Energy), 1984a. Final Environmental Impact Statement, L-Reactor Operation, Savannah River Plant, Aiken, South Carolina, DOE/EIS-0108, Savannah River Operations Office, Aiken, South Carolina.

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DOE (U.S. Department of Energy), 1987. Impingement and Entrainment at the River Water Intakes of the Savannah River Plant, submitted to the U.S. Army Corps of Engineers as Special Condition B of Section 404 Permit #84-2Z-088 for the L-Lake Embankment, Savannah River Operations Office, Aiken, South Carolina. BD-5

Du Pont (E. I. du Pont de Nemours and Company, Inc.), 1985. Comprehensive Cooling-Water Study, Annual Report, DP-1697, Volumes 1-11, J. B. Gladden, M. W. Lower, H. E. Mackey, W. L. Specht, and E. W. Wilde (editors), Savannah River Laboratory, Aiken, South Carolina.

Mackey, H. E., Jr., C. E. Davis, L. Price, and W. Fay, 1987. Habitat Evaluation Procedure (HEP) Assessment for Thermal Mitigation Alternatives for C- and K-Reactors, DPST-87-578, E. I. du Pont de Nemours and Company, Savannah River Laboratory, Aiken, South Carolina. BC-2

Wilde, E. W., 1986. Chlorination/Dechlorination Studies Relating to Proposed Cooling Towers for K- and C-Reactors, DP-1730, E. I. du Pont de Nemours and Company, Savannah River Laboratory, Aiken, South Carolina. BE-1 BC-16

CHAPTER 2

COOLING WATER ALTERNATIVES AND PROPOSED ACTION

The U.S. Department of Energy (DOE) initially identified possible cooling water systems that it could implement for the K- and C-Reactors and the D-Area coal-fired powerhouse, and documented them in the Thermal Mitigation Study (DOE, 1984b). Based on a structured screening process and comments received on its Notice of Intent to prepare this environmental impact statement (EIS), DOE has identified reasonable cooling water alternatives that this EIS considers in detail.

Section 2.1 describes the screening process by which DOE determined the reasonable cooling water alternatives considered in this EIS; Section 2.2 describes these alternatives; Section 2.3 compares the environmental consequences of these alternatives.

2.1 SCREENING PROCESS

DOE used a structured screening process to identify, from among the many possible alternatives for cooling water systems for K- and C-Reactors and the D-Area coal-fired powerhouse, those that would be reasonable from environmental, engineering, scheduling, and cost perspectives. The Thermal Mitigation Study (DOE, 1984b) documents this screening process. DOE performed this screening in a three-step process:

1. Identification of possible alternatives

2. Selection of feasible compliance alternatives using "exclusionary" criteria

3. Selection of reasonable compliance alternatives using "discriminatory" criteria

The first step divided all alternative cooling water systems into two categories: those that could meet the State of South Carolina's Class B water classification standards and those that could not. For those alternatives that could not meet these water classification standards (such as rubble dams, small cooling lakes, and the current once-through systems), DOE did not consider any further assessment because both Federal and State regulations would prohibit the designation of streams to a classification other than Class B for the transport or assimilation of waste.

For those alternatives that could meet Class B water classification standards, DOE identified potential subcategories of generic cooling water systems for K- and C-Reactors and, separately, for the D-Area coal-fired powerhouse. These systems were:

Cooling towers
- Once-Through
- Recirculating

- Cooling lakes and ponds
  - Offstream ponds
  - Cooling lakes
  - Multisource ponds/lakes

- Cooling lake/pond and cooling-tower combinations
  - Cooling lakes/ponds before cooling towers
  - Cooling lakes/ponds after cooling towers

For the D-Area coal-fired powerhouse, the identified alternatives included:

- Cooling towers
  - Once-Through
  - Recirculating

- Direct discharge to the Savannah River

- Increased flow with mixing

DOE then developed minimum requirements for K- and C-Reactors for use in identifying possible alternatives for each of the generic categories. These requirements included sufficient surface area in cooling lakes or ponds for heat dissipation, and sufficient cooling capacity in once-through and recirculating cooling towers to attain a 32.2°C discharge during extreme meteorological conditions. Using these minimum requirements, DOE identified 22 possible cooling water alternatives for K- and C-Reactors and 4 alternatives for the D-Area powerhouse.

DOE applied "exclusionary criteria" to the possible cooling water alternatives to identify the feasible compliance alternatives. For K- and C-Reactors, the exclusionary criteria consisted of:

- The expected ability to perform successful Section 316(a) demonstrations if the Class B temperature limits were to be exceeded in the receiving stream after mixing

- A minimum of 400 acres of cooling-lake surface at or below 32.2°C to support a balanced biological community

- Sufficient cooling capacity to require, for screening purposes, no more than a 10 percent annual average production loss.

Application of these criteria led to the identification of 17 feasible compliance alternatives for K- and C-Reactors. DOE considered each of the four possible cooling water alternatives for the D-Area powerhouse to be feasible.

In the third step, DOE screened the 17 feasible compliance alternatives for K- and C-Reactors and the 4 alternatives for the D-Area powerhouse on the basis of "discriminatory" criteria to determine the reasonable compliance alternatives. These criteria included environmental impacts, implementation schedules, capital and operating costs, and relative operating complexity (i.e., multiple reactor cooling systems versus recirculation systems versus once-through systems). Based on these discriminatory criteria, DOE identified the following reasonable compliance alternatives:

K-Reactor

- 1400-acre once-through cooling lake between Pen Branch and Four Mile Creek above the railroad track
- Recirculating cooling tower
- Once-Through cooling tower
- Once-Through cooling tower to a 600-acre once-through cooling lake on Indian Grave Branch with an embankment about 300 meters above the confluence with Pen Branch
- 800-acre cooling lake with a 400-acre hot arm to a once-through cooling tower with an embankment located about 610 meters above Road A on Pen Branch

C-Reactor

- 1400-acre once-through cooling lake between Pen Branch and Four Mile Creek below the railroad track
- Recirculating cooling tower
- Once-Through cooling tower
- Once-Through cooling tower to a 500-acre once-through cooling lake on a tributary of Four Mile Creek with an embankment about 300 meters above the confluence with Four Mile Creek
- 800-acre cooling lake with a 400-acre hot arm to a once-through cooling tower with an embankment on Four Mile Creek about 1280 meters above Road A

D-Area Powerhouse

- Direct discharge to the Savannah River (bypassing Beaver Dam Creek)
- Increased flow with mixing

As part of the scoping process, DOE invited interested parties to comment on the alternatives it would consider in this environmental impact statement (50 FR 30728). Based on the screening process documented in the Thermal Mitigation Study (DOE, 1984b) and its preliminary determination of alternatives to be considered in this environmental impact statement, DOE decided to consider the alternatives of once-through and recirculating cooling towers for K- and C-Reactors, and increased flow with mixing and direct discharge to the Savannah River for the D-Area coal-fired powerhouse. In addition, DOE is required to consider the "no action" alternative in accordance with the Council on Environmental Quality's regulations for implementing the procedural provisions of the National Environmental Policy Act (NEPA).

Appendix A provides a more detailed description of the screening process and criteria that DOE used to identify the reasonable alternatives for evaluation in this environmental impact statement.

2.2 PROPOSED ACTION

The proposed action is to construct and operate cooling water systems for the K- and C-Reactors and the D-Area powerhouse to attain compliance with the State of South Carolina's Class B water classification standards. Based on the screening process described in Section 2.1, the alternatives considered in this EIS are the construction and operation of once-through or recirculating cooling towers for K- and C-Reactors, increased flow with mixing or direct discharge to the Savannah River for the D-Area powerhouse, and no action. DOE's preferred alternatives are to construct and operate once-through cooling towers for K- and C-Reactors and to implement increased flow with mixing for the D-Area powerhouse.

The following sections describe these alternatives. The descriptions are based on preliminary and conceptual designs; specific engineering parameters and costs are subject to change during future design phases.

2.2.1 K-REACTOR COOLING WATER ALTERNATIVES

The cooling water alternatives for K-Reactor are the construction and operation of a once-through cooling tower, the construction and operation of recirculating cooling towers, and no action.

2.2.1.1 Once-Through Cooling Tower (Preferred Alternative)

The once-through cooling tower described in the Thermal Mitigation Study (DOE, 1984b) and the draft EIS (DOE, 1986) was a mechanical-draft tower that would receive the cooling water from K-Reactor from a new pump pit. Cooled water
TC from the tower basin would then flow by gravity to a 100-acre offstream holding pond which would be used to dissipate chlorine (cooling-tower biocide), before the water was discharged to Indian Grave Branch and Pen Branch. The thermal performance of the once-through cooling system was not designed to utilize the holding pond for additional cooling.

AD-1 Since the completion of the Thermal Mitigation Study and the Draft EIS (DOE,
1986), further design evaluations and studies have been performed to determine
BB-1 optimal performance parameters and to achieve lower costs. These evaluations
BB-2 and studies have indicated that there are several areas in which optimization
of performance and cost savings can be realized in the construction and opera-
BB-3 tion of once-through towers without introducing major changes in the nature or
BC-4 magnitude of the environmental impacts. These areas include the consideration
of gravity-feed versus pumped-feed towers, natural-draft versus mechanical-
BC-6 draft towers, and a chemical injection system for either dissipation or neu-
BC-14 tralization of chlorine biocide versus holding ponds (and their sizing).
Similarly, these evaluations and studies have also led to the development of
thermal performance criteria that, when incorporated in the final design of a

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once-through cooling-tower system, would reduce the potential for cold shock (i.e., reduce the difference between ambient stream temperatures and stream temperatures when the cooling water is being discharged) to fish.

The following sections describe the once-through cooling-tower for K-Reactor incorporating current design considerations, and the major differences associated with a natural-draft versus a mechanical-draft tower.

Description

For a once-through natural-draft system with gravity feed, the cooling water discharged from K-Reactor would flow by gravity from a new underground reinforced-concrete diversion box constructed around the existing effluent pipe, through a new 1.8-meter diameter pipe approximately 50 meters long to a new riprap-lined effluent canal. This canal would begin just outside of the Reactor Area fence and would extend southwesterly under Road B approximately 750 meters to a collection box to be constructed approximately 300 meters south of Road B. The box would channel the cooling water into another 1.8-meter-diameter pipe, which would deliver it to a natural-draft cooling tower located between Road B and Indian Grave Branch, discharges from which would enter the Branch. Figures 2-1 and 2-2, which are based on preliminary design information, show a flow diagram and a site layout, respectively, of this once-through system. TC

Based on preliminary design information, the natural-draft, once-through, reinforced-concrete cooling tower would be approximately 100 meters in diameter and about 150 meters high. The tower would utilize Chlorinated Polyvinyl Chloride (CPVC) and Polyvinyl Chloride (PVC) fill to withstand the high cooling water temperatures. The tower would be situated over a reinforced-concrete basin, which would receive the cooled water flowing through the tower. An underground steel pipe would carry the flow by gravity to a new riprap-paved canal 50 meters long and 30 meters wide that would convey cooled effluent into Indian Grave Branch at a point 800 meters downstream from the present discharge point of the K-Reactor effluent canal.

A small water-treatment building would be located near the cooling tower. It would be used to store a chemical biocide (probably sodium hypochlorite) that would be injected into the cooling water stream at the tower inlet to prevent biofouling in the tower system. BB-1 BB-2

This building would contain a system for injecting a dechlorination agent (probably sodium sulfite) into the cooling tower cold water basin. The dechlorinating agent would be injected in sufficient quantities to meet established chlorine effluent limits. Chemical storage tanks and distribution piping would be provided, as would metering pumps and controls, which would be located in the small water-treatment building near the cooling tower. BB-1

A new control room located near the cooling tower would contain the necessary switchgear and instrumentation for the operation of all chemical-treatment equipment. TC

The cooling-tower area would be enclosed by a patrol road and fence with personnel and vehicular gates. Access roads would be provided, and parking, loading, and equipment storage areas would be paved at the cooling tower and

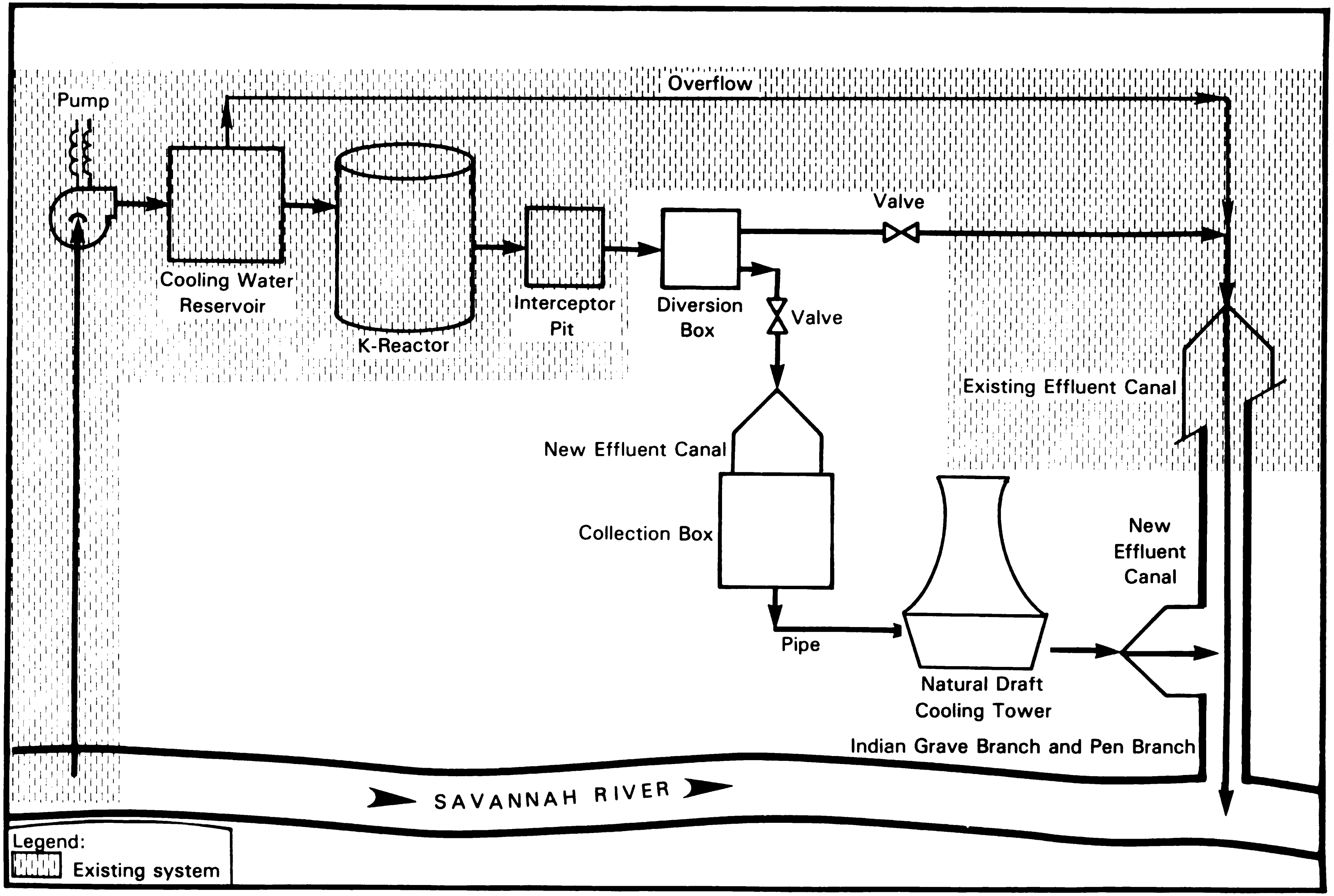

Figure 2-1. K-Reactor Once-Through Cooling Tower System Flow Diagram

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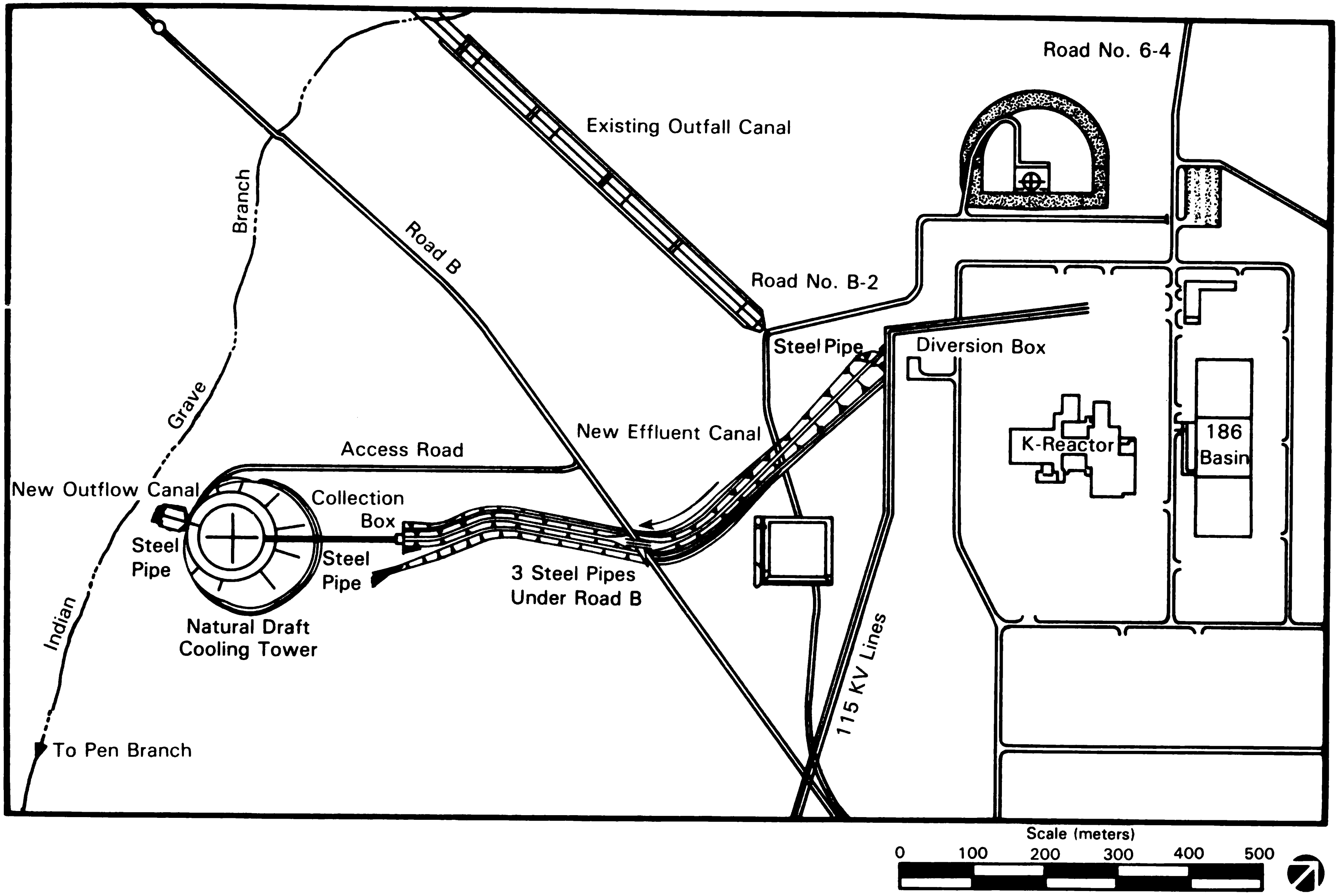

Figure 2-2. K-Reactor Once-Through Cooling Tower System

accessory buildings. Areas around the cooling tower would be regraded and seeded, or, if necessary, covered with stone or paving as appropriate to restore natural surface drainage. An adequate stormwater-drainage system would be constructed inside the fenced area; it would include erosion protection and would discharge into natural drainage ways.

TC Electrical loads for the gravity-feed, natural-draft cooling tower system would be small, consisting primarily of lighting and control equipment. The existing K-Area substations should be adequate, but two new electric lines would be run from K-Area to the cooling tower area along the proposed canal.

Outside lighting and power distribution at the new cooling-tower facilities would be provided. Communications facilities would be extended from the existing K-Area system. Monitoring instrumentation for this cooling system would be installed in the K-Reactor Central Control Room. It would contain monitoring and control instruments that would be connected to instrumentation at the cooling-tower facilities. These instruments would measure water temperature at the tower discharge and water flow to the stream. New alarms in the Central Control Room would indicate a high cooling-tower discharge temperature.

Most of the cooling water system construction would be completed with minimal impact on reactor operation. Careful scheduling would ensure that the work necessary to connect the system with the existing facilities is accomplished during scheduled reactor shutdowns.

Safety practices during construction would be in accordance with applicable safety standards. Occupational exposure to low-level radiation and to chemical contact or inhalation will be minimized by monitoring procedures and by protective equipment and clothing.

TC Preliminary design evaluations and studies have indicated that optimization of performance and cost savings would be realized by the construction and operation of a natural-draft, once-through cooling tower rather than a mechanical-draft tower as described in the Thermal Mitigation Study (DOE, 1984b) and the draft EIS (DOE, 1986). The description of a mechanical-draft tower would not differ appreciably from that presented above for the natural-draft tower. The major differences would be the size of the tower (e.g., approximately 150 meters high for the natural-draft tower versus 20 meters for the mechanical-draft tower) and the extent of the electrical system upgrade (e.g., the natural-draft tower could require less system upgrade due to the elimination of the fans and motors associated with the mechanical-draft tower).

Thermal Performance

BB-3 BC-4 BC-14 The once-through cooling tower would be designed to enable the discharge to meet the State of South Carolina's Class B water classification standards (i.e., a maximum instream temperature of 32.2°C). This would be accomplished through the design conditions of a 4.4°C approach to a wet bulb temperature of 27.8°C. In the rare instances where the design wet bulb is exceeded, the reactor will be operated at reduced power so that the standards are always met.

The K-Reactor tower discharge to Pen Branch includes the 11.3 cubic meters per second of secondary cooling water flow, less approximately 0.8 cubic meter per second of water evaporated in the tower. The Pen Branch flow (at Road B), other than the K-Reactor effluent, is approximately 0.03 cubic meter per second. TC

Table 2-1 lists monthly average water temperatures along the cooling water flow path (based on Bush Field meteorology data from 1953 through 1982), along with the ambient stream temperatures. Additionally, Table 2-1 lists downstream temperatures under extreme summer conditions (July 1980). TC TE

The cooling tower will be designed and operated in such a manner as to meet the maximum weekly average temperature (MWAT) criteria (EPA, 1977) to minimize thermal shock of fish that could occur with a reactor scram (Muhlbaier, 1986). During average winter and spring conditions, the discharge from the once-through cooling tower would raise the ambient stream temperature in Pen Branch above the 2.8°C maximum temperature rise specified in the State of South Carolina's Class B water classification standards. Accordingly, a Section 316(a) study would be performed to demonstrate whether a balanced biological community would be maintained. TE

Resource Utilization

The existing withdrawal of about 11.3 cubic meters per second of water from the Savannah River to K-Reactor would be unchanged for the once-through cooling-tower alternative. Discharges from K-Reactor to the river would be reduced by about 0.8 cubic meter per second because of evaporation, and the total suspended solids concentration would be reduced by settlement in the cooling-tower cold water basin. Chemical biocide added to the cooling water to protect the tower would be neutralized. All discharges would meet State of South Carolina Class B water classification standards. BB-1 BB-2

Construction of a once-through natural-draft cooling tower system would be completed in approximately 36 months after a 9-month lead design period. The estimated peak contractor manpower requirement, based on preliminary design information, is about 200 persons for K-Reactor, assuming a combined workforce with C-Reactor. The maintenance and operating workforce would be increased by approximately four mechanics. Approximately 25 acres of uplands would be disturbed by all construction activities. TC TC

Since the once-through cooling tower system is gravity flow with a natural draft tower, the additional electricity requirements would be only for lighting and chemical feed equipment. TC

The present peak electrical load in K-Area is about 30.3 megawatts. An insignificant quantity of additional power would be required for lighting and other electrical equipment. TC

The estimated present-worth cost for the once-through natural-draft cooling tower at K-Reactor with gravity feed is approximately $43 million, including production losses ($41.4 million without production losses). Estimated annual operating costs are $6.4 million. In addition to these costs, the estimated AD-1 BC-6

Table 2-1. Monthly Predicted Mean and Maximum (in Parentheses) Temperatures (°C) Along Cooling Water Flow Path of K-Reactor Once-Through Cooling Tower

Location	Temperature for											
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Discharge to creek	19(28)	20(28)	23(28)	24(30)	26(30)	28(31)	29(32)	29(32)	28(31)	24(31)	23(29)	21(28)
Pen Branch at												
Road A	18(27)	19(27)	22(27)	24(29)	26(30)	28(31)	29(32)	29(32)	28(31)	24(30)	22(28)	20(27)
Railroad bridge	18(26)	18(26)	21(26)	23(29)	26(30)	28(31)	29(31)	29(31)	28(30)	24(29)	21(27)	19(26)
Swamp delta	16(24)	17(24)	20(25)	23(27)	25(29)	28(30)	29(31)	28(31)	27(30)	23(28)	20(26)	18(24)
Upstream from Steel Creek	10(17)	12(17)	16(19)	18(21)	21(24)	24(26)	26(27)	25(27)	23(24)	18(21)	15(18)	11(16)
Mouth[a]	10(15)	12(16)	16(19)	18(20)	21(24)	24(26)	25(27)	25(26)	22(24)	17(21)	15(17)	11(15)
Ambient creek[b]	8(18)	10(18)	15(22)	18(23)	21(24)	23(27)	23(27)	23(26)	21(26)	19(23)	13(21)	12(17)

a. Includes Steel Creek flow.
b. U.S. Geological Survey data for water year 1985 for station 021973471; Pen Branch at Road B (USGS, 1986).

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cost to conduct a Section 316(a) demonstration study is estimated $1.25 million. Preliminary design criteria suggest a 0.2-percent annual average loss of reactor power attributable to the operation of a once-through cooling-tower system in comparison to the No-Action alternative. AD-1 BC-6

2.2.1.2 Recirculating Cooling Towers

If a closed-cycle, recirculating cooling tower system were selected to be constructed, the cooling water discharges from K-Reactor would be conveyed initially in the same manner as in the once-through system (i.e., the same diversion box, pipe, canal, collection box, and pipe). However, the natural-draft cooling tower would be somewhat smaller than in the once-through design and the discharge from this tower would be pumped to a mechanical-draft tower near the existing K-Reactor cooling water reservoir (186-K basin). Figures 2-3 and 2-4, which are based on preliminary design information, show a flow diagram and a site layout, respectively, of this recirculating system.

The natural-draft cooling tower, when installed with the mechanical-draft tower in series, would be approximately 85 meters in diameter and 120 meters high. Six 1750 horsepower (1300 kilowatt) pumps would be provided to transfer the cooling water from the cold water basin under the first tower through a new steel pipe to the second tower. This 1.8-meter diameter, underground steel pipe would run approximately 2 kilometers from the natural-draft tower northeasterly under Road B and around the south and east sides of K-Area to the inlet of the mechanical-draft cooling tower. This second tower would be constructed on top of about 5 meters of earth fill, so its discharge could flow by gravity back to the Building 186-K basin for reuse. AD-1 BC-13

The first tower would utilize chlorinated polyvinyl chloride (CPVC) and polyvinyl chloride (PVC) fill to withstand the high cooling water temperatures. The second tower could use standard polyvinyl chloride fill, because the water reaching this tower would have been partially cooled at the first tower. The second tower would be approximately 70 meters in diameter by 20 meters high, and would have 12 fans, each with a 190-kilowatt motor.

A small water-treatment building would be located near each cooling tower. The buildings would be used to store a chemical biocide (probably sodium hypochlorite) that would be injected into the cooling water stream to prevent biofouling in the tower system. This would allow for injection of a non-chromated, organic based, chemical corrosion inhibitor. This chemical has been approved by SCDHEC for use in cooling tower systems and is presently being used at SRP. BB-1 BB-2 BC-17

Since the recirculating system would be designed to reduce production loss as well as to meet environmental regulations, no piping has been provided to completely bypass any cooling tower. Internal bypass valves would be included in each cooling tower to divert water directly to the cold water basin. These bypass valves, as well as sectionalizing valves which can isolate parts of the tower fill, would be used for cold weather start-ups and could be used during equipment repairs, if necessary. AD-1 BC-13

Whenever water is recirculating, approximately 0.5 cubic meter per second of the second tower discharge would flow by gravity through a weir to the existing overflow pipeline from Building 186-K. This pipeline would flow by

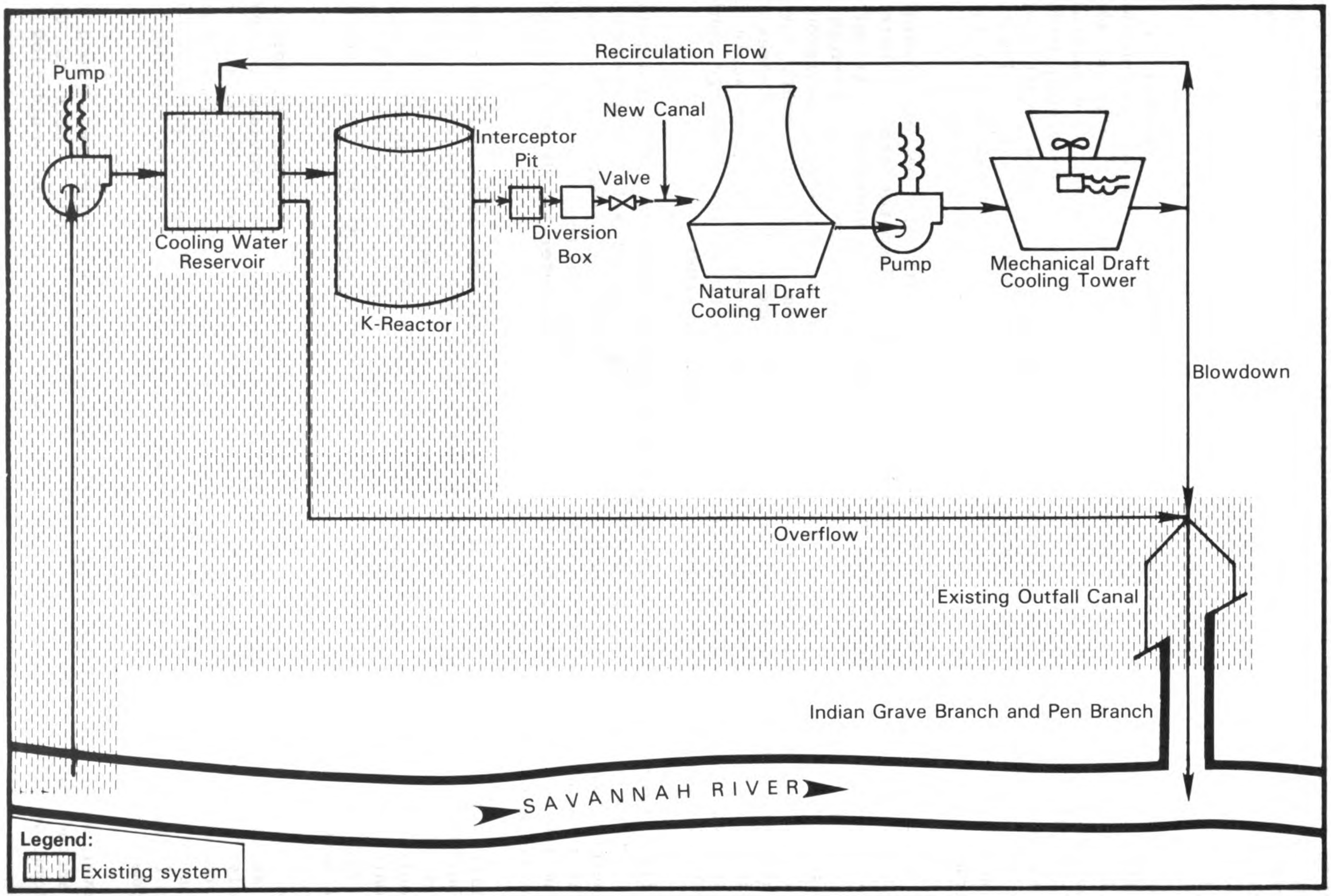


Figure 2-3. K-Reactor Recirculating Cooling Tower System Flow Diagram

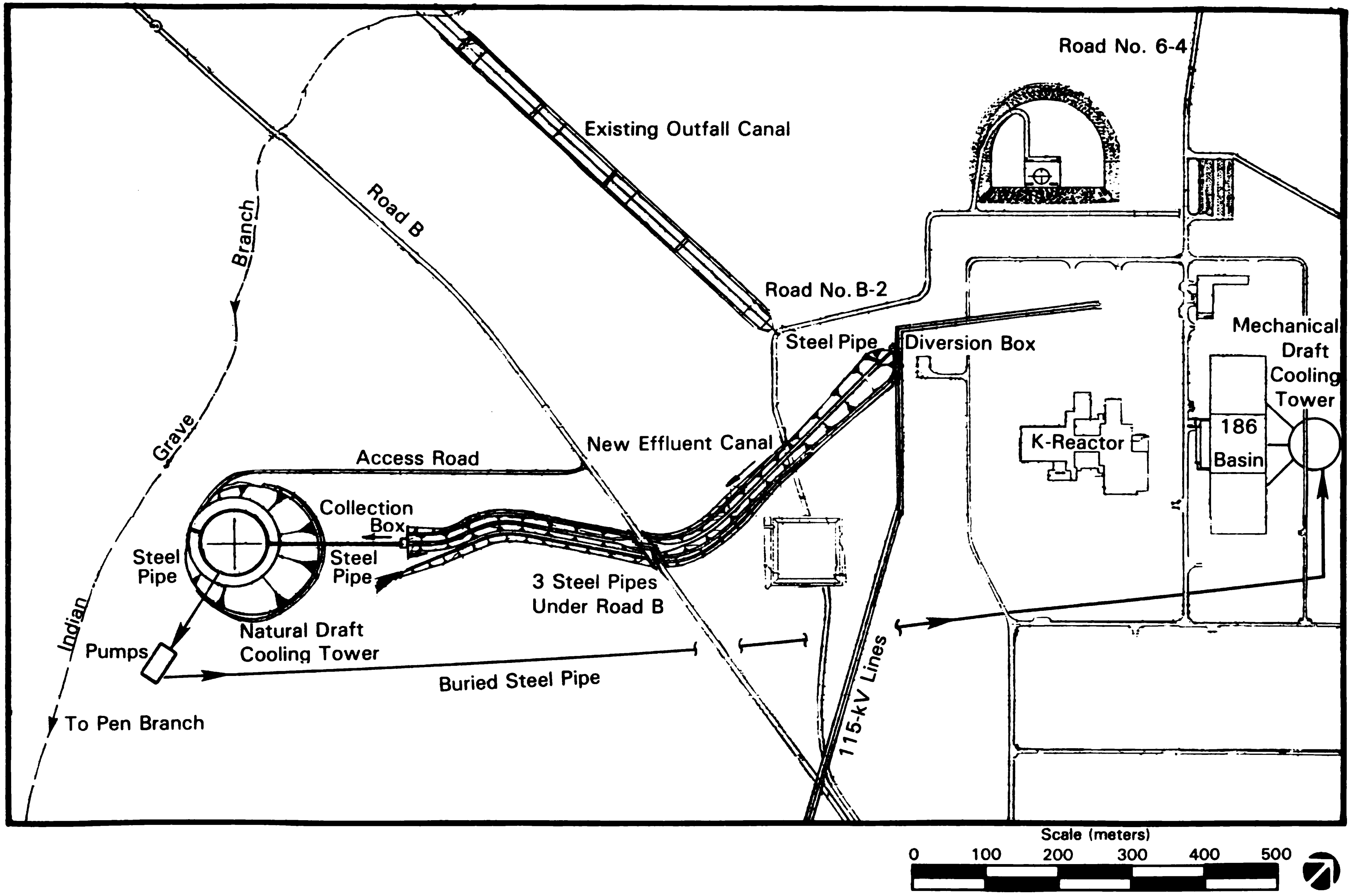


Figure 2-4. K-Reactor Recirculating Cooling Tower System

AO-1 BC-13 gravity back into the existing outfall canal. The flow would then follow the present path of cooling water to the Savannah River. This blowdown flow is necessary to limit the increase in concentrations of solids and chemicals in the cooling water due to evaporation. The blowdown stream would be treated with a dechlorination chemical (probably sodium sulfite) before reaching the existing outfall canal and Indian Grave Branch.

The natural-draft cooling-tower area would be inside a patrol road and fence as described for the once-through system. Access to this area would be from existing Road B. The existing fence and patrol road along the east side of the K-Reactor area would be relocated to encompass the new mechanical-draft cooling tower and accessories.

A new electrical control room would be located within the K-Reactor production area near the second cooling tower. This room would contain the necessary switchgear and instrumentation for the operation of the cooling tower fans and the chemical-treatment equipment. Another new control room would be constructed near the natural-draft tower for operation of the pumps.

AO-1 BC-13 The recirculating system would require an upgrade of two sections of 115-kilovolt overhead line totaling 10.5 kilometers. The upgrade would be the same whether a recirculating system is installed in K-Area or in C-Area or in both areas. Both primary substations in the reactor area would be expanded to handle the increased electrical load.

Dual 13.8-kilovolt electrical supplies would be provided to each location having recirculating pumps or cooling tower fans.

The recirculation system pumps located at the natural draft cooling tower would be supplied from two independent electrical power supplies. Loss of one power supply could cause temporary loss of one half of the pumps depending on electrical power system design. Recirculation flow could be reduced by up to 50 percent during this period; amount of reduction would be dependent on excess head capacity of the pumps. For conservatism, it is assumed that up to 5.1 cubic meters per second could be discharged to the stream if pumps were not provided with automatic transfer on loss of one electrical power supply.

TC The present design concept for a recirculating system includes pump start/stop buttons and pump running lights. No interlocks would be provided, or are considered necessary, to scram the reactor.

The K-Reactor central control room would be provided with push buttons and motor running lights for six pumps and 12 fans, discharge effluent (blowdown) flow and temperature indicators, and push buttons and position indicators for two diversion box isolation gates.

Thermal Performance

BC-4 BC-14 BC-15 The recirculating cooling tower system would be designed for low tower discharge temperatures leading to compliance with the State of South Carolina's Class B water classification standards (i.e., a maximum instream temperature of 32.2°C). The preliminary design parameters of a 2.8°C approach to a 26.7°C wet bulb will assure compliance with this standard, even at the maximum hourly wet bulb measured at Bush Field (1953 through 1982), 28°C.

For the preliminary design parameters cited above, the blowdown flow to Pen Branch would be about 0.5 cubic meter per second at 2.5 cycles of concentration; the corresponding withdrawal from the Savannah River would be about 1.6 cubic meters per second to make up the blowdown and evaporation losses from the system, as well as auxiliary system flows and 186-K basin overflow.

Table 2-2 lists monthly average water temperatures for the discharge along the cooling water flow path (based on meteorological data at Bush Field from 1953 through 1982), along with the ambient stream temperatures. In addition, Table 2-2 lists downstream temperatures under extreme summer conditions (July 1980). Cooling water discharges from the recirculating cooling-tower system would not always comply with the State of South Carolina's Class B water classification standard that requires that "...free-flowing waters shall not be increased more than 5°F (2.8°C) above natural temperature conditions...." Accordingly, a Section 316(a) study would be performed to demonstrate whether a balanced biological community would be maintained. BC-4 BC-14 BC-15

Resource Utilization

K-Reactor presently receives approximately 11.3 cubic meters of cooling water per second from the Savannah River. This continuous flow passes through the reactor heat exchangers and discharges down Indian Grave Branch and Pen Branch back to the Savannah River. TC If the recirculating-cooling-towers alternative were implemented, the discharge from K-Reactor would be reduced to about 1 cubic meter per second. TC The maximum amount of water removed from the river would also be reduced to about 1.6 cubic meters per second.

This alternative would be constructed in approximately 42 months after a 9-month design period. The estimated peak manpower requirement for K-Reactor is 300 persons, assuming a combined workforce with C-Reactor. TC The maintenance and operating workforce would be increased by approximately six mechanics. Approximately 50 acres of uplands would be disturbed by all construction activities. TC

The estimated present peak electrical load for K-Area is about 30.3 megawatts. The electrical load would be decreased approximately 6.4 megawatts because of the 85 percent reduction in electrical load to pump water from the Savannah River to the 186-K basin. The total yearly energy reduction caused by this project would be the equivalent of the electricity produced by the combustion of approximately 12,800 barrels of crude oil. TC

The estimated present-worth cost of this alternative would be approximately $90 million including production losses ($58 million without production losses). Estimated annual operating costs are $4.4 million. In addition to these costs, the estimated cost to perform a Section 316(a) demonstration study is $1.25 million. Preliminary design criteria suggest a 3.7-percent annual average loss of reactor power attributable to the operation of a recirculating cooling-tower system in comparison to the no-action alternative. AD-1 BC-6

2.2.1.3 No Action - Existing System

The existing once-through cooling water system for K-Reactor withdraws approximately 11.3 cubic meters of water per second from the Savannah River at

Table 2-2. Monthly Predicted Mean and Maximum (in Parentheses) Temperatures (°C) Along Cooling Water Flow Path--K-Reactor Recirculating Cooling Towers

Location	Temperature for											
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Discharge to creek	14(25)	15(25)	18(26)	20(28)	23(28)	26(29)	27(30)	26(30)	25(29)	20(28)	18(27)	15(26)
Pen Branch at												
Road A	11(19)	12(18)	16(20)	19(24)	23(27)	26(28)	27(29)	27(29)	24(27)	19(25)	15(21)	12(19)
Railroad bridge	9(17)	11(17)	15(19)	19(23)	23(26)	26(28)	27(29)	27(29)	24(27)	18(23)	15(19)	11(17)
Swamp delta	8(15)	11(16)	15(18)	19(22)	23(26)	26(28)	28(29)	27(29)	24(26)	17(21)	14(17)	9(15)
Upstream from Steel Creek	7(14)	10(14)	14(16)	15(17)	17(20)	21(23)	23(24)	22(23)	18(19)	13(17)	12(15)	8(12)
Mouth[a]	10(14)	11(15)	15(19)	18(20)	21(24)	25(26)	25(27)	23(24)	20(23)	13(19)	15(17)	11(14)
Ambient creek[b]	8(18)	10(18)	15(22)	18(23)	21(24)	23(27)	23(27)	23(26)	21(26)	19(23)	13(21)	12(17)

a. Includes Steel Creek flow.
b. U.S. Geological Survey data for water year 1985 for station 021973471; Pen Branch at Road B (USGS, 1986).

BB-3
BC-14

the 1G and 3G pumphouses. From these pumphouses the water passes through an interconnected network of underground pipe to the Building 186-K basin which has a capacity of approximately 95,000 cubic meters.

The cooling water is drawn by gravity through the reactor heat exchangers to an interceptor pit and then through an underground steel pipe. The water flows to a reinforced-concrete headwall at the existing K-Reactor cooling water outfall canal. This canal, lined with concrete and stone riprap, dissipates the energy of the discharge as it flows to Indian Grave Branch. The discharge then flows along Indian Grave Branch and Pen Branch and into the Savannah River about 8 kilometers downstream from the D-Area powerhouse and the river-water pumping stations.

K-Reactor discharges approximately 11.3 cubic meters of reactor cooling water per second at an average temperature of 70°C to 77°C. This flow includes 10.5 to 10.9 cubic meters per second from the reactor heat exchangers and 0.3 to 0.6 cubic meter per second of service water and other flows. It does not include any overflow from the 186-K basin, which is normally 0.2 cubic meter per second but can be as high as 0.95 cubic meter per second. This overflow is always at ambient water temperature; therefore, it adds no heat load. Estimated annual operating costs for the no-action alternative are $6.2 million.

Thermal Performance

Approximately 96 percent of the 11.3 cubic meters (10.5 to 10.9 cubic meters per second) pumped from the Savannah River to K-Area is used as secondary cooling water, with the remainder (0.3 to 0.6 cubic meter) used for auxiliary systems. The temperature of the secondary cooling-system water discharge normally ranges between 47°C (average summer) and 61°C (average winter) above ambient. Virtually the entire flow withdrawn from the Savannah River is discharged to Pen Branch, with the auxiliary systems water mixing with the heated secondary cooling water. TC

The temperature of the effluent water varies with the temperature of the river water, although the seasonal fluctuations of the latter are moderated by an inverse relationship between intake water temperature and temperature increase. Table 2-3 indicates monthly average and extreme temperatures along the cooling water flow path, along with ambient stream temperatures. The downstream heat-loss characteristics are based on meteorological data from Bush Field between 1953 and 1982; the extreme summer conditions are for July 1980.

Table 2-3 illustrates that the State of South Carolina's Class B water classification standard of a maximum instream temperature of 32.2°C is exceeded at all times along points in the stream during the operation of K-Reactor. The heat loss along the stream implies an evaporation rate of approximately 0.5 cubic meter per second between the discharge and the delta - less than 5 percent of the discharge flow.

Table 2-3. Monthly Predicted Mean and Maximum (in Parentheses) Temperatures (°C) Along K-Reactor Cooling Water Flow Path: No Action (Existing System)

Location	Temperature for											
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Discharge to outfall	69(70)	69(71)	70(72)	71(73)	72(73)	73(74)	74(75)	74(75)	73(75)	72(74)	71(73)	70(72)
Pen Branch at												
Road A	61(63)	60(62)	61(63)	63(65)	66(67)	67(68)	68(69)	68(69)	68(69)	67(68)	64(66)	62(64)
Railroad bridge	52(54)	51(53)	52(54)	55(56)	57(59)	59(60)	59(60)	60(60)	59(60)	58(59)	54(56)	53(55)
Swamp delta	42(44)	42(44)	43(44)	46(48)	48(50)	50(51)	51(51)	51(51)	50(51)	48(49)	45(46)	43(45)
Upstream from Steel Creek	16(21)	17(21)	20(22)	24(26)	27(29)	29(30)	30(31)	30(31)	28(29)	24(26)	20(22)	17(20)
Mouth[a]	13(17)	15(18)	18(21)	21(23)	24(27)	27(28)	28(29)	28(29)	26(27)	22(24)	17(19)	14(17)
Ambient creek[b]	8(18)	10(18)	15(22)	18(23)	21(24)	23(27)	23(27)	23(26)	21(26)	19(23)	13(21)	12(17)

a. Includes Steel Creek flow.
b. U.S. Geological Survey data for water year 1985 for station 021973471; Pen Branch at Road B (USGS, 1986).

BB-3
BC-14

2.2.2 C-REACTOR COOLING WATER ALTERNATIVES

The cooling water alternatives for C-Reactor are the construction and operation of a once-through cooling tower, the construction and operation of recirculating cooling towers, and no action.

2.2.2.1 Once-Through Cooling Tower (Preferred Alternative)

The once-through cooling tower described in the Thermal Mitigation Study (DOE, 1984b) and the draft EIS (DOE, 1986) is a mechanical-draft tower that would receive the cooling water from C-Reactor from a new pump pit. Cooled water from the tower basin would then flow by gravity to a 100-acre offstream holding pond, which would be used to dissipate chlorine (cooling tower biocide) TC
before the water was discharged to Four Mile Creek. The thermal performance of the once-through cooling-tower system was not designed to utilize the holding pond for any additional cooling.

Since the completion of the Thermal Mitigation Study and the Draft EIS (DOE, 1986), further design evaluations and studies have been performed to determine optimal performance parameters and to achieve lower costs. These evaluations and studies have indicated that there are several areas in which optimization
of performance and cost savings can be realized in the construction and opera- AD-1
tion of once-through towers without introducing major changes in the nature or BB-1
magnitude of the environmental impacts. These areas include the consideration BB-2
of gravity-feed versus pumped-feed towers, natural-draft versus mechanical- BB-3
draft towers, and a chemical injection system for either dissipation or neu- BB-4
tralization of chlorine biocide versus holding ponds (and their sizing). BC-6
Similarly, these evaluations and studies have also led to the development of BC-14
thermal performance criteria that, when incorporated in the final design of a once-through cooling-tower system, would reduce the potential for cold shock (i.e., reduce the difference between ambient stream temperatures and stream temperatures when the cooling water is being discharged) to fish.

The following sections describe the once-through cooling-tower for C-Reactor TC
incorporating current design considerations, and then the major differences associated with a natural-draft versus a mechanical-draft tower.

Description

For a once-through natural-draft system with gravity feed, the cooling water discharged from C-Reactor would flow by gravity from a new underground reinforced-concrete diversion box constructed around the existing effluent pipe, through a new 1.8-meter diameter pipe approximately 100 meters to a new riprap-lined effluent canal. This canal would begin just outside of the Reactor Area fence and would extend southwesterly approximately 1160 meters to a collection box to be constructed approximately 120 meters north of Road 3. TC
The box would channel the cooling water into another 1.8-meter-diameter pipe, which would deliver it under Road 3 to a natural-draft cooling tower located between Road 3 and Castor Creek, a small tributary of Four Mile Creek, discharges from which would enter Castor Creek. Figures 2-5 and 2-6, which are based on preliminary design information, show a flow diagram and a site layout, respectively, of this once-through system.

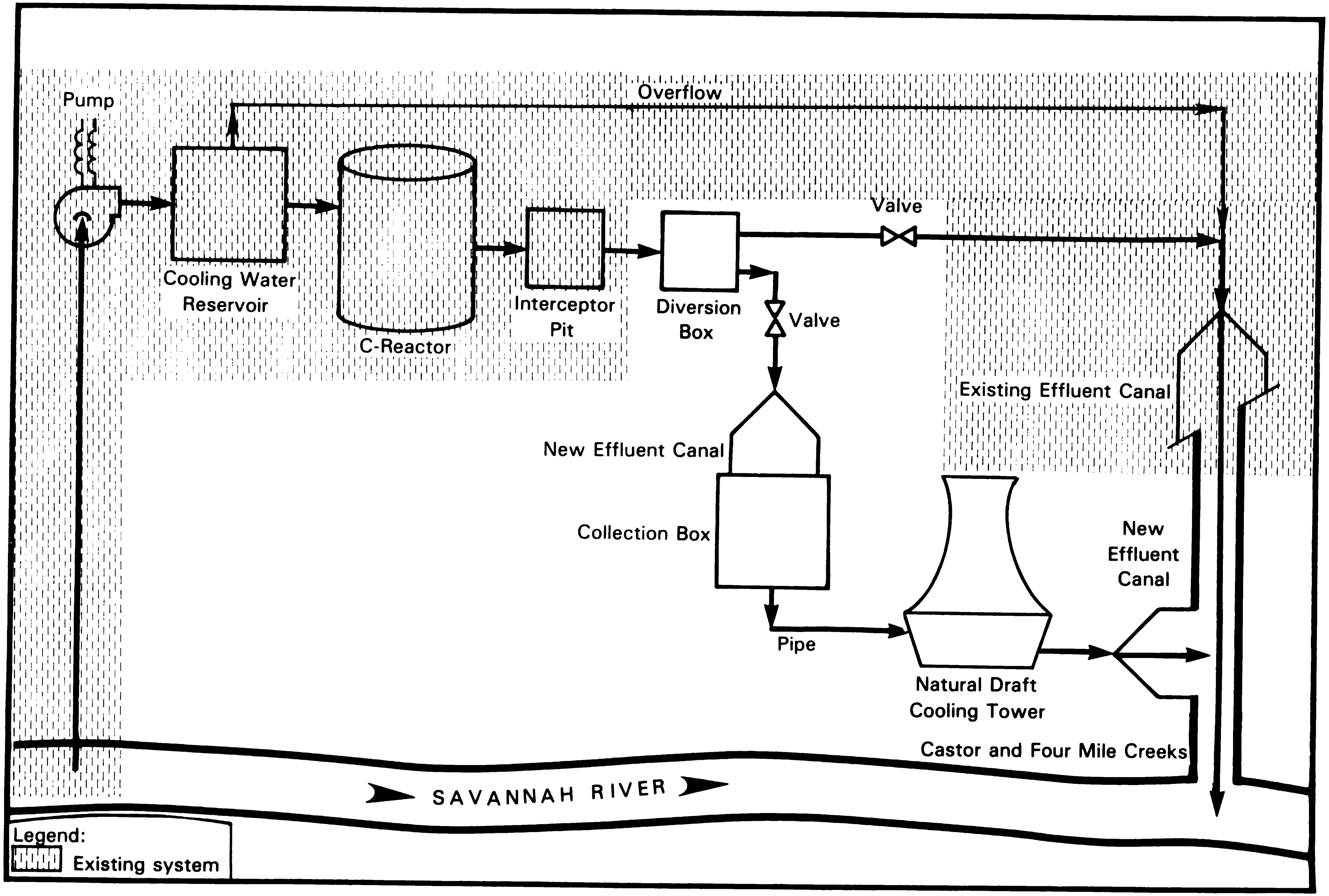


Figure 2-5. C-Reactor Once-Through Cooling Tower System Flow Diagram

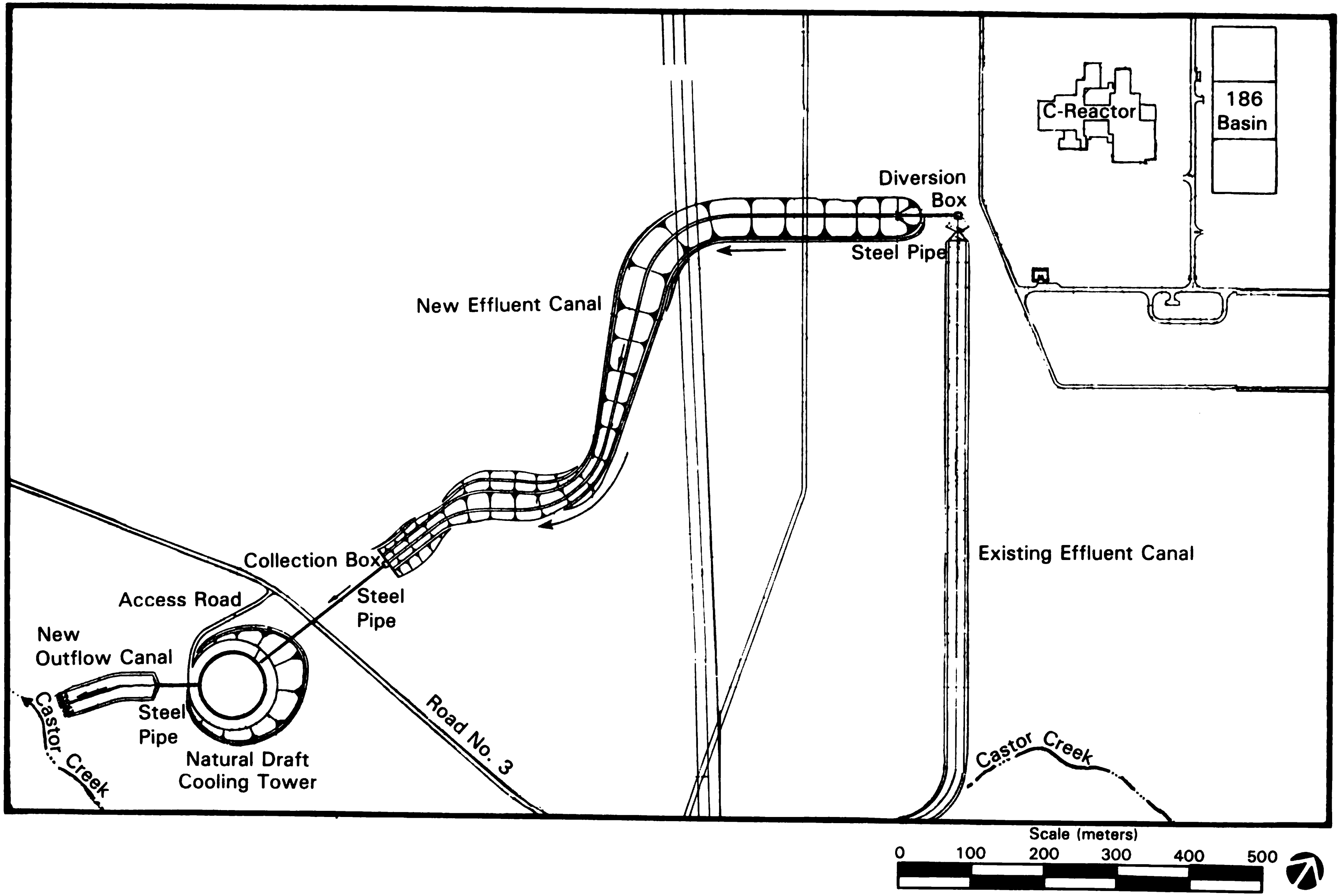


Figure 2-6. C-Reactor Once-Through Cooling Tower System

Based on preliminary design information, the natural-draft, once-through, reinforced-concrete cooling tower would be approximately 100 meters in diameter and about 150 meters high. The tower would utilize Chlorinated Polyvinyl Chloride (CPVC) and Polyvinyl Chloride (PVC) fill to withstand the high cooling water temperatures. The tower would be situated over a reinforced-concrete basin, which would receive the cooled water flowing through the tower. An underground steel pipe would carry the flow by gravity to a new riprap-paved canal 150 meters long and 30 meters wide that would convey cooled effluent into Castor Creek at a point 150 meters downstream from the present discharge point of the C-Reactor effluent canal.

TC

A small water-treatment building would be located near the cooling tower. It would be used to store a chemical biocide (probably sodium hypochlorite) that would be injected into the cooling water stream at the tower inlet to prevent biofouling in the tower system.

BB-1
BB-2

This building would contain a system for injecting a dechlorination agent (probably sodium sulfite) into the cooling tower cold water basin. The dechlorinating agent would be injected in sufficient quantities to meet established chlorine effluent limits. Chemical storage tanks and distribution piping would be provided, as would metering pumps and controls, which would be located in the small water-treatment building near the cooling tower.

A new control room located near the cooling tower would contain the necessary switchgear and instrumentation for the operation of all chemical-treatment equipment.

TC

The cooling-tower area would be enclosed by a patrol road and fence with personnel and vehicular gates. Access roads would be provided, and parking, loading, and equipment storage areas would be paved at the cooling tower and accessory buildings. Areas around the cooling tower would be regraded and seeded, or, if necessary, covered with stone or paving as appropriate to restore natural surface drainage. An adequate stormwater-drainage system would be constructed inside the fenced area; it would include erosion protection and would discharge into natural drainage ways.

TC

Electrical loads for the gravity-feed, natural-draft cooling tower system would be small, consisting primarily of lighting and control equipment. The existing C-Area substations should be adequate, but two new electric lines would be run from C-Area to the cooling tower area along the proposed canal.

Outside lighting and power distribution at the new cooling-tower facilities would be provided. Communications facilities would be extended from the existing C-Area system. Monitoring instrumentation for this cooling system would be installed in the C-Reactor Central Control Room. It would contain monitoring and control instruments that would be connected to instrumentation at the cooling-tower facilities. These instruments would measure such conditions as water temperature at the tower discharge and water flow to the stream. New alarms in the Central Control Room would indicate a high cooling-tower discharge temperature.

Most of the cooling water system construction would be completed with minimal impact on reactor operation. Careful scheduling would ensure that the work necessary to connect the system with the existing facilities is accomplished during scheduled reactor shutdowns.

Safety practices during construction would be in accordance with applicable safety standards. Occupational exposure to low-level radiation and to chemical contact or inhalation would be minimized by monitoring procedures and by protective equipment and clothing.

Preliminary design evaluations and studies have indicated that optimization of performance and cost savings would be realized by the construction and operation of a natural-draft, once-through cooling tower rather than a mechanical-draft tower as described in the Thermal Mitigation Study (DOE, 1984b) and the draft EIS (DOE, 1986). The description of a mechanical-draft tower would not differ appreciably from that presented above for the natural-draft tower. The TC
major differences would be the size of the tower (e.g., approximately 150 meters high for the natural-draft tower versus 20 meters for the mechanical-draft tower) and the extent of the electrical system upgrade (e.g., the natural-draft tower could require less system upgrade due to the elimination of the fans and motors associated with the mechanical-draft tower).

Thermal Performance

The once-through cooling tower would be designed to enable the discharge to meet the State of South Carolina's Class B water classification standards (i.e., a maximum instream temperature of 32.2°C). This would be accomplished through the design conditions of a 4.4°C approach to a wet-bulb temperature of 27.8°C. In the rare instances when the design wet-bulb temperature was exceeded, the reactor would be operated at reduced power such that the Class B Water Classification standards are always met.

The C-Reactor tower discharge to Four Mile Creek would include the 11.3 cubic TC
meters per second of secondary cooling water flow, less approximately 0.8 cubic meter per second of water evaporated in the tower. The Four Mile Creek flow (at Road A-7), other than the C-Reactor effluent, is approximately 0.6 cubic meter per second. Table 2-4 lists monthly average water temperatures along the cooling water flow path (based on an average of Bush Field meteorological data for 1953 through 1982) with the corresponding ambient stream temperature for the preliminary design of the once-through cooling tower. Additionally, Table 2-4 lists downstream temperatures under extreme (July 1980) summer conditions.

The cooling tower would be designed and operated in such a manner as to meet the maximum weekly average temperature (MWAT) criteria (EPA, 1977) to minimize thermal shock of fish that could occur with a reactor scram (Muhlbaier, BC-14
1986). The discharge from the once-through cooling tower would raise the ambient stream temperature in Four Mile Creek above the 2.8°C maximum temperature rise specified in the State of South Carolina's Class B water classification standards. Accordingly, a Section 316(a) study would be performed to demonstrate whether a balanced biological community would be TC
maintained.

Table 2-4. Monthly Predicted Mean and Maximum (in Parentheses) Temperatures (°C) Along Cooling Water Flow Path of C-Reactor Once-Through Cooling Tower

Location	Temperature for											
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Discharge to creek	19(28)	20(28)	23(28)	24(30)	26(30)	28(31)	29(32)	29(32)	28(31)	24(31)	23(29)	21(28)
Four Mile Creek at												
Road A	18(26)	18(26)	21(26)	23(28)	25(29)	28(30)	29(31)	29(31)	27(30)	23(29)	21(27)	19(26)
Road A-13	17(24)	17(24)	21(25)	23(28)	25(29)	28(30)	29(31)	28(31)	27(30)	23(28)	20(26)	18(25)
Swamp delta	15(22)	16(22)	19(23)	22(26)	25(28)	27(30)	28(30)	28(30)	26(29)	22(26)	19(24)	16(22)
Mouth	13(20)	14(20)	18(21)	20(24)	23(27)	26(28)	27(29)	27(29)	25(27)	20(24)	17(21)	14(19)
Ambient creek[a]	9(19)	11(19)	15(24)	19(25)	22(27)	25(31)	25(29)	25(29)	23(28)	21(25)	13(23)	13(18)

a. U.S. Geological Survey data for water year 1985 for station 02197342; Four Mile Creek at Road A-7 (USGS, 1986).

BB-3
BC-14

Resource Utilization

The existing withdrawal of about 11.3 cubic meters per second of water from the Savannah River to C-Reactor would be unchanged for the once-through cooling-tower alternative. Discharges from C-Reactor to the river would be reduced by about 0.8 cubic meter per second due to evaporation, and the total suspended solids concentration would be reduced by settlement in the cooling-tower cold water basin. Chemical biocide added to the cooling water to protect the tower would be neutralized. All discharges would meet State of South Carolina Class B water classification standards. BB-1 BB-2

Construction of a once-through natural-draft cooling tower system would be completed in approximately 36 months after a 9-month lead design period. The estimated peak contractor manpower requirement, based on preliminary design information, is about 200 persons for C-Reactor, assuming a combined workforce with K-Reactor. The maintenance and operating workforce would be increased by approximately four mechanics. Approximately 35 acres of uplands would be disturbed by all construction activities. TC

Since the once-through cooling tower system is gravity flow with a natural draft tower, the additional electricity requirements would be only for lighting and chemical feed equipment.

The present peak electrical load in C-Area is about 30.3 megawatts. An insignificant quantity of additional power would be required for lighting and other electrical equipment. TC

The estimated present-worth cost for the once-through natural-draft cooling tower at C-Reactor with gravity feed would be approximately $44 million, including production losses ($42.4 million without production losses). Estimated annual operating costs are $6.4 million. In addition to these costs, the estimated cost to conduct a Section 316(a) demonstration study is $1.25 million. Preliminary design criteria suggest a 0.2-percent annual average loss of reactor power attributable to the operation of a once-through cooling-tower system in comparison to the no-action alternative. AD-1 BC-6

2.2.2.2 Recirculating Cooling Towers

If a closed-cycle, recirculating cooling tower system were constructed, the cooling water discharges from C-Reactor would be conveyed initially in the same manner as in the once-through system (i.e., the same diversion box, pipe, canal, collection box, and pipe under Road 3). However, the natural-draft cooling tower would be somewhat smaller than in the once-through design, and the discharge from this tower would be pumped to a mechanical-draft tower near the existing C-Reactor cooling water reservoir (186-C basin). Figures 2-7 and 2-8, which are based on preliminary design information, show a flow diagram and a site layout, respectively, of this recirculating system. AD-1 BC-13

The natural-draft cooling tower, when installed with the mechanical-draft tower in series, would be approximately 85 meters in diameter and 120 meters high. Six 1750 horsepower (1300 kilowatt) pumps would be provided to transfer the cooling water from the cold water basin under the first tower through a new steel pipe to the second tower. This 1.8-meter diameter, underground steel pipe would run approximately 2 kilometers from the natural-draft tower

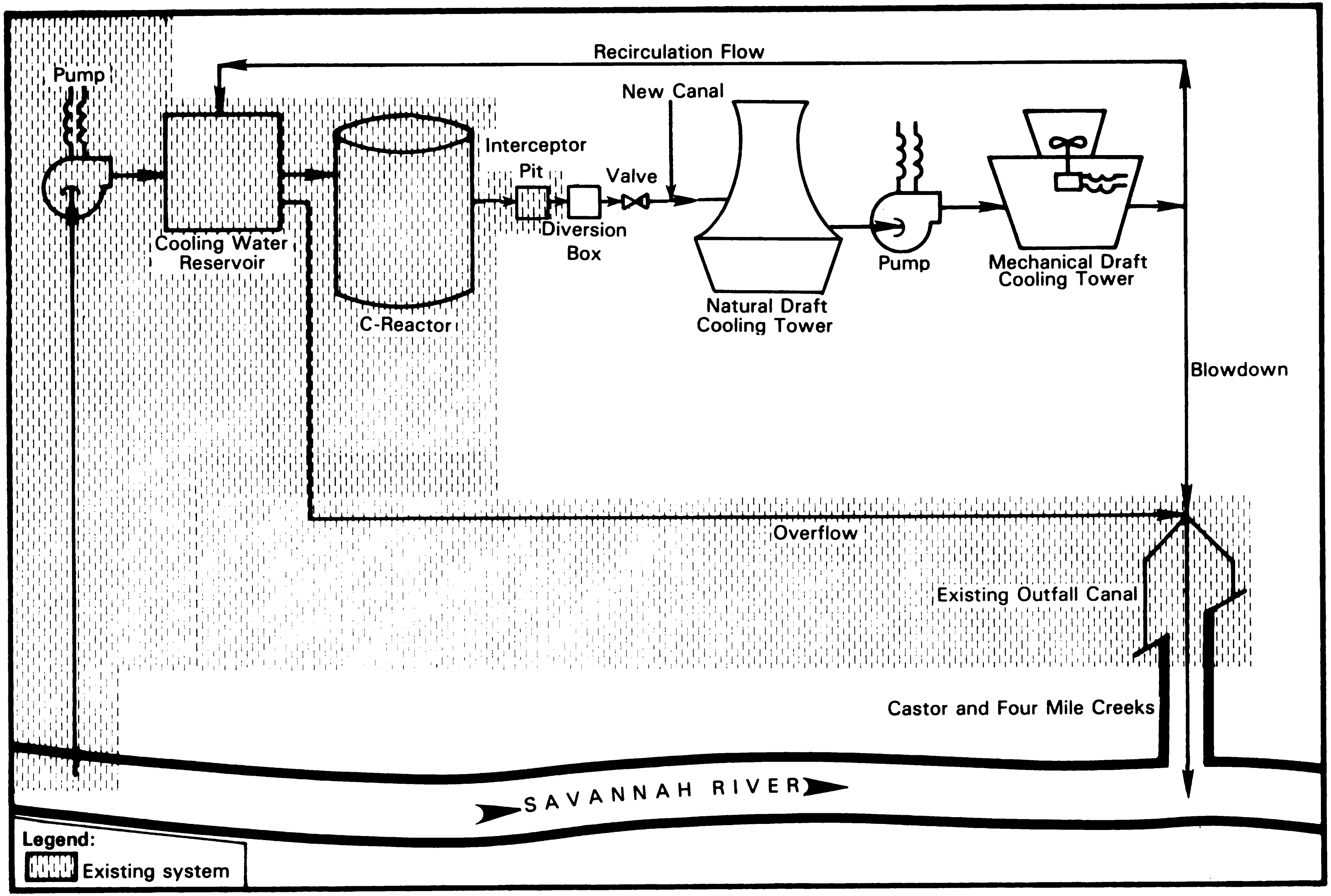


Figure 2-7. C-Reactor Recirculating Cooling Tower System Flow Diagram

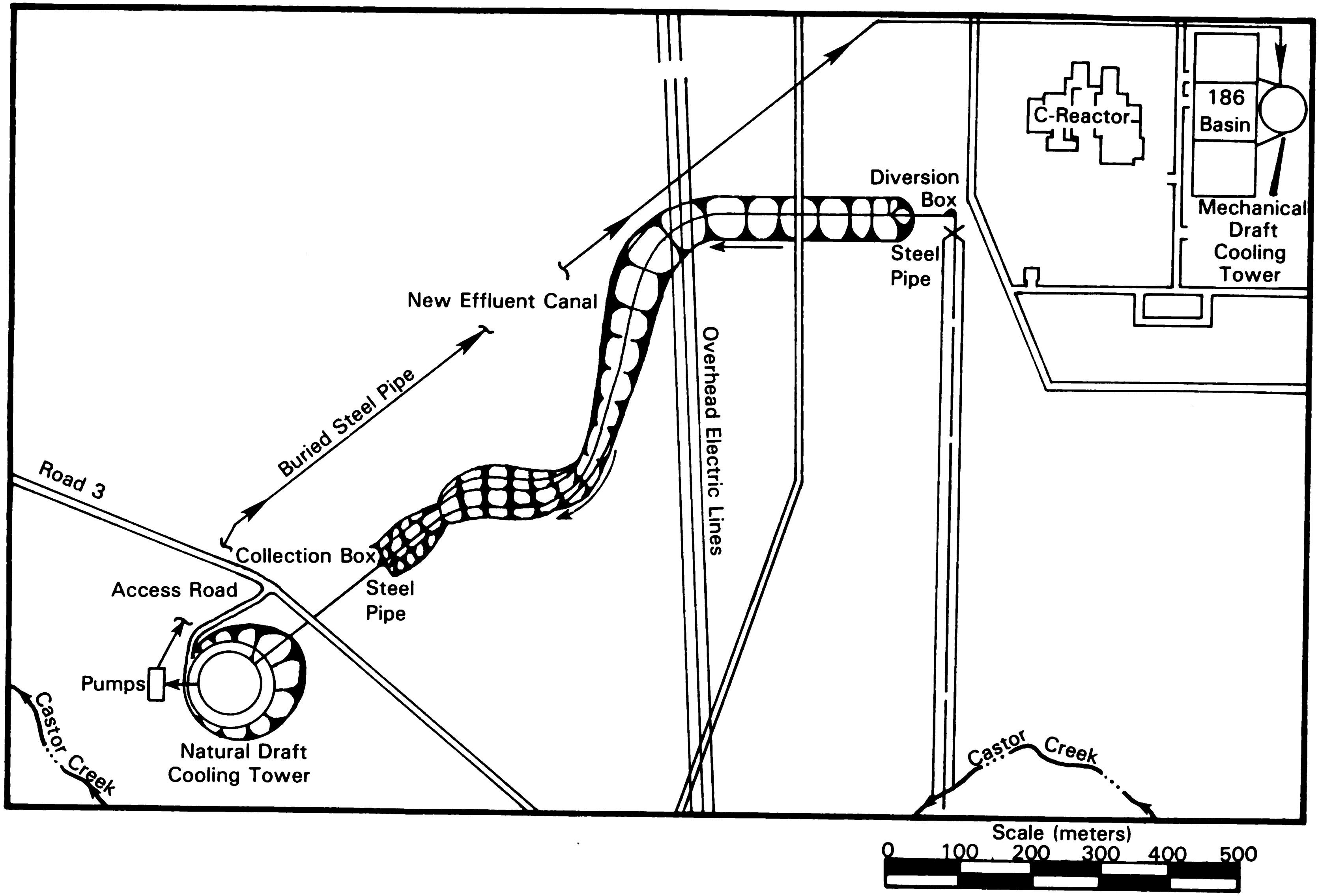


Figure 2-8. C-Reactor Recirculating Cooling Tower System

northeasterly under Road 3, along the gravity flow canal, and around the north and east sides of C-Area to the inlet of the mechanical-draft cooling tower. This second tower would be constructed on top of about 5 meters of earth fill, so its discharge could flow by gravity back to the Building 186-C basin for
AO-1 BC-13 reuse.

The first tower would utilize chlorinated polyvinyl chloride (CPVC) and polyvinyl chloride (PVC) fill to withstand the high cooling water temperatures. The second tower could use standard polyvinyl chloride fill, because the water reaching this tower would have been partially cooled at the first tower. The second tower would be approximately 70 meters in diameter by 20 meters high and would be equipped with 12 fans, each with a 190-kilowatt motor.

A small water-treatment building would be located near each cooling tower.
BB-1 These buildings would be used to store a chemical biocide (probably sodium
BB-2 hypochlorite) that would be injected into the cooling water stream to prevent biofouling in the tower system. This would allow for injection of a non-chromated, organic-based, chemical corrosion inhibitor. This chemical has been approved by SCDHEC for use in cooling tower systems and is presently being used at SRP.

Since the recirculating system would be designed to reduce production loss, as well as to meet environmental regulations, no piping has been provided to completely bypass any cooling tower. Internal bypass valves would be included in each cooling tower to divert water directly to the cold water basin. These bypass valves, as well as sectionalizing valves which can isolate parts of the tower fill, would be used for cold weather start-ups and could be used during equipment repairs, if necessary.

Whenever water would be recirculated, approximately 0.5 cubic meter per second of the second tower discharge would flow by gravity through a weir to the
AO-1 existing overflow pipeline from Building 186-C. This pipeline flows by
BC-13 gravity back into the existing outfall canal. The flow would then follow the present path of cooling water to Four Mile Creek and the Savannah River. This blowdown flow is necessary to limit the increase in concentrations of solids and chemicals in the cooling water due to evaporation. The blowdown stream would be treated with a dechlorination chemical, probably sodium sulfite, before reaching the existing outfall canal and Castor Creek.

The natural-draft cooling-tower area would be inside a patrol road and fence as described for the once-through system. Access to this area would be from existing Road 3. The existing fence and patrol road along the east side of the C-Reactor area would be relocated to encompass the new mechanical-draft cooling tower and accessories.

A new electrical control room would be located within the C-Reactor production area near the second cooling tower. This room would contain the necessary switchgear and instrumentation for the operation of the cooling tower fans and the chemical-treatment equipment. Another new control room would be constructed near the natural-draft tower for operation of the pumps.

AO-1 The recirculating system would require an upgrade of two sections of
BC-13 115-kilovolt overhead line totaling 10.5 kilometers. The upgrade would be the

same whether a recirculating system is installed in K-Area or in C-Area or in both areas. Both primary substations in the reactor area would be expanded to handle the increased electrical load.

Dual 13.8-kilovolt electrical supplies would be provided to each location having recirculating pumps or cooling tower fans.

The recirculation system pumps located at the natural draft cooling tower would be supplied from two independent electrical power supplies. Loss of one power supply could cause temporary loss of one half of the pumps depending on electrical power system design. Recirculation flow could be reduced by up to 50 percent during this period; amount of reduction would be dependent on excess head capacity of the pumps. For conservatism, it is assumed that up to 5.1 cubic meters per second could be discharged to the stream if pumps were not provided with automatic transfer on loss of one electrical power supply.

AO-1
BC-13

The present design concept for a recirculating system includes pump start/stop buttons and pump running lights. No interlocks would be provided, or are considered necessary, to scram the reactor.

The C-Reactor central control room would be provided with push buttons and motor running lights for six pumps and 12 fans, discharge effluent (blowdown) flow and temperature indicators, and push buttons and position indicators for two diversion box isolation gates.

Thermal Performance

The recirculating cooling-tower system would be designed for low tower discharge temperatures leading to compliance with the State of South Carolina's Class B water classification standards (i.e., a maximum instream temperature of 32.2°C). The preliminary design parameters of a 2.8°C approach to a 26.7°C wet bulb will assure compliance with this standard, even at the maximum hourly 28°C wet bulb temperature measured at Bush Field from 1953 to 1982.

BC-3
BC-15

For the preliminary design parameters cited above, the blowdown flow to Four Mile Creek would be about 0.5 cubic meter per second at 2.5 cycles of concentration; the corresponding withdrawal from the Savannah River would be about 1.6 cubic meters per second to make up the blowdown and evaporation losses from the system, as well as auxiliary system flows and 186-C basin overflow. Table 2-5 lists monthly average water temperatures for the discharge along the cooling water flow path (based on the preliminary design parameters and meteorological data at Bush Field from 1953 through 1982), along with ambient stream temperatures.

Additionally, Table 2-5 lists downstream temperatures under extreme summer conditions of July 1980. Cooling water discharges from the recirculating cooling-tower system would not always comply with the State of South Carolina's Class B water classification standard that requires that "...free-flowing waters shall not be increased more than 2.8°C above natural temperature conditions...." Accordingly, a Section 316(a) study would be performed to demonstrate whether a balanced biological community would be maintained.

TC

Table 2-5. Monthly Predicted Mean and Maximum (in Parentheses) Temperatures (°C) Along Cooling Water Flow Path--C-Reactor Recirculating Cooling Towers

Location	Temperature for											
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Discharge to creek	14(25)	15(25)	18(26)	20(28)	23(28)	26(29)	27(30)	26(30)	25(29)	20(28)	18(27)	15(26)
Four Mile Creek at												
Road A	9(16)	11(16)	15(18)	18(21)	22(25)	25(27)	27(28)	26(28)	23(25)	17(21)	14(18)	10(15)
Road A-13	8(15)	11(16)	15(18)	18(21)	22(25)	25(28)	27(29)	26(28)	23(25)	17(21)	14(17)	9(15)
Swamp delta	8(15)	10(15)	14(17)	19(21)	22(26)	26(28)	27(29)	27(29)	24(26)	17(20)	13(16)	9(14)
Mouth	7(14)	10(14)	14(17)	17(19)	20(23)	24(25)	25(26)	25(25)	21(23)	15(19)	13(15)	8(13)
Ambient creek[a]	9(19)	11(19)	15(24)	19(25)	22(27)	25(31)	25(29)	25(29)	23(28)	21(25)	13(23)	13(18)

a. U.S. Geological Survey data for water year 1985 for station 02197342; Four Mile Creek at Road A-7 (USGS, 1986).

BC-3
BC-15

Resource Utilization

C-Reactor presently receives approximately 11.3 cubic meters of cooling water per second from the Savannah River. This continuous flow passes through the reactor heat exchangers and discharges down Castor Creek and Four Mile Creek back to the Savannah River. If the recirculating cooling-towers alternative were implemented, the discharge from C-Reactor would be reduced to about 1 cubic meter per second. The amount of water removed from the river would be reduced to about 1.6 cubic meters per second. TC

This alternative would be constructed in approximately 42 months after a 9-month design period. The estimated peak manpower requirement for C-Reactor is 300 persons, assuming a combined workforce with K-Reactor. The maintenance and operating workforce would be increased by approximately six mechanics. Approximately 60 acres of uplands would be disturbed by all construction activities. TC TC

The present peak electrical load for C-Area is about 30.3 megawatts. The electrical load would be decreased approximately 6.4 megawatts because of the 85 percent reduction in electrical load to pump water from the Savannah River to the 186-C basin. The total yearly energy reduction caused by this project would be the equivalent of the electricity produced by the combustion of approximately 12,800 barrels of crude oil. TC

The estimated present-worth cost of this alternative would be approximately $90 million including production losses ($58 million without production losses). Estimated annual operating costs are $4.4 million. In addition to these costs, the estimated cost to conduct a Section 316(a) demonstration study is $1.25 million. Preliminary design criteria suggest a 3.7-percent annual average loss of reactor power attributable to the operation of a recirculating cooling-tower system, in comparison to the no-action alternative. AD-1 BC-6

2.2.2.3 No Action - Existing System

The existing once-through cooling water system for C-Reactor withdraws approximately 11.3 cubic meters of water per second from the Savannah River at the 1G and 3G pumphouses. From these pumphouses the water passes through an interconnected network of underground pipe to the Building 186-C basin which has a capacity of approximately 95,000 cubic meters.

The cooling water is drawn by gravity through the reactor heat exchangers to an interceptor pit and then through an underground steel pipe. The water flows to a reinforced-concrete headwall at the existing C-Reactor cooling water outfall canal. This canal, lined with concrete and stone riprap, dissipates the energy of the discharge as it flows to Castor Creek, a tributary of Four Mile Creek. The discharge flows along Castor Creek and Four Mile Creek and into the Savannah River about 8 kilometers downstream from the D-Area powerhouse and the river-water pumping stations.

C-Reactor discharges approximately 11.3 cubic meters of cooling water per second at an average temperature of 70°C to 77°C. This flow includes 10.5 to 10.9 cubic meters per second from the reactor heat exchangers and 0.3 to 0.6 cubic meter per second of service water and other flows. It does not include any overflow from the 186-C basin, which is normally 0.2 cubic meter per second but can be as high as 0.95 cubic meter per second. This overflow is always at ambient water temperature; therefore, it adds no heat load. Estimated annual operating costs for the no-action alternative are $6.2 million.

Thermal Performance

TE The temperature of the secondary cooling-system water at C-Reactor normally ranges between 47°C (average summer) and 61°C (average winter) above ambient. Virtually the entire flow withdrawn from the Savannah River is discharged to Four Mile Creek, with the auxiliary systems water mixing with the heated secondary cooling water.

The temperature of the effluent water varies with the temperature of the river water, although the seasonal fluctuations of the latter are moderated by an inverse relationship between intake water temperature and temperature increase. Table 2-6 indicates monthly average and summer extreme temperatures along the cooling water flow path. The downstream heat-loss characteristics are based on meteorological data from Bush Field between 1953 and 1982; the extreme summer conditions are for July 1980. Table 2-6 also lists ambient creek temperatures.

Table 2-6 illustrates that the State of South Carolina's Class B water classification standard that specifies a maximum instream temperature of 32.2°C is exceeded at all times along points in the creek during C-Reactor operation. The heat loss along the creek implies an evaporation rate of approximately 0.5 cubic meter per second between the discharge and the delta - less than 5 percent of the discharge flow.

2.2.3 D-AREA POWERHOUSE ALTERNATIVES

The alternatives for the D-Area coal-fired powerhouse are increased flow with mixing (DOE's preferred alternative), direct discharge to the Savannah River, and no action. The following sections describe these alternatives.

2.2.3.1 Increased Flow with Mixing (Preferred Alternative)

The D-Area powerhouse uses water pumped from the Savannah River for cooling. Most of this water is discharged from the condensers into an excavated canal that flows into Beaver Dam Creek about 1700 meters upstream from the Savannah River swamp.

A closed-loop recirculation system utilizing an existing cooling tower can provide an alternative cooled water supply for one of the four units.

During current normal operations, water is pumped by three of six pumps located in the Building 681-5G pumphouse, situated on a small inlet cove about 1.6 kilometers upstream from the mouth of Beaver Dam Creek. The rated capacity of each pump is about 0.8 cubic meter per second, with a maximum sustained flow for all six pumps of about 4.5 cubic meters per second. The water flows through an underground pipeline to a raw-water receiving basin in Building 483-1D. Excess water not utilized in the powerhouse and 400-Area water-treatment plant overflows a weir to mix with the powerhouse effluent stream before discharging into the D-Area outfall canal (see Figure 2-9). The

Table 2-6. Monthly Predicted Mean and Maximum (in Parentheses) Temperatures (°C) Along C-Reactor Cooling Water Flow Path: No Action (Existing System)

Location	Temperature for											
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Discharge to outfall	69(70)	69(71)	70(72)	71(73)	72(73)	73(74)	74(75)	74(75)	73(75)	72(74)	71(73)	70(72)
Four Mile Creek at												
Road A	49(51)	49(51)	50(52)	53(55)	55(57)	57(58)	57(58)	58(58)	57(58)	55(57)	52(53)	50(52)
Road A-13	42(45)	42(44)	44(45)	46(48)	49(51)	50(51)	51(52)	51(52)	50(51)	49(50)	45(47)	43(45)
Swamp delta	32(35)	33(35)	34(36)	38(39)	40(42)	42(43)	43(43)	43(44)	42(42)	39(40)	35(37)	33(35)
Mouth	24(27)	24(27)	27(29)	30(32)	33(35)	35(36)	36(37)	36(37)	34(35)	31(33)	27(29)	25(27)
Ambient creek[a]	9(19)	11(19)	15(24)	19(25)	22(27)	25(31)	25(29)	25(29)	23(28)	21(25)	13(23)	13(18)

a. U.S. Geological Survey data for water year 1985 for station 02197342; Four Mile Creek at Road A-7 (USGS, 1986).

BB-3
BC-14

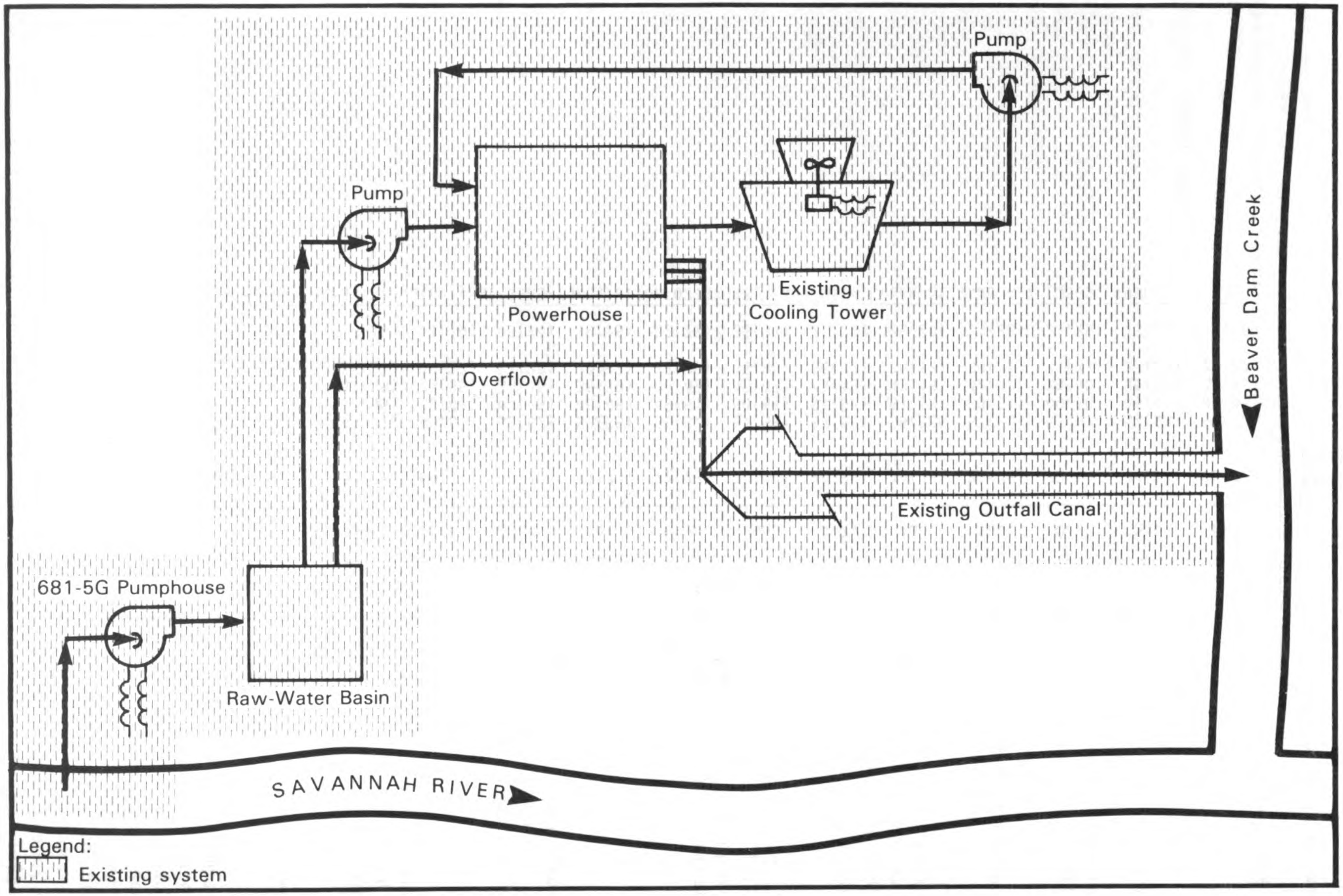


Figure 2-9. D-Area Existing System Flow Diagram

corresponding flow rate in Beaver Dam Creek at the SRP Health Protection Department monitoring station using various numbers of pumps is as follows: three pumps, 2.6 cubic meters per second; four pumps, 3.5 cubic meters per second; five pumps, 4.0 cubic meters per second; and 6 pumps, 4.5 cubic meters per second.

The increased-flow-with-mixing cooling water alternative would require the intermittent use of four to six pumps to provide a total flow (as much as 4.5 cubic meters per second at the HP monitoring station) of Savannah River water to the raw-water receiving basin. The overflow rate would be adjusted to maintain a maximum instream temperature of 32.2°C. The temperature would be monitored by an automatic monitoring station, maintained at the compliance point, and displayed in the powerhouse control room. The existing one-unit recirculation system with a cooling tower would continue to operate as at present.

Because sufficient pumping capacity is already available in the Building 681-5G pumphouse, no major new construction would be necessary to implement increased flow with mixing, and the plan could be implemented immediately. However, increased operation of the existing pumps would require circulation of more water from the Savannah River, consumption of more electricity, and a slight increase in maintenance cost.

Thermal Performance

The temperature of the D-Area cooling water withdrawn from the Savannah River rises as it passes through the powerhouse condensers. The flow from one of the four powerhouse condensers normally is directed to a cooling tower (design conditions for the cooling tower are: hot-water temperature, 40°C; wet-bulb temperature, 24°C; discharge temperature, 32°C). The blowdown flow from the cooling tower is negligible compared to the flow through the once-through system. The rate of evaporation from the cooling tower at design conditions is approximately 0.01 cubic meter per second; thus, essentially all of the water (99.5 percent at normal flow) withdrawn from the Savannah River for D-Area cooling is discharged to Beaver Dam Creek.

The temperature of the cooling water discharge from the D-Area powerhouse would vary due to variations in the temperature of the water withdrawn from the Savannah River and powerhouse loadings. Table 2-7 shows monthly average water temperatures along the cooling water flow path (based on meteorological data for Bush Field from 1953 through 1982) along with the corresponding ambient stream temperatures, assuming operation of as many as five pumps (4.0 cubic meters per second) during extreme summer conditions. Discharge tempera- TC
tures are based on measured values from 1985 and 1986.

Table 2-7 indicates that under average seasonal meteorological conditions the discharge to the creek from the operation of the D-Area powerhouse will meet the State of South Carolina's Class B water classification standard of a maximum instream temperature of 32.2°C, provided that, under extreme summer conditions, the flow to the raw-water basin will be increased from 2.6 to as high as 4.0 cubic meters per second to decrease the discharge temperature. The current discharge from the D-Area powerhouse would continue to exceed the TC
Class B water classification standard of a maximum 2.8°C ambient rise in

BB-3
BC-14

Table 2-7. Monthly Predicted Mean and Maximum (in Parentheses) Temperatures (°C) Along Cooling Water Flow Path of D-Area Powerhouse for Increased Flow with Mixing Alternative

	Temperature for											
Location	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Discharge to creek	18(27)	16(22)	21(27)	24(29)	28(30)	29(32)	28(30)	28(31)	27(31)	27(32)	26(31)	19(31)
Swamp delta	17(25)	16(21)	20(26)	24(28)	27(30)	28(31)	28(30)	28(31)	27(30)	26(31)	24(29)	18(28)
Mouth	13(20)	14(19)	17(21)	20(24)	24(27)	26(29)	27(29)	27(29)	25(27)	21(26)	19(23)	14(21)
Ambient creek[a]	8(15)	9(14)	12(17)	15(20)	19(22)	21(25)	23(27)	23(26)	23(26)	20(23)	17(22)	12(18)

a. Average U.S. Geological Survey data for water years 1976 to 1985 for station 02197320; Savannah River near Jackson, South Carolina (USGS, 1977, 1978, 1979, 1980, 1981, 1982, 1983, 1984, 1985, 1986).

stream temperature. A Section 316(a) demonstration study would be performed to show whether a balanced biological community would be maintained.

Resource Utilization

The current flows in Beaver Dam Creek downstream from the D-Area discharge canal average approximately 2.6 cubic meters per second. During extreme summer conditions, the implementation of this alternative would increase that flow to a maximum of 4.0 cubic meters per second, and would temporarily affect an estimated 4 acres each of uplands and wetlands. TC

No appreciable change in the chemical characteristics of the effluent is expected because no chemicals would be used in implementing this alternative.

Each operating pump at the Building 681-5G pumphouse consumes approximately 8700 kilowatt-hours of electricity per day. When all four D-Area units are operating, three pumps are required to supply cooling water. Assuming that additional pumping is continued all day whenever the discharge water temperature exceeds 31°C, the estimated increase in electric-power consumption is approximately 6 percent. The amount of electricity used at this pumphouse is a small portion of the overall SRP use. Therefore, the incremental increase in the use of electricity for D-Area would be extremely small.

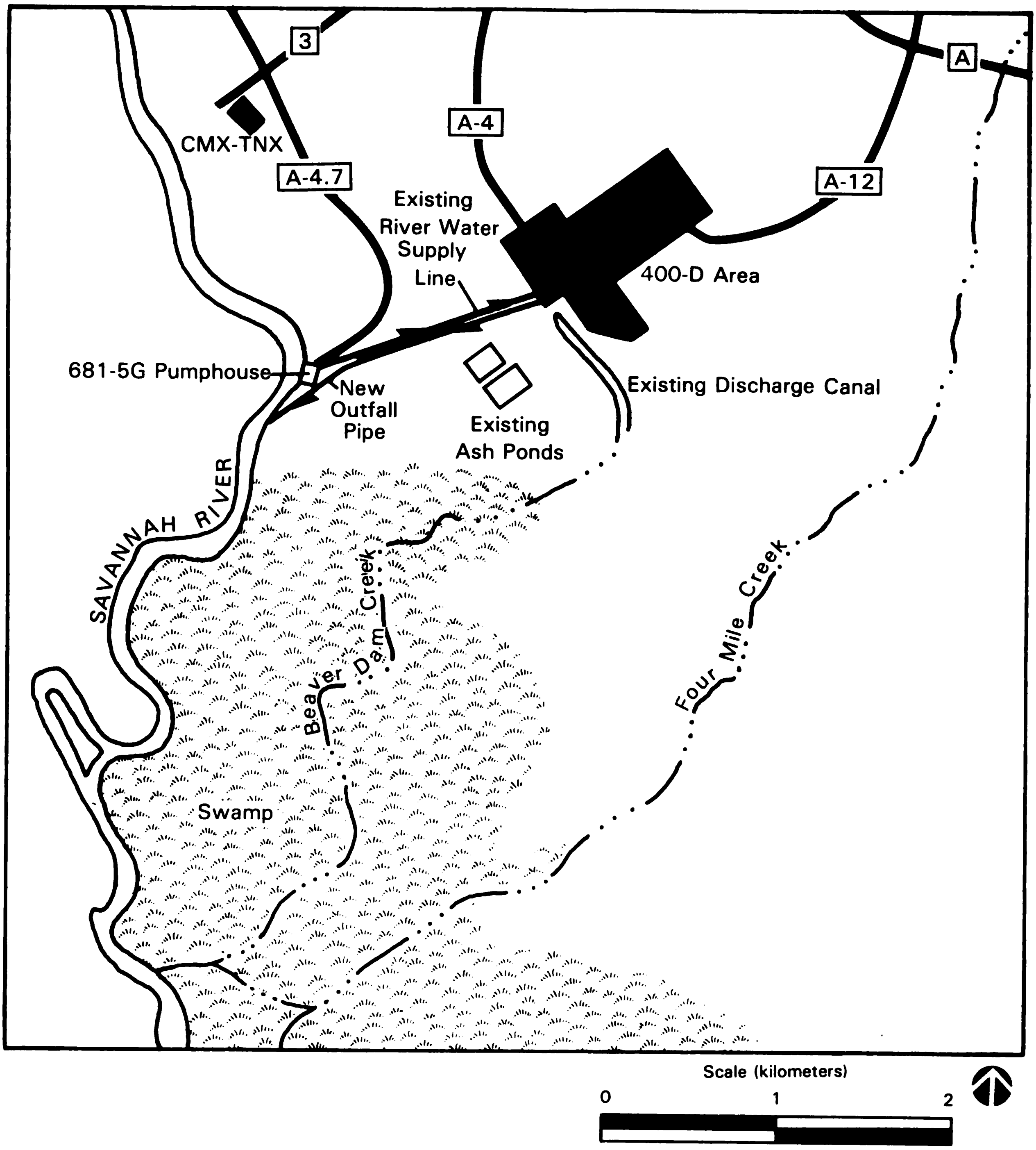
The estimated increase in annual operating cost for incremental electric consumption is $30,000. In addition, the cost to conduct a Section 316(a) demonstration study is estimated at $1.25 million.

2.2.3.2 Direct Discharge to Savannah River

Another alternative for the cooling water discharge from the D-Area powerhouse is the extension of the existing discharge piping to the Savannah River (Figures 2-10 and 2-11). The existing cooling water system would continue to pump the present flow from the Building 681-5G pumphouse to the Building 483-1D raw-water receiving basin and through the condensers. The existing cooling tower would continue to operate as a recirculating system for one condenser. However, the existing discharge headers from the condensers would be intercepted by a new interceptor sump. From this point a new underground pipe about 1.5 kilometers long would enable the water to flow by gravity to the Savannah River, about 91 to 152 meters downstream from the Building 681-5G pumphouse. The existing effluent discharge canal would no longer receive cooling water, but would continue to receive overflows from the raw-water basin.

The new pipeline would be located between the existing supply pipeline from the pumphouse and the existing power lines running to the pumphouse. It would cross under an unnamed stream and extend through approximately 400 meters of swamp before reaching the river.

The discharge structure at the river would be a sparging type extending into the river about 90 to 150 meters downstream of the 5G intake structure to avoid any recirculation. The discharge structure would promote mixing cooling water effluent with the river water flow.



TC

Figure 2-10. D-Area Discharge to Savannah River Alternative

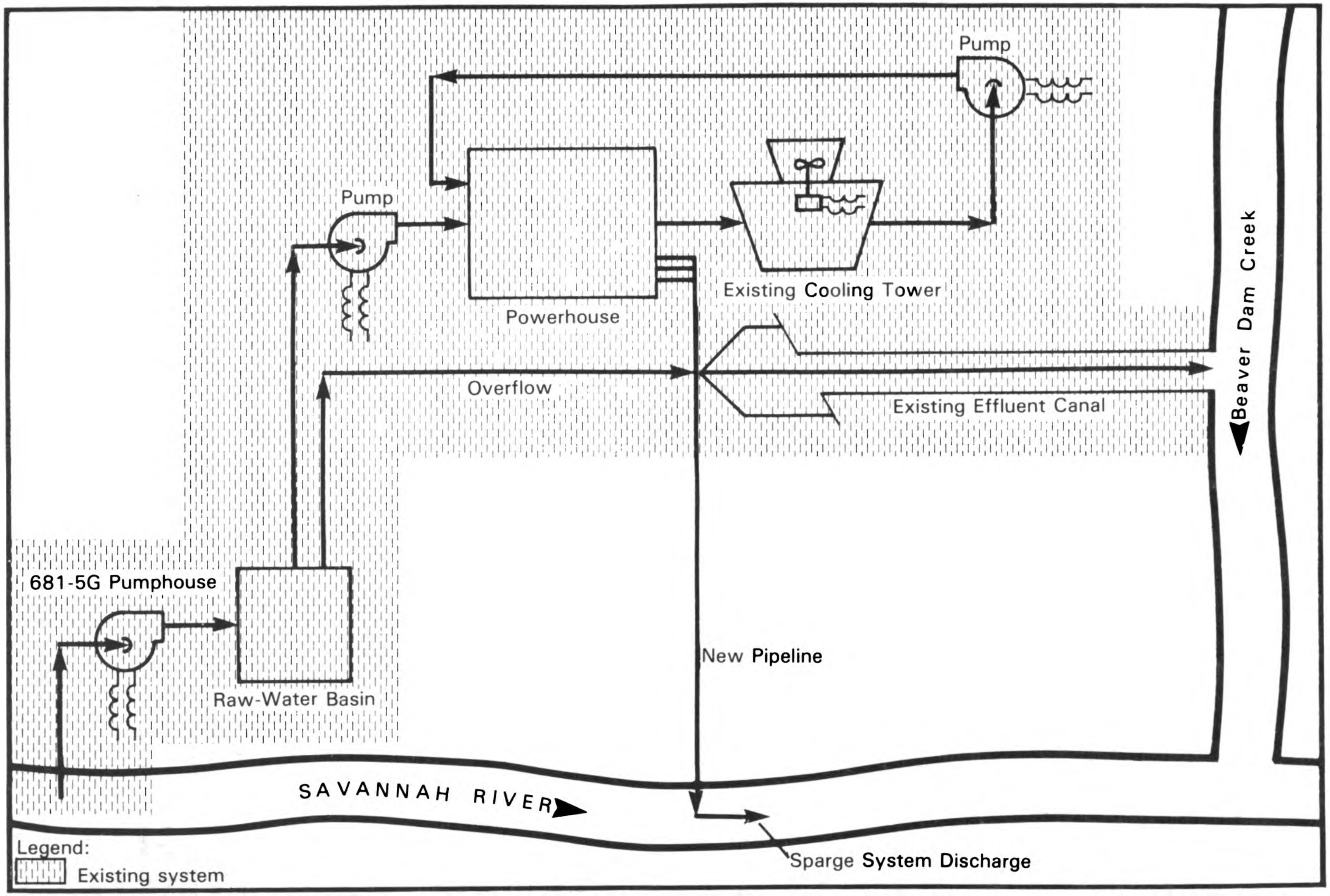


Figure 2-11. D-Area Direct Discharge to Savannah River Flow Diagram

Thermal Performance

With the direct-discharge alternative, the temperature of the D-Area powerhouse cooling water discharge would vary due to variations in the temperature of water withdrawn from the Savannah River and powerhouse loadings. Table 2-8 shows the seasonal variation in river and discharge temperatures and indicates that these temperatures for all average seasonal conditions are less than 32.2°C, assuming an 8°C rise in the temperature of cooling water withdrawn from the Savannah River as it passes through the powerhouse condensers. During extreme summer conditions the discharge temperature is 36°C.

In accordance with the State of South Carolina's regulations for water classifications and standards, the ambient water temperatures of Class B waters may not be increased by more than 2.8°C or exceed a maximum of 32.2°C as a result of thermal discharges, unless a mixing zone has been established. The purposes of the mixing zone are to allow the safe passage of aquatic organisms and to allow protection and propagation of a balanced indigenous population of aquatic organisms. This zone is to be based on critical flow conditions.

Table 2-8 lists the percentages of total cross-sectional areas and widths corresponding to temperatures of less than 2.8°C and temperatures of less than 32.2°C. Even under summer extreme conditions, the zone of passage would encompass 93 percent (width) and 99 percent (cross-sectional area) of the Savannah River.

Resource Utilization

The existing flow of water from the Savannah River to the D-Area powerhouse would be unchanged. Flow in the existing effluent canal, however, would be reduced from the current average of about 2.6 cubic meters per second to about 0.5 cubic meter per second during normal powerhouse operations. At maximum powerhouse operations, the flow in the canal would be about 0.3 cubic meter per second. This flow would increase to about 0.9 cubic meter per second when the powerhouse is shut down. Beaver Dam Creek would receive intermittent rainfall runoff and groundwater seepage in addition to this reduced flow. Chemical and suspended-solids characteristics of the cooling water effluent would be unchanged.

Connection of the new outfall pipe to the existing condenser outlet piping would require temporary shutdown of units operating in a once-through mode at the time of connection.

Construction of the pipeline to the river could be accomplished in approximately 22 months with a peak contractor manpower requirement of 40 persons. No increase in the maintenance or operation workforce would be necessary. The 22-month construction schedule includes the building of a new temporary road, a support structure for the pipeline through low-lying areas, and the submittal and approval of necessary permits. An estimated 5 acres of uplands and 1 acre of wetlands would be disturbed by construction. Any excess excavated material would be removed from the construction area and deposited at an approved spoil site so that natural drainage would not be disturbed.

Construction of the sparge system would disturb the river bank, and it would be restored to protect the floodplain system downstream.

Table 2-8. Temperatures and Passage Zone Sizes for D-Area Powerhouse Direct Discharge Into Savannah River[a]

Location or area	Winter average	Spring average	Summer average	Summer extreme[b]
Temperature (°C)				
Withdrawal from river	8	17	23	28
Discharge to river	16	25	31	36
Maximum river cross-sectional area (percent of total) having temperature (°C) less than				
2.8 (excess)	99.7	99.7	99.5	99.3
32.2 (absolute)	100	100	100	99.7
Maximum river width (percent of total) having temperature excess (°C) less than				
2.8 (excess)	95	95	94	93
32.2 (absolute)	100	100	100	96

a. Based on results of thermal modeling as described in Appendix B.
b. Modeling parameters for summer extreme use minimum 7-day average flow with an average frequency of once in 10 years (7Q10) for the Savannah River.

BB-3
BC-14

The capital cost of this alternative would be approximately $14 million. There would be $50,000 additional annual operating costs associated with this alternative.

2.2.3.3 No Action - Existing System

Under the no-action alternative, the existing withdrawal of Savannah River water and discharge to Beaver Dam Creek would continue. An average of about 2.6 cubic meters per second of water would be pumped from the Savannah River to the D-Area powerhouse for cooling and then discharged from the cooling system to Beaver Dam Creek.

Thermal Performance

Table 2-9 lists monthly average water temperatures along the cooling water flow path (based on meteorological data at Bush Field from 1953 through 1982), along with corresponding ambient stream temperatures; discharge temperatures are based on 1985 and 1986 measurements.

Table 2-9. Temperatures (°C) Along Cooling Water Flow Path--D-Area Powerhouse--No Action (Existing System)

Location	Temperature for											
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Discharge to creek	18(27)	16(22)	21(27)	24(29)	28(32)	29(34)	28(33)	28(33)	27(33)	27(34)	26(33)	19(31)
Swamp delta	17(25)	16(21)	20(26)	24(28)	27(31)	28(33)	28(33)	28(32)	27(32)	26(32)	24(30)	18(28)
Mouth	17(22)	17(21)	20(24)	24(27)	27(29)	29(31)	30(31)	29(31)	28(30)	25(29)	22(27)	18(23)
Ambient creek[a]	8(15)	9(14)	12(17)	15(20)	19(22)	21(25)	23(27)	23(26)	23(26)	20(23)	17(22)	12(18)

a. Average U.S. Geological Survey data for water years 1976 to 1985 for station 02197320; Savannah River near Jackson, South Carolina (USGS, 1977, 1978, 1979, 1980, 1981, 1982, 1983, 1984, 1985, 1986).

BB-3
BC-14

Table 2-9 indicates that during average conditions, the discharge to the creek will meet the maximum instream temperature standard of 32.2°C. However, under extreme meteorological conditions, the discharge temperature could be 2°C greater than that allowed by the State of South Carolina's Class B water classification standard. The discharge from the D-Area powerhouse would exceed the Class B water classification standard of a maximum 2.8°C ambient rise in stream temperature.

2.3 COMPARISON OF ALTERNATIVES

For each of the three facilities, selection of the no-action alternative would result in a continuation of present cooling water discharges that would not comply with the State of South Carolina's Class B water classification standard of a maximum instream temperature of 32.2°C. The construction and operation of either once-through or recirculating towers for K- and C-Reactors and implementation of either increased flow with mixing or construction and operation of direct discharge to the Savannah River for the D-Area powerhouse would result in discharges that would comply with this standard. Construction and operation of once-through or recirculating cooling towers for K- and C-Reactors and implementation of increased flow with mixing for the D-Area powerhouse would also require the conduct of Section 316(a) studies to determine whether a balanced biological community would be maintained, because discharges from these alternatives would exceed the Class B water classification standard of a maximum instream ambient temperature rise of 2.8°C. The following comparison discusses the major differences that would occur from the implementation of each of the alternatives. BB-3

2.3.1 ALTERNATIVES FOR K-REACTOR

Either of the two cooling-tower alternatives would reduce significantly the thermal impacts in Pen Branch and the Savannah River swamp. The major environmental difference between these alternatives is that the recirculating cooling towers would withdraw less water from the river (about 1.6 cubic meters per second) and release less to the creek (about 1 cubic meter per second) than the once-through tower (about 11.3 and 10.5 cubic meters per second, respectively). This would result in reduced entrainment losses of fish eggs and larvae and reduced impingement losses of adult and juvenile fish with the recirculating towers. The reduced flow in Pen Branch and its delta would also result in successional reestablishment of a greater amount of wetlands than would occur with the once-through alternative; on the other hand, the lower flow would also reduce the existing amount of aquatic habitat in the creek and parts of the swamp than would occur with the once-through tower. TE

Both alternatives would allow the reestablishment of aquatic faunal and floral communities, and spawning and foraging in presently uninhabited areas. However, the once-through cooling-tower alternative would exhibit a greater amount of water-level fluctuation, causing some stress to aquatic organisms.

The implementation of recirculating cooling towers would cause fewer thermal effects than once-through towers; however, the flooded habitat area would be smaller. Most aquatic communities would benefit from the reduced flow and decreased magnitude of the water-level fluctuations with the implementation of a recirculating system. Neither alternative would cause cold shock, because TC both would meet the Maximum Weekly Average Temperature criteria for winter shutdowns would be met. Dissolved-solids concentrations in the discharge would be higher with the recirculating alternative because of cycles of concentration; however, total suspended solids discharged would be greatly reduced.

The fluctuating water levels and high flow rates associated with the once-through alternative could destroy nests, eggs, and hibernation sites of the American alligator. This alternative would also minimize the availability of preferred foraging habitat for the endangered wood stork. The implementation of the recirculating cooling tower would greatly improve habitat quality for the American alligator and the wood stork. Because of the reduced flow, eggs, nests, and hibernation sites of the American alligator should not be affected adversely.

TC

The following relative rankings of future wildlife effects were determined for the various cooling water alternatives (Mackey et al., 1987). Effects to terrestrial wildlife from the construction of the once-through and recirculation cooling towers are essentially equal, because either type of tower would be constructed at the same locations, and pipeline and other support facilities would affect essentially the same locations. Small stream fish species would benefit more from the recirculation alternative in the upper reaches of the creeks. In the middle and lower reaches, species such as the catfish and sunfish would benefit more from the once-through alternative. In the deep swamp environment, fish that are more likely to use the swamp during the spawning period would benefit more from the recirculation alternative. In the Savannah River swamp, wading birds would benefit more from the recirculation alternative. Overwintering waterfowl such as the mallard would benefit more either from present SRP operations or from the once-through cooling-tower alternative; these alternatives either maintain the existing marsh-type environment in the swamp for wintering waterfowl or permit the expansion of this type of habitat as deep swamp wetlands (cypress/typelo) are reduced and converted to more open wetlands due to releases of high flows of cooling water effluent.

AD-1
BC-13

The impacts of both systems on air quality would be similar; however, because a recirculating cooling-tower system includes two towers operated in series with 2.5 cycles of concentration, the maximum ice accumulation near the towers would be greater for the recirculating system (7 millimeters versus less than 1 millimeter), as would the maximum annual deposition of total solids (2.2 kilograms per acre per year within about 2 kilometers from the tower versus 0.5 kilogram per acre per year for the once-through tower). Because these deposition rates are far below the levels that can cause reduced vegetation productivity (83 kilograms per acre per year), no impacts on vegetation or wildlife are expected.

TC
BC-22

The operation of the once-through cooling tower would not cause any significant changes in the remobilization of radionuclides contained in the Pen Branch bed, because the flow in the creek would remain essentially unchanged. The operation of recirculating towers would result in a calculated decrease of about 0.12 curie of cesium released to the Savannah River over a year due to the reduced flow. The implementation of either the once-through cooling tower or recirculating cooling towers would slightly reduce the radiological doses to the maximum individual and the population compared with the existing direct-discharge system, which are presently well within standards. The decrease in maximum individual and collective (population) doses, however, would be greater for recirculating cooling towers than for once-through towers.

The once-through cooling-tower system for K-Reactor would cost approximately $47 million less to construct than recirculating cooling towers. However, recirculating towers would cost approximately $2 million less to operate each year. In addition, recirculating cooling towers would require approximately 6 months longer to construct. The implementation of recirculating cooling towers would lower reactor power by 3.7 percent, in comparison to only 0.2 percent with the once-through system. Costs to conduct a Section 316(a) Demonstration study would be the same for both alternatives.

Table 2-10 provides a summary comparison of the alternatives for K-Reactor.

2.3.2 ALTERNATIVES FOR C-REACTOR

The comparisons of impacts of the two cooling-tower alternatives are similar to those associated with K-Reactor. The recirculating cooling towers would allow the reestablishment of approximately 1000 acres of wetlands, compared to more limited revegetation with the once-through cooling-tower alternative; however, there would be less aquatic habitat in the creek and swamp because of lower flow associated with the recirculating system. BC-19 BD-3

The implementation of either system would result in cooling water discharges that are in compliance with the 32.2°C Class B water classification standard for temperature and dissolved oxygen. Both systems would improve habitat over existing conditions for the alligator and wood stork.

Similar impacts to air quality and noise would be expected from both systems. However, the recirculating cooling-tower system would include two towers in series with 2.5 cycles of concentration; these towers would cause greater ice buildup (7 millimeters versus less than 1 millimeter). Salt deposition would also be greater with the recirculating towers (2.2 kilograms per acre per year within about 2 kilometers) than with a once-through system (0.5 kilogram per acre per year). Because these deposition rates are far below the levels that can cause reduced vegetation productivity (83 kilograms per acre per year), no impacts on vegetation are expected.

The remobilization of radionuclides and dose effects would be similar to those described for K-Reactor. The recirculating cooling towers would result in a calculated decrease in the amount of cesium released to the Savannah River by about 0.21 curie per year. Both the maximum individual and the population doses would decrease through the implementation of either the once-through cooling-tower or the recirculating-cooling-towers alternative. BC-22

Table 2-11 provides a summary comparison of the alternatives for C-Reactor.

2.3.3 ALTERNATIVES FOR D-AREA

The implementation of the increased-flow alternative would not alter the flow or temperature of Beaver Dam Creek except during those periods (May through September) when the system could be activated to maintain water temperatures below 32.2°C. Therefore, the existing aquatic habitat would be maintained, and its value to alligators, fish, and other aquatic organisms would be

Table 2-10. Comparison of Cooling Water Alternatives for K-Reactor (page 1 of 5)

	Impacts	No action[a]	Once-through cooling tower (preferred alternative[b])	Recirculating towers
TC	SCHEDULE FOR IMPLEMENTATION	Current	Construction of this system would require about 36 months after a 9-month design period.	Construction of this system would require about 42 months after a 9-month design period.
AD-1 BC-6	PRELIMINARY PRESENT-WORTH (MILLION $)			
	- including production loss	$0	$43.0	$89.8
	- excluding production loss	$0	$41.4	$58.0
	ESTIMATED OPERATING COST (MILLION $ PER YEAR)	$6.2	$6.4	$4.4
	SOCIOECONOMICS	No additional work force required.	Peak construction workforce of 200 persons; four additional mechanics required for operation.	Peak construction workforce of 300 persons; six additional mechanics required for operation.
AD-1 BC-13	WATER WITHDRAWAL AND DISCHARGE RATES	About 11.3 cubic meters per second would continue to be withdrawn from the Savannah River and discharged into Indian Grave/Pen Branch.	Withdrawal the same as for no action; discharge to Indian Grave/Pen Branch would be about 92% of that for no action or 10.5 cubic meters per second.	Withdrawal of river water would be about 4.5% of that for no action or 1.6 cubic meters per second. Discharge to Indian Grave/Pen Branch would be about 10% of that for no action or about 1 cubic meter per second.
BB-1 BB-2 BB-3 BC-10	WATER QUALITY	Dissolved oxygen concentrations are below standards intermittently during the summer and total suspended solids are slightly higher than ambient stream levels.	State Class B water classification standards for dissolved oxygen concentrations would be met. There would be some reduction in total suspended solids.	State Class B water classification standards for dissolved solids concentrations would be higher than no action or once-through cooling tower because of cycles of concentration; however, total suspended solids discharged would be greatly reduced.

Table 2-10. Comparison of Cooling Water Alternatives for K-Reactor (page 2 of 5)

Impacts	No action[a]	Once-through cooling tower (preferred alternative[b])	Recirculating towers	
TEMPERATURE AND FLOW EFFECTS	Water temperature in Indian Grave/Pen Branch would exceed State Class B water classification standards. There would continue to be few aquatic organisms in the thermal areas of Pen Branch and its delta. A thermal barrier will prevent aquatic movement in Indian Grave/Pen Branch. Fish spawning in the creek and delta would remain reduced. There would continue to be a potential for cold shock during the winter.	State Class B water classification standards for temperature (32.2°C) would be met; a Section 316(a) Demonstration study will be performed for exceedances of 2.8°C rise in ambient stream temperatures. Aquatic organisms would become established in present thermal areas. Thermal barrier would be removed. Creek and delta would be opened to fish spawning and foraging. There would be no potential for cold shock because MWAT (EPA, 1977) criteria would be met. Water levels would continue to fluctuate.	State Class B water classification standards for temperature (32.2°C) would be met; a Section 316(a) study would also be performed. Similar mitigation of thermal effects that would occur with once-through towers, except habitat area for spawning and foraging would be smaller because of reduced flow; magnitude of water level fluctuations would be less.	BB-3
ENTRAINMENT/ IMPINGEMENT	Water withdrawal would continue to cause entrainment losses of about 13.4×10^6 fish eggs and larvae and the loss of about 2942 fish to impingement annually.	Effects would be about the same as for no action.	Annual entrainment and impingement losses would be reduced to about 2.0×10^6 fish eggs and larvae and 427 fish, respectively.	BD-5
HABITAT	Flow and temperature impacts would continue to result in the loss of about 26 acres of wetlands each year.	Wetland losses would decrease; some successional revegetation would occur. About 25 acres of uplands would be affected by construction.	Wetland losses would essentially cease and about 500 acres of wetlands would successively revegetate; about 50 acres of uplands would be affected by construction.	BC-19 BD-3
SOLIDS DEPOSITION	None.	Maximum annual total-solids deposition within about 2 km of the tower would be	Maximum annual total-solids deposition within about 2 km of the tower would be about	TC

Table 2-10. Comparison of Cooling Water Alternatives for K-Reactor (page 3 of 5)

	Impacts	No action[a]	Once-through cooling tower (preferred alternative[b])	Recirculating towers
			about 0.5 kilogram per acre per year. Deposition rates are far below levels that cause reduced vegetation productivity.	2.2 kilograms per acre per year. Deposition rates are far below levels that cause reduced vegetation productivity.
TC	ENDANGERED SPECIES	Thermally affected areas of Pen Branch and swamp would continue to be too hot for alligators. Low fish densities and high water levels limit forage value for wood stork. No impacts on shortnose sturgeon and red-cockaded woodpecker.	Alligator habitat would be improved by lower water temperatures. Some improvement of wood stork foraging habitat would result from increased fish concentrations although continued high flows would maintain deep water conditions. No impacts on shortnose sturgeon, red-cockaded woodpecker, and bald eagle.	Some alligator habitat would be available; however, lower flows would decrease potential habitat area resulting in less improvement than with once-through towers. Potential for improvement of wood stork habitat would be increased due to lower water levels in the creek and delta. No impacts on shortnose sturgeon, red-cockaded woodpecker, and bald eagle.
	AIR QUALITY	No impacts.	Construction would result in temporary small increases in carbon monoxide and hydrocarbons from engine exhaust. Also some transient increases in airborne dust.	Construction impacts would be similar to those for once-through tower.
TC			Maximum annual-mean frequency of reduced ground-level visibility to less than 1000 m would be about 2 hours per year.	Reduction in ground-level visibility would be about 2 hours per year.
TC			Maximum ice accumulation on horizontal surfaces would be no more than 1 mm.	Maximum ice accumulation on horizontal surfaces would be no more than 1 mm beyond 0.8 km of the tower. Maximum predicted thickness

Table 2-10. Comparison of Cooling Water Alternatives for K-Reactor (page 4 of 5)

Impacts	No action[a]	Once-through cooling tower (preferred alternative[b])	Recirculating towers	
			would be 7 mm, occurring within 0.4 km of the tower with a total frequency of 88 hours per winter season.	TC
		Maximum occurrence of visible plumes would be about 180 hours per year within 0.4 km of the tower and 30 hours per year at 2 km.	Visible plume occurrence would be less frequent than that of once-through towers (180 hours per year within 2 kilometers of the tower).	TC
NOISE	No impacts.	Construction would cause some temporary increases in noise in the project area.	Same as for once-through tower.	
		Operation noise beyond about 152 m from the tower would be negligible.	Operation noise beyond about 152 m from the tower would average less than 70 decibels. Sound would consist of fan noise and falling water.	TC
ARCHAEOLOGICAL AND HISTORIC SITES	No impacts.	No impacts.	No impacts.	
RADIOCESIUM TRANSPORT	About 16.2 Ci of radiocesium were released from the K-Reactor area through 1980. Creek sediments at the Pen Branch delta exhibit average cesium-137 concentrations of 4.7 picocuries per gram.	The operation of this alternative would not result in any significant changes in remobilization of radionuclides since flow in Pen Branch would remain essentially unchanged.	The operation of this alternative would reduce flows in Pen Branch resulting in a calculated decrease in the cesium released to the Savannah River of about 0.12 Ci per year.	BC-22
RADIOLOGICAL RELEASES AND DOSES	Cumulative maximum individual effective whole-body dose would continue at about 3.3 millirem per year. Collective effective whole-	Amount of radioactivity released would not change; however, pathway would be affected. Annually, about 50 additional Ci of	Annually, about 425 additional Ci of tritium would be released to atmospheric pathway and 425 less Ci of tritium would be released to liquid	

Table 2-10. Comparison of Cooling Water Alternatives for K-Reactor (page 5 of 5)

Impacts	No action[a]	Once-through cooling tower (preferred alternative[b])	Recirculating towers
BC-22 BC-22	body dose to regional population and downstream water consumers would be about 81 person-rem per year. Population doses are about 0.074 percent of natural background.	tritium would be released to atmospheric pathway and about 50 Ci less of tritium would be released to liquid pathway. This would reduce maximum individual effective whole-body dose by 1.1 x 10^{-4} millirem per year; collective effective whole-body dose to regional population and downstream water consumers would decrease by 0.028 person-rem per year.	pathway. Change in cesium-137 and tritium release would reduce maximum individual effective whole-body dose by about 0.070 millirem per year; collective effective whole-body dose to regional population and downstream water consumers would decrease by about 0.48 person-rem per year.

a. No action is defined as the continuation of existing operations of K-Reactor.

b. The preferred alternative is to construct and operate once-through cooling towers (gravity feed and natural draft). Characterization of environmental effects is based on a natural-draft cooling tower.

Table 2-11. Comparison of Cooling Water Alternatives for C-Reactor (page 1 of 5)

Impacts	No action[a]	Once-through cooling tower (preferred alternative[b])	Recirculating towers	
SCHEDULE FOR IMPLEMENTATION	Current	Construction of the system would require about 36 months after a 9-month design period.	Construction of the system would require about 42 months after a 9-month design period.	TC
PRELIMINARY PRESENT WORTH (MILLION $)				
- including production loss	$0	$44.0	$89.8	AD-1 BC-6
- excluding production loss	$0	$42.4	$58.0	
ESTIMATED OPERATING COST INCREASE (MILLION $ PER YEAR)	$6.2	$6.4	$4.4	
SOCIOECONOMICS	No additional work force required.	Peak construction workforce of 200 persons; four additional mechanics required for operation.	Peak construction workforce of 300 persons; six additional mechanics required for operation.	
WATER WITHDRAWAL AND DISCHARGE RATES	About 11.3 cubic meters per second are withdrawn from the Savannah River and discharged into Four Mile Creek.	Withdrawal the same as for no action; discharge to Four Mile Creek would be about 92% of that for no action or 10.5 cubic meters per second.	Withdrawal of river water would be about 14.5% of that for no action or 1.6 cubic meters per second. Discharge to Four Mile Creek would be about 10% of that for no action or about 1 cubic meter per second.	AD-1 BC-12
WATER QUALITY	Dissolved oxygen concentrations in Four Mile Creek are below standards intermittently during summer and total suspended solids are slightly higher than ambient stream levels.	State Class B water classification standards for temperature (32.2°C) and dissolved oxygen concentrations would be met. There would be some reduction in total suspended solids.	State Class B water classification standards for dissolved solids concentrations in discharge would be higher than no action or once-through cooling tower because of cycles of concentration; however, total suspended solids discharged would be greatly reduced.	BB-1 BB-2 BB-3 BC-10

Table 2-11. Comparison of Cooling Water Alternatives for C-Reactor (page 2 of 5)

	Impacts	No action[a]	Once-through cooling tower (preferred alternative[b])	Recirculating towers
BB-3	TEMPERATURE AND FLOW EFFECTS	Water temperature in Four Mile Creek would exceed State Class B water classification standards. There would continue to be few aquatic organisms in thermal areas of Four Mile Creek and its delta. Thermal barrier would prevent aquatic movement in Four Mile and Castor Creeks. Fish spawning in creek and delta would remain reduced. There would continue to be potential for cold shock during winter.	State Class B water classification standards for temperature (32.2°C) would be met; Section 316(a) Demonstration study would be performed for exceedances of 2.8°C rise in ambient stream temperatures. Aquatic organisms would become established in present thermal areas. Thermal barrier would be removed. Creek and delta would be opened to fish spawning and foraging. There would be no potential for cold shock because MWAT (EPA, 1977) criteria would be met. Water levels would continue to fluctuate.	State Class B water classification standards for temperature (32.2°C) would be met; Section 316(a) study would also be performed. Mitigation of thermal effects similar to once-through tower would occur, except habitat area for aquatic spawning and foraging would be smaller because of reduced flow, and magnitude of water level fluctuations would be less.
BD-5	ENTRAINMENT/ IMPINGEMENT	Water withdrawal would continue to cause entrainment losses of about 13.4 x 10^6 fish eggs and larvae and the loss of about 2942 fish to impingement annually.	Effects would be about the same as for no action.	Annual entrainment and impingement losses would be reduced to about 2.0 x 10^6 fish eggs and larvae and 427 fish, respectively.
BC-19 BD-3	HABITAT	Flow and temperature impacts would continue to result in the loss of about 28 acres of wetlands each year.	Wetland losses would decrease; some successional revegetation would occur. About 35 acres of uplands would be affected by construction.	Wetland losses would essentially cease and about 1000 acres of wetlands would successively revegetate; about 60 acres of uplands would be affected by construction.
TC	SOLIDS DEPOSITION	None.	Maximum annual total-solids deposition within about 2 km of the tower would be	Maximum annual total-solids deposition within about 2 km of the tower would be about

Table 2-11. Comparison of Cooling Water Alternatives for C-Reactor (page 3 of 5)

Impacts	No action[a]	Once-through cooling tower (preferred alternative[b])	Recirculating towers
		about 0.5 kilogram per acre per year. Deposition rates are far below levels that cause reduced vegetation productivity.	2.2 kilograms per acre per year. Deposition rates are far below levels that cause reduced vegetation productivity. TC
ENDANGERED SPECIES	Thermally affected areas of Four Mile Creek and swamp would continue to be too hot for alligators. Low fish densities and high water levels limit forage value for wood stork. No impacts on shortnose sturgeon and red-cockaded woodpecker.	Alligator habitat would be improved by lower water temperatures. Some improvement of wood stork foraging habitat would result from increased fish concentrations although continued high flows would maintain deep water conditions. No impacts on shortnose sturgeon, red-cockaded woodpecker, and bald eagle.	Some alligator habitat would be available; however, lower flows would decrease potential habitat area resulting in less improvement than with once-through tower. Potential for improvement of wood stork habitat would be increased due to lower water levels in the creek and delta. No impacts on shortnose sturgeon, red-cockaded woodpecker, and bald eagle. TC
AIR QUALITY	No impacts.	Construction would result in temporary small increases in carbon monoxide and hydrocarbons from engine exhaust. Also some transient increases in airborne dust.	Construction impacts would be similar to those for once-through tower.
		Maximum annual-mean frequency of reduced ground-level visibility to less than 1000 m would be about 2 hours per year.	Reduction in ground-level visibility would be about 2 hours per year.
		Maximum ice accumulation on horizontal surfaces would be no more than 1 mm.	Maximum ice accumulation on horizontal surfaces would be no more than 1 mm beyond 0.8 km of the tower. Maximum TC

Table 2-11. Comparison of Cooling Water Alternatives for C Reactor (page 4 of 5)

	Impacts	No action[a]	Once-through cooling tower (preferred alternative[b])	Recirculating towers
TC				predicted thickness would be 7 mm, occurring within 0.4 km of the tower with a total frequency of 88 hours per winter season.
TC			Maximum occurrence of visible plumes would be about 180 hours per year within 0.4 km of the tower and 30 hours per year at 2 km.	Visible plume occurrence would be 100 hours per year within 2 km of the towers.
	NOISE	No impacts.	Construction would cause some temporary increases in noise in the project area.	Same as for once-through tower.
			Operation noise beyond about 152 m from the tower would be negligible.	Operation noise beyond about 152 m from the tower would average less than 70 decibels. Sound would consist of fan noise and falling water.
	ARCHAEOLOGICAL AND HISTORIC SITES	No impacts.	One small nonsignificant prehistoric lithic and ceramic scatter near Four Mile Creek would be disturbed.	Same site would be disturbed as with once-through tower.
BC-22	RADIOCESIUM TRANSPORT	About 21.9 Ci of radiocesium were released from the C Reactor area through 1980. Creek sediments at SRP Road A-7 exhibit average cesium-137 concentrations of 37.5 picocuries per gram.	The operation of this alternative would not result in any significant changes in remobilization of radionuclides since flow in Four Mile Creek would remain essentially unchanged.	The operation of this alternative would reduce flows in Four Mile Creek resulting in a calculated decrease in cesium released to the Savannah River of about 0.21 Ci per year.
	RADIOLOGICAL RELEASES AND DOSES	Cumulative maximum individual effective whole-body dose would continue at about	Amount of radioactivity released would not change; however, pathway would be	Annually, about 425 additional Ci of tritium would be released to atmospheric pathway

Table 2-11. Comparison of Cooling Water Alternatives for C-Reactor (page 5 of 5)

Impacts	No action[a]	Once-through cooling tower (preferred alternative[b])	Recirculating towers
	3.3 millirem per year. Collective effective whole-body dose to the regional population and downstream water consumers would be about 81 person-rem per year. Population doses are about 0.074 percent of natural background.	affected. Annually, about 50 additional Ci of tritium would be released to atmospheric pathway and about 50 Ci less of tritium would be released to liquid pathway. This would reduce maximum individual effective whole-body dose by 1.1×10^{-4} millirem per year and collective effective whole-body dose to regional population; downstream water consumers would decrease by 0.028 person-rem per year.	and 425 less Ci of tritium would be released to liquid pathway. Change in cesium-137 and tritium releases would reduce maximum individual effective whole-body dose by about 0.12 millirem per year; collective effective whole-body dose to regional population and downstream water consumers would decrease by about 0.66 person-rem per year. BC-22

a. No action is defined as the continuation of existing operations of C-Reactor.

b. The preferred alternative is to construct and operate once-through cooling towers (gravity feed and natural draft). Characterization of environmental effects is based on a natural-draft cooling tower.

improved because of lower water temperatures and intermittent higher flows. The direct-discharge alternative would remove the D-Area powerhouse thermal discharge from Beaver Dam Creek and would reduce the creek flow to near-ambient levels. This alternative would result in a significant reduction in the available aquatic habitat in the creek, and would adversely affect alligators that now use these areas. Heated effluent discharged directly into the Savannah River would not adversely affect the River's aquatic habitat because a zone of passage would be maintained.

The increased-flow alternative would affect an estimated 4 acres of wetlands and 4 acres of uplands due to intermittent flooding when the system is operating. Construction of the pipeline for the direct-discharge alternative would adversely affect about 1 acre of wetlands and 5 acres of uplands.

Entrainment and impingement impacts would remain at present levels for the direct-discharge alternative. However, increased flow with mixing would
BD-5 result in annual entrainment losses of about 6.0×10^4 fish eggs and larval and impingement losses of about 113 fish.

Habitat for the American alligator and the wood stork would not be affected appreciably by the increased-flow alternative; however, during its operation, the intermittent increases in water level could decrease the area of foraging habitat for the wood stork. Implementation of the direct-discharge system would degrade much of the existing alligator and wood stork habitat in Beaver Dam Creek due to the significant decrease in flow and elimination of slightly warmer winter temperatures.

No radiological impacts will occur from the implementation of either alternative for the D-Area powerhouse.

Table 2-12 provides a summary comparison of the alternatives for D-Area.

Table 2-12. Comparison of Cooling Water Alternatives for D-Area (page 1 of 3)

Impacts	No action[a]	Increased flow with mixing (preferred alternative)	Direct discharge to Savannah River
SCHEDULE FOR IMPLEMENTATION	Current	Current	Construction of this alternative would require about 22 months.
PRELIMINARY PRESENT-WORTH (MILLION $)	$0	$0	$14
ESTIMATED OPERATING COST INCREASE (MILLION $ PER YEAR)	$0	$0.03	$0.05
SOCIOECONOMICS	No additional workforce required.	No additional workforce required.	Peak construction workforce of 40 persons.
WATER WITHDRAWAL AND DISCHARGE RATES	About 2.6 cubic meters per second would continue to be withdrawn from the Savannah River and discharged to Beaver Dam Creek.	Withdrawal and discharge rates would be the same as for no action except when withdrawal and discharge rates each could be as high as 4.5 cubic meters per second to meet the 32.2°C State Class B water classification standard.	Withdrawal and discharge rates would be the same as for no action; however, thermal discharge would be directly to the Savannah River. All powerhouse thermal discharges would be removed from Beaver Dam Creek.
TEMPERATURE AND FLOW EFFECTS	Water temperatures in Beaver Dam Creek would continue to exceed the 32.2°C State Class B water classification standard during periods from May through September; water temperatures would also exceed the maximum ambient stream temperature rise standard of 2.8°C. Concentrations of suspended solids would remain slightly higher than in ambient streams.	Water temperatures in the stream would meet the 32.2°C State Class B water classification standard; a Section 316(a) Demonstration study will be performed for exceedances of 2.8°C rise in ambient stream temperature. Slight increases in suspended solids concentrations would occur during periods of increased flow. Aquatic fauna would become established in	In Beaver Dam Creek, water temperatures would be at ambient levels year-round. In the Savannah River, water temperatures beyond a mixing zone at the discharge point would meet the State Class B water quality classification standard of 32.2°C. Low water levels in Beaver Dam Creek would greatly reduce existing aquatic habitat; however, the absence of thermal stress would allow full use of this habitat by aquatic organisms. There would be no

Table 2-12. Comparison of Cooling Water Alternatives for D-Area (page 2 of 3)

BD-5

Impacts	No action[a]	Increased flow with mixing (preferred alternative)	Direct discharge to Savannah River
	There would continue to be reduced numbers of aquatic organisms and spawning in the thermally affected areas of Beaver Dam Creek during the warmer months. A thermal barrier would continue to restrict movement of fish in the creek.	present thermally affected areas of Beaver Dam Creek. Habitat area would increase during periods of increased flow. There would be no thermal barrier in the creek.	thermal barrier in the creek. Fish spawning would be limited because of reduced habitat. An adequate zone of passage would be present in the river.
ENTRAINMENT/ IMPINGEMENT	Water withdrawal would continue to cause entrainment losses of about 2.0×10^6 fish eggs and larvae and the loss of about 1718 fish due to impingement annually.	Increased water withdrawal over that for no action would increase entrainment losses by about 2.4×10^4 fish eggs and larvae and the loss of an additional 113 fish due to impingement annually.	Effects would be about the same as for no action.
HABITAT	No impacts.	Operation would result in an estimated loss of about 4 acres of wetlands and about 4 acres of uplands.	Construction would result in an estimated loss of about 1 acre of wetlands and 5 acres of uplands.
AIR QUALITY	No impacts.	No impacts.	No impacts.
ENDANGERED SPECIES	Existing thermal areas of Beaver Dam Creek would continue to support a large alligator population. The adjacent swamp area would continue to be used by wood storks for foraging. No impacts on other endangered species.	No changes in existing alligator habitat. Some decrease in wood stork foraging habitat during increased flow periods. No impacts on other endangered species.	Loss of most of alligator habitat due to decreased temperatures and lowered water levels in Beaver Dam Creek. Loss of much of wood stork foraging habitat due to lowered water levels in Beaver Dam Creek. No impacts on other endangered species.

Table 2-12. Comparison of Cooling Water Alternatives for D-Area (page 3 of 3)

Impacts	No action[a]	Increased flow with mixing (preferred alternative)	Direct discharge to Savannah River
ARCHAEOLOGICAL AND HISTORICAL SITES	No impacts.	One site will be recommended for eligibility for nomination to the National Register of Historic Places. A "no effect" determination was obtained from the South Carolina SHPO with concurrence from the Advisory Council on Historic Preservation.	Survey of pipeline area revealed no historic sites.
RADIOLOGICAL RELEASES	No impacts.	No impacts.	No impacts.

AT-1
AT-2
AZ-1

a. No action is defined as the continuation of existing operations of the D-Area coal-fired powerhouse.

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