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

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. AD-1 BB-1 BB-2 BB-3 BC-4 BC-6 BC-14

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

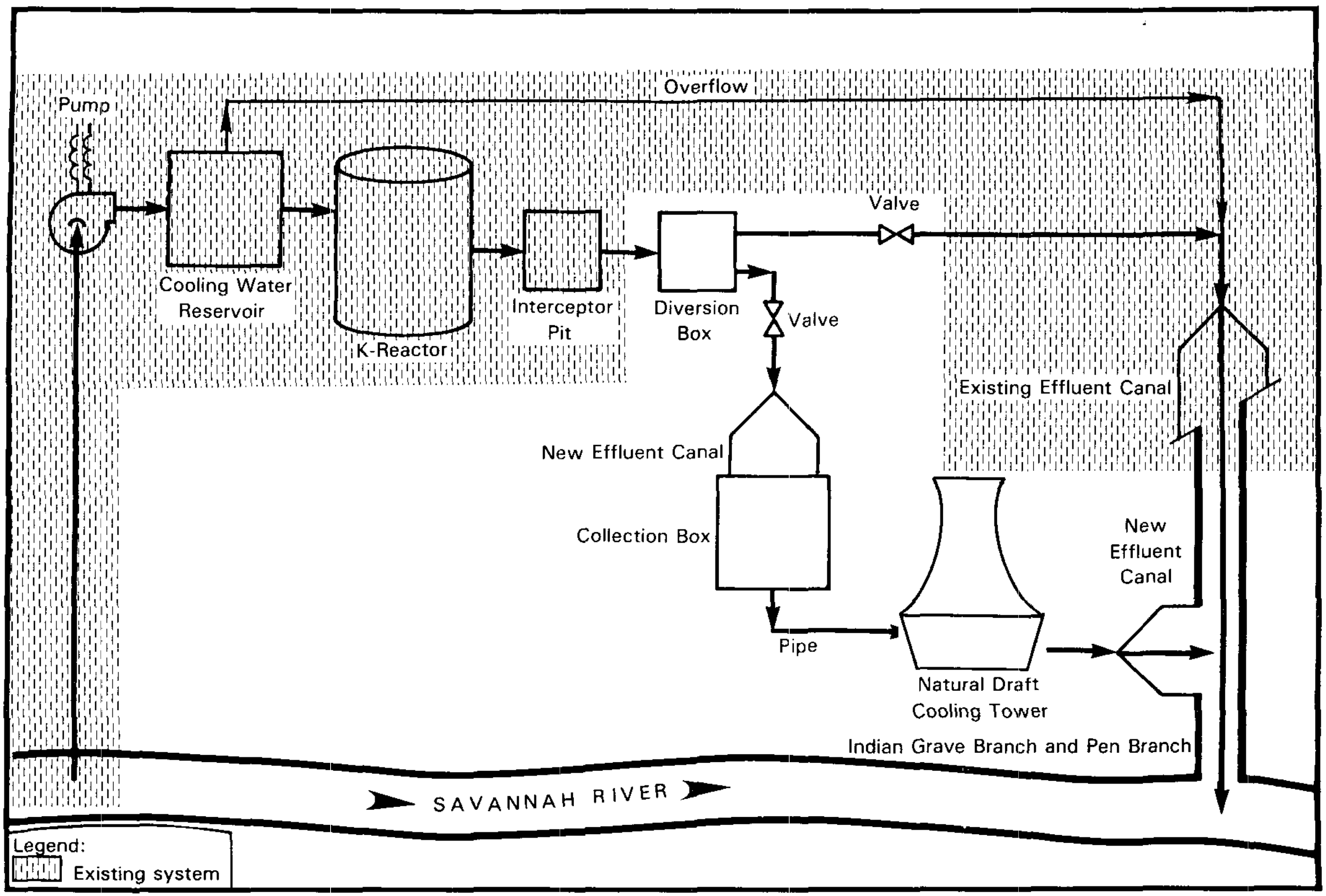


Figure 2-1. K-Reactor Once-Through Cooling Tower System Flow Diagram

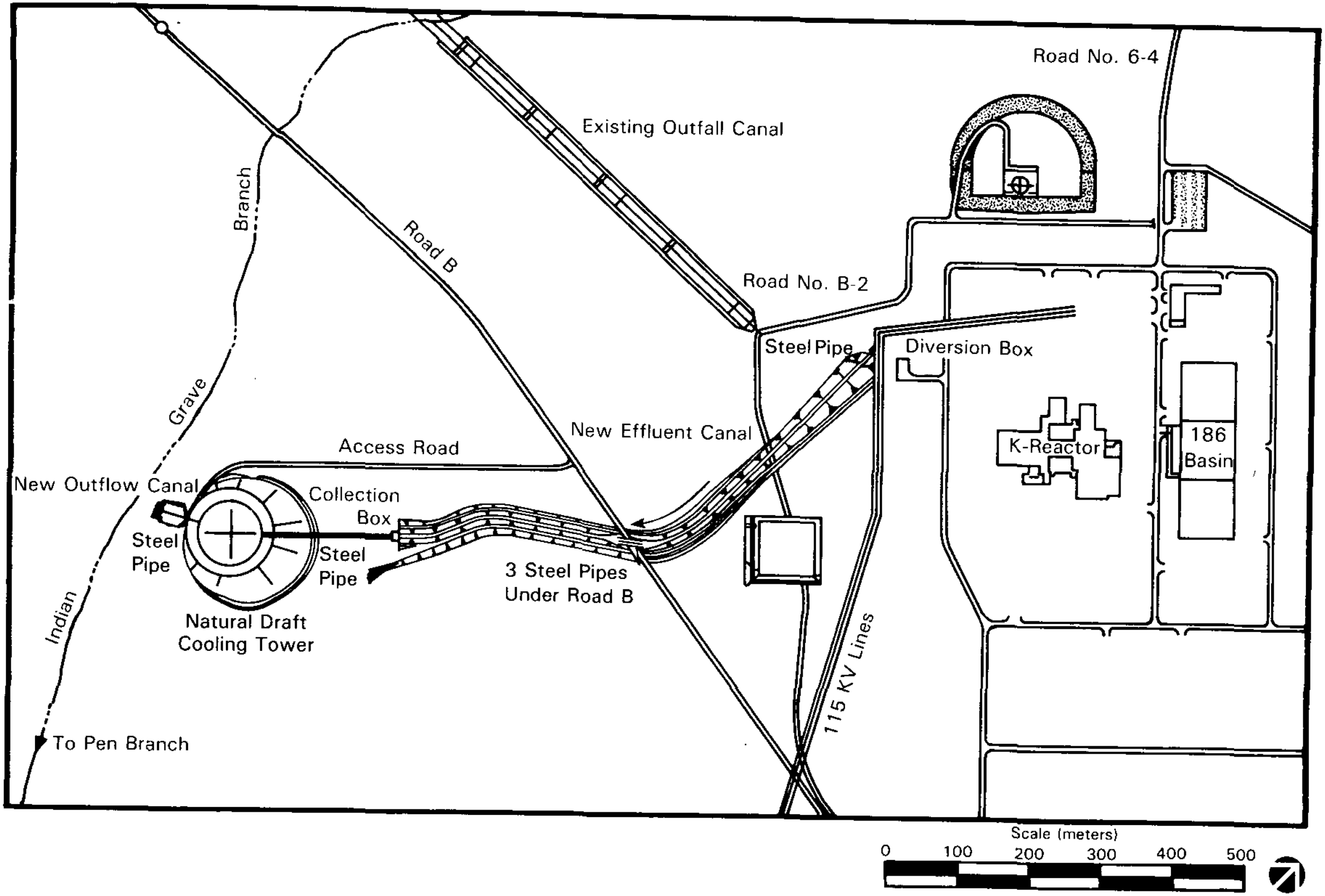


Figure 2-2. K-Reactor Once-Through Cooling Tower System

TC

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.

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
TC 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

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
BB-3 (i.e., a maximum instream temperature of 32.2°C). This would be accom-
BC-4 plished through the design conditions of a 4.4°C approach to a wet bulb
BC-14 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 TC 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.

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 TC with the ambient stream temperatures. Additionally, Table 2-1 lists downstream temperatures under extreme summer conditions (July 1980). 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 BB-1 total suspended solids concentration would be reduced by settlement in the BB-2 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.

Construction of a once-through natural-draft cooling tower system would be TC 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 TC approximately four mechanics. Approximately 25 acres of uplands would be disturbed by all construction activities.

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

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

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

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).

BB-3
BC-4
BC-14

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

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.

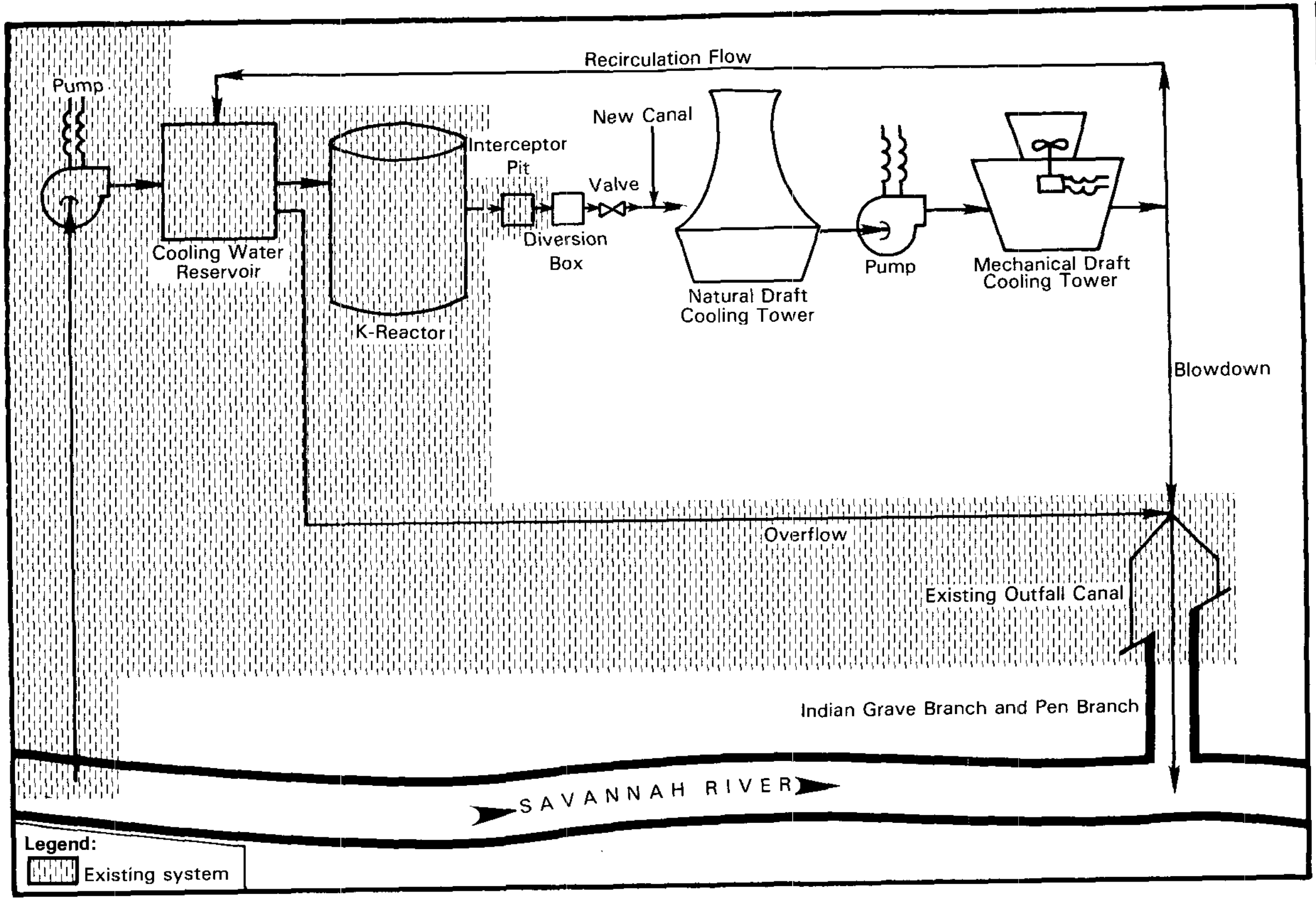
The natural-draft cooling tower, when installed with the mechanical-draft
tower in series, would be approximately 85 meters in diameter and 120 meters
high. Six 1750 horsepower (1300 kilowatt) pumps would be provided to transfer AD-1
the cooling water from the cold water basin under the first tower through a
new steel pipe to the second tower. This 1.8-meter diameter, underground BC-13
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.

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 hypo- BB-1
chlorite) that would be injected into the cooling water stream to prevent BB-2
biofouling in the tower system. This would allow for injection of a non- BC-17
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 com-
pletely 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 AD-1
tower fill, would be used for cold weather start-ups and could be used during BC-13
equipment repairs, if necessary.

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



AO-1
BC-13

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

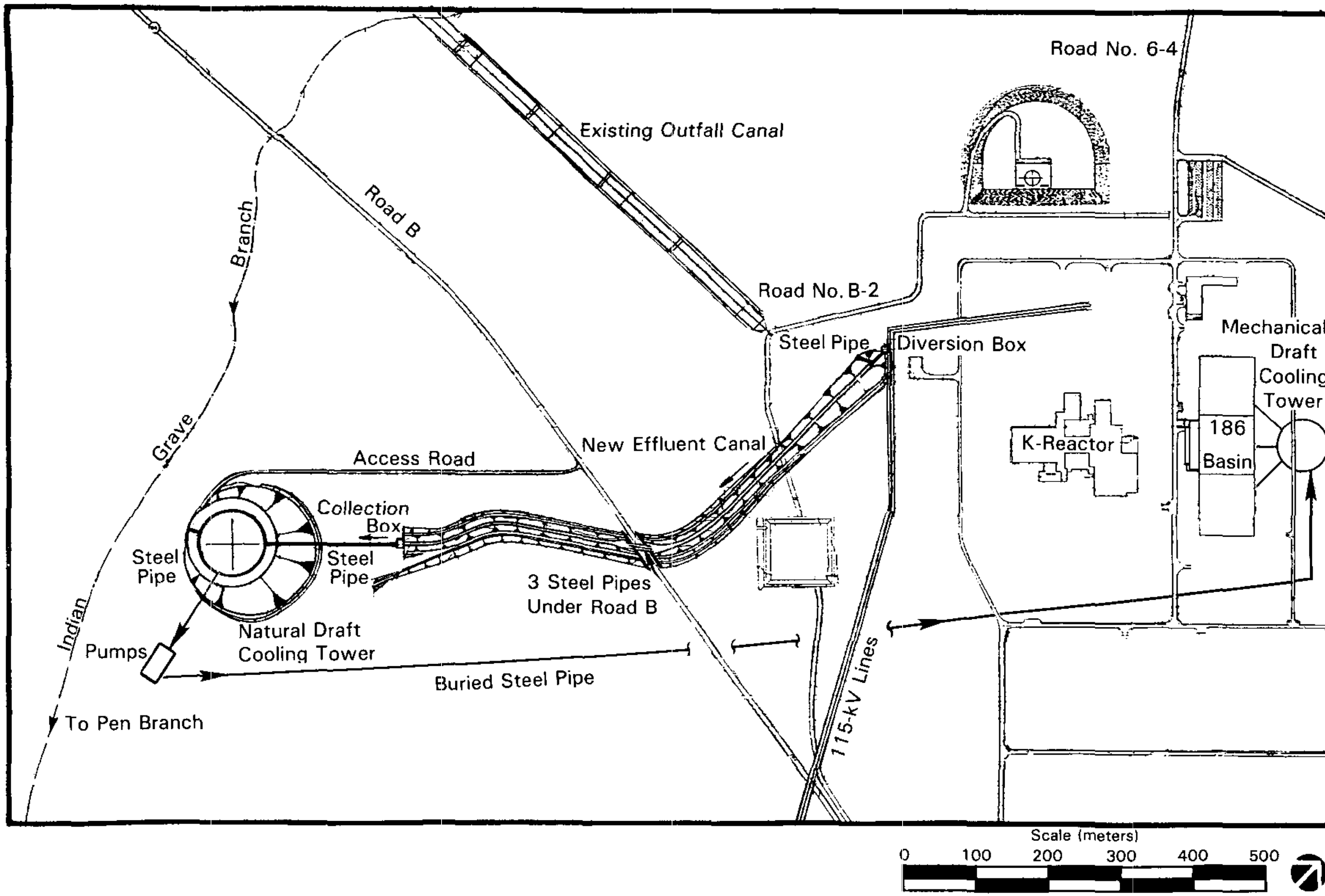


Figure 2-4. K-Reactor Recirculating Cooling Tower System

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
AO-1 necessary to limit the increase in concentrations of solids and chemicals in
BC-13 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.

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
AO-1 having recirculating pumps or cooling tower fans.

BC-13

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.

The present design concept for a recirculating system includes pump start/stop
TC buttons and pump running lights. No interlocks would be provided, or are con-
sidered 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

The recirculating cooling tower system would be designed for low tower dis-
BC-4 charge temperatures leading to compliance with the State of South Carolina's
BC-14 Class B water classification standards (i.e., a maximum instream temperature
BC-15 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. If the recirculating-cooling-towers alternative were implemented, the discharge from K-Reactor would be reduced to about 1 cubic meter per second. The maximum amount of water removed from the river would also be reduced to about 1.6 cubic meters per second.

TC
TC

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. 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
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*

	Temperature for											
Location	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)	BB-3 BC-14
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).

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)

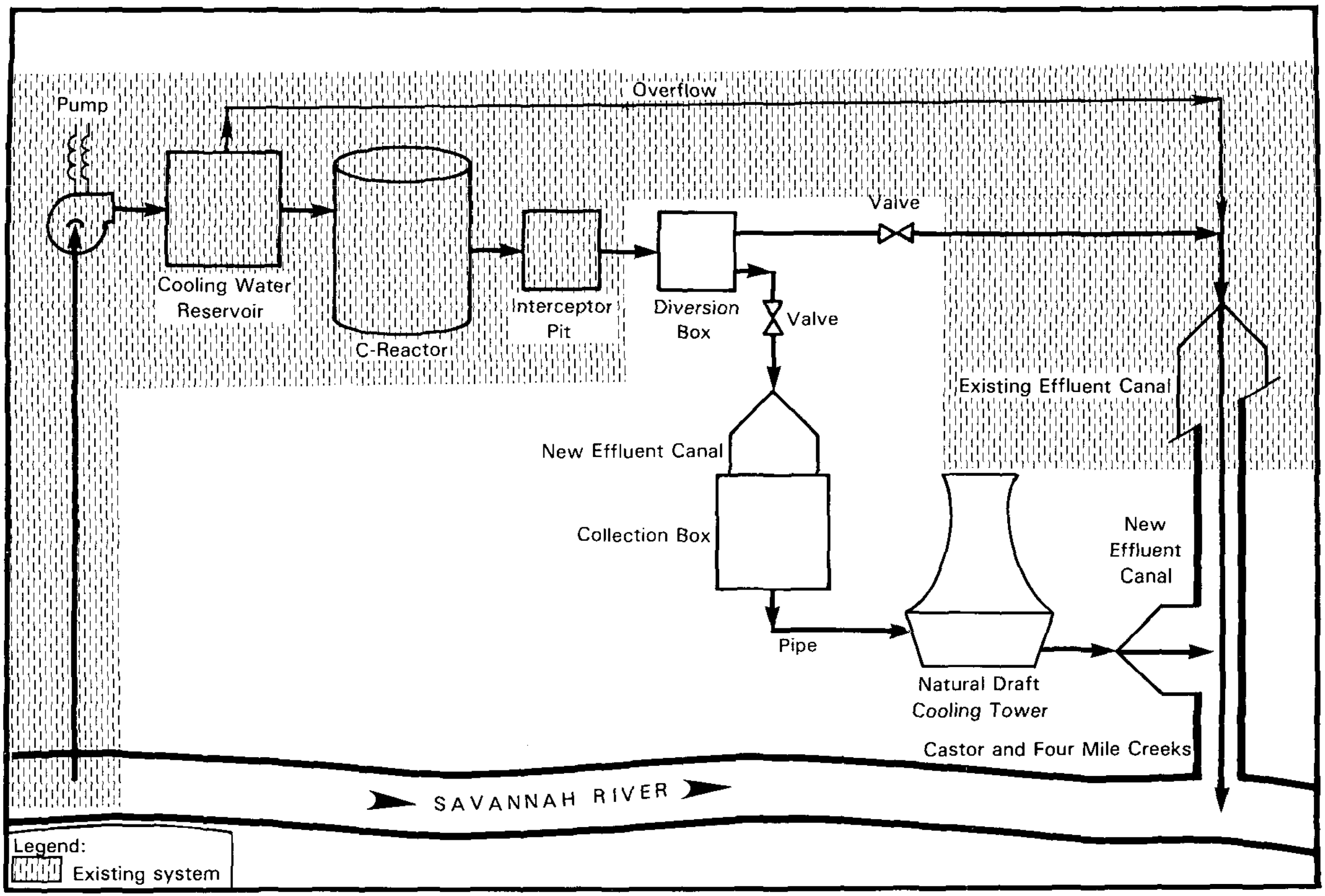
The once-through cooling tower described in the Thermal Mitigation Study (DOE, 1984b) and the draft EIS (DOE, 1986) is a mechanical-draft tower that would receive the cooling water from C-Reactor from a new pump pit. Cooled water from the tower basin would then flow by gravity to a 100-acre offstream holding pond, which would be used to dissipate chlorine (cooling tower biocide) 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. TC

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 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. AD-1 BB-1 BB-2 BB-3 BB-4 BC-6 BC-14

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

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. 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. TC



TC

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

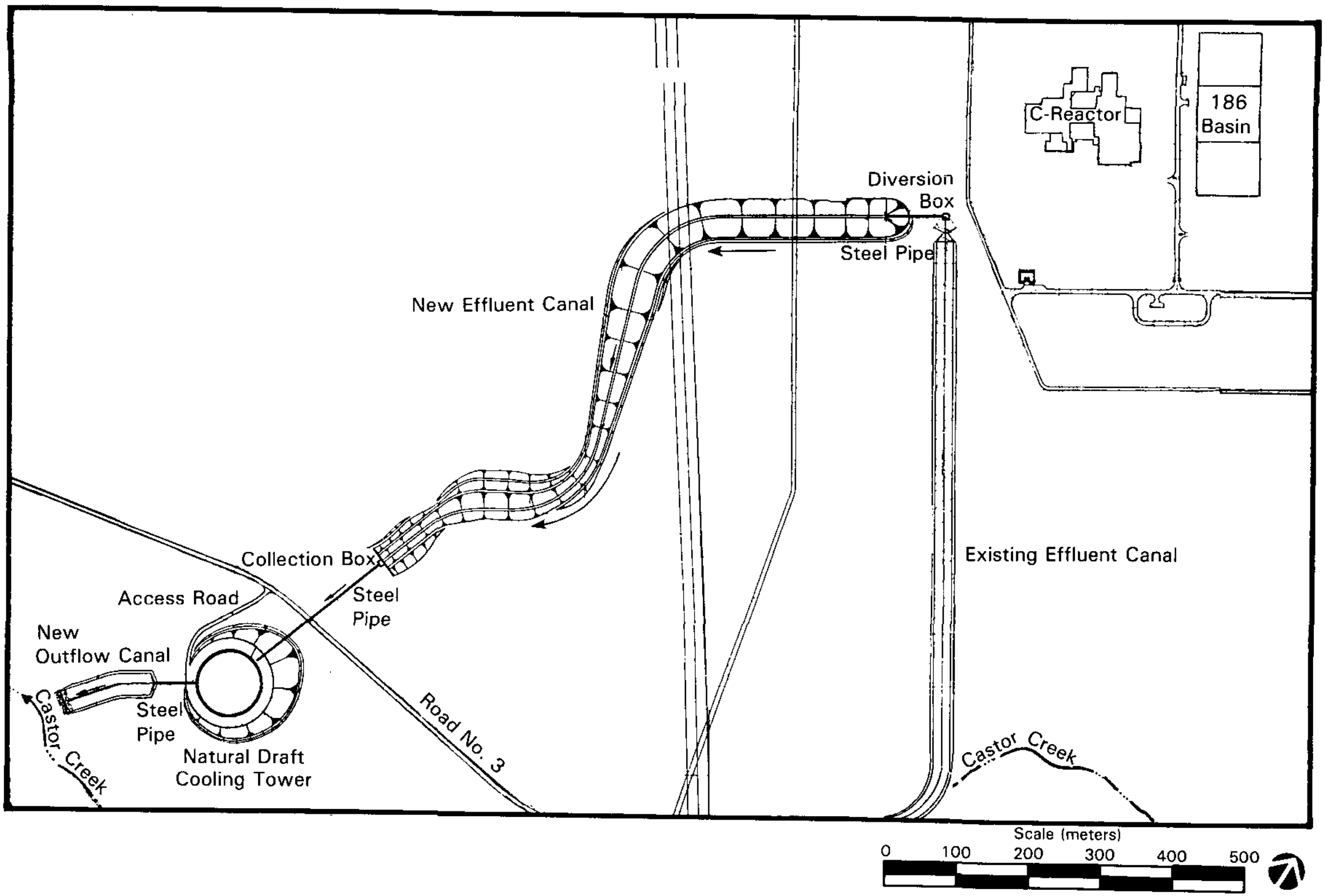


Figure 2-6. C-Reactor Once-Through Cooling Tower System

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 TC 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.

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 BB-1 would be injected into the cooling water stream at the tower inlet to prevent BB-2 biofouling in the tower system.

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.

Electrical loads for the gravity-feed, natural-draft cooling tower system TC 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 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). TC

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 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. TC

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, 1986). BC-14 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 maintained. TC

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 BB-1
suspended solids concentration would be reduced by settlement in the cooling- BB-2
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.

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.

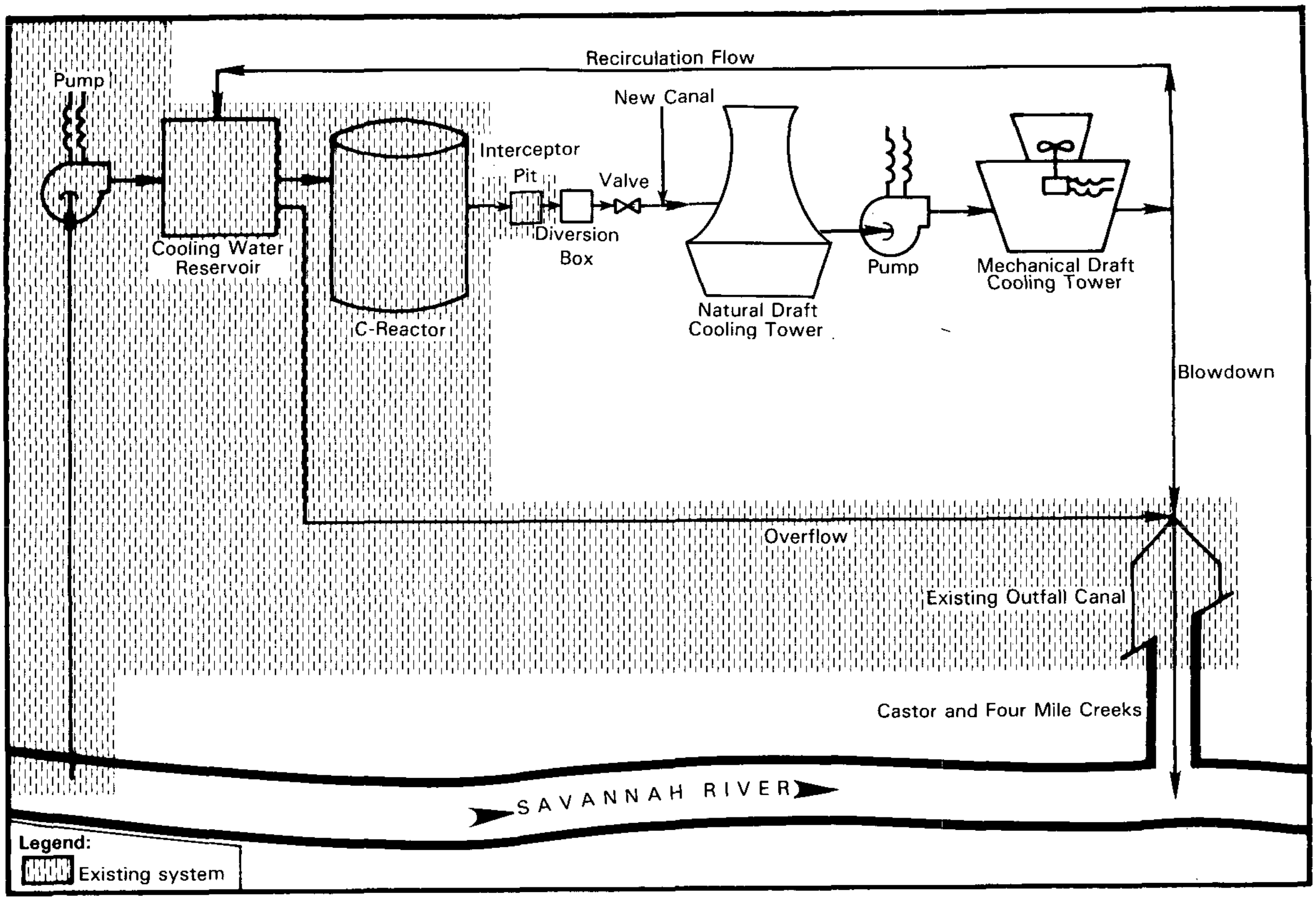
The present peak electrical load in C-Area is about 30.3 megawatts. An insignificant quantity of additional power would be required for lighting and other electrical equipment. TC

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, AD-1
the estimated cost to conduct a Section 316(a) demonstration study is $1.25 BC-6
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.

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 AD-1
and a site layout, respectively, of this recirculating system. 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



AO-1
BC-13

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

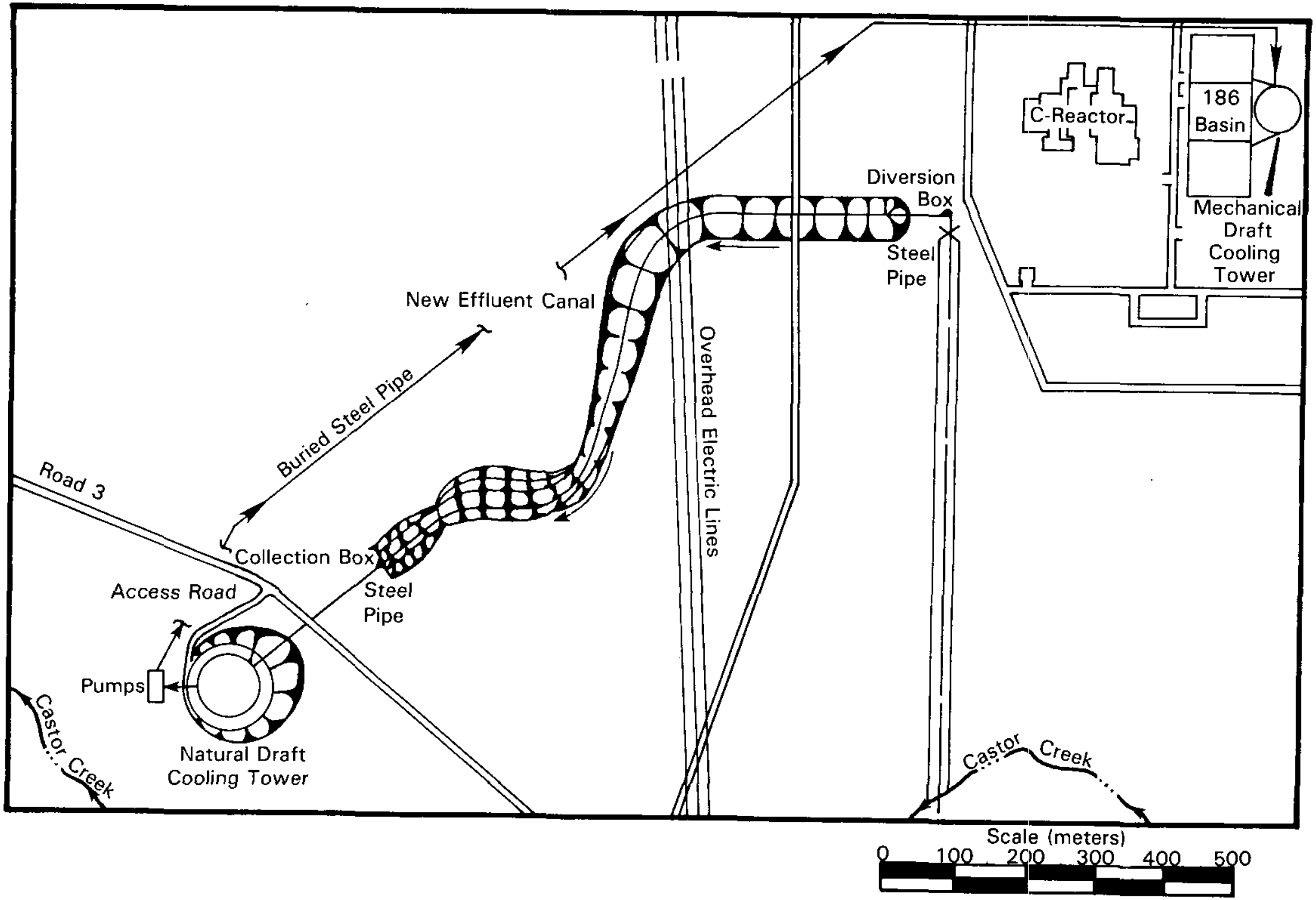


Figure 2-8. C-Reactor Recirculating Cooling Tower System

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)

BB-3
BC-14

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

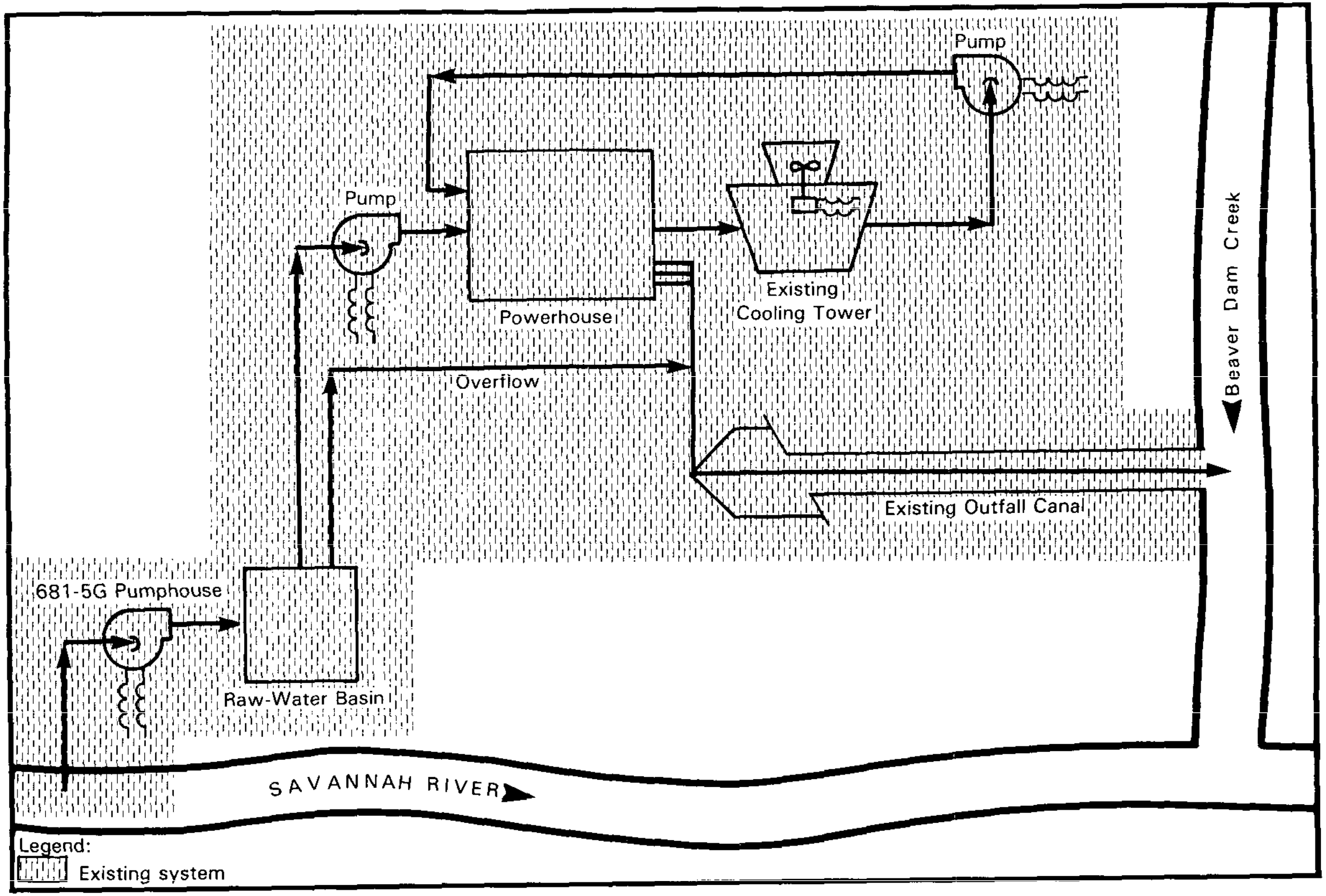


Figure 2-9. D-Area Existing System Flow Diagram

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 temperatures are based on measured values from 1985 and 1986. TC

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 Class B water classification standard of a maximum 2.8°C ambient rise in TC

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

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(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).

BB-3
BC-14

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.

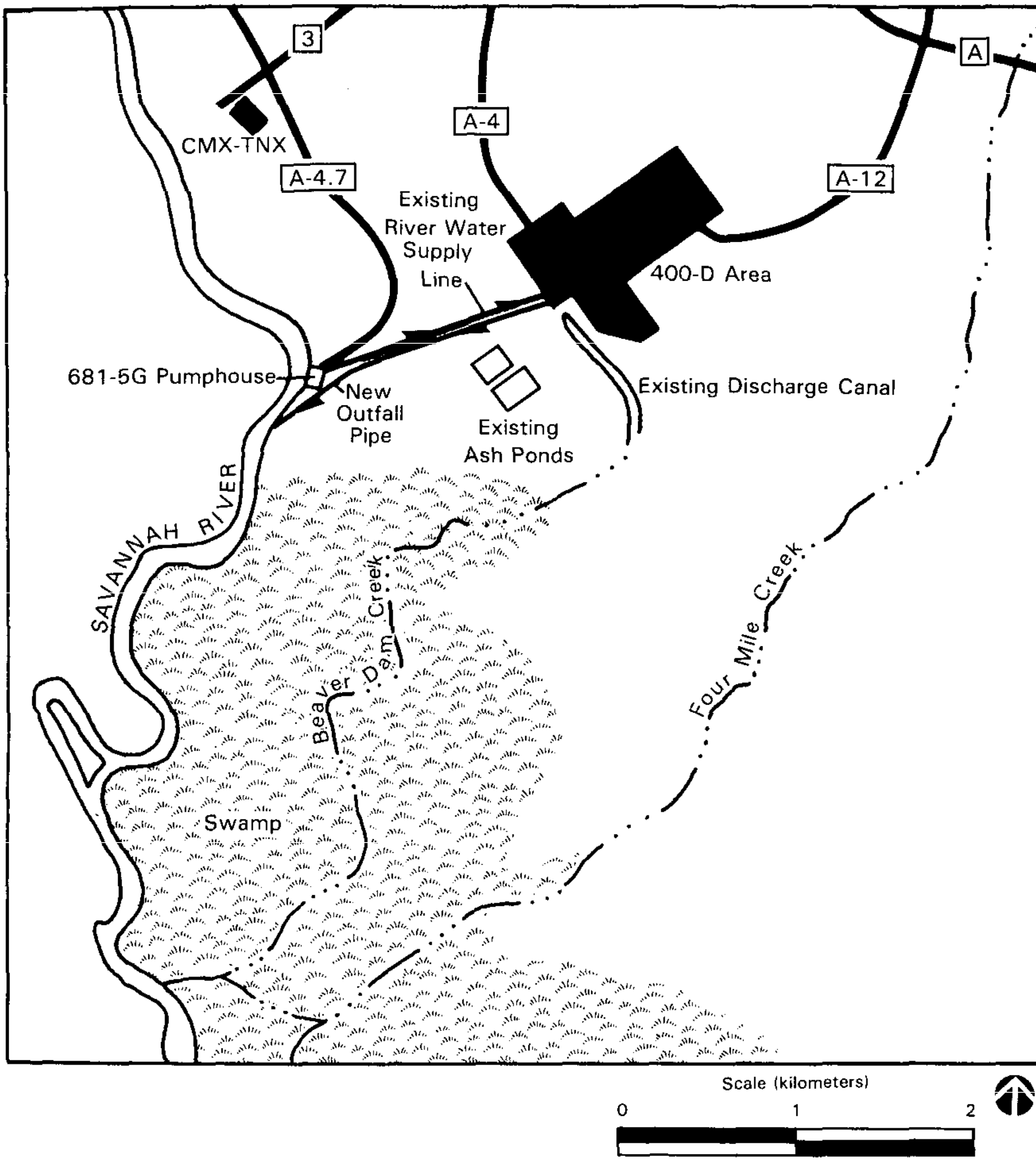
The estimated increase in annual operating cost for incremental electric consumption is $30,000. In addition, the cost to conduct a Section 316(a) demonstration study is estimated at $1.25 million.

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

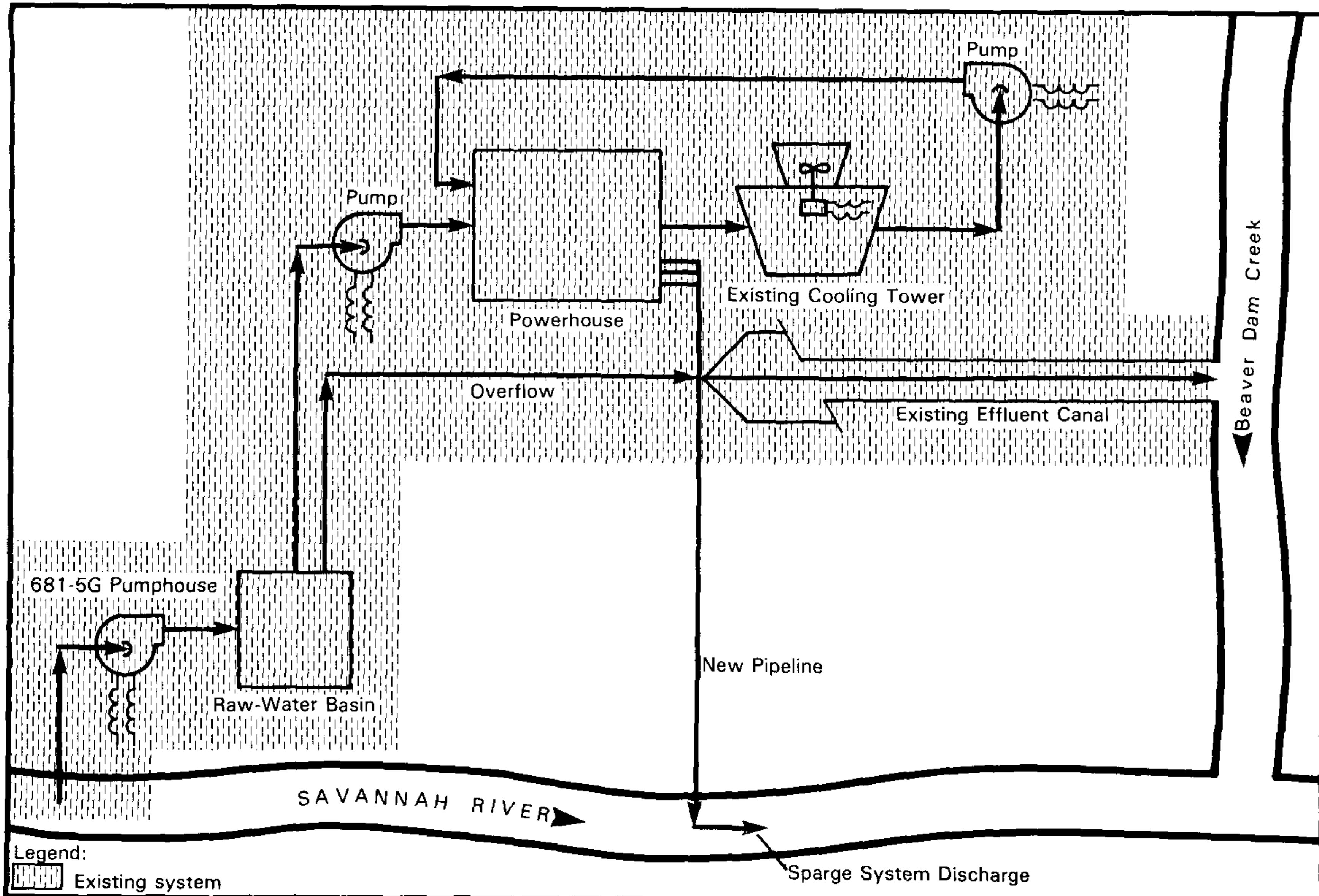


Figure 2-11. D-Area Direct Discharge to Savannah River Flow Diagram

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)

BB-3
BC-14

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).

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.

The following relative rankings of future wildlife effects were determined for
TC 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.

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
AD-1 would be greater for the recirculating system (7 millimeters versus less than
BC-13 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.

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
TC the reduced flow. The implementation of either the once-through cooling tower
BC-22 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 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.	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)

BC-22

BC-22

Impacts	No action[a]	Once-through cooling tower (preferred alternative[b])	Recirculating towers
	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	
- excluding production loss	$0	$42.4	$58.0	AD-1 BC-6
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 13.4×10^6 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.
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)

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.

BD-5

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.

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

AT-1
AT-2
AZ-1

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