The L-Area is not subject to local flooding. Pen Branch to the west and north, and Steel Creek to the east and south provide adequate drainage. Opposite L-Reactor these streams are at least 15 meters below the reactor floor elevation under normal flow conditions.

4.3 TRANSPORTATION

4.3.1 Onsite and offsite shipments

Onsite

The proposed restart of L-Reactor would increase the total number of onsite shipments by an amount typical of the individual reactor areas now operating. Rail shipments of irradiated fuel from the reactor to the separations plants could be made with existing casks and equipment using current rail crews. Truck shipments involving unirradiated reactor fuel, deionizer casks, and wastes could also be made with existing equipment using the SRP traffic and transportation (T&T) crews currently assigned to these tasks. Higher volume shipments, such as scrap metal, waste dumpsters, and D_2O drums, would require purchase of additional equipment and a modest increase in T&T crews. Also, the operation of L-Area would require about the same number of nonradioactive shipments by T&T and vendor trucks as the other individual reactor areas. No significant impact on SRP transportation systems is expected from the operation of L-Area.

Shipments on the SRP rail system would include the following:

1. Empty casks to transport reactor fuel elements.

2. Intact irradiated fuel in 70-ton casks (CD casks) on flatbed railcars to 200-F or 200-H areas.

3. Any irradiated fuel with cladding defects in a special containment device ("harp") within a 55-ton failed fuel element cask to a 200-Area.

4. Occasional containers of helium or Polybor or other nonradioactive materials.

Onsite truck shipments for L-Area would include the following:

1. Unirradiated fuel in steel shipping boxes and other reactor lattice components from the 300-M area.

2. Irradiated lithium-aluminum control rods and blanket assemblies in a 45-ton cask on a flatbed trailer from the L-Area disassembly basin to 200-H area.

3. Irradiated scrap metal in a 15-ton cask or replacement cask from the L-Area disassembly basin to the SRP burial ground (about 80 shipments annually).

4. Moderator (D_2O) in stainless steel 55-gallon drums to and from other reactor areas and the 400-D area where contaminant removal and purification facilities are located (about 700 drums annually).

5. D_2O purification deionizers from 100-L area. After the resin is depleted, the deionizer would be shipped to 100-K area in a cask on a special flatbed trailer for dedeuterization before being shipped to the burial ground (about three annually). A replacement D_2O equilibrated purification deionizer would be shipped concurrently from 100-K to 100-L area.

6. Basin water deionizers mounted in casks on a special trailer to Building 245-H area for regeneration and return to L-Area service (about five annually).

7. Liquid and gas samples on a pickup truck to laboratories on each shift.

8. Dry wastes in collection pans on a daily basis and boxes of wastes intermittently generated during jobs such as replacing containment filters to the SRP burial ground.

9. Liquid light-water wastes to the underground storage tank in 100-C area (infrequently) or, when volumes are large, to F-Area waste management tanks, in an unshielded tank trailer.

10. Nonradioactive materials to L-Area on Savannah River Plant or vendor trucks.

Offsite

Shipments from off the site to support L-Area operation would include petroleum distillate products from major distribution terminals in Augusta, Georgia, and Aiken County, South Carolina; chemicals from normal distribution points; solid depleted uranium and 1.1-percent uranium-235 from the Feed Materials Production Center in Fernald, Ohio; and highly enriched uranium metal billets from the Y-12 plant in Oak Ridge, Tennessee. The latter shipments would be safeguarded (see Section 4.3.2.2). Operation of L-Reactor would increase the amount of plutonium metal shipped offsite from Savannah River Plant in special safeguarded Department of Energy (DOE) vehicles and also would increase the number of DOE-escorted shipments of uranyl nitrate hexahydrate solution shipments to the Y-12 plant in Oak Ridge, Tennessee.

These offsite shipments of nuclear and other hazardous materials would be subject to the same Department of Transportation (DOT) regulations (49 CFR 170-179) as other similar cargo already in commerce.

Primary reliance for safety in the transport of hazardous materials, including nuclear material, is placed on the packaging. The nuclear packaging standards are established by DOT, DOE Orders, and some of the states through which materials are transshipped. These standards are established according to the type and form of material for containment, shielding, nuclear criticality safety, and heat dissipation. The standards for nuclear materials provide that the packaging shall prevent the loss or dispersal of the radioactive contents, retain shielding efficiency, assure nuclear criticality safety, and provide

adequate heat dissipation under normal conditions of transport and under specified accident damage test conditions (i.e., the design-basis accident). The quantity of material contained in packages not designed to withstand accidents is limited, thereby limiting the risk from releases that could occur in an accident. The quantity of material contained in a shipping package also must be limited so that the standards for external radiation levels, temperature, pressure, and containment are not exceeded.

Protection of the public from external radiation is provided by limitations on the radiation levels at the surface of, and at specified distances from, the outside of packages of nuclear materials and by storage and segregation provisions for such packages in transit. The number of packages in a single vehicle or area is limited to control the aggregate radiation level and to ensure nuclear criticality safety in the event of conceivable accidents. In addition, shipments of special nuclear materials such as plutonium and enriched uranium are safeguarded against theft or sabotage by use of DOE equipment and DOE couriers.

Nuclear materials shipped offsite are packaged by the operating contractor as required by DOT specifications with a DOE- or NRC-approved certificate of compliance for the packaging selected. The packaged material is transferred to the custody of DOE-SR, which becomes the consignor for the shipment.

Pollutant emissions

Pollutants would be released to the atmosphere from transportation operations associated with the L-Reactor operation. Table 4-26 lists the pollutant emissions from vehicles associated with L-Reactor operation that would occur both on and off the Savannah River Plant.

Table 4-26. Transportation-related nonradiological emission of pollutants associated with L-Reactor operation[a]

	Cars and light trucks	Trucks less than 10 tons	Trucks[b] off SRP site
Fuel	gasoline	diesel	diesel
Annual fuel consumption (liters)	147,600	64,300	199,900
Kilometers traveled per year	643,600	290,000	491,000
Annual emissions (kg)			
Particulates	215	850	1,440
Sulfur dioxide	160	310	530
Nitrogen oxide	2,000	1,720	2,910
Carbon monoxide	40,800	470	790
Hydrocarbons	3,550	1,050	1,780
Tire particulates	80	180	260

[a]Adapted from CRC Press (1972).
[b]Average 10-ton.

Transportation associated with L-Reactor operation at the Savannah River Plant is expected to consist of cars and light trucks for 643,700 kilometers burning 147,600 liters of gasoline and trucks weighing less than 10 tons for 241,000 to 491,000 kilometers burning 64,400 liters of diesel fuel each year. This would consist of an incremental transportation increase of 8 percent for the total Savannah River Plant. Neither the increased onsite or offsite transportation pollutant sources are expected to significantly impact ambient air quality.

The potential for transportation accidents involving shipments of materials offsite is assumed to be comparable to that for general truck transportation in the United States. Based on accident rates and injury and fatality rates (AEC, 1972; Clarke et al., 1976), 0.4 injury and 0.02 fatality are expected annually from truck accidents associated with offsite shipments of L-Reactor materials.

The potential for transportation accidents onsite with resultant injury or fatality is much less than for public highways. Shipments onsite are almost never made during shift change and occur when traffic densities on the SRP highways are very low. Therefore, the risk of injury or fatality from operation of vehicles onsite is much less than one per year.

4.3.2 Radiological impacts

4.3.2.1 Routine radiation exposures

Onsite transportation

Nuclear materials moved onsite are packaged to contain the material during transit and shielded to minimize radiation exposures to drivers, riggers, and others near the material during transportation activities. The DOE contract permits the operating contractor to use procedural controls, escorts, and traffic controls to transport materials onsite.

The 70-ton railroad casks used to ship irradiated reactor fuel are separated from the locomotive by one or two spacer cars. The incremental exposure to the rail crew is estimated to be less than 10 millirem per year, based upon 1979 and 1980 exposure records.

The casks used to ship irradiated materials from reactor areas by truck are mounted on assigned trailers and do not require rigging. The annual radiation exposures, averaged over a 6-year period, were 330 millirem per year or less to the drivers who exclusively transport scrap metal and deionizer casks from the three operating reactors. Radiation exposure records show that cumulative exposures to T&T employees average about 2 to 3 person-rem per year per reactor area for all rigging and transportation activities.

Offsite transportation

The radiation levels from offsite shipments on exclusive-use vehicles to or from SRP are well below DOT radiation limits for transportation of nuclear materials. Typical measured radiation levels from these shipments are (1) depleted uranium shapes - less than 1 percent of DOT radiation limits, (2) uranyl nitrate

uranium shapes - less than 1 percent of DOT radiation limits, (2) uranyl nitrate solutions in MC 311 cargo tanker - less than 2 percent of DOT radiation limits, and (3) safe secure transporter (SST) - about 10 percent of DOT radiation limits.

The radiological exposure from transportation of these nuclear materials from and to SRP is small, about 0.01 person-rem per year to the population along the shipping route; this subject was addressed in the NRC report, Final Environmental Statement on the Transportation of Radioactivity by Air and Other Modes (NRC, 1977a). Therefore, the consequences will not be examined in detail in this study.

4.3.2.2 Safeguards

Enriched uranium and plutonium resulting from L-Area operation would be
TC| shipped to and from Savannah River Plant in packages that meet the DOT Type A_2 requirements. These shipments would be safeguarded in the DOE's existing SST system with a courier escort. This transporter is essentially a mobile vault with built-in deterrent and disabling devices and special electronically coded locks set in vault-type doors; it is operated by carefully selected, specially trained personnel.

MC 311 or MC 312 cargo tankers are used to transport enriched uranyl nitrate hexahydrate solution. They are moved with SST tractors with a DOE escort.

4.3.2.3 Accident release risks

The cumulative risks from accidents during onsite transportation activities (in curies per year) for a single reactor are estimated to be about 2×10^{-3} curie beta-gamma per year, 2×10^{-5} curie alpha per year, and 3×10^{-2} curie tritium per year, as shown in Table 4-27. The radiological risks expressed as curie-per-year values were calculated using the GASPAR code defined in NRC Regulatory Guide 1.109 (NRC, 1977b), as modified for accidental releases.

The calculated total-body radiological risk to the offsite population from accidental release of nuclear materials in transport to and from L-Area operation would be 1.1 person-rem per year and, to the maximally exposed member of the population, would be 0.017 millirem per year (Table 4-28).

In the NRC analysis of radiological risks from radionuclide transport, several serious accidents were postulated and the release of radioactive material was assumed. However, the consequences of most events were determined to be not severe. The most serious postulated accident results in one early fatality and exposure of 60 persons to significant levels of radiation. The probability of such an event was estimated to be less than 3×10^{-9} per year for shipping rates in 1975 and is expected to decrease further due to more stringent shipping requirements that have been initiated or are planned (NRC, 1977a). Uranyl hexahydrate solution is shipped in DOT MC-311 or MC-312 cargo tanks that might, after an accident, release uranyl nitrate solution on or near a bridge and could contaminate a stream supplying a public water supply. In an extreme

Table 4-27. Annual onsite risk during transportation for L-Area

Shipping operation	Risk (Ci/yr)[a]		
	Beta-gamma	Alpha	Tritium
Irradiated fuel	1×10^{-6}	1×10^{-9}	$\sim 2 \times 10^{-4}$
Unirradiated fuel		Very small	
100-Area sample trucks	--	--	$\sim 2 \times 10^{-2}$
Scrap metal		Extremely small	
Solid wastes	$<1 \times 10^{-6}$	$<1 \times 10^{-9}$	
Moderator shipments	--	--	$\sim 3 \times 10^{-3}$
Unshielded trailer shipments	2×10^{-3}	2×10^{-5}	
Deionizers			
Reactor basin	1×10^{-6}	1×10^{-9}	
Purification		Very small	
Total	2×10^{-3}	2×10^{-5}	$\sim < 3 \times 10^{-2}$

[a]Adapted from Du Pont (1982b).

Table 4-28. Annual radiological risk to the public from potential transportation accidents

Dose commitment	Risk	
	Maximum individual (mrem)	Population (person-rem)
Total body	1.66×10^{-2}	1.12
Bone	5.31×10^{-1}	3.55×10^{1}
Lung	5.29×10^{-2}	2.68
Liver	6.07×10^{-2}	3.96
Thyroid	8.29×10^{-5}	9.52×10^{-3}
Kidney	4.61×10^{-2}	3.01
GI-tract	7.33×10^{-4}	4.93×10^{-2}

accident scenario involving a major fire, some respirable particulates might be generated. The integrated radiological risk to the population along the route from these scenarios is about 2×10^{-6} person-rem per shipment.

4.4 L-REACTOR MITIGATION ALTERNATIVES

This section includes evaluations of the following mitigation alternatives: safety-system alternatives, cooling-water alternatives, and alternatives for the

disposal of liquid waste and 186-Basin sludge. This section describes the effects of the possible implementation of each of these alternatives and its mitigation costs and schedules.

4.4.1 Safety-system alternatives

In part because of their low-temperature, low-pressure operation, SRP reactors have a low potential for an accidental widespread dispersion of radioactivity. Also, SRP reactors are equipped with instrumentation, computer controls, supplementary shutdown systems, and multiple cooling systems that provide a high degree of safety assurance against accidents that might cause fuel melting and releases of radionuclides to the environment. The following systems are being considered to mitigate potential accident consequences:

- Remote storage system
- Low-temperature adsorption system
- Tall stack
- Internal containment system
- Leaktight dome

After a brief description of each system the systems are compared using the following measures:

1. Technical feasibility
2. Capital cost
3. Cost of lost production
4. Total cost
5. Benefit in extra person-rem averted beyond existing confinement system performance
6. Cost/benefit ratio in dollars per extra person-rem averted, assuming an accident occurs
7. Timing

4.4.1.1 Existing confinement system (preferred alternative)

SRP reactors were built in the early 1950s, before containment systems became an accepted practice for nuclear reactors. In the 1960s, a variety of containment/confinement systems were considered for SRP reactors; the vented confinement system was selected as the optimum balance between cost and risk. The cost of a containment vessel over the large, sprawling SRP reactor buildings is considered to be impractical compared to the risk associated with improbable reactor accidents.

SRP reactors are designed and operated to make the melting of fuel or target material, with the consequent release of radioactivity to the environment, highly improbable. Nevertheless, these reactors are equipped with a confinement system, which consists of a series of filters through which air is exhausted from the reactor building. This system traps moisture and particulates and absorbs radioactive iodine on carbon filters. Noble gases and tritium would pass through the system and would be exhausted to the atmosphere from a 61-meter stack.

The confinement systems for the SRP reactors are not subject to overpressurization because the system is vented through filters and a stack. Furthermore, these reactors operate at a coolant temperature and pressure much lower than a commercial power reactor. The "stored energy" within an operating SRP reactor is much less than that within an operating power reactor; therefore, the risk of overpressurization is much less.

Calculated offsite doses for average meteorology with this system do not exceed 0.39 rem to the whole body and 1.5 rem to the thyroid of the individual receiving the maximum exposure for the range of postulated accidents. |TC

4.4.1.2 Remote storage system

Among several possible improvements to the confinement system is a remote storage system, as illustrated in Figure 4-13. In this system the reactor room exhaust is separated from other reactor-building exhausts and fed through a large online storage tank, as shown in Figure 4-13. Nearly 1 hour of normal reactor room exhaust flow could be contained in the long storage tank. One hour after an accident, the storage tank would be isolated so that the initial release of radioactive material would be trapped. Any further effluent from the reactor room would bypass the storage tank. Downstream of the storage tank, the reactor room exhaust flow joins flow from the purification and below-grade areas, such that all building exhaust flow (except from assembly and disassembly) passes through a large sand filter and underground carbon filters. Thus, releases of noble gases and tritium occurring during the first hour would be retained and radioactive iodine and airborne particulates would be captured regardless of the source or duration of the accident. |TC

Exhaust from either purification (e.g., blanket gas-venting) or below-grade areas (e.g., heavy-water spills) can be procedurally diverted into the storage tank (see Figure 4-13) to improve control of other minor incidents. A 300-meter stack would help mitigate the consequences of a possible upstream failure to contain the release. It is included as a part of this alternative.

4.4.1.3 Low-temperature adsorption system

Another possible improvement to the confinement system is a low-temperature solid-adsorption system using hydrogen mordenite as a noble gas adsorbent in addition to more conventional filters. Laboratory experiments have been conducted and a concept has been proposed for this multipurpose system. However, this concept would require much more development work before engineering feasibility

could be demonstrated. This system is schematically illustrated in Figure 4-14. The reactor-room air flow is separated from other process area exhaust flow. During normal operation, all of the exhaust air from the reactor room and the process areas passes through the filter compartments just as it does with the existing confinement system. Immediately following an accident the reactor room exhaust flow would be diverted through a separate filter train powered by a new 8500-cubic-meter-per-hour fan before it entered the normal operation filters. The noble gas adsorption train would have to be designed compact enough to be placed within the reactor room. The diverted reactor room exhaust air would first pass through a hydrogen recombiner, a high efficiency particulate filter, and a special iodine trap. The bulk moisture and tritium would then be removed in a combination chiller/molecular sieve trap before the air passes through multiple low-temperature (-40 to -60°C) adsorption beds of hydrogen mordenite. This system is expected to remove about 99 percent of the noble gases and tritium released in addition to providing much better iodine retention.

4.4.1.4 Tall stacks

Tall stacks for the reactor exhaust have been considered as a means of increasing the dispersion of reactor effluents. They can provide an appreciable reduction in exposure to the maximum individual onsite doses near the reactor and reduce site boundary doses. However, the tall stack concept does not reduce population dose as well as the other concepts.

4.4.1.5 Containment system

Commercial power reactors in the United States are built in large cylindrical buildings, which serve as containment vessels. They usually are built of heavy reinforced concrete with steel liners that are relatively leak-tight under moderate pressure. Such a containment is designed to withstand the pressure (about 0.34 megapascal) that would result if the reactor piping system suddenly burst and released the reactor coolant (steam and water at about 15.2 megapascals of pressure and 293°C) to the reactor building. The containment would retain most of the fission products, even in this improbable situation. A small amount of leakage of fission products from the containment system is permitted and has been accepted by NRC as having extremely small impacts.

The following paragraphs describe two variations of a containment system for SRP reactors.

<u>Internal containment structure</u>

In this concept, a leaktight containment zone would be created inside the existing building. A leakage rate below 1.7 cubic meters per hour might be achieved with this system, but continued maintenance to achieve this standard would be very difficult.

The internal containment zone would consist primarily of the actuator tower, the reactor process room (extended out to include the charge and discharge machine service area and up to enclose the shield door gantry), the heat exchanger bay (beyond the cooling-water headers), and the main pump rooms. The entire containment zone would be lined with steel plate (Figures 4-15 and 4-16) backed by several concrete floor and wall thicknesses. Penetrations would be seal-welded in most cases and nonshrink grout would be used to seal the inside of conduits and cable trays. Special closures would be installed for the discharge and exit canal, presentation point, corridors, personnel doors, pump shaft penetrations, etc.

A heat-removal system would be provided to prevent pressurization from the heat released after a meltdown accident. A deluge spray system would cool the open volume inside the containment zone. After use of the initial supply of water from the disassembly basin and the 186-Basin, the water would be recycled from the -40 floor through a heat exchanger and back through the spray nozzles.

A new recirculating ventilation system would also be needed for the containment zone. This system would always be online except for purging during shutdowns. The existing once-through ventilation system (throttled appropriately) would serve the reactor building outside the containment zone. During normal operation, 10-percent outside makeup air would be admitted into the actuator tower and the crane service area to keep these areas accessible.

External containment structure

Another containment concept for the SRP reactors would be a leaktight dome structure over the entire reactor building complex (the stack would protrude). While theoretically possible, such a massive dome would be, at best, a formidable engineering challenge.

The dome itself would be a concrete structure semi-ellipsoidal in shape approximately 183 meters in diameter at the base and 61 meters high. The concrete would be lined with welded steel plating to achieve leaktightness (less than 0.1 percent leakage of the enclosed volume per day). The below-grade areas would also have to be sealed with steel plate to achieve the same standard of leaktightness. Extensive modifications to the existing ventilation system would be required to supply the new dome and to isolate and recirculate air inside the dome following an accident.

4.4.1.6 Comparison of alternatives

Table 4-29 provides the various measures of comparison outlined above for the alternative safety systems described. The existing confinement is the preferred alternative. The cost-benefit ratios per person-rem averted all appear extremely high for any of the alternatives compared to the present confinement system, particularly when the benefit includes the probability of the hypothesized accident occurring. By comparison, EPA (1976) has recognized a range from $250,000 to $500,000 per health effect averted as reasonable. (This range corresponds to a range from $30 to $60 per person-rem averted based on BEIR III estimates of cancer fatalities.) NRC has assigned a different (and larger) value of $1000 per person-rem as a basis for estimating the need for additional

equipment to reduce public exposures from radioactivity in effluents from nuclear power plants (10 CFR 50, Appendix I).

4.4.2 Cooling-water alternatives*

4.4.2.1 Introduction

The L-Reactor secondary coolant system would withdraw water from the Savannah River. This water would be pumped from the river through pipelines into the 95-million-liter 186-L cooling-water reservoir. From there it would flow through heat exchangers that transfer heat from the heavy-water primary coolant to the secondary cooling water. Under the reference case (direct discharge to Steel Creek), the heated river water would leave L-Reactor at a rate of about 11 cubic meters per second and at temperatures as high as 73°C; it would flow from the discharge canal into Steel Creek and then into the Savannah River.

The preferred cooling-water alternative of the Department of Energy is to construct a 1000-acre lake before L-Reactor resumes operation, to redesign the reactor outfall, and to operate L-Reactor in a way that assures a balanced biological community in the lake (i.e., to maintain 32.2°C or less for about 50 percent of the lake). The impacts of the 1000-acre cooling lake were bracketed in the Draft EIS by the 500-acre and 1300-acre cooling lakes. After L-Reactor is operating, DOE will conduct studies to determine the effectiveness of the cooling lake and to decide on the need for precooling devices to allow for greater operational flexibility. The preferred cooling-water alternative is discussed in detail in Appendix L.

This section describes possible thermal mitigation measures that could be implemented either before or after the restart of L-Reactor and their projected environmental effects, and assesses them with respect to meeting regulatory thermal criteria. Implementation of some of these alternative systems before direct discharge occurs would, to various degrees, reduce the environmental impacts to the Steel Creek system. If a cooling-water alternative is implemented after L-Reactor restart with direct discharge, the environmental impacts described in Section 4.1.1 would already have occurred. However, successional recovery of the Steel Creek system would begin after the mitigation alternative had been implemented. The extent of the successional recovery would depend on the thermal mitigation alternative implemented.

The evaluation of each alternative cooling system was based on its engineering feasibility, schedule, cost, L-Reactor production efficiency, and environmental effects. In general, the engineering costs presented in this section were based on limited design data. These costs can be used as a basis for a comparison of alternatives; however, they are not suitable for budgetary considerations. Schedules are based on normal construction work practices; some could be accelerated with increased costs. Estimates of construction personnel

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*Because of the extensive revisions to this section, vertical change bars have not been used.

requirements are also presented. Actual construction personnel requirements can vary based on the final construction design and schedule considerations. Both once-through and recirculating cooling-water measures have been considered to reduce the environmental impacts of the heated discharge. Alternative cooling systems include the following four categories: (1) once-through alternatives, including direct discharge (reference case); (2) cooling towers (including once-through, recirculation, and partial recirculation); (3) recirculation alternatives using lakes; and (4) other mitigation alternatives.

Steel Creek flows southwesterly from its headwaters near P-Area to the Savannah River swamp, where it is joined by flows from Pen Branch and Four Mile Creek. A delta has formed where Steel Creek adjoins the Savannah River swamp. After flowing through the swamp, Steel Creek discharges into the Savannah River. The length of Steel Creek from the L-Reactor outfall to the delta is about 11 kilometers. The distance from the delta to the confluence with the Savannah River is about 2 kilometers.

The average flow rate of Steel Creek is about 0.6 cubic meter per second at Road B; this includes natural flow (0.17 cubic meter per second) and some non-heated process water from P-Reactor (0.45 cubic meter per second) (Section 3.4.1.2). Table 4-30 lists ambient temperatures calculated for selected points along Steel Creek. Figure 4-17 shows monthly average ambient temperatures in Steel Creek at the L-Reactor outfall (calculated), at Road A (measured), and at the mouth of Steel Creek (calculated). Table 4-8 (Section 4.1.1.5) summarizes the water quality data for Steel Creek.

Table 4-30. Calculated ambient temperatures (°C) for selected locations along Steel Creek during summer, spring, and winter

Location	Summer[a]	Summer[b]	Spring[b]	Winter[b]
Near L-Reactor	33	29	22	8
Road A	33	29	22	8
Swamp at delta	33	29	22	8
Mid-swamp	29	26	19	6
Mouth of creek at river	30[c]	27[c]	21[c]	12[c]

[a]Based on worst 5-day meteorological conditions (July 11-15, 1980).
[b]Based on 30-year average values for meteorological conditions (1953-1982) and the actual power of an operating reactor.
[c]Temperature increase due to mixing with K-Reactor effluent.

Predicted water temperatures are based on monthly average winter, spring, and summer meteorological conditions from 1953 to 1982; the extreme summer meteorological conditions are based on the most severe 5-day period from 1976 to 1980 (July 11 to 15, 1980). Five-day, worst-case meteorological conditions provide the basis for a conservatively high estimate of discharge and downstream temperatures that are likely to result from the implementation of a thermal mitigation alternative. The selection of 5-day worst-case meteorology is also based on a typical cycle of consecutive meteorological conditions; it is considered representative of extreme temperatures for which the maintenance of a

balanced biological community can be measured under Section 316(a) of the Federal Water Pollution Control Act of 1972. Summer average temperatures have been included to show the discharge and Steel Creek temperatures that could be expected if significant temperature excursions above and below average did not occur.

Several of the cooling-water alternatives described in the following sections would require borrow pits or spoils piles, and could cause siltation. Borrow pits of suitable materials and similar quantities have been used in the past at the Savannah River Plant. For the alternatives described in the sections that follow, the most economically suitable pit would be identified and reclaimed.

Spoil piles of the size expected have also been developed for past construction activities at the Savannah River Plant and have met the necessary environmental control requirements. In this particular instance, spoil from any excavation in the former floodplain of Steel Creek would be monitored for radioactive species and would be disposed of in a suitable manner if such activity is found to be necessary.

Siltation would be controlled during all phases of construction.

Chapter 7 presents Federal and State environmental requirements applicable to the resumption of L-Reactor operation. These requirements emphasize air quality, water quality (including thermal discharge limits), the disposal of solid and hazardous wastes, the protection of fish and wildlife, and the preservation of cultural resources.

Appendix I describes floodplain and wetlands impacts associated with each alternative.

In recognition of the requirements for the discharge of dredged or fill material related to the potential construction of certain cooling alternatives discussed in this section, each alternative description contains information, as appropriate, on effects of such discharges pursuant to Section 404 of the Clean Water Act of 1977 and EPA regulations (40 CFR 230).

4.4.2.2 Once-through alternatives

Eleven alternative cooling systems that would receive direct discharge for L-Reactor have been evaluated. These include (1) the reference case (direct discharge), (2) a spray canal, (3) small lakes without sprays and with one or two sets of sprays, (4) a 500-acre lake without sprays and with one or two sets of sprays, and (5) a 1000-acre lake without sprays. Each would discharge heated effluent into Steel Creek at a rate of about 11 cubic meters per second. Two other alternatives would divert the discharge effluent into Pen Branch at about the same temperature and flow rate. The following sections describe and evaluate the environmental consequences of these various alternative cooling systems.

For once-through alternatives that require the use of a cooling lake, DOE will perform safety analyses for the design of the embankment to assure its stability during construction, closure, filling, drawdown, and under all conditions of lake operation, including appropriate earthquake loading. The design

will also assure that the embankment is safe against overtopping during the inflow of the design flood and during wave action. The purpose of these analyses will be to assure public safety, because a failure of the cooling-lake embankment could have adverse impacts on portions of the Seaboard Coast Line Railroad and South Carolina Highway 125 (SRC Road A) where they cross Steel Creek or other onsite streams below a cooling lake.

Impounded water for a cooling lake would cause a local ground-water mound in the water-table aquifer. This effect would dissipate with depth and is expected to have only a small effect on water levels in the McBean Formation. The green clay is an important confining unit separating the McBean from the underlying Congaree Formation. It would prevent the increased head associated with a cooling lake from impacting the head differential between the Tuscaloosa and Congaree Formations (see Figure 3-9). It is also an important barrier to the migration of contaminants from near the surface to lower hydrostratigraphic units. In the Separation Areas, the green clay (about 2 meters thick) supports a head difference of about 24 meters between the McBean and Congaree Formations. Based on water samples obtained for tritium analysis from the Congaree near the H-Area seepage basin, the green clay has effectively protected the Congaree ground water from contamination seeping into the ground (Marine, 1965). In the L-Area, the green clay is about 7 meters thick. At the Par Pond pumphouse along the strike of the McBean and Congaree Formations, the green clay also supports a large head difference; the water pumped from the Congaree Formation shows no evidence of tritium contamination, even though tritium concentrations in that lake were measured at 27,000 picocuries per liter. Water pumped from the Congaree by the pumphouse well exhibited tritium concentrations of 170 picocuries per liter or less in comparison to concentrations of 260 ± 60 picocuries per liter in offsite well water (Ashley and Zeigler, 1981).

4.4.2.2.1 Direct discharge to Steel Creek (reference case)

During direct discharge, heated cooling water would enter Steel Creek at the end of the existing outfall canal (as shown on Figure 4-18); the water would cool gradually as it flows to the river through the lower reaches of Steel Creek and the Savannah River swamp (Figure 4-19). No construction would be required. Because reactor discharge and associated impacts would be similar to those that occurred during previous L-Reactor operation, this alternative is called the "reference case."

The reference case would require no new structures, equipment, or capital costs. The present worth (based on a discount rate of 10 percent and operating cost for a period of 20 years) would be $29 million, and the annualized cost (for this alternative, the same as the operating cost) would be $3.4 million. Operating costs would be associated primarily with pumping the secondary cooling water from the Savannah River to the 186-L basin and with pumping water through the reactor heat exchangers (Du Pont, 1983d).

This alternative would use about 11 cubic meters per second of water from the Savannah River. Water would be discharged at a rate of 10.9 cubic meters per second (minor evaporative losses). Direct discharge is the only option available that would allow L-Reactor operation to begin in 1984. As the reference case, it has a 100-percent production efficiency.

The temperature of the water discharge would vary by month; it would depend on the temperature of the supply water from the Savannah River and on the

operating power of the reactor. The operating power would vary with the temperature of the water used for cooling. Figure 4-20 shows the estimated downstream temperatures in Steel Creek in the spring, summer, and winter. Table 4-31 lists downstream temperatures for this alternative.

Table 4-31. Temperatures (°C) downstream in Steel Creek with direct discharge

Location	Summer[a]	Summer[b]	Spring[b]	Winter[b]
Discharge temperature[c]	73[d]	71	69	66
Road A	54	53	50	46
Swamp at delta	46	45	41	36
Mid-swamp	37	35	31	25
Mouth of creek at river	34	33	28	21

[a]Based on worst 5-day meteorological conditions (July 11-13, 1980) and estimated operating power of reactor. Five-day worst-case meteorological conditions provide the basis for a conservatively high estimate of discharge and downstream temperatures that are likely to result from the implementation of a thermal mitigation alternative. The selection of 5-day worst-case meteorology is also based on a typical cycle of consecutive meteorological conditions; it is considered to be representative of extreme temperatures for which the maintenance of a balanced biological community can be measured under Section 316(a) of the Federal Water Pollution Control Act of 1972.

[b]Based on 30-year average values for meteorological conditions and actual power of an operating reactor. Summer average temperatures have been included to show the discharge and Steel Creek temperatures that could be expected if significant temperature excursions above and below average did not occur.

[c]The temperature of the water entering Steel Creek.

[d]The secondary cooling-water discharge temperature during extreme summer meteorological conditions has been reduced to 73°C. This reduced discharge temperature reflects reduced reactor operating power to compensate for increased temperatures in the cooling-water supply drawn from the Savannah River during the warmest summer months.

Direct discharge would not provide thermal mitigation. The 73°C maximum discharge temperature from this alternative would be well above the 32.2°C discharge limit promulgated by the State of South Carolina. Because of the high discharge flow rates, Steel Creek temperatures would approach the cooling-water discharge temperature near the outfall. This alternative would result in year-round noncompliance with State discharge limits in Steel Creek, but could be in compliance in the Savannah River when a mixing zone is considered.

Initially, direct discharge will eliminate about 730 acres of wetlands in the Steel Creek corridor, the Steel Creek delta, and the Savannah River swamp. These wetlands, which have become established during the past 15 years through the process of natural succession, are structurally different from the closed

canopy of mature cypress and tupelo gum that existed before the SRP began operations (Sharitz, Irwin, and Christy, 1974). Furthermore, these wetlands are classified as Resource Category 2 by the U.S. Fish and Wildlife Service. This resource category and designation criteria include "high value for evaluation species and scarce or becoming scarce." The mitigation planning goal specifies that there be "no net loss of inkind habitat value" (USDOI, 1981). The vegetation of the corridor, which extends from the L-Reactor outfall to the delta, consists primarily of forested (73 percent) and scrub-shrub (24 percent) wetlands. The dominant flora of the forested wetland is alder, wax myrtle, and willow. Alder dominates the scrub-shrub wetland. Between 310 and 420 acres of the Steel Creek delta, which is dominated by forested (45 percent) and scrub-shrub (36 percent) wetland, would also be eliminated; this includes feeding and roosting habitat for 1200 mallards and 400 wood ducks.

Fish and other food sources would no longer inhabit the impacted Steel Creek or the delta-swamp area. Although 2280 acres of the wetlands along Steel Creek above L-Area and along Meyers Branch above its confluence with Steel Creek would not receive direct thermal discharges, access to these areas by fish from the Savannah River would be restricted. The entrance to Boggy Gut Creek, an offsite tributary immediately downriver of Steel Creek, could be blocked by the thermal plume at times and fish access would be limited. Wetland areas of Boggy Gut Creek total about 230 acres.

Thermal plumes in the Savannah River resulting from SRP operations (including L-Reactor), Vogtle Nuclear Power Plant (under construction), and the Urquhart Power Plant at Beech Island would not interact. A zone of passage for anadromous fish and other aquatic organisms would exist in the river near the Savannah River Plant.

The thermal plume in the Savannah River would increase the overall river temperature by less than 0.8°C about 2.4 kilometers downstream after total mixing; the calculated 1-week-in-10-year maximum increase resulting from SRP operations, including L-Reactor, would be 2.3° to 2.4°C. The expected thermal impacts of direct discharge in the river would be small, except near the mouth of Steel Creek, where temperatures could be high enough to exclude the creek and portions of the swamp as spawning areas for riverine and anadromous fish.

Before 1982, the endangered shortnose sturgeon had not been reported in the middle reaches of the Savannah River near the Savannah River Plant. In 1982, two shortnose sturgeon larvae were collected at River Mile 157.3, which is upstream from the 1G pumphouse. In 1983, seven shortnose sturgeon larvae were collected, five in the Savannah River adjacent to SRP (two from the canal and three from the river). Two larvae were also collected at River Miles 79.9 and 97.5, both of which are more than 60 miles downriver from SRP. Thus, impingement or entrainment could cause some larval mortality (ECS, 1983b). DOE included these factors and other data in the biological assessment and consultation process with the National Marine Fisheries Service, which concurred that this alternative would have no adverse effects on the shortnose sturgeon (Oravetz, 1983).

An estimated 23 to 35 individuals of the endangered American alligator inhabit parts of Steel Creek from the L-Reactor outfall to the cypress-tupelo forest adjacent to the Steel Creek delta; they also use areas lateral to Steel Creek, including Carolina bays, backwater lagoons, and beaver ponds. This

species is described in greater detail in Section 4.1.1.4 and Appendix C. Direct discharge would eliminate feeding and breeding habitat in the Steel Creek corridor and portions of the swamp. The mobility of adult alligators should eliminate any mortality due to the direct impact of heated water. Juveniles would have greater difficulty avoiding thermal effluents, and would be exposed to greater predation. DOE included these factors and other data in the biological assessment and in continuing consultations with the U.S. Fish and Wildlife Service (Sires, 1983).

The wood stork is classified as threatened by the State of South Carolina, and as endangered by the U.S. Fish and Wildlife Service. A total of 478 observations was made in the Savannah River swamp in 1983, of which 102 were in the Steel Creek delta. Although roosting by the wood stork in the Steel Creek area is infrequent, the Steel Creek delta represents an important foraging site for breeding storks from the Birdsville rookery. This alternative would eliminate this foraging habitat. DOE will include these factors and other data in the biological assessment and consultation process with the U.S. Fish and Wildlife Service.

The fish egg and larvae entrainment produced by this alternative would result in 7.7×10^6 additional eggs and 11.9×10^6 additional larvae lost annually because of water requirements by L-Reactor. Based on 1982 and 1983 sampling data, these totals represent approximately 3 to 6 percent of the fish eggs and larvae in the Savannah River water passing the intake canal. This alternative would cause an estimated 16 additional fish per day to be impinged on the intake screens (5840 annually; average fish weight would be about 14 grams).

This alternative would remobilize and transport radiocesium from the Steel Creek system when cooling-water discharges resume. Approximately 4.4 ± 2.2 curies of radiocesium would be transported from the creek during the first year of resumed operations. Thereafter, radiocesium transport would decrease by an estimated 20 percent per year (Section D.4). Expected maximum concentrations in the Savannah River would average less than 0.5 picocurie per liter during average flow conditions. The Beaufort-Jasper County and Cherokee Hill (serving Port Wentworth, Georgia) water-treatment plants obtain their raw water from the Savannah River more than 100 river miles downstream from Steel Creek. Finished (potable) water from these plants is expected to contain no more than 0.09 picocurie of cesium-137 per liter, or 2200 times less than the EPA drinking-water standard (200 picocuries per liter).

In the tenth and subsequent years, L-Reactor would discharge about 14,600 curies of tritium each year to the environment via liquid effluent. About 75 percent of this total would be diverted to a low-level radioactive seepage basin; about 30 percent of the tritium discharged to the seepage basin is expected to evaporate. About 6000 curies per year would be discharged to Steel Creek via ground-water transport (assuming radioactive decay during the 4.4-year travel time to the outcrop, but neglecting dispersion effects). The remaining 25 percent (approximately 3600 curies per year) would be carried in the cooling water (Table 4-9).

Five archeological sites eligible for listing on the National Register would be subject to erosion and flooding from the implementation of this alternative. These include one prehistoric site and four historic sites. Cold water

testing has indicated that erosion is occurring. A mitigation plan of rip-rapping is being designed whereby these sites will be protected in accordance with the Archeological Mitigation Plan. This plan has been approved by the South Carolina State Historic Preservation Officer (SHPO) and the Advisory Council on Historic Preservation (ACHP) (Lee, 1982). This mitigation is being designed by the Institute of Archeology and Anthropology of the University of South Carolina and will be completed prior to restart.

Steel Creek has received various reactor effluents since 1954, which have impacted its substrate accordingly. Increased flows that were sometimes an order of magnitude above normal altered the erosion-sedimentation patterns of the stream corridor (Smith et al., 1981). Upstream areas where stream gradients are high (7.8 meters per kilometer near L-Reactor) are severely eroded; downstream areas with low gradients (1.0 meter per kilometer near Cypress Bridge) receive sediments that drop from suspension as the water velocity decreases. Suspended solid loads in Steel Creek reached levels of 99 milligrams per liter during large rainfall storm events (Giesy and Briese, 1978) and declined from 80 milligrams per liter at Road A-14 to 14 milligrams per liter at the HP monitoring station at Cypress Bridge on Steel Creek during flows as high as 4 cubic meters per second in 1980.

This alternative would require no dredging and filling; thus, the substrate would not be affected by these activities. However, the combination of increased flow and temperatures would have adverse impacts on the substrate of Steel Creek. This substrate consists of Bibb sandy loam (Figure C-2); it is stabilized by macrophytic vegetation. The direct discharge of cooling-water effluent from L-Reactor would increase the flow rate at the outfall from about 0.6 (which includes the natural Steel Creek flow measured at Road B and some nonheated process water from P-Reactor) to about 11.4 cubic meters per second (1.36 for natural and P-Reactor discharges + 10.9 for L-Reactor cooling water - 0.85 consumptive use = 11.4) at Cypress Bridge, about 2.8 kilometers below Road A. The resulting erosion of upstream segments and the deposition downstream would alter the substrate elevation and contour of the Steel Creek corridor, scouring and burying vegetation. North of Road A, only vegetation rooted above the water level is expected to survive. The anticipated maximum delta growth rate at the swamp would be 3 surface acres per year from the deposition of sediments. No alteration of substrate elevation or contours of the Savannah River is expected.

In Steel Creek, reduced light penetration caused by turbidity from suspended particulates would lower the photosynthetic rates of those remaining thermotolerant and thermophilic algae, such as blue-greens. The reduction and elimination of submerged vegetation could create locally high oxygen demand due to decomposition.

Spawning and feeding success by the remaining fish species that move to avoid the heated effluent would be reduced due to siltation by suspended particulates from the initial restart of the reactor. This impact is expected to decrease as the turbidity decreases and sediments become more stable. As the effluent moves away from the reactor outfall and flow velocities decrease, turbidity would decline and more organisms would occur, beginning with those most tolerant to siltation effects. The expected total suspended and dissolved solid

concentrations at Road A would be much less than the water-quality/drinking-water standard (Table 4-6). As discussed in Section 4.1, no significant impact on swamp-water quality is expected.

As listed in Table 3-6, Steel Creek has a varied history with regard to the release of reactor effluents. The release of thermal effluents into Steel Creek from L- and P-Reactors reached a peak of about 23 cubic meters per second in 1961. In 1963, P-Reactor effluents were diverted to Par Pond; thus, thermal discharges to Steel Creek were reduced to about 11 cubic meters per second, about 1.3 times the maximum flow expected after heavy rains. Since 1968, Steel Creek has received only infrequent and short-term inputs of thermal effluents (Smith, Sharitz, and Gladden, 1981, 1982; Du Pont, 1982b).

The flow of water in the swamp is altered when the Savannah River is in flood stage (about 27.7 meters) with a flow rate of about 440 cubic meters per second. Under flooding conditions, Four Mile Creek, Pen Branch, and Steel Creek discharge to the Savannah River at Little Hell Landing after they cross an off-site swamp (Creek Plantation Swamp). Data gathered from 1958 through 1980 indicate that, on the average, the Savannah River reaches flood stage at the Savannah River Plant 79 days (22 percent) of each year, predominantly from January through April (see Figure 3-6).

The direct discharge of cooling-water effluent into Steel Creek would require the following: (1) consultations with the FWS, (2) the preparation of a biological assessment for endangered species, (3) an NPDES permit, and (4) a 316(a) demonstration (see Chapter 7). An Army Corps of Engineers 404 permit would not be required.

4.4.2.2.2 Spray canal

A spray system would be added to the cooling-water outlet of L-Reactor to cool the discharged water by spraying it in the atmosphere before it enters Steel Creek. The spray canal (Figure 4-21) would utilize a gravity-power spray cooling system installed in the outfall canal. The system would operate in much the same manner as a conventional pumped spray system by dissipating a portion of cooling-water heat. Vegetation within 300 meters of the spray canal would have to be removed to enhance air circulation and increase cooling efficiency. The estimated time required to design and construct this alternative under normal construction practice is between 18 and 24 months. Penstock construction would not affect reactor operation if the L-Reactor startup occurs before this alternative is implemented. However, pipe header and nozzle installation would require reactor shutdown for 3 to 6 months. The valve chamber could be constructed during reactor operation except for cutting existing pipe and installing valves. These tasks could be performed during the same shutdown used for installing nozzles.

The estimated capital cost for constructing the spray canal is $9 million, with an annual operating cost of $3.5 million (Du Pont, 1983d). The present worth of this alternative would be $38 million and the annualized cost would be $4.5 million. An estimated 130 construction personnel would be required for the construction of the spray canal.

This alternative would use approximately 11 cubic meters of water per second from the Savannah River. Reactor production efficiency for this option

would be 100 percent. However, the use of reduced power would be necessary to meet State of South Carolina water-quality standards. Table 4-32 lists the estimated downstream temperatures in Steel Creek in the summer, spring, and winter without a reduction of power.

Table 4-32. Temperatures (°C) downstream in Steel Creek with once-through discharge using a spray canal

Location	Summer[a]	Summer[b]	Spring[b]	Winter[b]
Discharge temperature[c]	68	66	64	61
Road A	53	52	49	45
Swamp at delta	45	44	40	35
Mid-swamp	37	35	30	25
Mouth of creek at river	34	33	27	21

[a]Based on worst 5-day meteorological conditions (July 11-15, 1980) and estimated operating power of the reactor.

[b]Based on 30-year average values for meteorological conditions (1953-1982) and actual power of an operating reactor. Summer average temperatures have been included to show the discharge and Steel Creek temperatures that could be expected if significant temperature excursions above and below average did not occur.

[c]Temperature entering Steel Creek.

Compared to direct discharge, the spray canal alternative would provide limited thermal mitigation. The 68°C maximum discharge temperature and the 66°C average summer temperature would both be well above the 32.2°C State discharge limit. Due to the large cooling-water discharge rate (about 10.6 cubic meters per second), Steel Creek temperatures would approach the cooling-water discharge temperature near the outfall, because mixing the discharge with natural flows would result in only a slight temperature reduction.

Implementation of this alternative would result in year-round noncompliance with the State discharge limits. This alternative would not meet discharge limits in Steel Creek but would be in compliance in the Savannah River when a mixing zone is considered.

The implementation of the spray canal alternative would discharge water at about the same rate as direct discharge and would achieve minimal cooling. Thus, the environmental impacts of this alternative would be slightly greater than those for direct discharge; they are summarized as follows:

- Between 730 and 1000 acres of wetlands would be eliminated, including habitat for the endangered American alligator, the endangered wood stork, and migratory waterfowl. These wetlands are classified as Resource Category 2 by the U.S. Fish and Wildlife Service. This resource category and designation criteria include "high value for evaluation species and scarce or becoming scarce" (USDOI, 1981). The mitigation planning goal specifies that there be "no net loss of inkind habitat

value." In addition, about 2500 acres of wetlands could be isolated to aquatic biota by thermal temperatures.

- To achieve optional cooling performance using a spray system, vegetation within 300 meters of the unit would have to be removed. This would impact an additional 55 acres of wetlands and 55 acres of upland conifers. Thus, the total amount of impacted habitat would be 55 acres of uplands and between 785 and 1055 acres of wetlands.

- Approximately 16 fish per day (5840 fish annually) would be impinged; annual entrainment of fish eggs and larvae would be 7.7×10^6 and 11.9×10^6, respectively.

- Approximately 4.2 curies of radiocesium would be remobilized and transported into the Savannah River during the first year of resumed operations. Liquid releases of tritium from L-Reactor to the Savannah River would be reduced to about 9340 curies per year.

- Five archeological sites eligible for the National Register would be subject to erosion and flooding, including one prehistoric site and four historic sites.

- Increased flow would further erode the Steel Creek corridor, and delta growth would increase at approximately 3 surface acres per year.

No impact to the substrate, water quality, or naturally occurring turbidity levels would occur as a result of dredging and filling because construction activities would be confined to the existing discharge canal from L-Area during periods of reactor downtime.

This alternative would require the following permits or processes: (1) a U.S. Army COE 404 permit, (2) an SCDHEC 401 certification, (3) an NPDES permit, (4) a 316(a) demonstration, (5) consultations with the FWS, (6) the preparation of a biological assessment for endangered species.

If the spray canal cooling system alternative is implemented before direct discharge occurs, the environmental impacts would be slightly greater than those attributable to direct discharge.

4.4.2.2.3 Small lakes

This system, which would use several small dams (rubble dams) on Steel Creek to create small lakes (Figure 4-22), would provide some thermal mitigation to the lower portions of Steel Creek and the swamp compared to the reference case (direct discharge). A series of several rubble dams would create small lakes with a combined area of about 120 acres, which would pool water to provide an increased stream surface area and decreased stream velocity to enhance cooling. The dams would be created by dumping large stone or broken concrete in Steel Creek at accessible locations. The dams would be 1.5 to 2.4 meters high; they could be solid or porous, but better results could be expected with solid dams. Each small dam would consist of about 3500 cubic meters of material; the total volume for the seven dams would be about 24,500 cubic meters. Slightly contaminated spoil from the surface portion of the embankment foundations in the Steel Creek floodplain, estimated to contain a total of 0.2 curie of cesium-137

and 0.02 curie of cobalt-60, would be separated, contained, replaced outside the wetlands upstream of the dam, and covered with subsurface spoil to prevent erosion during the construction period. This relocation would have no effect on net cesium transport estimates. All other material would be removed and used for backfill in the borrow areas. Sediment would collect upstream from each solid dam. Water spilling over the dams would increase the heat dissipation effectiveness of the system by increasing the exposure of the hot water to air.

Locations of the dams would be selected to minimize the relocation of existing roads, power lines, and cables and to maximize the potential for cooling in the upper reaches of the creek. Access roads would be minimized and their locations selected to prevent environmental impacts. The estimated time required to design and construct the small rubble dams, without an expedited schedule, is between 18 and 24 months (Du Pont, 1983d). On an expedited schedule, construction of this alternative would be possible in about 6 months. For the construction of these dams, diversion channels would be required around each dam site to reroute heated effluent. These could probably be constructed during a short (1-month) reactor shutdown. Another 1-month period would be required after dam construction is completed to reroute the water back over dams by filling the diversion channels.

The estimated capital costs for small rubble dams would be $6 million. The annual operating cost would be $3.4 million, and the present worth would be $35 million. Annualized cost would be $4.1 million (Du Pont, 1983d). An estimated 75 personnel would be required for construction of the rubble dams.

Water use for this alternative would be about 11 cubic meters per second. Production efficiency for this alternative would be 100 percent. However, water-quality standards could not be met without a reduction in power.

Small lakes could reduce the temperature at the entry to the swamp to about 40°C, or about 4°C cooler than that for direct discharge, under severe summer conditions. The water discharge temperature from L-Reactor would vary by month, depending on the temperature of the supply water from the Savannah River, meteorological conditions, and the reactor operating power. The temperature at the creek mouth would be about 33°C, or 1°C cooler than for a direct discharge (see Table 4-33).

Small lakes would provide limited thermal mitigation. The 43°C average summer discharge temperature would not comply with the State 32.2°C discharge limit. With the small lakes alternative, water temperatures in the mid-swamp and at the mouth of Steel Creek could be about 7°C above ambient during extreme summer conditions, but would be as much as 15°C above ambient in the winter. This could result in the concentration of fish in the heated areas during the colder months, which, in turn, could subject them to potential cold shock during any shutdown.

The small lakes would result in the loss of between 420 and 580 acres of wetlands in the Steel Creek corridor and between 310 and 420 acres in the delta-swamp area. In addition, about 2500 acres of wetlands could be isolated due to thermal temperatures. The wetlands that would be impacted by this alternative are classified as Resource Category 2 by the U.S. Fish and Wildlife Service.

Table 4-33. Temperatures (°C) downstream in Steel Creek with small lakes

Location	Summer[a]	Summer[b]	Spring[b]	Winter[b]
Discharge temperature (from downstream impoundment)	45	43	40	34
Road A	44	42	38	32
Swamp at delta	40	38	34	27
Mid-swamp	34	33	28	21
Mouth of creek at river	33	31	26	18

[a]Based on worst 5-day meteorological conditions (July 11-15, 1980) and estimated operating power of the reactor.

[b]Based on 30-year average values for meteorological conditions 1953-1982) and actual power of an operating reactor. Summer average temperatures have been included to show the discharge and Steel Creek temperatures that could be expected if significant temperature excursions above and below average did not occur.

This resource category and designation criteria include "high value for evaluation species and scarce or becoming scarce." The mitigation planning goal specifies that there be "no net loss of inkind habitat value" (USDOI, 1981).

This alternative would have about the same adverse impacts as direct discharge on habitat of the endangered American alligator, the endangered wood stork, and migratory waterfowl.

The impacts of impingement and entrainment would be the same as those for direct discharge--the impingement of 16 fish per day (5840 fish per year) and the annual entrainment of 7.7×10^6 fish eggs and 11.9×10^6 fish larvae.

The transport of radiocesium down Steel Creek from this alternative would be lower than that for direct discharge. Conservatively, no more than 4.4 ± 2.2 curies would be transported in the first year of operation (see Section L.4.1.2.2). Liquid releases of tritium from L-Reactor to the Savannah River would be reduced to about 7880 curies per year.

The area subject to impact by this alternative contains one prehistoric site and four historic sites eligible for the National Register. These sites would be subject to erosion and flooding due to the high water-flow conditions and the establishment of one or more small lakes. Erosion and transport of sediment are expected to be slightly reduced in relation to direct discharge. A delta growth rate of about 2 acres per year is anticipated.

No appreciable change is expected in the chemical characteristics of the effluent as the result of its passing through the impoundments, except about 6 percent of the suspended solids would be removed from the river water by the 186-Basin and the impoundments. The water quality of the impoundments should be somewhat similar to that of Par Pond; an ion-concentration ratio (impoundment-to-river-water) of less than 1.3 is expected (Tilly, 1974).

This alternative would require the following permits or processes: (1) a U.S. Army COE 404 permit, (2) an SCDHEC 401 certification, (3) an NPDES permit, (4) a 316(a) demonstration, (5) consultations with the FWS, and (6) the preparation of a biological assessment for endangered species.

If this alternative is implemented before the restart of L-Reactor, the environmental impacts would be as described above. If it is implemented after direct discharge occurs, the environmental impacts would be the same as those described in Section 4.4.2.2.1 (i.e., loss of 730 to 1000 acres of wetlands, etc.). Any mitigative effects resulting from the small impoundments would not begin until the end of the 18- to 24-month construction period.

4.4.2.2.4 Small lakes with upstream spray cooling (one set)

This alternative is very similar to the alternative described in the previous section, except there would be a gravity spray module in the outfall canal. The final lake discharge water would flow at a rate of about 11 cubic meters per second and would be at a temperature of about 44°C under extreme summer conditions.

Small lakes with spray cooling (one set) could be designed and constructed in 18 to 24 months. During the construction (if L-Reactor operation is restarted before construction of the rubble dams), diversion channels would be required around each dam site to route heated effluent around construction areas. These could probably be built during a short (1-month) reactor shutdown. Another 1-month period would be required after construction to reroute water back over the dams by filling the diversion channels. Spoil from the surface portion of the embankment foundation in the Steel Creek floodplain, estimated to contain a total of 0.2 curie of cesium-137 and 0.02 curie of cobalt-60, would be separated, contained, replaced outside the wetlands upstream of the dam, and covered with subsurface spoil to prevent erosion during the construction period. This relocation would have no effect on net cesium transport estimates. All other material would be removed and used for backfill in the borrow areas.

The estimated capital costs for the small lakes and single-spray cooling system would be about $15 million. Annual operating and maintenance costs would be $3.5 million, the present worth would be $44 million, and the annualized cost would be $5.2 million (Du Pont, 1983e). An estimated 105 construction personnel would be required.

The flow rate for this alternative would be 11 cubic meters per second and the production efficiency would be 100 percent. Table 4-34 lists Steel Creek temperatures for various seasons without a reduction in power. However, the alternative could not meet water-quality standards without a reduction in power.

Discharge temperatures for this alternative would be above the 32.2°C State limit most of the year.

The use of small lakes with a single spray system would result in the loss of between 420 and 580 acres of wetlands in the Steel Creek corridor. The spray canal would also eliminate 55 acres of wetlands and 55 acres of upland habitat. Between 215 and 335 acres of wetlands in the delta and swamp would also be impacted, primarily due to flow. Thus, between 690 and 970 acres of wetlands and

Table 4-34. Temperatures (°C) downstream in Steel Creek with small lakes and one set of spray coolers

Location	Summer[a]	Summer[b]	Spring[b]	Winter[b]
Discharge temperature[c]	44	43	39	34
Road A	43	42	38	32
Swamp at delta	40	38	34	27
Mid-swamp	34	32	27	20
Mouth of creek at river	33	31	25	18

[a]Based on worst 5-day meteorological conditions (July 11-15, 1980) and estimated operating power of the reactor.

[b]Based on 30-year average values for meteorological conditions (1953-1982) and the actual power of an operating reactor. Summer average temperatures have been included to show the discharge and Steel Creek temperatures that could be expected if significant temperature excursions above and below average did not occur.

[c]Temperature of water leaving downstream impoundment.

55 acres of uplands would be effected by this alternative. The wetlands that would be impacted by this alternative are classified as Resource Category 2 by the U.S. Fish and Wildlife Service. This resource category and designation criteria include "high value for evaluation species and scarce or becoming scarce" (USDOI, 1981). The mitigation planning goal specifies that there be "no net loss of inkind habitat value." In addition, about 2280 acres of wetlands along Meyers Branch and along Steel Creek above the L-Reactor outfall would be isolated from riverine and anadromous fishes.

Effluent temperatures in the mid-swamp during summer and spring would be 7°C to 9°C above ambient. Winter temperatures in the mid-swamp and at the mouth of Steel Creek would be as high as 14°C above ambient. Thus, fishes might be attracted to the mouth of Steel Creek in winter.

The impacts of impingement and entrainment would be the same as those for direct discharge--the impingement of 16 fish per day (5840 fish per year) and the annual entrainment of 7.7×10^6 fish eggs and 11.9×10^6 fish larvae.

Conservatively, the transport of radiocesium down Steel Creek would be less than 4.4 ± 2.2 curies the first year of operation (see Section L.4.1.2.2). Liquid releases of tritium from L-Reactor to the Savannah River would be reduced to about 7800 curies per year.

The area subject to impact by these alternatives contains one prehistoric site and four historic sites eligible for the National Register. These sites would be subject to erosion and flooding due to the high water-flow conditions and the establishment of one or more small lakes. A mitigation plan would be developed and implemented prior to restart similar to that described for direct discharge.

Erosion and transport of sediment would increase because of the increased flow rate (about 10.5 cubic meters per second). A delta growth rate of about 2 acres per year is anticipated.

No appreciable change is expected in the chemical characteristics of the effluent as the result of its passing through the impoundments, except about 6 percent of the suspended solids would be removed from the river water by the 186-Basin and the impoundments. The water quality of the impoundments should be somewhat similar to that of Par Pond; an ion-concentration ratio (impoundment-to-river-water) of less than 1.3 is expected (Tilly, 1974).

This alternative would require the following permits or processes: (1) a U.S. Army COE 404 permit, (2) an SCDHEC 401 certification, (3) an NPDES permit, (4) a 316(a) demonstration, (5) consultations with the FWS, and (6) the preparation of a biological assessment for endangered species.

If this alternative is implemented before direct discharge occurs, the environmental effects would be as described above. If it is implemented after direct discharge occurs, the environmental effects would be the same as those described in Section 4.4.2.2.1 (i.e., loss of 730 to 1000 acres of wetlands, etc.). The mitigative effects resulting from small lakes with one set of spray coolers would not begin until the end of the 18-to 24-month construction period.

4.4.2.2.5 Small lakes with upstream and downstream spray cooling (two sets)

Small lakes with two sets of spray cooling would also mitigate some of the environmental effects of a direct discharge system. The gravity spray canal system would be installed to obtain about 5°C of cooling before the water enters the first pond. The small dams would create pools that would slow the movement of the water and enhance cooling. The second spray system would be in the last shallow pond.

Small lakes with spray cooling (two sets) could be designed and constructed in 18 to 24 months. If L-Reactor operation is restarted before the construction of the rubble dams, the estimated reactor downtime would be between 3 and 4 months to accomplish the tasks. During the construction, diversion channels would be required around each dam site to route heated effluent around construction areas. These could probably be built during a short (1-month) reactor shutdown. Another 1-month period would be required after construction to reroute water back over the dams by filling the diversion channels. Spoil from the surface portion of the embankment foundation in the Steel Creek floodplain, estimated to contain a total of 0.2 curie of cesium-137 and 0.02 curie of cobalt-60, would be separated, contained, replaced outside the wetlands upstream of the dam, and covered with subsurface spoil to prevent erosion during the construction period. This relocation would have no effect on net cesium transport estimates. All other material would be removed and used for backfill in the borrow areas.

The estimated capital costs for the small lakes with spray cooling (two sets) would be approximately $9 million for the spray canal system plus $5.5 million for the rubble dams plus as much as $14.5 million for the supplemental spray system; the total cost would be about $29 million.

Operating and maintenance costs would be higher than those for the direct discharge system because of the added costs of operating the spray modules in the ponds. Annual operating and maintenance costs for this alternative would be $3.5 million. The present worth of the alternative would be $60 million and the annualized cost would be $7.1 million (Du Pont, 1983d). An estimated 135 construction personnel would be required.

Production efficiency for this alternative would be 100 percent. However, State water-quality standards could not be met without a reduction in power. The flow rate would be 10.4 cubic meters per second.

During the passage through these ponds, the water would be cooled to about 43°C under extreme summer conditions. This cooling could be increased by the spray cooling modules in the final lake, where the water would be cooled to about 39°C before being released to Steel Creek above Road A. Table 4-35 lists Steel Creek temperatures for the various seasons without power reduction.

Table 4-35. Temperatures (°C) downstream in Steel Creek with small lakes and two sets of spray coolers

Location	Summer[a]	Summer[b]	Spring[b]	Winter[b]
Discharge temperature[c]	39	38	34	29
Road A	39	37	33	27
Swamp at delta	37	35	30	23
Mid-swamp	33	31	26	18
Mouth of creek at river	32	30	24	17

[a]Based on worst 5-day meteorological conditions (July 11-15, 1980) and estimated operating power of the reactor.

[b]Based on 30-year average values for meteorological conditions (1953-1982) and actual power of an operating reactor (Du Pont, 1983d). Summer average temperatures have been included to show the discharge and Steel Creek temperatures that could be expected if significant temperature excursions above and below average did not occur.

[c]Temperature of water leaving downstream impoundment.

The use of small lakes with two spray systems would result in the loss of between 420 and 580 acres of wetlands in the Steel Creek corridor. These wetlands are classified as Resource Category 2 by the U.S. Fish and Wildlife Service. This resource category and designation criteria include "high value for evaluation species and scarce or becoming scarce." The mitigation planning goal specifies that there be "no net loss of inkind habitat value" (USDOI, 1981). In addition, about 55 acres of wetlands and 55 acres of uplands would be lost for the construction of the spray canal. Furthermore, 75 acres of uplands would be eliminated by the second spray pond. Between 215 and 335 acres of wetlands in the delta would also be eliminated, primarily by high flow. Thus, between 690 and 970 acres of wetlands and 70 acres of uplands would be eliminated by this alternative. In addition, about 2500 acres of wetlands along Steel Creek above the L-Reactor outfall and along Meyers Branch and Boggy Gut Creek will be isolated from riverine and anadromous fishes.

Effluent temperatures in summer in the mid-swamp and at the mouth of Steel Creek would be as high as 6°C above calculated ambient temperatures. Winter temperatures of 18°C and 17°C (which are 11° to 12°C above ambient) at the swamp and mouth of Steel Creek, respectively, might attract fish. Additional wetlands in the delta and swamp would be eliminated by high flow.

Discharge temperatures for small lakes with two sets of spray cooling are above the 32.2°C State limit. Discharge temperatures over the 32.2°C requirement would occur on most summer days; compliance could be expected during part of the spring and all of the winter months.

The impacts of impingement and entrainment would be the same as those for direct discharge--the impingement of 16 fish per day (5840 fish per year) and the annual entrainment of 7.7×10^6 fish eggs and 11.9×10^6 fish larvae.

Conservatively, the transport of radiocesium down Steel Creek would be no more than 4.4 ± 2.2 curies the first year of operation (see Section L.4.1.2.2). Liquid releases of tritium from L-Reactor to the Savannah River would be reduced to about 7770 curies per year.

The area subject to impact by these alternatives contains one prehistoric site and four historic sites eligible for the National Register. These sites would be subject to erosion and flooding due to the high water-flow conditions and the establishment of one or more small lakes. A mitigation plan would be developed and implemented prior to restart similar to that described for direct discharge.

Erosion and transport of sediment would increase because the flow rate would be about 10.4 cubic meters per second. A delta growth rate of about 2 acres per year is anticipated.

No appreciable change is expected in the chemical characteristics of the effluent as the result of its passing through the impoundments, except about 6 percent of the suspended solids would be removed from the river water by the 186-Basin and the impoundments. The water quality of the impoundments should be somewhat similar to that of the Savannah River.

This alternative would require the following permits or processes: (1) a U.S. Army COE 404 permit, (2) an SCDHEC 401 certification, (3) an NPDES permit, (4) a 316(a) demonstration, (5) consultations with the FWS, and (6) the preparation of a biological assessment for endangered species.

If small lakes with spray cooling (two sets) are implemented before direct discharge occurs, the environmental effects would be as described above. If this alternative is implemented after direct discharge starts, the environmental effects would be the same as those described in Section 4.4.2.2.1 (i.e., loss of 730 to 1000 acres of wetlands, etc.). The mitigative effects resulting from rubble dams with sprays (two sets) would not begin until the end of the 18- to 24-month construction period.

4.4.2.2.6 500-acre lake

The topography along Steel Creek is suitable for the construction of a 500-acre lake (Figure 4-23). The lake would be separated physically into three

sections of about equal length with underflow baffles to enhance its cooling efficiency. The baffles would prevent short circuiting of hot water and would maximize the use of the surface area. The final (underflow) baffle would discharge water from several feet below the lake surface at a rate of about 10.7 cubic meters per second.

The estimated time to design and construct a 500-acre lake, without an expedited schedule, would be 31 months. With an expedited schedule, the lake could be completed in 6 months. If L-Reactor is restarted before this alternative is implemented, a discharge structure could be constructed away from the existing stream while reactor effluent flows continued. When this structure is complete, a short (1-month) shutdown might be required to divert flows through the structure. Also, clearing directly adjacent to the stream would be accomplished during this shutdown.

The construction of the embankment and clearing the 500 acres could be completed while flows are discharged through the structure. Gates in the structure would be closed to fill the 500-acre lake. The construction of the large earthen embankment and baffle structures required for the 500-acre lake would cause some temporary increases in suspended solids in the creek. The quantity of fill material required would be about 450,000 cubic meters. Spoil from the surface portion of the embankment foundation in the Steel Creek floodplain, estimated to contain a total of 0.2 curie of cesium-137 and 0.02 curie of cobalt-60, would be separated, contained, replaced outside the wetlands upstream of the dam, and covered with subsurface spoil to prevent erosion during the construction period. This relocation would have no effect on net cesium transport estimates. All other material would be removed and used for backfill in the borrow areas. The embankment would be about 475 meters long; it would have a height of about 22 meters. The width at its base would be about 120 meters. Impacts to downstream areas can be minimized by the use of turbidity screens. During construction, the number of access roads would be minimized and their locations selected to prevent environmental impacts.

Water use from the Savannah River would be about 11 cubic meters per second and production efficiency would be 100 percent. The estimated capital cost for a single impoundment is $12 million; the capital cost would increase by $2 million if underflow baffles are included. The annual operating cost would be $3.4 million. The present worth of the lake would be $41 million, and the annualized cost is $4.8 million (Du Pont, 1983d). An estimated 345 construction personnel would be required for construction of the 500-acre lake.

Table 4-36 lists the estimated downstream temperatures in Steel Creek in the summer, spring, and winter without reduction in power. This arrangement would minimize diurnal temperature variations in the lake and provide additional cooling capacity during hot weather (about 5°C and 3°C cooler than the direct discharge at the mid-swamp and creek mouth, respectively).

A 500-acre lake would provide limited thermal mitigation. The 37°C discharge temperature from the lake would exceed the State 32.2°C discharge limit. Additionally, the temperature of Steel Creek would increase significantly more than the State temperature increase limit of 2.8°C. The temperatures could be lowered by reducing reactor power.

Table 4-36. Temperatures (°C) downstream in Steel Creek with a single 500-acre lake

Location	Summer[a]	Summer[b]	Spring[b]	Winter[b]
Discharge temperature[c]	37	36	31	24
Road A	37	35	30	24
Swamp at delta	36	34	28	20
Mid-swamp	32	30	24	16
Mouth of creek at river	31	29	23	15

[a]Based on worst 5-day meteorological conditions (July 11-15, 1980) and estimated operating power of the reactor.

[b]Based on 30-year average values for meteorological conditions (1953-1982) and actual power of an operating reactor. Summer average temperatures that could be expected if significant temperature excursions above and below average did not occur.

[c]Temperature of water leaving lake.

The water temperature at mid-swamp would be 5°C, 6°C, and 10°C above ambient in summer, spring, and winter, respectively (Table 4-36). The water temperature at the mouth of Steel Creek would be 4°C above ambient in summer, 5°C above ambient in spring, and 9°C above ambient in winter. Cold shock to fishes is possible.

The 500-acre lake would impact between 435 and 595 acres of wetlands in the Steel Creek corridor. Approximately 360 acres of uplands would be inundated by the lake. Impacts to wetlands in the delta and swamp due primarily to flow would range between 215 and 335 acres. Thus, this alternative would affect between 650 and 930 acres of wetlands and 360 acres of uplands. Furthermore, approximately 2280 acres of wetlands along Meyers Branch and above L-Reactor would be thermally or physically isolated from riverine and anadromous fishes. Because the lake would achieve an average water temperature of 37°C, it would be biologically devoid of life except for thermophilic flora. The wetlands that would be impacted by this alternative are classified as Resource Category 2 by the U.S. Fish and Wildlife Service. This resource category and designation criteria include "high value for evaluation species and scarce or becoming scarce." The mitigation planning goal specifies that there be "no net loss of inkind habitat value" (USDOI, 1981).

This alternative would have about the same adverse impacts as direct discharge on habitat of the endangered American alligator, the endangered wood stork, and migratory waterfowl.

The impacts of impingement and entrainment would be the same as those for direct discharge--the impingement of 16 fish per day (5840 fish per year) and the annual entrainment of 7.7×10^6 fish eggs and 11.9×10^6 fish larvae.

The transport of radiocesium down Steel Creek from this alternative would be about the same as that for direct discharge. Conservatively, about 4.4 ± 2.2 curies would be released during the first year of operation (see Section

L.4.1.2.2). Liquid releases of tritium from L-Reactor to the Savannah River would be reduced to about 7880 curies per year.

The area subject to impact by this alternative contains one prehistoric site and four historic sites eligible for the National Register. These sites would be subject to erosion and flooding due to the high water-flow conditions and the establishment of one or more small lakes. Mitigation would be similar to that discussed for direct discharge.

Erosion and transport of sediment are expected to be slightly reduced in relation to direct discharge. A delta growth rate of about 2 acres per year is anticipated.

No appreciable change is expected in the chemical characteristics of the effluent as the result of its passing through the lake, except about 6 percent of the suspended solids would be removed from the river water by the 186-Basin and the impoundments. The water quality of the lake should be somewhat similar to that of the Savannah River.

This alternative would require the following permits or processes: (1) a U.S. Army COE 404 permit, (2) an SCDHEC 401 certification, (3) an NPDES permit, (4) a 316(a) demonstration, (5) consultations with the FWS, and (6) the preparation of a biological assessment for endangered species.

If this alternative is implemented before the restart of L-Reactor, the environmental impacts would be as described above. If it is implemented after direct discharge occurs, the environmental impacts would be the same as those described in Section 4.4.2.2.1 (i.e., loss of 730 to 1000 acres of wetlands, etc.). Any mitigative effects resulting from the 500-acre-lake alternative would not begin until the end of the 18- to 31-month construction period.

4.4.2.2.7 500-acre lake with spray cooling (one set)

The cooling efficiency of the 500-acre lake (Figure 4-23) could be enhanced through the addition of a spray module. The gravity-power spray cooling system (Figure 4-21 and Section 4.4.2.2.2) would operate in much the same manner as a conventional pumped spray system by dissipating a portion of cooling-water heat into the atmosphere.

The estimated time required to design and construct the lake is a total of 31 months without expediting. On an expedited basis, the lake could be constructed in 6 months. Assuming that the permit process for the lake begins when the design of the spray canal is initiated, then the lake construction would be completed about 19 months after the spray canal. This schedule assumes that there would be no major permitting delays. Before the implementation of this alternative could begin, a budget proposal would have to be submitted to the U.S. Congress to seek funding appropriations.

The construction of the spray system would begin after permits have been obtained from the appropriate State and Federal agencies. The estimated time required to design and construct the spray system is about 12 months (on an expedited basis). A new valve chamber (shown in Figure 4-21) and a penstock would be installed as part of the spray canal system, along with pipe headers

and nozzles. L-Reactor operation would begin at the same time the construction of the spray canal and the lake get underway.

Provisions would be made for the diversion or controlled channeling of more than 11 cubic meters per second of increased water flow that would occur when L-Reactor begins operation. The water flow would include L-Reactor cooling water, storm runoff, and natural Steel Creek flows. This water would be diverted around active construction areas.

Depending on when the diversion around the construction area first occurs, a short shutdown (about 1 month) might be required to implement the diversion. Clearing the vegetation directly adjacent to the stream could be accomplished during this shutdown. When the embankment is completed and the land is cleared, the control gates in the diversion structure would be closed to fill the lake.

The construction of the earthen embankment, baffle structures, and water diversion system for the lake would cause some temporary increases in suspended solids in the creek. Suitable precautions would be taken (1) during the construction operations necessary to establish a foundation for the impoundment, (2) during any necessary diversion of Steel Creek, and (3) during emplacement of the fill to ensure that undue silt and debris loads do not move downstream from the construction site. Turbidity screens could minimize impacts to downstream areas. About 450,000 cubic meters of fill material would be required for the dam and baffles.

Borrow pits of suitable materials and similar quantities have been used in the past for similar construction at the Savannah River Plant. For this alternative, the most economically suitable pit would be identified and controlled. Spoil piles of the size expected for this alternative have been developed for past construction activities at the Savannah River Plant and have met necessary environmental control requirements.

During construction, the location and number of access roads would be minimized to reduce environmental impacts. Spoil from the surface portion of the embankment foundation in the Steel Creek floodplain, estimated to contain a total of 0.2 curie of cesium-137 and 0.02 curie of cobalt-60, would be separated, contained, replaced outside the wetlands upstream of the dam, and covered with subsurface spoil to prevent erosion during the construction period. This relocation would have no effect on net cesium transport estimates. All other material would be removed and used for backfill in the borrow areas.

Capital costs for the combined lake-and-spray system would be approximately the $9-million cost of the spray canal system plus the $12-million cost of the 500-acre lake, a total cost of about $21 million. Underflow baffles would increase the capital cost by about $2 million. Operating and maintenance costs would be about the same as those for direct discharge if a gravity spray system is utilized ($3.5 million). The present worth of this alternative would be $50 million and the annualized cost would be $5.9 million (Du Pont, 1983d). An estimated 375 construction personnel would be required.

Approximately 11 cubic meters per second would be withdrawn from the Savannah River and used as the secondary cooling-water supply. Production efficiency

would be 100 percent. However, reactor operation would be limited in the summer by the ambient temperature of the Savannah River.

Table 4-37 lists the estimated downstream temperatures in Steel Creek for the summer, spring, and winter without a reduction in power. Ambient temperatures in Steel Creek at Road A are about 25°C in summer, 20°C in spring, and 7°C in winter; this is based on 10 years of measurements (Du Pont, 1983d).

Table 4-37. Temperatures (°C) downstream in Steel Creek with a 500-acre lake with spray cooling (one set of sprays)

Location	Summer[a]	Summer[b]	Spring[b]	Winter[b]
Discharge temperature[c]	37	35	30	23
Road A	37	35	30	23
Swamp at delta	36	33	28	20
Mid-swamp	32	30	24	16
Mouth of creek at river	31	29	23	15

[a]Based on worst 5-day meteorological conditions (July 11-15, 1980) and estimated operating power of the reactor.

[b]Based on 30-year average values for meteorological conditions (1953-1982) and the actual power of an operating reactor (Du Pont, 1983d). Summer average temperatures have been included to show the discharge and Steel Creek temperatures that could be expected if significant temperature excursions above conditions and below average did not occur.

[c]Temperature of water leaving lake.

The gravity spray canal system would provide about 5°C cooling in the summer before the water entered the 500-acre lake. This water (at 73°C) would be cooled to about 37°C during its travel through the lake (under worst-case meteorological conditions). As shown in Table 4-37, this alternative would exceed the 32°C discharge temperature limit on extreme summer days but would be in compliance on average summer days. These temperatures could be reduced by a reduction in power.

The environmental consequences of using a cooling system with one set of sprays until a 500-acre lake became operational would include impacts from the elevated water temperature and the increased rate of flow.

The construction of the spray canal (Section 4.4.2.2.2) would necessitate the removal of vegetation within 300 meters of the unit to achieve the best cooling performance, causing a slightly greater impact on wetlands than direct discharge. These impacts from the spray canal alone (until the lake is constructed), which would result from high water temperatures (i.e., delta-T = 8°C at the swamp in summer) and flow rate (about 10.6 cubic meters per second) include:

- Between 705 and 985 acres of wetlands would be eliminated, including habitat for the endangered American alligator, the endangered wood

stork, and migratory waterfowl. These wetlands are classified as Resource Category 2 by the U.S. Fish and Wildlife Service. This resource category and designation criteria include "high value for evaluation species and scarce or becoming scarce." The mitigation planning goal specifies that there be "no net loss of inkind habitat value" (USDOI, 1981). In addition, about 2500 acres of wetlands would be isolated to aquatic biota by thermal temperatures, and 415 acres of uplands would be inundated.

- Approximately 16 fish per day (5840 fish annually) would be impinged; annual entrainment of fish eggs and larvae would be 7.7×10^6 and 11.9×10^6, respectively.

- Conservatively, no more than 4.4 ± 2.2 curies of radiocesium would be remobilized and transported into the Savannah River during the first year of resumed operations (see Section L.4.1.2.2). Liquid releases of tritium from L-Reactor to the Savannah River would be reduced to about 9340 curies per year.

- Five archeological sites eligible for the National Register would be subject to erosion and flooding, including one prehistoric site and four historic sites. A mitigation plan would be designed by the Institute of Archeology and Anthropology of the University of South Carolina and would be completed prior to restart.

- Increased flow would further erode the Steel Creek corridor, and delta growth would increase at approximately 3 surface acres per year.

No impact to the substrate, water quality, or naturally occurring turbidity levels would occur as a result of dredging and filling because construction activities would be confined to the existing discharge canal from L-Area during periods of reactor downtime.

The construction of the 500-acre lake would cause short-term impacts to the substrate, water quality, and naturally occurring turbidity levels of Steel Creek as a result of dredging and filling.

The lake would impound about 6 kilometers of Steel Creek from the L-Reactor outfall to its dam near Road A (SC Route 125). Biota would have already been eliminated in this portion of the creek from the operation of the spray cooling system. Because the lake would achieve an average water temperature of 37°C, it would be biologically devoid of life except for thermophilic flora. It could also thermally isolate Meyers Branch and physically isolate the upper reaches of Steel Creek (about 2280 acres of wetlands) from fishes and other aquatic and semiaquatic biota. Access to wetlands associated with Boggy Gut Creek (about 230 acres) will be unaffected.

The rate of flow of the effluent discharged below the dam for this once-through alternative would be about 10.5 cubic meters per second. The temperature of the effluent in summer would be 37°C.

In spring, water temperatures in the mid-swamp and at the mouth of Steel Creek would be within 6°C of calculated ambient temperatures (Table 4-37). Thus, anadromous and riverine fishes would have access to the swamp for spawning

and foraging. Winter temperatures in the swamp and at the mouth of Steel Creek would be about 10°C and 9°C above ambient, respectively. Although there is a potential for fishes to concentrate in these warmer waters during the winter, no adverse impacts to the Savannah River due to effluent discharge are expected. Although this option would achieve thermally viable water temperatures in the swamp and at the mouth of Steel Creek, the discharge rate below the dam would have adverse impacts on the Steel Creek delta and portions of the swamp. The flow and scouring effect of the effluent would uproot most of the existing vegetation almost immediately; the remaining vegetation would eventually succumb to high flow. Other wetland vegetation would experience elevated water levels, and their root systems would be inundated. Mortality, especially after continuous inundation, would occur to even the most water-tolerant species (i.e., willow and alder).

An estimated 215 to 335 acres of wetlands would be eliminated in the Savannah River swamp and Steel Creek delta. This would include important foraging habitat for the endangered wood stork. In addition, important roosting and feeding habitat for as many as 1200 mallard ducks and 400 wood ducks would be lost. There would be negligible impact to the American alligator below the Steel Creek delta.

This alternative would require the following permits or processes: (1) a U.S. Army COE 404 permit, (2) an SCDHEC 401 certification, (3) an NPDES permit, (4) a 316(a) demonstration, (5) consultations with the FWS, and (6) the preparation of a biological assessment for endangered species.

If this alternative is implemented before direct discharge occurs, the environmental impacts would be as described above. If it is implemented after direct discharge occurs, the mitigative effects would be that riverine and anadromous aquatic biota would have access to the Savannah River swamp.

4.4.2.2.5 500-acre lake with spray cooling (two sets)

Another alternative system would combine the 500-acre lake with two spray cooling systems. The gravity spray canal system described in Section 4.4.2.2.2 would be installed to obtain about 5°C of cooling in the summer before the water enters the 500-acre lake. This water would be cooled to about 37°C during its travel through the lake under extreme summer conditions. A spray system below the dam would cool the water to about 32°C before discharging it to Steel Creek (Figure 4-24). To reduce energy requirements (and, thus, operating and maintenance costs), the hydraulic head created by the lake would be used to power a gravity spray system below the dam.

The combined lake-and-spray system could be designed and constructed on a normal schedule within the same 31-month timespan that the lake alone would require. The 31-month schedule would assume that construction permits could be obtained with no major delays. An accelerated schedule could shorten this time. Implementation would also be contingent on funding. The three components could be built simultaneously; the embankment construction would be the limiting feature of the schedule. The reactor downtime would be from 3 to 6 months. Spoil from the surface portion of the embankment foundation in the Steel Creek floodplain, estimated to contain a total of 0.2 curie of cesium-137 and 0.02 curie of cobalt-60, would be separated, contained, replaced outside the wetlands upstream of the dam, and covered with subsurface spoil to prevent erosion during

the construction period. This relocation would have no effect on net cesium transport estimates. All other material would be removed and used for backfill in the borrow areas.

Capital costs for the combined lake-and-spray system would be approximately the $9-million cost of the spray canal system plus the $12-million cost of the 500-acre lake plus about $15 million for the additional spray system; the total cost would be about $36 million. If underflow baffles are included, capital costs would increase by $2 million. Operating and maintenance costs would be about the same as those for direct discharge ($3.5 million) if gravity spray systems are utilized. The present worth of this alternative would be $65 million and the annualized cost would be $7.6 million (Du Pont, 1983d). An estimated 405 construction personnel would be required.

Approximately 11 cubic meters per second would be withdrawn from the Savannah River and used as the secondary cooling-water supply. Production efficiency would be 100 percent. However, reactor operation would be limited in the summer by the ambient temperature of the Savannah River.

Table 4-38 lists the estimated downstream temperatures in Steel Creek for the summer, spring, and winter without reduction in reactor power. The 500-acre lake with two sets of spray coolers would normally comply with the maximum discharge temperature of 32.2°C during extreme meteorological conditions.

Table 4-38. Temperatures (°C) downstream in Steel Creek with a 500-acre lake with spray cooling (two sprays)

Location	Summer[a]	Summer[b]	Spring[b]	Winter[b]
Discharge temperature[c]	32	30	25	18
Road A	32	30	25	18
Swamp at delta	32	30	24	16
Mid-swamp	30	28	22	13
Mouth of creek at river	30	28	22	13

[a]Based on worst 5-day meteorological conditions (July 11-15, 1980) and estimated operating power of the reactor.

[b]Based on 30-year average values for meteorological conditions (1953-1982) and the actual power of an operating reactor. Summer average temperatures have been included to show the discharge and Steel Creek temperatures that could be expected if significant temperature excursions above and below average did not occur.

[c]Temperature of water leaving lake.

The environmental impacts of this alternative are summarized as follows:

- This alternative would significantly reduce thermal impacts. Summer and spring temperatures in the mid-swamp and at the mouth of Steel Creek would be within 4°C of ambient. Water temperatures in the swamp and at

the mouth of Steel Creek in winter would be as high as 7°C above ambient. Thus, temperatures in the winter could cause fish to concentrate near the mouth of Steel Creek, and also subject them to cold shock.

- Approximately 705 to 985 acres of wetlands would be affected, including habitat of the endangered American alligator, the endangered wood stork, and migratory waterfowl. The wetlands that would be impacted by this alternative are classified as Resource Category 2 by the U.S. Fish and Wildlife Service. This resource category and designation criteria include "high value for evaluation species and scarce or becoming scarce." The mitigation planning goal specifies that there be "no net loss of inkind habitat value" (USDOI, 1981). In addition, 490 acres of upland habitat would be inundated. About 100 acres of wetlands would be isolated by this alternative.

- Approximately 16 fish per day (5840 fish annually) would be impinged; the annual entrainment of fish eggs and larvae will be 7.7×10^6 and 11.9×10^6, respectively.

- Conservatively, no more than 4.4 ± 2.2 curies of radiocesium would be remobilized and transported to the Savannah River during the first year of resumed L-Reactor operation (see Section L.4.1.2.2). Liquid releases of tritium would be about 7670 curies per year.

- Five archeological sites eligible for the National Register would be subject to erosion and flooding, including one prehistoric site and four historic sites. A mitigation plan would be developed and implemented prior to restart similar to that described for direct discharge.

- The increased flow (to about 10.4 cubic meters per second) would further erode the Steel Creek corridor, and delta growth will increase at a rate of approximately 2 surface acres per year.

- Short-term impacts to the substrate, water quality, and naturally occurring turbidity levels would occur as a result of dredging for the construction of dams and spray systems. These impacts are discussed in Section 4.4.2.2.3.

- Local ground-water levels would be raised due to the reservoir.

This alternative would require the following permits or processes: (1) a U.S. Army COE 404 permit, (2) an SCDHEC 401 certification, (3) an NPDES permit, (4) a 316(a) demonstration, (5) consultations with the FWS, and (6) the preparation of a biological assessment for endangered species.

If the 500-acre lake with two spray cooling systems is implemented before direct discharge occurs, the environmental impacts would be as described above. If it is implemented after direct discharge occurs, the environmental impacts would be the same as those described in Section 4.2.2.2.1 (i.e., loss of 730 to 1000 acres of wetlands, etc.). The primary mitigative effect resulting from this alternative would be that riverine and anadromous aquatic biota could inhabit the Savannah River swamp system, Meyers Branch, and Boggy Gut Creek.