Table 4-6. Maximum ground-level concentrations of radiological air constituents at the Savannah River Site boundary under the Shut Down and Deactivate Alternative.

Radiological Constituent	Modeled maximum air concentration[a] (pCi/m^3)	Dose from all pathways (mrem/yr)
cesium-137	7.2×10^{-6}	3.6×10^{-4}
cobalt-60	1.1×10^{-7}	1.6×10^{-6}
plutonium-239	7.9×10^{-9}	3.5×10^{-5}
TC promethium-146	7.9×10^{-9}	9.5×10^{-9}
uranium-233	9.6×10^{-7}	9.3×10^{-5}
thorium-229	4.5×10^{-9}	4.7×10^{-6}
radium-225	4.5×10^{-9}	1.8×10^{-7}
actinium-225	4.5×10^{-9}	3.0×10^{-8}

a. DOE assumed 30 disturbances per month (i.e., once per day) of the lakebed so that the calculated air concentration is an upper bound of the concentration over any time period (e.g., week, month, year).

4.1.4.2.3 Shut Down and Maintain

The effects of this alternative would be the same as those described in Section 4.1.4.2.2. Impacts to the existing SRS ambient air quality would be minimal.

4.1.5 ECOLOGY

This section describes the plant and animal communities in and around L-Lake, and characterizes the potential impacts of the Proposed Action and alternatives. The Affected Environment and Environmental Impacts sections are divided into three categories based on the wildlife habitat that is present: Terrestrial Ecology, Aquatic Ecology, and Wetlands. Section 4.1.5.1 describes the affected environment by habitat type; the potential impacts of the Proposed Action and alternatives are discussed in Section 4.1.5.2.

Wetlands and potential impacts to wetlands are discussed in considerable detail in Sections 4.1.5, 4.2.5, and 4.3.5, in accordance with the requirements of 10 CFR 1022. The floodplain and wetlands assessment required by 10 CFR 1022 is included in these sections. Section 4.3.5.3 discusses threatened and endangered species separately because several, such as the bald eagle and wood stork, range widely, and thus are not restricted to a particular drainage basin or reservoir. They also warrant additional consideration because they are protected by Federal law and therefore have special status under the National Environmental Policy Act (40 CFR 1508.27).

4.1.5.1 Affected Environment

L-Lake contains phytoplankton, zooplankton, macroinvertebrate, and fish communities characteristic of productive southeastern reservoirs with significant nutrient inputs and long growing seasons. A variety of reptiles and amphibians also occur in and around the lake. Birds (shorebirds, wading birds, and birds of prey) and mammals forage around L-Lake and drink its water. Several thousand ducks use L-Lake in winter. Small numbers of (threatened) bald eagles, (endangered) wood storks, and (threatened) American alligators are found in the L-Lake area at certain times of the year.

4.1.5.1.1 Terrestrial Ecology

The terrain surrounding L-Lake is almost entirely upland, with the exception of a few small tributaries entering the reservoir (one from the east and two from the west), the Steel Creek headwaters draining into the north (upper) end of the lake, and the Steel Creek corridor below the L-Lake dam. These uplands are dominated by pine forests and pine plantations, which approach to within 10 meters of the shore, where wax myrtle (*Myrica certifera*) becomes dominant. Some oaks, such as water oak (*Quercus nigra*) and willow oak (*Q. phellos*) occasionally become established in the understories of the less densely populated pine stands. These more open pine stands will often also contain black cherry (*Prunus serotina*), black gum (*Nyssa sylvatica*), and persimmon (*Diospyros virginiana*), as well as yellow jessamine (*Gelsemium sempervirens*), Japanese honeysuckle (*Lonicera japonica*), broomsedge (*Andropogon virginicus*), and an occasional bear-grass (*Yucca filamentosa*).

On the east side of the reservoir, the pines are mostly long-leaf (*P. palustris*) with some loblolly and slash pine. There are also a couple of small inclusions of oak-hickory forest. The long-leaf pines were planted in the early 1950s, with the exception of a few small inclusions planted in 1988 (SRFS 1997). Two small stands of loblolly towards the north end of the reservoir were established in 1941 and 1937. A third, and much larger stand (approximately 230 acres) of loblolly pines planted in 1971, is more centrally located away from the lake shore to the east. A single, approximately 150-acre (0.6 square kilometer) stand of slash pines is located along the shore at the north end of the lake and adjacent to the south side of SRS Road B. These trees were established in 1950. TC

On the west side of the reservoir, the pines are mostly slash (*Pinus elliottii*) and loblolly (*P. taeda*) and were established from 1947 to 1957 (SRFS 1997). A couple of small inclusions of loblolly pines were established in 1982. There are also two small inclusions of oak-hickory (*Quercus* spp.) forest on this side. These hardwoods tend to occur in areas of higher soil moisture.

The area on and around the dam at the south end of the lake is open and grassy and maintained in grass through regular mowing. The grasses are typical cultivated lawn grasses (e.g., fescue and rye). Below the dam, directly in the Steel Creek corridor, are wetlands dominated by sweetgum (*Liquidambar styraciflua*), tulip poplar (*Liriodendron tulipifera*), Nuttall oak (*Q. nuttallii*), and willow (*Salix* spp.). At elevations immediately above these wetlands are slash and long-leaf pines that were planted in the 1950s (SRFS 1997).

At the north end of the lake, on the north side of SRS Road B, is L-Area. On the west side of L-Area is an open, regularly mowed grassy area and a stand of slash pines that were planted in 1957. South of the reactor are young stands of loblollies that were established in 1989. Along the west side of the Steel Creek headwaters is an old stand of oak-hickory forest that became established in 1916 and along the shoreline is a stand of mature sweetgum and tulip poplar. The uplands on the east side of the headwaters are dominated by loblolly pines that were established in 1946 and 1953 (SRFS 1997). TC

Only two sensitive plant species occur within a half mile of the reservoir. These species are wild indigo (*Baptisia lanceolata*) and sandhill lily (*Nolina georgiana*) (SRFS 1996). Neither of these species is federally recognized as threatened or endangered and their status in the State is currently unresolved (Knox and Sharitz 1990). Both are centrally located east of the reservoir in the uplands.

Due to its location (near the Fall Line, where two physiographic provinces meet), large size [300 square miles (780 square kilometers)], climate (wet summers and mild winters), wide variety of terrestrial and aquatic habitats, and protection from public intrusion, the SRS contains diverse reptile and amphibian communities (Gibbons and Patterson 1978; Gibbons and

Semlitsch 1991). Some 36 species of snakes, 26 frogs and toads, 17 salamanders, 12 turtles, 9 lizards, and a single crocodilian (the American alligator) have been found on the SRS (Wike et al. 1994). Amphibians and reptiles in the Steel Creek corridor and delta were surveyed before the construction of L-Lake (Smith, Sharitz, and Gladden 1981, 1982). Surveys of amphibians and reptiles were also conducted along the shoreline of L-Lake from 1986 to 1989 as part of the L-Lake/Steel Creek biomonitoring program, which was designed to assess the degree to which the creation of the reservoir altered amphibian and reptile community structure (Scott, Patterson, and Giffin 1990). Table 4-7 shows the number of amphibian and reptile species collected during the pre-impoundment and post-impoundment periods.

These surveys suggest that amphibian and turtle species richness in the L-Lake area declined after Steel Creek was impounded, while lizard and snake species richness remained stable or increased (Wike et al. 1994). Three species of salamanders that were abundant in the upper Steel Creek area in 1981 and 1982, the mole salamander (*Ambystoma talpoideum*), marbled salamander (*Ambystoma opacum*), and dwarf salamander (*Eurycea quadridigitata*), were present in much lower numbers in 1989. These three species are largely terrestrial as adults, using temporary waterbodies (pools formed by heavy spring rains) for breeding and may have been displaced by the waters of L-Lake. Several frog species commonly collected in 1981 and 1982, including the southern leopard frog [*Rana utricularia (R. sphenocephala)*], green tree frog (*Hyla cinerea*), and southern cricket frog (*Acris gryllus*) were either not collected or were infrequently collected in 1989. An increase in the abundance of aquatic predators, such as largemouth bass, water snakes (*Nerodia* spp.), and cottonmouth "moccasins" (*Agkistrodon piscivorous*) after the impoundment of Steel Creek possibly led to the decline in frog populations. In addition, several turtles [e.g., the eastern mud turtle (*Kinosternon subrubrum*) and Florida cooter (*Pseudemys floridana*)] that were abundant in Steel Creek in the early 1980s either did not occur or were uncommon in the L-Lake area by the late 1980s. All three species are adapted to aquatic or semiaquatic life, so the cause of the apparent decrease in abundance is unclear.

Conversely, species richness of lizards and snakes remained relatively stable in the vicinity of L-Lake after its creation. Some of the lizard species that prefer drier habitats, such as the six-lined race runner (*Cnemidiphorus sexlineatus*), generally decreased in numbers from 1987 to 1989, but the decrease might be due to natural variability (Scott, Patterson, and Giffin 1990). Almost all snake species captured in 1981 and 1982 were collected in higher numbers in 1986 through 1989 after the reservoir was created. In addition, several other reptile species appear to

Table 4-7. Number of amphibian and reptile species collected from Steel Creek and lower reaches of L-Lake before and after the creation of L-Lake.

Group	Steel Creek 1981-1982	L-Lake 1986	L-Lake 1989
Salamanders	11	6	3
Frogs and toads	13	7	5
Turtles	8	5	2
Lizards	6	7	6
Snakes	7	10	10
Total	45	35	26

Sources: Smith, Sharitz, and Gladden (1982); Scott, Patterson, and Giffin (1990).

have benefited, or are presumed to have benefited, from the construction of L-Lake. These species include the American alligator (*Alligator mississipiensis*), snapping turtle (*Chelydra serpentina*), softshell turtle (*Apalone* spp.), and yellow-bellied slider (*Chrysemys scripta*), all of which are aquatic or semiaquatic species.

Appendix D, Table D-1 lists species of reptiles and amphibians collected from Steel Creek and L-Lake sampling locations during the 1981 to 1989 period.

Although the birds of L-Lake have not been inventoried, the Savannah River Ecology Laboratory conducted surveys of birds in the Steel Creek watershed prior to the construction of L-Lake (Smith, Sharitz, and Gladden 1981). TE More than 90 species were identified, including a variety of common native songbirds [Carolina wren (*Thryothorus ludovicianus*), northern cardinal (*Cardinalis cardinalis*), northern mockingbird (*Mimus polyglottos*)], neotropical migrant songbirds [prothonotary warbler (*Protonotaria citrea*), summer tanager (*Piranga rubra*), red-eyed vireo (*Vireo olivaceus*)], birds of prey [red-tailed hawk (*Buteo jamaicensis*), barred owl (*Strix varia*)], upland game birds [northern bobwhite (*Colinus virginianus*), wild turkey (*Meleagris gallopavo*)], and wading birds [great blue heron (*Ardea herodias*) and great egret (*A. alba*)]. Three species – white-eyed vireo (*Vireo griseus*), Carolina wren, and tufted titmouse (*Parus bicolor*) – were particularly abundant in surveys in the summer of 1981 (Smith, Sharitz, and Gladden 1981). Appendix D, Table D-2 lists bird species known to occur in the Steel Creek drainage and nearby wetlands. It also includes a number of waterfowl, wading bird, and raptor species observed in the L-Lake area in more recent years by scientists involved in research and monitoring (Scott, Patterson, and Giffin 1990; Bildstein et al. 1994).

Large numbers of waterfowl have wintered on the SRS since the early 1950s, when public access was restricted and hunting banned (Du Pont 1987a). The lower reaches of Steel Creek attracted significant numbers of wintering waterfowl in the 1970s when effluent from L-Reactor and P-Reactor created expanses of marsh and open water in portions of the swamp bordering the Savannah River. By the mid-1980s, the Steel Creek delta and adjacent swamp forests were used extensively by foraging mallards (*Anas platyrhynchos*) and wood ducks (*Aix sponsa*) (Du Pont 1987a). Other waterfowl commonly observed in the Steel Creek delta in the 1980s included black ducks (*Anas rubripes*), blue-winged teal (*Anas discors*), and hooded mergansers (*Lophodytes cucullatus*).

The completion of L-Lake in 1985 provided additional habitat in the Steel Creek drainage for wintering waterfowl and other waterbirds. Numbers of waterfowl using L-Lake over the October to April migratory period increased from 424 in 1986-1987, to 488 in 1987-1988, to 3,143 in 1988-1989 (Scott, Patterson, and Giffin 1990). In the final year of the study, the most abundant species was the lesser scaup (*Aythya affinis*) (1,609 observed), followed by mallard (818), bufflehead (*Bucephala albeola*) (180), and ruddy duck (*Oxyura jamaicensis*) (121). Numbers of "water-dependent" birds such as coots (*Fulica americana*), cormorants (*Phalacrocorax* sp.), and grebes (*Podilymbus podiceps* and *Podiceps auritus*) using L-Lake also steadily increased over the course of the study, from 2,372 in 1986-1987, to 3,353 in 1987-1988, to 3,934 in 1988-1989 (Scott, Patterson, and Giffin 1990).

Kennamer (1994) presents data on wintering waterfowl use of SRS reservoirs from 1982 to 1994. Four diving duck species – lesser scaup, ring-necked duck (*Aythya collaris*), ruddy duck, and bufflehead – dominated aerial counts of waterfowl. In the first several years after L- L7-06
Lake filled, ducks continued to use Par Pond L11-08
heavily and use L-Lake very little. By 1988-1989, however, L-Lake was used by several thousand wintering waterfowl. The total number of waterfowl wintering on the SRS did not increase over this period: the increased use of

L-Lake corresponded with a decreased use of Par Pond and its subimpoundments (Ponds B and C). In the winter of 1991-1992, during the first winter of the Par Pond drawdown, water-
L7-06 fowl (particularly ring-necked ducks and lesser
L11-08 scaup) showed a pronounced preference for L-Lake. This shift in usage was attributed to the decimation of the *Corbicula* (Asiatic clam) population in Par Pond caused by the rapid drawdown. *Corbicula* are an important food source for diving ducks, particularly ring-necked ducks and lesser scaup (Hoppe, Smith, and Wester 1986). In 1992-1993 and 1993-1994, waterfowl use of Par Pond increased as its water level stabilized and aquatic vegetation and
TC invertebrate populations recovered. This increased use of Par Pond was accompanied by somewhat lower waterfowl use of L-Lake.

L-Lake has become an important foraging area for wading birds since its creation. Bildstein et al. (1994) compared wading bird use of L-Lake with that of Par Pond and Pond B between the fall of 1987 and the summer of 1989. Surveys conducted over this 2-year period indicated that wading bird densities were significantly higher at L-Lake than at the two older (built in 1958) reservoirs. Wading birds using L-Lake showed a preference for shallow areas where wetland plants had been planted (see "Wetlands" section that follows).

Seven species of wading birds [great blue heron, great egret, snowy egret (*Egretta thula*), little blue heron (*E. caerulea*), tricolored heron (*E. tricolor*), green-backed heron, and wood stork (*Mycteria americana*)] were observed at L-Lake, with highest abundance in summer and fall. Great blue herons and great egrets made up 96 percent of all wading birds observed in upper L-Lake and 87 percent of wading birds observed in lower L-Lake (Bildstein et al. 1994).

The relatively heavy wading bird use of L-Lake could be related to the attractiveness of the reservoir as a foraging area (Bildstein et al. 1994). L-Lake provides ideal conditions for wading birds – shallow coves with patches of emergent vegetation. This enables wading birds to stalk around the edges of the weedy patches, preying on small fish concentrated in the vegetation.

More than 20 mammal species occur in the Steel Creek area. These include three shrew species, two mole species, seven species of mice, voles, and woodrats, three squirrel species (gray squirrel, fox squirrel, and flying squirrel), gray fox (*Urocyon cinereoargenteus*), white-tailed deer (*Odocoileus virginianus*), feral swine (*Sus scrofa*), raccoon (*Procyon lotor*), beaver (*Castor canadensis*), otter (*Lutra canadensis*), muskrat (*Ondatra zibethicus*), opossum (*Didelphis virginiana*), striped skunk (*Mephitis mephitis*), and bobcat (*Felix rufus*) (Smith, Sharitz, and Gladden 1982). Many of these species forage in the wetlands and marshy areas around L-Lake; others occur in adjacent uplands. Appendix D, Table D-3 lists mammal species that probably occur in the bottomland hardwood forests and river swamps of the SRS, including the forested margins of L-Lake.

4.1.5.1.2 Aquatic Ecology

As a condition of National Pollutant Discharge Elimination System Permit Number SC0000175, issued in 1984, DOE monitored aquatic communities in L-Lake (and Steel Creek downstream of the L-Lake Dam) to demonstrate that heated effluent from L-Reactor did not prevent the development of a balanced biological community in the lower half of the reservoir or in Steel Creek. As a result, the water quality and aquatic communities of L-Lake were monitored intensively from January 1986 through December 1992. The results of these monitoring studies were presented in a Clean Water Act Section 316(a) Demonstration (Gladden et al. 1989), a series of biological monitoring reports (Carson and Cichon 1993; Westbury 1993; Bowen 1993a,b), several journal articles (e.g., Paller, Gladden, and Heuer 1992), and a number of monographs (e.g., Bowers 1991).

Plankton

L-Lake reached full pool for the first time in October 1985; the phytoplankton community of L-Lake was studied from January 1986 through December 1992 (Carson and Cichon 1993). During the first 2 years of study, the phytoplankton was dominated by the blue-green alga, *Microcystis aeruginosa*, under bloom conditions. The bloom ended by 1988, even though phosphorus loading from river water pumped to L-Lake remained very high. From 1987 to 1992, phytoplankton diversity increased while primary productivity and chlorophyll-*a* declined. Besides blue-green algae, important groups in terms of biovolume or numbers included the green and golden-brown algae, diatoms, cryptomonads, and dinoflagellates. Although less so in recent years, L-Lake is distinctly eutrophic in terms of chlorophyll and primary productivity levels and phytoplankton community composition.

Zooplankton were investigated in L-Lake over the same 1986-1992 period. Substantial numbers of taxa (species and genera) appeared quickly during the first year of L-Lake's existence, but taxa richness gradually declined in succeeding years, mainly from fewer protozoan and rotifer taxa (Bowen 1993b). Throughout the study protozoa, mainly ciliates, dominated the community in terms of numbers, and although densities of rotifers and crustaceans were similar to other lakes in the region, protozoan densities were atypically high in L-Lake. Eutrophic lakes are often characterized as having an important detrital component in the open water, supporting large bacterial populations. This is based on the close correlation often observed between the biomass of phytoplankton and heterotrophic bacteria (Wetzel 1983). A high density of ciliate protozoans, as found in L-Lake, is consistent with a high phytoplankton and bacterial biomass because ciliates graze bacteria.

Crustacean zooplankton were small in L-Lake; all cladocerans became rare in summer and adult copepods were infrequently found (Bowen 1993b). Changes in zooplankton size corresponded with increased pressure from fish predation. Feeding by larval and juvenile fish appeared to place strong pressure on zooplankton communities in the summer, and the presence of larger cladocerans was correlated with the abundance of threadfin shad both seasonally and from year to year. Threadfin shad, which are members of the clupeid (shad and herring) family, typically feed on zooplankton in open water areas (Baker and Schmitz 1971), and were present in large numbers in L-Lake until at least 1991. Clupeids are known to alter the size structure of zooplankton communities (Brooks and Dodson 1965).

Benthic Macroinvertabrates

Specht (1996) conducted surveys of L-Lake benthic macroinvertebrates in September 1995 and compared measures of density, relative abundance, and community structure with those obtained in 1988-1989 during L-Lake biomonitoring studies. Macroinvertebrate densities at 6.6-foot (2-meter) depths were lower in 1995 than 1988-1989, while densities at 13.1-foot (4-meter) depths changed little. The relative abundance of larval chironomids of the group Chironomini declined substantially, while those of the group Tanytarsini increased. Amphipods (microcrustaceans), oligochaetes (aquatic earthworms), Turbellaria (flatworms), bivalves (especially the Asiatic clam *Corbicula fluminea*), and the phantom midge larvae (*Chaoborus punctipennis*) all increased in abundance.

Most noteworthy was the increase in amphipods, whose relative abundance was low in 1988-1989 (less than 1 percent of total at most sampling locations), but ranged from 5 to 31 percent of benthic organisms collected at the various sampling locations in 1995. Amphipods are often abundant in the vegetated littoral zones of lakes, where they feed on decaying vegetation or attached algae as juveniles and become opportunistic scavengers (omnivores) as adults (Pennak 1978; Covich and Thorp 1991).

Specht (1996) suggested that the changes in the L-Lake macroinvertebrate community were due, in part, to the establishment of aquatic macrophyte beds along the margins of the reservoir. Aquatic macrophytes stabilize the substrate (bottom sediments) of reservoirs, benefiting both benthic organisms and fish, and provide benthic macroinvertebrates with shelter and food (Boyd 1971; Minshall 1984). As a result, many benthic macroinvertebrates (e.g., aquatic insects) tend to be less abundant and less diverse on bare substrates (sand or clay) and more diverse and abundant in areas with aquatic vegetation (Minshall 1984). Specht (1996) also related changes in the L-Lake benthos community to aging of the reservoir, as early-successional species were replaced by species characteristic of a more mature ecosystem.

Fish

L-Lake was stocked with approximately 40,000 juvenile bluegill (*Lepomis macrochirus*) in the fall of 1985 and 4,000 juvenile largemouth bass (*Micropterus salmoides*) in the spring of 1986. These introductions were intended to speed the development of a balanced biological community in the lower half of the reservoir. Both species are ubiquitous in the southeastern United States, and are often stocked in farm ponds and new impoundments because they grow rapidly, feed on a variety of invertebrate and vertebrate prey, and adapt readily to a variety of lentic conditions.

DOE evaluated community structure of L-Lake fish monthly from 1986 through 1989 and quarterly during 1990 and 1991 as part of the Clean Water Act Section 316(a) study discussed above. Fish were collected by electrofishing at 20 stations in five regions of the middle and lower portions of the reservoir (Paller 1996). Supplemental sampling occurred in November and December of 1995 to determine if any obvious changes in fish community structure had occurred since 1991.

Statistical analysis of fish collections revealed patterns of community structure that corresponded with five distinct time periods. Table 4-8 lists the relative abundance of fish species that were regularly collected over the five time periods, designated Period 1, Period 2, Period 3, Period 4, and Period 5 (P1, P2, P3, P4, and P5).

During Period 1, collections were dominated by three Lepomids (redbreast sunfish, spotted sunfish, and dollar sunfish), two shiners (coastal shiner and golden shiner), and a livebearer, the eastern mosquitofish; all are native to the streams and swamps of the Atlantic Coastal Plain (Lee et al. 1980; Rohde et al. 1994).

By the end of Period 2, shiners and mosquitofish were rare in L-Lake samples, and bluegill (stocked 2 years earlier) made up 79.3 percent of all fish collected. Redbreast were still common (16.1 percent of all fish collected) but were only half as abundant as they were in Period 1. Two other native Lepomids, the spotted sunfish and the dollar sunfish, declined in abundance, unable to compete with bluegill and redbreast, which are better suited for reservoir life.

Interspecific competition probably was responsible for the change in community structure observed between Period 1 and Period 2 (Paller, Gladden, and Heuer 1992). As noted above, two species (bluegill and largemouth bass) adapted to reservoir life were stocked in L-Lake in 1985 and 1986 and rapidly out-competed the smaller-bodied (and slow-growing) insectivores (e.g., mosquitofish, shiners, and brook silversides) that were in the Steel Creek system when the stream was dammed. Moreover, these minnow-like species became prey for the expanding population of largemouth bass stocked in the spring of 1986. The juvenile largemouth bass stocked in 1986 would have been large enough to feed on mosquitofish, shiners, and silversides by their second year (1987) in the reservoir (Carlander 1977).

By Period 3, L-Lake had developed into a typical small-reservoir fish community, with large numbers of bluegill and redbreast, increasing numbers of threadfin shad, and smaller numbers

Table 4-8. Relative abundance of L-Lake fish species, 1986 through 1995.

Species		January - June 1986	July 1986 - July 1987	August 1987 - June 1989	July - December 1989	November 1995
		P1	P2	P3	P4	P5
Bluespotted sunfish	*Enneacanthus gloriosus*	0.2	<0.1	0.0	<0.1	0.0
Bluegill	*Lepomis macrochirus*	1.2	79.3	45.8	16.1	12.3
Brook silverside	*Labidesthes sicculus*	2.3	<0.1	0.1	1.1	28.5
Brown bullhead	*Ameiurus nebulosus*	0.0	<0.1	0.0	0.0	0.3
Chain pickerel	*Esox niger*	0.1	<0.1	<0.1	0.1	4.0
Coastal shiner	*Notropis petersoni*	20.9	0.7	0.1	0.1	13.3
Creek chubsucker	*Erimyzon oblongus*	0.8	<0.1	0.0	0.0	0.0
Dollar sunfish	*Lepomis marginatus*	4.4	0.2	<0.1	0.0	0.3
Flat bullhead	*Ameiurus platycephalus*	0.1	0.1	0.5	0.4	0.0
Gizzard shad	*Dorosoma cepedianum*	0.0	<0.1	0.7	0.8	1.3
Golden shiner	*Notemigonus crysoleucas*	13.7	0.4	0.1	0.4	1.9
Ironcolor shiner	*Notropis chalybaeus*	0.0	<0.1	0.0	0.0	0.0
Lake chubsucker	*Erimyzon sucetta*	0.1	<0.1	0.0	0.0	1.4
Largemouth bass	*Micropterus salmoides*	1.4	1.8	4.2	2.9	4.0
Eastern mosquitofish	*Gambusia holbrooki*	14.4	<0.1	<0.1	0.0	0.0
Northern hogsucker	*Hypentelium nigricans*	0.1	0.0	0.0	0.0	0.0
Redbreast sunfish	*Lepomis auritus*	32.3	16.1	24.3	27.1	9.8
Spotted sunfish	*Lepomis punctatus*	6.2	0.6	0.2	<0.1	1.8
Threadfin shad	*Dorosoma petenense*	0.0	<0.1	23.2	49.9	0.0
Warmouth	*Lepomis gulosus*	0.3	0.1	0.4	0.4	2.7
Yellow bullhead	*Ameiurus natalis*	0.5	0.1	0.2	0.1	0.2
Yellow perch	*Perca flavescens*	<0.1	<0.1	<0.1	0.3	17.6

Source: Paller (1996).

of largemouth bass. Many of the small stream and swamp species that were present in the watershed when the reservoir was built had become rare, among them the bluespotted sunfish, creek chubsucker, coastal shiner, dollar sunfish, spotted sunfish, and mosquitofish.

Threadfin shad was the most abundant species in Period 4 collections, with redbreast and bluegill second and third in abundance (Paller 1996). These three species comprised more than 90 percent of all fish collected. Largemouth bass made up a small percentage (2.9 percent) of fish collected, and was the only top-of-the-food-chain predator present in significant numbers.

By late 1995 (Period 5), the community structure of L-Lake fish had changed markedly. A number of the resident stream species, such as brook silverside, coastal shiner, and creek chubsucker, that had become a minor component of the fish community from 1986 through 1989 became much more common. Other species, such as yellow perch and chain pickerel, which had previously been uncommon to rare, became fairly abundant. Threadfin shad, which made up 23.2 percent of fish collected in Period 3 and 49.9 percent of fish collected in Period 4, were not collected in Period 5.

These shifts in species dominance appeared to be independent of L-Reactor operations and resultant temperature and dissolved oxygen fluctuations (Paller 1996). Several of the species (e.g., coastal shiner, spotted sunfish, dollar sunfish), whose abundance declined during years (1986-1988) when L-Reactor was operating, are adapted to life in small Coastal Plain streams where water temperature and dissolved oxygen levels show wide daily and seasonal fluctuations. Others, such as the mosquitofish and golden shiner, are extremely hardy species that are tolerant of high water temperatures and low levels of dissolved oxygen (Tomelleri and Eberle 1990; Rohde et al. 1994).

Threadfin shad, which were apparently introduced to L-Lake as eggs or larvae entrained in Savannah River water in 1986 or 1987 (Paller 1996), increased in abundance over the ensuing 2 to 3 years, taking advantage of the reservoir's healthy plankton populations. As a consequence, the fish community structure shifted by Period 4 (1989) to one dominated by threadfin shad, with relative abundance of Lepomids (notably bluegill) declining. Reduced bluegill recruitment into the population appears to have resulted from intense largemouth bass predation on juvenile Lepomids, including bluegill (Paller 1996).

As noted previously, supplemental fish sampling was conducted in late 1995 to update the first 5 years (1986 to 1991) of surveys. The change in species composition from Period 4 (1991) to Period 5 (1995) was pronounced, with several of the original stream species (e.g., coastal shiner and brook silverside) reappearing in significant numbers and threadfin shad disappearing from samples (Paller 1996). Several species that had been rare before (yellow perch and chain pickerel) became relatively abundant in Period 5.

Examination of the habitat requirements of the species that increased in abundance during Period 5 suggested possible reasons for the changes in species composition. Three of the four species that increased most (brook silversides, yellow perch, and chain pickerel) are phytophilous species that spawn over aquatic vegetation (Paller 1996). The remaining species, coastal shiner, has more general spawning requirements, but because it is small and occupies the littoral zone, it benefits from the protection from predators afforded by aquatic vegetation.

Aquatic vegetation had become well established along the shoreline of L-Lake by 1995. Much of this vegetation was originally established in 1987 as a result of artificial plantings along 12,000 feet (4,000 meters) of shoreline in the lower portions of the reservoir (Wein, Kroeger, and Pierce 1987). Approximately 40 species were planted with the objective of creating submerged/floating-leafed, emergent, and upper emergent/shrub zones (see "Wetlands" section that follows). Vegetation cover within the submerged zone of the planted areas increased from 1 percent in 1987 to 22 percent in 1989 (Westbury 1993) and continued to increase through 1991. Among the most abundant species were eelgrass (*Vallisneria americana*), lotus (*Nelumbo lutea*), and pondweed (*Potamogeton diversifolius*).

Although the expansion of aquatic vegetation throughout the littoral zone of L-Lake explains many of the fish assemblage changes associated with Period 5, it does not account for the apparent absence of threadfin shad. In addition, predation alone probably was not responsible for the decline of threadfin shad because shad were abundant during Periods 3 and 4 when largemouth bass were well established and abundant. Lack of food probably contributed to the decline of threadfin shad in L-Lake (Paller 1996). Analysis of the contents of threadfin shad gizzards in 1988 and 1989 indicated that algae comprised a large part of their diet. The standing crop of phytoplanktonic algae (as indicated by chlorophyll-*a*) remained relatively high in L-Lake through 1989 but dropped precipitously in 1990 and 1991. Microcrustaceans and rotifers, other important foods of L-Lake threadfin shad, also exhibited large declines over time and by 1990 many microcrustaceans were comparatively rare (Wike et al. 1994).

Several factors probably contributed to declines in phytoplankton and zooplankton densities in L-Lake. Threadfin shad predation contributed directly to the decline of large zooplankton in L-Lake, especially larger daphnids and copepods (Taylor, DeBiase, and Mahoney 1993). However, nutrient availability might have played a part. L-Lake received relatively high levels of total phosphorus and nitrogen in the water pumped from the Savannah River. Inputs of river water declined markedly after L-Reactor was shut down in mid-1988, reducing nutrient loading.

Entrainment and Impingement of Fishes

In early 1988, when K-, L-, and P-Reactors last operated, the maximum rate of river water withdrawal at the 1G and 3G intakes was about 380,000 gallons per minute (24 cubic meters per second) – 179,000 gallons per minute (11.3 cubic meters per second) each for once-through cooling at K-and L-Reactors, 22,000 gallons per minute (1.4 cubic meters per second) for makeup water at P-Reactor. Based on studies conducted in the 1980s, this rate of withdrawal would result in an estimated 18 million fish larvae and 9 million fish eggs entrained annually during the spring and summer spawning period. During the 1980s, clupeid (shad and herring), centrarchid (sunfish and crappie), and cyprinid (minnow and common carp) larvae were entrained most often, while eggs of two species, American shad and striped bass, were most often entrained, comprising 73 percent of all eggs drawn into river water intakes. The *Final EIS for Continued Operation of K-, L-, and P-Reactors* concluded that any impacts to fisheries from entrainment of fish eggs and larvae at SRS would be small and limited to fish populations in the immediate vicinity of the Site (DOE 1990).

Studies conducted at the 1G and 3G Pumphouse intakes in the 1980s indicated that approximately 6,000 fish were lost to impingement annually. Sunfish (bluespotted sunfish, redbreast sunfish, and warmouth) and shad (threadfin and gizzard shad) were the groups most often impinged. DOE did not attempt to assess the significance of these impingement losses, but they probably were comparatively minor (DOE 1990).

Since 1988, there has been a dramatic reduction in the rates of surface water withdrawn from the Savannah River. By 1988, all SRS production reactors had been shut down and placed under review to determine their future status (Arnett, Mamatey, and Spitzer 1995). As of 1994, four reactors were shut down permanently and the fifth, K-Reactor, was in cold standby. In June 1996, only one of the 10 pumps in the 3G Pumphouse was operating, pumping approximately 28,000 gallons per minute (1.8 cubic meters per second) for maintenance of L-Lake water levels; auxiliary equipment cooling in K-, L-, and P-Areas; fire protection in K-, L-, and P-Areas; and sanitary wastewater in K-, L-, and P-Areas.

4.1.5.1.3 Wetlands Ecology

The filling of L-Lake inundated approximately 225 acres (0.9 square kilometer) of wetlands and 775 acres (3.1 square kilometers) of uplands in the Steel Creek corridor. An additional 100 acres (0.4 square kilometer) of uplands were lost due to relocation of electric and cable rights-of-way. Between 735 and 1,015 acres (3.0 and 4.1 square kilometers) of wetlands in the Steel Creek corridor, Steel Creek delta, and the Savannah River swamp received impacts (DOE 1984).

A study conducted during the summer of 1981 documented the vegetation of the Steel Creek corridor for use in evaluating the Steel Creek ecosystem prior to the restart of L-Reactor (Smith, Sharitz, and Gladden 1981). Aerial photographs taken in 1978 and field studies conducted in 1981 were used to map the corridor. The portion of the Steel Creek corridor that was inundated by L-Lake was a forested wetland system characterized by a narrow band of alder (*Alnus* spp.) bordering the stream with other woody species such as sweetgum (*Liquidambar styraciflua*) and red maple (*Acer rubra*) occurring on the banks. As the stream corridor became broader farther south, wax myrtle (*Myrica cerifera*), willow (*Salix* spp.), and blackberry (*Rubus* spp.) dominated the floodplain community behind the alder band. The classification system used for mapping followed the Cowardin method with some modification to more accurately portray the features of this system (Smith, Sharitz, and Gladden 1981).

The area of the corridor that was later inundated by the reservoir had wetlands ranging from open water to forested. The vegetation was classified as scrub-shrub or forested wetland. The five specific mapping units identified are listed in Table 4-9.

Appendix D, Table D-4 describes the five mapping units in the portion of the Steel Creek corridor inundated by the lake.

During lake construction, approximately 1,034 acres (4.2 square kilometers) were clear cut, including 356 acres (1.4 square kilometers) of bottomland hardwood and shrub wetlands, 360 acres (1.5 square kilometers) of upland hardwoods and pine forests, and 125 acres (0.5 square kilometer) of other areas within the lake basin. Outside the lake basin an additional 193 acres (0.8 square kilometer) of mostly upland pine and hardwood forests were clear cut for power line rights-of-way and other construction-related sites (McCort, Lee, and Wein 1988). Most vegetation in the lakebed was removed or burned onsite. The shoreline was cleared 3 to 5 feet (1 to 1.5 meters) above the maximum pool elevation and seeded to control erosion. The shoreline vegetation above the cleared area was primarily planted pine (Wike et al. 1994). Trees in the floodplain of Steel Creek were not harvested because they were potentially contaminated from radioisotopes in the Steel Creek sediments. These trees and the timber in two coves in the lower half of the lake and the area above Road B were left standing as wildlife habitat (McCort, Lee, and Wein 1988; Westbury 1993).

Although DOE intended that L-Lake be used to mitigate the impacts of thermal effluent from L-Reactor on Steel Creek and the Savannah River, its use resulted in new impacts requiring mitigation (McCort, Lee, and Wein 1988). One component of the mitigation required by the regulatory agencies was the establishment of a Balanced Biological Community within L-Lake. DOE decided to accelerate the process of natural succession by planting wetland vegetation within the cooler southern end of L-Lake in an effort to establish a Balanced Biological Community more quickly. Wetlands and vegetation play important roles in nutrient cycling, sediment retention, and shoreline stabilization, and are a major factor in establishing a Balanced Biological Community. The establishment of wetland/littoral vegetation provided (1) organic matter for soil development and decomposers; (2) substrate for attached algae; (3) habitat for aquatic insects and other macroinvertebrates; and (4) cover and food for fish and wildlife (Wein, Kroeger, and Pierce 1987).

Table 4-9. Wetland community types occurring in the Steel Creek corridor.[a]

Wetland type	Mapping unit
Aquatic Bed	Open water
Scrub-shrub - Broad-leaved deciduous	*Alnus serrulata*
Forested - Broad-leaved deciduous	*Salix* sp.
Forested - Broad-leaved deciduous	*Alnus serrulata-Myrica cerifera*
Forested - Broad-leaved deciduous	*Liquidambar styraciflua-Acer rubrum-Salix* sp.

a. Source: Smith, Sharitz, and Gladden (1981).

Establishment of wetland vegetation along the shoreline of L-Lake occurred through natural colonization and planting of aquatic macrophytes. Shortly after L-Lake filled in October 1985, aquatic macrophytes became established on the cleared shoreline (Wike et al. 1994). Between January and July 1987, an extensive vegetation transplanting program managed by the Savannah River Ecology Laboratory accelerated the colonization of the L-Lake littoral zone by aquatic macrophytes and wetland plants. DOE invited a panel of experts in the areas of wetland ecology and restoration to the Savannah River Site. The panel developed a management plan for establishing an appropriate wetland plant community, which recommended that Par Pond serve as the primary source of plant material because its vegetation was adapted to elevated water temperatures, it was close to L-Lake, and the species found in it were representative of natural wetland species in the region.

The panel also proposed the establishment of zones of vegetation to represent species patterns found in Par Pond and natural lakes in the region. The zones were differentiated by species composition and defined by water level. The upper emergent-shrub zone, formed by trees, shrubs, and some emergents lies above the waterline up to 3 feet (1 meter) above mean high water and can flood periodically. The emergent zone consists of erect plant species that occur mostly in shallow water at depths of less than 1 foot (0.3 meter). The third zone consists of submersed and floating-leaved plant species that occur in deeper water. Approximately 12,000 feet (4,000 meters) of the shoreline at the southern end of L-Lake were planted with 100,000 individual plants representing more than 40 species. Perennial herbaceous plants were excavated by hand from Par Pond, but trees, one emergent herb (*Sagittaria latifolia*), and seed of some grasses were obtained from commercial sources. Species that were planted are listed in Appendix D, Table D-5. Major limitations to successful vegetation establishment were identified at the outset. These included steep slopes, fluctuating water levels, and low nutrient substrates [Wein, Kroeger, and Pierce 1987; additional details concerning planting densities, methods, and techniques are provided in Kroeger (1990) and USACE (1995)].

Kroeger (1990) and Westbury (1993) provide the most recent published data pertaining to wetland vegetative cover at L-Lake. During the summers of 1987, 1988, and 1989, the Savannah River Ecology Laboratory surveyed the vegetation in planted and unplanted areas to monitor the establishment and survival of plants in the submersed/floating-leaved, emergent, and upper emergent/shrub zones of L-Lake (Kroeger 1990). Of the nine species planted in the submersed and floating-leaved zone, American lotus (*Nelumbo lutea)* and water celery (*Vallisneria americana)* were the only surviving species in 1989. Wave action and low initial planting numbers were cited as reasons for the disappearance of some species. In 1989, 38 percent of the plots surveyed contained vegetation and mean cover per plot had increased to 22 percent. The rapid colonization of empty plots by *V. americana* and *N. lutea* along with cattails (*Typha latifolia*) moving from the emergent zone into the submersed and floating-leaved zone were cited as factors. No submersed or floating-leaved plants occurred in the unplanted areas, and most plots were unvegetated (Wike et al. 1994).

Approximately 30 species were planted in the emergent zone, and by 1989 most were still surviving. By 1989, 84 percent of the plots sampled had vegetation, and mean cover per plot was 40 percent. Within the planted areas, increases in *Eleocharis* spp., *T. latifolia*, *Hydrocotyle umbellata*, *V. americana*, and the *Panicum/Sacciolepis* group of grasses accounted for the increases. *N. lutea* and *V. americana* moved into the emergent zone from the submersed and floating-leaved zone and became important components of the emergent zone. In the unplanted areas, 85 percent of the plots remained unvegetated from 1987 to 1989. Plots with vegetation had low species diversity (Wike et al. 1994).

All species planted in the upper emergent/shrub zone in 1987 were present in 1989. Most (84.4 percent) of the plots had vegetation, primarily terrestrial species during the period from 1987 to 1989. Mean cover per plot in planted areas was 55 percent in 1989. Changes in species from 1987 to 1989 included major growth of willow (*Salix nigra*) shoots, decreases in relative frequency and cover of shoreline grasses, an increase in frequency and cover of *Panicum/Sacciolepis*, and a decrease in frequency and cover of *T. latifolia*. *S. nigra*, and the *Panicum/Sacciolepsis* grasses were the most important species in this vegetation zone. The emergents, *Juncus effusus*, *Polygonum* spp., *Sagittaria latifolia*, and *T. latifolia*, were also important species in this zone. In unplanted areas, facultative emergent and terrestrial species were the most important components. No *Juncus*, *Polygonum* spp., or *Panicum/Sacciolepsis* were found. *S. nigra* had a higher frequency in the unplanted areas than in the planted areas (Wike et al. 1994).

Discussions of changes in species composition and abundance in the unplanted areas of the littoral zone of L-Lake can also be found in the reports produced under the Biological Monitoring Program for L-Lake and Steel Creek, which was part of the project to ensure the establishment of a Balanced Biological Community. Data covering the period from November 1985 through December 1987 are discussed in Gladden et al. (1989). Westbury (1993) summarizes the results of 7 years of data covering the January 1986 through December 1992 period.

In the first 5 years (1986 through 1990) after the creation of L-Lake, plant community development was limited to emergent aquatic macrophytes and wetland plants near the shoreline. In 1991 and 1992, submersed and floating-leaved macrophytes such as *V. americana* and *Potamogeton diversifolius* greatly increased in abundance. Appendix D, Table D-6 lists the plant taxa mapped in the study plots in descending order of their whole lake (four study plots) annual mean areal coverage. The species-specific annual mean areal cover (square meters per hectare) and frequency are based on 16 samples (four stations × four seasons) (Westbury 1993).

A seed bank study at L-Lake (Collins and Wein 1995) detected the presence of a total of 136 different taxa (see Appendix D Table D-7). Thirty-three percent were well represented while 35-46 percent of taxa occurred only once. Collins and Wein found that shallow water [less than 13 inches (33 centimeters) deep] and the shoreline above waterline had more germinable
TC seeds and a greater number of taxa than water deeper than 13 inches. The study concluded that periodic drawdown, may enhance seed bank and vegetation development in a reservoir such as L-Lake by redistributing seeds with the changing waterline and by allowing input of seeds of facultative wetland species (Collins and Wein 1995).

A recent mapping effort by Savannah River Ecology Laboratory mapped areal coverage and estimated acreage for three vegetation classes: submersed aquatic, floating-leaved, and emergent vegetation (Wein 1996). Aerial photographs taken in March 1996 were used to map the submersed aquatic vegetation. The floating-leaved and emergent vegetation were mapped using Global Positioning System data collected during the summer of 1996. Table 4-10 lists the classes of vegetation and area of coverage for each. The dominant species in the submersed aquatic class were *V. americana*, *P. diversifolius*, and *Myriophyllum aquaticum*. *N. lutea* was the predominant floating-leaved wetland species. The emergent class of vegetation was dominated by *T. latifolia*, *P. hemitomon*, *Eleocharis quadrangulata*, and *Hydrocotyle umbellata*.

Table 4-10. Aquatic macrophyte coverage of L-Lake, 1996.[a]

Class name	Area in acres (square kilometers)	Percentage
Open water	969 (4.0)	88.8
Submersed	76 (0.3)	7.0
Floating-leaved	19 (<0.1)	1.7
Emergent	27 (0.1)	2.5
Total	1,091 (4.4)	100.0

a. Source: Wein (1996).

4.1.5.2 Environmental Impacts

4.1.5.2.1 No Action

Terrestrial Ecology

The No-Action Alternative would have little or no effect on semiaquatic and terrestrial animals that forage around L-Lake and drink its water. There would be normal cycles of abundance caused by disease outbreaks, predator-prey interactions, and variation in the availability of food and other resources.

Aquatic Ecology

Under the No-Action Alternative, DOE would continue to maintain L-Lake at its current level of approximately 190 feet (58 meters) and provide make-up water for the K-Reactor 186-Basins. Over time, however, the reservoir could become less productive as a result of normal reservoir aging processes. As primary productivity decreases, there would be an attendant decline in zooplankton production, fish production, and fish growth. Most reservoirs experience declines in primary and secondary productivity 5 to 10 years after filling, then reach trophic equilibrium with relatively stable aquatic communities that show typical seasonal fluctuations in abundance and biomass. Summer is typically the period of peak productivity and late winter the period of lowest productivity. The productivity of L-Lake has been maintained by the continuous pumping of nutrients to the reservoir along with large volumes of Savannah River water. In time, L-Lake would become a more typical, moderately productive coastal plain reservoir. TE

Under this alternative, DOE would continue to withdraw approximately 5,000 gallons per minute (0.3 cubic meter per second) of Savannah River water. This is 1.3 percent of the rate of river water withdrawal in the mid-1980s [up to 380,000 gallons per minute (24 cubic meters per second)] when millions of larval fish were entrained and thousands of adult fish were impinged annually. Based on studies conducted from 1983 through 1985, a withdrawal of 380,000 gallons per minute (24 cubic meters per second) results in an average loss of approximately 17,600,000 fish larvae and 9,300,000 fish eggs during the February-July spawning season (DOE 1990). Assuming entrainment losses were proportional to the rate of river water withdrawal, an estimated 234,000 larval fish and 117,000 fish eggs would be lost each spawning season under the No-Action Alternative. Because use of the smaller (5,000-gallon-per-minute) pump greatly reduces the approach velocities at the intake structure, impingement losses would be negligible, limited to small numbers of fish already weakened by disease, stress, cold shock, or some other debilitating factor(s).

Wetlands Ecology

Under the No-Action Alternative, wetland vegetation along the shoreline of L-Lake would show subtle changes in community structure (i.e., species dominance) caused by year-to-year variation in rainfall, runoff, and other natural influences. There probably would be continued expansion of littoral wetlands, partic-ularly in the southeast region of the reservoir.

4.1.5.2.2 Shut Down and Deactivate

Terrestrial Ecology

This alternative would affect semiaquatic and terrestrial animals that depend on L-Lake for critical habitat needs such as breeding and nesting areas, food, and water. The amount of shoreline, which is an ecological edge or "ecotone," would shrink as the reservoir recedes. There would be less habitat available for amphibians, reptiles, semiaquatic mammals (muskrats, beavers, raccoons), and wading birds. Small mammals and upland game birds would be forced to venture farther from shoreline cover to drink and forage around reservoir edges and would be more exposed to predators. As the lake recedes, many animals may be forced to disperse from the area, expending energy and becoming more vulnerable to predation.

Based on the behavior of wintering waterfowl in 1991-1992, when Par Pond was first drawn down, diving ducks (particularly ring-necked ducks and lesser scaup) that have traditionally wintered on L-Lake could be forced to move to Par Pond, the nearest body of water that offers food and protection from hunters. Depending on the amount of available food in Par Pond, these "displaced" diving ducks would either over-winter on Par Pond or would be forced to leave the Savannah River Site in search of suitable wintering habitat. In 1991-1992, Par Pond diving ducks moved to L-Lake in response to the Par Pond drawdown, but the combined pressure of feeding ducks from both reservoirs quickly depleted L-Lake's supply of *Corbicula* (Kennamer 1994). Most diving ducks ultimately left the Savannah River Site. This suggests that diving ducks that have traditionally wintered on L-Lake could be forced to disperse to Par Pond or offsite reservoirs if L-Lake's water level drops dramatically in the late fall or winter, particularly if large numbers of *Corbicula*, which are concentrated in shallow, near-shore areas, are killed.

If the Shutdown and Deactivate Alternative is implemented, animals would be exposed to contaminants in sediments and could accumulate contaminants via incidental ingestion (contaminated soil ingested along with vegetation and prey items), inhalation of contaminated airborne soil (or dust), and ingestion of contaminated vegetation growing in the newly exposed lakebed. Potential risks from exposures to contaminants are evaluated in more detail in Section 4.3.5.3 and Appendix B.

Aquatic Ecology

The Shut Down and Deactivate Alternative would result in the creation of a much smaller reservoir or a stream meandering through the old lakebed. Hydrological models predict that L-Lake would slowly recede if water was not pumped to the reservoir because the watershed could not supply sufficient water to compensate for natural losses and the required releases to Steel Creek (del Carmen and Paller 1993a). After 10 to 50 years as the lake drained, the aquatic component of the L-Lake ecosystem would shift from a plankton-based system (in which energy flowed by photosynthetic activity from phytoplankton to zooplankton to planktivorous fish to carnivorous fish) to a detritus-based system (in which energy is transferred from nonliving organic matter to detritus-feeding organisms and their predators).

The L-Lake watershed would supply much lower levels of nutrients to L-Lake than water pumped from the Savannah River. Lower rates of nutrient loading usually result in less productivity, improved water clarity, and less zooplankton, phytoplankton, macroinvertebrate, and fish biomass. Similar effects would occur in the periphyton and consumers utilizing this resource in littoral areas. Indirect effects, such as shifts in species composition brought about by nutrient limitation, could change predator-induced effects in species composition of prey and, in turn, prey food resources. For example, increased predation or competition due to limited nutrients could lower threadfin shad densities (assuming this species recovered from its decline), releasing zooplankton from predation pressure. This could result in more efficient grazing of the phytoplankton by large-bodied zooplankton, enhancing water clarity and the growth of phytoplankton species able to avoid grazing. Prediction of the nature and extent of this potential indirect effect is not possible, nor is it necessarily a deleterious effect, viewing the system as a whole.

Surviving aquatic communities would be reduced in terms of numbers (abundance), diversity (species richness), and productivity (plant and animal biomass produced per unit time). The degree to which these aquatic communities would be reduced would largely be a function of lake level, although other factors (such as timing and speed of lake recession) could be important.

A number of researchers have documented responses of reservoir macroinvertebrate communities to water level drawdowns (Wegener, Williams, and McCall 1974; Benson and Hudson 1975; Marshall 1978). Benthic organisms are affected directly and indirectly by water level changes. Direct effects include exposure to extremes of heat and cold. Depending on the duration of the drawdown and weather conditions (temperature, relative humidity, and cloud cover) benthic organisms may be killed or may survive by burrowing into soft substrates. Indirect effects of drawdown include dessication of algae and aquatic vascular plants that supply benthic organisms with food and shelter. Exposed periphyton may be killed in a matter of days, while exposed vascular plants may live for several months, depending on temperature and rainfall.

The most obvious impact of lake level drawdown on macroinvertebrates would be reductions in population size due to loss of habitat. The extent of these reductions in population size would depend on the area and type of habitat affected. For example, macrophytes offer a more complex habitat than bare substrates and support a more diverse and abundant macroinvertebrate fauna. If water levels recede below the macrophyte beds, there would be large losses among benthic populations that use macrophytes as habitat. Smaller losses of macroinvertebrates would be expected from the exposure of bare substrate habitat or substrate covered with algae (periphyton). Losses of benthic organisms would be reduced if lake levels were to recede slowly, allowing aquatic macrophytes to become established in the new littoral zone.

The impacts of rapid drawdowns may be exacerbated by the effects of erosion. When reservoir drawdowns are gradual, wetland and upland plants are more likely to become established on the exposed lakebed, minimizing erosion and sedimentation. When drawdowns are more rapid and pronounced, erosion is more apt to occur because more lakebed is exposed and bare sediments are exposed to the elements for longer periods. In these instances, silt and sediment could be carried downgradient by runoff to settle out in the shallows. Silt can interfere with food collection and respiration of benthic organisms and can smother eggs and larvae.

When Par Pond was drawn down in 1991, a large proportion of the littoral macroinvertebrate benthos was destroyed (DOE 1995a). Mussels and clams were particularly hard hit. The introduced clam *Corbicula fluminea*, which is widespread in L-Lake, is incapable of long downslope migrations (Folsom 1983). When exposed to air, most *Corbicula* die within a few days. Survival is dependent upon temperature and humidity, with clams surviving an average of 27 days at 20°C and high humidity and only 7 days at 30°C and low humidity (Folsom 1983). Large clams can survive longer than small clams, and burrowing in mud can increase survival time.

Because *Corbicula* tend to be concentrated in shallow, well-oxygenated (littoral) areas (Folsom 1983) and are unable to move downslope in response to rapidly-changing water levels, they would likely be devastated by a sudden or prolonged reservoir drawdown. This could have short-term impacts on fish and waterfowl that feed heavily on *Corbicula.* Because of the species' high reproductive potential, stable water levels in the spring or fall could produce a rapid population expansion. Thus, cycles of increased and decreased abundance of *Corbicula* as the reservoir recedes probably would occur until dissolved oxygen levels became limiting.

DOE might also be able to predict changes in benthic invertebrate community structure that would accompany lower water levels in L-Lake. Wegener, Williams, and McCall (1974) examined benthic macroinvertebrate populations of a Florida lake before, during, and after an extreme drawdown that exposed 50 percent of the lake bottom. Standing crops of profundal benthos, which remained under water during the drawdown, were slightly reduced during the drawdown but increased after the lake was refilled. Densities of oligochaetes and certain larval dipterans were stable or increased, while densities of mayflies (Ephemeridae and Baetidae) decreased. The littoral-zone benthos showed a similar trend, with a complete loss of macroinvertebrates during the drawdown, and densities of oligochaetes, chironomids, and mayflies of the family Baetidae increasing after the lake refilled. Marshall (1978) found that oligochaetes became relatively more abundant in years with low water levels in Lake McIlwaine, while chironomids increased in abundance following flooding.

These differences could be due to the manner in which different macroinvertebrate groups colonize (or recolonize) new areas. Oligochaetes are usually more abundant in deeper waters and may have the advantage of already being established when water levels recede. On the other hand, chironomids have winged adults, allowing them to rapidly colonize new habitat, such as newly flooded areas. Therefore an increase in the relative abundance of oligochaetes may be expected for L-Lake during the drawdown, particularly if dissolved oxygen levels are low. Many oligochaetes possess anatomical and behavioral adaptations that aid in oxygen uptake and transport (Brinkhurst and Gelder 1991).

As the water level drops, fish habitat would be reduced and exposed littoral zone vegetation, which would provide fish with critical spawning habitat, food, and cover, would die. If lake levels eventually stabilize at or fluctuate around a lower level, a reservoir (or pond) fish community would likely develop, although numbers and diversity of fish probably would be reduced. If the reservoir empties, the reservoir fish community would be eliminated, probably through fish kills in the final stages of the drawdown when fish are forced into small areas and stressed by overcrowding, low dissolved oxygen levels, and temperature extremes.

In time, a stream channel would become established in the lakebed, and streamside vegetation would slow erosion. Accumulated sediment in the stream would be washed downstream by heavy rains and floods. After many years, a stream ecosystem similar to other small, blackwater streams in the area would develop. Based on the investigations of fish community structure conducted by Paller (1994) and others, a relatively simple fish community comprised of small, schooling insectivores (shiners and chubs), small sunfish, and catfish (madtoms and bullheads) probably would develop over time. Depending on sediment loads, rainfall, and the success of the revegetation efforts planned for the exposed lakebed, this could take years or decades.

Under this alternative, no river water would be withdrawn at the 3G Pumphouse. This would completely eliminate entrainment and impingement and could have a small positive impact on fish populations in the immediate vicinity of the SRS pumphouses and intakes.

Wetlands Ecology

Natural wetlands in the sandhills of the Upper Coastal Plain of South Carolina have evolved with widely fluctuating water levels. The two best examples are the bottomland hardwood swamps along the Savannah River and its tributaries and Carolina bays. Water levels in the bottomland hardwood swamps fluctuate on an annual cycle, with levels declining during the spring and summer and rising during the winter. Short-term fluctuations such as floods in the spring and long-term fluctuations such as droughts that extend over several growing seasons produce some variation in the "normal" annual cycle (Sharitz, Irwin, and Christy 1974). Water levels in Carolina bays show similar cycles. A bay might be dry for years, and a period of above-normal rainfall will create standing water and saturated soils.

The L-Lake reservoir level simulation completed in 1994 (Jones and Lamarre 1994) modeled the reservoir level over two different time periods with different precipitation assumptions (1969 through 1980 with normal rainfall; and 1980 through 1990 with drought conditions). Two models, a precipitation-based (rainfall, runoff) model and a streamflow-based model, were used. Assuming a sustained and constant minimum release rate of 10 cubic feet per second (0.28 cubic meter per second) into Steel Creek and no groundwater recharge or discharge, the model shows that the lake cannot sustain full pool. However, in only one simulation did the lake completely empty.

Using 1980-1990 (drought years) data and the streamflow-based approach, modeling indicated that the reservoir would drop 70 feet (21.3 meters) over a 10-year period and empty completely (Jones and Lamarre 1994). The simulation showed that the lake would drop 34 feet (10.4 meters) over a 10-year period using data from drought years and employing the precipitation-based approach. The streamflow-based simulation showed that the lake would drop 15 feet (4.6 meters) over a 10-year period during years with normal rainfall (1969-1980 data).

Modeling also indicated that the lake level would drop slowly during the summer months and stabilize or even rise during the winter months. This reflects the fact that the models are based on stream flow and precipitation in the region. These cycles of drying and flooding are typical of bottomland hardwood swamps on the SRS and in the southeast.

The drought of the late 1980s allowed upland species such as loblolly pine and facultative wetland species such as sweetgum to invade Carolina bays on the SRS as their waters receded over a 3- or 4-year period. When the bays refilled in the early 1990s, the water drowned out the upland species and allowed wetland species such as buttonbush and maidencane to regain their dominance (Pechmann et al. 1993). TC

Based on historic data and the models, the reservoir would probably recede during the growing season. As the lake level slowly recedes, wetland plants growing in the emergent zone probably would move downslope with the water. Seed in the shoreline and shallow-water areas would germinate when exposed, and a dense growth of wetland and upland species would quickly cover the sediments (Collins and Wein 1995). This occurred in Lost Lake (near M-Area) following the waste site remediation and restoration in early 1991. In the fall of 1991, successful naturally invading species at Lost Lake included *Eleocharis acicularis*, *Eupatorium* sp., *Typha latifiolia*, *Polygonum* sp., *Panicum dichotomiflorum*, *Setaria* sp., and *Cephalanthus occidentalis* (Wike et al. 1994). After the drawdown of Par Pond in 1991, similar reinvasion of the newly exposed shoreline was observed in August 1992 (Mackey and Riley 1996). L11-10 L11-14

As L-Lake recedes, the submersed and floating-leaved aquatics probably would desiccate and die as they become stranded. During high rainfall years, some littoral-zone wetland plants would survive in shallow water over the summer but probably would die during the next drought cycle. As the waters of the reservoir recede, this cycle of drying and dessication (during years in which the reservoir drops several feet or more), the reestablishment and even expansion (during wet years in which the reservoir drops a foot or less), and drying and dessication would repeat until the reservoir reaches equilibrium or empties. As noted above, the annual drop in lake elevation could range from 1.5 feet to 7.0 feet (0.5 to 2.1 meters) per year (Jones and Lamarre 1994).

Wetlands surrounding L-Lake would convert to uplands (through natural succession) as the lake levels drop. Wetland species such as red maple and sweetgum would continue to grow as the shoreline recedes, but upland species would, in time, assert their dominance.

Lowering the reservoir levels slowly would mitigate impacts to wetlands and to the animals that inhabit the wetlands along the shore. Erosion should be minimal during most years along much of the shoreline but could be a problem along the steeper section between elevations at 170 feet (52 meters) and 190 feet (58 meters) on the northeast shore, particularly in drought years.

L05-01 L06-03 L08-01 L13-02 L13-06 As noted in Section 3.2.1, DOE would apply appropriate measures to revegetate the bare lakebed and attempt to reestablish the ecosystem that existed before the creation of the reservoir. These measures would include fertilizing and seeding bare areas to prevent erosion and could include a variety of other soil conservation measures, such as silt fences, sediment barriers, and fabric blankets, which promote seed growth as well as control erosion. These erosion control measures would be part of a larger effort to restore the stream ecosystem and associated floodplain forest that existed before SRS operations dramatically altered this ecosystem.

DOE is currently drafting a plan for restoration of the upper portion of Steel Creek and its floodplain forest in consultation with soil scientists, ecologists, and foresters at the Savannah River Forest Station and Westinghouse Savannah River Company Savannah River Technology Center.

TC If DOE selects the Proposed Action, the Record of Decision for the EIS would contain a commitment to prepare a Mitigation Action Plan, as well as a more detailed implementation plan that provides a step-by-step guide to restoring the plant communities of the riparian corridor and floodplain that were lost when L-Lake was created. In addition to the soil stabilization measures discussed earlier, this plan would include provisions for planting and/or transplanting trees and shrubs that are likely to survive and propagate in the Steel Creek floodplain. The Mitigation Action Plan would also contain monitoring requirements to ensure the success of the restoration. The lack of woody vegetation in the bare lakebed (and the shallow water table) would simplify the reforestation effort and ensure a high degree of success because there would be no other trees competing for water, nutrients, and space.

4.1.5.2.3 Shut Down and Maintain

Impacts of the Proposed Action would be the same as the Shut Down and Deactivate Alternative, except that if the River Water System was restarted and flows to L-Lake were increased, water levels could rise and inundate the shoreline. If the water level rises rapidly, the upland vegetation would die after a period of inundation. Wetland species would recolonize the shoreline when the rate of filling slowed and the lake level stabilized.

4.1.6 LAND USE

4.1.6.1 <u>Affected Environment</u>

Located in southwestern South Carolina, the SRS occupies an area of approximately 300 square miles (800 square kilometers). The