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Environmental Impact Statement

Waste Management Activities for Groundwater Protection Savannah River Plant Aiken, South Carolina

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APPENDIX A

GEOLOGY AND SUBSURFACE HYDROLOGY

This appendix discusses the geology and subsurface hydrology of the Savannah River Plant (SRP) and its surroundings. Included in the following sections are descriptions of the regional geologic setting, seismology and geologic hazards, hydrostratigraphy, groundwater hydrology, groundwater quality, groundwater use, hydrogeologic interrelationships, groundwater recharge and discharge, and water budget for the Separations area and the Burial Ground.

A.1 GEOLOGY AND SEISMOLOGY

This section contains information on the important geologic features in the region surrounding the SRP and within its boundaries. The geologic features discussed include the regional geologic setting, seismology, and geologic hazards.

A.1.1 REGIONAL GEOLOGIC SETTING

A.1.1.1 Tectonic Provinces

The North American continent is divided tectonically into foldbelts of recent or ancient deformation, and platform areas where flat-lying or gently tilted rocks lie upon basements of earlier foldbelts (King, 1969). The Southeastern United States contains two platform areas (the Cumberland Plateau province and the Coastal Plain province) and three foldbelts (the Blue Ridge province, the Valley and Ridge province, and the Piedmont province) (Figure A-1).

The Savannah River Plant is located in the Aiken Plateau physiographic division of the Atlantic Coastal Plain province (Figure A-1) (Cooke, 1936; Du Pont, 1980a). The center of the Plant is approximately 40 kilometers southeast of the fall line that separates the Atlantic Coastal Plain province from the Piedmont province (Davis, 1902). Crystalline rocks of the Piedmont (Precambrian and Paleozoic age) underlie a major portion of the gently seaward-dipping Coastal Plain sediments of Cretaceous and younger age (Figure A-1). Sediment-filled basins of Triassic and Jurassic age (their exact age is uncertain) occur within the crystalline basement throughout the Coastal Plain of Georgia and the Carolinas (Du Pont, 1980a). One of these, the Dunbarton Triassic Basin, underlies parts of the Plant (Figure A-1) (Du Pont, 1980a; Stephenson, Talwani, and Rawlins, 1985).

A.1.1.2 Stratigraphy*

Metamorphic and Crystalline Basement Rock

Near the center of the Plant, metamorphic and crystalline rock are buried beneath about 280 meters of unconsolidated-to-semiconsolidated Coastal Plain sediments (Marine, 1966). The surface of the rock dips to the southeast at a gradient of about 6.8×10^{-3} (6.8 meters/kilometer) (Siple, 1967), and the TE
rock is exposed at the fall line about 40 kilometers northwest of the SRP.

Immediately overlying the basement rock is a layer of saprolite, which is the residual product of weathering of the crystalline and metamorphic rock. The combined saprolite and basal clay at the bottom of the Coastal Plain Sediments forms an effective seal that restricts the flow of water between the Coastal Plain sediments and the basement complex.

Triassic-Jurassic Sedimentary Rock

The Dunbarton Basin, formed by normal faulting of the crystalline and metamorphic basement rock during the Triassic-Jurassic Period, is filled by sandstones, shales, and conglomerates, and buried beneath about 370 meters of Coastal Plain sediments (Figure A-1). The northwest boundary of the basin has been well defined by seismic traverses and by a well that penetrated 490 meters of Triassic-Jurassic rock and then passed into the crystalline and metamorphic rock below. The southeast margin is not as well defined, because there are no well data similar to those defining the northwest margin (Marine, 1976). The depth to the bottom of the Dunbarton Basin is not known from well penetration. A well near the center of the basin that was drilled to a depth of 1300 meters did not penetrate the underlying crystalline rock.

The rocks of the Dunbarton Basin consist of poorly sorted shale, siltstone, TE
sandstone, and conglomerate. The coarser material is found near the northwest
margin, where fanglomerates are abundant. Nearer the center, sandstone, silt- TE
stone, and shale predominate; however, the sorting is always extremely poor (Marine and Siple, 1974).

Cretaceous Sediments

The terminology for the stratigraphic units used in this EIS is modified from that used by Siple (1967). The Middendorf and Black Creek Formations (GCS, 1986) have been determined to be more accurate nomenclature for what had been referred to as the "Tuscaloosa Formation" in many studies of groundwater at

*The accepted names for stratigraphic units have evolved over the years as additional information on the age of the units and their correlation with similar units in other areas has surfaced. This is reflected in the different names used by authors to identify subsurface units. The stratigraphic nomenclature used in this document is the same as the usage of authors whose works have been referenced. Therefore, different portions of the text might use different names for the same geologic units. Likewise, the same name may be used for geologic units or portions of units that are otherwise different. Figure A-2 shows the correlation of units used by the various authors. The terminology used in this document is largely that of Siple (1967).

the Savannah River Plant. Figure A-2 shows a tentative correlation of these units to stratigraphic terminology described in recent publications.

The Cretaceous-Age sands and sediments (Figure A-2) consist primarily of fluvial and estuarine deposits of cross-bedded sand and gravel with lenses of silt and clay. They rest directly on saprolite, a residual clay from weathering of the crystalline and metamorphic rock. The Cretaceous Sediments are overlain conformably by the Ellenton Formation but, near the Fall Line where the Ellenton is absent, they are overlain unconformably by sediments of Tertiary and Quaternary age (Siple, 1967). The Cretaceous Sediments crop out in a belt that extends from western Tennessee to North Carolina. In South Carolina, this belt is 15 to 50 kilometers wide. The thickness of the Cretaceous Sediments ranges from 0 at the Fall Line to about 230 meters beneath the L-Reactor on the Savannah River Plant.

In this area, the Cretaceous Sediments consist of light gray-to-white, tan, and buff-colored, cross-bedded quartzitic-to-arkosic coarse sand and gravel, with lenses of white, pink, red, brown, and purple silt and clay (Siple, 1967). Ferruginous sandstone concretions, siderite nodules, and lenses of kaolin 0.5 to 12 meters thick are present in the Cretaceous Sediments. The chief minerals in the sediments are quartz, feldspar, and mica, which were derived from weathering of the igneous and metamorphic rocks of the Piedmont province to the northwest.

Ellenton Formation

The Ellenton Formation (terminology after Siple, 1967), which overlies the Cretaceous Sediments (Figure A-2), consists of dark lignitic clay with coarse sand units. It is thought to be Paleocene in age and is unconformably overlain by the Congaree Formation (of the Eocene Epoch). The Ellenton Formation sediments are entirely within the subsurface; they range to about 30 meters in thickness.

The lignitic clay is dark gray to black, sandy, and micaceous. It is interbedded with medium quartz sand and contains pyrite and gypsum. The upper part of the formation is characterized by gray salty-to-sandy clay with which gypsum is associated. This clay is about 3 to 5 meters thick in the central part of the Plant; it thickens to 10 meters in A- and M-Areas. The lower part consists generally of medium-to-coarse clayey quartz sand, but it contains very coarse and gravelly quartz sand in some areas (Siple, 1967).

Congaree Formation

The Congaree Formation (terminology after Siple, 1967) was included in the McBean Formation by Cooke (1936), and this usage was followed by the U.S. Army Corps of Engineers (COE, 1952) during the original foundation studies for the construction of the SRP (Marine and Root, 1978). The lower part of the original McBean was raised to formational status and called the Congaree Formation and the Warley Hill Marl by Cooke and MacNeil (1952). In discussing geology and groundwater at the Plant, Siple (1967) used the term "McBean" to include both deposits that are equivalent to the Claiborne Formation/Group of the Gulf Coastal Plain and only the upper part of these deposits. In much of the area studied by Siple, the two units could not be distinguished, either where exposed or in well logs (Marine and Root, 1978). TE

Subsequent investigations at the Plant have shown that it is desirable to distinguish the McBean Formation - as used in the restricted sense, rather than as used by Siple (1967) - from the Congaree Formation. These two units are separated by a clay layer informally called the "green clay" (Figure A-2).

TC The Congaree and McBean deposits strike about N 60°E and dip at a gradient of about 1.5×10^{-3} to 1.7×10^{-3} (1.5 meters/kilometer to 1.7 meters/kilometer) toward the south or southeast (Siple, 1967). Their thickness ranges from zero near the fall line to about 76 meters in southeastern Allendale County. In the central part of the Plant, the Congaree and McBean TC deposits are about 61 meters thick, of which about 37 meters is the Congaree Formation.

In the vicinity of the Separations Areas, the Congaree Formation consists of gray, green, and tan sand with some layers of gray, green, or tan clay (Marine and Root, 1978). In the northwest part of the Plant, it consists primarily of tan clayey sand. It is slightly glauconitic in some places and slightly cal- TC careous in others. A pisolitic clay zone at the base of the Congaree and McBean deposits defines the base of the Congaree Formation (Siple, 1967).

The green clay layer at the top of the Congaree Formation appears to be discontinuous in the northwest SRP area (i.e., updip). To the south, the green clay appears to thicken to about 7 meters in L-Area and 18 meters in the southeastern portions of the Plant to become what is called in Georgia the Blue Bluff Marl of the Lisbon Formation. The Marl is found at the Vogtle Nuclear Power Station in Georgia, in wells in the southern part of the SRP, and in offsite areas to the south. The green clay is gray to green, dense, and occasionally indurated (Marine and Root, 1978). The induration of the clay is caused commonly by dense compaction and siliceous cement. Calcareous cement is usually absent from this zone but, farther south, calcareous cement might be more common.

TC Although subdivision of the Congaree and McBean group might be warranted in the SRP area and in other parts of South Carolina and Georgia, such subdivision appears less warranted toward the Fall Line, because the shoreward facies of each unit grade into a comparatively thin zone, and criteria for distinguishing them become doubtful (Siple, 1967). This is confirmed by drilling in M-Area, where the green clay is thin and discontinuous and the sediments of both McBean and Congaree are very similar in appearance.

McBean Formation

TE As discussed above, the term "McBean" was used originally to designate all deposits of the same age as the "Claiborne" sediments of the Gulf Coastal Plain in this area; it is now used to designate only the upper part of these sediments. The McBean Formation can be divided into two subunits: an upper unit consisting of tan, clayey sands and occasionally red sand (Marine and Root, 1978), and a lower unit consisting of light, tan-to-white calcareous, clayey sand (Figure A-2). This lower unit is locally called the "calcareous TE zone"; in some places, it contains void spaces that resulted in rod drops and lost circulation during drilling operations (COE, 1952). To the northwest, these void spaces appear to decrease, so no calcareous zone exists in M-Area. However, to the southeast, the calcium carbonate content of the zone increases, as do void spaces. Southeast of the Plant, the zone becomes a limestone with only small amounts of sand.

The McBean Formation is considered the shoreward facies of the Santee limestone to the southeast (Siple, 1967). In the SRP area, the calcareous zone may represent a tongue of the Santee limestone. Toward the fall line to the northwest of the SRP, it becomes more difficult to distinguish the several Eocene formations, and Siple (1967) maps the Eocene deposits as undifferentiated. In the northwest SRP area (M-Area), the calcareous zone is replaced by a clayey sand unit.

Barnwell Formation

The Barnwell Formation (terminology after Siple, 1967) directly overlies the McBean Formation and is exposed over a considerable area of Aiken and Barnwell Counties. The formation thickens to the southeast from zero in the northeastern part of Aiken County to about 27 meters at the southeast boundary of Barnwell County. In the Separations Areas, the unit is about 30 meters thick. TC

The Barnwell Formation consists mainly of deep red, fine-to-coarse clayey sand and compact, sandy clay. Other parts of the formation contain beds of mottled gray or greenish-gray sandy clay and layers of ferruginous sandstone that range in thickness from 0.03 to 1 meter. Beds of limestone occur in the Barnwell Formation in Georgia, but none have been recognized in South Carolina. Factors indicate that a considerable part of the Barnwell Formation was deposited as a calcareous sandstone in a near-shore or estuarine environment. Some evidence of the original calcareous nature of the formation is indicated by the comparatively high proportion of calcium carbonate found in groundwater circulating in this unit (Siple, 1967).

In the Separations Areas, the Barnwell Formation is divisible into three parts:

1. The lowest unit, the "tan clay," commonly consists of two thin clay layers separated by a sandy zone. The entire unit is about 3 to 4.5 meters thick and is semicontinuous over the area.

2. Above the tan clay is a silty sand unit 0 to 12 meters thick.

3. Above the silty sand is a unit of clayey sand that runs up to 30 meters thick. This sand, which may include beds of silty clay or lenses of silty sand, is slightly less permeable than the underlying silty sand.

Upland Unit

The Upland Unit (Hawthorn equivalent; Siple, 1967) is exposed over a very large area of the Atlantic Coastal Plain and is perhaps the most extensive surficial deposit of Tertiary age in this region. It is bounded on top and bottom by erosional unconformities and is present at the surface in the higher areas of Aiken County. It ranges in thickness from 0 in northwestern Aiken County to about 25 meters near the Barnwell-Allendale County Line.

The Upland Unit consists of a fine, sandy, phosphatic marl or soft limestone, and brittle shale resembling Fuller's earth. Updip, however, in the vicinity of Aiken and Barnwell Counties, it is characterized by tan, reddish-purple, and gray sandy, dense clay that contains coarse gravel, limonitic nodules, and disseminated pods of kaolinitic material.

Tertiary Alluvium

Alluvial deposits of Late Tertiary age occur irregularly and discontinuously on the interstream divides. They are composed of coarse gravel and poorly sorted sand and have been tentatively classified by Siple (1967) as Pliocene in age. Their thickness ranges from 1.5 to 6 meters.

Terrace Deposits

Cooke (1936) recognized seven marine terraces of Pleistocene age on the Atlantic Coastal Plain in South Carolina. He indicated that the four highest terraces are present in the Savannah River Valley. The deposits that may be associated with these terraces are about 10 meters thick or less (Cooke, 1936).

Holocene Alluvium

Alluvium of Holocene age occurs in the tributary and main channels of the Savannah River. These deposits, which are generally cross-bedded and heterogeneous in composition, range in thickness from 1.5 to 9 meters (Siple, 1967).

A.1.1.3 Geomorphology

The SRP is located on the Aiken Plateau as defined by Cooke (1936). The Aiken Plateau slopes from an elevation of approximately 200 meters at the Fall Line to an elevation of about 75 meters to the southeast. The surface of the Aiken Plateau is highly dissected and is characterized by broad, interfluvial areas and narrow, steep-sided valleys. Because of the Plant's proximity to the
TC Piedmont Province and the Savannah River, it has somewhat more relief than the near-coastal areas, with onsite elevations ranging from 27 to 104 meters above sea level. Relief on the Aiken Plateau is as much as 90 meters (Siple, 1967). The plateau is generally well drained, although small, poorly drained depressions occur. These depressions are similar in character to Carolina bays.

On the Aiken Plateau there are several southwest-flowing tributaries to the Savannah River. These streams commonly have asymmetrical valley cross sections, with the northwest slope being gentler than the southeast slope. This is because the stream courses are generally parallel to the strike of the Coastal Plain formations. Erosion of the Coastal Plain sediments by the water course results in gentle dip slopes on the northwest, or updip, sides of the valleys. The landforms produced by these geomorphic processes resemble cuestas.

Since the early 1950s, the flow rates of Four Mile Creek and Pen Branch, including Indian Grave Branch, have been increased from about 1 cubic meter per second to the present 12 cubic meters per second by the discharge of cooling water and process effluent directly into the creeks. The stream profiles of the two creeks are beginning to change owing to erosion of the stream channels and deposition near the mouths of the creeks. Depositional environments in both creeks presently extend from their deltas to approximately 2.4 kilometers below SRP Road A, where near-neutral (neither erosion nor deposition) conditions exist (Ruby, Rinehart, and Reel, 1981).

A.1.2 SEISMOLOGY AND GEOLOGIC HAZARDS

A.1.2.1 Geologic Structures and Seismicity

The down-faulted Dunbarton Triassic Basin underlies the SRP and contains several interbasinal faults. However, the sediments overlying these faults show no evidence of basin movement since their deposition during the Cretaceous Period (Siple, 1967; Du Pont, 1980a). Other Triassic-Jurassic basins have been identified in the Coastal Plain tectonic province of South Carolina and Georgia; these features may be associated with the South Georgia Rift (Du Pont, 1980a; Popenoe and Zietz, 1977; Daniels, Zietz, and Popenoe, 1983). The Piedmont, Blue Ridge, and Valley and Ridge tectonic provinces, which are associated with Appalachian Mountain building, are northwest of the fall line (Figure A-1). Several fault systems occur in and adjacent to the Piedmont and the Valley and Ridge tectonic provinces; the closest of these, the Belair Fault Zone (about 40 kilometers from the SRP), is not capable of generating major earthquakes (Case, 1977).

There is no conclusive evidence of recent displacement along any fault within 300 kilometers of the SRP with the possible exception of (a) the geophysically inferred faults (Lyttle et al., 1979; Behrendt et al., 1981; Talwani, 1982; Hamilton, Berendt, and Ackermann, 1983) in the meizoseismal area of the 1886 Charleston earthquake, which occurred approximately 145 kilometers from the Plant (Du Pont, 1982a), and (b) seismically inferred strike-slip motion on the northwest flank of the Dunbarton Basin (Stephenson, Talwani, and Rawlins, 1985). Table A-1 shows the significant geologic structures and fault systems in the SRP region and gives the age of last movement.

Surface mapping, subsurface boring, and geophysical investigations at the SRP have failed to detect any faulting of the sedimentary strata that would affect SRP facilities. Several surficial faults, generally less than 300 meters in length and with displacements of less than 1 meter, have been mapped; however, none of these are considered capable, as they are overlain by younger sediments that show no evidence of faulting. The time since the last movement on these surficial faults is believed to be 0.5 million years or more (Du Pont, 1980a).

Two major earthquakes have occurred within 300 kilometers of the SRP: the Charleston earthquake of 1886, which had an epicentral modified Mercalli intensity (MMI) of X, and was located about 145 kilometers from the SRP; and the Union County, South Carolina, earthquake of 1913, which had an epicentral shaking of MMI VII to VIII, and was located approximately 160 kilometers from the SRP (Langley and Marter, 1973). An estimated peak horizontal shaking of 7 percent gravity (0.07g) was calculated for the site during the 1886 earthquake (DOE, 1982b). Site intensities and accelerations for other significant earthquakes are listed in Table A-2.

Probabilistic and deterministic analyses have established a design-basis, horizontal earthquake acceleration of 0.20g for key seismic-resistant buildings

Table A-1. Significant Geologic Structures in SRP Region[a]

Structural feature	Closest point to site: km	Closest point to site: Direction	Age of last movement
Valley and Ridge Province Faults	350	NW	Late Paleozoic
Blue Ridge Province Faults (Carterville, Whitestone, and Fries-Hayesville-Altoona Faults)	280	NW	Late Paleozoic
Cape Fear Arch	250	NE	Pleistocene
Brevard Fault Zone	225	NW	Pre-Mesozoic
Westerfield Fold-Fault System	225	NE	Pre-Eocene
Deep River Basin (N.C. and S.C.)	215	NE	Triassic-Jurassic
Gold Hill Fault	210	NW	Late Paleozoic
Columbia Triassic Basin	155	NE	Pre-Cretaceous
Towaliga Fault, Kings Mt. Belt	135	NW	Late Paleozoic
Clubhouse Crossroads Faults	115	SE	Pre-Miocene (?)
Columbia Reverse Faults and Clastic Dikes	105	NE	Late Miocene
Charleston Triassic (?) Basin	80	SE	Triassic-Jurassic
Decatur-Coffee County (Georgia) Graben and Faults	65	SE	Pre-Pliocene
Eastern Piedmont Fault System (Modoc, Flat Rock, Goat Rock, Bartletts Ferry, and Towaliga Faults)	65	NW	Late Paleozoic
Belair Fault Zone	40	NW	Pre-Miocene to Recent[b]
Langley Graben	27	NW	Pre-Miocene (?)
Dunbarton Triassic (?) Basin	Onsite	Onsite	Pre-Late Cretaceous

[a]Source: Du Pont, 1980a.
[b]NRC has determined that, although age of last movement is not precisely known, Belair Fault Zone is not capable in sense of 10 CFR 100 (Case, 1977).

at the SRP. This acceleration has a return period of about 5000 years (Du Pont, 1982b).

On June 8, 1985, an earthquake with a local magnitude of 2.6 (maximum intensity MM III) and a focal depth of 0.96 kilometer occurred at the SRP. The epicenter was just to the west of C- and K-Areas (Figure A-3). The acceleration produced by the earthquake was less than 0.002g. No aftershocks were recorded by the SRP Seismic Network (Stephenson, Talwani, and Rawlins, 1985).

A.1.2.2 Seismic Events and Liquefaction Potential

Liquefaction is the transformation of water-saturated granular material from a solid or semisolid state to a liquid state; this results from an increase in the pore water pressure, which is caused by intense shaking. Earthquakes may cause liquefaction of near-surface, water-saturated silts and sands, making the materials lose their shear strength and flow (Keller, 1979).

The seismicity of the SRP is discussed in Section A.1.2.1. As noted in that section, liquefaction induced by earthquakes with a maximum horizontal acceleration of less than 0.20g is not a potential problem for SRP facilities (Du Pont, 1980a; Langley and Marter, 1973).

A.2 GROUNDWATER RESOURCES

This section discusses the groundwater resources at the SRP. For the purposes of this environmental impact statement (EIS), the definition of groundwater resources includes hydrostratigraphy, groundwater hydrology, and groundwater quality.

A.2.1 HYDROSTRATIGRAPHY

Three distinct hydrogeologic systems underlie the SRP: (1) the Coastal Plain sediments, where water occurs in porous sands and clays; (2) the crystalline metamorphic rock beneath the Coastal Plain sediments, where water occurs in small fractures in schist, gneiss, and quartzite; and (3) the Dunbarton Basin (Triassic/Jurassic Age) within the crystalline metamorphic complex, where water occurs in intergranular spaces in mudstones and sandstones. The latter two systems are unimportant as groundwater resources near the Plant.

The Coastal Plain sediments, which contain several important aquifers, consist of a wedge of stratified sediments that thickens to the southeast. Near the center of the Plant, the sediments are about 300 to 400 meters thick and consist of sandy clays and clayey sands. The sandier beds generally form aquifers and the clayier beds form aquitards. The Coastal Plain sedimentary section at the Plant consists of the Hawthorn, Barnwell, McBean, Congaree, Ellenton, and Tuscaloosa Formations, as defined by Siple, 1967. These units correlate to those used by Geological Consulting Services (GCS, 1986). Figure A-2 shows the correlation of these stratigraphic terms. Table A-3 describes the lithology and water-bearing characteristics of the hydrostratigraphic units underlying the Plant.

The Cretaceous Sediments (Middendorf and Black Creek Formations; GCS, 1986) form a particularly prolific groundwater unit because of their thickness and high permeability. In areas of the South Carolina Coastal Plain within 40 kilometers of the Fall Line, the Cretaceous Sediments are a major supplier of groundwater (Siple, 1967); wells commonly yield more than 5500 cubic meters per day of good-quality water. The Cretaceous Sediments rest on saprolite, a residual clay weathered from the crystalline metamorphic bedrock, and consist of a sequence of sand and clay units. The combined saprolite and basal clay form an effective seal that separates water in the Coastal Plain sediments from water in the crystalline metamorphic rock. The sand units combined are about 140 meters thick and supply water to the Plant.

Paleocene sediments, including the Ellenton Formation, overlie the Cretaceous Sediments and consist of clay with coarse sand units. The known Ellenton sediments are entirely within the subsurface. The clays in the Ellenton are apparently continuous enough to act as a confining bed that separates the water in the Congaree from that in the Black Creek Formation.

The Congaree Formation includes a lower unit of sand with clay layers and an upper clay layer known as the "green clay." The Congaree sand beds constitute an aquifer second only to the Cretaceous Sediments in importance, with yields as high as 3600 cubic meters per day (Siple, 1967). The green clay appears to be continuous and supports a large head difference between the Congaree and the overlying McBean Formation. This head difference is as much as 21 meters near the Central Shops and 24 meters in the Separations Areas, even though the clay layer is only 2 to 3 meters thick in these areas (D'Appolonia, 1980; Du Pont, 1983). North and west of Upper Three Runs Creek, the green clay is discontinuous and, therefore, is effective only locally as a confining unit (aquitard). In the southeastern part of the Plant, the green clay is believed to be about 18 meters thick (Du Pont, 1983).

The McBean Formation, as defined by the SRP (Marine and Root, 1978), consists of a lower unit of calcareous clayey sand and an upper unit of clayey sands (lower part of Dry Branch Formation; GCS, 1986). Groundwater occurs in both units, but neither is a prolific aquifer. The formation is incised by Upper Three Runs Creek and Four Mile Creek.

The Barnwell Formation, which overlies the McBean Formation, consists of (1) a clay unit known as the "tan clay" (part of Dry Branch Formation; GCS, 1986), (2) a silty sand unit (upper part of Dry Branch Formation; GCS, 1986), and (3) a clayey sand unit that can include beds of silty clay or lenses of silty sand (Tobacco Road Equivalent; GCS, 1986). Borings in the Separations Areas and about 2 kilometers east of the Central Shops indicate that the tan clay is about 2 meters thick and that it commonly consists of two thin clay layers separated by a sandy zone (D'Appolonia, 1980; Du Pont, 1983). In some areas of the Plant, the tan clay is not easily identified in foundation borings, drillers' logs, or geophysical logs; however, this clay has not always been readily apparent in soil cores, even in areas where it is known to support a significant head differential.

The Barnwell and Upland Unit (Hawthorn; Siple, 1967) Formations are incised by Upper Three Runs Creek, Four Mile Creek, and their unnamed tributaries. The water table is usually within the Barnwell Formation but in low-lying areas can be in the underlying McBean or Congaree Formations. Because of the large amounts of clay and silt mixed with the sands, the Barnwell generally does not yield water to wells except from occasional sand lenses.

The South Carolina Hazardous Waste Management Regulations (SCHWMR) and the Resource Conservation and Recovery Act (RCRA) [270.14(c)(2)] require the determination of the hydrogeologic zones that are most susceptible to impacts from waste management units. These zones are the unsaturated zone, the uppermost aquifer, the principal confining unit, and the principal confined aquifer (shallowest confined aquifer beneath the SRP). Figure A-2 shows the relationship of these zones to one another and their tentative correlation with other stratigraphic nomenclature. Each hydrogeologic zone is summarized below. TC

Formational terminology used in this discussion is largely that of Geological Consulting Services (GCS, 1986).

The unsaturated zone is a 25- to 45-meter-thick sandy unit containing clay lenses. This zone is comprised of the Upland unit and, in some areas of the Plant, the Tobacco Road and Dry Branch Formations.

The uppermost aquifer is a 35-meter-thick sandy unit composed of two zones. The upper water-table zone, composed primarily of the clayrich, fine-grained sands of the McBean Formation (in some areas of the Plant, areas of higher water table) includes portions of the Dry Branch and Tobacco Road Formations. The lower zone, composed of the coarse-grained Congaree Formation and the upper sand and clay of the Ellenton Formation.

Based on an evaluation of hydraulic properties as well as head differences between subsurface zones, the lower three units of the Ellenton Formation are believed to form the principal confining zone beneath the Plant. These units form a section approximately 15 meters thick composed of two clay beds (middle and lower Ellenton) and the lower Ellenton sand lenses. The sands in these lenses are commonly coarse grained, but generally are supported by a clay matrix that impedes fluid movement. The middle clay is generally a dense, low-permeability clay that can be locally discontinuous or more permeable. The lower clay, however, is an average of 3 meters thick (maximum of 15 meters), is dense, has a low permeability, and is believed to be continuous over the SRP area. Table A-4 summarizes the hydraulic conductivity of the Ellenton Formation.

The confined aquifer is a sandy zone averaging about 30 meters in thickness. This zone is capped by the overlying Ellenton Formation confining unit. In this appendix, the shallowest confined aquifer is referred to as the Black Creek aquifer. The aquifer beneath the Black Creek is referred to as the Middendorf aquifer (see Figure A-2).

A.2.2 GROUNDWATER HYDROLOGY

A.2.2.1 Hydrologic Properties

The flow of groundwater in the natural environment depends strongly on the three-dimensional configuration of hydrogeologic units through which flow takes place. The geometry, spatial relations, and interconnections of the pore spaces determine the effective porosity (percentage of void space effectively transmitting groundwater) and the hydraulic conductivity of the hydrogeologic unit. These factors largely control groundwater flow through geologic media.

The Coastal Plain sediments beneath the Plant are heterogeneous, and they are anisotropic with respect to the hydrologic properties controlling groundwater flow. Tables A-5 and A-6 list typical hydrologic properties of the Coastal Plain sediments in the Separations Areas and A/M-Areas, respectively. These tables indicate that the horizontal component of hydraulic conductivity in the Barnwell Formation is considerably greater than the vertical component. In this case, the horizontal conductivity is at least 100 times the vertical conductivity; consequently, groundwater tends to move laterally within this hydrogeologic unit. Although not shown in Tables A-5 or A-6, this general relationship is expected to apply to all coastal plain sedimentary units (Freeze and Cherry, 1979).

The following paragraphs describe important hydrodynamic properties of specific geologic units beneath the Plant.

Crystalline Metamorphic Rock

Water injection and removal tests on packed-off sections of rock indicate two types of fractures in the crystalline rock (Marine, 1966). The first type consists of minute fractures that pervade the entire rock mass but transmit water extremely slowly. Rock that contains only this type of fracture is called "virtually impermeable rock." The other type of fracture is confined to definite zones that are vertically restricted but laterally correlatable and have larger openings that transmit water faster. Rock that includes this type of fracture is called "hydraulically transmissive rock."

Representative values of hydraulic conductivity are 1.2×10^{-5} meter per day for virtually impermeable rock, and 0.033 meter per day for hydraulically transmissive rock (Marine, 1975). An analysis of a two-well tracer test with tritium indicates a fracture porosity of 0.08 percent in a hydraulically transmissive fracture zone (Webster et al., 1970). Laboratory analyses of
TC cores indicate an average intergranular porosity of 0.13 percent (Du Pont, 1983).

Triassic/Jurassic Sedimentary Rock

The Triassic sediments consist of poorly sorted, consolidated gravel, sand, silt, and clay. The coarser material is presumed to be near the northwest margin of the Dunbarton Basin, where fanglomerates are abundant. Nearer the center of the basin, sand, silt, and clay predominate. The sorting is extremely poor, which causes an extremely low primary porosity in the Triassic rocks (Marine and Siple, 1974). Groundwater does occur in the primary porosity of the Triassic rock, but the hydraulic conductivity is extremely low and water movement is almost nonexistent.

The hydraulic conductivity of the Triassic sedimentary rock, as determined from field tests, ranges from 4×10^{-6} to 4×10^{-9} meter per day (Marine and Siple, 1974). Average total porosity is 8.0 percent for sandstones and
TC 3.3 percent for mudstones. Average effective porosity is 7.0 percent for sandstones and 0.53 percent for mudstones (Du Pont, 1983).

Cretaceous Sediments

According to a field study of the Cretaceous Sediments aquifer (Tuscaloosa or Black Creek/Middendorf equivalent), the average transmissivity is 1500 square meters per day, and the median is 1400 square meters per day (Marine and Routt, 1975). Storage coefficients determined for the formation averaged
TC 4.5×10^{-4}, and Siple (1967) assumed effective porosities of 20 to 30 percent (Du Pont, 1983).

Ellenton Formation

In general, Siple (1967) did not distinguish between the Ellenton and the Cretaceous Sediments aquifer in reporting the results of pumping tests.

Because there is no piezometric map exclusively of the Ellenton Formation, little is known about the lateral flow of water within the formation. Table A-4 summarizes recent hydraulic conductivity data collected on the Ellenton Formation.

Congaree Formation

The results of two tests conducted near the center of the Plant indicate a hydraulic conductivity of nearly 40 meters per day in the Congaree Formation, although one of the values (0.73 meter per day) for M-Area is 50 times less than this. The median conductivity value obtained in 10 slug tests (decay of an instantaneous head change) in sandy zones of the Congaree Formation in the Separations Areas is 1.8 meters per day (Root, 1977a,b). The median conductivity, as determined in two water-level recovery tests, is 1.5 meters per day (Du Pont, 1983).

Data from laboratory tests conducted by the U.S. Army Corps of Engineers (COE, 1952) indicate a median value of 43 percent for the total porosity of the upper part of the Congaree Formation. The effective porosity is estimated to be 20 percent. A pumping test in the northwest portion of the plant yielded a value of 14 percent (Du Pont, 1983). TC

McBean Formation

The median hydraulic conductivity of the upper sand of the McBean Formation (equivalent to Lower Dry Branch Formation; GCS, 1986) has been reported to be 0.13 meter per day, about twice that of the calcareous zone (Du Pont, 1983). An effective porosity of 20 percent is reasonable.

Fluid losses during drilling operations make the calcareous zone appear very permeable. However, the results of pumping tests in the zone indicate a low hydraulic conductivity (Du Pont, 1983). Apparently, zones of higher permeability do not connect over large distances, and the regional permeability of the calcareous zone is lower than drilling observations suggest.

Barnwell Formation

Pumping tests to determine the hydraulic conductivities of the Barnwell Formation (Du Pont, 1983) indicate the median conductivity to be 0.04 meter per day for the clayey sand unit (Tobacco Road equivalent; GCS, 1986). Although no tests were made on the silty sand unit, a pumping test in a sand lens within this unit indicated a hydraulic conductivity of 0.3 meter per day.

Upland Unit

Because the Upland Unit (Hawthorne equivalent; Siple, 1967) in the SRP area is usually unsaturated, no pumping tests have been performed. There is no piezometric map of the formation in the SRP area. Flow paths are predominantly vertical; there are only short horizontal flow paths.

A.2.2.2 Head Relationships

The elevation of the free-standing groundwater above a sea-level datum is referred to as the hydraulic head. Figure A-4 shows the hydraulic heads for the principal hydrostratigraphic units near the center of the Plant, typified by H-Area. These data are for one location in the Separations Areas where water-level differences are probably at their maximum. Near the discharge areas of creek valleys, water elevations of the several Tertiary aquifers converge. Although not shown in this figure, the head in the lower part of the Cretaceous aquifer (Middendorf equivalent) is generally higher than that in the shallower aquifer (Black Creek) by at least 6 meters (DOE, 1984).

Figure A-4 indicates that the water elevation in the Ellenton Formation is above that in the Cretaceous Sediments aquifer. The cause of this appears to be continuous pumping from the Cretaceous Sediments aquifer in H-Area, which has created a cone of depression in these deeper units but probably has not affected water levels significantly in the Ellenton aquifer. Figure A-5 shows the cones of depression in the potentiometric surface of the Cretaceous Sediments aquifer in F- and H-Areas (Killian et al., 1987a). TC

The hydraulic heads shown in Figure A-4 also indicate that there is not a direct hydraulic connection between the Ellenton and the overlying Congaree Formation. Although the clays that separate the Ellenton and the Congaree are not thick, they are apparently extensive and continuous enough to impede the hydraulic connection. A pisolitic clay at the base of the Congaree appears to be extensive and might constitute the principal confining bed that separates the Congaree and the deeper hydrologic system (Siple, 1967). The upper part of the Ellenton is a sandy clay, which also functions as a confining bed between the Ellenton and the Congaree.

Finally, Figure A-4 shows that the head in the Congaree Formation in the Separations Areas is the lowest of any hydrostratigraphic unit in the Coastal Plain system. This is attributable to two conditions: (1) the low permeability of the green clay, through which recharge must take place, and (2) the high hydraulic conductivity of the Congaree sands below the green clay, which enhances lateral movement and discharge to the deeper creek valleys. The upward recharge of water to the Congaree from the Ellenton-Cretaceous Sediments aquifer system is also impeded by clay layers at the base of the Congaree and in the Ellenton.

Figures A-6 and A-7 describe the head difference between the water in the Black Creek and Congaree Formations. The two maps show a change due to improved data control (more measuring points) and, to a lesser extent, show the effects of pumpage on and off the SRP. Had the data control available in 1987 been available in 1982, it is quite likely the maps would have been very similiar.

TC

The more recent data (Bledsoe, 1987) are more accurate. The earlier map was based on limited data and was included in the Draft EIS, because it was the best data available at the time of the publication of the Draft EIS.

The head in the Congaree is higher than that of the Cretaceous Sediments in an area surrounding A- and M-Areas and in the vicinity of P- and R-Areas and Par Pond. Figure A-8 shows the vertical-head relationships along a cross-section passing through M-Area, where the Cretaceous Sediments aquifer water elevation is below that of the Congaree. A continuous decline in head with depth indicates that this location is a recharge area for the Cretaceous Sediments aquifer, as is much of the area of the Aiken Plateau northwest of the Plant.

TC Hydraulic head reversal discussed above is not fixed in time or space, as water levels fluctuate in response to a number of factors such as aquifer use, i.e., pumping onsite for water supply and process water and pumping offsite for agricultural, industrial, and municipal purposes; the amount of natural recharge received by the different aquifers; and climatic factors. The discussion in this section demonstrates the complexity and the transient nature of the hydrogeologic regime beneath the SRP (see Figures A-12, A-17, and A-20).

Because of flow directions and head relationships, the potential for offsite impacts on water quality in the Black Creek aquifer is extremely small. The most important factor for offsite impacts is the prevailing flow direction for water in the Black Creek toward the Savannah River, not toward municipalities that border the Plant. The most important factor for onsite impacts is the upward gradient between the Congaree and the Upper Tuscaloosa over parts of the SRP.

TE Impacts on the Black Creek aquifer have been confirmed in one monitoring well cluster on the SRP. This cluster is in the western recharge area (A- and M-Areas), where the clay barrier thins beneath an area where spillage from rail cars and transfer facilities took place during the early days of SRP operation. The migration of these constituents is being defined; their source has been under remediation for nearly two years. Data analyzed to date do not define any flow paths for these constituents toward offsite water users. The area of final discharge of the groundwater originating from these sources is the Savannah River. These constituents would require at least several hundred years to reach the river. The pumpage of recovery wells (and supply wells for process water) in A- and M-Areas increases this travel time.

Where the upward gradient exists between the Black Creek and the Congaree, water is prevented from flowing into the Black Creek aquifer. An exception occurs in areas where large volumes of water are pumped from the Black Creek; in these areas, pumpage could reverse the upward gradient. The area most susceptible to these impacts is H-Area, where the head differential is relatively small and pumpage is great. A modeling study (Duffield, Buss, and Spalding, 1987) indicates that a maximum head differential (downward potential) of about 5 feet has developed in the eastern portion of H-Area (see Figure A-5). Moderate pumpage from the Black Creek also occurs in U-Area, the Central Shops Area, TNX-Area, the Classification Yard, and the U.S. Forest Service offices. The potential for reversing the upward gradient that occurs naturally in these areas is significantly less than that in H-Area. Any contaminants that would be drawn into the Black Creek by this pumpage would flow to the pumping well and, therefore, would not impact offsite areas.

Water elevations in the McBean Formation (includes lower portion of Dry Branch Formation; GCS, 1986) exhibit a difference of about 0.6 meter in hydraulic head between the top of the McBean and its base (Du Pont, 1983). This indicates a better hydraulic connection between the sandy unit of the McBean and the calcareous zone than that between the McBean and either the Congaree Formation below or the Barnwell Formation above. As previously noted, the green clay impedes the downward movement of water from the McBean to the Congaree in the central part of the Plant, as illustrated by a hydraulic-head differential of about 17 meters. Moreover, the tan clay in the Barnwell (Siple, 1967) impedes the vertical movement of water from the Barnwell into the McBean. TC Although the tan clay is not as continuous as the green clay, the head differential between the Barnwell and the McBean is about 4 meters where the tan clay is present. TE

Figure A-4 shows the relationship of water elevations in the Barnwell Formation to those in the formations below. The hydraulic head decreases with depth within the Barnwell Formation. Although the tan clay impedes the downward movement of water, the McBean Formation is recharged by water that passes through this hydrostratigraphic unit.

The water table is commonly within the Barnwell Formation (equivalent to Tobacco Road and upper Dry Branch Formations; GCS, 1986), although in the creek valleys it successively occupies positions in the lower formations. Surface drainage and topography strongly influence the flow path at every point on the potentiometric surface. Even small tributaries of the larger creeks cause depressions in the water table, diverting groundwater flow toward them. Because the Upland Unit in the SRP region is usually unsaturated, a potentiometric map has not been constructed. Flow paths are predominantly vertical, although there are some short, horizontal flow paths along perched water tables.

A.2.2.3 Groundwater Flow

Water moves through the ground from areas of high head to areas of lower head. In general, on the Atlantic Coastal Plain, the gradient is seaward from the higher areas of the Aiken Plateau toward the continental shelf. Of major significance is the modification of this general southeastward movement caused by the incision of the Savannah and Congaree Rivers and their tributaries (see Figure A-9). Groundwater in the regions of these rivers and tributaries is diverted toward the hydraulic low caused by natural discharge to the surface water. The depth of dissection of streams at the SRP has a significant influence on the direction of flow in most hydrostratigraphic units. The direction of flow in the shallow groundwater is most affected by small streams; in the deeper groundwater, it is affected by major tributaries. The direction of flow in the Paleocene and deeper formations is affected mainly by the Savannah River. Locally, the direction of flow in any unit can be modified by groundwater withdrawals from wells.

The velocity (V) of groundwater flow can be calculated by the following formula:

$$V = \frac{IK}{e} \qquad \text{(A-1)}$$

where:

- I = hydraulic gradient
- K = hydraulic conductivity
- e = effective porosity

The velocity also can be measured directly by tracers. Table A-7 lists typical vertical and horizontal groundwater velocities for important hydrogeologic units on the SRP.

Figures A-9 and A-10 show hydraulic heads of the Cretaceous Sediments, which constitute the primary aquifer in the region. Where the elevation of the outcrop area is high, as on the Aiken Plateau north of the Plant, water naturally recharged to the aquifer exceeds that naturally discharged to local streams; this excess water moves southeastward through the aquifer. Where the elevation of the outcrop area is low, as along the Savannah River Valley in the northwest section of the Plant, water naturally discharges from the aquifer to the river. Under the Plant, the direction of groundwater movement in the Cretaceous sands is southwesterly toward the Savannah River Valley.

On the Plant, the recharge of the Congaree is by groundwater flow from offsite areas and by the infiltration of precipitation; the shallower formations on the Plant are recharged by the infiltration of precipitation (about 40 centimeters per year) (Root, 1983). However, discharge into Upper Three Runs Creek and the Savannah River has a dominant effect on Congaree groundwater flow (Figure A-11). Over parts of the Plant area, hydraulic heads in the Congaree are lower than those in the Cretaceous Sediments aquifer, precluding downward flow into the Cretaceous Sediments in these areas (Figure A-7). However, as noted in Section A.2.2.2, in two areas this condition is reversed, indicating that the Cretaceous Sediments aquifer might receive recharge from the overlying Congaree aquifer. Also, in small local areas where the Cretaceous Sediments aquifer head normally exceeds the head in the Congaree aquifer, drawdown from water production wells in the Cretaceous Sediments aquifer might lower its head below that of the Congaree, creating a potential for localized downward flow (Figure A-5).

On a regional basis, the dissecting creeks divide the groundwater in the Congaree and higher formations into discrete subunits. Even though the hydraulic characteristics of the formations might be similar throughout the area, each subunit has its own natural recharge and discharge areas. In the central part of the Plant, the only stream that intersects the Congaree is Upper Three Runs Creek.

The McBean Formation (terminology from Siple, 1967) is incised by Upper Three Runs Creek, several of its larger tributaries, Four Mile Creek, Pen Branch, and Steel Creek. Thus, groundwater that enters the McBean Formation over much of the interior of the Plant is restricted to its connection with other subunits of the McBean because of stream incision.

The water table at the Plant is commonly within the Barnwell Formation (terminology from Siple, 1967), although in the creek valleys it successively occupies positions in the lower formations. Surface drainage and topography strongly influence the water-table flow path. Even small tributaries of the larger creeks cause depressions in the water table, diverting groundwater flow toward these creeks. The Upland Unit, which is perhaps the most extensive surficial deposit in this region, usually is unsaturated. Its flow paths are predominantly vertical, although there are short horizontal paths.

The overall flow pattern of the unsaturated zone at the Plant is vertical. Precipitation infiltrates into the Barnwell Formation and percolates downward, with the greatest amount eventually reaching the Congaree Formation. The tan clay diverts some water in the Barnwell laterally to creeks. The green clay diverts more water in the McBean Formation laterally to creeks. The remaining water is believed to move vertically into the Congaree Formation. The Ellenton and Cretaceous Sediments aquifer are separated hydraulically from the Congaree and are not recharged significantly on the site. Both the primary recharge and discharge controls on the water in the Cretaceous Sediments are outside the SRP area. The Cretaceous Sediments act as a conduit through which water passes beneath the SRP area en route from recharge zones in the Aiken Plateau to discharge zones in the Savannah River Valley.

Figure A-12 shows the distribution of groundwater flow between hydrologic units in the vicinity of A- and M-Areas. Although not specifically applicable to the entire SRP subsurface, the relationships shown in this figure are generally the same as those that can be expected in other parts of the Plant.

A.2.3 GROUNDWATER QUALITY

A.2.3.1 Regional Groundwater Quality

The water in the Coastal Plain sediments tends to be of good quality; hence, it is suitable for industrial and municipal use with minimal treatment. It is generally soft, slightly acidic, and low in dissolved and suspended solids (Du Pont, 1983). Table A-8 lists the results of chemical analyses of groundwater from various regional formations in the Coastal Plain sediments; the following paragraphs describe these results. The descriptions will focus on the total dissolved solids (TDS) content of the groundwater, because the amount of dissolved solids is a consideration in the suitability of the water for domestic use and because it can serve as a measure of the presence of some types of contaminants.

Crystalline Metamorphic Rock

Water from the crystalline metamorphic rock has a TDS content of about 6000 milligrams per liter, which is largely calcium (500 milligrams per liter), sodium (1300 milligrams per liter), sulfate (2500 milligrams per liter), and chloride (1100 milligrams per liter).

Triassic/Jurassic Sedimentary Rock

Two water samples from the Dunbarton Basin of Triassic/Jurassic Age had TDS contents (almost entirely sodium chloride) of about 12,000 and 18,000 milligrams per liter (Du Pont, 1983).

Cretaceous Sediments Aquifer

Water from the Cretaceous Sediments aquifer is low in TDS. Because the water is soft and acidic, it has a tendency to corrode most metal surfaces (Siple, 1967). This is especially true if the water contains appreciable amounts of dissolved oxygen and carbon dioxide. The dissolved oxygen content of water from the Cretaceous Sediments around the Separations Areas is very low (Marine, 1976), and the sulfate content is about 13 milligrams per liter. The dissolved oxygen content is inversely related to the sulfate content of the water. In the northwest part of the Plant near the recharge area, water in the Cretaceous Sediments aquifer is near saturation with dissolved oxygen while the sulfate content is very low.

Ellenton Formation

Chemical analyses of water from the Ellenton Formation (Siple, 1967) show a TDS content somewhat higher than that of water from the Cretaceous Sediments aquifer, but still very low at less than 50 milligrams per liter.

Congaree Formation

Table A-8 compares two analyses of water from sands in the Congaree Formation. The analyses are similar to those reported for Eocene limestone (Siple, 1967). The zones in the formation probably contained some calcareous cement, giving rise to relatively high concentrations of ionic species in the water.

McBean Formation*

Samples of water from Eocene sand (Lower Dry Branch equivalent; GCS, 1986) and limestone probably include some water from both the sandy and calcareous zones. The water from these zones is low in TDS, with that from sandy zones being much lower. The differences in the chemical characteristics of water from the two zones are readily apparent. Well HC3D in the upper sandy zone has a TDS content of 14 milligrams per liter and low concentrations of all other constituents. The other wells, which are screened in the calcareous zone, have a TDS content of more than 50 milligrams per liter and high concentrations of calcium and bicarbonate. The pH of water from the calcareous zone is near 7, while that of water from the sandy zone is generally less than 5.

Barnwell Formation*

Table A-8 lists five analyses of water from the Barnwell Formation (Tobacco Road and upper Dry Branch equivalents; GCS, 1986) in the Separations Areas. The TDS content is low, and the concentrations of calcium and bicarbonate ions are not as high as in the McBean and Congaree Formations. The pH of water from the Barnwell Formation is slightly acidic, similar to that of groundwater from other formations in the area.

A.2.3.2 Mixed Chemical and Radionuclide Contamination

Groundwater is monitored at 49 of the 54 SRP hazardous and mixed waste management facilities for the parameters listed in Table A-9. Nine of the 54 facilities have been designated as RCRA interim-status hazardous waste management facilities. These are the F-Area seepage basins (three basins), H-Area seepage basins (three basins), M-Area settling basin and Lost Lake, and the inactive Mixed Waste Management Facility (MWMF) within the operating low-level radioactive waste burial grounds between F- and H-Areas. Groundwater contamination at the F- and H-Area seepage basins and the M-Area settling TE

*Stratigraphic terminology from Siple, 1967. See Figure A-2.

basin is discussed here to provide examples of the modes of contamination, possible pathways of contaminants, and water quality within the SRP subsurface. Appendix B discusses contamination at other facilities covered in this EIS in detail.

The seven unlined basins and Lost Lake have received hazardous wastes and radioactive materials since the mid- to late-1950s. Geophysical and geochemical testing and groundwater monitoring have been performed at these sites to assess the nature, extent, and rate of migration of hazardous wastes and hazardous constituents (DOE, 1985).

Suspected contaminants were identified by a statistical comparison of upgradient and downgradient water quality known as the Student's t-test. Assuming an appropriate experimental design as well as a good sampling and analysis technique, the t-test can provide a basis for rejecting or not rejecting sampling variation as a possible factor to account for the difference between upgradient and downgradient wells when the number of samples taken is small. Rejecting sampling variation at some level of confidence means that the difference between wells is due to factors other than sampling variation. A failure to reject means that the difference between wells could be sampling variation, among other factors. The cutoff points for f-test scores were probabilities of less than or equal to 0.05 and greater than 0.25. Values less than or equal to 0.05 were classified as probable contaminants; those greater than 0.25 were improbable contaminants. Scores between these two values were considered to be possible contaminants.

Tables A-10 and A-11 list the contaminant potential based on the t-test for selected parameters at the F-Area and H-Area seepage basins, respectively. Statistical analyses performed in 1983 identified elevated values of TDS, sodium, nitrate, gross alpha, and gross beta in relation to the values for upgradient monitoring wells at the F- and H-Area seepage basins. The low pH of the groundwater in downgradient monitoring wells also reflected the operation of the seepage basins in these two waste management areas.

The reliability of the 1983 results was evaluated when improvements were made in sampling and sample preservation methods in 1984. Pumps were installed to provide adequate flushing of the wells before sampling, and all samples for metals analyses were filtered before preservatives were added. Results following the initiation of the new techniques indicated that inadequate flushing (using a manual bailing technique) and solids in the samples analyzed were contributing to the erroneous positive results previously obtained.

Special sampling and testing for the hazardous constituents identified in 40 CFR 261, Appendix VIII, were performed in 1985 at the F- and H-Area seepage basins. No organic compounds attributable to basin operation were observed in significant concentrations at either location. However, various hazardous constituents were measured in downgradient monitoring wells at the F- and H-Area seepage basins (Table A-12). TC

Contaminants from the F- and H-Area seepage basins migrate to springs along Four Mile Creek (approximately 60 to 500 meters). This migration has been

TC

Table A-12. Hazardous Constituents Measured in Downgradient Monitoring Wells at F- and H-Area Seepage Basins[a]

	Maximum Concentrations (mg/l)	
Constituent	F-Area basins[b]	H-Area basins[c]
Antimony	0.035	0.320
Barium	0.280	0.223
Cadmium	0.70	0.010
Lead	0.167	0.220
Mercury	0.00034	0.72
Nickel	0.100	0.064
Selenium	0.490	d

[a]Constituents were observed during RCRR Appendix VIII data searches performed in January and March of 1985.
[b]Source: Killian et al., 1987a.
[c]Source: Killian et al., 1987b.
[d]Below detection.

verified through observations of a tritium plume from Basin 3 in the F-Area, as shown in Figure A-13. Other contaminants, except those affected by sorption properties of the site soils, are expected to follow the general behavior of the tritium plume.

Routine discharges to the M-Area settling basin (which overflowed to Lost Lake) were discontinued in July 1985. The U.S. Department of Energy (DOE) has submitted a Part B closure plan for this hazardous waste management facility (DOE, 1985, 1987). At the basin and Lost Lake, TDS, chloride, dissolved organic carbon, nitrate, gross alpha, and radium have been observed at concentrations above background values. Table A-13 lists the potential for contamination at the M-Area settling basin. Special studies for hazardous constituents in the groundwater at the settling basin have identified chlorinated hydrocarbons (degreasing compounds); metals were not detected in significant concentrations. However, the pH in downgradient monitoring wells reflects basin operation (DOE, 1985).

Extensive groundwater monitoring studies around A- and M-Areas have been conducted since chlorinated hydrocarbons were discovered in the groundwater in 1981. The distribution of these organic compounds has been determined vertically and horizontally, but assessment studies are continuing (DOE, 1985). Figure A-14 shows a cross-section through the settling basin and Lost Lake depicting isoconcentrations of total chlorinated hydrocarbons. The main body of the plume is moving slowly to the southeast at about 7 to 8 meters per year. Monitoring studies have demonstrated that volatile organics have not migrated beyond the SRP boundary.

A groundwater remediation program was initiated in A- and M-Areas in 1983 to contain the vertical and horizontal migration of the chlorinated hydrocarbon plume in the Tertiary sands and to remove the chlorocarbons from the groundwater. This project involves the use of a 1.5-cubic-meter-per-minute air stripper that is fed by 11 recovery wells (South Carolina Bureau of Air Quality Control Permit 0080-0055-CB and Bureau of Water Pollution Control Permit 10389). On the average, the air stripper has been removing more than 2600 kilograms of chlorinated hydrocarbons per month from the groundwaters.

The characteristics of the movement and extent of contamination at F-, H-, and M-Areas are expected to approximate the behavior of contamination at other waste management units. The specific characteristics of the contamination at other facilities is primarily controlled by: (1) properties of the contaminant(s), (2) depth to groundwater, (3) contaminant retention properties of the subsurface materials, (4) degree of heterogeneity of the subsurface materials, (5) groundwater flow speed and direction, and (6) distance to groundwater outcrop.

Hazardous metal constituents have been observed in groundwater monitoring wells at the low-level radioactive waste burial grounds facility (643-G and 643-7G). Lead and cadmium concentrations averaged about 43 and 39 micrograms per liter (parts per billion), but ranged to 398 and 365 micrograms per liter, respectively. Although approximately 10 tons of mercury have been disposed of at these facilities, little mercury has been observed in monitoring wells.

Concentrations of mercury at the perimeter wells are generally less than 1 microgram per liter (National Primary Drinking Water Standards for lead, cadmium, and mercury are 50, 10, and 2 micrograms per liter, respectively). Because the wells used to measure these constituents were constructed of galvanized casings, the concentrations are considered questionable.

A.2.3.3 Radionuclide Contamination

Radium, tritium, and certain alpha-emitting radionuclides have been detected in the groundwater at concentrations above the standards for all geographic areas but Area 6, and a high level of concern for such contamination has been determined for Areas 2, 4, 5, 7, 8, 9, and 10. Figure 2-1 and Table 2-2 show the locations of these geographic areas.

Because of its high mobility and abundance, tritium is the most prevalent radionuclide that reaches the water table. Other radionuclides in the waste, particularly strontium-90, cesium-137, plutonium-238, and plutonium-239, tend to be adsorbed by the soil column in the groundwater flow paths beneath the seepage basins and the burial grounds. These radionuclides migrate very slowly because they are strongly adsorbed by soil particles.

TE

Tritium is present in some waste streams and burial grounds leachates as tritiated water, which behaves like normal water and cannot be separated practically from uncontaminated groundwater. The flow and transport properties of tritiated groundwater are indistinguishable from those of groundwater that has not been affected by tritiated leachate. Based on monitoring performed at the low-level radioactive waste burial grounds, the groundwater beneath the MWMF probably has been contaminated by tritium and, to a lesser extent, by other radionuclides.

Tritium was the only radionuclide detected migrating from the K-Area containment basins to Pen Branch. Weekly water-flow measurements combined with studies of tritium concentrations in Indian Grave Branch, a tributary of Pen Branch, indicated a migration of 7500 curies in 1984.

Tritium discharged to the F- and H-Area seepage basins has migrated from the basins and contaminated the water-table aquifer to concentrations in excess of 40,000,000 picocuries per liter (Du Pont, 1983). The migration of radioactivity from the F- and H-Area seepage basins and the low-level waste burial ground was measured with continuous samplers and flow records in Four Mile Creek in 1984. The total measured migration of tritium was 2320 curies from the F-Area seepage basins and 12,500 curies from the H-Area seepage basins and the low-level waste burial grounds. The amount of strontium-90 that migrated from the F- and H-Area seepage basins was 0.20 and 0.12 curie, respectively. Because of the desorption of cesium-137 in streambeds, the migration of this radionuclide, if it occurs, cannot be measured. Table A-14 shows the 1984 migration of tritium and strontium-90 from the seepage basins.

Table A-14. Migration of Tritium and Strontium-90 from Seepage Basins in 1984 (Ci)

Location	Tritium	Strontium-90
200-F seepage basin to Four Mile Creek (FM-A7 minus FM-4)[a]	2320	0.20
200-H seepage basins to Four Mile Creek (FM-2B minus FM-1)[a]	8020	0.12
Burial Ground and 200-H seepage basin 4 (FM-3A minus FM-3)[a]	4480	0.01
K-Area containment basin to Indian Grave Branch	7500	0.01

[a]Designators for sampling locations on Four Mile Creek.

Many laboratory and field studies of soil-to-water distribution coefficients (K_d) have been conducted on the Plant to relate soil adherence to waste migration (Prout, 1958). These studies reveal that the soil column acts to restrict the free passage of most radionuclides. Radiostrontium, radiocesium, plutonium, and many other radionuclides are largely removed from the flowing groundwater due to adsorption by clay particles. As with most physical and chemical interactions, the amount of adsorption is governed by complex equilibrium equations. Changes in the pH of the groundwater and the mass balance between other constituents are two conditions that can affect the degree of adsorption by clay particles. Changes in these conditions can cause additional contaminants to be adsorbed or some contaminants to be released from the clays, depending on the sense in which the equilibrium is shifted (Freeze and Cherry, 1979).

Two long-lived mobile radionuclides, technetium-99 and iodine-129, form stable anionic species that adhere poorly to soil and tend to migrate at about the speed of the groundwater. Preliminary data indicate that although both technetium and iodine have been found in groundwater by ultrasensitive analytical methods, neither is present in concentrations that can be measured by accepted routine monitoring procedures. The maximum measured concentration of
TE technetium-99 was 20 picocuries per liter, and that of iodine-129 was 1 picocurie per liter (Du Pont, 1983).

Tritium is the principal radioactive contaminant in the groundwater beneath the burial ground. According to calculations, approximately 28,000 curies of tritium are in this plume. Under 643-7G and 643-28G, the water-table aquifer exhibits concentrations that range from about 20,000 to 34,000,000 picocuries per liter. Perimeter monitoring wells generally exhibit lower concentrations, averaging about 300,000 picocuries per liter. However, tritium has reached the Congaree Formation at concentrations of about 20,000 picocuries per liter [National Primary Drinking Water Standard for tritium is 20,000 picocuries per liter] (Hubbard and Emslie, 1984). Table A-15 lists other radionuclides detected in the groundwater beneath the burial ground (Du Pont, 1983).

TC Table A-15. Radionuclides Detected in Groundwater Beneath Burial Ground[a] (pCi/L)

Radionuclide	Average concentration	Drinking-water standard
Tritium	300,000[b]	20,000
Cobalt-60	13	100
Strontium-90	19	8
Cesium-137	12	200
Plutonium-238	5	15
Plutonium-239	3	
Total Plutonium	8	15[c]

[a]The limits for tritium, cobalt-60, strontium-90, and cesium-137 are the maximum concentration limits if only one manmade beta- or gamma-emitting radionuclide is present.
[b]Perimeter wells.
[c]Total plutonium.

Approximately 80 percent of the groundwater plume from the low-level radioactive management facility flows toward outcrop springs along Four Mile Creek, in much the same manner as the plume from the F-Area seepage basins (Figure A-11). The remaining plume flows toward Upper Three Runs Creek, but extends only about 200 meters beyond 643-7G. Groundwater in the Congaree Formation in this area flows to Upper Three Runs Creek.

A.2.4 GROUNDWATER USE

A.2.4.1 Important Aquifers

As noted in Section A.1.1., the subsurface waters in the vicinity of the SRP include six major hydrostratigraphic units. The geohydrologic characteristics of these units, their aeral configurations, and their recharge/discharge relationships control the vertical and horizontal movement of groundwater at the Plant (see Sections A.2 and A.3). Section A.1 explains the stratigraphic nomenclature used at the SRP.

At present, the Plant does not withdraw groundwater from the crystalline, metasediment basement rocks and overlying saprolite. The Cretaceous Sediments aquifer, which is 170 to 250 meters thick at the Plant, is the most important regional aquifer. At the Plant, the Cretaceous Sediments consist of two aquifers separated by a clay aquitard (Figure A-2). The lower aquifer consists of about 90 meters of medium-to-coarse sand (Middendorf); the overlying aquifer (Black Creek) consists of about 45 meters of well-sorted medium-to-coarse sand. The Ellenton Formation clays cap the Cretaceous Sediments forming an aquitard that restricts the flow of groundwater between the Cretaceous Sediments aquifer and the overlying units.

The Congaree is another important regional aquifer. In this area, only the Cretaceous Sediments exceed the Congaree's water-producing potential. The Congaree's intermediate depth (Figure A-5) also makes it attractive for water wells. An extensive clay layer at the base of the Congaree forms a confining bed that separates the permeable sands of the Congaree from the sands in the underlying Ellenton and Cretaceous Sediments units (DOE, 1984). The green clay (Figure A-4), a marker bed at the top of the Congaree, exhibits very low hydraulic conductivity; it is, therefore, a significant aquitard (Section A.2.1), particularly south and east of Upper Three Runs Creek. The SRP does not withdraw large quantities of groundwater from the McBean, Barnwell-Hawthorn, or stream valley alluvium deposits (stratigraphic terminology from Siple, 1967; see Figure A-2). The McBean, however, becomes increasingly more important as an aquifer to the east of the Plant.

The water table is commonly located in the stream valley alluvium deposits and in the Barnwell. The McBean is usually under semiconfined conditions. In contrast, groundwater in the Congaree (to the south and east of Upper Three Runs Creek) and the Cretaceous Sediments is under confined conditions. Cretaceous Sediments water wells near the Savannah River (e.g., in D-Area) often flow because the potentiometric level of the groundwater is greater than the elevation of the land surface. Figure A-4 shows the head relationships near H-Area, close to the center of the Plant. Section A.3 discusses these relationships. Section A.3 also discusses interactions between surface water and groundwater, groundwater flow patterns, recharge/discharge, and water budgets.

A.2.4.2 Regional and Local Groundwater Use

DOE surveyed groundwater use in South Carolina in an area within about 32 kilometers from the center of the SRP. DOE obtained information for this survey from the South Carolina Department of Health and Environmental Control, the South Carolina Water Resources Commission, the U.S. Geological Survey, local universities, and files at the SRP (DOE, 1984; RPI, 1985). The survey did not include users in Georgia, because the strength of groundwater flow toward the Savannah River in the area bordering the river tend to outweigh any hydrologic gradient in the Georgia direction (Du Pont, 1983). See Sections 2.2.2, 2.2.3, 3.1, and 3.2 for information on this phenomenon (Figures A-8, A-15, A-16, and A-17).

This survey found that groundwater is the primary source of water for domestic, industrial, municipal, and agricultural use in the vicinity of the SRP. The Cretaceous Sediments, which occur at shallower depths as they approach the fall line, form the base for most municipal and industrial water supplies in Aiken County. Domestic water supplies depend primarily on the Barnwell, McBean, and Congaree Formations. In Barnwell and Allendale Counties, the Cretaceous Sediments occur at increasingly greater depths; some municipal users, therefore, get their water from the shallower Congaree and McBean Formations or from their limestone equivalents (Section A.1; Du Pont, 1983). In these counties, domestic supplies come from the Barnwell and the McBean Formations.

The survey identified 56 major municipal, industrial, and agricultural groundwater users in the study area. The total estimated pumpage in this area is about 135,000 cubic meters per day. Figures A-15 and A-16 show the locations of the major users and the groundwater flow paths for the Congaree and Cretaceous Sediments aquifer, respectively. Tables A-16 and A-17 provide pertinent data.

Municipal Use

The survey identified 20 municipal users that have a combined withdrawal rate of about 52,605 cubic meters per day (Table A-16). Within the study area, the total municipal pumpage from the Cretaceous Sediments aquifer is about 36,920 cubic meters per day. Total municipal pumpage from the McBean Formation is about 545 cubic meters per day; the Congaree Formation supplies 15,140 cubic meters per day for municipal use.

Industrial and Agricultural Use

The survey identified 36 industrial and agricultural users, including 13 on the SRP. Table A-17 lists these users. Total industrial pumpage from the Cretaceous Sediments is about 71,940 cubic meters per day, including 38,550 cubic meters withdrawn daily by the SRP.

The Sandoz Plant, about 29 kilometers south of the center of the SRP, is the largest offsite industrial user. Since 1978, it has pumped about 4165 cubic meters per day from one Cretaceous Sediments well.

In 1980, irrigation from groundwater sources in Allendale and Barnwell Counties, including areas outside the study area, amounted to average annual pumping rates of 15,000 and 4100 cubic meters per day, respectively (DOE, 1984). Major growth in the use of irrigation systems in these counties has occurred during the last several years. Some of these irrigation systems draw from the Cretaceous Sediments, but some are in the limestone equivalent of the McBean and Congaree Formations. The largest agricultural user identified in the survey, B. Oswald Company, pumps about 8175 cubic meters per day from the Tuscaloosa aquifer. In Barnwell County, the Green Blade Turf Grass Farm withdraws about 1895 cubic meters per day from Tertiary aquifers.

Domestic Use

In addition to large municipal, industrial, and agricultural users, the files of the South Carolina Department of Health and Environmental Control list 25 small communities and mobile home parks, 4 schools, and 11 small commercial interests as groundwater users. Wells serving these users generally have pumps with capacities of 54 to 325 cubic meters per day; they do not draw large quantities of water. Most of these wells produce from shallow aquifers. Total withdrawal from these 40 users is estimated to be less than 2000 cubic meters per day. However, incomplete State records provide little information on screened zone, formation, or actual usage.

Two South Carolina State Parks are within the survey area: Aiken State Park, with seven wells; and Barnwell State Park, with two wells. Several shallow wells produce small quantities of water for SRP guardhouses. The pump capacity of each of these wells is less than 40 liters per minute.

A.2.4.3 SRP Groundwater Use

Table A-18 lists pumping rates for the period 1968 to 1985 for individual areas on the Plant. Figure A-15 shows the locations of most of these areas. The greatest groundwater pumpage on the Plant occurs in A-, F-, and H-Areas. Figure A-18 shows the total pumpage on the Plant. The projected 1985 groundwater use is 26.8 cubic meters per minute. Siple (1967) concluded that (1) the Cretaceous Sediments aquifer can supply about 37.8 cubic meters per minute for SRP operation with no adverse effects on the pumping capabilities of existing 1960 wells; and that (2) potentially, the aquifer could produce more water if the well fields were properly designed. In 1960, SRP pumpage from the Cretaceous Sediments was about 18.9 cubic meters per minute.

A.3 SURFACE WATER/GROUNDWATER RELATIONSHIP

This section provides a summary description of the interrelationships between the various hydrogeologic units that constitute the SRP groundwater system, a description of the recharge and discharge areas on the Plant, and a summary description of a water balance study on the Plant.

A.3.1 HYDROGEOLOGIC INTERRELATIONSHIPS AT SRP

As discussed in Sections A.1.1 and A.2.1, the Coastal Plain sedimentary aquifers at the Plant include the Hawthorn (upland unit), Barnwell, McBean, Congaree, Ellenton, and Cretaceous Sediments (stratigraphic terminology from Siple, 1967; see Figure A-2). Water-table (unconfined) conditions generally occur in the Barnwell aquifer. Groundwater in the underlying units generally occurs under semiconfined and confined conditions. The principal aquitards (units with low hydraulic conductivity) include the tan clay, the green clay, the basal Congaree-Ellenton clay, and clay units in the Cretaceous Sediments (Figures A-1 and A-4).

Precipitation at the Plant averages about 120 centimeters per year. Although there might be both spatial and temporal variations in the fraction of this precipitation that recharges the groundwater, the overall average recharge near the SRP Burial Ground and the Separations Areas is about 30 percent, or 38 centimeters per year. This water moves predominantly in a vertical direction through the unsaturated zone at a rate of about 0.9 to 2.1 meters per day, as determined by tracer tests, to recharge the water table (Haskell and Hawkins, 1964). Upon reaching the water table, the water travels a path that has both vertical and horizontal components. The magnitude of these two components depends on the vertical and horizontal components of the hydraulic conductivity. Clay layers of low hydraulic conductivity tend to impede vertical flow and enhance horizontal flow. If the horizontal hydraulic conductivity is low, water will tend to "pile up" above the clay, and the water table will be high. On the other hand, if the horizontal hydraulic conductivity is high, the water will be conducted more quickly away from the recharge area, and the water table will be low.

The water table is high in H-Area because the tan clay inhibits the downward movement of water and the low horizontal hydraulic conductivity of the Barnwell Formation does not permit rapid removal of the water in a horizontal direction. The hydraulic head builds up in the Barnwell Formation sufficiently to drive the water through the material of low hydraulic conductivity; some goes vertically through the tan clay and some moves laterally to nearby streams.

Water that enters the McBean Formation also follows a path that has both vertical and horizontal components. The water recharging this formation through the tan clay is the nominal surface recharge (38 centimeters per year) minus the amount of water that is removed from the Barnwell by lateral flow (about 25 centimeters per year; see Section A.3.3.1). The discharge points for the McBean Formation are more distant from their respective groundwater divides than those of the Barnwell Formation.

The green clay has a lower hydraulic conductivity than the materials above; as a result, recharge to the Congaree through this clay is less than the recharge to the McBean. In addition, the Congaree has a higher hydraulic conductivity than the materials above; as a result, lateral flow is enhanced, making the potentiometric levels in the Congaree much lower than those above, as shown in Figures A-4 and A-19. The discharge areas for the Congaree are the valleys of the Savannah River and Upper Three Runs Creek.

Cretaceous Sediments potentiometric levels in H-Area are above those of the Congaree (Figure A-4), indicating that in this area the Cretaceous Sediments are not recharged naturally from the Congaree. Water in the Cretaceous Sediments passing beneath H-Area is recharged through the Tertiary sediments to the north of the Plant. Some water is discharged from the Cretaceous Sediments upward into the overlying sediments in the Savannah River valley where it borders the Plant. Most of the remaining groundwater moves northwest to the outcrop area of the Cretaceous Sediments, where water discharges directly to the Savannah River and its tributaries (Figure A-10). Water levels in the Cretaceous Sediments in the Savannah River valley are commonly above land surface and wells in these areas flow naturally. Figures A-8, A-9, A-15, and A-16 show that water from either formation does not naturally flow between South Carolina and Georgia. Instead, groundwater moves toward the Savannah River from both states in the vicinity of the SRP site. Figure A-20 shows the vertical head relationships between the Congaree, the upper Cretaceous Sediments aquifer, and the lower Cretaceous Sediments aquifer in the southern part of the Plant. The head relationship between the Congaree and the upper Cretaceous Sediments is the same here as in H-Area, but the difference is greater. This area is greatly influenced by the drawing down of the head in the Congaree, as groundwater flows from the Congaree into the Savannah River valley.

TC

The head relationships in the northwest part of the Plant (M-Area) are quite different, as shown on Figure A-21. In this updip area (Figure A-1), the green clay is very discontinuous and not as thick as it is farther downdip. The tan clay can be missing entirely. Thus, there is little impedance to downward vertical flow within the Tertiary sediments, and the water levels are farther below the land surface than in H-Area. Another very important factor is that the geologic character of the Congaree Formation in M-Area is different from that in H-Area; the geologic material is not as well sorted and its hydraulic conductivity is lower. As a result, the lateral flow of water in the Congaree is insufficient to draw its water level down below that of the Cretaceous Sediments aquifer in M-Area, and a downward head differential exists from the Congaree to the Cretaceous Sediments. Closer to the Savannah River, the discharge from the Congaree draws its water level down below that of the Cretaceous Sediments aquifer.

The locations of areas in which there is a head reversal between the Congaree and the Cretaceous Sediments aquifer, and areas in which there is not, were obtained from a map showing the differences between the Cretaceous Sediments and Congaree potentiometric surface maps (Du Pont, 1983). The resulting head differential map (Figure A-22) shows that the head in the Cretaceous Sediments is higher than that in the Congaree in a broad area within about 10 kilometers from the Savannah River and Upper Three Runs Creek. The head in the Congaree is higher in an area around M-Area and in the vicinity of Par Pond. This map was constructed by subtracting two potentiometric surface maps that contained limited data; thus, it should not be used to predict detailed head relationships, but only to indicate directions of expected vertical gradients in broad areas.

A.3.2 GROUNDWATER RECHARGE AND DISCHARGE AT SRP

Water enters the groundwater system in recharge areas and moves through the system, as dictated by hydraulic gradients and hydraulic conductivities, to discharge areas. Groundwater moves from areas of high potential energy (usually measured by combined elevation and pressure heads) to areas of lower potential energy.

The hydraulic gradient on the Atlantic Coastal Plain is generally southeastward toward the Atlantic Ocean. The southeastward groundwater flow is modified by the incised channels of the Savannah and Congaree Rivers and their tributaries. Groundwater flows toward the areas of low potential energy (low hydraulic head areas) created by natural discharge to stream channels and wetlands.

TC The Savannah River Plant is drained almost entirely by five major streams: Upper Three Runs Creek, Four Mile Creek (including Beaver Dam Creek), Pen Branch, Steel Creek, and Lower Three Runs Creek (Figure A-23). The depth of dissection of these streams has a significant influence on groundwater discharge areas and the directions of groundwater flow. The flow direction in the shallow groundwater, typically in the Barnwell Formation, is most affected by small onsite streams (see, for example, Figures A-24 through A-29). Flow directions in the McBean Formation are affected by Upper Three Runs and Four Mile Creeks (Figure A-30), those in the Congaree Formation by Upper Three Runs Creek and the Savannah River (Figures A-31 and A-9), and those in the Ellenton and Cretaceous Sediments by the Savannah River only. Locally, the direction of normal groundwater flow in any hydrogeologic unit is modified by groundwater withdrawals from wells (Figure A-5). The locations of recharge and discharge areas on the Plant are summarized in Table A-19.

Figure A-15 shows the potentiometric surface of the Cretaceous Sediments aquifer near the Plant. Recharge occurs principally in offsite outcrop areas near the Fall Line. If the elevation of the outcrop area is high, as on the Aiken Plateau northeast of the Plant, precipitation recharged to the Cretaceous Sediments exceeds the groundwater naturally discharged to local streams and withdrawn by water wells. This excess water moves southeastward through the aquifer. Where the elevation of the outcrop is low, as along the Savannah River valley just north of the northwest sector of the Plant, groundwater naturally discharges to the Savannah River. Under the Plant, the groundwater flow in the Cretaceous Sediments is southwesterly toward the river (Du Pont, 1983).

Recharge to the Congaree Formation is principally in offsite areas. At the Plant there is appreciable recharge from the McBean Formation in M- and A-Areas but almost none from overlying units southeast of Upper Three Runs Creek. The natural discharge areas for the Congaree on the Plant are the wetlands along Upper Three Runs Creek and the Savannah River. As shown in Figures A-19, A-31, and A-11, the water levels in the Congaree are drawn down significantly by groundwater discharge to Upper Three Runs Creek and the Savannah River.

Recharge to the McBean Formation is from the Barnwell Formation in the central areas of the Plant and in offsite areas. The natural discharge areas are Upper Three Runs and Four Mile Creeks (Figure A-30).

Thus, in summary, the dissecting creeks divide the groundwater in the Congaree Formation into discrete subunits (see Figure A-23). Depending on the depth of dissection, groundwater is confined to its own subunit. Thus, even though the hydraulic characteristics of the formation might be similar throughout the area, each subunit has its own recharge and discharge areas. If dissection is through most of the formation thickness, then no water will move from one subunit to another. As with the Congaree Formation, creeks in the region dissect the McBean Formation and divide the hydrogeologic unit into separate subunits.

Because the McBean is a shallower formation than the Congaree, smaller creeks with less deeply incised valleys make these divisions. The subunits of the McBean are, therefore, smaller than those of the Congaree. In the Separations Areas, the only stream that cuts into the Congaree is Upper Three Runs Creek, whereas the McBean is incised by Upper Three Runs Creek and several of its larger tributaries, Four Mile Creek, Pen Branch, and Steel Creek. Thus, as shown in Figure A-30, groundwater that enters the McBean in the Separations Area cannot flow to other subunits of the McBean (Du Pont, 1983). TC

The water table at the Plant southeast of Upper Three Runs Creek is commonly within the Barnwell Formation, although in the creek valleys it successively occupies positions in the lower formations (e.g., Figure A-19). Recharge to the Barnwell is from precipitation. Natural discharge from the water table is to the creeks and their tributaries. The surface drainage and topography strongly influence the groundwater flow in the unconfined aquifer. Even small tributaries of the larger creeks cause depressions in the water-table elevation (see Figures A-24 through A-28). The Upland Unit, which overlies the Barnwell on much of the Plant, is unsaturated; its flow paths are predominantly vertical with only short, horizontal flow paths.

Northwest of Upper Three Runs Creek, the water table is much deeper and lies within the McBean Formation (Du Pont, 1985a, b). Discontinuous clays that are believed to correlate to the green clay mark the lower boundary of this unit. The groundwater beneath these clays is in the Congaree Formation under semi-confined conditions. Because the depth of the water table is about 33 meters, streams in this portion of the Plant exhibit little control over groundwater flow.

A.3.3 WATER BUDGET FOR SEPARATIONS AREAS AND SRP BURIAL GROUND

Precipitation falling on the earth's surface enters the groundwater system by infiltration, enters the surface water by runoff, or returns to the atmosphere by evaporation. The water budget is essentially a water-material balance used by hydrologists to determine the distribution of precipitation within the hydrosphere. Hubbard and Emslie (1984) used the water-budget method to determine whether significant groundwater flow paths exist below the Barnwell Formation at the SRP Burial Ground between F- and H-Areas (Figure A-12). TC

A simplified water budget for the Separations Area can be quantified as follows:

$$P - R - G - ET = S \qquad (A-2)$$

where:

P = input precipitation

R = surface and subsurface runoff, water that moves rapidly to drainage ditches and streams

G = water percolated downward to recharge the groundwater at the water table

ET = evapotranspiration, evaporation from the surface and transpiration through vegetation to the atmosphere

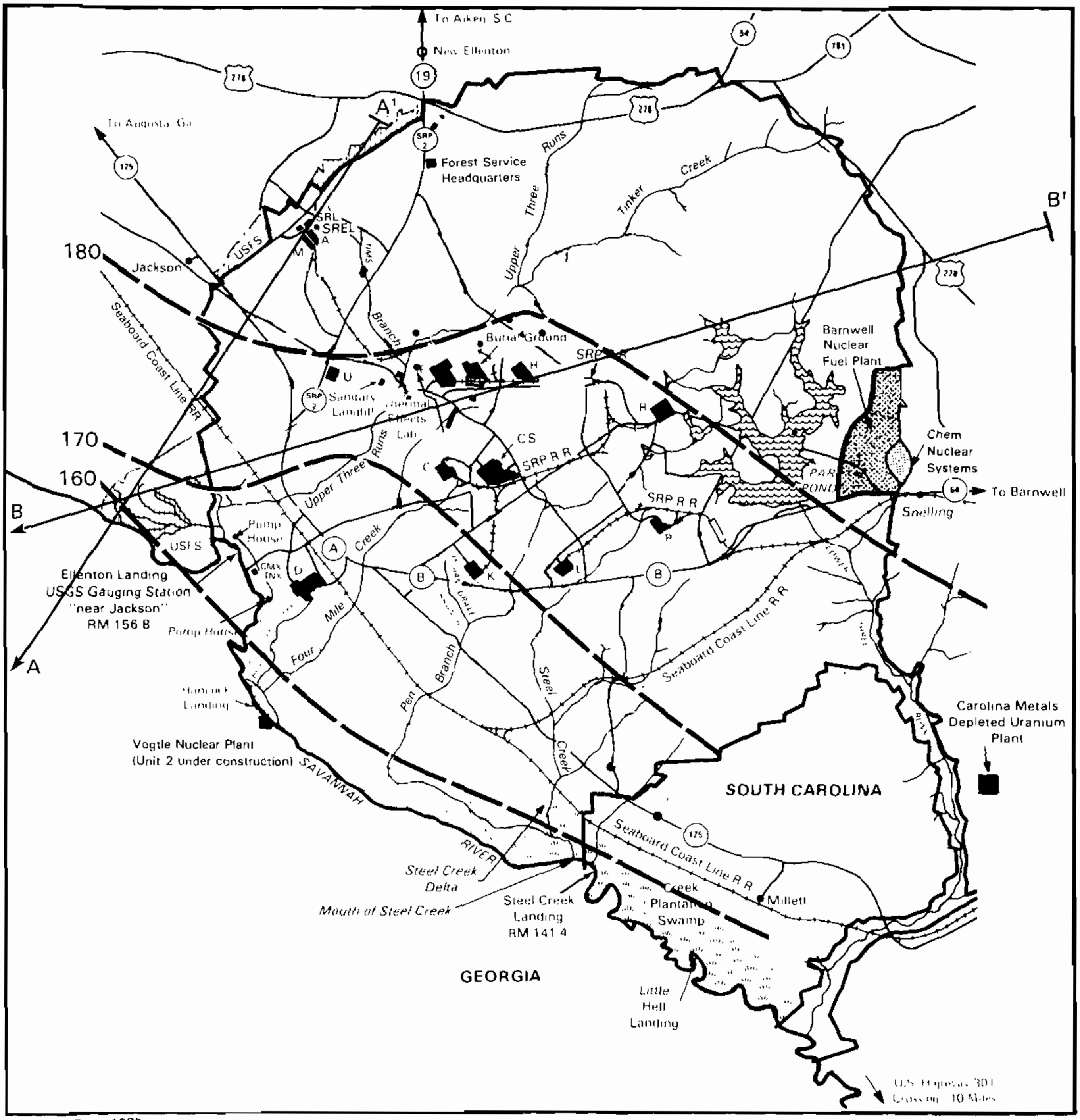
S = storage of water, as reflected in the rising and falling of the water table

Groundwater migrates slowly toward places of lower hydraulic potential, discharging as springs, seeps, or the base flow of streams. Over sufficiently long periods, often a water-year, storage can be neglected, so discharge can be assumed to equal recharge.

Mean annual precipitation, runoff, and evapotranspiration were estimated to be 119.4, 5.1, and 76.2 centimeters, respectively. The total groundwater recharge was estimated by subtracting runoff and evaporation from the precipitation, or 38.1 centimeters.

Groundwater in most of the Burial Ground area migrates slowly westward and southward toward Four Mile Creek and its F-Effluent tributary (Figure A-24). Groundwater was seen to enter a tributary of Four Mile Creek at seeps and springs during a rain-free period in May and June 1980. At a "tan clay" outcrop 61 meters above sea level, the groundwater discharge averaged 8.2 liters per second over four measurements made during this period. This measurement, converted to other units and combined with the estimated watershed area of 2.1 square kilometers, gives the groundwater discharge above the tan clay as 0.004 cubic meter per second per square kilometer or 12.7 centimeters per year.

These discharge measurements provide the basis for inferring that a residual recharge of 25.4 centimeters per year (38.1 centimeters minus 12.7 centimeters) reaches aquifers below the tan clay, the McBean, and the Congaree. However, there is believed to be little recharge of the Congaree in this part of the Plant because of the low hydraulic conductivity of the green clay. Root (1983) showed that the assumption of zero recharge of the Congaree could be used in mathematical modeling of groundwater flow at the Burial Ground.



Source: Du Pont, 1983.

Legend:

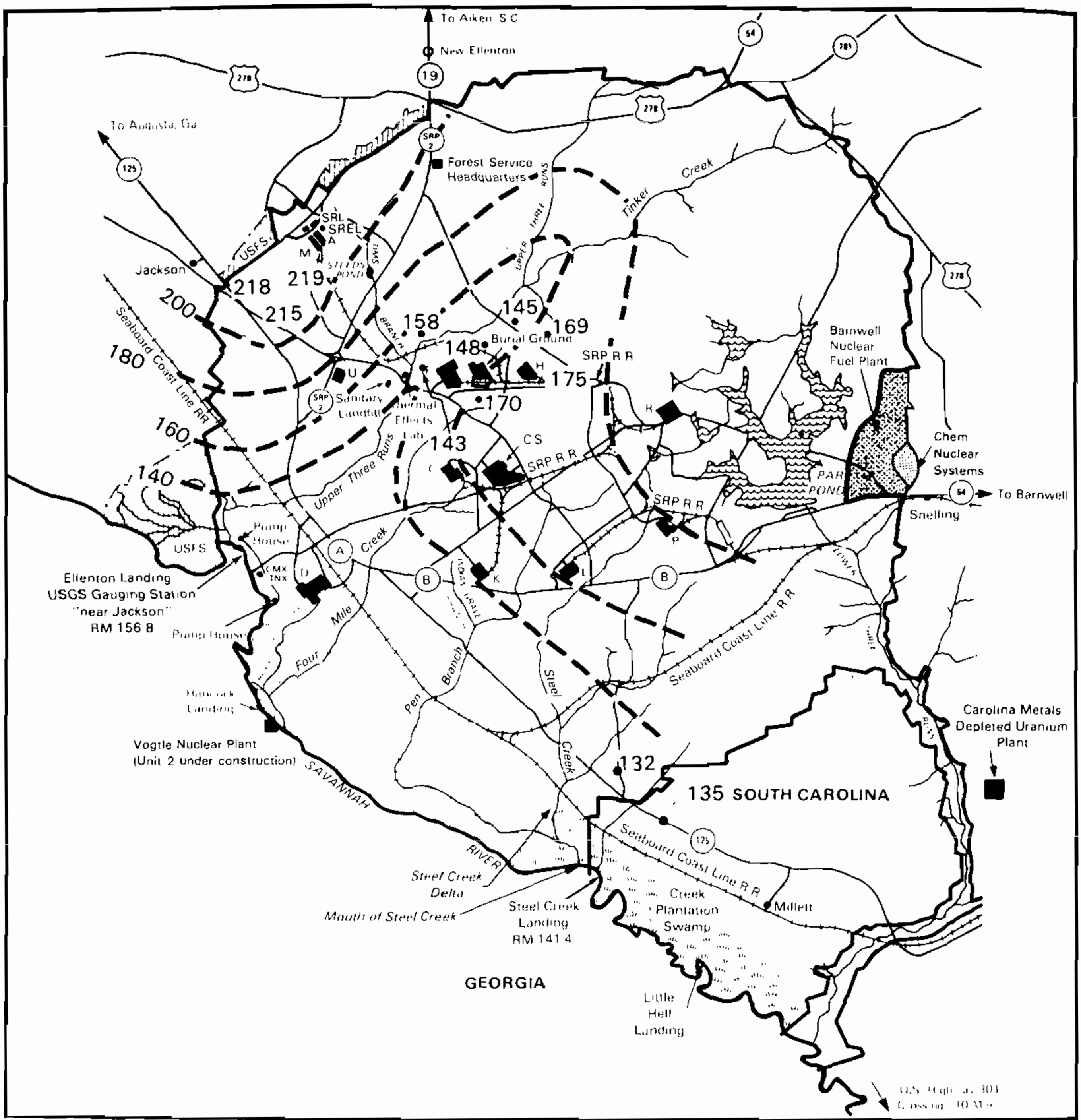
- C,K,R,L,P Reactor Areas
- F,H Separations Areas
- M Fuel and Target Fabrication
- D Steam and Power Plant, Heavy Water Production
- A Savannah River Laboratory and Administration Area
- CS Central Shop
- RM River Mile
- U *Heavy Water Control Test Facility*

Road A = Highway 125

Note: Contours and water levels in feet above mean sea level.
1.0 foot = 0.3048 meter.

TC

Figure A-10. Potentiometric Map of Cretaceous Sediments Aquifer at Savannah River Plant (1982)



Source: Du Pont, 1983.

Scale (kilometers) 0 5 10 15

Legend:

- C,K,R,L,P Reactor Areas
- F,H Separations Areas
- M Fuel and Target Fabrication
- D Steam and Power Plant, Heavy Water Production
- A Savannah River Laboratory and Administration Area
- CS Central Shop
- RM River Mile
- U Heavy Water Control Test Facility

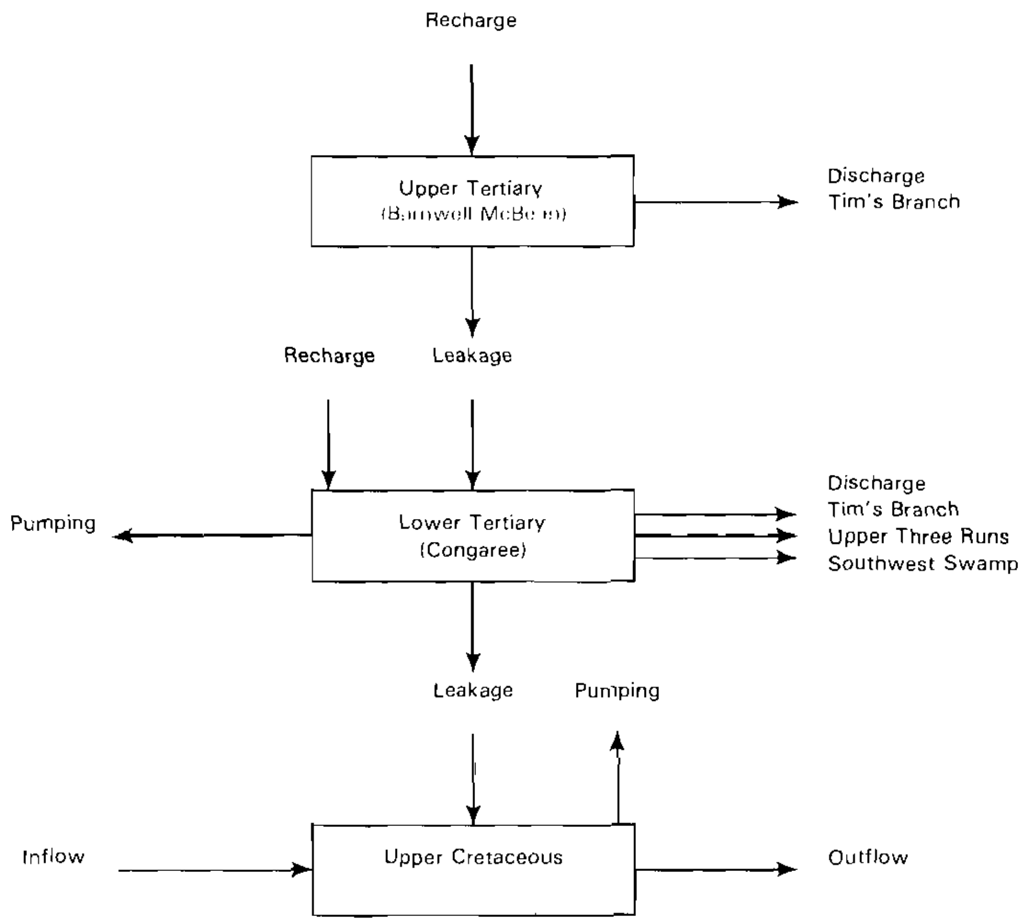
TC

Road A = Highway 125

Note: Contours and water levels in feet above mean sea level.
1.0 foot = 0.3048 meter.

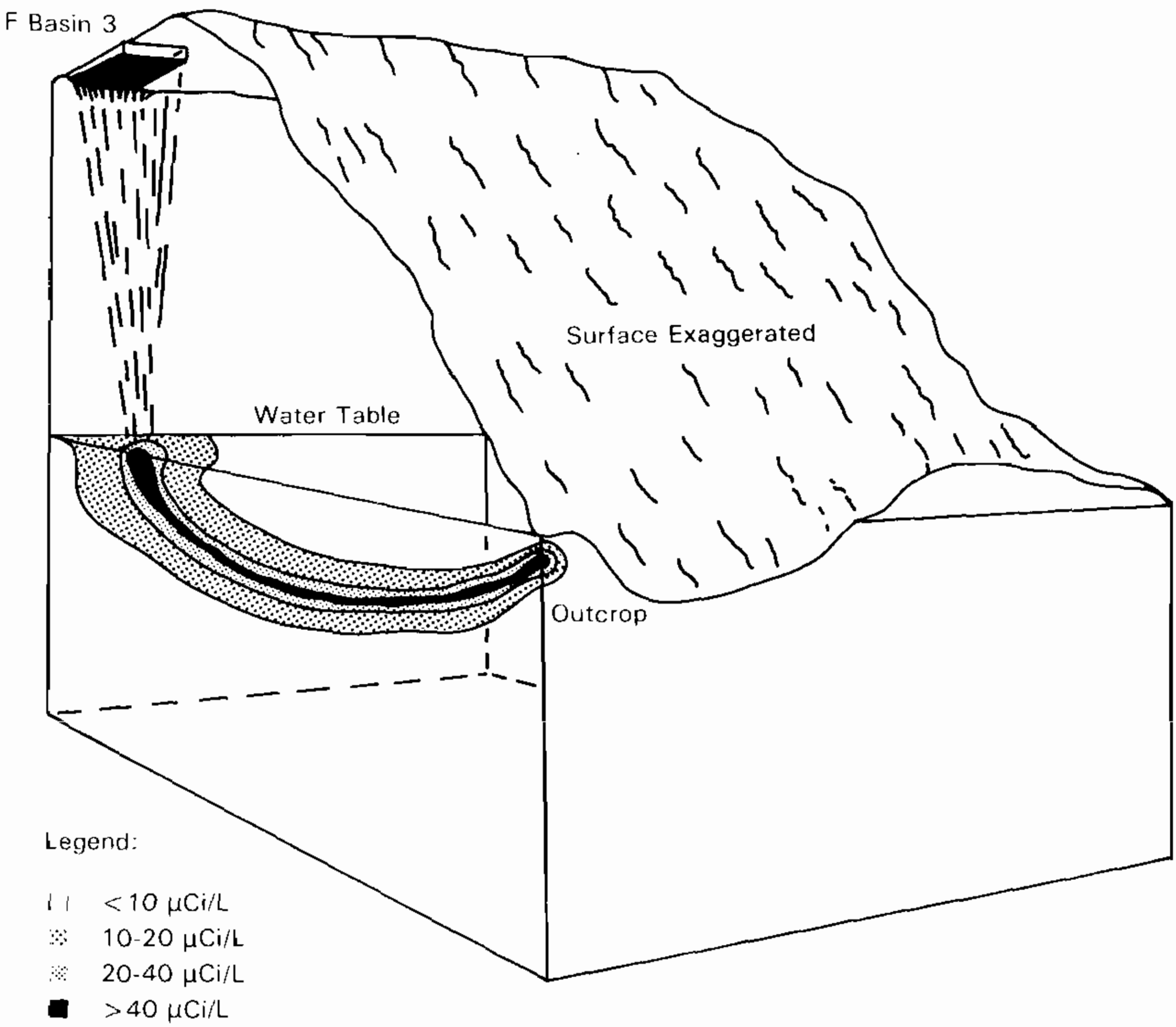
TE

Figure A-11. Potentiometric Map of Congaree Formation at Savannah River Plant (1982)



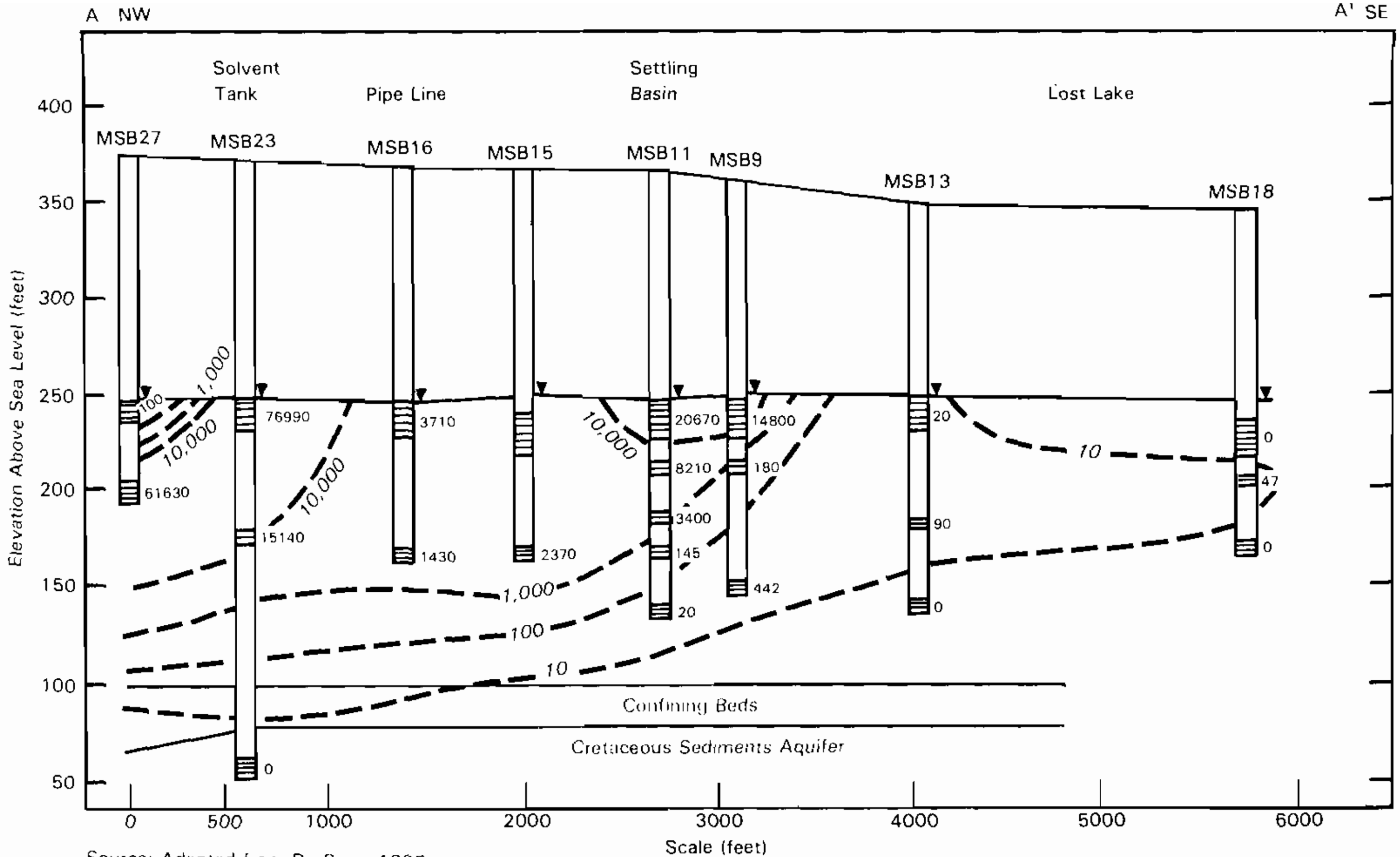
Source: Du Pont, 1985a. Hydrostratigraphic unit terminology after Siple, 1967; see Figure A-2.

Figure A-12. Distribution of Groundwater Flow Between Hydrologic Units in the Vicinity of A- and M-Areas



Source: Du Pont, 1983.
Note: Distance from basin 3 to outcrop is approximately 450 meters.
Depth to water-table from basin 3 is approximately 20 meters.

Figure A-13. Subsurface Flow Path from F-Area Seepage Basin 3



Source: Adapted from Du Pont, 1985a.

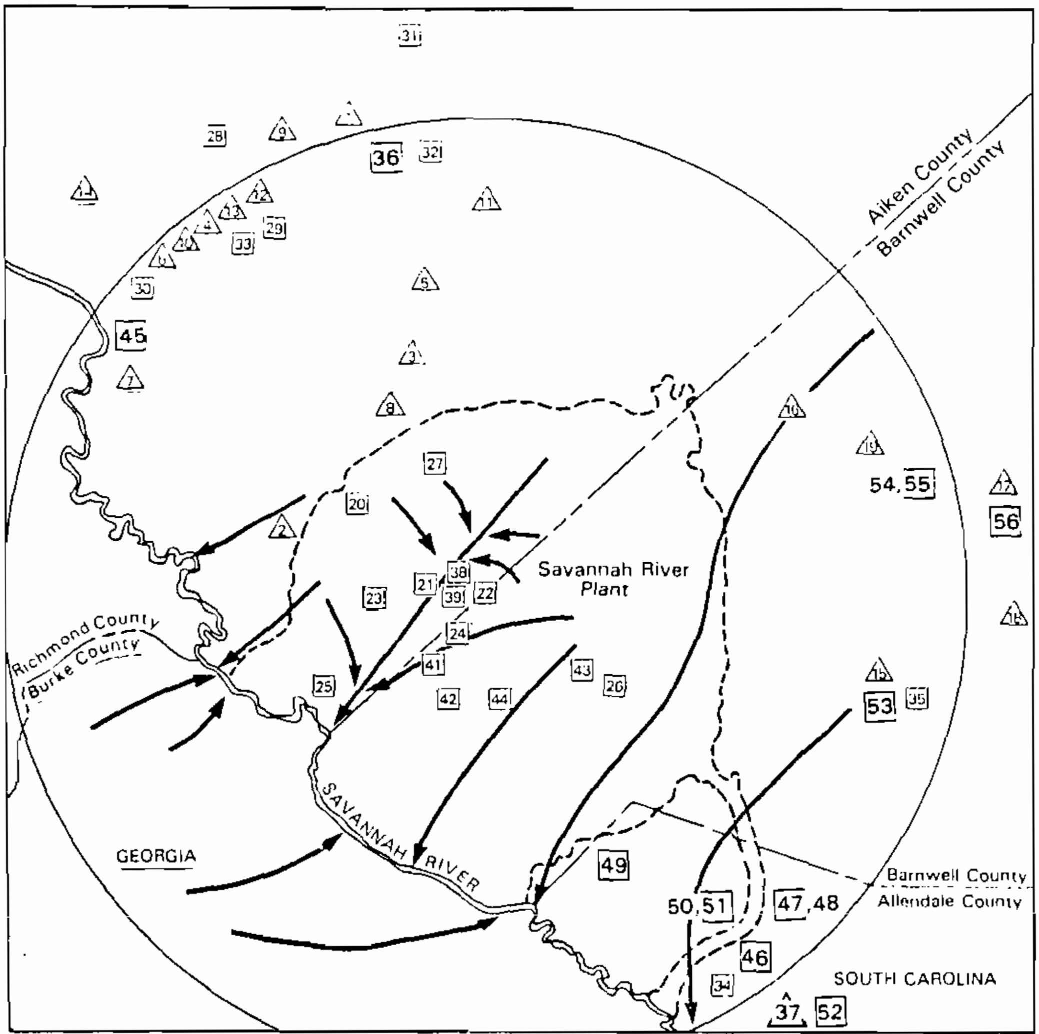
Legend:

▼ Water Table Elevation

37 Screened Zone and Concentration (ppb)

Note: 1.0 foot = 0.3048 meter

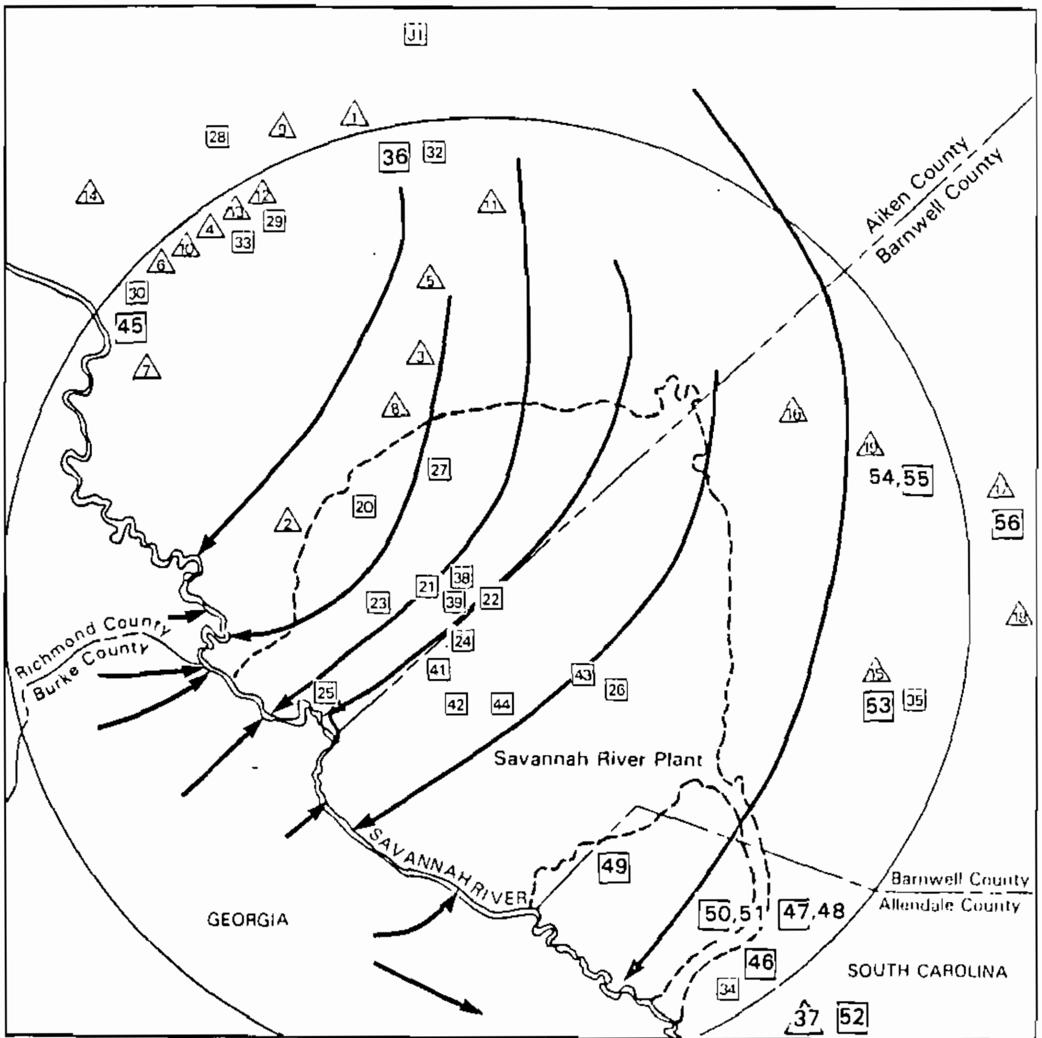
Figure A-14. Cross-Section Through M-Area Showing Total Chlorinated Hydrocarbon Concentrations (ppb) in Groundwater (April-July 1984)



Source: DOE, 1984.
Note: Users are identified in Tables A-17 and A-18.
Legend:
- △ Municipal user
- ☐ Industrial/agricultural user
- ← Direction of groundwater flow in Congaree Formation

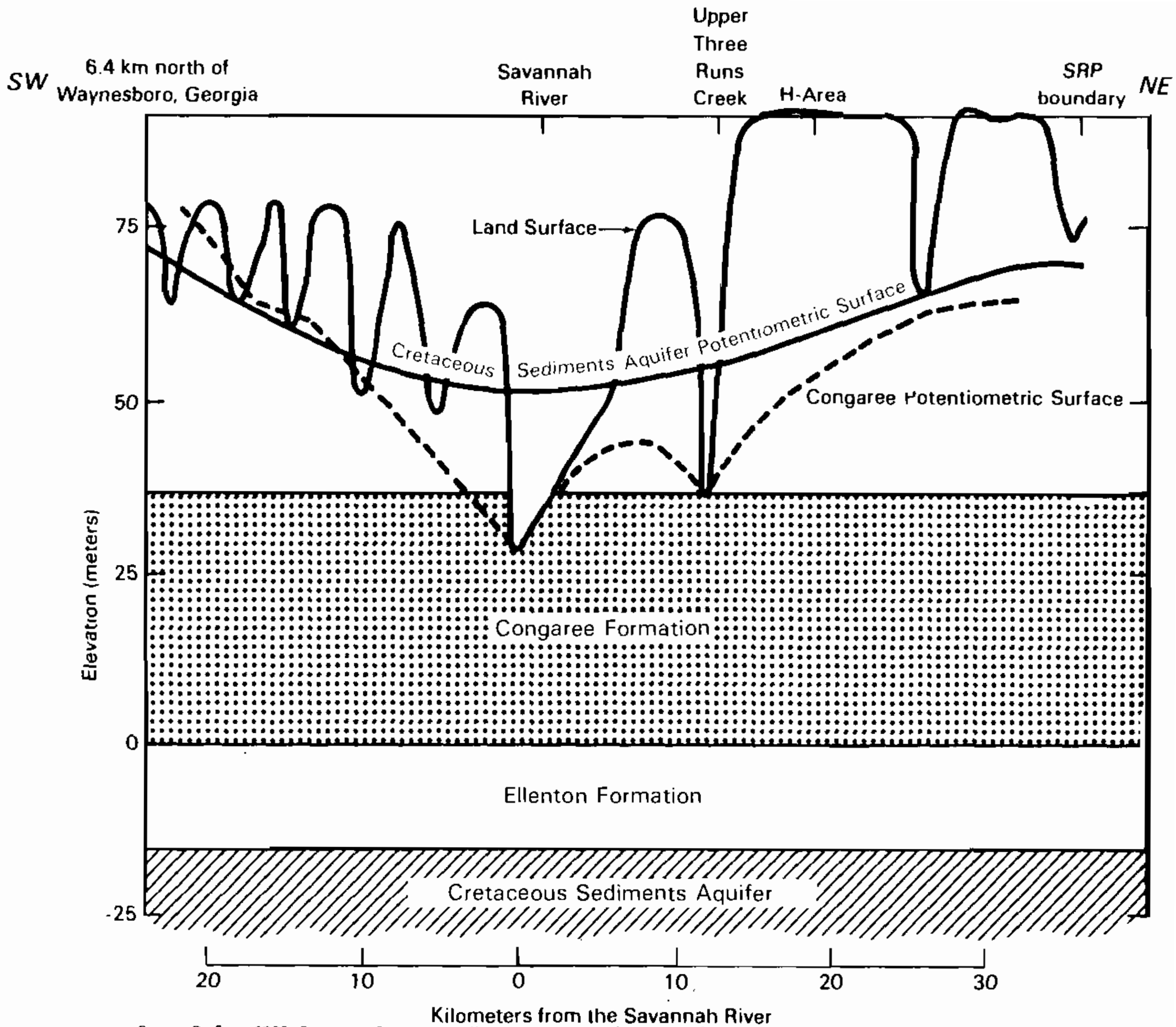
Scale (kilometers)
0 5 10 15 20

Figure A-15. Locations of Municipal and Industrial Groundwater Users Within a 32-Kilometer Radius of the Center of Savannah River Plant, Showing the Direction of Groundwater Flow in the Congaree Formation



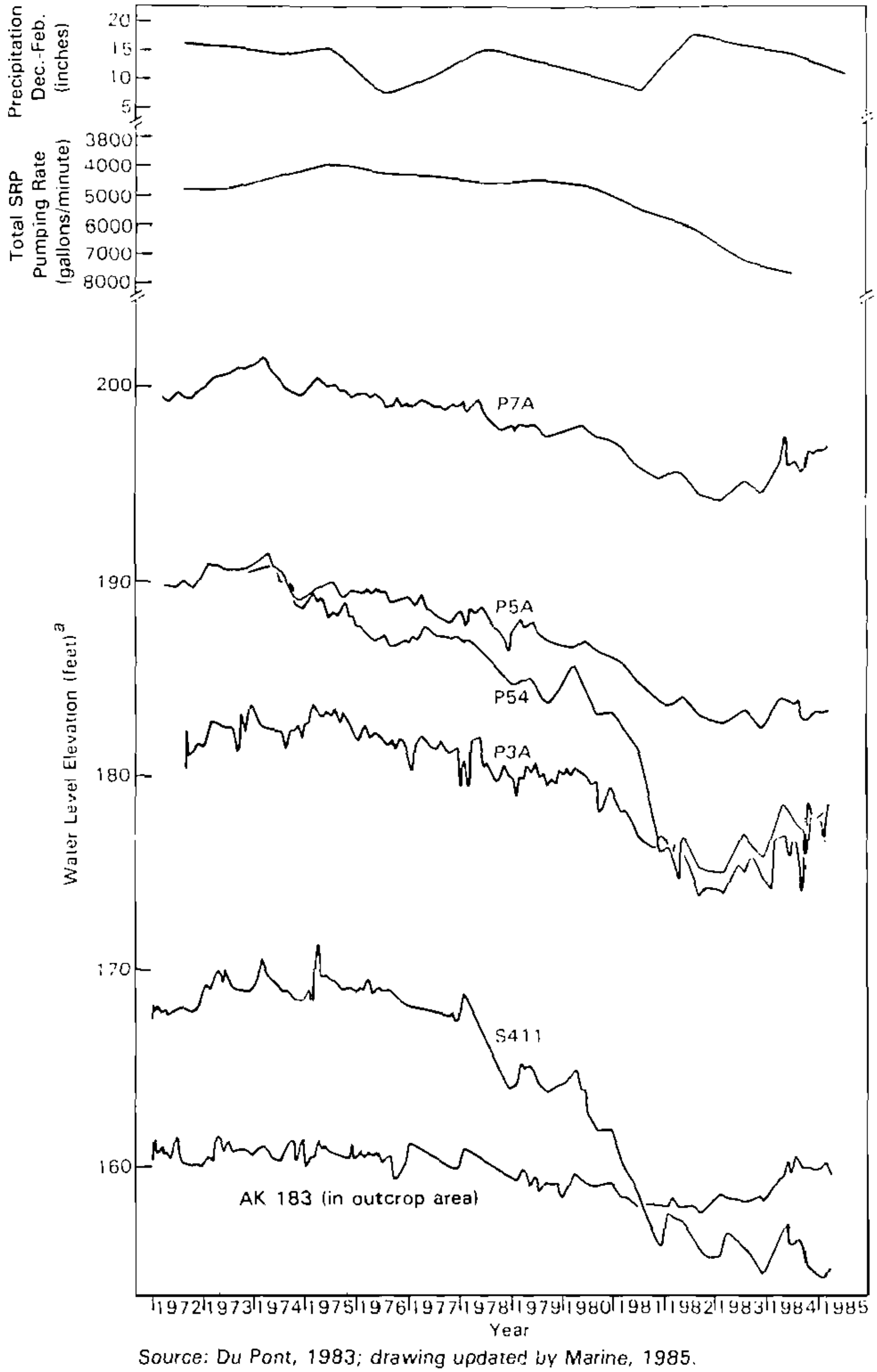
Source: DOE, 1984.
Note: Users are identified in Tables A-17 and A-18.
Legend:
△ Municipal user
□ Industrial/agricultural user
← Direction of groundwater flow in Cretaceous Sediments Aquifer

Figure A-16. Locations of Municipal and Industrial Groundwater Users Within a 32-Kilometer Radius of the Center of Savannah River Plant, Showing the Direction of Groundwater Flow in the Cretaceous Sediments Aquifer



Source: Du Pont, 1983; Cretaceous Sediments aquifer water levels from Siple, 1967; Congaree water levels from Faye and Prowell, 1982.
Note: See Figure A-10 for line of section.

Figure A-17. Hydrogeologic Section Perpendicular to the Savannah River Through H-Area

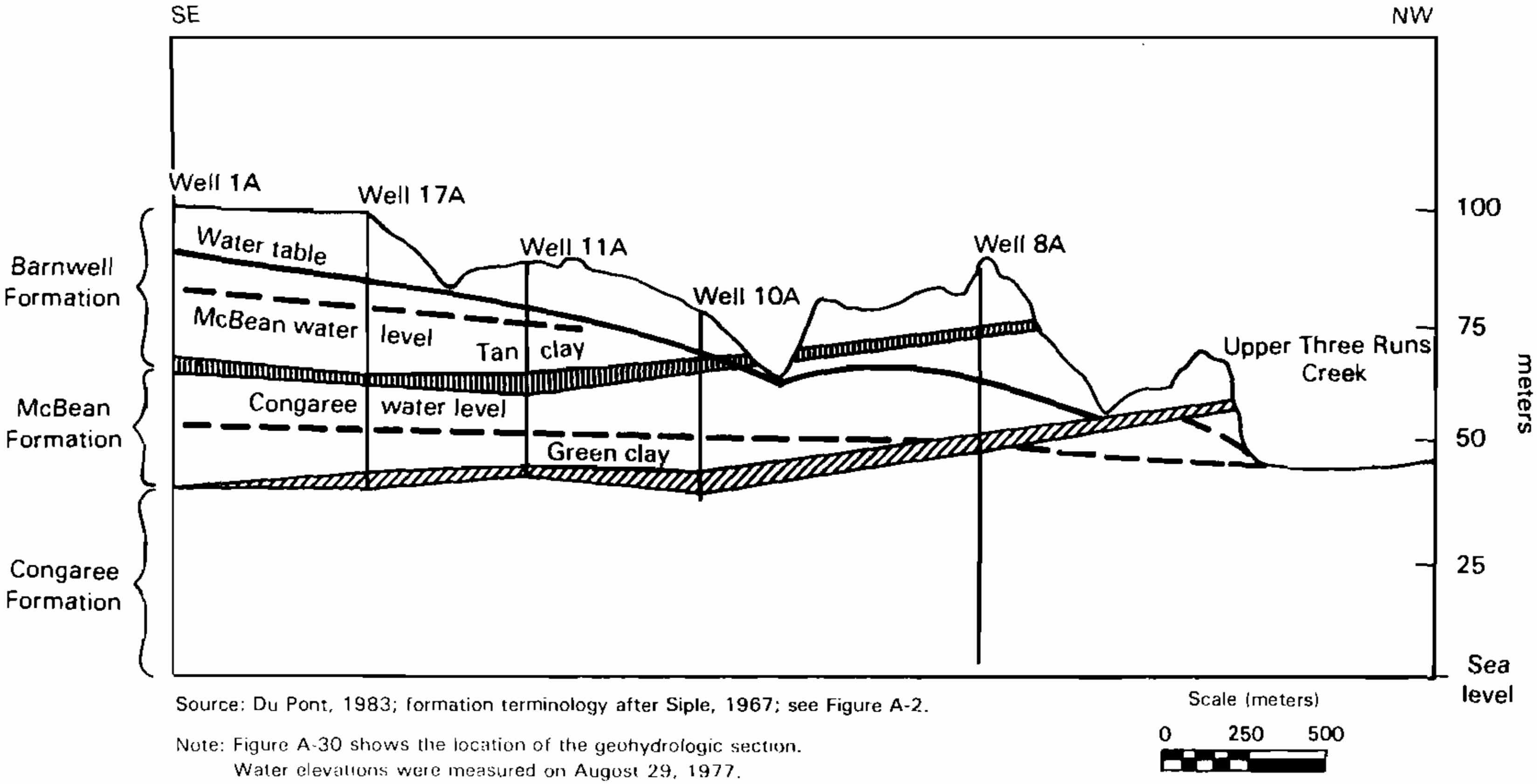


Source: Du Pont, 1983; drawing updated by Marine, 1985.

Note: Figure A-23 shows the well locations. Well S411 is screened in the Ellenton Formation; the remaining wells are screened in the Cretaceous Sediments Aquifer.

[a]1.0 foot = 0.3048 meter

Figure A-18. Hydrographs of Cretaceous Sediments Aquifer and Ellenton Formation

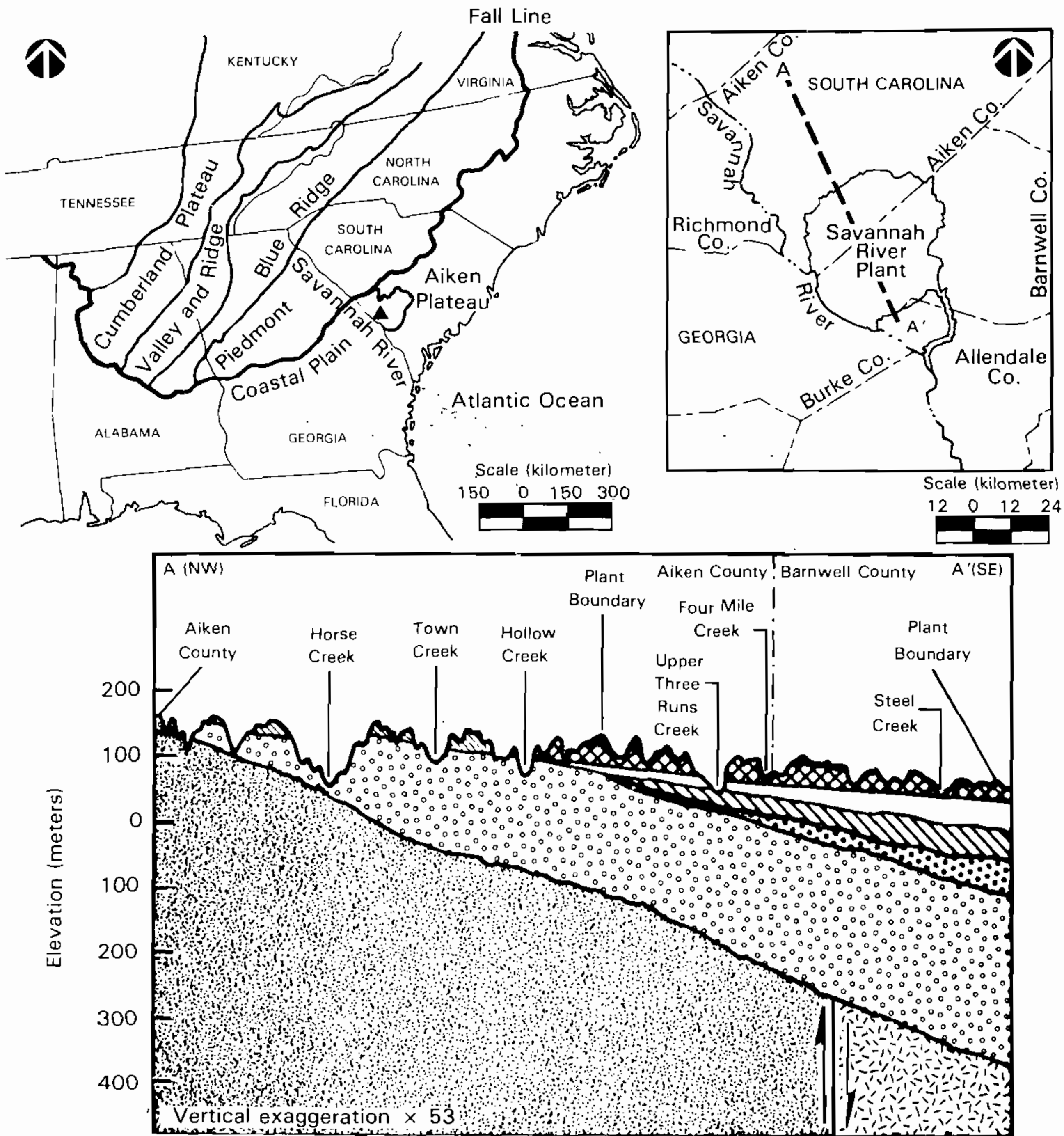


Source: Du Pont, 1983; formation terminology after Siple, 1967; see Figure A-2.

Note: Figure A-30 shows the location of the geohydrologic section.
Water elevations were measured on August 29, 1977.

Figure A-19. Geohydrologic Section in Central Part of the Savannah River Plant

TE



TE

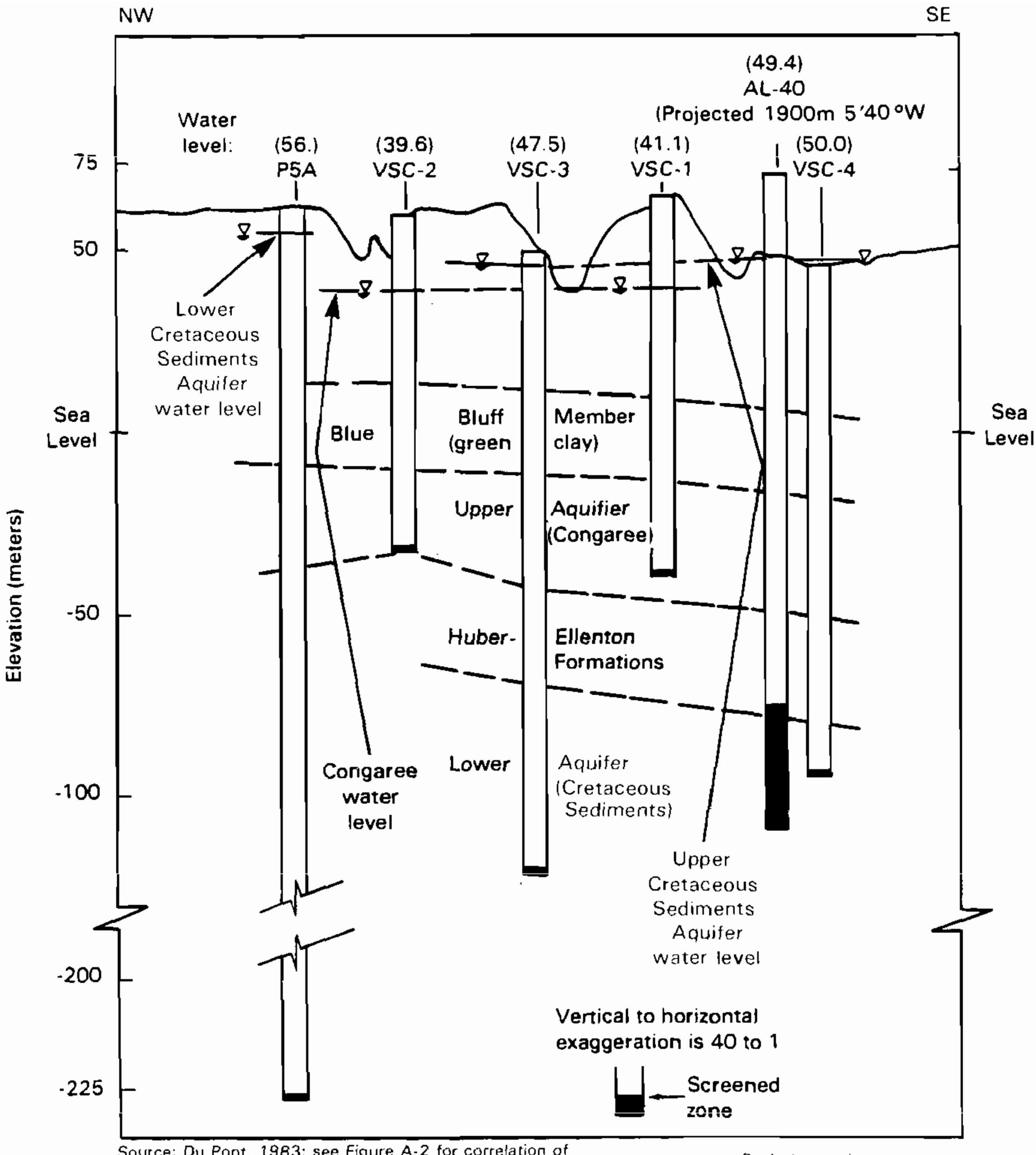
Source: Adapted from DOE, 1984; modified from Siple, 1967; formation terminology after Siple, 1967.

Scale (kilometer)
0 8 16

Legend:

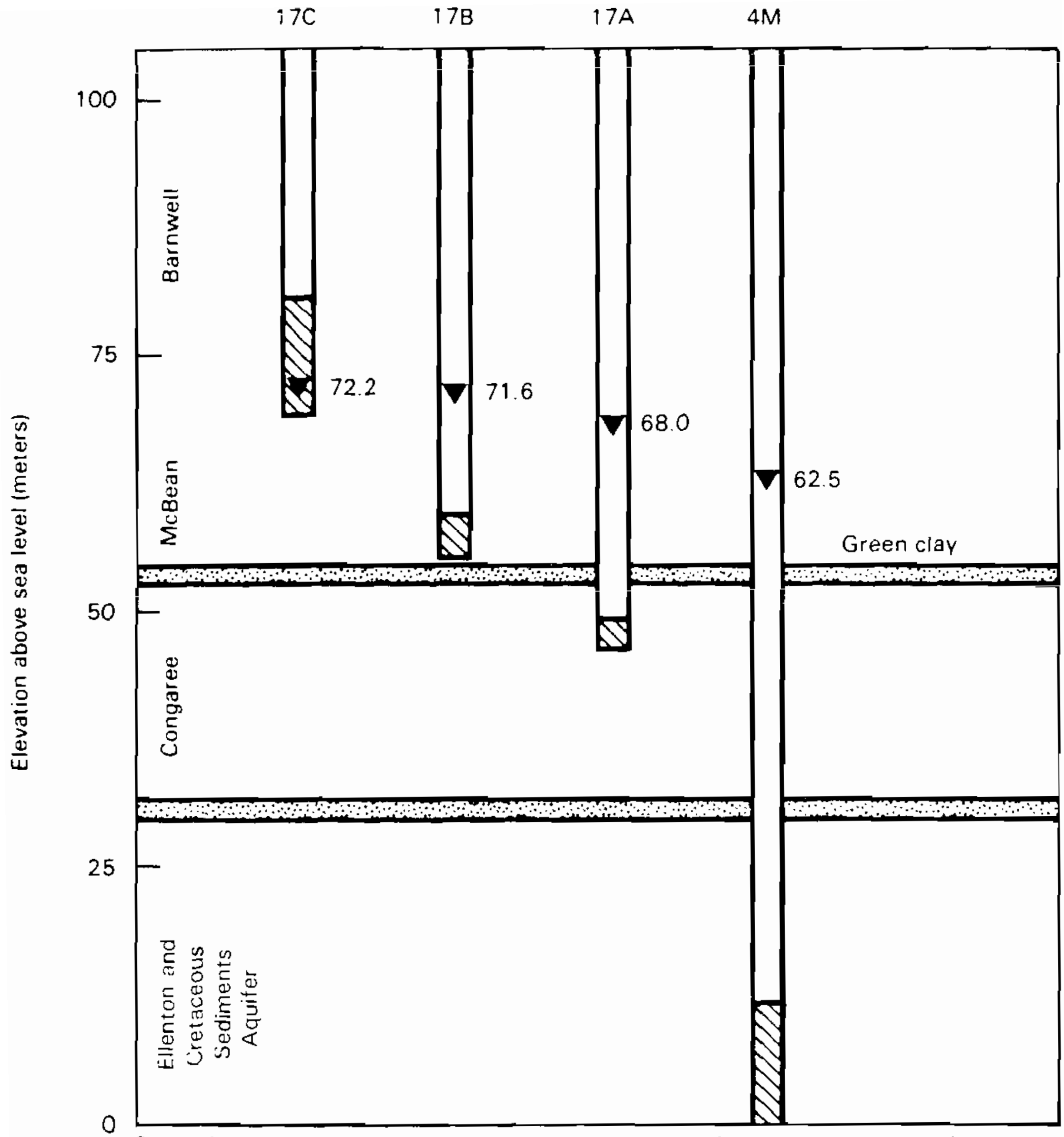
- Hawthorn (Fluvial Upland Unit)
- Barnwell
- Tertiary rocks undifferentiated
- McBean
- Congaree
- Crystalline metamorphic rock
- Ellenton
- Tuscaloosa
- Dunbarton Triassic Basin

Figure A-1. Generalized Northwest to Southeast Geologic Profile, and SRP Regional Site Locator



Source: Du Pont, 1983; see Figure A-2 for correlation of aquifer terminology with that of other recognized units.
Note: Figure A-23 shows the location of well cluster.

Figure A-20. Comparison of Groundwater Elevations in the Congaree Formation to Those in the Cretaceous Sediments Aquifer in the Southern Part of the Savannah River Plant (1982)

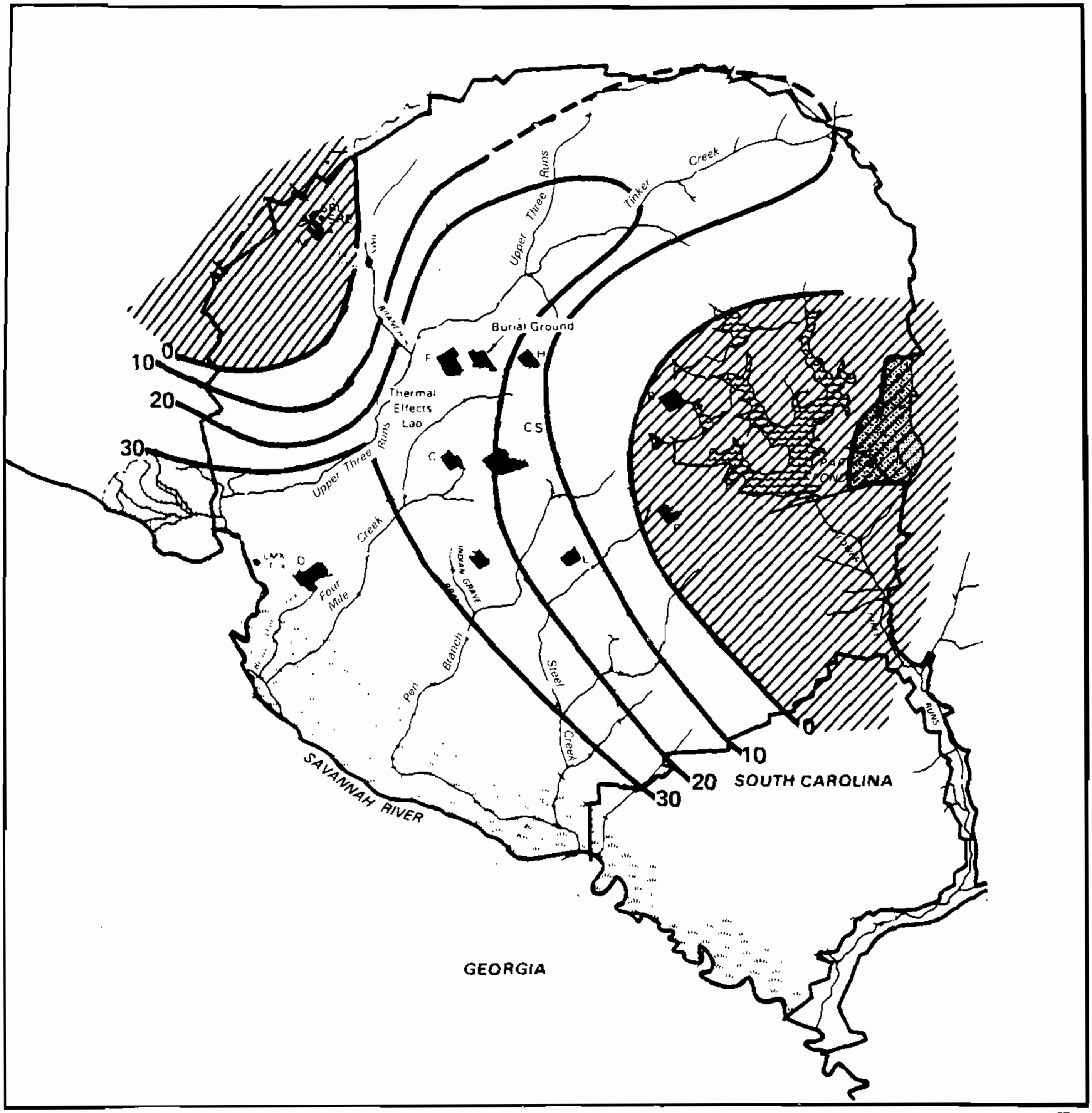


Source: Du Pont, 1983; hydrostratigraphic unit terminology after Siple, 1967; see Figure A-2.
Note: Figure A-23 shows the location of this profile.

Legend:

▼ Water elevation
Clay layer
Screen and gravel zone

Figure A-21. Vertical Head Relationships Near M-Area in 1982



Source: Du Pont, 1983.

Legend:

- C,K,R,L,P *Reactor Areas*
- F,H Separations Areas
- M Fuel and Target Fabrication
- D Steam and Power Plant, Heavy Water Production
- A Savannah River Laboratory and Administration Area
- CS Central Shop

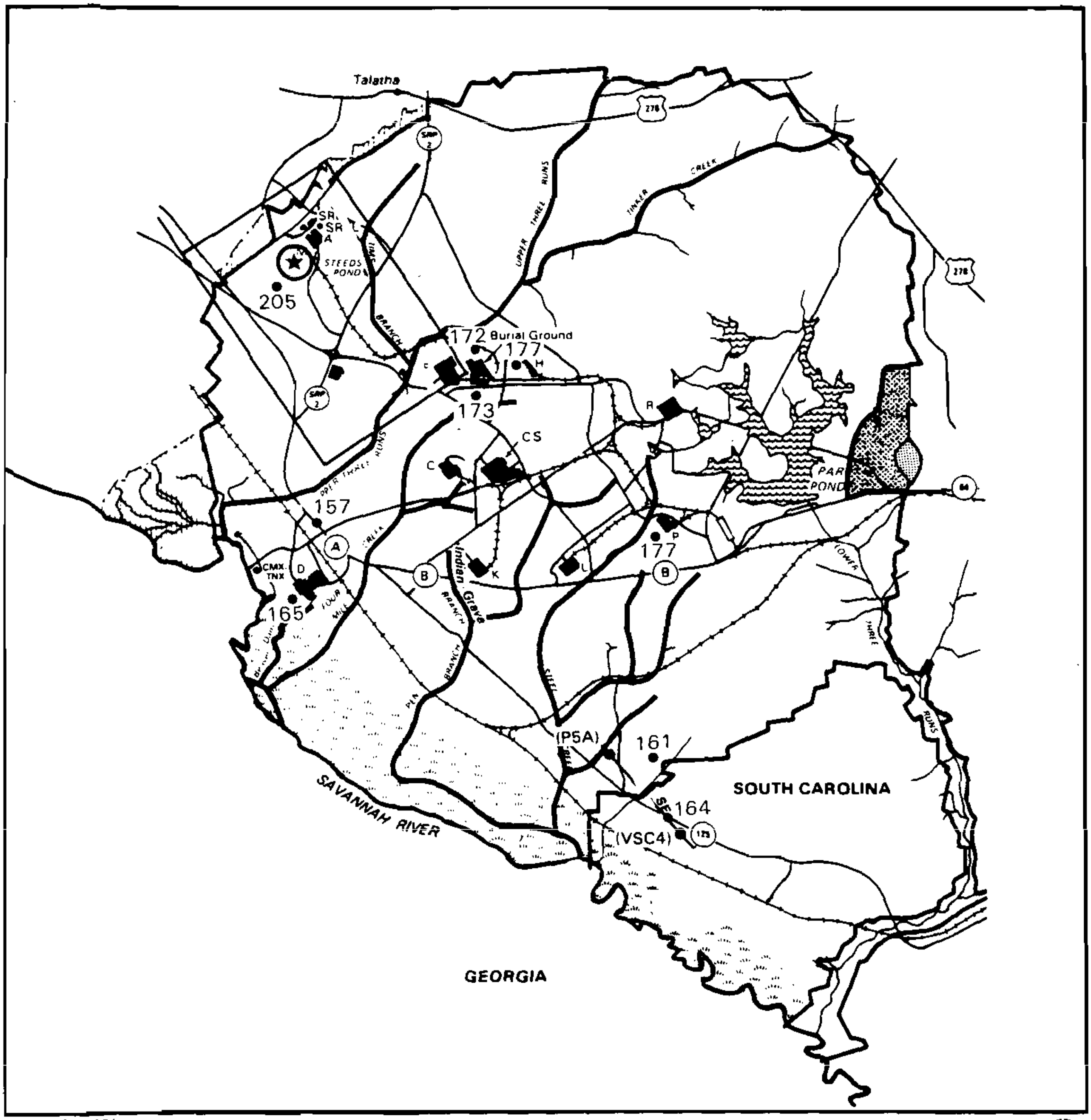
Scale (kilometers): 0 5 10 15

(hatched pattern) Area where the Congaree head exceeds the Cretaceous Sediments aquifer head.

—10— Contour showing locations where the head in the Cretaceous Sediments aquifer is 10 feet (1.0 foot = 0.3048 meter) above the head in the Congaree.

TE

Figure A-22. Generalized Map of the Head Difference Between the Cretaceous Sediments Aquifer and Congaree Formations at the Savannah River Plant (1982)



Source: DOE, 1984.

Legend:

C,K,R,L,P Reactor Areas
F,H Separations Areas
M Fuel and Target Fabrication
D Steam and Power Plant, Heavy Water Production
A Savannah River Laboratory and Administration Area
U Heavy Water Control Test Facility

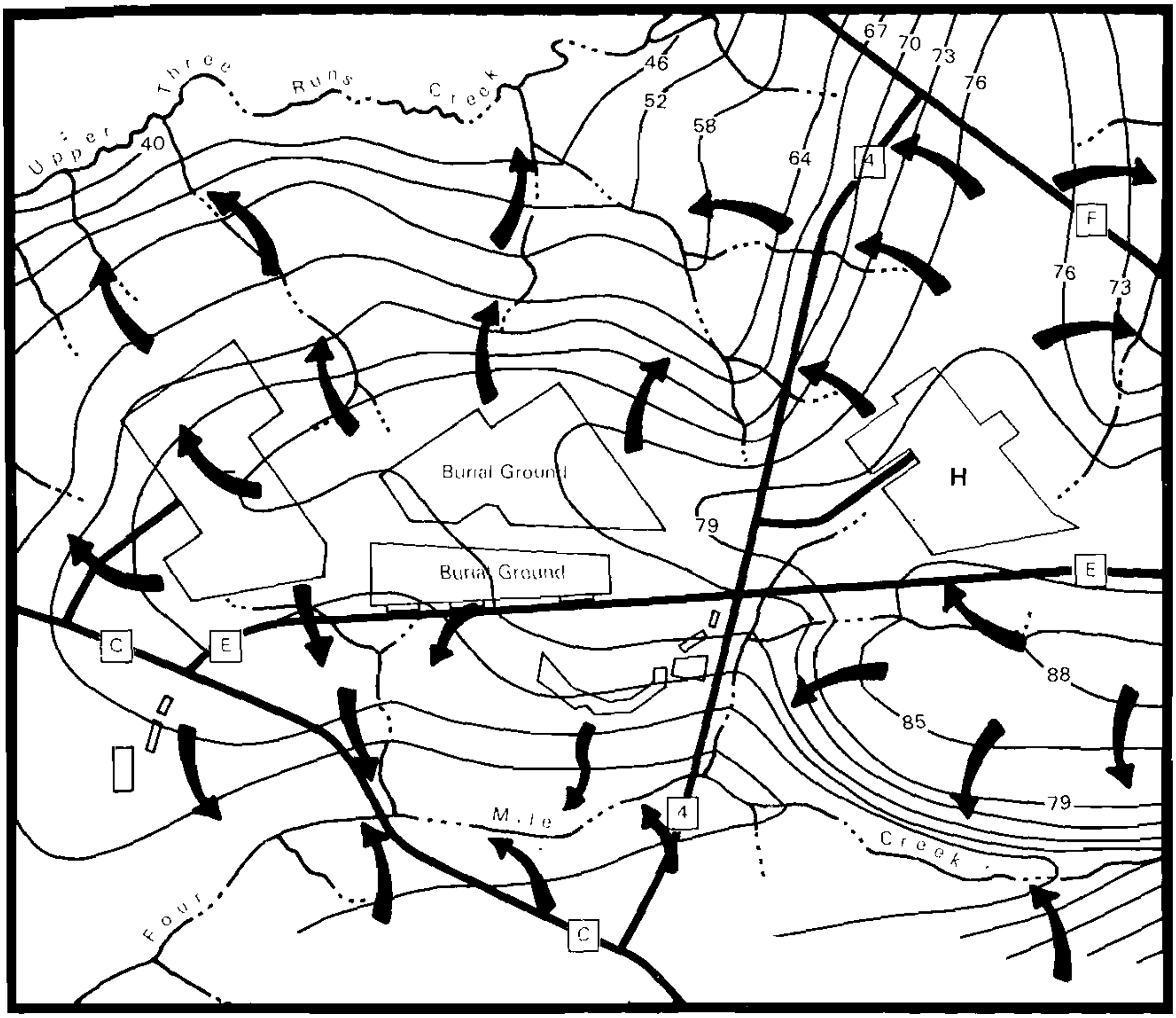
Cluster of wells shown in Figure A-21.

Location of profile shown in Figure A-20.

Scale (kilometers)
0 5 10 15

Figure A-23. Location of the Cluster of Wells Shown in Figures 3-9, A-20, and A-21

TE



Source: Du Pont, 1983.

Direction of groundwater flow

Note: Numbers indicate meters above mean sea level.
Contour interval = meters.
1.0 foot = 0.3048 meter

Scale (meters)
0 500 1000

Figure A-24. Average Elevation of the Water-Table in the Separations Areas at the Savannah River Plant During 1968

Source: Reichart, 1967.

Direction of groundwater flow

Note: 1.0 foot = 0.3048 meter

C Reactor Area

Scale (meters)

0 300 600

Figure A-25. Water-Table Elevation (in feet above mean sea level) at C-Area During the Period 1961-1967

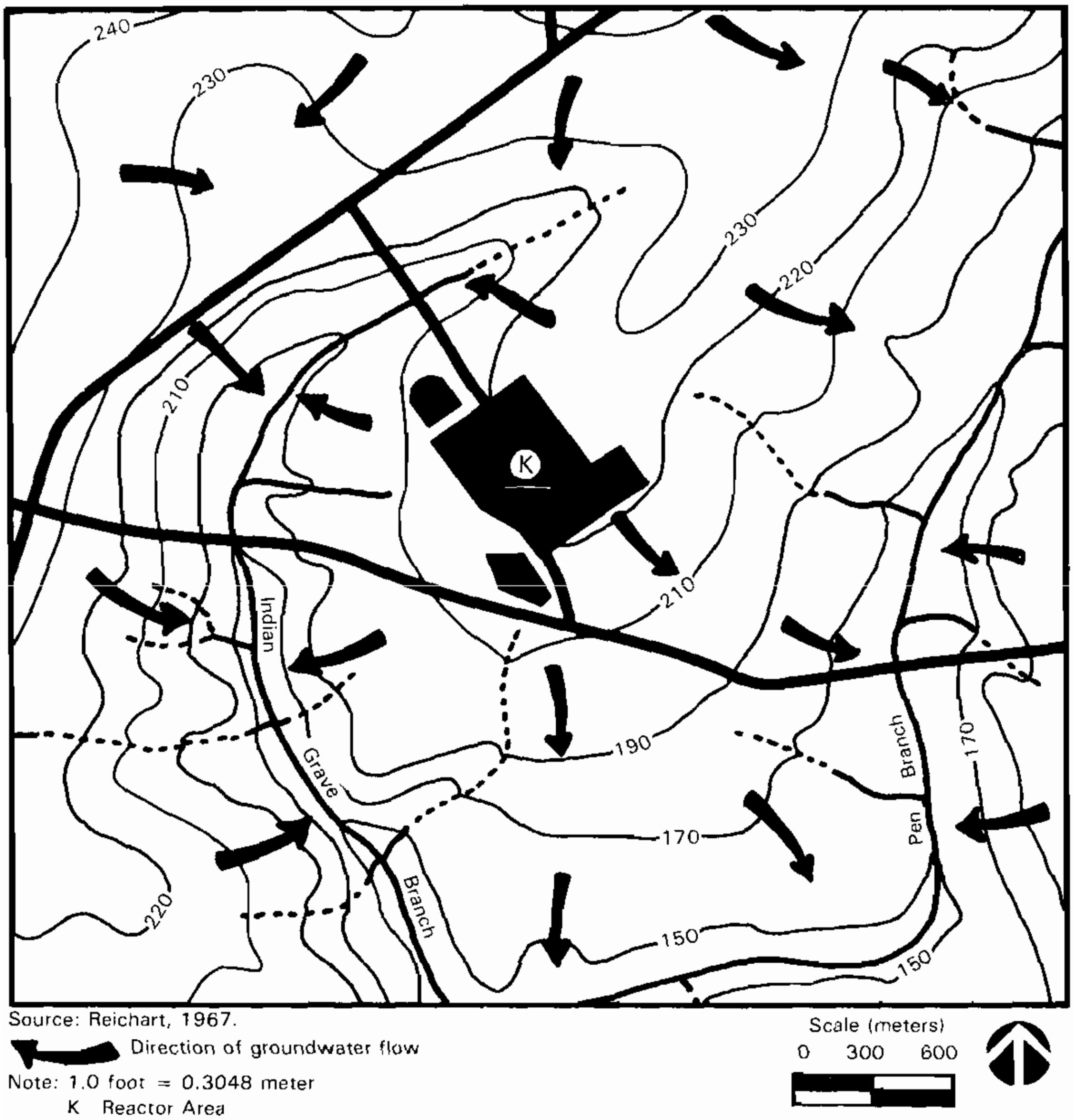


Figure A-26. Water-Table Elevation (in feet above mean sea level) at K-Area During the Period 1961-1967

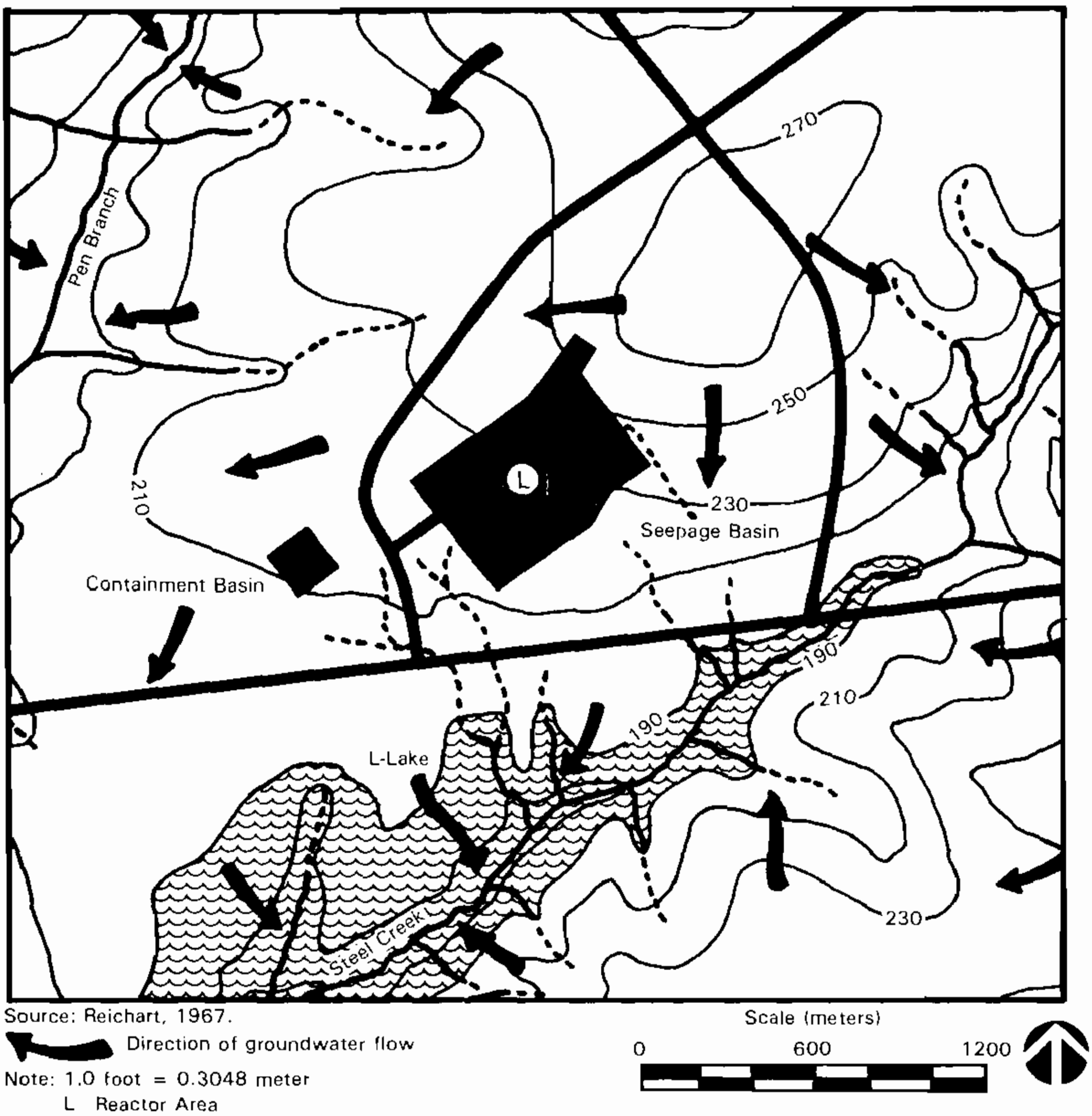


Figure A-27. Water-Table Elevation (in feet above mean sea level) at L-Area During the Period 1961-1967

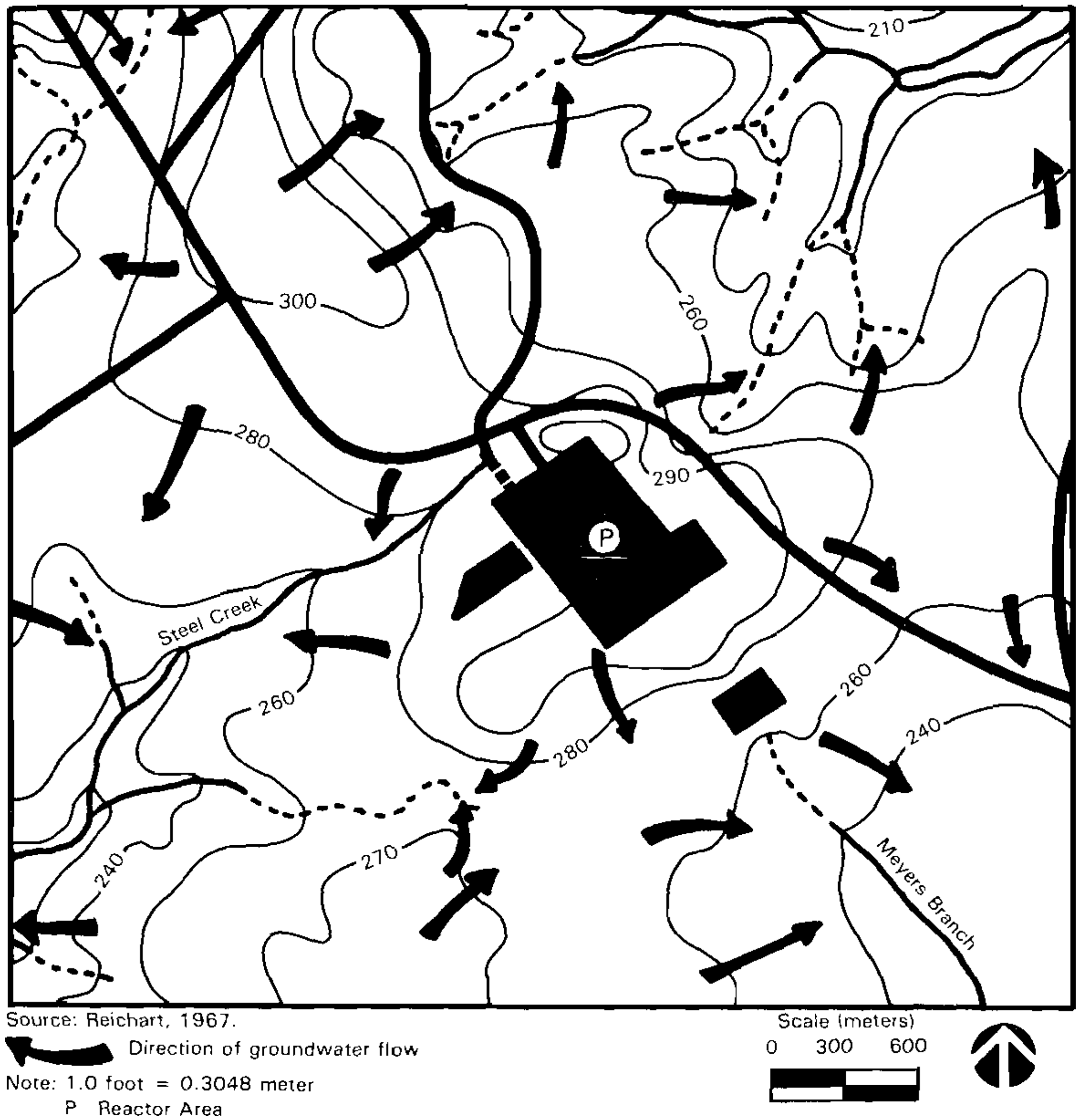


Figure A-28. Water-Table Elevation (in feet above mean sea level) at P-Area During the Period 1961-1967

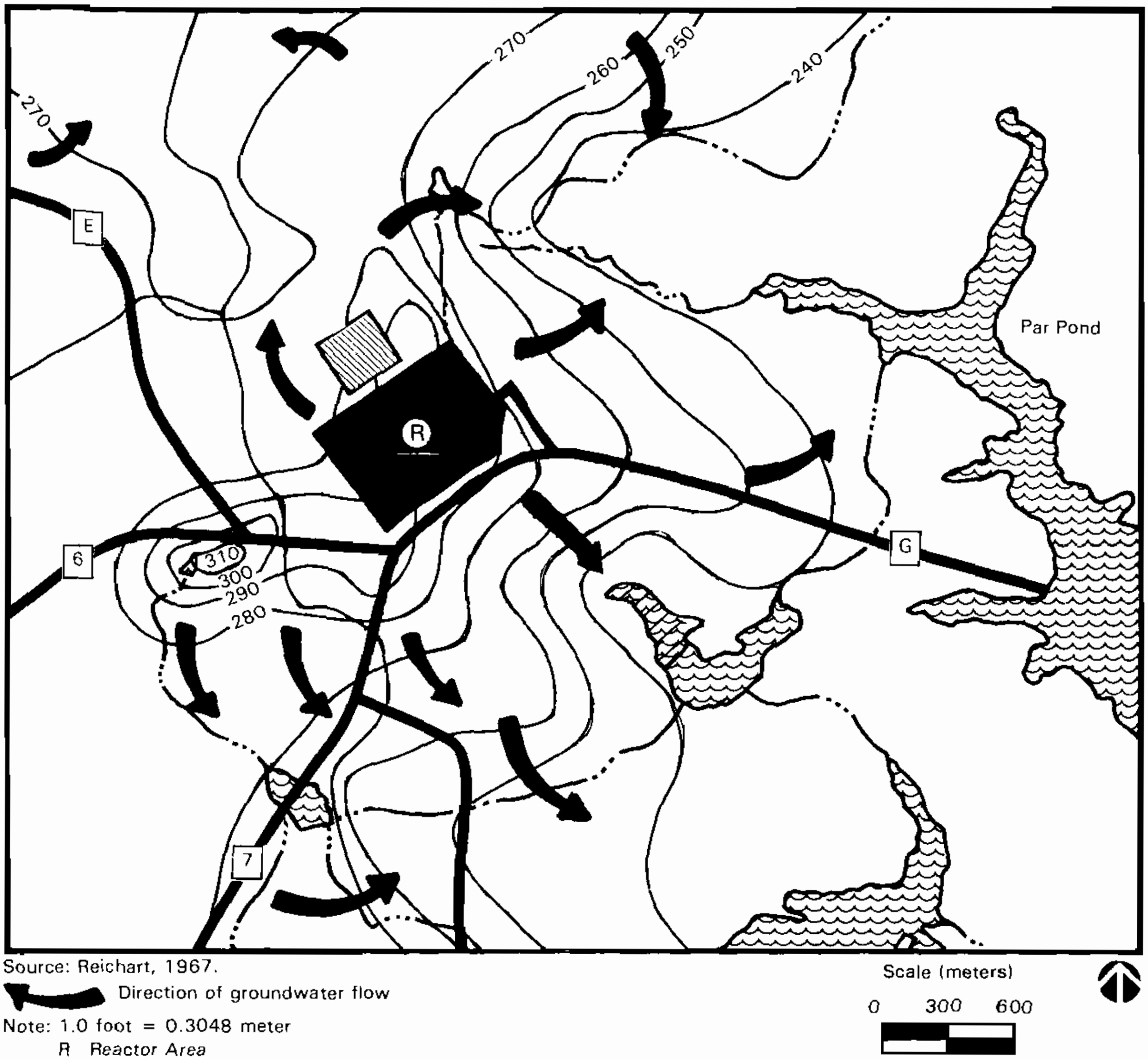
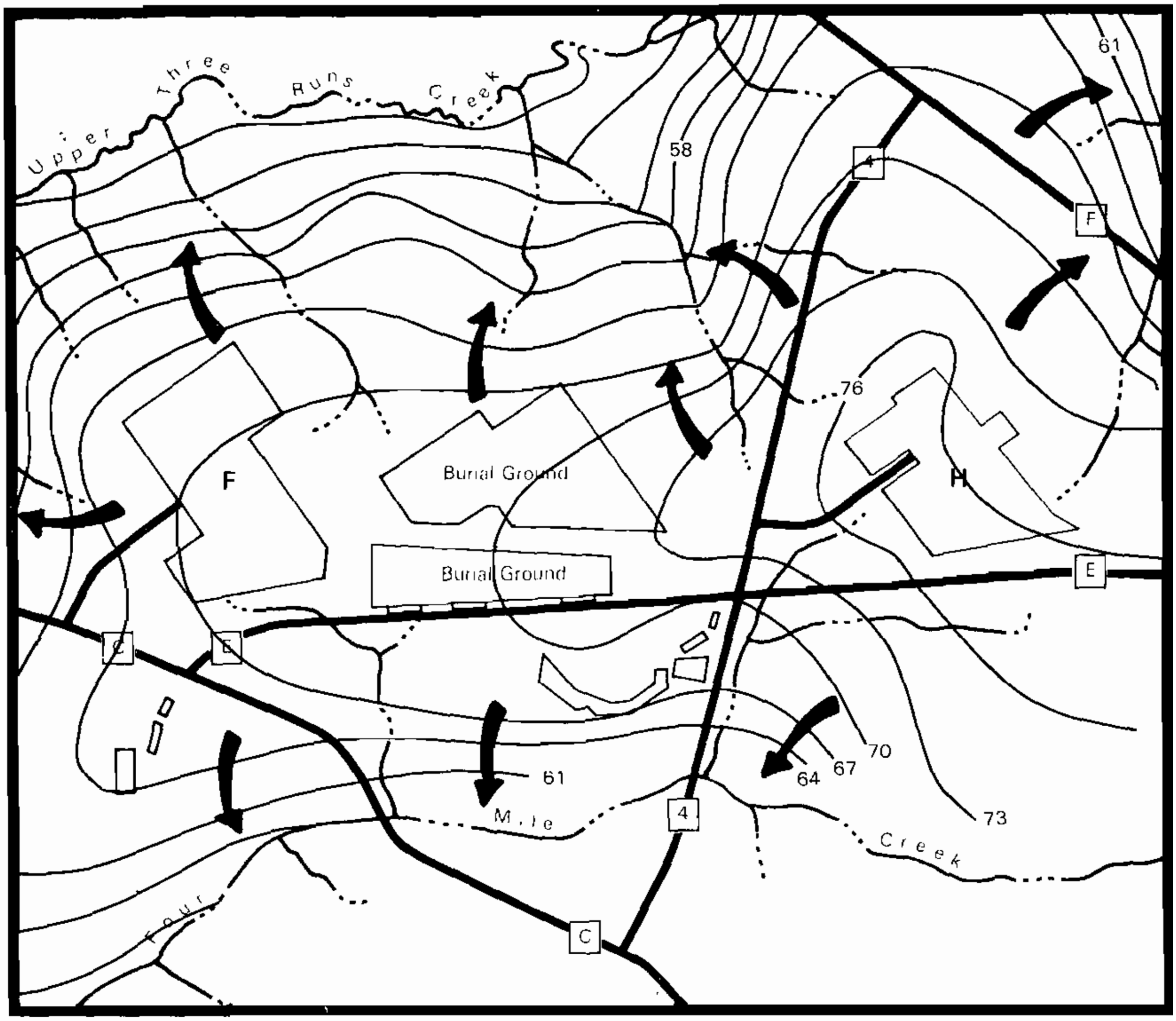


Figure A-29. Water-Table Elevation (in feet above mean sea level) at R-Area During the Period 1961-1967



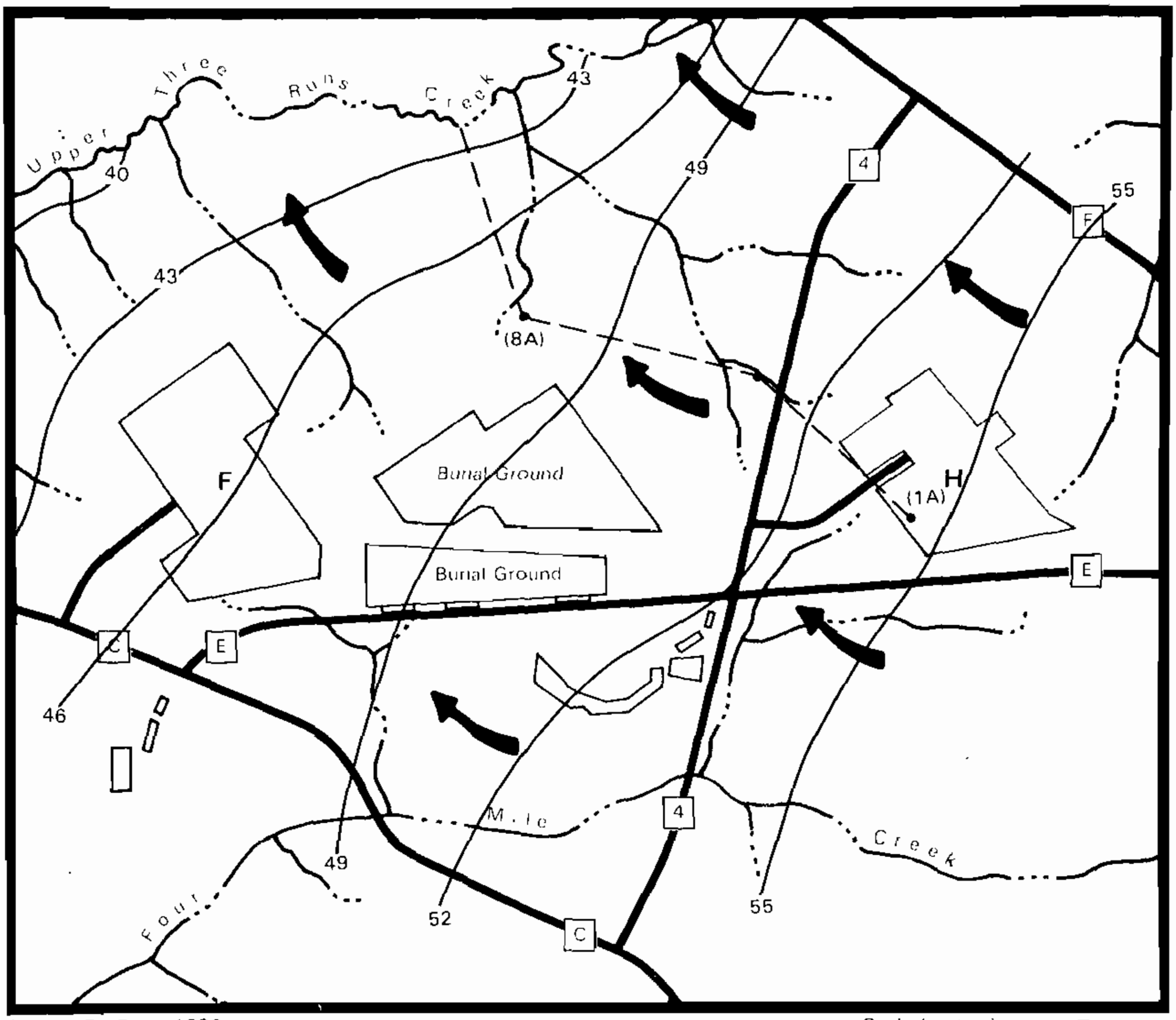
Source: Du Pont, 1983; formation terminology after Siple, 1967; see Figure A-2.

Direction of groundwater flow

Note: Numbers indicate meters above mean sea level.
Contour interval = 3 meters
1.0 foot = 0.3048 meter

Scale (meters)
0 300 600

Figure A-30. Potentiometric Surface of the Upper Part of the McBean Formation in the Separations Areas at the Savannah River Plant (August 29, 1977)



Source: Du Pont, 1983.

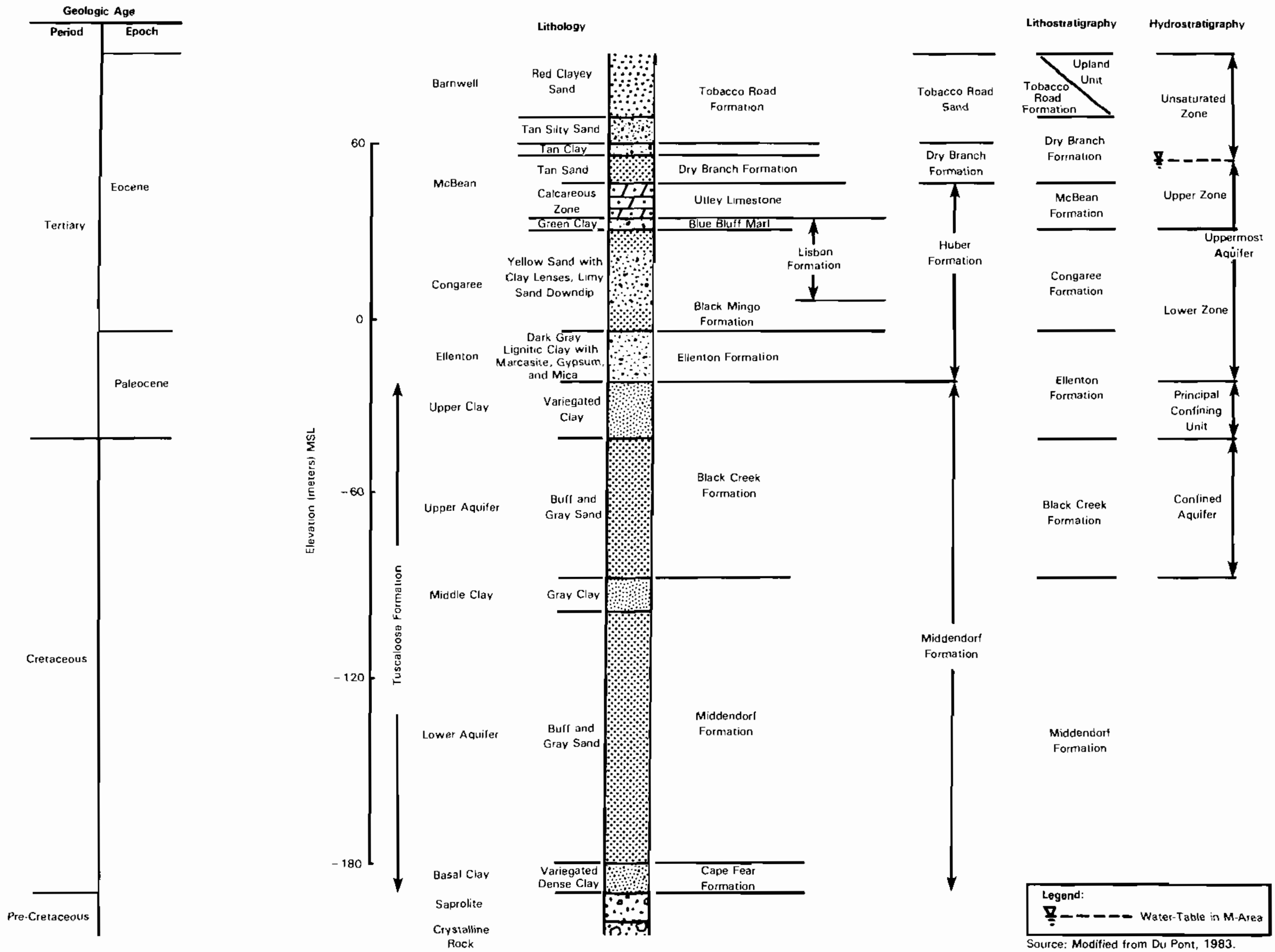
Direction of groundwater flow

Scale (meters)
0 300 600

Note: Numbers indicate meters above mean sea level.
Contour interval = 3 meters
1.0 foot = 0.3048 meter

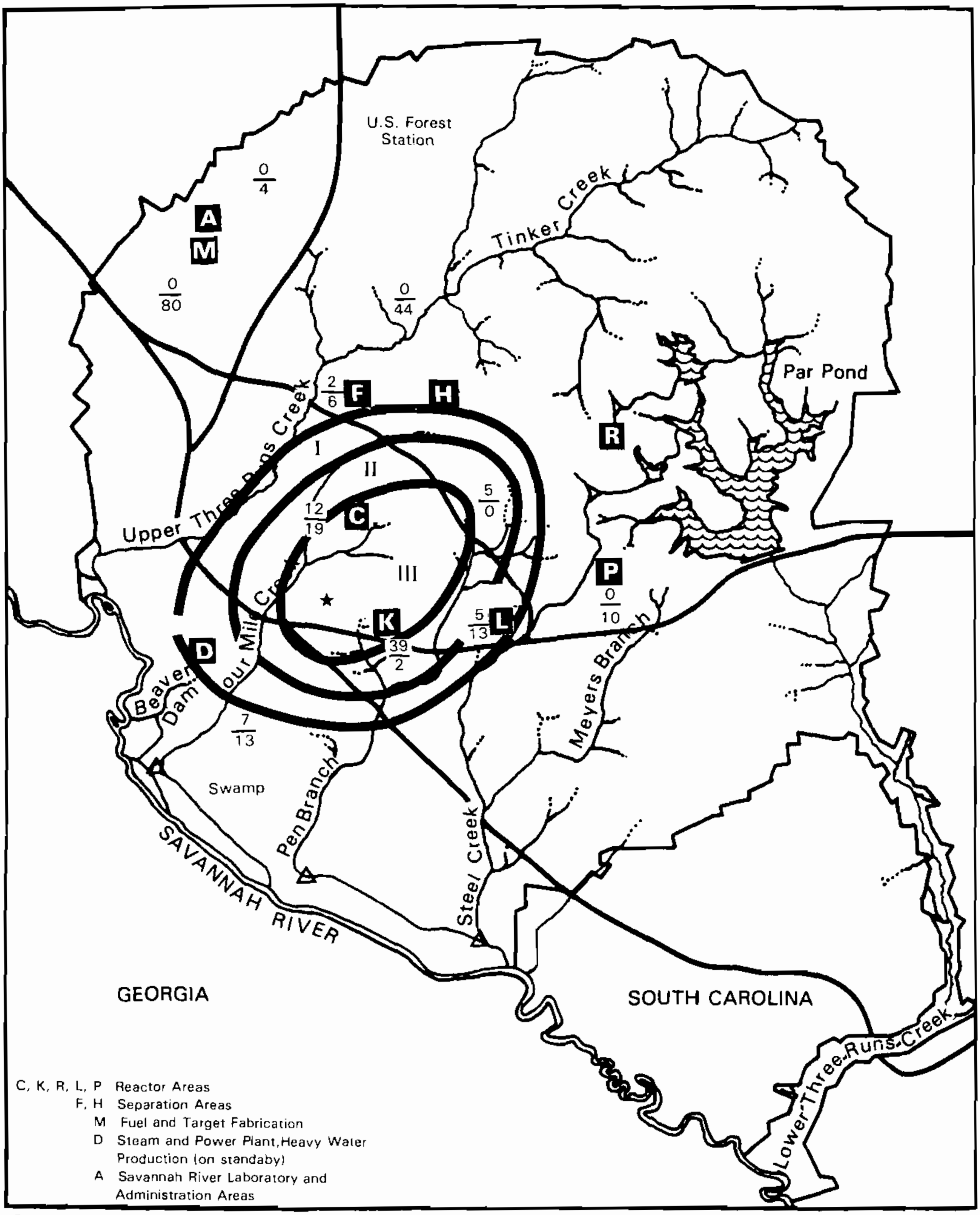
(8A) (1A) Profile of geohydrologic section shown in Figure A-18.

Figure A-31. Potentiometric Map of the Upper Part of the Congaree Formation in the Separations Areas at the Savannah River Plant (August 29, 1977)



TC

Figure A-2. Tentative Correlation of Stratigraphic Terminology of Southwestern South Carolina Coastal Plain



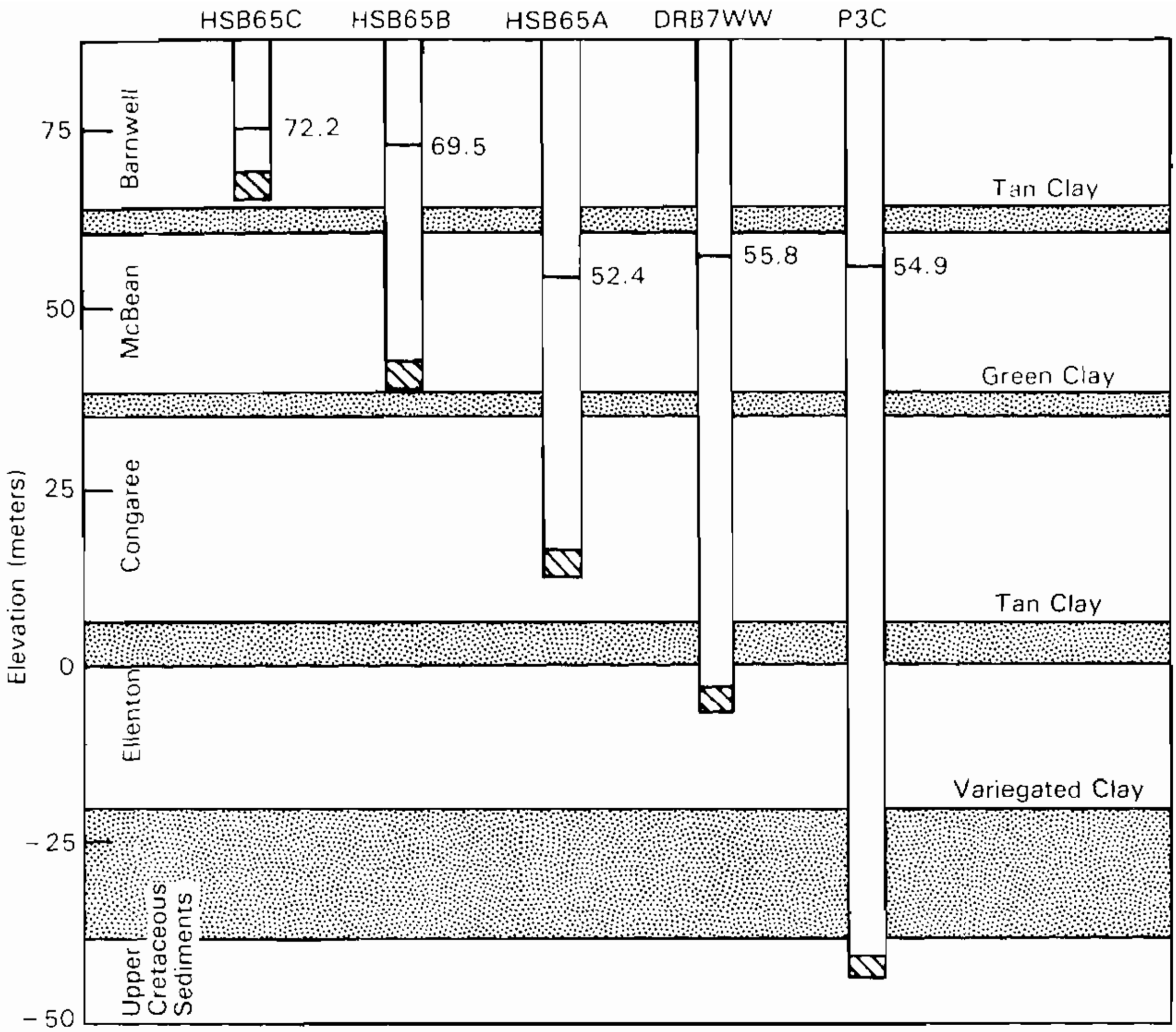
TC Source: Stephenson, Talwani, and Rawlins, 1985

★ Instrumental Epicenter

12 Number of Felt / 17 Number of Not Felt — By Area Reporting

Scale (kilometers) 0 4 8

Figure A-3. Isoseismal Map Showing Reported Intensities for the June 1985 Earthquake at the Savannah River Plant



Source: Du Pont, 1985a. Hydrostratigraphic unit terminology after Siple, 1967; see Figure A-2.

Legend:

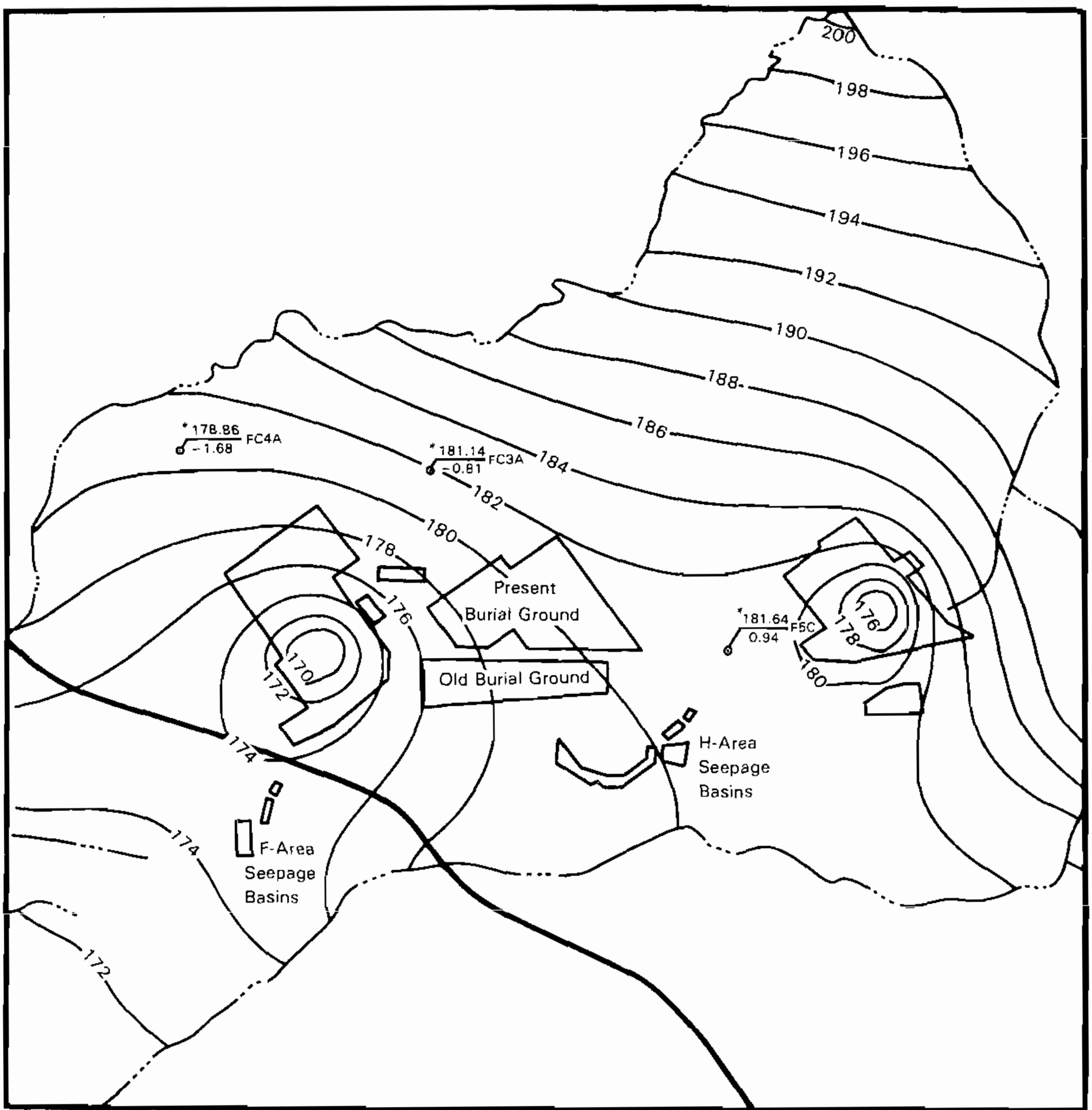
Clay layer

Screen zone

Note: Water levels in HSB65A, B, and C measured 3/8/85
Water levels in DRB7WW and P3C measured 3/18/85

Figure A-4. Vertical Head Relationship Near the H-Area Seepage Basins

TC



TC | Source: Killian *et al.*, 1987.

TE | Note: 1.0 foot = 0.3048 meter

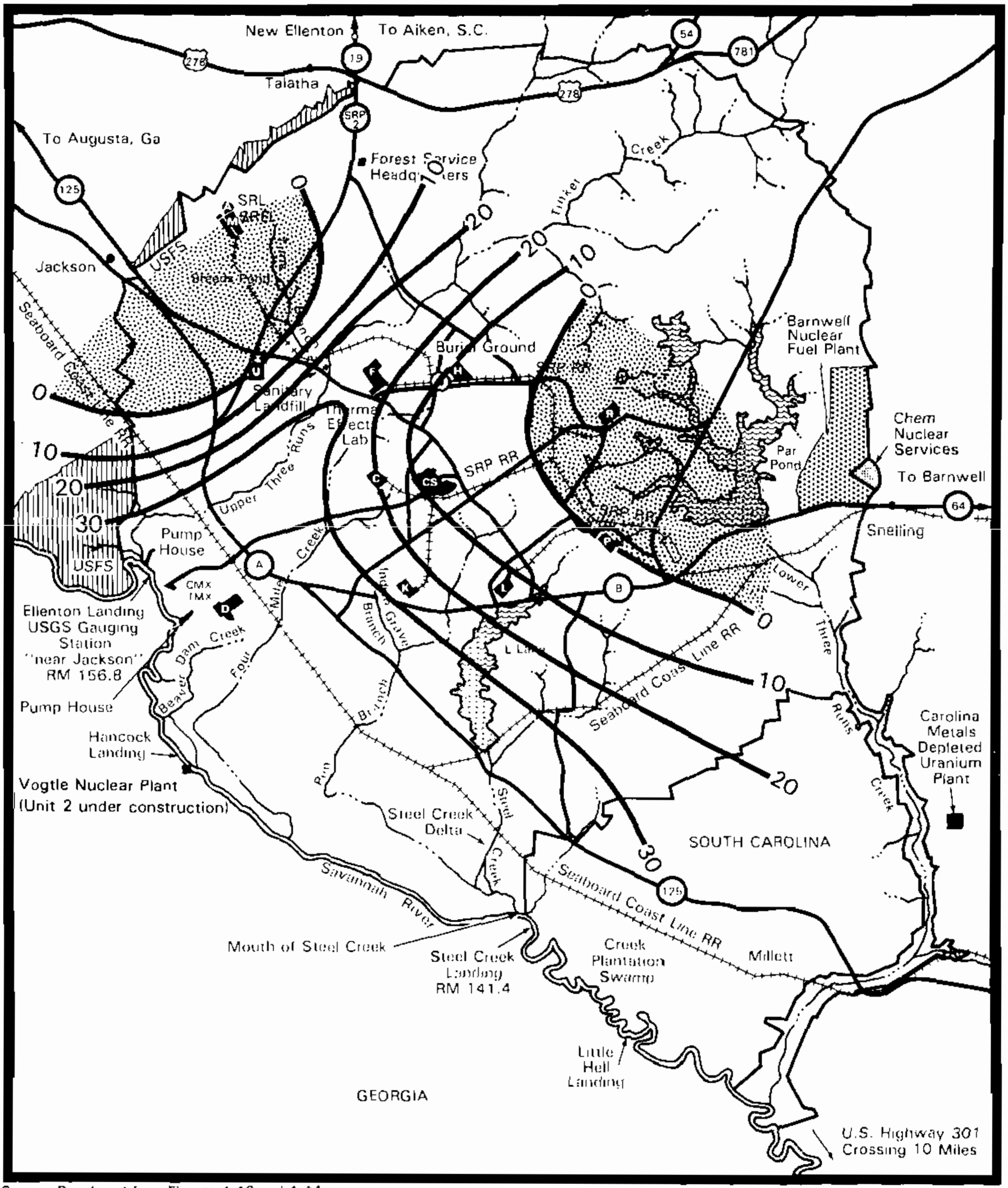
Scale (meters)
0 500 1000

Legend:
Steady-State Hydraulic Head Isopleth, ft msl 240

Well Location..... observed hydraulic head / residual* well designation

*Residual = observed hydraulic head - calculated hydraulic head

Figure A-5. Calculated Potentiometric Surface for the Cretaceous Sediments Aquifer in the F- and H-Areas



Source: Developed from Figures A-10 and A-11

Scale (kilometers)

0 2 4 6 8

Legend:

C,K,R,L,P	Reactor Areas
F,H	Separations Areas
M	Fuel and Target Fabrication
D	Steam and Power Plant, Heavy Water Production
A	Savannah River Laboratory and Administration Area
CS	Central Shops
RM	River Mile
U	Heavy Water Control Test Facility

Road A = Highway 125

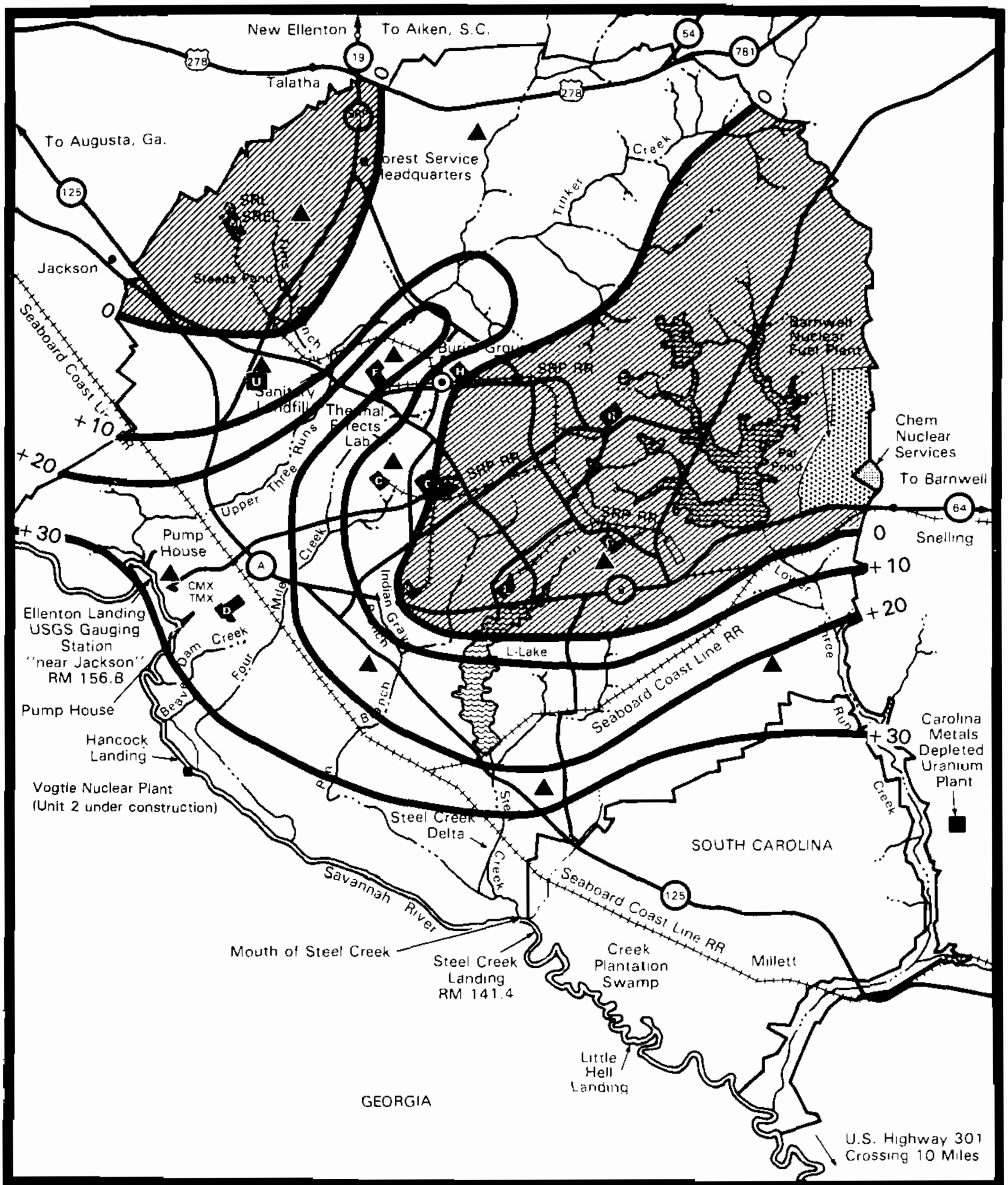
Contours indicate areas where head in Upper Cretaceous sediments is greater than head in Congaree. Contour interval equals 10 feet (1.0 foot = 0.3048 meter).

Area where head in the Upper Cretaceous sediments aquifer *is less than head in the Congaree Formation.*

TC

Figure A-6. Head Difference Between Upper Cretaceous Sediments Aquifer and Congaree Formation at Savannah River Plant (1982)

TC



Source: Adapted from Du Pont, 1983b.

Scale (kilometers) 0 2 4 6 8

Legend:

C,K,R,L,P Reactor Areas
F,H Separations Areas
M Fuel and Target Fabrication
D Steam and Power Plant, Heavy Water Production
A Savannah River Laboratory and Administration Area
CS Central Shops
RM River Mile
U Heavy Water Control Test Facility

Road A = Highway 125

Contours indicate areas where head in Upper Cretaceous sediments is greater than head in Congaree. Contour interval equals 10 feet (1.0 foot = 0.3048 meter).

▨ Area of Downward Gradient

▲ Observation Well Cluster

Figure A-7. Head Difference Between Upper Cretaceous Sediments Aquifer and Congaree Formation at Savannah River Plant (1987)

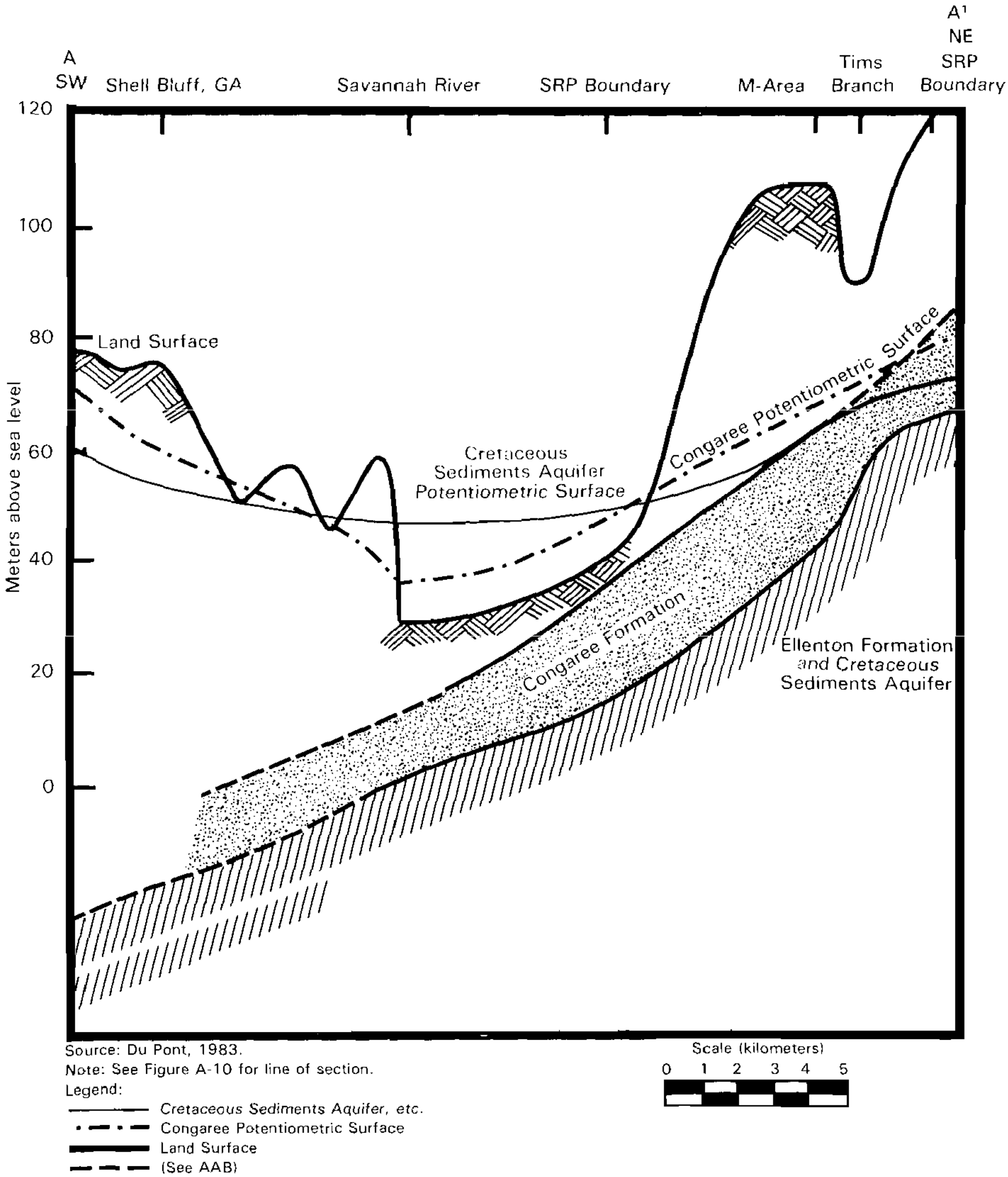
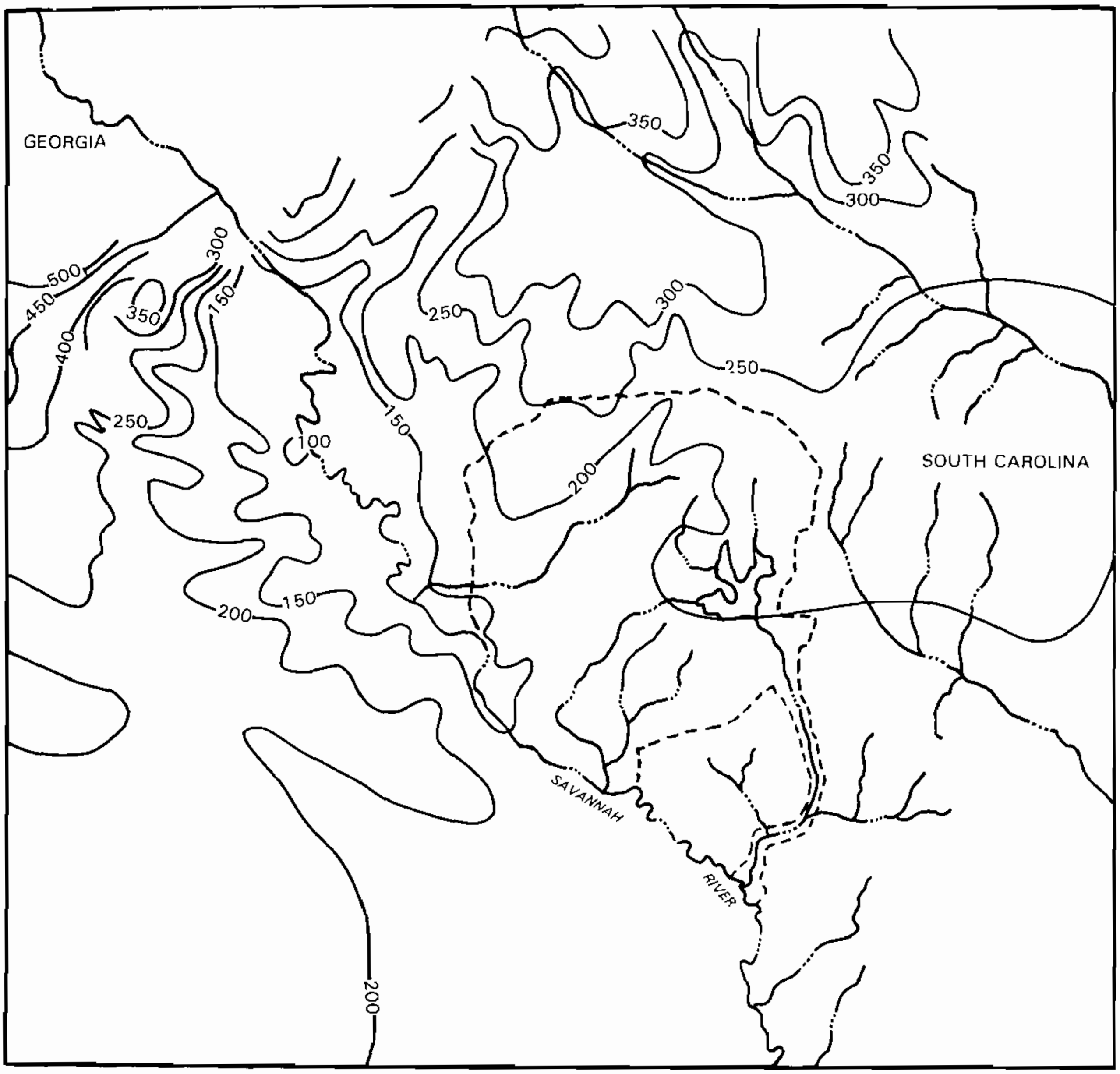


Figure A-8. Hydrologic Section Perpendicular to Savannah River Through M-Area



Source: Faye and Prowell, 1982.

Legend:

—100— Potentiometric surface Contours and water elevations in feet above mean sea level; 1.0 foot = 0.3048 meter.

- - - - - SRP boundary

Streams

Scale (kilometers) 0 5 10 15 20

TC

Figure A-9. Potentiometric Surface of the Cretaceous Sediments Aquifer

Table A-10. F-Area Seepage Basin Contaminant Potential[a]

Parameter	Contamination potential	Known releases from process	Concentration in process streams[b]	Number of wells failing student's t-test
pH	Probable	2-2.7	2.8-11	3
Total dissolved solids	Probable	--	--	2
Cadmium	Improbable	None known	Not detectable	2
Copper	Possible	Infrequent	<0.001-0.3 ppm	2
Manganese	Possible	Infrequent	0.0004-2 ppm	2
Sodium	Probable	Frequent[c]	0.004-30 ppm	2
Nickel	Possible	None known	<0.0007-0.3 ppm	1
Zinc	Possible	Frequent	<0.001-2 ppm	1
Fluoride	Possible	Frequent	--	1
Nitrate	Probable	Frequent[c]	43-93,000 ppm	2
Gross alpha	Probable	Frequent	<1-2,250 d/mL	2
Gross beta	Probable	Frequent	--	2
Radium	Probable	Frequent	--	2
Foaming agents	Possible	Past[d]	--	1
Phenol	Improbable	None known	--	1

[a]Adapted from Du Pont, 1985a.
[b]Key: ppm, parts per million; d/mL, disintegrations per milliliter.
[c]In excess of 454 kilograms per year.
[d]Laundry facilities discharged to basin prior to 1982.

Table A-11. H-Area Seepage Basin Contaminant Potential[a]

Parameter	Contamination potential	Known releases from process	Concentration in process streams[b]	Number of wells failing student's t-test
pH	Probable	3.0-8.4	2.8-11	3
Conductivity	Probable	--	--	2
Total dissolved solids	Probable	--	--	2
Chloride	Possible	Frequent[c]	--	1
Iron	Possible	Frequent[c]	<0.01-1.8 ppm	1
Mercury	Probable	Infrequent	5-6 ppm	1
Manganese	Possible	Infrequent	<0.01-38 ppm	1
Sodium	Probable	Frequent[c]	<0.1-3,260 ppm	3
Nitrate	Probable	Frequent[c]	0.1-18,000 ppm	2
Gross alpha	Probable	Frequent	<5 d/ml	1
Gross beta	Probable	Frequent	--	1
Radium	Probable	Frequent	--	2

[a]Adapted from Du Pont, 1985a.
[b]Key: ppm, parts per million; d/mL, disintegrations per milliliter.
[c]In excess of 454 kilograms per year.

Table A-13. M-Area Settling Basin Contaminant Potential[a]

Parameter	Contamination potential	Known releases from process	Concentration in basin influent: Maximum	Concentration in basin influent: Average	Number of wells failing student's t-test
Total dissolved solids	Possible	--	--	--	1
Chloride	Possible	Frequent	--	--	1
Dissolved organic carbon	Probable	Frequent	--	--	1
Cadmium	Improbable	None known	0.008 ppm	0.005 ppm	1
Copper[b]	Improbable	None known	0.04 ppm	0.04 ppm	1
Manganese	Improbable	None known	<0.005 ppm	<0.005 ppm	3
Nickel[b]	Possible	Frequent	1.55 ppm	0.68 ppm	3
Nitrate	Probable	Frequent[c]	1190 ppm	151 ppm	1
Gross alpha	Possible	Frequent	--	--	2
Radium	Possible	Frequent	--	--	3
Gas-chromatograph scan	Probable	Infrequent	--	--	2
Phenol	Improbable	None known	--	--	1

[a]Adapted from Du Pont, 1985a.
[b]In 1982, core samples 4.6 meters deep were taken from basin. Analyses of cores indicated that concentrations of this metal reached background levels at depth of 1.2 meters.
[c]In excess of 454 kilograms per year.

Table A-16. Groundwater Pumpage for Municipal Supplies[a]

Map location[b]	User	Distance from center of SRP (km)	Population served	Average daily use (m^3/day)	Water-bearing formation	Type of source	Basis of estimate[c]
1	City of Aiken	34	28,000	9,520	Cretaceous sediments	Wells, springs	4
2	Town of Jackson	16	3,152	1,070	Cretaceous sediments	2 wells	4
3	Town of New Ellenton	13	4,000	1,360	Cretaceous sediments	2 wells	4,2
4	Town of Langley	31	1,330	490	Cretaceous sediments	2 wells	3
5	College Acres	21	1,264	430	Cretaceous sediments	3 wells	4,2
6	Bath Water District	31	1,239	1,230	Cretaceous sediments	2 wells	3
7	Beech Island	27	4,500	1,910	Cretaceous sediments	3 wells	2,4
8	Talatha	11	1,200	480	Cretaceous sediments	2 wells	4,2
9	Breezy Hill W&S	39	4,500	1,530	Cretaceous sediments	2 wells	4
10	Burnettown	31	1,200	570	Cretaceous sediments	2 wells	3
11	Montmorenci/Couchton WD	23	4,232	1,600	Cretaceous sediments	3 wells	3,5
12	Warrenville	31	788	1,135	Cretaceous sediments	4 wells	3
13	Johnston	31	1,560	545			
	Howlandville	31	1,232	420	Cretaceous sediments	1 well	4
	Gloverville	31	1,440	545			
14	Belvedere	39	6,300	2,140	Cretaceous sediments	5 wells	4
15	Barnwell	26	6,500	15,140	Congaree	11 wells[d]	3
16	Williston	19	3,800	2,650	McBean-Cretaceous sediments	4 wells	
17	Blackville	32	2,975	1,135	Cretaceous sediments	3 wells	3,4
18	Hilda	35	315	110	Cretaceous sediments	1 well	4,2
19	Elko	23	315	545	McBean	1 well	1
37	Allendale	40	4,400	8,050	Cretaceous sediments	5 wells	1
			Total municipal use:	52,605 m^3/day			

[a]Adapted from DOE, 1984.
[b]See Figures A-14 and A-15.
[c]Key: 1 = RPI, 1985 (reported use); 2 = RPI, 1985 (well test yield); 3 = DOE, 1984, Appendix F; 4 = per capita use of 0.34 cubic meter per day (Clark, Viessman, and Hammer, 1977); 5 = interview.
[d]Portions of this amount supply local industry.

Table A-17. Groundwater Pumpage for Industrial and Agricultural Supplies

Map location[a]	User	Distance from center of SRP (km)	Population served	Average daily use (m^3/day)	Water-bearing formation	Type of source	Basis of estimate[b]
			SAVANNAH RIVER PLANT				
20	A/M-Areas	10	2,131	7,155	Cretaceous sediments	4 wells	6
21	F-Area	3	800	10,510	Cretaceous sediments	6 wells	6
22	H-Area	0	825	11,880	Cretaceous sediments	5 wells	6
23	U-Area	6	110	330	Cretaceous sediments	3 wells	6
24	Central Shops (CS)	11	600	1,095	Cretaceous sediments	3 wells	6
25	CMX-TNX	13	50	1,355	Cretaceous sediments	3 wells	6
26	Class. Yd.	10	35	30	(c)	1 well	6
38	DWPF[d]	1	530	1,080	Cretaceous sediments	2 wells	3
39	FMF[e]	1	280	290	Cretaceous sediments	(c)	3
41	C-Area	5	(b)	1,470	Cretaceous sediments	2 wells	6
42	K-Area	9	(b)	1,470	Cretaceous sediments	3 wells	6
43	P-Area	9	(b)	1,900	Cretaceous sediments	4 wells	6
44	L-Area	9	(b)	1,355	Cretaceous sediments	2 wells	6
			AIKEN COUNTY, SOUTH CAROLINA				
27	U.S. Forest Service	11	70	20	Cretaceous sediments	1 well	3
28	Graniteville Company	32	2,156	525	Cretaceous sediments	1 well	3
29	J. M. Huber Company	29	(c)	8,440	Cretaceous sediments	1 well	3
30	Augusta Sand & Gravel	35	(c)	3,595	Cretaceous sediments	1 well	3
31	Cyprus Mines Corp.	32	(c)	1,420	Cretaceous sediments	1 well	3
32	Florida Steel Corp.	32	(c)	75	Cretaceous sediments	1 well	3
33	Valchem	29	(c)	410	Cretaceous sediments	1 well	3

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Table A-17. Groundwater Pumpage for Industrial and Agricultural Supplies (continued)

Map location[a]	User	Distance from center of SRP (km)	Population served	Average daily use (m^3/day)	Water-bearing formation	Type of source	Basis of estimate[b]
36	Houndslake Country Club	33	(c)	3,380	Cretaceous sediments	2 wells	2
45	S.C. Generating Company	32	(c)	650	Cretaceous sediments	2 wells	2
		ALLENDALE COUNTY, SOUTH CAROLINA					
34	Sandoz Co.	29	(c)	4,165	Cretaceous sediments	1 well	1
46	B. Terry, Sr.	27	(c)	400	Tertiary	1 well	1
47	J. P. Stevens Company	30	(c)	95	Cretaceous sediments	1 well	1
48	Ellis Country Store	30	(c)	160	Cretaceous sediments	1 well	1
49	Duncan Farms	20	(c)	980	Cretaceous sediments	1 well	1
50	J. Furse	23	(c)	355	Cretaceous sediments	1 well	1
51	W. Smith	23	(c)	135	Tertiary	1 well	1
52	B. Oswald	40	(c)	8,175	Cretaceous sediments	1 well	1
		BARNWELL COUNTY, SOUTH CAROLINA					
35	E. T. Barwick, Inc.	26	400	945	Cretaceous sediments	2 wells	3
53	Burlington, Inc.	25	(c)	2,725	Tertiary	2 wells	1
54	Mathis Farms	28	(c)	410	Tertiary	1 well	1
55	Edisto Exp. Sta.	28	(c)	435	Congaree	1 well	1,3
56	Green Blade Turf Grass, Inc.	33	(c)	1,895	Tertiary	1 well	1

Total industrial and agricultural use: 77,940 m^3/day

[a]See Figures A-14 and A-15; adapted from DOE, 1984.
[b]Key: 1 = RPI, 1985 (reported use); 2 = RPI, 1985 (well test yield); 3 = DOE, 1984 Appendix F; 4 = per capita use of 0.34 m^3/day (Clark, Viessman, and Hammer, 1977); 5 = interview; 6 = Quarterly Water Use Reports submitted by DOE to South Carolina Water Resources Commission.
[c]Data not available.
[d]DWPF is under construction. Exact number of water wells and pumping requirements are not firmly established. Current plans (December 1983) indicate usage of less than 1080 cubic meters per day supplied by one or two wells, each with capacity of 5450 cubic meters per day (DOE, 1984).
[e]FMF is under construction. Pumping requirements are not firmly established (DOE, 1984).

Table A-18. Average Continuous Groundwater Pumping Rates by Area at Savannah River Plant, 1968 to 1985 (m^3/min)

Area	Wells	1968-1974 (average)	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985[a]
A/M	4	5.0	4.3	4.2	4.4	4.0	4.1	4.4	5.1	5.03	6.81	6.06	4.97
F	6	6.2	3.9	4.5	4.6	4.5	5.0	5.2	5.3	5.87	6.06	8.33	7.30
H	5	5.9	5.8	6.5	6.3	6.7	6.8	6.9	7.4	7.19	7.19	8.33	8.25
CS	3	0.26	0.36	0.44	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.66	0.76
D	(b)	0.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
U	3	0.47	0.38	0.28	0.28	0.28	0.28	0.28	0.28	0.34[c]	0.34[c]	0.19[c]	9.19[c]
C	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28	1.13	1.13	1.13	1.02
K	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28	1.13	1.13	0.95	1.02
L	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28	0.28	0.94	0.95	0.94
P	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28	1.13	1.32	1.32	1.32
CMX-TNX	3	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.61	1.13	1.04	0.94
Total		18.5	14.9	16.1	16.3	16.2	16.9	17.5	20.4	23.8	27.0	29.0	26.8

[a]Projected from January-June groundwater use data.
[b]Wells are no longer in use.
[c]Includes temporary construction area.

Table A-19. Groundwater Recharge and Discharge Zones at Savannah River Plant

Formation	Recharge	Discharge	Confining layers
Barnwell (and Upland Unit)	Winter rainfall 31.2 cm/yr; total recharge about 38 cm/yr.	Onsite streams. Recharge through tan clay to McBean.	Tan clay at base; generally absent in M-Area.
McBean	From Barnwell (through tan clay in central SRP); offsite areas.	Upper Three Runs Creek and Four Mile Creek. Almost no recharge through "green clay" to Congaree in central SRP; appreciable recharge in A- and M-Areas.	Tan clay at top; absent in A- and M-Areas. Green clay at base; discontinuous in A- and M-Areas.
Congaree	Principally in offsite areas; appreciable recharge from McBean in A- and M-Areas.	Savannah River and wetlands along Upper Three Runs Creek. Little recharge downward through basal clay and upper Ellenton clay to Ellenton sands, or upward through green clay.	Green clay at top; discontinuous in A- and M-Areas. Pisolitic clay at base. Top of Ellenton.
Ellenton	From underlying Cretaceous sediments and offsite areas; some recharge from Congaree.	Upper clay layer of Cretaceous sediments may be discontinuous or contain sandy zones that permit communication.	Lower pisolitic clay of Congaree. Upper clay layer of Ellenton. Upper clay layer of Cretaceous sediments; usually not effective confining layer.
Cretaceous sediments	Principally from offsite areas; outcrop area 15-50 km wide in South Carolina near fall line and in major stream valleys.	Upper Cretaceous sediments aquifer to lower unit of Ellenton. Groundwater beneath SRP flows to sink along Savannah River.	Upper clay layer of Ellenton. Upper clay layer of Cretaceous sediments; usually not effective confining layer. Middle clay layer. Basal clay layer.

Table A-2. Site Intensities for Significant Earthquakes[a]

Earthquake							
Date[b]	Location	Latitude	Longitude	Maximum intensity	Distance from site (km)	Reported or estimated site intensity	Estimated site acceleration (g)
Jan. 13, 1811	Burke Co., Ga.	33.2	62.2	V	55	III-IV	0.02
1811-1812 (3 shocks)	New Madrid, Mo.	36.3	89.5	XI-XII	850	V-VI	0.05
Nov. 2, 1875	Lincolnton, Ga.	33.8	82.5	VI	100	III-IV	0.02
Sept. 1, 1886	Charleston, S.C.	32.9	80.0	X	145	VI	0.07
Oct. 22, 1886	Charleston, S.C.	32.9	80.0	VII	155	III-IV	0.02
May 31, 1897	Giles Co., Va.	37.3	80.7	VIII	455	III	0.01
June 12, 1912	Charleston, S.C.	33.0	80.2	VII	135	III-IV	0.02
Jan. 1, 1913	Union Co., S.C.	34.7	81.7	VII-VIII	160	IV	0.02
Aug. 1, 1920	Charleston, S.C.	33.1	80.2	VII	135	III-IV	0.02
Feb. 3, 1972	Bowman, S.C.	33.5	80.4	V	115	IV	0.02
Aug. 2, 1974	Willington, S.C.	33.9	82.5	VI	105	IV	0.02
Nov. 22, 1974	Charleston, S.C.	33.9	80.1	VI	145	III-IV	0.02

[a]Source: DOE, 1982b.
[b]Based on Greenwich Mean Time.

Table A-3. Hydrostratigraphic Units Near Savannah River Plant

Geologic unit	Geologic age	Outcrop	Description	Water yield	Thickness (m)
Alluvium[a]	Recent Epoch	River and creek bottoms	Fine-to-coarse sand, silt, and clay	Very little	0 to 9
Terrace deposits[a]	Pleistocene Epoch	In floodplains and terraces of stream valleys	Tan to gray sand, clay, silt, and gravel on higher terraces	Moderate to none	0 to 9
Upland Unit[a]	Post Eocene	Surface of Aiken Plateau	Gravel and sandy clay	Little or none	0 to 10
Hawthorn Formation[a]	Post Eocene	Large part of ground surface	Tan, red, and purple sandy clay with many "clastic dikes"	Little or none	0 to 10
Barnwell Formation[a]	Eocene Epoch	Large part of ground surface near streams	Red, brown, yellow, and buff fine-to-coarse sand and sandy clay	Limited but sufficient for domestic use	0 to 27
McBean and Congaree Formations[a]	Eocene Epoch	In banks of larger streams	Yellow-brown-to-green, fine-to-coarse glauconite-quartz sand, intercalated with green, red, yellow, and tan clay, sandy marl, and lenses of siliceous limestone	Moderate to large	30 to 76
Ellenton Formation[a]	Paleocene Epoch	None on SRP	Dark-gray-to-black sandy, lignitic, micaceous clay containing disseminated crystalline gypsum and coarse quartz sand	Moderate to large; higher sulfate and iron than water from other formations	1 to 30
Tuscaloosa[a]	Cretaceous Period	None on SRP	Tan, buff, red, and white cross-bedded, micaceous, quartzitic and arkosic sand and gravel imbedded with red, brown and purple clay and white kaolin	Large (well production up to 7.6 m^3/min); soft (low in total solids)	170 to 250
Newark Series "red beds"[b]	Triassic/Jurassic Period	None on SRP	Dark-brown and brick-red sandstone, siltstone, and claystone containing gray calcareous patches; fanglomerates near border	Very little	>914
Basement rocks of Slate Belt and Charlotte Group[c]	Precambrian and Paleozoic Eras	None on SRP	Hornblende gneiss, chlorite-hornblende schist, and lesser amounts of quartzite; covered by saprolite layer derived from basement rock	Very little	Thousands

[a]Coastal Plain sediments.
[b]Dunbarton Basin sediments.
[c]Crystalline and metamorphic rock.
Note: Formation Terminology after Siple, 1967.

Table A-4. Hydraulic Conductivity (cm/sec) of Ellenton Formation

Geologic unit	Vertical conductivity		Horizontal conductivity	
	Range	Average	Range	Average
Middle clay	2.2×10^{-9} - 1.4×10^{-5}	1.1×10^{-7}	1.6×10^{-9} - 7.3×10^{-5}	8.61×10^{-5}
Lower sand	3.5×10^{-9} - 3.9×10^{-4}	4.4×10^{-5}	1.1×10^{-8} - 2.6×10^{-4}	9.39×10^{-5}
Lower clay	1.8×10^{-8} - 4.0×10^{-7}	1.9×10^{-7}	2.3×10^{-8} - 6.7×10^{-7}	3.12×10^{-7}

Source: DOE, 1987.

Table A-5. Typical Hydrologic Properties in Separations Areas[a]

Hydrogeologic unit	Hydraulic conductivity (m/day)		Effective porosity	Transmissivity (m^2/day)	Storage coefficient
	Horizontal (Kh)	Vertical (Kv)			
Barnwell Formation					
Upper	1.2	0.003	0.25	3	0.25
Lower	3	0.008	0.25	3	0.25
Tan clay	--	0.0016	--	--	--
McBean Formation					
Upper	3	--	0.25	50	0.25
Calcareous zone	3	--	0.25	50	0.25
Green clay	--	3.4×10^{-6}	--	--	--
Congaree Formation					
Upper	34	--	0.25	670	0.0002
Lower	17	--	0.25	670	0.0002
"Tuscaloosa" Formation	40.8	--	0.20	2480	0.00045

[a]Sources: Scott et al., 1987; Root, 1983; Du Pont, 1983. Terminology used for hydrogeologic units is after Siple, 1967 (see Figure A-2).

Table A-6. Typical Hydrologic Properties in A- and M-Areas[a]

Hydrogeologic unit	Hydraulic conductivity (m/day)		Effective porosity	Transmissivity (m^2/day)	Storage coefficient
	Horizontal (Kh)	Vertical (Kv)			
McBean Formation					
Upper	3	--	0.25	6	0.25
Lower	3	--	0.25	55	0.25
Congaree Formation					
Upper	9	--	0.14	215	0.14
Lower	10	--	0.14	145	0.14
Basal clay	--	0.00018	--	--	--
Ellenton clay - Upper Tuscaloosa clay	--	0.0012	0.07	--	--
"Tuscaloosa" Formation	12.2	--	0.20	1050	0.00043

[a]Sources: DOE, 1984, 1985; Du Pont, 1983. Terminology used for hydrogeologic units is after Siple, 1967 (see Figure A-2).

Table A-7. Typical Groundwater Velocities for Important Hydrogeologic Units on Savannah River Plant[a]

Hydrogeologic unit	Test area	Groundwater velocity (m/yr)	
		Vertical	Horizontal
Unsaturated zone material	--	0.9-2.1	--
			4
Barnwell Formation	--	--	0.7-21.0
	BG[b]	2.1	3.0
	A/M	--	0.34-3.4
McBean Formation	F/H	--	3.8 (sand)
	F/H	--	2.2 (calcareous zone)
	F	--	22-56 (sand)
	H	--	111 (sand)
McBean and Congaree Formations	A/M	--	6.1
Congaree Formation	F/H	--	13.4
	F	--	5.15
Ellenton Formation			
Cretaceous Sediments Aquifer	--	--	54.9

[a]Sources: Haskell and Hawkins, 1964; Du Pont, 1983, 1985a; Hubbard and Emslie, 1984; Siple, 1967. Hydrogeologic unit terminology largely after Siple, 1967 (see Figure A-2).
[b]Radioactive waste burial ground.

Table A-8. Analysis of Groundwater from Coastal Plain Formations at Savannah River Plant (mg/L)[a]

Date sampled	Source of water: Well	Source of water: Screen depth (m)	Source of water: Formation	Properties: Temperature (°C)	Properties: pH[c]	Properties: Conductivity (micromhos/cm)
12/16/66	HC1E	13.1-14.6	Barnwell[b]	21.7	5.8	48
10/25/77	HC2F	22.6-24.1	Barnwell	23.0	5.04	NM
08/01/74	HC3F	16.8-18.3	Barnwell	NM	5.2	15
10/18/77	HC6B	25.9-27.4	Barnwell	22.0	6.30	NM
07/25/74	HC3E	28.3-29.9	Barnwell	NM	5.7	18
07/23/74	HC3D	36.9-38.4	McBean	NM	4.8	11
04/28/66	HC2H	40.8-43.9	McBean[c]	23.2	7.1	103
11/23/77	HC6A	42.4-43.9	McBean	21.2	6.93	NM
02/21/72	905-72G	33.5-48.8	McBean	NM	7.0	NM
07/19/74	HC3A	70.1-71.6	Congaree	NM	6.4	130
01/19/78	FC2A	70.4-71.6	Congaree	19.6	6.15	NM
02/21/72	905-31A	134.1-163.4	Cretaceous sediments	NM	5.5	17
02/29/72	905-41D	102.1-149.4	Cretaceous sediments	NM	6.6	NM
02/21/72	905-43H	201.2-259.1	Cretaceous sediments	NM	4.3	54
02/21/72	905-67U	187.5-220.2	Cretaceous sediments	NM	5.15	19

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Table A-8. Analysis of Groundwater from Coastal Plain Formations at Savannah River Plant (mg/L)[a] (continued)

Date Sampled	Well	Chemical constituents[d]														
		Ca^{+2}	Mg^{+2}	K^{+}	Na^{+}	Fe	Si	Al	Mn	HCO_3^-	Cl^-	SO_4^{-2}	NO_3^-	PO_4^{-3}	F^-	TDS
12/16/66	HC1E	3.3	0.3	1.6	TR[e]	0.52	6.8	TR	0.02	12	6.0	1.0	3.8	0.0	0.0	34
10/25/77	HC2F	0.42	0.05	0.10	3.96	<0.2	3.9	<1	<0.02	NM	3.7	0.25	5.8	0.32	0.01	20
08/01/74	HC3F	1.7	0.43	0.25	2.9	<0.1	2.9	NM	NM	4.0	3.3	1.0	0.78	NM	NM	15
10/18/77	HC6B	3.72	0.03	1.91	2.20	<0.2	4.6	<1	<0.03	18.3	1.5	0.62	5.1	0.01	0.01	30
07/25/74	HC3E	5.4	0.25	0.54	2.5	<0.1	4.6	NM	NM	16.3	3.0	1.8	<0.0001	NM	NM	26
07/23/74	HC3D	0.8	0.37	0.22	1.7	<0.1	5.5	NM	NM	2.1	3.0	1.0	<0.0001	NM	NM	14
04/28/66	HC2H	11	0.4	3.0	TR	0.02	12	0.1	0.00	45	4.1	5.8	0.2	0.78	0.01	66
11/23/77	HC6A	13.8	0.02	0.64	2.57	<0.2	5.4	<1	<0.02	49.3	2.3	0.62	0.05	0.01	0.01	51
02/21/72	905-72G	7.0	9.2	0.90	12.5	0.012	0.60	NM	0.05	27.5	1.6	10.2	0.11	0.18	NM	56
07/19/74	HC3A	28	0.54	0.55	1.5	<0.1	9.4	NM	NM	72	2.8	2.2	0.001	NM	NM	81
01/19/78	FC2A	11.1	0.07	0.94	1.45	<0.2	10.7	<1	<0.03	42.7	3.92	10.5	0.05	0.12	0.01	61
02/21/72	905-31A	0.11	1.7	NM	1.75	0.01	0.56	NM	<0.05	5.4	0.8	2.3	2.3	0.06	NM	10
02/29/72	905-41D	1.4	3.5	4.3	11.0	<0.05	0.6	NM	<0.05	9.9	0.59	15.0	15.0	0.3	NM	42
02/21/72	905-43H	0.82	1.52	1.15	1.82	0.14	0.9	NM	0.05	0.97	0.60	11.3	11.3	--	NM	22
02/21/72	905-67U	0.22	1.5	0.43	1.6	0.05	0.44	NM	0.05	0.97	0.71	3.5	3.5	--	NM	10

[a]Adapted from Du Pont, 1983. Formation terminology largely from Siple, 1967 (see Figure A-2).
[b]Upper zone.
[c]Calcareous zone.
[d]Key: Ca^{+2}, calcium; Mg^{+2}, magnesium; K^{+}, potassium; Na^{+}, sodium; Fe, iron; Si, silicon; Al, aluminum; Mn, manganese; HCO_3^-, bicarbonate; Cl^-, chloride; SO_4^{-2}, sulfate; NO_3^-, nitrate; PO_4^{-3}, phosphate; F^-, fluoride; TDS, total dissolved solids; NM, not measured; TR, trace.
[e]Measured at well head.

Table A-9. Groundwater Monitoring Parameters

Minimum	Comprehensive	
Water-table elevation	Coliform bacteria	Zinc
Field pH	Color	Cyanide
Laboratory pH	Corrosivity	Fluoride
Conductivity	Odor	Hydrogen sulfide
Total dissolved solids	Turbidity	Nitrate
Field temperature	Silver	Sulfate
Laboratory temperature	Arsenic	Gross alpha
Chloride	Barium	Gross beta
Dissolved organic carbon	Beryllium	Radium
Total organic carbon	Cadmium	Foaming agents
Total organic halogen	Chromium	Gas-chromatograph scan
Two site-specific metals	Copper	Phenol
	Iron	Endrin
	Mercury	Lindane
	Manganese	Methoxychlor
	Sodium	Toxaphene
	Nickel	2,4-D
	Lead	2,4,5-TP Silvex
	Selenium	

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APPENDIX B

EXISTING WASTE SITES

This appendix discusses the existing waste sites at the Savannah River Plant (SRP) and describes each of the waste sites considered in this environmental impact statement (EIS). Data and information in this appendix was derived from the individual waste site Environmental Information Documents (EIDs) referenced at the end of the appendix. TC

The EIS uses the terms "hazardous," "low-level radioactive," and "mixed" (i.e., hazardous and low-level radioactive) in their most common sense, without specific regard to technical or regulatory definitions, unless indicated. The U.S. Department of Energy (DOE) does not intend this EIS to be a permit application for existing SRP facilities or a vehicle to resolve the applicability of Resource Conservation and Recovery Act (RCRA) requirements to existing SRP facilities or waste sites. Ongoing regulatory activities and the expanded SRP groundwater monitoring and characterization program will provide the basis for the application of requirements to existing facilities and waste sites.

B.1 INTRODUCTION

B.1.1 OVERVIEW OF WASTE SITES

Plant operations generate waste materials that include hazardous wastes; low-level radioactive wastes; mixed wastes* containing both hazardous and radioactive materials; and other wastes, such as sanitary and solid wastes, including rubble. On the SRP, 168 sites have received wastes. Ninety-one of these sites are not considered in detail in this EIS. No decision is made on waste management activities that may occur at these 91 waste sites. TC Of these, 74 active and inactive sites have not received hazardous, low-level radioactive, or mixed wastes. Most of these sites are rubble pits and piles, coal pile runoff containment basins, ash basins and piles, erosion control sites, and experimental sewage/sludge application sites. Table B-1 describes these 74 sites. DOE's Groundwater Protection Plan for the Savannah River Plant (DOE, 1984a) discusses future actions to be taken at several of the 74 sites, including groundwater monitoring and closure actions.

In addition to these 74 sites, 17 waste sites have received or could have received hazardous, low-level radioactive, or mixed wastes. These 17 sites are not considered in detail in the sections (2.2 and 4.2) and appendixes (B and F) of this EIS that describe existing waste sites. TE These sites consist of four hazardous waste storage facilities that have been permitted by the South Carolina Department of Health and Environmental Control (SCDHEC) and meet all applicable Federal and State regulatory requirements; the L-Area seepage basin, which receives periodic low-level radioactive discharges from the

*Unless otherwise stated, in this appendix "mixed waste" is a generic term that refers to the waste's characteristics (i.e., having both a hazardous and a low-level radioactive content) rather than its regulatory definition.

Table B-1. Waste Sites Not Containing Hazardous, Low-Level Radioactive, or Mixed Wastes

Waste sites	Number of sites	Description
Rubble and scrap pits and piles (includes former military sites)	25	Contain nonhazardous and nonradioactive materials such as concrete, brick, tile, asphalt, hard plastics, glass, rubber products, scrap metal, burned wood, and nonreturnable drums. Rubble pits no longer receive waste material.
Ash basins and piles	15	Contain ash sluice water or dry ash from powerhouses. Sampling results indicate waste concentrations are not hazardous. Four ash basins and three ash piles no longer receive ash.
Experimental sewage/ sludge application sites	9	Research programs on reclamation of borrow pits and enhancement of forest productivity where sewage sludge is injected below surface of borrow pits and either disked or sprayed on experimental pine plots. Industrial solid waste permit for sites issued by SCDHEC.
Coal-pile runoff containment basins	7	Contain runoff from coal piles. Results of sampling indicate a pH greater than 2.0; waste constituents, including heavy metals, are less than the EP toxicity maximum concentrations.
Erosion control sites	7	Contain nonhazardous and nonradioactive material that includes concrete, asphalt, bricks, roofing material, stumps and spoil. Four sites no longer receive waste material.
Asbestos disposal pits	4	Contain asbestos, metal pipe, plastic bags, scrap, and piping insulation (not regulated as a water contaminant but as an inhalation hazard). Three sites are no longer active. They are permitted by SCDHEC under NESHAP.
Sanitary landfill	1	Contains material such as paper, plastics, rubber, wood, cardboard, and rags. Landfill operated under a domestic waste permit issued by SCDHEC.

Table B-1. Waste Sites Not Containing Hazardous, Low-Level Radioactive, or Mixed Wastes (continued)

Waste sites	Number of sites	Description
Sanitary sludge disposal pit	1	Contains nonhazardous and nonradioactive sanitary sewage sludge.
D-Area waste oil	1	Receives, mixes, and stores waste oil for burning with coal at the D-Area powerhouse. TE
Oil-storage pad	1	Concrete pad with curbing used before February 1979 to store drums of oil and solvents. All material stored on the pad has been removed.
Fire department hose training facility	1	Facility where oil was ignited in a shallow pit surrounded by an asphalt dike. Use of training facility has been discontinued.
Gas-cylinder disposal facility	1	Contains empty gas cylinders, from which all hazardous materials were released. Area covered with asphalt.
TNX storage area	1	Contains drummed, nonhazardous waste stored on pallets that rest on crushed rock.

L-Reactor disassembly basin, and which was discussed extensively in the Final Environmental Impact Statement, L-Reactor Operation, Savannah River Plant (DOE, 1984b); three reactor containment basins in P-, L-, and C-Areas; six active reactor seepage basins and the K-Area containment basin; and two linedretention basins in the F and H Separations Areas that would be used to store and contain radioactive water temporarily in the event of an accident or emergency.

The three 190-million-liter earthen containment basins in P-, L-, and C-Areas would receive radioactive water only if a reactor accident, such as a loss of coolant or a loss of circulation, were to occur and a 225,000-liter underground tank and a 1.9-million-liter tank in each reactor area were unable to contain the contaminated water. With completion of the F- and H-Area effluent treatment facility (see Section 1.2.1), the two lined 15-million-liter retention basins in F- and H-Areas would be used only as an emergency backup to two 9.4-million-liter basins whose purpose is to store potentially contaminated water temporarily before treatment in the effluent treatment facility. The six active reactor seepage basins and the K-Area containment basin receive periodic low-level radioactive discharges from the disassembly basins at C-, TC

K-, and P-Reactors. These active sites are discussed in Sections 2.4 and 4.4 of this EIS, which assess various approaches to the management of disassembly-basin purge water.

TE The remaining 77 active and inactive waste sites on the SRP contain or might contain hazardous, low-level radioactive, or mixed wastes. The identification and numbers of sites are based on the facility numbering system used at the SRP. For example, the F-Area seepage basins are interconnected and received the same waste. These basins were analyzed as a single unit (for modeling, risk assessment, and closure options). However, for consistency with the SRP facility numbering system, they are counted as three "waste sites" in summary tables and text. The actual number of waste systems assessed in this EIS is 47 in contrast to the 77 sites identified below.

These 77 sites include 37 that have received or might have received hazardous wastes. These 37 sites, none of which currently receives waste, include 15 burning rubble pits; 7 chemicals, metals, and pesticides (CMP) pits; 6 acid/caustic basins; 2 waste-oil seepage basins; a basin that has received miscellaneous chemicals; the metals burning pit; the Silverton Road waste site; the metallurgical laboratory basin; a hydrofluoric acid spill area; the Savannah River Laboratory (SRL) oil test site; and the Gunsite 720 rubble pit.

The 77 waste sites also include 19 that have received or might have received low-level radioactive waste. These include 1 active site, the radioactive waste burial ground, which currently receives low-level radioactive waste. There are also 18 inactive sites: 7 basins that have received periodic discharges of disassembly-basin purge water, 7 Bingham pump outage pits, 2 separations area retention basins (unlined), the Ford Building waste site, and the TNX burial ground. None of the 18 sites receives low-level radioactive waste.

In addition to sites that have received or might have received either hazardous or low-level radioactive waste, 21 have received or might have received mixed waste (a combination of hazardous and low-level radioactive waste). These include six active separations area seepage basins. There are also 15 inactive sites: 4 SRL seepage basins, 2 separations area seepage basins, the new TNX seepage basin, the M-Area settling basin, Lost Lake, the old TNX seepage basin, the Road A chemical basin, the L-Area oil and chemical basin, the old radioactive waste burial ground, the Ford Building seepage basin, and the mixed waste management facility. TE

B.1.2 GEOGRAPHIC GROUPINGS OF WASTE SITES

In general, the locations of the 77 waste sites that contain or might contain hazardous, low-level radioactive, or mixed wastes are near the facilities from which they receive or received waste. This results in several clusters, or groupings, of waste sites.

Because actions at a waste site, including groundwater withdrawal, might affect the groundwater transport of waste in other sites, SRP calculated a conservative boundary of influence for each waste site based on the planned actions, extent of data availability, and type of waste (Du Pont, 1984). The intersections and overlappings of the individual site boundaries led to the identification of 10 geographic groupings of waste sites and two miscellaneous areas, each containing a single waste site, where a crossover of actions taken for waste sites in one grouping with actions taken in another grouping would not be expected. Figure B-1 shows these geographic groupings and miscellaneous areas.

Table B-2 lists the 77 waste sites in the geographic groupings and the miscellaneous areas that contain or might contain hazardous, low-level radioactive, and mixed wastes. This table also lists the type of waste that is contained or that might be contained at each site and whether the site currently receives waste material.

B.2 A- AND M-AREA WASTE SITES

The location of this geographic grouping of waste sites is along the northwest edge of the SRP where Road 1 leads to the Administration Area (700-A). Figure B-2 shows the boundaries of this geographic grouping and the locations of the waste sites within it. The boundaries are defined primarily by the areas of influence assigned to the SRL seepage basins, the M-Area settling basin, and Lost Lake. A-Area, the Fuel and Target Fabrication (300-M) Area, and most of Road D are within these boundaries. Surface drainage is primarily to Tims Branch, a tributary of Upper Three Runs Creek.

B.2.1 POTENTIALLY HAZARDOUS WASTE SITES*

B.2.1.1 716-A Motor Shop Seepage Basin (904-101G)

The 716-A motor shop seepage basin is adjacent to Building 716-A in A-Area. The basin is about 63 meters long, 11 meters wide, and 2 meters deep. The sloping berm of adjacent railroad tracks constitutes one side of the basin while the other three are an earthen dike about 2 meters high.

History of Waste Disposal

In 1977, the 716-A motor shop seepage basin began receiving liquid effluent from the 716-A motor shop oil-water separator by means of an underground drain line. Waste types in water included trace amounts of engine oil, kerosene, ethylene glycol, and soapy water. In the basin, the liquid wastes were permitted to seep naturally into the soil. In August 1983, all discharges to the basin ceased.

Evidence of Contamination

Initial sampling of the liquid remaining in the 716-A motor shop seepage basin indicated the presence of low quantities of motor oil, grease, ethylene glycol, and kerosene. The results of extraction procedure (EP) toxicity analyses found all metals were below RCRA guidelines (Huber, Johnson, and Bledsoe, 1987). TC

SRP installed two groundwater monitoring wells near the basin in May 1983. Well sampling began in February 1984. Results of groundwater-quality analyses indicate elevated levels of total organic halogens, which are attributed to M-Area sources. TC

*See discussion of site type on page B-1.

Table B-2. Waste Sites by Geographic Grouping

	Areas/waste sites	Building	Currently receiving waste	Potential category[a]
A- and M-Areas				
1-1[b]	716-A motor shop seepage basin	904-101G	No	Hazardous
1-2	Metals burning pit	731-4A	No	Hazardous
1-3	Silverton Road waste site	731-3A	No	Hazardous
1-4	Metallurgical laboratory basin	904-110G	No	Hazardous
1-5	Miscellaneous chemical basin	731-5A	No	Hazardous
1-6	A-Area burning/rubble pit	731-A	No	Hazardous
1-7	A-Area burning/rubble pit	731-1A	No	Hazardous
1-8	SRL seepage basin	904-53G	No	Mixed
1-9	SRL seepage basin	904-53G	No	Mixed
1-10	SRL seepage basin	904-54G	No	Mixed
1-11	SRL seepage basin	904-55G	No	Mixed
1-12	M-Area settling basin	904-51G	No	Mixed
1-13	Lost Lake	904-112G	No	Mixed
F- and H-Areas				
2-1	F-Area acid/caustic basin	904-74G	No	Hazardous
2-2	H-Area acid/caustic basin	904-75G	No	Hazardous
2-3	F-Area burning/rubble pit	231-F	No	Hazardous
2-4	F-Area burning/rubble pit	231-1F	No	Hazardous
2-5	H-Area retention basin	281-3H	No	Low-level radioactive
2-6	F-Area retention basin	281-3F	No	Low-level radioactive
2-7	Radioactive waste burial ground	643-7G	Yes	Low-level radioactive
2-8	Mixed-waste management facility	643-28G	No	Mixed

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Table B-2. Waste Sites by Geographic Grouping (continued)

	Areas/waste sites	Building	Currently receiving waste	Potential category[a]
F- and H-Areas (continued)				
2-9	Radioactive waste burial ground (inactive)	643-G	No	Mixed
2-10	F-Area seepage basin	904-41G	Yes	Mixed
2-11	F-Area seepage basin	904-42G	Yes	Mixed
2-12	F-Area seepage basin	904-43G	Yes	Mixed
2-13	F-Area seepage basin (old)	904-49G	No	Mixed
2-14	H-Area seepage basin	904-44G	Yes	Mixed
2-15	H-Area seepage basin	904-45G	Yes	Mixed
2-16	H-Area seepage basin	904-46G	No	Mixed
2-17	H-Area seepage basin	904-56G	Yes	Mixed
R-Area				
3-1	R-Area burning/rubble pit	131-R	No	Hazardous
3-2	R-Area burning/rubble pit	131-1R	No	Hazardous
3-3	R-Area acid/caustic basin	904-77G	No	Hazardous
3-4	R-Area Bingham Pump outage pit	643-8G	No	Low-level radioactive
3-5	R-Area Bingham Pump outage pit	643-9G	No	Low-level radioactive
3-6	R-Area Bingham Pump outage pit	643-10G	No	Low-level radioactive
3-7	R-Area seepage basin	904-57G	No	Low-level radioactive
3-8	R-Area seepage basin	904-58G	No	Low-level radioactive
3-9	R-Area seepage basin	904-59G	No	Low-level radioactive
3-10	R-Area seepage basin	904-60G	No	Low-level radioactive
3-11	R-Area seepage basin	904-103G	No	Low-level radioactive
3-12	R-Area seepage basin	904-104G	No	Low-level radioactive
C- and CS-Areas				
4-1	CS burning/rubble pit	631-1G	No	Hazardous
4-2	CS burning/rubble pit	631-5G	No	Hazardous
4-3	CS burning/rubble pit	631-6G	No	Hazardous
4-4	C-Area burning/rubble pit	131-C	No	Hazardous

Footnotes on last page of table.

Table B-2. Waste Sites by Geographic Grouping (continued)

	Areas/waste sites	Building	Currently receiving waste	Potential category[a]
C- and CS-Areas (continued)				
4-5	Hydrofluoric acid spill area	631-4G	No	Hazardous
4-6	Ford Building waste site	643-11G	No	Low-level radioactive
4-7	Ford Building seepage basin	904-91G	No	Mixed
TNX-Area				
5-1	D-Area burning/rubble pit	431-D	No	Hazardous
5-2	D-Area burning/rubble pit	431-1D	No	Hazardous
5-3	TNX burying ground	643-5G	No	Low-level radioactive
5-4	TNX seepage basin (old)	904-76G	No	Mixed
5-5	TNX seepage basin (new)	904-102G	Yes	Mixed
D-Area				
6-1	D-Area waste oil basin	631-G	No	Hazardous
Road A Area				
7-1	Road A chemical basin	904-111G	No	Mixed
K-Area				
8-1	K-Area burning/rubble pit	131-K	No	Hazardous
8-2	K-Area acid/caustic basin	904-80G	No	Hazardous
8-3	K-Area Bingham Pump outage pit	643-1G	No	Low-level radioactive
8-4	K-Area seepage basin	904-65G	No	Low-level radioactive
L-Area				
9-1	L-Area burning/rubble pit	131-L	No	Hazardous
9-2	L-Area acid/caustic basin	904-79G	No	Hazardous

Footnotes on last page of table.

Table B-2. Waste Sites by Geographic Grouping (continued)

Areas/waste sites		Building	Currently receiving waste	Potential category[a]
L-Area (continued)				
9-3	CMP pit	080-17G	No	Hazardous
9-4	CMP pit	080-17.1G	No	Hazardous
9-5	CMP pit	080-18G	No	Hazardous
9-6	CMP pit	080-18.1G	No	Hazardous
9-7	CMP pit	080-18.2G	No	Hazardous
9-8	CMP pit	080-18.3G	No	Hazardous
9-9	CMP pit	080-19G	No	Hazardous
9-10	L-Area Bingham Pump outage pit	643-2G	No	Low-level radioactive
9-11	L-Area Bingham Pump outage pit	643-3G	No	Low-level radioactive
9-12	L-Area oil and chemical basin	904-83G	No	Mixed
P-Area				
10-1	P-Area burning/rubble pit	131-P	No	Hazardous
10-2	P-Area acid/caustic basin	904-78G	No	Hazardous
10-3	P-Area Bingham Pump outage pit	643-4G	No	Low-level radioactive
Miscellaneous Areas				
11-1	SRL oil test site	080-16G	No	Hazardous
11-2	Gunsite 720 rubble pit	N80,000; E27,350[c]	No	Hazardous

[a]This EIS uses the terms "hazardous," "low-level radioactive," and "mixed" (i.e., hazardous and low-level radioactive) in their most common sense, without specific regard to technical or regulatory definitions, unless indicated.
[b]The numbering system arbitrarily identifies the geographic group and each site with that group. For example, Site 1-1 represents the first site in geographic group 1.
[c]No building number; located by SRP map coordinate system.

TE | The sediment beneath the basin will be sampled and characterized at a future date prior to finalizing any closure plans.

Waste Characterization

Limited data are available on the extent of contamination and the characteristics of the wastes involved at the 716-A motor shop seepage basin. Most of the available raw data have been gathered via groundwater monitoring (Huber, Johnson, and Bledsoe, 1987). TC

B.2.1.2 Metals Burning Pit (731-4A)

The metals burning pit is in A-Area to the northwest of Road C-1 and between M-Area and Road C. The site is approximately 2130 meters south of the M-Area settling basin and 3350 meters from the closest SRP boundary. It has dimensions of approximately 120 meters by 120 meters.

History of Waste Disposal

The history of the metals burning pit is uncertain. The site was originally a disposal pit for lithium-aluminum and other waste metals generated from M-Area operations, which began in 1952. According to 1974 photographs, the waste metals were burned periodically within an area of approximately 3900 square meters. Photographs of the metals burning pit taken in late 1973 and early 1974 show piles of metal shavings, pieces of aluminum metal, plastic pipe, approximately 30 metal drums, and other miscellaneous metal scraps. These wastes were in two discrete areas: a large, long pile approximately 2 to 3 meters high, 10 meters wide, and 30 meters long, and a series of small piles oriented in a semicircular arc. Some of the piles appeared to contain ash from metal burning operations. The area was graded and backfilled with 1 to 2 meters of cover in the spring of 1974. TC

Evidence of Contamination

No characterization studies of the soils under or around the metals burning pit have been performed to date. However, soil sampling is planned. Four groundwater monitoring wells have been installed at the site (Pickett, Muska, and Marine, 1987). TC

Waste Characterization

Limited data are available to verify the existence or define the extent of contamination at the metals burning pit or to characterize the wastes that might be present. Most of the available raw data pertain to the groundwater. The migration potential of the waste deposited in the metals burning pit cannot be determined readily from the available data.

B.2.1.3 Silverton Road Waste Site (731-3A)

The Silverton Road waste site is just south of M-Area and north of Route 125. The nearest SRP boundary is about 1.6 kilometers northwest of the site. The site covers a total area of approximately 13,150 square meters, with dimensions of about 62 meters by 212 meters.

History of Waste Disposal

The site startup date is unknown; no records of waste disposal activities have been kept. Visual inspection and photographic documentation indicate that metal shavings, construction debris, tires, drums, tanks, and asbestos were major components of the waste. The site was closed in 1974 and is now covered with soil and vegetation.

Evidence of Contamination

Groundwater at the Silverton Road waste site has been monitored since 1981. Nine single groundwater monitoring wells and seven 3-well clusters are located near the site. To date, the contaminants identified in the groundwater are trichloroethylene, tetrachloroethylene, trichloromethane, and 1,1,1-trichloroethane. Most of the constituents found in the groundwater near the site were below Federal drinking-water standards. Infrequently, concentrations of barium, cadmium, chromium, and lead were found to exceed the standards. However, because such concentrations were observed infrequently, the data were considered to be nonrepresentative and possibly erroneous (Scott, Killian, Kolb, Corbo, and Bledsoe, 1987).

Waste Characterization

Limited data are available on the extent of contamination and characteristics of the wastes at the Silverton Road site. Most of the available raw data pertain to the groundwater (Scott, Killian, Kolb, Corbo, and Bledsoe, 1987).

Historic data from monitoring wells indicate the presence in the groundwater of chlorinated aliphatic hydrocarbons (trichloroethylene, 1,1,1-trichloroethane, trichloromethane, and tetrachloroethylene), which have a potential for transport by advection as solutes.

B.2.1.4 Metallurgical Laboratory Basin (904-110G)

The metallurgical laboratory basin is in A-Area adjacent to Building 745-A. The basin is approximately 31 meters long, 12 meters wide, and 1.5 meters deep.

History of Waste Disposal

The metallurgical laboratory basin received wastewater effluent from Building 723-A from 1956 to 1985. Discharges to the basin consisted of small quantities of laboratory wastes from metallographic sample preparation (degreasing, cleaning, etching) and corrosion testing of stainless steels and nickel-based alloys. The wastewater flowed to the basin via an underground process sewer pipeline. The discharge rate to the basin was 3.8 cubic meters per day. Historically, the typical wastes released to the basin were water and nitric acid. From 1983 on, hazardous substances and materials were bottled and stored. Before 1983, hazardous materials were sent to the basin only in trace amounts. Table B-3 lists the estimated composition of releases to the basin during its operational history (Michael, Johnson, and Bledsoe, 1987).

Evidence of Contamination

A characterization study of the sediments in and around the metallurgical laboratory basin has been completed, as has an analysis of the basin water and groundwater. Soil analyses indicate that all tested parameters are below EP toxicity guidelines. Analysis of water samples collected from the basin indicate that drinking standards are met for all parameters except pH and iron.

Table B-3. Estimated Composition of Wastes Released to Building 723-A Metallurgical Laboratory Basin (1956-1985)[a]

TE

Chemical	Total release over 30 years	Present release
Acetone	20 liters	Not released after 3/83
1,1,1-trichloroethane	150 liters (past 3-5 years)	Not released after 3/83
Trichloroethylene	6 liters	Not released after 1978
Carbon tetrachloride (tetrachloromethane)	500 liters	Not released after 1978
Hydrofluoric acid[b]	2 liters	Not released after 3/83
Nitraad[b] (as purchased, is composed of HF, acetic acid, and fluoride salts)	140 liters	Not released after 3/83
Potassium cyanide or sodium cyanide	1 liter	Not released after 1976
Cyanide (plating solution)[c]	4 liters	Not released after 1976
Hydrochloric acid	190 liters	45 liters/year
Nitric acid (65%)	39,800 liters	1,300 liters/year
Molybdic acid	10 grams	1 gram (rarely used)
Oxalic acid	23 liters	10 liters/year
Phosphoric acid	53 liters	1.6 liters/year
Picric acid	100 grams	0.4 liter/year
Sulfuric acid	15 liters	4 liters/year
Sodium hydroxide	3 liters	2 liters/year
Potassium hydroxide	30 liters	8 liters/year
Trisodium phosphate	60 liters	8 liters/year

Footnotes on last page of table.

TE

Table B-3. Estimated Composition of Wastes Released to Building 723-A Metallurgical Laboratory Basin (1956-1985)[a] (continued)

Chemical	Total release over 30 years	Present release
Sodium sulfite	270,000 grams	11,000 grams/year
Sodium carbonate/bicarbonate	45 liters	8 liters/year
Ammonium persulfate	1 liter	0.5 liter/year
Ethyl alcohol	1,300 liters	420 liters/year
Kerosene	114 liters	Not released after 2/85
Methyl methacrylate (Koldweld resin)	150 liters	6 liters/year
Ferric chloride	1,900 liters	0.4 liter/year
Water (cooling water from corrosion test, rinse water from photo process, lab rinsewater)	3,800 liters/day	3,800 liters/day

TC

[a]Source: Michael, Johnson, and Bledsoe, 1987.
[b]Currently bottled and stored.
[c]Solution reused until all metal is depleted.

Waste Characterization

TC

Data are available for the chemical analyses performed on the basin water, groundwater, and sediments from the metallurgical laboratory basin. Lead and volatile organic compounds were assessed at this site.

TC

The potential for the migration of contaminants deposited in the metallurgical laboratory basin cannot be determined readily from the available data.

B.2.1.5 Miscellaneous Chemical Basin (731-5A)

The miscellaneous chemical basin site is located to the northeast of Road C-1 and between the A/M-Area and Road C. The site is approximately 2 kilometers south of the M-Area settling basin and 3 kilometers from the closest SRP boundary. The chemical basin is approximately 6 meters wide, 6 meters long, and 0.3 meter deep.

History of Waste Disposal

The origin and history of this site are not certain. This small, shallow basin was located in an old "borrow pit." The basin received liquid chemical wastes, presumably waste solvents and used oil. A 1974 photograph of the site shows a small, discolored (possibly from the disposal of waste oil) sandy area inside a shallow berm. Partially full drums might have been emptied at this site and the empty drums discarded in the metals burning pit. The basin was posted with a sign that read "Chemical Waste Disposal - Keep Out." The site has been regraded, although the exact date is not recorded (probably 1974).

Evidence of Contamination

There are no groundwater wells currently in place. An analysis of surface soils at the miscellaneous chemical basin in January 1986 detected several chlorinated hydrocarbons (Pickett, Muska, and Marine, 1987). | TC

Waste Characterization

A program of soil gas sampling undertaken in January 1986 indicated the presence of volatile organic compounds (VOCs), some of which might have originated in M-Area and been disposed of at this site. Modeling assessed trichloroethylene at this site. | TC

B.2.1.6 A-Area Burning/Rubble Pits (731-A and 731-1A)

The A-Area burning/rubble pits are at the northwest corner of the Plant, south of M-Area and west of Road D. The pits (731-A) are approximately 100 meters long, 55 meters wide, and 3 meters deep. Pit 731-1A measures 174 meters long, 10 meters wide, and 3 meters deep.

History of Waste Disposal

The A-Area burning/rubble pits are two of the many burning pits utilized on the Savannah River Plant. They consisted of shallow excavations, usually 3 to 4 meters deep, where burnable waste was disposed of on a continuous basis beginning in 1951. Waste types reportedly included paper, plastics, wood, rubber, rags, cardboard, oil, degreasers, and drummed solvents. The waste was burned periodically, usually monthly. Disposal of chemically contaminated oils was not permitted.

The burning of waste in the pits was discontinued in October 1973. At that time, a layer of soil was placed over the remaining waste and the pits were opened to receive rubble. Rubble disposed of at this site reportedly includes paper, lumber, cans, and empty galvanized-steel barrels and drums. As each pit reached its capacity, it was closed and covered with soil to grade level.

Evidence of Contamination

No sampling and analysis of the soil underlying these pits have been performed. However, groundwater monitoring wells were installed at all of the burning/rubble pits in 1983 and 1984. No groundwater contamination has been observed to date (Huber, Johnson, and Marine, 1987). | TC

Waste Characterization

Limited data are available for these sites. Most of the available raw data have been gathered via groundwater monitoring. No groundwater contamination has been observed to date (Huber, Johnson, and Marine, 1987). | TC

B.2.2 MIXED WASTE SITES*

TE

B.2.2.1 SRL Seepage Basin 1 (904-53G)

Seepage basin 1 is one of a group of four basins south of Road A-1 and west of Road D-1 in the northwestern section of the SRP, about 1 kilometer from the nearest boundary. The four basins are connected sequentially in cascade via overflow channels. The final basin has no overflow; consequently, fluid losses from the SRL waste sites are from seepage through the bottom of the basins or from evaporation (Fowler et al., 1987). TC

History of Waste Disposal

Basins 1 (904-53G), 2 (904-53G), and 3 (904-54G) were excavated from natural soils and surrounded by perimeter dikes. By contrast, the construction of basin 4 (904-55G) required substantial filling at the north end (adjacent to Tims Branch) to achieve both the basin bottom and the dike crest elevations.

TC

The capacity of basin 1 is 1520 cubic meters; basin 2, 3200 cubic meters; basin 3, 5440 cubic meters; and basin 4, 14,700 cubic meters. Basins 1 and 2 were placed in operation in 1954, and basins 3 and 4 were added in 1958 and 1960, respectively. The basins were in operation until October 1982. The depth of water remaining varies from dry (basin 4) to 1.2 meters (basin 2).

Evidence of Contamination

Most of the radionuclides and inorganics are strongly sorbed to basin sediments. Their concentrations are elevated in the first 30 centimeters and decline to "background" levels at about 62 centimeters. The constituents include americium-241, cesium-137, cobalt-60, curium-243 and 244, plutonium-239 and 240, radium-228, strontium-90, uranium-235 and 238, cerium-144, ruthenium-106, arsenic, barium, cadmium, chromium, copper, lead, magnesium, manganese, nickel, silver, zinc, mercury, cyanide, fluoride, and sulfate. Analysis of core samples for volatile, base/neutral, and acidic organic compounds indicates very little contamination. Most elements were detected at levels below 1 microgram per gram of soil (Fowler et al., 1987). TC

Twelve monitoring wells have been installed around the basins. Six water-table monitoring wells were drilled in 1981 immediately adjacent to the basins. Three water-table wells and three deep wells were installed as part of a basin characterization program in 1983.

Data from the nine groundwater monitoring wells indicate the following:

- Inorganic contaminants are generally below maximum contaminant levels (MCLs).

- Trichloroethylene and tetrachloroethylene are significant organic contaminants. The pattern of contaminated wells indicates that these constituents are from sources other than the basins.

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*See page B-1 for a discussion of waste site categories.

Waste Characterization

During the A-Area basins' 28-year loading history, 128,820 cubic meters of water were discharged to them. Alpha and beta-gamma activity in the total discharge did not exceed 100 and 50 disintegrations per minute per milliliter, respectively. The average of alpha and beta-gamma activity was 50 disintegrations per minute per milliliter. Fissile content of the waste transferred to the basins in 1982 averaged 0.4 millicurie per month. The levels of uranium and plutonium in the analyses were as follows: uranium-238, 90 percent; plutonium-238, 5 percent; and plutonium-239, 5 percent.

Table B-4 compares the MCL observed in the SRL seepage basins with the U.S. Nuclear Regulatory Commission (NRC) Class A limits. The sediments are well below the limits for land disposal.

Table B-4. Measured Soil Contamination Versus NRC 10 CFR 61 Land-Disposal Limits for SRL Seepage Basins (pCi/g)

Nuclide	Maximum basin-soil measurement	NRC Class A limit
Tritium	7×10^{4}	3×10^{7}
Cobalt-60	9×10^{1}	5×10^{8}
Strontium-90	2×10^{3}	3×10^{4}
Cesium-137	2×10^{3}	3×10^{4}
Plutonium-239	2×10^{2}	1×10^{5}
Americium-241	3×10^{1}	1×10^{5}
Curium-243	4×10^{2}	1×10^{5}

The RCRA EP toxicity test establishes the guidelines for classifying a waste as hazardous or nonhazardous. Test results indicate that concentrations in the SRL seepage-basin sediments of constituents classified as hazardous by the U.S. Environmental Protection Agency (EPA) are generally low (less than 1 microgram per gram); in most cases these compounds are undetectable or are present at "laboratory-blank" levels that follow no clear source/transport pattern. The test also indicates that the sediments in the basins do not contain toxic levels of metals. No samples exceed the EPA maximum concentrations, and only mercury in basin 1 exceeds 10 percent of the EPA maximum concentration (40 CFR 261.24). The sediments in the SRL seepage basins contain very low levels of hazardous constituents. Therefore, no contamination is present in the sediments other than low-level radioactivity. Organic constituents in the groundwater do not exceed primary drinking-water standards (40 CFR 141). TE

TE B.2.2.2 <u>SRL Seepage Basins 2 (904-53G), 3 (904-54G), and 4 (904-55G)</u>

The general history of all SRL seepage basins is discussed in Section B.2.2.1.

History of Waste Disposal

Basins 2, 3, and 4 are part of the four-basin system discussed in Section B.2.2.1.

Evidence of Contamination

TC In August 1972, basin 4 temporarily went dry. Four 30-centimeter-deep core samples were obtained and divided into segments for gamma spectroscopy (Stone and Christensen, 1983). The levels of strontium-89 and 90 in the cores were determined. The top sediment sample contained from 80 to 90 percent of each of the radionuclides except strontium. The other radionuclides showed decreases in activity with increasing depth. The calculated inventories were as follows: cesium-137, about 0.46 curie; ruthenium-106, 0.41 curie; cerium-141 and 144, 0.05 curie; cobalt-60, 0.04 curie; and strontium-89 and -90, 0.01 curie.

Basin 4 refilled during 1973, went dry again in 1974, and has remained dry since 1974. Four sediment samples were collected and analyzed in 1974. Table B-5 lists the results of analyses of these cores. The highest measured
TC activity was near the surface, and the values decreased with depth.

Waste Characterization

Waste characteristics for all four basins are discussed in Section B.2.2.1
TC (Fowler et al., 1987).

TE B.2.2.3 <u>M-Area Settling Basin (904-51G)</u>

TC Figure B-2 shows the location of the M-Area settling basin. Water flows from the M-Area manufacturing facility entered the settling basin via a process-sewer line. A ditch conveyed overflows from the settling basin through a natural seepage area; the discharges eventually entered Lost Lake.
TC Lost Lake has no outlet (Pickett, Colven, and Bledsoe, 1987). The following sections discuss the history of waste disposal, evidence of contamination, and
TC waste characteristics at the settling basin (Pickett, Colven, and Bledsoe, 1987; Hollod et al., 1982).

History of Waste Disposal

When production started in M-Area in 1954, process waters were released to Tims Branch, a tributary of Upper Three Runs Creek. In an effort to restrict the offsite transport of enriched uranium, the settling basin was constructed in 1958 to settle out and contain the uranium (Christensen and Gordon, 1983). Process sewers continued to direct some M-Area waste flows to Tims Branch. In the fall of 1978, eleven 208-liter drums containing tetrachloroethylene were dumped into the settling basin, but the exact location of the dumping is not known. In addition, from the fall of 1978 to the spring of 1979, drums of tetrachlorethylene were dumped into the sewer line leading to the settling basin to dispose of remaining solvent after the transition to a new cleaning solvent (1,1,1-trichloroethane).

TE

Table B-5. Radioactivity of Sediment in SRL Seepage Basin 4 (nCi/g)

Radionuclide	Sediment depth (cm)	Sample site[a] 1	2	3	4
Cesium-137	0-6.4	0.714	0.044	1.100	0.215
	6.4-12.7	0.042	0.002	0.207	0.034
	12.7-19.1	0.007	0.001	0.036	0.002
	19.1-24.1	0.003	0.001	0.004	-
	24.1-30.5	0.002	-	0.001	-
Cesium-134	0-6.4	0.037	0.003	0.092	0.016
	6.4-12.7	0.003	0.001	0.009	0.001
	12.7-19.1	0.001	0.001	0.001	0.001
	19.1-24.1	0.001	0.001	0.001	0.001
	24.1-30.5	0.001	0.001	0.001	0.001
Ruthenium-106	0-6.4	Trace	Trace	Trace	Trace
Cobalt-60	0-6.4	0.050	0.007	0.078	0.020
	6.4-12.7	0.002	0.001	0.008	0.001
	12.7-19.1	0.001	0.001	0.004	0.001
	19.1-24.1	0.001	0.001	0.001	-
	24.1-30.5	0.001	-	0.001	-
Alpha	0-6.4	0.150	0.140	0.230	0.020
	6.4-12.7	0.020	0.002	0.019	0.006
	12.7-19.1	0.009	0.002	0.007	0.002
	19.1-24.1	0.003	0.002	0.006	-
	24.1-30.5	0.002	0.002	0.001	-

[a]Samples taken in 1974 at four locations in basin 4, with the northwest corner designated as 1 and the others numbered counter-clockwise from inlet.

In May 1982, all discharges to Tims Branch were diverted to the settling basin. Most noncontact process effluents, such as cooling water and surface drainage, were diverted back to Tims Branch in November 1982. In late 1983, significant flow-rate reductions were implemented in the 300-M Area processes. All discharges to the settling basin stopped on July 16, 1985. The current water level in the settling basin fluctuates with rainfall events but, in general, has receded approximately 0.5 meter from the normal operating level.

Evidence of Contamination

A 1982 study of soils beneath the settling basin indicates that the top of the soil column has higher than background concentrations of such metals as zinc, lead, mercury, copper, and uranium (Hollod et al., 1982). Nickel concentrations decline to background level at about 0.3 meter. The average concentrations of metals observed in a 1985 study (Pickett, 1985) are similar, in most cases, to the results reported in the 1982 study. Uranium was detected at four locations sampled in 1985. The 1985 study also included soils next to the settling basin, which yielded no evidence of metals contamination.

The 1982 study found the concentration of each of three chlorinated hydrocarbons (trichloroethylene, tetrachloroethylene, and 1,1,1-trichloroethane) in the underlying basin soil to be quite variable, both vertically and horizontally. Unlike the data on metal contaminants, the analyses for hydrocarbons in 1985 differ from those of 1982 (Pickett, 1985).

These results indicate that the more mobile hydrocarbons in the soil beneath the settling basin have migrated toward the water table, while the less mobile metals have remained fairly stationary. These results indicate that the basin and its sediments are no longer a source of organic contamination.

Analyses of samples indicate that the settling basin and process-sewer line are the major sources of organic or inorganic contamination of groundwater in M-Area. The data also indicate that the seepage and Lost Lake areas are also sources of organic or inorganic contamination, but to a lesser degree. Judging from their elevated levels in settling basin influents and the consistency of their background and downgradient concentrations, the following are probable contaminants: nitrate, sodium, total dissolved solids, and organics.

Degreaser solvents have entered the groundwater in the Tertiary sediments in M-Area from several known surface sources. The settling basin was one of three primary surface sources. The maximum concentration of such solvents occurs at the water table under the settling basin. At a greater depth (about 23 meters below the water table), the maximum concentration is only 61 parts per million but the plume occupies a larger area than it does at the water table. Near the base of the Tertiary sediments (37 meters below the water table), both the maximum concentration and the area of the plume are much smaller, being restricted to the general area beneath the surface sources. Plumes of elevated concentrations of total dissolved solids and nitrate also occur in the vicinity of the settling basin and the M-Area process area.

Waste Characterization

The waste effluents discharged to the basin during M-Area operation generally can be characterized as electroplating rinse water from aluminum forming and metal finishing processes. The waste effluents contained hydroxide precipitates of aluminum, uranium, nickel, and lead, as well as nitrates and organic solvents. Depending on the operating schedule, they might also have contained acids (nitric, phosphoric, sulfuric) or caustics (sodium hydroxide).

Estimates of total uranium discharge to the settling basin were not available until after 1975, when flow instruments were installed. From 1974 through 1983, a total of 975 millicuries (approximately 2940 kilograms) of uranium-235 and uranium-238 were released to the basin. A total of approximately 1.6×10^6 kilograms of volatile organic solvents was discharged to M-Area process sewers, with about 0.9×10^6 kilograms of the total being released to the settling basin. The remainder was discharged to Tims Branch.

The results of 1985 analyses confirm that dissolved-metal and nutrient concentrations are usually higher in the lower 3 meters of liquid in the basin. A sludge layer also exists at the bottom of the basin. The thickness of the sludge ranges from 0.15 to 0.9 meter. The sludge is composed primarily of metal hydroxide and phosphate precipitates, as well as biogenic organic sediments. It also contains the major inventories of iron (1280 kilograms), nickel (3585 kilograms), chromium (240 kilograms), and uranium (3900 kilograms) in the basin.

A number of organic compounds are also present in significant amounts in the sludge, but they were not detected at any other sampling location. The total inventory of chlorinated hydrocarbons in the sludge is approximately 1 kilogram; the inventory is approximately 20 kilograms in the basin liquid.

A closure plan for the M-Area seepage basin was submitted in September 1984. Revisions to the plan were submitted in March and July 1985, and public hearings were held in July 1986. A revised Part B plan was submitted in April 1987. A postclosure care permit application for this basin was submitted with the SRP Part B permit application. Interim status is in effect until final administrative disposition of the Part B permit application. TE

B.2.2.4 Lost Lake (904-112G) TE

Lost Lake, which is located in M-Area (Figure B-2), is a natural Carolina bay of about 10 to 25 acres, depending on water level. Wastewater overflowed from the M-Area settling basin and entered Lost Lake from the north via an overflow ditch and natural seepage area. The ditch is presently dry. The following sections discuss the history of waste disposal, evidence of contamination, and waste characteristics at Lost Lake (Pickett, Colven, and Bledsoe, 1987). TC

History of Waste Disposal

Before construction of the settling basin, Lost Lake was dry except during periods of heavy precipitation. Water has accumulated in the Lake since the diversion of process effluents from Building 313-M to the basin in 1960. The water levels varied widely as a result of process discharges and rainfall. Lost Lake has no outlet; therefore, all wastewater that entered the area either seeped into the ground or evaporated. Section B.2.2.5 presents a more detailed discussion of previous waste disposal practices.

Discharges of waste effluents to the settling basin were discontinued on July 16, 1985. Lost Lake is expected to alternate between dry and wet, depending on precipitation.

Evidence of Contamination

The 1985 analytical results indicate that higher metal concentrations in the soils beneath Lost Lake generally correlate with the average depth of the water. Consequently, the area of the lake that has an elevation less than 102 meters, which is almost always wet, shows the highest levels of inorganic contamination. Concentrations of lead, barium, copper, nickel, manganese, and zinc exceed the M-Area background levels at both the 0.0- to 0.15-meter and the 0.15- to 0.45-meter depths. Concentrations of these metals at the 0.15- to 0.45-meter level are less than the SRP and Southeastern United States background concentrations. Magnesium concentrations are above all reference background levels at the 0.15- to 0.45-meter level. Uranium concentrations within the 102-meter contour are below the detection limit of 10 parts per TC billion (Pickett, Colven, and Bledsoe, 1987).

The levels of bis(2-ethylhexyl) phthalate and di-N-butyl phthalate are above detection limits in the soils beneath Lost Lake. Of the three chlorinated hydrocarbons (trichloroethylene, tetrachloroethylene, and 1,1,1-trichloroethane), only one, tetrachloroethylene, was detected in any Lost Lake soil sample.

Analyses of groundwater samples indicate that Lost Lake is not as great a source of organic or inorganic contaminants as the settling basin.

Waste Characterization

The characteristics of the wastewater discharged to Lost Lake from the settling basin overflow or effluent are similar to those described for the M-Area settling basin in Section B.2.2.5. Sampling results indicate that the contaminant levels in the settling-basin effluent are generally lower than those in its influent. Nitrate concentrations, conductivity, total dissolved solids, and concentrations of most metals (nickel, lead, copper, chromium, magnesium, iron, zinc, and manganese) are lower in the effluent.

B.2.3 MAJOR GEOHYDROLOGIC CHARACTERISTICS

The hydrostratigraphy of the A/M-Area is similar to the generalized hydrostratigraphy discussed in Appendix A with the following exceptions: (1) the "tan clay" is only about 0.9 meter thick and lies in the unsaturated zone; (2) the "calcareous zone" is not present; (3) the "green clay" is discontinuous; (4) the Congaree Formation has fewer separated lenses of clay and lenses of sand; and (5) the Ellenton Formation is mostly a gray, clayey sand or sandy clay that contains plentiful mica and deposits of marcasite or gypsum (Michael, TC Johnson, and Bledsoe, 1987; Scott, Killian, Kolb, Corbo, and Bledsoe, 1987). As a result of these different geologic features, the subsurface hydrologic characteristics also differ from those described in Appendix A. Because the green clay is less continuous, it does not impede downward water flow as much as in the central part of the Plant. Head changes are more gradual because extensive layers of clay are absent from the Tertiary sediments (Barnwell, McBean, and Congaree Formations). In addition, the potentiometric head of the Tertiary sediments is greater than that of the Middendorf/Black Creek (Tuscaloosa) Formation in the A/M-Area. Therefore, heads decline continuously with depth (Figure B-3), and there is no head reversal at the Congaree-Ellenton boundary as there is in the central part of the Plant. Recent TC evidence suggests that the head reversals between the Congaree and "Tuscaloosa" in certain parts of the Plant may not currently exist (Bledsoe, 1987). This indicates that the A- and M-Area geographic grouping is located above a potential recharge zone of the Middendorf/Black Creek Formation (Pickett, Colven, and Bledsoe, 1987).

The water table in the area is mainly within the McBean Formation, although locally it might be within the Barnwell. Natural discharge from the water table is to Tims Branch, the swamps along the Savannah River, and Hollow Creek northwest of the Plant. Figure B-4 is a water-table map for the A/M-Area, based on measurements obtained in July 1984. The water-table gradients in the area range from about 0.002 to 0.008 meter per meter, with the steeper gradients in the direction of Tims Branch. Results from a 30-day pump test in the A/M-Area indicate a transmissivity of 5.3 square meters per day and a storage coefficient of 0.20 for the Tertiary sediments. The test well was screened from a depth of 39.6 to 58 meters below the land surface. The researchers calculated an average hydraulic conductivity of 1.6 meters per day for the Tertiary sediments and a flow velocity ranging from about 5.8 to 22.8 meters per year for gradients of 0.002 to 0.008 meter per meter (Pickett, Colven, and Bledsoe, 1987). TC

Laboratory permeability tests were performed on undisturbed samples from the clayey units of the Ellenton and upper Middendorf/Black Creek Formations (Marine and Bledsoe, 1985). The results of these tests indicate a vertical hydraulic conductivity ranging from 4.0×10^{-7} to 5.2×10^{-9} centimeter per second and a horizontal hydraulic conductivity ranging from 5.7×10^{-7} to 1.1×10^{-8} centimeter per second. The effective porosities determined for these samples range from 0.024 to 0.137 (dimensionless). These compare to average effective porosities of 0.20 and 0.30 generally used for the Tertiary sediments and the Middendorf/Black Creek, respectively. Researchers calculated an average vertical flow velocity of 0.4 meter per year across the Ellenton Formation using a hydraulic conductivity of 1×10^{-7} centimeter per second, an effective porosity of 0.07, a hydraulic head difference of 7.3 meters, and an average clay thickness of 12.2 meters (Michael, Johnson, and Bledsoe, 1987). TC

B.2.4 ONGOING AND PLANNED MONITORING

Groundwater monitoring is proceeding at the 13 waste management facilities in the A- and M-Area geographic grouping. Well-water samples are analyzed quarterly for RCRA and South Carolina Hazardous Waste Management Regulations (SCHWMR) parameters at hazardous and mixed waste management facilities. Typically, wells are monitored for gross alpha, gross nonvolatile beta, and tritium at low-level waste-management facilities. At least 55 wells in this geographic area are used to monitor groundwater in the vicinity of the 13 facilities. Additional wells would obtain better definitions of subsurface conditions and any potential contamination.

Waste site characterization programs have been completed at 10 of the waste management facilities and are being implemented at three others. Characterization generally includes representative sampling of the waste, sampling of the soil and sediment under the waste site, and sampling of the soil and sediment around any existing overflow ditches and process sewers.

Table B-6 lists the representative monitoring wells at each waste management facility; the site investigations that have occurred; and the results of groundwater, soil, and vegetation monitoring. TE

B.3 <u>F- AND H-AREA WASTE SITES</u>

This geographic grouping of waste sites is about 10 kilometers southeast of A-Area. It consists of waste sites associated with the Separations (200-F and -H) Areas and the Radioactive Waste Burial Grounds, which are just north of Road E. Figure B-5 shows the locations of the waste sites within this TC grouping. The boundaries are defined primarily by the areas of influence assigned to the F- and H-Area seepage basins, the radioactive waste burial grounds, and the mixed waste management facility. Surface drainage is to Upper Three Runs Creek on the north and to Four Mile Creek on the south.

B.3.1 POTENTIALLY HAZARDOUS WASTE SITES*

B.3.1.1 F-Area Acid/Caustic Basin (904-74G)

The F-Area acid/caustic basin is one of six basins on the SRP. These basins are unlined earthen depressions nominally 15 meters long, 15 meters wide, and 2 meters deep.

History of Waste Disposal

The acid/caustic basins were built from 1952 to 1955 to provide for mixing and neutralization of dilute sulfuric acid and sodium hydroxide solutions from water treatment facilities before their discharge to local streams.

Dilute sulfuric acid and sodium hydroxide solutions were used to regenerate ion-exchange units in water purification processes, and the spent dilute solutions were discharged to the acid/caustic basins through acid-resistant sewers. Other wastes included water rinses of the ion-exchange units (both before and after regeneration), steam condensate from the heater in the sodium hydroxide storage tanks, and rain that collected in the storage tank spill containment enclosures. The F-Area Basin remained in service until in-process neutralization facilities became operational in 1982. All of the acid/caustic basins, including that of F-Area, are now inactive.

Evidence of Contamination

Work to identify the environmental impacts of the basins is in progress. A program to sample the contents and the soils beneath the basins is under way. Review of existing data from the monitoring wells installed around the basins shows no significant impacts on groundwater quality (Ward, Johnson, and Marine, 1987). TC

Waste Characterization

Limited data are available on the extent of contamination and characteristics of the wastes involved at this site. Data have been gathered via groundwater monitoring and soil sampling. Data collected to date reveal no indication of contamination.

Analytical results of the characterization program indicate elevated levels of chromium, mercury, lead, phosphate, copper, sodium, sulfate, barium, and selenium in the sediment sampled from one or more of the basins. Results of EP toxicity tests performed on the basin sediment samples from each of the basins indicate that all concentrations of each of the metals analyzed are below 1 percent of the maximum concentrations provided by the EPA (40 CFR 261.24).

*See discussion of site type on page B-1.

B.3.1.2 H-Area Acid/Caustic Basin (904-75G)

The H-Area acid/caustic basin is one of six such basins in the Reactor and Separations Areas. These basins are unlined earthen depressions nominally 15 meters long, 15 meters wide, and 2 meters deep.

History of Waste Disposal

See Section B.3.1.1. The H-Area basin remained in service until in-process neutralization facilities became operational in 1982.

Evidence of Contamination

Groundwater monitoring wells have not been installed around the H-Area basin.

Waste Characterization

Limited data are available pertaining to any sampling or monitoring program associated with the H-Area acid/caustic basin.

B.3.1.3 F-Area Burning/Rubble Pits (231-F and 231-1F)

The F-Area burning/rubble pits are in the northwest portion of the Plant, west of F-Area and east of Road C. The configuration of the pits is approximately that of a parallelogram, each being 84 meters long, 23 meters wide, and 3 meters deep.

History of Waste Disposal

See Section B.2.1.6. Rubble disposed of at this site reportedly includes concrete, metal, lumber, and telephone poles.

Evidence of Contamination

See Section B.2.1.6.

Waste Characterization

See Section B.2.1.6.

B.3.2 LOW-LEVEL RADIOACTIVE WASTE SITES

B.3.2.1 H-Area Retention Basin (281-3H)

TC The H-Area retention basin is southwest of the H-Area perimeter fence (Scott, Killian, Kolb, Corbo, and Marine, 1987). It is at the lip of a slope leading to a tributary of Four Mile Creek at an elevation of 81 meters. It is 36.6 meters long, 61 meters wide, and 2.1 meters deep. Its volume is 8.53×10^4 liters.

TC The basin is on the Four Mile Creek side of the water-table divide (Scott, Killian, Kolb, Corbo, and Marine, 1987). The groundwater beneath it migrates toward the tributary of Four Mile Creek that flows toward H-Area. The average water-table gradient from the basin to this tributary is 0.03 meter per meter.

The H-Area retention basin is fenced but not backfilled, and it is surrounded by vegetation.

History of Waste Disposal

The retention basins in the Separations Area were used from 1955 to 1973 (Scott, Killian, Kolb, Corbo, and Marine, 1987). The basins are currently not in use. These open, unlined basins provided temporary storage for potentially contaminated cooling water and contaminated storm water from the waste tank farms and, therefore, kept wastewater from discharging into nearby streams. When radioactivity was encountered in the cooling water or storm water, such water was immediately diverted from surface drainage streams to the retention basins. Leaks of process material to cooling water and spills of radioactive waste to the storm sewer could have caused the contamination. During the holding period, some water seeped into the ground. The exact quantities of water disposed of in the retention basins are unknown. TC

Evidence of Contamination/Waste Characterization

In 1977, researchers performed radiological surveys of soil and vegetation around the H-Area retention basins (Scott, Killian, Kolb, Corbo, and Marine, 1987). Radiation above guidelines was measured at levels up to 90 millirads per hour near the edge of the basin. Vegetation near the basin exhibited cesium-137 at 8200 to 8900 picocuries per gram and strontium-89 and 90 at 58,000 picocuries per gram. No guidelines are issued for vegetation. An area of approximately 930 square meters has shown levels of radioactivity. TC

B.3.2.2 F-Area Retention Basin (281-3F)

The F-Area retention basin is outside and south of the F-Area perimeter fence and east of Building 281-8F. The basin is in an area of level topography on the Aiken Plateau at an elevation of 82 meters above sea level. Surface drainage from the surrounding area flows to Four Mile Creek, about 1200 meters away. The slopes toward Four Mile Creek are very gentle in the vicinity of the basin, but they become progressively steeper approaching the creek. The basin is rectangular, with dimensions of 36.6 by 61 by 2.1 meters. Its volume is 8.53×10^4 liters (Scott, Killian, Kolb, Corbo, and Marine, 1987). TC

The retention basin is on the Four Mile Creek side of the water-table divide. Groundwater beneath the basin migrates toward the creek. The average water-table gradient from the basin to Four Mile Creek is 0.009 meter per meter.

History of Waste Disposal

The F- and H-Area retention basins have similar disposal histories (see Section B.3.2.1); however, F-Area was excavated to 0.6 meter below the original floor of the basin, backfilled with dirt, and covered with grass.

Evidence of Contamination/Waste Characterization

During the latter part of 1978, approximately 970 cubic meters of contaminated soil containing about 11.5 curies of cesium-137 and 0.5 curie of strontium-90 was removed from the F-Area retention basin and transported to the burial ground. TC

An analysis, performed in 1979, determined that most of the residual cesium-137 in the basin floor was in the top 30 centimeters of soil, while there were concentrations of strontium-89 and 90 at depths to 180 centimeters. Of the remaining basin soil, calculations based on core samples indicated that about 0.05 curie of cesium-137 and 1.3 curies of strontium-90 remain in the basin sediments.

B.3.2.3 Present Radioactive Waste Burial Ground (643-7G)

The present radioactive waste burial ground (643-7G) is between the F and H Separation Areas (Figure B-5). The burial ground is an area of approximately 61 acres consisting of trenches and greater confinement boreholes and pads used for the storage or disposal of low-level, intermediate-level, and transuranic (TRU) solid waste. The mixed waste management facility (643-28G), a site of approximately 58 acres used for the disposal of candidate mixed wastes, is completely within the boundaries of 643-7G. The total combined area (643-7G and 643-28G) is 119 acres. Section B.3.3.1 discusses the mixed waste management facility. This section discusses the history of disposal, evidence of contamination, and waste characteristics (Jaegge et al., 1987) at 643-7G.

History of Waste Disposal

The present burial ground (643-7G) has received waste generated after 1972. Bulky low- and intermediate-level wastes are disposed of in trenches 6 meters wide, up to 300 meters long, and 6 meters deep. The trenches are backfilled with a minimum of 1.2 meters of soil. These trenches are the shallow-land burial (SLB) type.

Since mid-1984, newly generated low-level waste has been containerized in metal boxes and stored in engineered low-level trenches (ELLTs). Transuranic waste contaminated to greater than originally 10, currently 100 nanocuries per gram is placed in containers and stored retrievably on concrete pads at ground level and covered with 1.2 meters of soil.

Evidence of Contamination

Groundwater contamination at the combined 643-7G and 643-28G area is monitored with 19 perimeter wells and 26 grid wells within the perimeter of 643-7G. The groundwater beneath the monitored portion of 643-7G and 643-28G contains an estimated 1 millicurie of nonvolatile beta emitters and 0.5 millicurie of alpha emitters. Tritium measurements suggest a total activity of tritium beneath the monitored area of 5600 curies.

The burials of tritium waste in the unmonitored eastern portion of 643-28G suggest that a plume of tritium will develop in the groundwater in that area and subsequently flow toward 643-7G.

Nonradioactive chemical species have been monitored in groundwater at 643-G and 643-7G (Jaegge et al., 1987). Detected constituents are mercury, cadmium and lead.

Waste Characterization

Examples of the materials that have been stored or might be disposed of in 643-7G include the following:

- Contaminated equipment
- Reactor hardware and resins
- Spent lithium-aluminum targets
- Incidental waste from laboratory and production operations
- Shipments from off the site

B.3.3 MIXED WASTE SITES

B.3.3.1 Mixed Waste Management Facility (643-28G)

The mixed waste management facility (MWMF) is near the F- and H-Area separations facilities (Figure B-5). With an area of approximately 58 acres, the MWMF consists of a number of individual trenches that were used for the disposal of candidate mixed wastes. The trenches are within the boundaries of a larger facility (643-7G) known as the radioactive waste burial ground. TE

History of Waste Disposal

The MWMF received wastes from 1972 to March 1986. Candidate mixed wastes are disposed of in SLB trenches that are generally about 6 meters wide and 6 meters deep and have variable lengths up to 500 meters. The trenches, separated by about 3 meters, were backfilled daily during landfilling activities. See Section B.3.2.3. TC

Evidence of Contamination

Hazardous constituents have been identified at the boundaries of 643-7G and 643-28G. However, it has not been determined which of the waste management facilities is the source of these constituents. A monitoring program has been proposed to determine the presence and extent of groundwater contamination. Monitoring was performed during the characterization of the combined radioactive waste burial grounds (643-7G).

Waste Characterization

Candidate mixed wastes placed in the MWMF trenches consist of scintillation fluids and waste oil. The oil originated from pumps in the tritium facilities and reactor areas. Before storage, the waste oil was placed in 208-liter drums containing an absorbent material. Other wastes stored include lead shielding, cadmium, and incidental waste from laboratory and production operations. The mobility and rate of migration of these wastes have not been determined.

B.3.3.2 Old Radioactive Waste Burial Ground (643-G)

The radioactive waste burial ground (643-G) is between the F and H Separations Areas (Figure B-5). The disposal site occupies a 76-acre area and is approximately 10 kilometers from the nearest Plant boundary. The following sections describe the history of waste disposal, evidence of contamination, and waste

characteristics at the site. Section B.3.2.3 discusses the newer burial ground (643-7G), which currently receives low-level radioactive wastes (Jaegge
TC et al., 1987).

History of Waste Disposal

This burial ground is a central site used for the disposal of solid radioactive waste.

The older burial ground began to receive waste in 1952 and was filled in 1972. It was divided into sections for accommodating various levels and types of radioactivity in waste materials: TRU alpha waste, low-level waste (alpha and beta-gamma), intermediate-level beta-gamma waste (intermediate- and low-level beta-gamma solid radioactive wastes are segregated according to radiation measurement), and waste generated off the site. The burial ground was operated in compliance with U.S. Atomic Energy Commission (AEC) regulations and DOE Orders regarding radioactive waste disposal. Inorganic constituents such as lead (used to shield a variety of waste forms), mercury (from gas
TE pumps in tritium facilities), and cadmium (from nuclear reactor control rods) have been placed in the burial ground.

Evidence of Contamination

Past SRP burial practice resulted in direct contact between waste and soil in near-surface backfilled trenches. The annual average gross alpha concentra-
TC tion for all but one well has been approximately constant and fairly low, 1 to 9 picocuries per liter (background level), since 1974. The average gross nonvolatile beta concentration increased in 1984 after having been fairly low and constant for the previous 5 years. Since 1974, the annual average gross nonvolatile beta concentrations have ranged from 13 to 76 picocuries per liter. One research well at the site remains considerably higher in gross alpha (231 picocuries per liter) and gross nonvolatile beta (15,453 picocuries per liter) activity than the other wells. The alpha and beta emitters present in this research well have been identified as primarily plutonium-238, plutonium-239, and strontium-90. The observed variations in concentration are under investigation to determine mechanisms.

Tritium is also found at the burial ground research wells but at much higher concentrations and in larger zones of contamination. The average tritium concentration rose in 1984 to 87.5 million picocuries per liter, more than twice the 1983 value, thus returning to levels observed in 1978, 1980, and 1981. Monitoring has also yielded evidence of nonradioactive chemical species. In 1984, a maximum concentration of 2.9 parts per billion of mercury was observed.

The estimated total activity of radionuclides in the groundwater beneath the 643-G burial grounds is 2.5 millicuries of alpha emitters, 16 millicuries of nonvolatile beta-gamma emitters, and 38,600 curies of tritium. As these data indicate, tritium, in contrast to alpha and nonvolatile beta emitters, is readily leached and moves freely with groundwater flow.

During the time the tributylphosphate-kerosene extraction solvents were stored in underground tanks, approximately 1600 liters of solvent were released to the groundwater as a result of tank leaks and process upsets. Some of the fission and activation products measured in monitoring wells are attributed to this source. Also, the decontamination of equipment with complexing agents might be responsible for the migration of nuclides to several research wells. See Section B.3.2.3.

Waste Characterization

Materials that have been disposed of at the burial ground include (1) contaminated equipment from the radiochemical Separations Area, (2) reactor hardware and resins, (3) spent lithium-aluminum targets, (4) oil from pumps in the tritium facilities and reactor areas, (5) mercury from gas pumps in the tritium facilities (approximately 9000 kilograms), (6) incidental waste from laboratory and production operations, (7) tritiated waste received from the Mound Laboratory, (8) plutonium process wastes from other DOE facilities, and (9) debris from U.S. military plane accidents.

Mechanisms that affect the mobility of radionuclides in groundwater are under investigation. The most likely mechanisms are (1) complex formation with organics, carbonate, and phosphate; and (2) competitive cation exchange with the soil, for groundwaters with high conductivity and high concentrations of various cations. Other conditions that might increase radionuclide migration are abnormal pH, low Eh or dissolved oxygen, and high iron concentrations.

B.3.3.3 F-Area Seepage Basin (904-41G)

Seepage basin 904-41G is one of three currently operating basins in F-Area (Figure B-5). Wastewater flowing to the basins enters basin 1 (904-41G) through a single underground pipe. It flows from basin 1 to basin 2 (904-42G) and then to basin 3 (904-43G) through underground pipelines. This section discusses the history of disposal, evidence of contamination, and waste characteristics common to all three operating basins (Killian et al., 1987a). TC

History of Disposal

Discharges from the F-Area separations facility began in 1955 to the basins. TC
Effluents include low-level radioactive and chemical wastewaters. The purpose of the basins is to provide a controlled release and appropriate decay time for tritium and to retain other radionuclides. The three F-Area seepage basins cover an area of approximately 5.5 acres and have a capacity of about 1.1×10^8 liters. Basin 1 has side dimensions of 27 by 84 meters and a capacity of about 8.9×10^6 liters. TC

Evidence of Contamination

One-meter soil cores have been collected from the bottoms of the F-Area seepage basins. The cores, which were collected at two or three locations per basin, were divided into 0.15-meter intervals for analysis of the 16 radionuclides and 25 cations and anions listed in Table B-7. Approximately 90 percent of the radionuclides, cations, and anions are contained within the top 0.3 meter of the basin soils. TE All radionuclides listed in Table B-7 except cerium-141 were observed in the soil cores. TE Curium-244, cobalt-60, cerium-144, ruthenium-103, and strontium-89 were present infrequently. Silver, beryllium, lead, selenium, tungsten, cyanide, and nitrites were not observed in the cores. Chromium, iron, fluorine, manganese, sodium, nitrate, and titanium were found frequently. The remaining cations and anions were observed less frequently.

TE

Table B-7. Parameters Analyzed in the F- and H-Area Basins Sediment-Characterization Study[a]

Radionuclides	Cations and anions	Cations and anions
Tritium	Arsenic	Nickel
Cobalt-60	Barium	Selenium[b]
Strontium-89, -90	Beryllium[b]	Silver[b]
Niobium-95	Bismuth	Sodium
Zirconium-95	Boron	Tin
Technetium-99	Cadmium	Titanium
Ruthenium-103, -106	Chromium	Tungsten[b]
Iodine-129	Copper	Zinc
Cesium-134, -137	Iron	Nitrates
Cerium-141,[b] -144	Lead[b]	Cyanide
Thorium-232	Lithium	Fluoride
Uranium-233, -235, -238	Mercury	Nitrites[b]
Plutonium-238, -239	Manganese	
Americium-241		
Curium-244		
Promethium-147		

TC [a]Source: Killian et al., 1987a.
[b]Not found.

In March 1985, a well downgradient from the seepage basins was sampled for RCRA Appendix VIII parameters. This well was believed to be the most contaminated downgradient well. The only detected parameters were the following: selenium, barium, cadmium, and nickel. Since 1981, the highest alpha, nonvolatile beta, and tritium concentrations in monitoring wells have been 2700 picocuries per liter, 160,000 picocuries per liter, and 36 million picocuries per liter, respectively.

TE In the fall of 1984, 13 new groundwater monitoring wells were installed in four clusters at the F-Area seepage basins. The well clusters are screened in the Barnwell, McBean, and Congaree aquifers. The wells were sampled first in March and April of 1985. The analyses show that, as expected, the highest levels of contamination are in the shallow water-table wells.

TC Strontium has been emerging in Four Mile Creek from the F-Area basins since 1967. The amount entering the creek annually is about 2 percent of the groundwater strontium inventory in F-Area. Maximum strontium-90 concentrations in groundwater and emergent seep lines range from 0.014 to 0.34 microcurie per liter (Christensen and Gordon, 1983). Alpha activity in groundwater between the basins and Four Mile Creek in the Separations Areas is attributed mainly to uranium discharged to the basins, plus a small amount of natural radioactivity. Alpha concentrations in F-Area groundwater and seep lines range from 1.4×10^{-5} to 6.5×10^{-3} microcurie per liter. Only tritium, strontium-90, and uranium have been detected routinely in groundwater between seepage basins in the Separations Areas and Four Mile Creek in concentrations greater than 10 times the natural background levels.

In 1968 and 1969, intensive groundwater monitoring studies of nitrate levels found values ranging from 100 to 300 milligrams per liter in F-Area, as opposed to concentrations of 3 milligrams per liter in natural groundwater. Values of pH were found to be in the range of 4 to 6 in the basin vicinity. Results of an April 1984 terrain conductivity survey at the F-Area seepage basins to determine areas of potential contaminant migration correlate well with the nitrate studies performed in the late 1960s; however, a new plume was suspected west of basin 3.

Waste Characterization

The primary sources of the effluent being discharged to the basins from the F-Area separations facility are the nitric acid recovery unit, the general-purpose evaporator overheads, the two waste tank farm evaporator overheads, and the overheads of several other process evaporators. Retention basin transfers are another source. The monitor upstream from basin 1 measures flows to the F-Area seepage basins and takes wastewater samples proportional to these flows. The average daily flow into the basins for 1985 was 411,000 liters per day. TC

The F-Area separations facility routinely has released wastewater containing nitrates to the seepage basins since startup in 1955. Release rates vary, but they average 234,300 kilograms per year, as measured from 1961 to 1970, in 1975, and in 1983.

F-Area operations sometimes use mercury to aid in dissolving aluminum-alloy fuels. The sodium hydroxide used in F-Area also contains trace amounts of mercury as an impurity. Most of the mercury is retained in high-level waste tanks, but some is discharged to the basins via evaporator overheads. An estimated 380 kilograms of mercury-contaminated wastewaters were released to the F-Area basins between 1955 and 1970. Between 1971 and the end of 1984, 61 kilograms of mercury were released to the basins.

In a 1983 influent characterization study, the waste stream entering the F-Area seepage basins was sampled nine times between September and December to obtain the concentrations of various chemical constituents. Table B-8 lists the results of that study. For the radionuclides, the number of curies conveyed to the seepage basins in 1982 and 1983 and the volume of effluent were used to calculate the average concentrations. TE

B.3.3.4 F-Area Seepage Basin (904-42G)

See Section B.3.3.3. Basin 2 (904-42G) is 27 by 161 meters with a capacity of 1.7×10^7 liters. TC

B.3.3.5 F-Area Seepage Basin (904-43G)

See Section B.3.3.3. Basin 3 (904-43G) has dimensions of 94 by 219 meters and a capacity of 8.3×10^7 liters. TC

B.3.3.6 F-Area Seepage Basin - Old (904-49G)

Seepage basin 904-49G in F-Area (Figure B-5) measures 59.4 by 91.4 meters. A berm about 1.5 meters wide at the top and about 12.2 meters wide at the bottom

TE

Table B-8. F-Area Seepage-Basin Influent Characteristics[a]

Constituent	Average concentration (mg/liter except for pH)	Constituent	Average concentration (pCi/liter)
Sodium	790	Am-241	308
Calcium	0.5	Ce-141	1,540
Iron	1.7	Ce-144	1,540
Ammonium	24	Cm-242	154
Barium	0.01	Cs-134	6,200
Aluminum	0.78	Cs-137	62,000
Nitrate	1220	I-131	15,400
Carbonate	131	Nb-95	62,000
Nitrite	2	Pm-147	7,690
Chloride	1.2	Pu-238	308
Sulfate	4.6	Pu-239	308
Phosphorus	2.2	Ru-103	30,800
pH	2.93	Ru-106	308,000
Lead	0.12	Sr-89	3,080
Mercury	0.004	Sr-90	6,200
Chromium	0.013	Tritium[b]	1.02×10^{8} [c]
Copper	0.010	U-235	2080
Fluoride	1.5	U-238	2080
Zinc	0.3	Zr-95	62,000

TC

[a]Source: Killian et al., 1987a.
[b]Not included in this specific study; concentration is an approximation based on 1983 data.
[c]Rounded value.

separates the basin into two compartments. The following sections describe TC the history of waste disposal, evidence of contamination, and waste characteristics at the seepage basin (Odum et al., 1987).

History of Waste Disposal

Basin 904-49G, constructed in 1954, was the first seepage basin used on the Plant. It received wastewater from F-Area from November 1954 until mid-May 1955. The seepage rate from this basin proved to be inadequate to handle the increasing volumes of wastewater from F-Area separations operations; thus, three additional basins were constructed in 1955 and routine use of the 904-49G basin was stopped. The basin has been used intermittently since 1955 to divert rainfall runoff or process water from Outfall F-2. Preceding sections discussed the three basins that replaced 904-49G.

Currently, the basin has an accumulation of rainwater with a maximum estimated depth of less than 45 centimeters. Before the summer of 1985, very little water remained in the basin; the total estimated volume was less than 567,000 liters. Current estimates indicate that the basin is seeping very slowly and acting much like a "wet weather pond," with the level increasing during rainy weather and decreasing during periods of low rainfall and high evaporation.

Evidence of Contamination

Recent sediment samples have been collected from the basin. Water and mud samples were collected from 41 different but unknown locations throughout the basin in June 1955. Four monitoring wells have been drilled around the basin; the most recent was installed in late 1984 and sampled during the first quarter of 1985. Sampling results for these wells indicate the presence of conductivity, turbidity, barium, chromium, copper, manganese, lead, zinc, fluoride, nitrate, gross alpha, and gross beta. Statistically significant differences between upgradient and downgradient wells for pH, conductivity, nitrate, barium, manganese, sodium, lead, gross alpha, and gross beta were observed. TC

Waste Characterization

See Section B.3.3.3.

During the operation of basin 904-49G, the wastes would have been sampled for radioactivity. Much of the waste probably was transferred directly to the seepage basin regardless of its chemical content.

The total radioactivity discharged to the basin has been estimated at 1.78 curies. This estimate was based on gross alpha and gross beta measurements and discharge volumes. Estimates of nonradioactive chemical releases (Table B-9) range from less than 19 kilograms of copper and 8 kilograms of nitrite to about 27,000 kilograms of nitrate. TC TE

B.3.3.7 H-Area Seepage Basin (904-44G)

Seepage basin 904-44G is one of four seepage basins in H-Area (Figure B-5). Currently, basins 1 (904-44G), 2 (904-45G), and 4 (904-56G) are in operation. Basin 3 (904-46G) has been inactive since 1962. The wastewater flowing to the basins enters through a single underground pipeline into basin 1. It travels from basin 1 to basin 2 and then to basin 4 through underground pipelines. This section discusses the history of disposal, evidence of contamination, and waste characteristics common to all four basins (Killian et al., 1987b). TC

History of Waste Disposal

The operating H-Area seepage basins have received hazardous and low-level radioactive wastewaters from the H-Area separations facility. The purpose of these basins is to provide a controlled release and appropriate decay time for tritium and to retain other radioactive materials in the soil. The four H-Area basins cover an area of approximately 13.8 acres. Discharges to basins 1, 2, and 3 began in 1955. In 1962, discharges to basin 3 stopped and the use of basin 4 began. Basins 1, 2, and 4 have a total capacity of about 1.4×10^8 liters at overflow conditions. Basin 1 has side dimensions of 27 by 73 meters and a volume of 4.2×10^6 liters. TC TC

TE

Table B-9. Estimated Nonradioactive Chemical Releases to Basin 904-49G[a]

TC

Cation/anion	Release (kg)
Ammonium	29
Calcium	193
Magnesium	93
Sodium	1,111
Iron	550
Copper	<19
Aluminum	72
Lead	<72
Zinc	180
Chloride	53
Nitrite	7.9
Nitrate	27,000[b]
Sulfate	886
Phosphate	48
Chromium	<72

TC

[a]Source: Odum et al., 1987
[b]Rounded value.

Evidence of Contamination

Several studies performed at the F- and H-Area seepage basins to characterize the soil indicate that cesium is retained well by sediments at the Plant, and that none has migrated far enough to be detected in groundwater between seepage basins in the Separations Areas and Four Mile Creek. Plutonium is retained higher up in SRP soils than cesium; sampling of F-Area basin 3 soil in 1971 to a depth of 3.0 meters showed that more than 99 percent of the plutonium is retained in the top 20 centimeters of soil, with a maximum concentration of 1.7 nanocuries per gram.

One-meter soil cores have been collected from the bottoms of the H-Area seepage basins. Cores collected at two to five locations per basin were divided into 15-centimeter intervals for analysis for 16 radionuclides and 25 cations
TE and anions (Table B-8). Approximately 90 percent of all the detected radionuclides, cations, and anions except tritium and nitrate are contained within
TC the top 0.3 meter of soil. With the exceptions of cerium-141, and zirconium-95, all radionuclides listed in Table B-8 were detected in the soil samples; ruthenium-103 was detected in only two samples. With the exceptions of beryllium, cadmium, and selenium, all cations and anions listed in the table were detected in the soil samples; silver, arsenic, cyanide, tungsten, and mercury were detected in only a few samples.

Quarterly groundwater monitoring, in compliance with RCRA and SCHWMR, began in the first quarter of 1982 with seven water-table wells near the H-Area seepage basins. An evaluation of the data for the first five quarters shows that the following parameters are probable groundwater contaminants because of their elevated levels in the basin influents and the consistency of groundwater data: pH, specific conductivity, total dissolved solids, mercury, sodium, nitrate, gross alpha, gross beta, and radium.

Groundwater monitoring for radioactivity parameters has been performed since Plant operations began. Results of alpha measurements for the past several years have shown that the highest concentrations (1.1 to 49.0 picocuries per liter) of alpha emitters are near basins 1 and 2. The highest nonvolatile beta concentrations (48 to 8500 picocuries per liter) are near and downgradient from basins 1, 2, and 3. Tritium concentrations are highest (1 million to 50 million picocuries per liter) near and downgradient from basins 1, 2, and 3.

In the fall of 1984, SRP installed 21 new groundwater monitoring wells in six clusters at the H-Area seepage basins to characterize contaminant migrations. The well clusters are screened in the water-table, Barnwell, McBean, and Congaree aquifers. Regular quarterly sampling began in March and April 1985. Samples were analyzed for tritium, nitrate, sodium, chromium, cadmium, and mercury. The analyses show, as expected, that the highest levels of contamination are in the shallow water-table wells. However, at one well, elevated levels of tritium, nitrate, and sodium were detected in the Congaree aquifer beneath the green clay. According to the results from the other wells screened in the Congaree, the green clay is a significant barrier to vertical contaminant migration. TE

Only tritium, strontium-90, and uranium have been detected routinely in groundwater between the seepage basins in the Separations Area and Four Mile Creek in concentrations greater than 10 times the natural background. Beta activity in groundwater at H-Area is attributed mostly to strontium. Although tritium moves at the same velocity as the groundwater, strontium moves slower than the groundwater because of the ion-exchange characteristics of the soil. Maximum strontium-90 concentrations in groundwater and emergent seep lines range from 5.5×10^{-5} to 1.8×10^{-3} microcurie per liter. Alpha activity in groundwater between the basins and Four Mile Creek in the Separations Areas is attributed mostly to uranium discharged to the basins, plus a small amount of natural radioactivity.

In 1968 and 1969, intensive groundwater monitoring studies of nitrate levels found values ranging from 100 to 250 milligrams per liter at H-Area, compared with concentrations of 3 milligrams per liter in natural groundwater. Also, pH values were found to be in the range of 4 to 6 in the basin vicinity. Results of an April 1984 terrain conductivity survey at the H-Area seepage basins to determine areas of potential contaminant migration correlate well with nitrate studies conducted in the late 1960s.

Special studies have been performed to characterize any potential transport of mercury from the H-Area seepage basins. Most of the mercury released to the basins is accounted for in the basin soil. However, data on mercury in soils from the outcrop along Four Mile Creek, in bottom sediments, and in suspended solids from the creek show that mercury from the H-Area basins is migrating into the creek, but in extremely small quantities. The only measurement of the outcropping of mercury into Four Mile Creek, made in 1971, showed 0.53 gram per day above the outcrop region and 0.89 gram per day below the outcrop, indicating that the basins were contributing about 0.36 gram per day. In a 1984 study, mercury was not observed in the water column at Four Mile Creek sites downstream from the F- and H-Area seepage basins. All mercury concentrations at the Four Mile Creek sites were less than 0.2 part per billion.

Waste Characterization

Primary sources of the wastewaters being discharged to the basins are the nitric acid recovery unit overheads, the general-purpose evaporator overheads, and the overheads of the two waste tank farm evaporators. Other sources of effluent are the cooling water from the tritium facilities, the water transferred from the retention basin, and the wastewater from receiving basins for offsite fuel. The Trebler monitor upstream from basin 1 measures flows to the H-Area seepage basins and takes wastewater samples proportional to these
TC flows. The average daily flow into the basins for 1985 was 577,000 liters per day.

TE Table B-10 summarizes an influent characterization study completed in 1983. The waste stream entering the H-Area seepage basins was sampled 11 times between September and December of that year to determine the concentrations of those chemicals listed in the table. For each radionuclide, the number of curies sent to the seepage basins in 1982 and 1983 and the volume of effluent were used to calculate the average concentration.

The H-Area separations facility routinely has released wastewaters containing nitrates to the seepage basins since startup in 1955. Nitric acid is the major source of nitrates released to the basins. Release rates vary, but they average 220,000 kilograms per year, according to measurements made from 1961 to 1970, in 1975, and in 1983.

Typically, the F- and H-Area basins also receive 90,800 kilograms of sodium hydroxide annually. Before mid-1982, 5450 kilograms of phosphoric acid and 544 kilograms of sodium dichromate were sent to the H-Area basins annually. Sodium hydroxide is present as a result of resin regeneration operations in H-Area. Phosphoric acid and sodium dichromate, used in lithium-aluminum target cleaning, are now sent to the waste tank farm evaporator rather than being discharged directly to the seepage basins.

The estimated cumulative chromium release to the H-Area basins from January 1981 through July 1983 is 740 kilograms. Chromium concentrations in wastewater going to the H-Area basins have been recorded since October 1980.

B.3.3.8 H-Area Seepage Basin (904-45G)

TC Basin 2 has side dimensions of 36 by 140 meters and a capacity of about 1.1×10^7 liters. See Section B.3.3.7.

B.3.3.9 H-Area Seepage Basin (904-46G)

TC Basin 3 has side dimensions of 87 by 152 and 133 by 148 meters and a capacity of about 8.1×10^7 liters. See Section B.3.3.7.

B.3.3.10 H-Area Seepage Basin (904-56G)

TC Basin 4 has a capacity of about 1.3×10^8 liters. See Section B.3.3.7.

Table B-10. H-Area Seepage Basins Influent Characteristics[a]

Constituent	Average concentration (mg/liter, except pH)	Constituent	Average concentration (pCi/liter)
Sodium	17.6	Am-241	13
Calcium	28.0	Ce-141	3,333
Iron	5.1	Ce-144	17,333
Zinc	3.1	Cm-242	6.7
Ammonia	8.0	Cm-244	6.7
Barium	0.08	Co-58	6,670
Potassium	1.0	Co-60	6,670
Aluminum	3.2	Cr-51	33,300
Manganese	0.560	Cs-134	10,000
Magnesium	1.3	Cs-137	60,000
Nitrate	538.0	I-131	3,333
Carbonate	47.0	Nb-95	13,300
Nitrite	1.0	Pm-147	10,000
Chloride	1.1	Pu-238	60
Sulfate	3.9	Pu-239	40
Fluoride	0.1	Ru-103	50,000
Silicon	6.3	Ru-106	50,000
Phosphorus	0.6	Sb-124	1,333
pH	2.37	Sb-125	1,333
Lead	0.18	Sr-89	3,300
Mercury	0.043	Sr-90	6,670
Chromium	0.072	Sr-95	6,670
Copper	0.43	Tritium[b]	9.6×10^{8} [c]
		U-235	33
		U-238	33
		Zn-65	6,670
		Zr-95	6,670

[a]Source: Killian et al., 1987b.
[b]Not included in this specific study; concentration is an approximation based on 1983 data.
[c]Average value based on 1985 data.

B.3.4 MAJOR GEOHYDROLOGIC CHARACTERISTICS

The information in Appendix A related to regional geohydrology was developed from investigations at these waste sites. In this geographic grouping, the Middendorf/Black Creek (Tuscaloosa) consists of two sandy aquifers separated by a confining bed of sandy clay. The Ellenton Formation acts as a confining bed above the Middendorf/Black Creek, although there are sandy parts of the Ellenton that will produce water. Below the Middendorf/Black Creek, a bed of dense clay acts as a confining bed. Locally, the Congaree Formation is 22 to 26 meters thick and consists of well-sorted sands with layers of clay. A pisolitic-clay zone defines the basal Congaree, and the green clay marks the boundary between the McBean and Congaree Formations. The McBean Formation has average thicknesses of 21 and 17 meters in H- and F-Areas, respectively. As described in Appendix A, the McBean consists of an upper clayey sand zone and a lower calcareous sandy clay zone. However, logs on the lithology in the vicinity of F-Area indicate that there is little calcareous material in the lower McBean (Killian et al., 1987a). The basal Barnwell Formation consists of a discontinuous tan clay zone, which acts as a semiconfining layer between the McBean and Barnwell Formations in some portions of the area. The thickness of the tan clay ranges from 2 to 4 meters. The local water table is generally within the Barnwell Formation, although the Barnwell yields limited quantities of water because of the large quantity of fine-grained sediments. The lithology of the Hawthorn Formation is similar to that of the Barnwell, and the two are considered a single hydrostratigraphic unit. Although the Hawthorn lies above the water table, local layers of low permeability occasionally cause perched water tables. Some studies have identified perched water tables at F-Area, 4 to 6 meters below the ground surface and extending 45 meters south toward Four Mile Creek (Killian et al., 1987a).

The vertical-head relationships for wells near the Burial Ground, shown in Figure B-6, are typical of other waste sites in this geographic grouping. The hydraulic pressure in the Congaree is the lowest in the natural hydrologic system at this location. Thus, water flows to the Congaree from both above and below.

The permanent water table at F-Area is about 18 meters below the ground surface, but at H-Area it is only 5 to 8 meters below the surface. Figure B-7 is a water-table map that is based on measurements made in June 1982. The natural discharge from the water table is to Upper Three Runs Creek and its tributaries, and to Four Mile Creek. The water-table divide between the two major creeks bisects the combined 643-7G and 643-28G area.

Hydrologic characteristics of the sediments in the Barnwell, McBean, and Congaree Formations in F- and H-Areas have been determined in a number of laboratory and field tests (Killian et al., 1987a,b). Table B-11 lists the results of small-scale pumping tests. A comparison of the values for hydraulic conductivity in Table B-11 with other values (Killian et al., 1987a,b) shows that a range of at least two orders of magnitude is reasonable for all three formations.

B.3.5 ONGOING AND PLANNED MONITORING

Groundwater monitoring is proceeding at 14 of the 17 waste management facilities in the F- and H-Area geographic grouping. Well-water samples are analyzed quarterly for RCRA and SCHWMR parameters at hazardous and mixed waste management facilities. Typically, the wells are monitored for gross alpha, gross nonvolatile beta, and tritium at low-level waste management facilities. In this geographic area there are 241 wells used to monitor groundwater. DOE plans additional wells to obtain better definition of subsurface conditions and contaminant transport.

Waste site characterization programs have been completed at some of the waste management facilities and are being implemented at others. Characterization generally includes representative sampling of the waste, sampling of the soil and sediment under the waste site, and sampling of the soil and sediment around overflow ditches and process sewers.

Table B-11. Results of Small-Scale Pumping Tests[a] TE

Pumping well	Transmissivity (m^2/day)	Thickness (m)	Hydraulic conductivity (m/day)	Screened zone[b]	Location
HC 2F			0.55	UB	H-Area
H 54	2.3	13.0	0.18	LB	H-Area and Road E
ZW 4	3.6	4.9	0.73	LB	North of Burial Ground
HC 2E			0.19	LB	H-Area
HC 6B			0.13	LB	H-Area
HC 4B			0.070	LB	H-Area
BGC 1D			0.11	LB	Burial Ground
G 28			0.16	LB	Burial Ground
F 73	6.7	14.0	0.49	UM	Road F at Road 4
H 64	9.3	12.0	0.76	UM	H-Area along Road E
F 55	4.9	14.0	0.37	UN	North of Burial Ground
HC 1C			0.29	UM	H-Area
HC 3D			1.7	UM	H-Area
HC 9B			0.46	UM	Northeast of H-Area
HC 13B			0.027	UM	H-Area
HC 8C			0.15	UM	North of Burial Ground
HC 7B			0.040	UM	East of Road F
HC 4A			0.11	UM	H-Area
BGC 1C			0.030	UM	Burial Ground
F 66	0.89	7.0	0.13	LM	Road F at Road 4
H 53	6.5	13.0	0.49	LM	H-Area seepage basin
F 60	2.6	12.0	0.21	LM	F-Area seepage basin
F 65	6.1	10.0	0.61	LM	West of F-Area
HC 6A			0.073	LM	H-Area
FC 1B			0.014	LM	F-Area
HC 3A			0.79	C	H-Area
FC 2A			0.37	C	F-Area
HC 8B			0.37	C	North of Burial Ground

[a]Source: Jaegge et al., 1987. TC
[b]Key: UB, Upper Barnwell Formation; LB, Lower Barnwell Formation; UM, Upper McBean Formation; LM, Lower McBean Formation; C, Congaree Formation.

TE Table B-12 lists the representative monitoring wells at each waste management facility, the site investigations that have occurred, and the results of groundwater, soil, and vegetation monitoring.

B.4 R-AREA WASTE SITES

This geographic grouping is approximately 6 kilometers east of H-Area. As shown on Figure B-8, the grouping contains R-Reactor, which has been on standby status since 1964, and waste sites that are typical of SRP reactor areas. The area drains primarily to Par Pond, to the southeast. The boundaries of this geographic grouping are defined by the areas of influence assigned to the reactor seepage basins, the burning/rubble pits, and the acid/caustic basin.

B.4.1 HAZARDOUS WASTE SITES

B.4.1.1 R-Area Burning/Rubble Pits (131-R and 131-1R)

The R-Area burning/rubble pits are near the central portion of the SRP, south of R-Area and Road G. Each site is roughly rectangular, being approximately 72 meters long, 10 meters wide, and 3 meters deep.

History of Waste Disposal

See Section B.2.1.6.

Evidence of Contamination

No groundwater contamination has been observed to date in the four wells associated with these sites. See Section B.2.1.6.

Waste Characterization

Limited data are available on the extent of contamination and characteristics of the wastes involved at this site. Most of the data have been gathered via groundwater monitoring. Data collected to date indicate no contamination (Huber, Johnson, and Marine, 1987). TC

B.4.1.2 R-Area Acid/Caustic Basin (904-77G)

The R-Area acid/caustic basin is one of six such basins in the Reactor and Separations Areas. These basins are unlined earthen depressions nominally 15 meters long, 15 meters wide, and 2 meters deep.

History of Waste Disposal

See Section B.3.1.1.

Evidence of Contamination

See Section B.3.1.1.

Waste Characterization

See Section B.3.1.1.

B.4.2 LOW-LEVEL RADIOACTIVE WASTE SITES

B.4.2.1 R-Area Bingham Pump Outage Pit (643-8G)

Bingham pump outage pit 643-8G is one of three inactive pits located outside the perimeter fence of R-Area (Figure B-8). Pits 1 (643-8G), 2 (643-9G), and 3 (643-10G) occupy approximately 460, 380, and 1270 square meters of land, respectively. This section discusses the history of disposal, evidence of contamination, and waste characteristics of all three R-Area Bingham pump outage pits (Pekkala, Jewell, Holmes, and Marine, 1987a). TC TC

History of Waste Disposal

Normally, all radioactive solid waste generated in the reactor areas is sent to solid waste burial ground 643-G/643-7G. An exception to this practice was made during 1957 and 1958, when the reactor areas initiated major modifications to their primary and secondary cooling water systems. The outages became known as the "Bingham pump outages." The radioactive waste generated in R-Area during the outages was surveyed, and solid waste with very low levels of or no surface contamination was buried in the outage pits. No pumps are buried in these pits. Subsequently, the outage pits were backfilled with clean soil. Waste with higher levels of contamination was sent to the radioactive solid waste burial ground.

The Bingham pump outage pits have been inactive since 1958; vegetation has grown uncontrolled over the sites. In 1970, radioactivity in samples of vegetation from the surface of the pits was compared with activity in vegetation growing at the SRP perimeter. Radioactivity in vegetation growing above the outage pits was elevated, although still very low. TE

Evidence of Contamination

No monitoring wells have been installed at the outage pits. No core sampling has been conducted there.

Waste Characterization

The pits contain construction equipment such as pipes, cables, ladders, drums, and boxes of miscellaneous hardware (Fenimore and Horton, 1974). At the time of burial, this waste had a radiation level of less than 25 milliroentgens per hour, and no alpha activity was noted. A conservative estimate of the activity buried in R-Area is 1 curie. Table B-13 lists the estimated inventories of this activity at the time of burial and at present. Radioactive decay since the waste was placed in the pits has reduced the inventories of cobalt-60, promethium-137, and ruthenium-103 and 106 to about 5 millicuries. Only cesium-137 and strontium-90 are expected to be present in measurable amounts. TE

TE

Table B-13. Estimated Radionuclide Inventory in Bingham Pump Outage Pits in R-, K-, L-, and P-Areas[a]

Radionuclide	At burial (Ci)	At present (mCi)
Cobalt-60	0.172	5
Strontium-90	0.112	60
Cesium-137	0.414	220
Promethium-147	0.172	0.1
Ruthenium-103, -106	0.130	1×10^{-6}

TC [a]Source: Pekkala, Jewell, Holmes, and Marine, 1987a.

B.4.2.2 R-Area Bingham Pump Outage Pit (643-9G)

Bingham pump outage pit 643-9G is the smallest of three inactive pits outside the R-Area perimeter fence (Figure B-8). Section B.4.2.1 discusses the history of disposal, evidence of contamination, and waste characteristics of all three pits.

B.4.2.3 R-Area Bingham Pump Outage Pit (643-10G)

Bingham pump outage pit 643-10G is the largest of the three inactive pits outside the R-Area perimeter fence (Figure B-8). Section B.4.2.1 discusses the history of disposal, evidence of contamination, and waste characteristics of all three pits.

TE B.4.2.4 R-Area Reactor Seepage Basins (904-57G, 904-58G, 904-59G, 904-60G, 904-103G, and 904-104G)

TE Six inactive and backfilled reactor seepage basins lie outside the R-Area perimeter fence (Figure B-8). Table B-14 lists their physical dimensions. The basins were constructed by excavating below grade and backfilling around the sides at grade level to form earthen dike walls. The depths varied according to estimated needs. The basins did not overflow; rather, water was released to the environment by evaporation and seepage. This section discusses the history of disposal, evidence of contamination, and waste TC characteristics of all six R-Area seepage basins (Pekkala, Jewell, Holmes, and Marine, 1987b).

History of Waste Disposal

Since 1957, earthen seepage basins have been used routinely and almost exclusively at the SRP for the disposal of low-level radioactive purge water from the reactor disassembly basins. This water purge is necessary to keep the tritium concentration in the disassembly-basin water at a level that ensures safe working conditions. Fourteen seepage basins in the reactor areas have TE received disassembly purge water (Stone and Christensen, 1983). Six of these basins are in R-Area.

Table B-14. Locations and Dimensions of R-Area Reactor Seepage Basins[a] TE

Basin	Building	Volume (m^3)	Dimensions (L x W x D, m)
1	904-103G	2.0×10^3	120 x 9 x 3
2	904-104G	2.0×10^3	40 x 14 x 3
3	904-57G	1.7×10^3	90 x 9 x 3
4	904-58G	2.1×10^3	93 x 11 x 3
5	904-59G	2.3×10^3	90 x 12 x 3
6	904-60G	6.2×10^3	150 x 14 x 5

[a]Source: Pekkala, Jewell, Holmes, and Marine, 1987b. TC

In R-Area, basin 1 went into service in June 1957 and began receiving low-level radioactive purge water. Beginning in November 1957, the R-Area seepage basins received approximately 200 curies of strontium-90 and 1000 curies of cesium-137 after the failure of an experimental fuel element during a calorimeter test in the emergency section of the disassembly basin. A large portion of this radioactivity was contained in basin 1. (Basins 2 through 6 went into operation after the incident.) Basin 1 was deactivated and backfilled in January 1958 because of surface outcrop and leakage to an abandoned sewer system. In 1960, basins 2 through 5 were deactivated and backfilled. The ground surface above the five basins was treated with herbicide and covered with asphalt. In addition, a kaolinite dike (down to the clay layer) was constructed around basin 1 and the northwest end of basin 3 to contain lateral movement of the radioactive contamination. Basin 6 was last used in 1964 and was backfilled in 1977. TC TE

Evidence of Contamination

Table B-15 lists the results of analyses of soil in and beneath the backfilled basins in R-Area. Five soil cores were collected in basin 1. One core each was collected from basins 2, 3, 4, and 5. Except for that from basin 3, the cores were centered on the zone beneath the basin that exhibited the highest radiation levels. The maximum radiation level was found in a narrow zone near the bottom of the backfilled basin; only minimal migration occurred below this interface. TE

Cesium-137 was the only gamma-emitter detected in the R-Area basins. As indicated in Table B-16, a maximum concentration of 8000 nanocuries per gram of soil (dry) was found in a segment of the core taken near the inlet discharge of basin 1. The greatest concentration of strontium-90, 41 nanocuries per gram, also was found in basin 1. According to radioassay results from a limited number of soil samples, basin 1 contains approximately 90 percent of the cesium-137 and 50 percent of the strontium-90 in the basin system. TE

Groundwater monitoring at the R-Area reactor seepage basins began in 1958, when 39 wells were drilled. Strontium-90 was first detected in groundwater shortly after the basins received purge water from the emergency section of the disassembly basin following the failure of an experimental fuel element in a calorimeter test in November 1957. Because of the differing stratigraphy of TE

TE

Table B-15. Radionuclides in R-Area Reactor Seepage Basin Soils [nCi/g soil (dry)][a]

Basin	Cesium-137, max.	Strontium-90, max.
1	8000	41
2	810	12
3[b]	0.34	<0.1
4	23	0.07
5	27	2.1

TC

[a]Source: Pekkala, Jewell, Holmes, and Marine, 1987b.
[b]Soil sampled above maximum zone of contamination.

TE

Table B-16. Radioactive Releases to R-Area Reactor Seepage Basins (Ci)[a,b]

Isotope	Release
Tritium[c]	2.0×10^{3}
Cobalt-60	7.2×10^{-2}
Strontium-90	1.0×10^{2}
Ruthenium-103, -106	5.5×10^{-8}
Cesium-137	4.7×10^{2}
Promethium-147	2.0×10^{-3}
Plutonium-239	3.0×10^{-1}

TC

[a]Source: Pekkala, Jewell, Holmes, and Marine, 1986b.
[b]Values cumulative through 1985; values decay-corrected.
[c]Most tritium believed to have left basins via atmosphere or groundwater.

the soils in which the basins were excavated, rapid movement of radioactivity from the basins to the groundwater was confined to the north end of basin 3 and the east end of basin 5.

In 1975, a substantial increase in strontium-90 activity (3400 picocuries per liter) occurred in a groundwater monitoring well on the east side of basin 1. Investigation revealed that the source of the contamination was migration through a construction sewer line that had been abandoned after the completion of R-Area. The sewer line traversed the basin 1 area. Additional wells were installed in 1976 and 1977 southeast of basin 1, but no further movement of contamination has been observed.

Only negligible amounts of tritium are believed to remain at the R-Area basins. Normally, significant amounts of alpha-emitting nuclides are not discharged to reactor seepage basins. However, the basin system in R-Area might have received a small amount of plutonium in 1957 as a result of a fuel element failure during a calorimeter test. The estimated amount of plutonium discharge to the R-Area basins is 3×10^{-1} curie. Essentially all of this plutonium would remain as current inventory.

Waste Characterization

Although many different radionuclides have been discharged to the R-Area reactor seepage basins, almost all of the radioactivity is due to tritium, strontium-90, and cesium-137. Table B-16 lists the inventory of radionuclides released to the seepage basins (corrected for radioactive decay through December 31, 1984). No significant amount of chemical contaminants is believed to have been discharged to the seepage basins. TC TE

Table B-17 lists yearly purge volumes from 1957 through 1964, when R-Reactor went on standby status.

Table B-17. Total Volume of Water Purged to R-Area Reactor Seepage Basins (liters)[a] TE

Year	Release
1957	6.813×10^{6}
1958	6.015×10^{6}
1959	7.570×10^{5}
1960	7.570×10^{5}
1961	1.136×10^{6}
1962	8.500×10^{5}
1963	1.136×10^{6}
1964[b]	7.570×10^{5}

[a]Source: Pekkala, Jewell, Holmes, and Marine, 1987b.
[b]R-Reactor has been in standby status since mid-1964.

B.4.3 MAJOR GEOHYDROLOGIC CHARACTERISTICS

Waste sites in the R-Area geographic grouping are on the Aiken Plateau near the topographic divide between the headwaters of Mill Creek (a tributary of Upper Three Runs Creek) to the north and the drainage to Par Pond to the east. Site-specific geohydrologic information is not available for this area; however, this EIS assumes that the subsurface geology is similar to that near F- and H-Areas (Appendix A), where much of the geohydrologic data on the SRP has been collected. A possible difference between the two areas is the vertical-head relationships of the Congaree and Middendorf/Black Creek (Tuscaloosa) Formations, as shown in Figure B-9. Recent evidence suggests that the vertical head relationships have changed and that the head reversal in the H-Area may currently be absent (Bledsoe, 1987). (See Figure A-7.)

Figure B-9 shows that the head in the Middendorf/Black Creek is lower than that in the Congaree for the general area of the R-Area geographic grouping, whereas in the central portion of the Plant a head reversal exists between the Middendorf/Black Creek and Congaree (higher head in the Middendorf/Black Creek). Consequently, contaminants could enter the Congaree from R-Area waste
TC | sites and migrate into the Middendorf/Black Creek aquifer (Pekkala, Jewell, Holmes, and Marine, 1987b). The head difference map is constructed by subtracting two piezometric maps for which data are somewhat sparse. Thus, the map is useful for indicating general areas of expected head relationships, but it might not be accurate on a site-specific basis.

Figure B-10 is a map of the local water table constructed from data on monitoring wells near R-Area. The natural discharge from the water table is to Mill Creek and several unnamed tributaries of Par Pond. The depth to the water table from the ground surface ranges from 6 to 9 meters near the R-Area seepage basins. The hydraulic gradient toward Mill Creek ranges from 0.006 to 0.009 meter per meter. (See the Glossary.)

B.4.4 ONGOING AND PLANNED MONITORING

Groundwater monitoring is proceeding at 9 of the 12 waste management facilities in the R-Area geographic grouping. Well-water samples are analyzed quarterly for RCRA and SCHWMR parameters at hazardous waste management facilities. Typically, the wells are monitored for gross alpha, gross nonvolatile beta, and tritium at low-level waste management facilities. At least 56 wells in this geographic area are used to monitor groundwater in the vicinity of the 12 facilities. DOE plans additional wells to obtain a better definition of subsurface conditions and contaminant transport.

Waste site characterization programs have been completed at 7 of the 12 facilities and are being implemented at 2 others. Characterization generally includes representative sampling of the waste, the soil and sediment under the waste site, and the soil and sediment around overflow ditches and process sewers.

TE | Table B-18 lists the monitoring wells at each waste management facility, the site investigations that have occurred, and the results of groundwater, soil, and vegetation monitoring.

B.5 C- and CS-AREA WASTE SITES

This geographic grouping is near the center of the Plant, a short distance south of F- and H-Areas. As shown in Figure B-11, it is actually two separate but closely spaced groupings, one formed by waste sites near C-Reactor and the other containing sites in and around the Central Shops (CS) Area. Tributaries to Four Mile Creek drain most of the area. The boundaries of this grouping are formed primarily by burning/rubble pits and the Ford Building seepage basin.

B.5.1 HAZARDOUS WASTE SITES

B.5.1.1 CS-Area Burning/Rubble Pits (631-1G, 631-5G, and 631-6G)

The three CS-Area burning/rubble pits are near the central portion of the SRP, north of CS-Area and south of Road 5. Pit 631-1G is approximately 61 meters long, 9 meters wide, and 3 meters deep. The two other pits measure 117 meters by 11 meters by 3 meters, and 88 meters by 9 meters by 3 meters.

History of Waste Disposal

Rubble disposed of at these sites reportedly includes paper, cans, lumber, and empty galvanized-steel barrels. See Section B.2.1.6.

Evidence of Contamination

See Section B.2.1.6.

Waste Characterization

See Section B.2.1.6.

B.5.1.2 C-Area Burning/Rubble Pit (131-C)

The C-Area burning/rubble pit is near the central portion of the SRP, northwest of C-Area and north of Road A-7. The site is roughly 107 meters long, 7.6 meters wide, and 3 meters deep. TE

History of Waste Disposal

Rubble disposed of at this site reportedly includes paper, wood, concrete, cans, and empty galvanized steel barrels. See Section B.2.1.6.

Evidence of Contamination

Groundwater monitoring wells were installed at all the burning/rubble pits in 1983 and 1984. Groundwater samples recently obtained from the four wells associated with this site have displayed elevated levels of total organic halogens. No sampling and analysis of the soil underlying the pit have been performed to date.

Waste Characterization

Limited data are available on this site. Most of the available raw data have been gathered via groundwater monitoring (Huber, Johnson, and Marine, 1987). TC

B.5.1.3 Hydrofluoric Acid Spill Area (631-4G)

The hydrofluoric acid spill area is west of the cement plant in the CS-Area south of Road 3. The site measures approximately 9 meters by 9 meters.

History of Waste Disposal

Very little is known about the hydrofluoric acid spill area, except that it predates 1970. The site is identified only by a warning sign indicating the presence of a potentially contaminated area. It is uncertain if a spill occurred at this site, or if contaminated soil or containers are buried there.

Evidence of Contamination

The posted warning sign is the only physical indication at the site that contaminants might be present in the subsurface environment. No soil sampling has been performed to date. Some groundwater sampling data are available from four monitoring wells surrounding the site.

Waste Characterization

Limited data are available for this site. Most data have been gathered via
TC groundwater monitoring of four wells that began in January 1985 (Huber and Bledsoe, 1987a).

The potential for migration of hydrofluoric acid is based largely on the ion-exchange potential of the soil environment. In the saturated pore space of the soil, compartment, hydrofluoric acid would be expected to dissociate and behave like a weak acid (Ka: 6.4×10^{-4}). The fluoride ions would be subject to reactions with colloid-size particles having the capability to exchange ionic constituents adsorbed on the particle surfaces.

Ion-exchange mechanisms (dissolution and precipitation) occur dynamically in the soil, and some fluoride ions probably can be found in solution owing to their displacement by other anionic species (i.e., carbonate and bicarbonate). Soil pH is a factor in ion-exchange selectivity. The data collected from groundwater sources near the hydrofluoric acid spill area indicate that fluoride ions are present, either in solution or adsorbed on colloidal particles (fluoride was detected in four of eight samples, at an average concentration of 0.15 milligram per liter).

Accordingly, there is a potential for groundwater transport of fluoride ions by advection. However, because groundwater flow through the porous medium
TE will introduce more sites for ion exchange, some permanent adsorption of fluoride ions probably will occur. In acidic conditions, attenuation of the fluoride concentration in the groundwater can be expected. Consequently, while migration of fluoride ions will occur, given the relatively low concentrations detected in the groundwater to date (maximum concentration: 0.17 milligram per liter), the attenuation mechanism can be expected to prevail; fluoride concentrations should decrease with increasing distance from the spill area.

B.5.2 LOW-LEVEL RADIOACTIVE WASTE SITE

The Ford Building waste site (643-11G) is north of the Ford Building in the CS-Area (Figure B-11). The site is rectangular, measuring approximately 7 meters by 52 meters. The following paragraphs discuss the waste site disposal
TC history, evidence of contamination, and waste characteristics (Huber et al., 1987).

History of Waste Disposal

The site origin and history are uncertain. The site is chained on three sides and identified by a regulated area sign and a "Clean Pans Only" sign. Beyond the chained area are pieces of lumber and a load lugger pan containing soiled rubber gloves. Outside the chained area are weathered shoe covers, step-off pads, and coveralls. Regulated work might have been performed there and the site improperly cleaned. TE

Evidence of Contamination

Soil characterization studies have not been performed and no monitoring wells have been installed specifically for this waste site. Monitoring wells for the Fire Department training facility and the Ford Building seepage basin are nearby. These wells are all crossgradient from the waste site, and are too far distant from the flow path of groundwater beneath the Ford Building waste site to be of value in monitoring groundwater conditions at this site. TE

Waste Characterization

Evidence indicates that regulated work might have been performed at the site, and protective clothing worn by the personnel was improperly disposed of. An oil line from the Ford Building ruptured in the vicinity of the waste site during the 1970s, releasing unknown quantities of oil.

B.5.3 MIXED WASTE SITE

The Ford Building seepage basin (904-91G) is in the CS-Area (Figure B-11). It is rectangular in shape and has an approximate 600 cubic meters capacity. The following sections discuss the history of disposal, evidence of contamination, and waste characteristics of the basin (Pekkala, Jewell, Holmes, Simmons, and Marine, 1987). TC

History of Waste Disposal

The Ford Building was used to repair the SRP's slightly contaminated process equipment. Highly contaminated equipment requiring repair was decontaminated in the individual custodial area before being transported to the Ford Building. Because of the contamination, wastewater generated at the Ford Building during the equipment repair work also contained low levels of contamination. Consequently, the wastewater was drained into a 23,000-liter retention tank adjacent to the Ford Building for sampling and radioanalysis. Then it was either released into the seepage basin or sent to Waste Management Operations (WMO) for concentration and disposal. TE TE

The purchase of new heat-exchanger heads for the reactor buildings reduced the need for heat-exchanger repairs, and the Ford Building seepage basin was retired in 1984. The basin is now dry except for occasionally impounded rainwater. Presently, wastewater generated in the Ford Building is removed for concentration, disposal, or storage. TC

Evidence of Contamination

In 1985, a comprehensive soil sampling and analysis program was performed to characterize sediment from the floor and walls of the Ford Building seepage basin, as well as sediment beneath the underground pipeline from the retention tank to the basin. Inside the basin, the concentration levels of cesium-137, cobalt-60, and strontium-90 are significantly above background. Along the pipeline, only strontium-90 shows elevated concentration levels. Along the basin walls, none of the radionuclides show elevated concentration levels.

The concentration profiles for most metals and inorganics in the basin floor dropped rapidly to background within the first 0.6 meter of soil depth. The metals with elevated concentration levels (i.e., greater than 2 times background) in the top 8 centimeters of basin soil are aluminum, cadmium, chromium, copper, iron, mercury, nickel, selenium, and zinc. In the soil beneath the pipeline, aluminum, arsenic, cadmium, chromium, and iron have elevated concentration levels. The inorganic ions with elevated concentration levels in the top 8 centimeters of basin soil are ammonia, nitrogen, fluoride, sulfate, and total phosphates. Along the pipeline, only total phosphate levels are elevated. Along the basin walls, none of the inorganic ions show elevated concentration levels. No significant concentrations of organics were detected in the basin floor and walls or beneath the pipeline.

Three monitoring wells are near the Ford Building seepage basin. A statistical analysis of groundwater monitoring data indicates that levels of nitrate, mercury, and lead are elevated. However, the concentrations of these constituents remain below maximum contaminant levels.

Waste Characterization

TE Table B-19 is an inventory of the radionuclides released into the basin from 1964 to 1984, including the 1984 decay corrections. In addition to radionuclides, trace amounts of surfactants, oils, and grease might have been added to the wastewater stream. Through the end of 1984, the basin received 1,440 cubic meters of wastewater.

TE Table B-19. Radioactive Releases to Ford Building Seepage Basin, 1964-1984 (Ci)[a]

TE

Isotope	Original release	Decay corrected, 1984
Tritium	4.7×10^{2}	1.6×10^{2}
Cobalt-60	6.9×10^{-4}	5.1×10^{-4}
Strontium-90	7.4×10^{-5}	7.0×10^{-5}
Cesium-137	2.4×10^{-4}	2.4×10^{-4}
Alpha (unidentified)	4.9×10^{-4}	4.9000×10^{-4}

TC [a]Source: Pekkala, Jewell, Holmes, Simmons, and Marine, 1987.

B.5.4 MAJOR GEOHYDROLOGIC CHARACTERISTICS

Waste sites in the C- and CS-Areas geographic grouping are on the Aiken Plateau between a tributary of Four Mile Creek and Pen Branch. Site-specific geohydrologic data for this area are sparse; the geohydrologic characteristics probably are similar to those in the F- and H-Areas geographic grouping (3.2 kilometers north). Appendixes A and B (Sections A.2 and B.3.4) discuss the geohydrology of the central portion of the Plant. Recent evidence suggests that a portion of the CS-Area may currently lie in a region of no head reversal (Bledsoe, 1987). TC

Three water supply wells are in the Central Shops area. They are located in the Middendorf/Black Creek (Tuscaloosa) Formation (904-83G), in the McBean (705-72G), and in both the McBean and the Middendorf/Black Creek (905-71G). Figure B-12 shows a log of well 905-71G. Of particular geohydrologic significance are the three major confining beds discussed in Appendix A (i.e., the tan clay, the green clay, and the Ellenton Formation). Although no site-specific information on vertical head gradients is available, this EIS assumes the head relationships are similar to those in F- and H-Areas (Section B.3.4). Hydraulic heads decline with depth down to the Congaree Formation, then reverse and increase with depth in the Middendorf/Black Creek.

Figure B-13 is a water-table map for C-Area. The natural groundwater discharge from the Barnwell and McBean Formations near the Ford Building waste site is believed to be to Pen Branch. The discharge from the Congaree is probably to the Savannah River (e.g., to the southwest) along a gradient of about 0.002 meter per meter (Huber et al., 1987). The water-table at the Ford Building waste site is about 14.6 meters below ground level. TC

B.5.5 ONGOING AND PLANNED MONITORING

Groundwater monitoring is under way at six of the seven waste management facilities in the C- and CS-Area geographic grouping. Well-water samples are analyzed quarterly at hazardous and mixed waste management facilities for RCRA and SCHWMR parameters. Typically, wells are monitored for gross alpha, gross nonvolatile beta, and tritium at low-level waste management facilities. In this geographic area, 15 wells are used to monitor groundwater. DOE plans additional wells for subsurface conditions and contaminant transport.

Characterization generally includes representative sampling of the waste, the soil and sediment under the waste site, and the soil and sediment around overflow ditches and process sewers.

Table B-20 lists the representative monitoring wells at each waste management facility, the site investigations, and the results of groundwater, soil, and vegetation monitoring. TE

B.6 TNX-AREA WASTE SITES

The TNX-Area geographic grouping is approximately 7 kilometers southwest of C-Reactor along Road 3 and about 15 kilometers south of A-Area in the southwest portion of the Plant. Drainage is to the Savannah River, which forms part of the western boundary of the area. The TNX facilities and portions of the D-Area coal-fired powerhouse are in this grouping. The old TNX seepage basin and the D-Area burning/rubble pits define the boundaries of this geographic grouping. Figure B-14 shows the locations of the five waste sites described in the following sections.

B.6.1 HAZARDOUS WASTE SITE

TC The D-Area burning/rubble pits are near the western perimeter of the Savannah River Plant, west of D-Area and east of Road A-4.7. The site configuration is a trapezoidal area of approximately 7000 square meters.

History of Waste Disposal

Rubble waste disposed of at these pits reportedly included concrete, metal, lumber, and telephone poles. See Section B.2.1.6.

Evidence of Contamination

See Section B.2.1.6.

Waste Characterization

See Section B.2.1.6.

B.6.2 LOW-LEVEL RADIOACTIVE WASTE SITE

TC The TNX burying ground is part of the TNX facility east of the Savannah River on the terrace known as the Ellenton Plain. The burying ground consists of three known areas on a bluff 45 meters above the Savannah River swamp. The sites known to contain radioactive waste are (1) an area beneath a transformer pad by Building 673-T, (2) a rectangular area beneath Building 711-T, and (3) an L-shaped area beneath Office Trailer Building 676-8T. A fourth area is believed to be east of Building 673-T. The SRP boundary nearest any of the burial sites is the Savannah River, approximately 396 meters west. The following sections discuss the history of waste disposal, evidence of contamination, and waste characteristics of the sites (Dunaway, Johnson, Kingley, Simmons, and Bledsoe, 1987a).

History of Waste Disposal

In 1953, an experimental evaporator containing approximately 590 kilograms of uranyl nitrate exploded at the TNX facility. Because the SRP radioactive waste burial ground (Building 643-G) was not in operation, debris from the explosion was collected and buried at the TNX burying ground (Building 643-5G). The waste included such materials as conduit, drums, tin, and structural steel. The site also received other waste, primarily depleted uranium characteristic of that generated at the process facility. No material was buried at the site after the SRP radioactive waste burial ground became operational.

Most of the material was excavated and sent to the SRP burial ground between 1980 and 1984. The remaining TNX burying sites are beneath asphalt, buildings, and transformer pads at depths of approximately 1.8 to 2.4 meters. An estimated 27 kilograms of uranyl nitrate remain buried. This is approximately 5 percent of the initial buried amount.

Evidence of Contamination

Uranyl nitrate is a possible contaminant of the soils surrounding the TNX burying ground, but no sediment data are available to confirm this possibility. There are no groundwater-monitoring wells in the immediate vicinity of the burying ground. Wells YSB 1A through 4A, around the new TNX seepage basin, are approximately 210 meters east; wells XSB 1 through 4, around the old TNX seepage basin, are approximately 91 meters west. Sections B.6.3.1 and B.6.3.2 discuss groundwater-monitoring data for these wells.

Waste Characterization

The original waste consists of conduit, drums, tin, and structural steel contaminated with uranyl nitrate. The site has also received depleted uranium characteristic of that generated from the process facility, as well as other undescribed waste.

B.6.3 MIXED WASTE SITES

B.6.3.1 TNX Seepage Basin - Old (904-76G)

The old TNX seepage basin is in the southwestern section of the TNX facility (Figure B-14). The basin was constructed in two sections: an inlet section and a large main section. Together they encompassed approximately 0.2 acre. The following sections describe the history of waste disposal, evidence of contamination, and waste characteristics at the seepage basin (Dunaway, Johnson, Kingley, Simmons, Bledsoe, and Smith, 1987; Simmons, Bledsoe, and Bransford, 1985). TC

History of Waste Disposal

The old TNX seepage basin was built in 1958 to receive wastewater from pilot-scale tests conducted at TNX in support of the Defense Waste Processing Facility (DWPF) and the Separations Areas (Dunaway, Johnson, Kingley, Simmons, Bledsoe, and Smith, 1987). In 1980, the basin was closed, and the wastewater flow to the basin was diverted to the new TNX seepage basin (Section B.6.3.2). When it was in operation, the old basin received process wastewater through an underground vitrified pipeline 20 centimeters in diameter. This pipeline entered the basin through the north wall of the settling section. A 13-centimeter weir permitted effluent from the settling section to flow into the main section. A weir of comparable size across the west wall of the main section directed basin overflow down into the nearby TNX swamp along Outfall X-2. During the basin's 22-year loading history, its overflow has created an outfall delta about 30 meters wide inside the swamp. TC

In 1981, the west wall of the basin was breached to drain the standing free waters into the adjacent wetlands. The basin was backfilled with a sand and clay mixture. Currently, part of the top of the old basin is paved with asphalt. Office Trailer Building 675-7T is on this pavement beside an equipment laydown area. Vegetation near the basin and outside the TNX security fence primarily consists of sparse-to-thick woods. Vegetation inside the fence is primarily centipede grass.

Evidence of Contamination

TE In 1984, a program was begun that defined the extent of chemical and radionuclide contamination in the vicinity of the old TNX seepage basin. This program included sampling and analyses of sediment from beneath the basin and continued sampling of the groundwater from seven monitoring wells.

The sampling detected curium-243, curium-244, plutonium-239, plutonium-240, radium-228, thorium-228, uranium-235, silver, chromium, copper, mercury, nickel, and cyanide in the basin sediment. These constituents were concentrated in the northeastern section of the basin within the top 61 centimeters of bottom sediment.

Groundwater monitoring results indicate that mercury, manganese, nickel, total organic halogens, and nitrate are present.

Waste Characterization

Approximately 40 compounds were in use at the TNX facility during the basin's operation. These compounds probably were sent to the basin at some time during its 22-year loading history. Among the significant wastes discharged to the basin were mercury and depleted uranium.

B.6.3.2 TNX Seepage Basin - New (904-102G)

The new TNX seepage basin is in the southeastern section of the TNX facility (Figure B-14). The basin consists of a small inlet section and a large seepage section. An underground pipe connects the two rectangular sections that encompass approximately 1620 square meters of land. A pipe through the southeast wall of the larger section directs the basin overflow down Outfall X-13. This outfall eventually empties into the Savannah River. The following sections describe the history of waste disposal, evidence of contamination, and waste characteristics at the seepage basin (Dunaway, Johnson, Kingley, TC Simmons, and Bledsoe, 1987b).

History of Waste Disposal

The new TNX seepage basin, operating since 1980, replaced the old basin (Section B.6.3.1). It receives process wastewater from pilot-scale tests conducted at the TNX facility in support of the DWPF and the Separations Areas. Batch discharges are neutralized before release to the basin. The basin is scheduled for closure in the third quarter of 1987 when the TNX Effluent Treatment Plant begins operation. The closure of the basin will follow applicable Federal and State regulations.

Evidence of Contamination

Soil samples were collected from cores beneath and adjacent to the basin during the fourth quarter of 1985. Analytical results indicate that no significant organic contamination exists in any of the sediments sampled. Phenol and thorium were detected at low concentrations in one layer of the sediment cores outside the basin. Barium, nickel, chromium, lead, nitrates, phosphate, and sodium were detected in the top 0.15 meter of sediment.

Four groundwater monitoring wells have been installed around the new TNX seepage basin. These wells are sampled quarterly and analyzed for nutrients, anions, metals, organics, radioactivity, and standard constituents.

Waste Characterization

Most of the wastewater sent to the basin after 1983 contains simulated nonradioactive DWPF sludge and other laboratory chemicals. Before 1983, simulated nonradioactive salt supernate was sent to the basin. Tables B-21 and B-22 list the composition of the sludge and supernate, respectively, and Tables B-23 and B-24 provide chemical analyses of the basin influent and effluent, respectively. The influent and effluent data were obtained from a 12-week characterization program initiated in January 1984. Average effluent flow rates are not available. TE

Table B-21. Composition of Simulated DWPF Sludge (percent)[a] TE

Component	Weight
Ferric hydroxide	43.19
Aluminum hydroxide	17.81
Silicon dioxide	4.94
Manganese dioxide	7.41
Sodium hydroxide	4.43
Zeolite[b]	4.87
Sodium nitrate	4.43
Calcium carbonate	5.66
Nickel hydroxide	3.42
Other chemicals	3.84

[a]Source: Dunaway, Johnson, Kingley, Simmons, and Bledsoe, 1987b. TC
[b]Linde Ion-Siv IE-95.

B.6.4 MAJOR GEOHYDROLOGIC CHARACTERISTICS

The near-surface geology of the TNX Area geographic grouping consists of river-terrace deposits of sand, silt, and clay, typically with a significant organic content. These materials are underlain successively by Tertiary sediments, which are difficult to distinguish, and the Ellenton and Middendorf/Black Creek (Tuscaloosa) Formations. Figure B-15 shows the stratigraphy in the vicinity of the old TNX seepage basin inferred from lithologic and geophysical logs developed for a nearby well (XSB-3T). In the central portion of the Plant, the McBean and Congaree Formations are separated by a confining layer described as the green clay (Appendix A).

A detailed water-table map is not available for the area. The natural discharge for the water-table aquifer is to the Savannah River swamp. The vertical head relationships in this area are similar to those in the F-Area where TC

TE

Table B-22. Chemical Composition of Simulated Salt Supernate (percent)[a]

Component	Weight
Sodium nitrate	41.6
Sodium nitrite	14.8
Sodium aluminate	9.10
Sodium hydroxide	19.06
Sodium carbonate	6.55
Sodium sulfate	8.34

TC

[a]Source: Dunaway, Johnson, Kingley, Simmons, and Bledsoe, 1987b.

TE

Table B-23. Analysis of TNX Seepage Basin Influent[a,b]

Parameter	Units	Average	Maximum	Minimum	Number of samples
BOD_5	mg/liter	40	311	<6	56
TSS	mg/liter	35	296	1	53
TDS	mg/liter	124	804	54	36
TOC	mg/liter	13	86	<5	57
Grease and oil	mg/liter	<5	7	<5	8
pH	pH	7.5-8.0	12.3	2.2	1018[c]
Flow rate	m^3/min	0.099	0.33	0.0038	1018[c]

TC

[a]Source: Dunaway, Johnson, Kingley, Simmons, and Bledsoe, 1987b.
[b]Values obtained from 24-hour, flow-weighted, composite samples collected from 676-3T manhole.
[c]Hourly.

TC TC

the head in the Middendorf/Black Creek is consistently above that of the Congaree. Thus, water cannot move from the Congaree to the Middendorf/Black Creek Formation. The piezometric surface of the "Tuscaloosa" in the vicinity of the TNX facility is commonly above the land surface (Dunaway, Johnson, Kingley, Simmons, and Bledsoe, 1987a). There are no available data on the hydraulic properties of the geologic strata underlying the TNX-Area waste sites.

B.6.5 ONGOING AND PLANNED MONITORING

Groundwater monitoring is proceeding at four of the five waste management facilities in the TNX-Area geographic grouping. Well-water samples are analyzed quarterly for RCRA and SCHWMR parameters at hazardous and mixed waste management facilities. Typically, wells are monitored for gross alpha, gross

Table B-24. Analysis of TNX Seepage Basin Effluent[a,b] TE

Parameter	Units	Average	Maximum	Minimum	Number of samples
BOD_5	mg/liter	29	133	<6	37
TSS	mg/liter	33	108	5	37
TDS	mg/liter	113	168	40	34
TOC	mg/liter	10	17	<5	37
Grease and oil	mg/liter	<5	5	4	10
pH	pH	9.8	11.6	7.5	35

[a]Source: Dunaway, Johnson, Kingley, Simmons, and Bledsoe, 1987b. TC
[b]Values from grab samples of basin overflow at Outfall X-13.

nonvolatile beta, and tritium at low-level waste management facilities. In this geographic area, 15 wells are used to monitor groundwater. DOE plans additional wells to obtain a better definition of subsurface conditions and contaminant transport.

Waste site characterization programs are completed at two of the facilities and are being implemented at two others. Characterization generally includes representative sampling of the waste, the soil and sediment under the waste site, and the soil and sediment around overflow ditches and process sewers.

Table B-25 lists the representative monitoring wells at each waste management facility, the site investigations that have occurred, and the results of groundwater, soil, and vegetation monitoring. TE

B.7 D-AREA WASTE SITES

This geographic grouping is approximately 1000 meters west of Road A (South Carolina Highway 125) and 1200 meters north of the D-Area steam plant (Figure B-14).

B.7.1 HAZARDOUS WASTE SITE

B.7.1.1 D-Area Waste Oil Basin (631-G) TE

The D-Area waste oil basin is in the western portion of the Plant, north of D-Area and west of Road A. The basin is approximately 117 meters long, 16 meters wide, and 2 meters deep.

History of Waste Disposal

The D-Area waste oil basin began receiving waste oil products from D-Area in 1952. This oil might have been contaminated with hydrogen sulfide. Other liquids potentially contaminated with toxic chemicals were brought to the oil basin. In 1973, when burning waste oil ceased plantwide, waste oils not TE acceptable for powerhouse incineration were deposited in the basin. The basin possibly received waste oil containing chlorinated organic compounds and other organics (Huber, Johnson, and Bledsoe, 1987). The basin was closed in January 1975 and was backfilled with soil. Approximately 0.3 meter of standing oil remained in the basin when it was backfilled.

Evidence of Contamination

Sampling and analysis of the soils beneath the basin have not been performed; however, the intention to do so in the future is documented. Three groundwater monitoring wells were installed near the basin in May 1983, and groundwater sampling began in March 1984. A fourth groundwater monitoring well was installed in June 1984. Based on groundwater monitoring results, tetrachloroethylene was selected for environmental assessment (Huber, Johnson, and Bledsoe, 1987).

Waste Characterization

Limited information is available on the nature and extent of contamination associated with the D-Area oil seepage basin. Historic data indicate oily wastes were deposited in large volumes, and some might have been contaminated with chlorinated compounds and other toxic chemicals.

B.7.2 MAJOR GEOHYDROLOGIC CHARACTERISTICS

The D-Area waste oil basin is located on a terrace deposit of the Savannah River. These sands, silts, and clays are 6 to 12 meters thick and blanket the underlying Tertiary deposits (COE, 1952). No detailed geologic data are available for the immediate area; however, the subsurface geology should be similar to the hydrostratigraphy of the nearby TNX basins (Section B.6.4). A U.S. Army Corps of Engineers study in D-Area (COE, 1952) indicates that a calcareous zone, a zone of low penetration resistance and high drill-mud loss, occurs between an elevation of 35 and 21 meters.

Four RCRA-type monitoring wells have been installed near the basin at depths of 10.7 to 12.8 meters from the ground surface. The water table in these wells has a depth of about 6 meters. The natural discharge from the water-table aquifer is to the Savannah River swamp. The higher piezometric surface in the Congaree and Middendorf/Black Creek (Tuscaloosa) aquifers at this location indicates that the hydraulic gradient of groundwater in confined aquifers is upward. Groundwater movement is downward in the water table (Huber, Johnson, and Bledsoe, 1987).

B.7.3 ONGOING AND PLANNED MONITORING

Groundwater monitoring is proceeding at the single waste-management facility in the D-Area geographic grouping. Four wells are used to monitor groundwater near this facility. Well-water samples are analyzed quarterly for RCRA and SCHWMR parameters.

A waste site characterization program is being implemented at the facility. Characterization generally includes representative sampling of the waste, the soil and sediment under the waste site, and the soil and sediment around overflow ditches and process sewers.

Table B-26 lists the representative monitoring wells at the waste management facility, the site investigations that have occurred, and the results of groundwater, soil, and vegetation monitoring. TE

B.8 ROAD A AREA WASTE SITE

This geographic grouping is approximately 400 meters southwest of Road A near the Road 6 intersection (Figure B-16). It is about 3 kilometers east of TNX and D-Area facilities.

B.8.1 MIXED WASTE SITE

B.8.1.1 Road A Chemical Basin (904-111G) TE

The Road A chemical basin is also known as the Baxley Road dump. It is approximately 800 meters west of the intersection of SRP Roads A and 6 (Figure B-16). The original basin was irregular in shape with average side dimensions of approximately 30 meters by 53 meters. The following sections describe the history of disposal, evidence of contamination, and waste characteristics at the basin (Pickett, Muska, and Bledsoe, 1987). TC

History of Waste Disposal

The history of disposal at the Road A chemical basin is vague. The basin was closed and backfilled in 1973. An area significantly larger than the original basin was graded and revegetated with vetch (*Sericea lespedeza*). The regraded area, about 3.6 acres, is surrounded by pines and hardwoods with a large stand of bottomland hardwood approximately 200 meters downslope.

Evidence of Contamination

No characterization studies of the soils beneath or around the basin have been performed. The analytical results from four monitoring wells indicate that lead is the only constituent that is significantly elevated in a downgradient well. TC

Waste Characterization

The nature and quantities of materials disposed in the basin are not known. A 1983 report lists the contents as miscellaneous radioactive and chemical aqueous wastes (Ross and Green, 1983). Based on slightly elevated levels in monitoring wells, lead and uranium-238 were selected for environmental analysis. TC

B.8.2 MAJOR GEOHYDROLOGIC CHARACTERISTICS

The Road A chemical basin is on the Aiken Plateau close to the escarpment that separates the Plateau from the Ellenton Plain. The ground surface in the basin area slopes toward the Ellenton Plain at a gradient of about 0.08 meter per meter. Four Mile Creek, Pen Branch, and the Savannah River are located approximately 1829 meters northwest, 2134 meters east, and 5486 meters west, respectively, from the basin site (Pickett, Muska, and Bledsoe, 1987). TC

No detailed geologic data are available on the vicinity of the Road A chemical basin. Four monitoring wells are near the basin; however, these wells are only about 18 meters deep. The closest borings with good geologic control include one well (XSB-3T) at the TNX facility, approximately 6 kilometers west-northwest of the basin (see Section B.6.4), and two wells drilled in D-Area by the U.S Army Corps of Engineers (COE, 1952). A well cluster (seven to eight wells) is currently being installed about 2.6 kilometers southeast of the basin. This well-drilling operation includes a continuously cored geologic boring at a depth of about 300 meters below the ground surface. The stratigraphy for this geographic grouping is believed to be similar to that shown in Figure B-15 for the TNX facility (Section B.6.4). The formational contacts at the Road A chemical basin would be slightly deeper than those shown in Figure B-15 because the unconsolidated coastal-plain sediments strike about N. 60°E and dip to the southeast at about 2 to 4 meters per kilometer, and the basin is geologically down-dip from well XSB-3T (Siple, 1967).

The water table at the Road A chemical basin is at an elevation of about 52 meters, or a depth of about 9 meters below the ground surface (Pickett, Muska,
TC and Bledsoe, 1987). The water table is probably within the McBean Formation and discharges westward to the Savannah River swamp. The natural discharge of the Congaree Formation is to Pen Branch, the Savannah River, and the marshes and swamps of the river. The vertical head relationships for this area are
TC assumed to be similar to those in the F-Area where Middendorf/Black Creek (Tuscaloosa) heads are higher than the Congaree heads (Pickett, Muska, and Bledsoe, 1987). Thus, water discharges from the Middendorf/Black Creek upward into the overlying sediments in the Savannah River Valley.

B.8.3 ONGOING AND PLANNED MONITORING

Groundwater monitoring is proceeding at the single waste management facility in the Road A Area geographic grouping. Four wells in this geographic area are used to monitor groundwater in the vicinity of this facility. Well-water samples are analyzed quarterly for RCRA and SCHWMR parameters.

TE Table B-27 lists the representative monitoring wells at the waste management facility, the site investigations, and the results of groundwater, soil, and vegetation monitoring.

B.9 K-AREA WASTE SITES

The approximate boundaries of the K-Area geographic grouping are Road B on the south and Road 6 on the northwest. This grouping is formed by waste sites associated with K-Reactor. Drainage is primarily to Indian Grave Branch, a tributary of Pen Branch. Figure B-17 locates the waste sites in this grouping and shows its proximity to the Road A Area waste site.

B.9.1 HAZARDOUS WASTE SITES

B.9.1.1 K-Area Burning/Rubble Pit (131-K)

K-Area burning/rubble pit is near the central portion of the Plant, east of K-Area and between Road 6-4.21 and Road 6-4.2. The site is rectangular, approximately 71 meters long, 10 meters wide, and 3 meters deep.

History of Waste Disposal

Rubble waste disposed at this site reportedly included paper, lumber, cans, empty galvanized steel drums, and scrap metal. See Section B.2.1.6.

Evidence of Contamination

See Section B.2.1.6.

Waste Characterization

See Section B.2.1.6.

B.9.1.2 K-Area Acid/Caustic Basin (904-80G)

The K-Area acid/caustic basin is one of six such basins in the Reactor and Separations areas. These basins are unlined earthen depressions with nominal dimensions 15 meters long, 15 meters wide, and 2 meters deep.

History of Waste Disposal

See Section B.3.1.1.

Evidence of Contamination

See Section B.3.1.1. Identification of the environmental impacts of the basins is in progress. A program to sample the contents and the soils beneath the basins is under way. A review of existing data from the monitoring wells installed around all the basins, except that in H-Area, shows no significant impacts on groundwater quality; however, some slight increases in sulfate, conductivity, and pH levels are noted for some of the basins.

Waste Characterization

See Section B.3.1.1.

B.9.2 LOW-LEVEL RADIOACTIVE WASTE SITES

B.9.2.1 K-Area Bingham Pump Outage Pit (643-1G)

The Bingham pump outage pits are outside the perimeter fences of K-, L-, P-, and R-Areas near the center of the Plant. They are between 7.2 and 9.8 kilometers from the nearest SRP boundaries. The K-Area pit is 9 kilometers from the nearest boundary on a gentle slope above a tributary of Indian Grave Branch 290 meters away. The following sections describe the history of waste disposal, evidence of contamination, and waste characteristics at the K-Area Pit (Pekkala, Jewell, Holmes, and Marine, 1987a).

History of Waste Disposal

Normally, all radioactive solid waste generated in the reactor areas is sent to solid waste burial ground 643-G/643-7G. An exception to this practice was made during 1957 and 1958 when the reactor areas initiated major modifications to their primary and secondary cooling water systems. C-Area was the first to modify, followed by K-, L-, P-, and R-Areas. The outages became known as the "Bingham pump outages." No pumps are buried in the waste pits. All radioactive waste generated was surveyed, and solid waste with very low levels of surface contamination was buried between May and September 1957 in a pit near the area. The pit contains miscellaneous construction equipment such as pipes, cables, ladders, drums, and boxes of miscellaneous hardware (Fenimore and Horton, 1974). The waste, with a volume of about 7700 cubic meters, was covered with clean backfill, including a final cover at least 1.2 meters thick.

The K-Area pit has been inactive since 1958; vegetation has grown uncontrollably over it.

Evidence of Contamination

In 1970, radioactivity in samples of vegetation from the surface of the Bingham pump outage pits was compared with activity in vegetation growing at the SRP perimeter. The vegetation from the outage pits showed little or no
TE elevation in activity (Table B-28). There are no nearby monitoring wells to provide groundwater information on the pits, and there is no history of pit
TC sediment characterization or core sampling. The bottom of the pit is 12 meters above the water table.

TE Table B-28. Radioactivity in Vegetation at Bingham Pump Outage Pits and at Plant Boundary (pCi/g)

		Alpha				Nonvolatile beta			
		Pits		Plant boundary		Pits		Plant boundary	
Area	Facility	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.1
K	643-1G	0.2	0.3	0.2	0.6	28	34	21	31
L	643-2G	0.8	1.8	0.2	0.6	35	48	21	31
L	643-3G	0.8	1.8	0.2	0.6	35	48	21	31
P	643-4G	0.4	0.6	0.2	0.6	23	27	21	31
R	643-8G	0.2	0.5	0.2	0.6	37	51	21	31
R	643-9G	0.2	0.5	0.2	0.6	37	51	21	31
R	643-10G	0.2	0.5	0.2	0.6	37	51	21	31

Waste Characterization

The radiation level of the construction material buried at all the Bingham pump outage pits was measured at less than 25 milliroentgens per hour; no alpha activity was noted. A conservative maximum estimate of the amount of activity buried in each area is 1 curie. Table B-13 lists the radionuclide inventory. TE

B.9.2.2 K-Area Reactor Seepage Basin (904-65G) TE

Seepage basin 904-65G is outside the K-Area perimeter fence (Figure B-17). It is 41 meters long, 21 meters wide, and 2 meters deep with a volume of 1.6 x 10^3 cubic meters. The basin was constructed by excavating below grade and backfilling around the sides at grade level to form earthen dike walls. The basin did not overflow; water was released to the environment by evaporation and seepage. The following sections describe the history of disposal, evidence of contamination, and waste characteristics of the basin (Pekkala, Jewell, Holmes, and Marine, 1987b). TC

History of Waste Disposal

See Section B.4.2.4. In addition to purge water from the K-Reactor disassembly basins, the K-Area reactor seepage basin received very low-level radioactive wastewater from other sources in the reactor area. This water had to meet the same contamination control limits as disassembly-basin purge water before it could be released to the seepage basin. Conventional water treatment chemicals also entered the disassembly-basin water in small amounts through additions for pH control, filter promotion, algae treatment, and minimal additions of wastewater to the settler tank from other sources in the reactor buildings. The seepage basin in K-Area was active from 1957 to 1960. It has not been backfilled. TE

Evidence of Contamination

Core samples were obtained from the basin in 1978, and most of the radioactivity was found to be in the top 30 centimeters of the cores. The maximum cesium-137 and strontium-90 concentrations were 510 and 140 picocuries per gram, respectively.

Four groundwater monitoring wells were installed around the K-Area seepage basin in 1984. As determined from the three downgradient wells, 1985 annual average alpha and nonvolatile beta activity ranged from 0.10 to 0.23 and 0.04 to 2.9 picocuries per liter, respectively. The 1985 annual average for tritium ranged from 110,000 to 160,000 picocuries per liter.

Waste Characteristics

Although many different radionuclides have been discharged to the seepage basin, tritium, strontium-90, and cesium-137 account for almost all the radioactivity. The radionuclide contaminants entered the disassembly-basin water as a film of water on the irradiated components discharged from the reactor tank to the disassembly basin. Table B-29 is an inventory of radionuclides released to the seepage basin. No significant quantities of chemical contaminants are believed to have been discharged to the seepage basin. TE

TE

Table B-29. Radioactive Releases to K-Area Reactor Seepage Basin (Ci)[a,b]

Isotope	Release
Tritium[c]	1.2×10^{2}
Cobalt-60	2.6×10^{-3}
Strontium-90	1.4×10^{-2}
Cesium-137	7.8×10^{-2}

TC

[a]Source: Pekkala, Jewell, Holmes, and Marine, 1987b.
[b]Values cumulative for years 1957-1960. All values are decay-corrected through 1985.
[c]Most tritium believed to have left basin via atmosphere or groundwater.

B.9.3 MAJOR GEOHYDROLOGIC CHARACTERISTICS

The waste sites in the K-Area geographic grouping are located with Indian Grave Branch on the west and Pen Branch on the east, where the water table below the area discharges. Little site-specific information is available for the subsurface geology; however, K-Area hydrostratigraphy is believed to be similar to the regional hydrostratigraphy discussed in Appendix A. Water-level measurements from other wells in the vicinity of K-Area have been used to construct a water-table map for the vicinity (Figure B-18).

The water-table elevation is about 60 meters. The estimated piezometric head in the Congaree Formation is about 43 meters, and about 51 meters in the Middendorf/Black Creek (Tuscaloosa). Thus, there is a downward hydraulic gradient to the Congaree, below which the gradient is upward (Ward, Johnson, and Marine, 1987). Recent evidence suggests that the upward gradient does not
TC currently exist in the K-Area (Bledsoe, 1987).

B.9.4 ONGOING AND PLANNED MONITORING

Groundwater monitoring is proceeding at three of the four waste management facilities in the K-Area geographic grouping. Well-water samples are analyzed quarterly for RCRA and SCHWMR parameters at hazardous waste management facilities. Wells are typically monitored for gross alpha, gross nonvolatile beta, and tritium at low-level waste management facilities. At least 12 wells in this geographic area are used to monitor groundwater in the vicinity of the facilities. DOE plans additional wells to better define subsurface conditions and contaminant transport.

A waste site characterization program has been completed at two of the facilities and is being implemented at the other two. Characterization generally includes representative sampling of the waste, the soil and sediment under the waste site, and the soil and sediment around overflow ditches and process sewers.

TE | Table B-30 lists the representative monitoring wells at each waste management facility, the site investigations that have occurred, and the results of groundwater, soil, and vegetation monitoring.

B.10 L-AREA WASTE SITES

This geographic grouping is formed by waste sites near L-Reactor, which went on standby status in 1968 and resumed operation in November 1985. This grouping is approximately 4 kilometers east of K-Reactor, north of Road B. Figure B-19 shows the locations of the waste sites in the L-Area geographic grouping. Within the boundaries of this grouping are the CMP pits and the L-Area burning/rubble pit, acid/caustic basin, and oil and chemical basin. Drainage is to Pen Branch on the west, and Steel Creek and L-Lake on the east.

B.10.1 HAZARDOUS WASTE SITES

B.10.1.1 L-Area Burning/Rubble Pit (131-L)

The L-Area burning/rubble pit is near the central portion of the Savannah River Plant, northwest of L-Area, north of Road 7, and east of Road 7-1. The site is rectangular, approximately 70 meters long, 9 meters wide, and 3 meters deep.

History of Waste Disposal

Rubble waste disposed at this site reportedly included paper, lumber, cans, empty galvanized steel drums, scrap metal, and batteries. See Section B.2.1.6.

Evidence of Contamination

See Section B.2.1.6.

Waste Characterization

See Section B.2.1.6.

B.10.1.2 L-Area Acid/Caustic Basin (904-79G)

The L-Area acid/caustic basin is one of six such basins in the Reactor and Separations Areas. These basins are unlined earthen depressions with nominal dimensions of 15 meters long, 15 meters wide, and 2 meters deep.

History of Waste Disposal

See Section B.3.1.1.

Evidence of Contamination

See Section B.3.1.1.

Waste Characterization

See Section B.3.1.1.

B.10.1.3 CMP Pits (080-17G, 17.1G, 18G, 18.1G, 18.2G, 18.3G, 19G)

The CMP pits consist of seven unlined pits that were used for the disposal of selected nonradioactive wastes. The pits were near the center of the Plant at the top of a hill near the head of Pen Branch. They are arranged linearly in two rows with 3 to 7 meters between the ends of adjacent pits. Each pit is 3 to 5 meters wide, 15 to 23 meters long, and 3 to 5 meters deep.

History of Waste Disposal

The CMP pits were used for waste disposal from 1971 to 1979. Typical waste disposed in the pits included drums of solvents such as trichloroethylene and tetrachloroethylene, and other liquid wastes such as fluorocarbons, oil, paint thinner, and acid. Beryllium, titanium, calcium, and cadmium were disposed of in a separate metals pit. Odd-shaped items such as spray cans and gas cylinders were placed in the pits in containers of various sizes. The waste in the CMP pits was excavated in 1984 and is being stored until it can be incinerated. The pits have been backfilled and closed.

Evidence of Contamination

Twenty-one groundwater monitoring wells were installed at the site to document the extent of existing contamination. Benzene, methylene chloride, tetrachloroethylene, toluene, and bis (2-ethylhexyl) phthalate have been detected in the groundwater at monitoring well CMP-9C (Scott, Kolb, Price, and Bledsoe, 1987). TC TE

Waste Characterization

Incomplete records partially document disposed wastes at the CMP pits. Site remedial work in 1984 included removal of wastes and contaminated soils. The results of the remedial work indicate that 99.5 percent of the wastes and contaminated soils had been removed from the site. An estimated 1500 cubic meters of contaminated soil remain.

B.10.2 LOW-LEVEL RADIOACTIVE WASTE SITES

B.10.2.1 L-Area Bingham Pump Outage Pit (643-2G)

L-Area Bingham Pump Outage Pit 643-2G is outside the L-Area perimeter fence near the center of the SRP. The pit is 9 kilometers from the nearest Plant boundary. It is on a gentle slope above the nearest flowing stream, a tributary of Pen Branch that is 360 meters away. The following sections discuss the history of waste disposal, evidence of contamination, and waste characteristics at this pit (Pekkala, Jewell, Holmes, and Marine, 1987a). TC

History of Waste Disposal

Section B.4.2.1 describes the general history of the Bingham Pump outage pits. The L-Area pit was active from September to November 1957. It is backfilled and overgrown with vegetation. TC

Evidence of Contamination

No groundwater monitoring, sediment characterization, or core sampling has been performed at the outage pits, but vegetation sampling was performed in
TC 1970. The vegetation showed elevated but low levels of contamination (see Section B.4.2.1). The water table is presently 2 meters below the bottom of the pit.

Waste Characterization

Section B.4.2.1 discusses the waste characteristics of the Bingham Pump outage pits.

B.10.2.2 L-Area Bingham Pump Outage Pit (643-3G)

L-Area Bingham Pump Outage Pit 643-3G is outside the L-Area perimeter fence near the center of the Plant. The pit is 9 kilometers from the nearest SRP boundary. It is situated on a gentle slope above the nearest flowing stream,
TE a tributary of Pen Branch that is 360 meters away.

History of Waste Disposal

Section B.4.2.1 describes the general history of the Bingham Pump outage pits. This pit was active from September 1957 to January 1958, and is
TE backfilled and overgrown with vegetation.

TE Evidence of Contamination

See Section B.10.2.1.

Waste Characteristics

See Section B.4.2.1.

B.10.3 MIXED WASTE SITES

TE B.10.3.1 L-Area Oil and Chemical Basin (904-83G)

The L-Area oil and chemical basin is outside the L-Area perimeter fence and between the acid/caustic basin and the area seepage basin (Figure B-18). The
TC unlined earthen basin has a surface area of 860 square meters and a capacity of approximately 2.3 million liters. The nearest Plant boundary is approximately 9.8 kilometers from the basin. The following sections describe the history of disposal, evidence of contamination, and waste characteristics at
TC the basin (Pekkala, Jewell, Price, and Bledsoe, 1987).

History of Waste Disposal

This basin began operation in 1961 and remained active until 1979. Although L-Reactor was placed on standby status in 1968, releases of wastewater to the
TE basin continued.

The basin has been inactive since 1979. Rainfall has kept some water in the basin at all times. The permeability of the basin floor probably has decreased by releases of oil and chemical mixtures.

Evidence of Contamination

Nine sediment cores were taken in the basin in early 1985. Approximately 0.3 to 0.6 meter of soft black ooze with a moisture content of 50 to 90 percent, followed by the tough basin-floor material, was encountered. Preliminary analyses indicate very low levels of contamination from metals; for example, no samples exceeded the EP-toxicity test criteria. TE

The upper 10 to 20 centimeters of sludge typically contain 1,000 to 10,000 picocuries per gram (dry weight) of radioactive material, dominated by cobalt-60 and unidentified beta emitters. The next 20 centimeters typically contain about 20,000 picocuries per gram (dry weight). Below this level, the basin floor material drops rapidly to background levels for most substances. Petroleum hydrocarbons were not detected in any samples. The basin water contains tritium, strontium-90, cobalt-60, cesium-137, and nitrate.

Low levels of radioactivity have been detected in monitoring wells near the basin. Chlorinated organics (TOH) as high as 100 parts per billion have been detected in two monitoring wells, but are not detectable in the basin water.

Waste Characterization

The L-Area oil and chemical basin received about 205,000 liters of wastewater annually. The total volume discharged through 1979 was 3.9 x 10^6 liters. The waste liquids consisted of small volumes of oil on top of water. The wastewater usually contained some chemicals that were not appropriate for discharge to SRP streams, regular seepage basins, or the waste management system in 200-Area. The oil in the wastewater drums or 1900-liter skid containers was only a small part of the total waste. Radioactive oil on the plant site usually was mixed with the absorbent Oil-dri and sent to the Burial Ground in 190-liter drums. The waste liquids sent to the L-Area oil and chemical basin came from all over the Plant, but were primarily from the reactor areas. Wastewater from the Building 717-G Hot Shop was sent to the basin until 1967. TC

As indicated in Table B-31, the major nuclides discharged to the basin include tritium, cobalt-60, strontium-90, cesium-137, and unidentified alpha and beta gamma. The current inventory is decay-corrected. The inventory shows a small amount of radioactivity that was released to the basin through Works Engineering repairs at the basin or in Building 717-G. Several filters in the reactor building's distillation and purification facilities had high radiation levels, and underwater work was necessary for personnel protection. A tank filled with water was placed inside the basin perimeter fence and used for shielding. After repairs were completed, including disassembly and assembly, the water was drained to the basin. TE

B.10.4 MAJOR GEOHYDROLOGIC CHARACTERISTICS

Waste sites in the L-Area geographic grouping are on the Aiken Plateau between Pen Branch to the west and Steel Creek to the east-southeast. Site-specific geologic investigations conducted in the vicinity of L-Area and the CMP pits

TE Table B-31. Summary of Radioactive Releases to L-Area Oil and Chemical Basin 904-83G (Ci)[a]

Isotope	Original release	Decay-corrected inventory
Tritium	3.4556×10^{4}	1.1553×10^{4}
Sulfur-35	1.6000×10^{-2}	7.6563×10^{-7}
Cobalt-60	3.7915	2.7935×10^{-1}
Strontium-90	3.7039×10^{-1}	2.1986×10^{-1}
Ruthenium 103, -106	3.5937×10^{1}	6.3956×10^{-5}
Cesium-134	1.0590×10^{-3}	4.4993×10^{-5}
Cesium-137	1.6210	9.9224×10^{-1}
Cerium 44, -141	9.5232×10^{-2}	1.8354×10^{-6}
Promethium-147	1.9828	8.3285×10^{-3}
Alpha (unidentified)	2.2852×10^{-3}	2.2852×10^{-3}
Beta-gamma (unidentified)	1.5550×10^{-3}	1.5550×10^{-3}

TC [a]Source: Pekkala, Jewell, Price, and Bledsoe, 1987.

reveal that the hydrostratigraphy of the area is similar to that discussed in Appendix A. Significant site-specific characteristics are as follows (Scott,
TC Kolb, Price, and Bledsoe, 1987; Pekkala, Jewell, Price, and Bledsoe, 1987; DOE, 1984a, b):

1. Upland unit. The transmissivity of gravel beds can be high but that of clays can be low.

2. Barnwell Formation. Clay lenses are nearly impermeable to downward infiltrating water. Sands should have moderate permeability.

3. McBean Formation. Lime sands and clays (calcarenite and marl) are generally of low permeability, but coarse, fossiliferous limestone lenses can be very permeable. The green clay at the base of the McBean Formation is about 7 meters thick in the vicinity of L-Area.

4. Congaree Formation. Interlayered sands, calcareous sands, and clays near the top of the formation should have moderate permeability. The thick (15-meter) clean sands near the base of this formation are very permeable and form a good aquifer.

5. Ellenton Formation. Most lithologies have low permeability; this generality can be deceiving because channel sands could provide very high permeability locally.

6. Upper Middendorf/Black Creek. The Middendorf/Black Creek section in hole CMP-11 begins at a depth of 125 meters (about 34 meters below

sea level). The principal sediments are fine, silty sands with occasional layers of silty clay or coarse sand. The interval from 126 to 161 meters has four clay layers, each about 0.6 meter thick.

In general, the sands become coarser toward the bottom of this interval. The permeability of the silty sands should be low to moderate and that of the coarser sands moderate to high.

The tan clay is not readily evident in data on the area derived from foundation borings, drillers' logs, and geophysical logs; however, even in other areas of the Plant where it supports a significant head difference, this clay layer is not always apparent in soil cores. The calcareous zone is evident in the McBean Formation. At depths of 30 to 40 meters from the ground surface, solution voids can exist, as indicated by mud losses and rod drops during the drilling of observation wells near the CMP pits (Scott, Kolb, Price, and Bledsoe, 1987). These areas are patchy with little or no interconnection of TC void areas.

Pump tests have been performed at monitoring wells in the vicinity of the CMP pits. Transmissivity data for various strata are summarized below (Pekkala, Jewell, Price, and Bledsoe, 1987): TC

Well	Stratum screened	Transmissivities measured (m^2/day)
CMP-8B	McBean (Aiken) fine sands	9.1
CMP-10, 11, 12, 14B, 15B	McBean moldic limestone	<185
	Barnwell/Dry Branch	0.5
CMP-8A, 12A, 15A	Congaree	75, 3, 0.2

Figure B-20 is a water-table map for the area. The map is from data collected in December 1963 when a number of shallow piezometers were available for the area. Recent data from several new wells (Pekkala, Jewell, Price, and Bledsoe, 1987) indicate that the water table is now 1 to 2 meters lower than TC shown in Figure B-20.

Near the CMP pits, the hydraulic heads of three wells screened in the lower part of the Congaree are between 55.2 and 56.1 meters. Water-level measurements for one well in the upper Tuscaloosa Formation indicate a head of 52.1 meters above mean sea level. Thus, there is a downward gradient of about 4 meters of head across the Ellenton Formation near the CMP pits (Scott, Kolb, Price, and Bledsoe, 1987). In the vicinity of L-Area, the water level in the TC Congaree is at an elevation of 53.5 meters, and that in the Middendorf/Black Creek (Tuscaloosa) is at 52.2 meters (Ward, Johnson, and Marine, 1987). TC

Judging from these water-level measurements, the head reversal found in other areas of the Plant is not present in this area. Recent (April 1987) evidence is in agreement with these earlier observations (Bledsoe, 1987).

B.10.5 ONGOING AND PLANNED MONITORING

Groundwater monitoring is proceeding at 10 of the 12 waste management facilities in the L-Area geographic grouping. Well-water samples are analyzed quarterly for RCRA and SCHWMR parameters at hazardous and mixed waste management facilities. Typically, wells are monitored for gross alpha, gross nonvolatile beta, and tritium at low-level waste management facilities. At least 21 wells in this geographic area are used to monitor groundwater in the vicinity of the 12 facilities. DOE plans additional wells to obtain a better definition of subsurface conditions and contaminant transport.

Waste site characterization programs are complete at nine facilities and are being implemented at another. Characterization generally includes representative sampling of the waste, the soil and sediment under the waste site, and the soil and sediment around overflow ditches and process sewers.

Table B-32 lists the representative monitoring wells at each waste management facility; the site investigations that have occurred; and the results of groundwater, soil, and vegetation monitoring. TE

B.11 P-AREA WASTE SITES

This geographic grouping is formed by waste sites associated with P-Reactor, which is approximately 4 kilometers northeast of L-Reactor (Figure B-21). Located along Road F, P-Reactor is southwest of Par Pond, through which its cooling water is recirculated. The northeast portion of this grouping drains to Par Pond, and the southwest portion drains to the headwaters of Steel Creek.

B.11.1 HAZARDOUS WASTE SITES

B.11.1.1 P-Area Burning/Rubble Pit (131-P)

The P-Area burning/rubble pit is northwest of P-Area and south of Road C-7. The site is nearly rectangular, approximately 64 meters long, 9 meters wide, and about 3 meters deep. TE

History of Waste Disposal

Rubble waste disposed of at this site included paper, wood, concrete, scrap metal, cans, and empty galvanized-steel barrels. See Section B.2.1.6.

Evidence of Contamination

See Section B.2.1.6.

Waste Characterization

See Section B.2.1.6.

B.11.1.2 P-Area Acid/Caustic Basin (904-78G)

The P-Area acid/caustic basin is one of six such basins in the Reactor and Separations Areas. These basins are unlined earthen depressions with nominal dimensions of 15 meters long, 15 meters wide, and 2 meters deep.

History of Waste Disposal

See Section B.3.1.1.

Evidence of Contamination

See Section B.3.1.1.

Waste Characterization

See Section B.3.1.1.

B.11.2 LOW-LEVEL RADIOACTIVE WASTE SITE

B.11.2.1 P-Area Bingham Pump Outage Pit (643-4G) TE

The P-Area Bingham pump outage pit 643-4G is outside the P-Area perimeter fence. This pit is 9.8 kilometers from the nearest Plant boundary. It is on a gentle slope just east of the divide between Steel Creek and Par Pond. The following sections describe the history of waste disposal, evidence of contamination, and waste characteristics at the P-Area pit (Pekkala, Jewell, Holmes, and Marine, 1987a). TC

History of Waste Disposal

Section B.4.2.1 describes the general history of the Bingham pump outage pits. The P-Area pit was active from January to November 1958, then was backfilled and allowed to revegetate.

Evidence of Contamination

No groundwater monitoring, sediment characterization, or core sampling has been performed at the outage pits. Vegetation sampling in 1970 showed elevated but low levels of radioactivity (see Section B.4.2.1). TC

Waste Characterization

See Section B.4.2.1.

B.11.3 MAJOR GEOHYDROLOGIC CHARACTERISTICS

The P-Area waste sites within this geographic grouping are on the Aiken Plateau between Steel Creek and Par Pond. Site-specific geologic investigations have not been conducted in the vicinity of P-Area; however, regional subsurface geology discussed in Appendix A is believed to be representative of the area. Four RCRA-type wells have been installed near P-Area. The depth to the water table in these wells ranges from 6.4 to 10.7 meters below the ground surface (Huber, Johnson, and Marine, 1987). Figure B-22 is a water-table map TC for the area. The natural discharge from the water-table aquifer is to Steel Creek west of P-Area and to tributaries of Par Pond to the east-northeast. This map, however, indicates expected head relationships only for general areas; site-specific information will be necessary to confirm the relationship for this area.

B.11.4 ONGOING AND PLANNED MONITORING

Groundwater monitoring is proceeding at two of the three waste management facilities in the P-Area geographic grouping. Well-water samples are analyzed quarterly for RCRA and SCHWMR parameters at hazardous waste management facilities. Typically, wells are monitored for gross alpha, gross nonvolatile beta, and tritium at low-level waste management facilities. At least eight wells in this geographic area are used to monitor groundwater in the vicinity of the six facilities. Additional wells are planned to obtain a better definition of subsurface conditions and contaminant transport.

Waste site characterization generally includes representative waste, the soil and sediment under the waste site, and the soil and sediment around overflow ditches and process sewers.

Table B-33 lists the representative monitoring wells at each waste management facility, the site investigations that have occurred, and the results of groundwater, soil, and vegetation monitoring. TE

B.12 MISCELLANEOUS AREA WASTE SITES

This section describes two waste sites, the SRL oil test site and the Gunsite 720 rubble pit, which are not within the boundaries of the 10 geographic groupings described in previous sections. The SRL oil test site is south of Road 3, a short distance from the CS-Area (see Figure B-11). The Gunsite 720 rubble pit is west of Road A, about 10 kilometers south of A-Area and 5 kilometers north of D-Area (see Figure B-14).

B.12.1 HAZARDOUS WASTE SITES

B.12.1.1 SRL Oil Test Site (080-16G)

The SRL oil test site is about 600 meters east of the intersection of Roads 3 and 5, and approximately the same distance south of the Central Shops complex near the central portion of the Plant. The site consists of 24 test plots with dimensions of 3.7 meters by 10.7 meters. Two other test plots with dimensions of 3 meters by 70 meters were added to the site subsequently. TC

History of Waste Disposal

The 26 test plots at the SRL oil test site were developed as part of a study to evaluate the biodegradation rate of waste oil. The plots received machine cutting oil characterized as having a viscosity similar to heavy automobile engine oil. The original 24 plots (12 test plots and 12 control plots) were constructed in 1975. Waste oil purchased offsite was sprayed onto the 12 test plots. Each oil plot received 415 liters of waste oil, was tilled to a depth of 15 centimeters, received another application of 415 liters, and was tilled again. Commercial fertilizer was applied to the plots at four different rates.

In 1976 two additional plots reportedly were built. One plot received 3120 liters of hydraulic fluid and the other received 4160 liters of paint thinner. TE

In 1978 a site use permit was requested to facilitate the disposal of about 50 drums of waste oil per year at the SRL oil test site, but the disposal of additional waste as a result of this request is not known. No waste oils were discarded at this site after 1980.

Evidence of Contamination

Two soil cores reportedly were taken from each test plot and analyzed at depths of 0 to 15 centimeters, 15 to 30 centimeters, and 30 to 45 centimeters. The plots were sampled before oil application, immediately after, 1 month after, about every 3 months after for 2 years, and then at 5 years. The results of the analysis revealed that over the 5-year period, no significant amounts of hydrocarbons were found at the 30- to 45-centimeter depth and slightly elevated hydrocarbons were found at the 15- to 30-centimeter depth (see Figure B-23). The results of an analysis of several chemical parameters revealed some increases of phosphorus, potassium, and calcium, but all concentrations (except phosphorus at the 0.15-centimeter depth) returned to background levels after 1 year.

The only contaminants that appear to be present at the site are asphalt rubble and residual waste oil that, for the most part, has been retained in the top 15 centimeters of the soil. A small amount might have migrated as deep as 30 centimeters. TC

Currently, there are no groundwater monitoring wells located at this site. TE

Waste Characterization

A lack of specific chemical/analytical data of the waste materials present at the site makes specific evaluations difficult. However, based on the limited data available, the potential for contaminant migration appears to be small. Samples from borings taken at the sites show that hydrocarbons exist at depths of 15 to 30 centimeters below the surface and marginally at the 30- to 45-centimeter depth. TC

B.12.1.2 Gunsite 720 Rubble Pit

The Gunsite 720 rubble pit (SRP map coordinates N80,000, E27,350) is an open area near D-Area, west of the first northbound dirt road from Road A-2. The site covers about 35 square meters. TC

History of Waste Disposal

The Gunsite 720 rubble pit consists of eight semiburied, corroded, 208-liter drums of unknown origin. There are no records of the disposal; however, the drums are suspected to contain nonradioactive liquid-chemical waste.

Evidence of Contamination

To date, no studies have been performed to determine the nature of the contents of the drums or the extent and levels of contamination.

Waste Characterization

Limited data are available on possible wastes disposed of at this site (Huber and Bledsoe, 1987b). TC

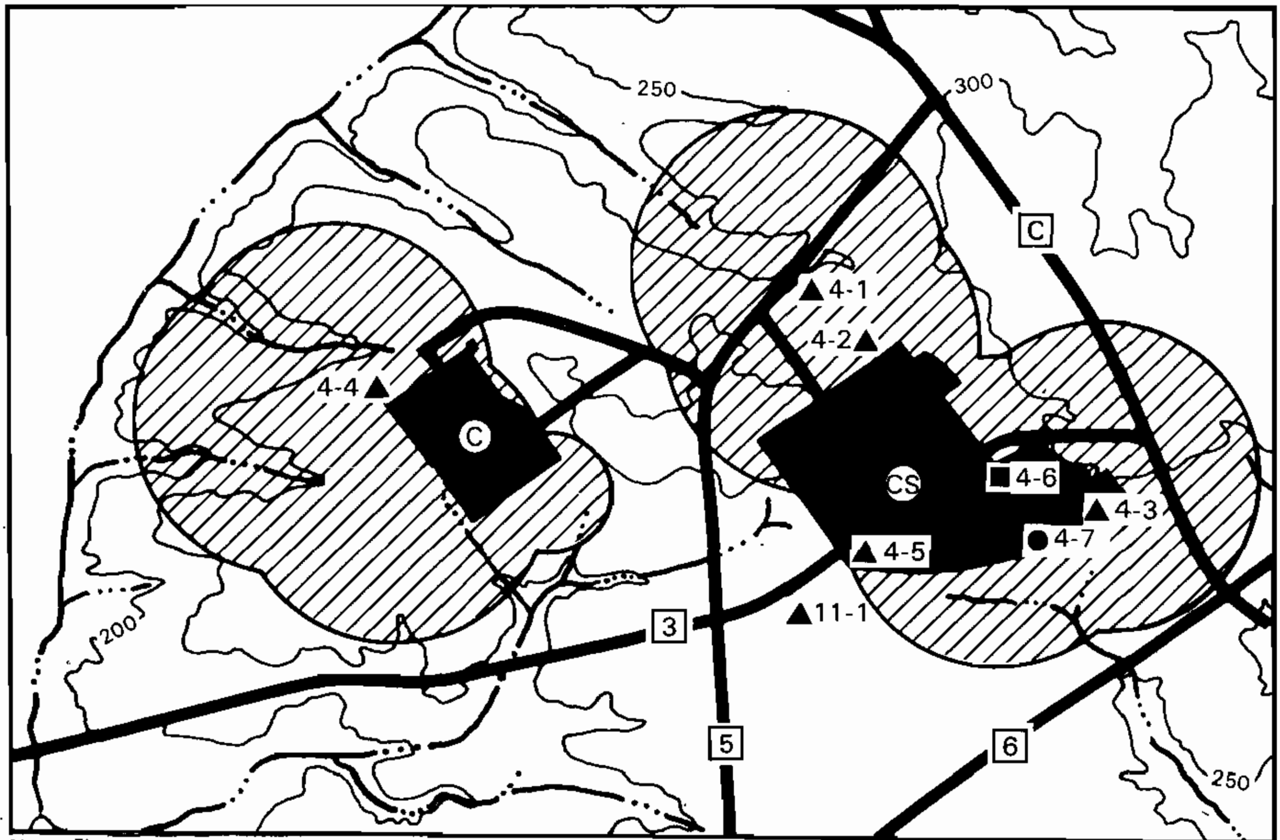
B.12.2 MAJOR GEOHYDROLOGIC CHARACTERISTICS

Representative data on the two waste sites in this geographic grouping are contained in Section B.5.4 for the SRL oil test site and Section B.6.4 for the Gunsite 720 rubble pit. In addition, Appendix A describes the important geologic and subsurface hydrologic characteristics of the SRP.

B.12.3 ONGOING AND PLANNED MONITORING

Table B-34 lists the site investigations that have occurred at each facility and the results of any groundwater, soil, and vegetation monitoring. TE

At present, there are no monitoring wells near the SRL oil test site or the Gunsite 720 rubble pit.



Note: Elevations are in feet above mean sea level
1.0 foot = 0.3048 meter
C Reactor Area
CS Central Shops

Scale (kilometers) 0 1 2

Number	Potential Waste Type	Site Name	Building Number
4-1	▲	CS Burning/Rubble Pit*	631-1G
4-2	▲	CS Burning/Rubble Pit*	631-5G
4-3	▲	CS Burning/Rubble Pit*	631-6G
4-4	▲	C-Area Burning/Rubble Pit*	131-C
4-5	▲	Hydrofluoric Acid Spill Area*	631-4G
4-6	■	Ford Building Waste Site*	643-11G
4-7	●	Ford Building Seepage Basin*	904-91G
11-1	▲	SRL Oil Test Site	080-16G

*Indicates that waste type may be contained in the waste site
▲—Hazardous
■—Low-level radioactive
●—Mixed

Figure B-11. C- and CS-Area Waste Sites

Formations and Depths of Well

Total Depth of all Strata	Depth of Each Stratum	Formation Found at Each Stratum
feet	feet	
80	20	Grey sandy clay
30	10	Yellow sandy clay
39	9	Grey sandy clay
59	30	Yellow clay and fine sand
93	34	Medium coarse sand and soft red clay
108	16	Soft white sandy clay
130	21	Medium coarse sand and white clay
135	5	Yellow clay
150	15	Chalky white clay with hard streaks of shell rock
190	40	Hard shell rock with sand and chalk
235	45	Soft yellow clay and sand with some shell
281	46	Coarse sand and little yellow clay and shell
291	30	Blue marl and firm sand
306	15	Medium course sand with blue marl
311	8	Fine sand and blue marl
358	44	Sandy blue marl
373	30	Sandy blue marl with mixture of clay
346	50	Sandy blue marl
438	80	Tight red and white clay, slow
450	15	Tight red clay, slow
476	26	Coarse white sand and gravel with streaks of clay
481	15	Chalky white clay with streaks of sand
508	17	Coarse white clay and chalky clay
518	10	Blue marl
537	10	Soft sandy blue marl
579	48	Coarse white sand with thin streaks of clay

Dimensions of Casing and Screen

Total Lengths of all Screens and Casings	Length of Each Screen and Casing	Screen or Casing	Size of Screen or Casing	Graph of Screen
feet	feet		inches	
180	180	Casing		
100	6	Casing	18	5/16
130	30	Casing	8	5/16
155	6	Slotted Pipe	8	5/16
525	420	Casing	8	5/16
575	50	Slotted Pipe	8	5/16
580	5	Casing	8	5/16

Figure B-12. Drilling Log of Well 905-71G

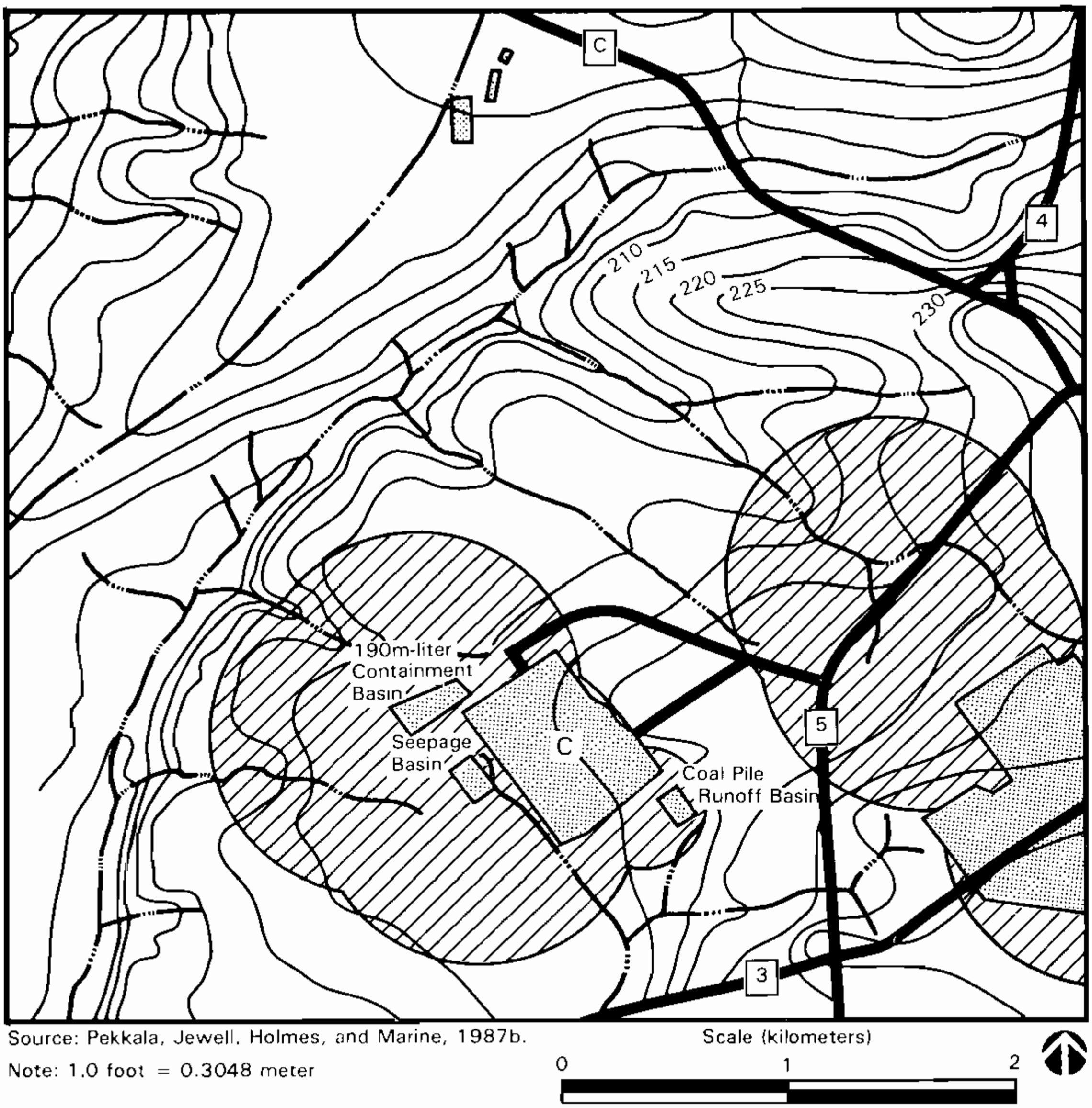
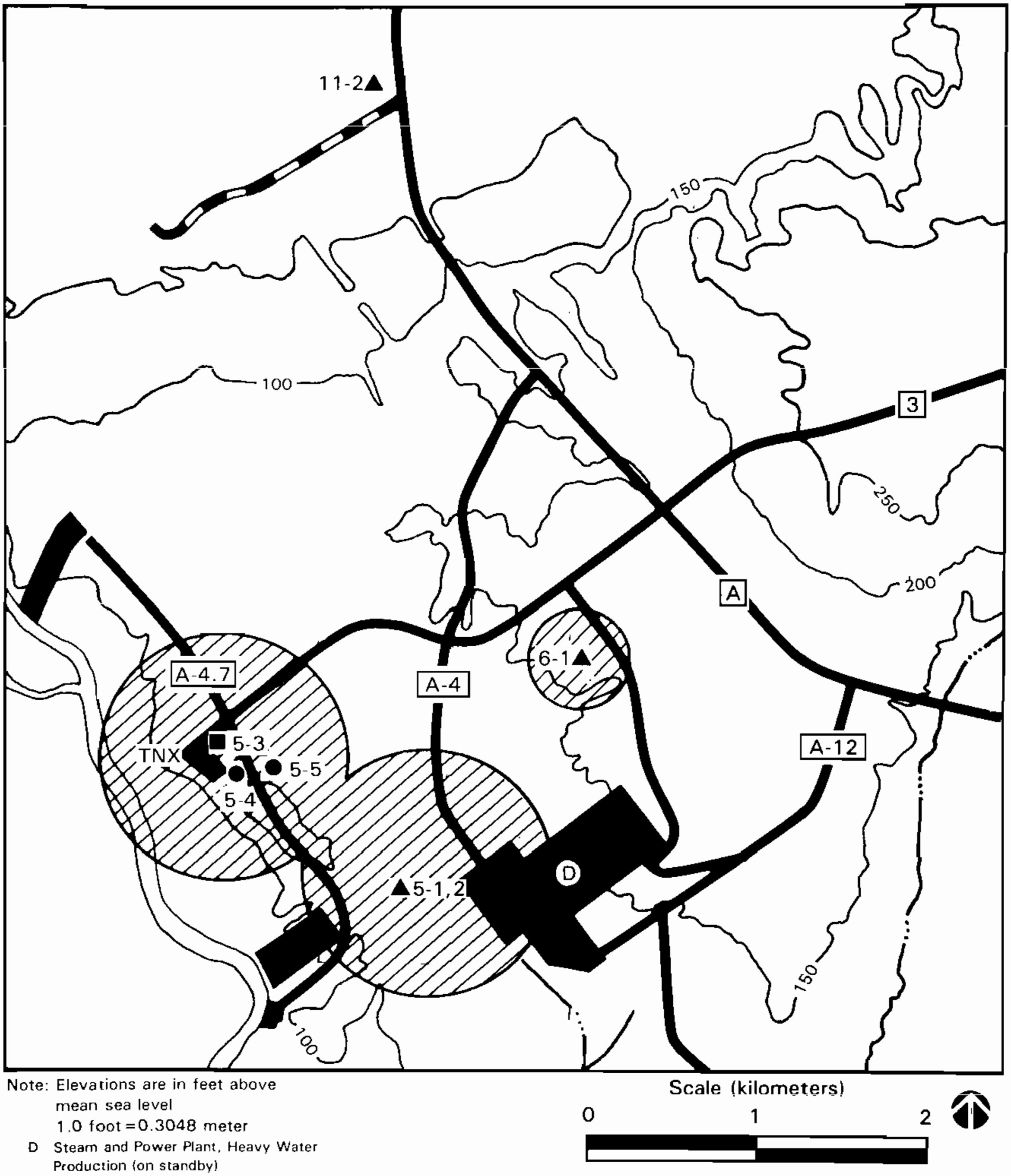


Figure B-13. Map of Water Table Near C-Area Showing Locations of Seepage Basins and Other Waste Sites (contours expressed in feet above mean sea level)



Note: Elevations are in feet above mean sea level
1.0 foot = 0.3048 meter

D Steam and Power Plant, Heavy Water Production (on standby)

TNX Pilot Scale Chemical Processing Facility

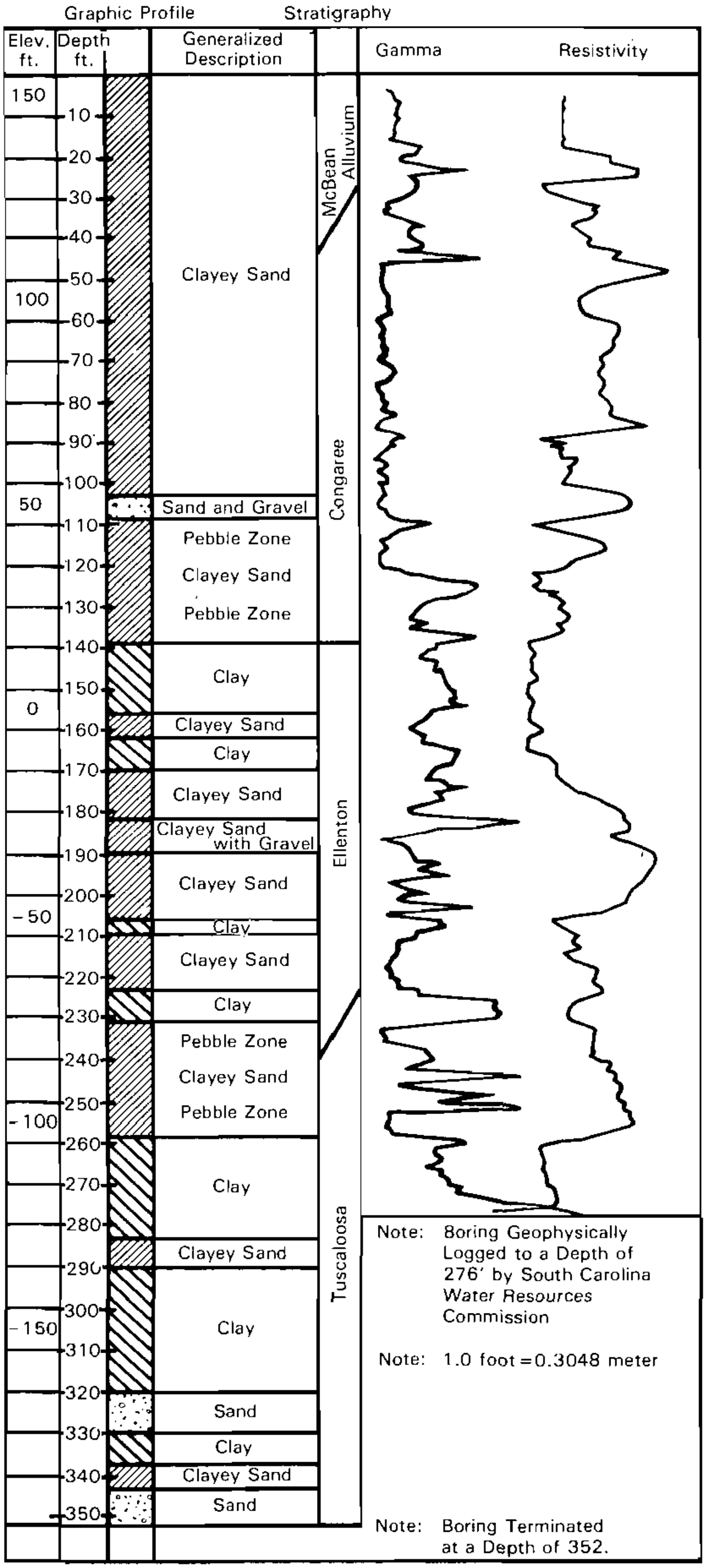
Legend on following page

Figure B-14. TNX-Area Waste Sites

Number	Potential Waste Type	Site Name	Building Number
5-1	▲	D-Area Burning/Rubble Pit*	431-D
5-2	▲	D-Area Burning/Rubble Pit*	431-1D
5-3	■	TNX Burying Ground	643-5G
5-4	●	TNX Seepage Basin (old)*	904-76G
5-5	●	TNX Seepage Basin (new)*	904-102G
6-1	▲	D-Area Oil Seepage Basin	631-G
11-2	▲	Gunsite 720 Rubble Pit	N80E27.35

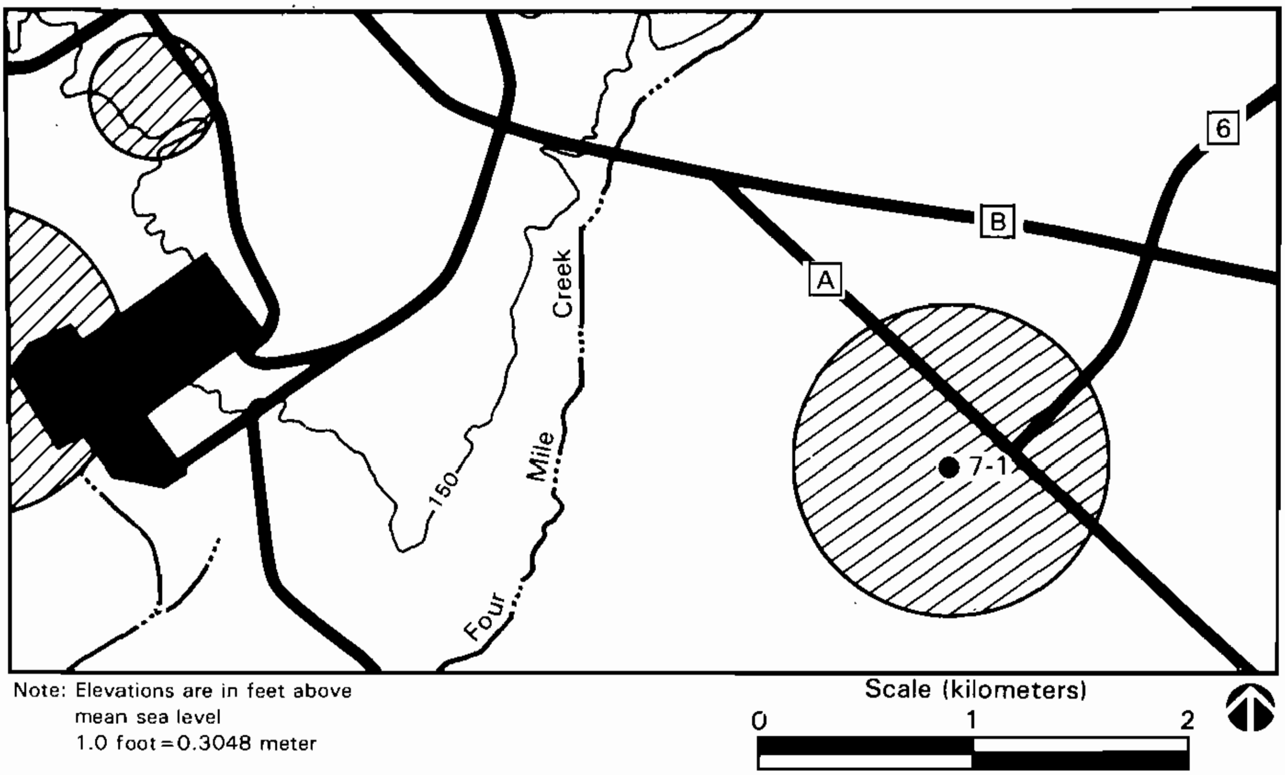
*Indicates that waste type may be contained in the waste site
▲—Hazardous
■—Low-level radioactive
●—Mixed

Figure B-14. TNX-Area Waste Sites (continued)



Source: Dunaway, Johnson, Kingley, Simmons, and Bledsoe, 1987.

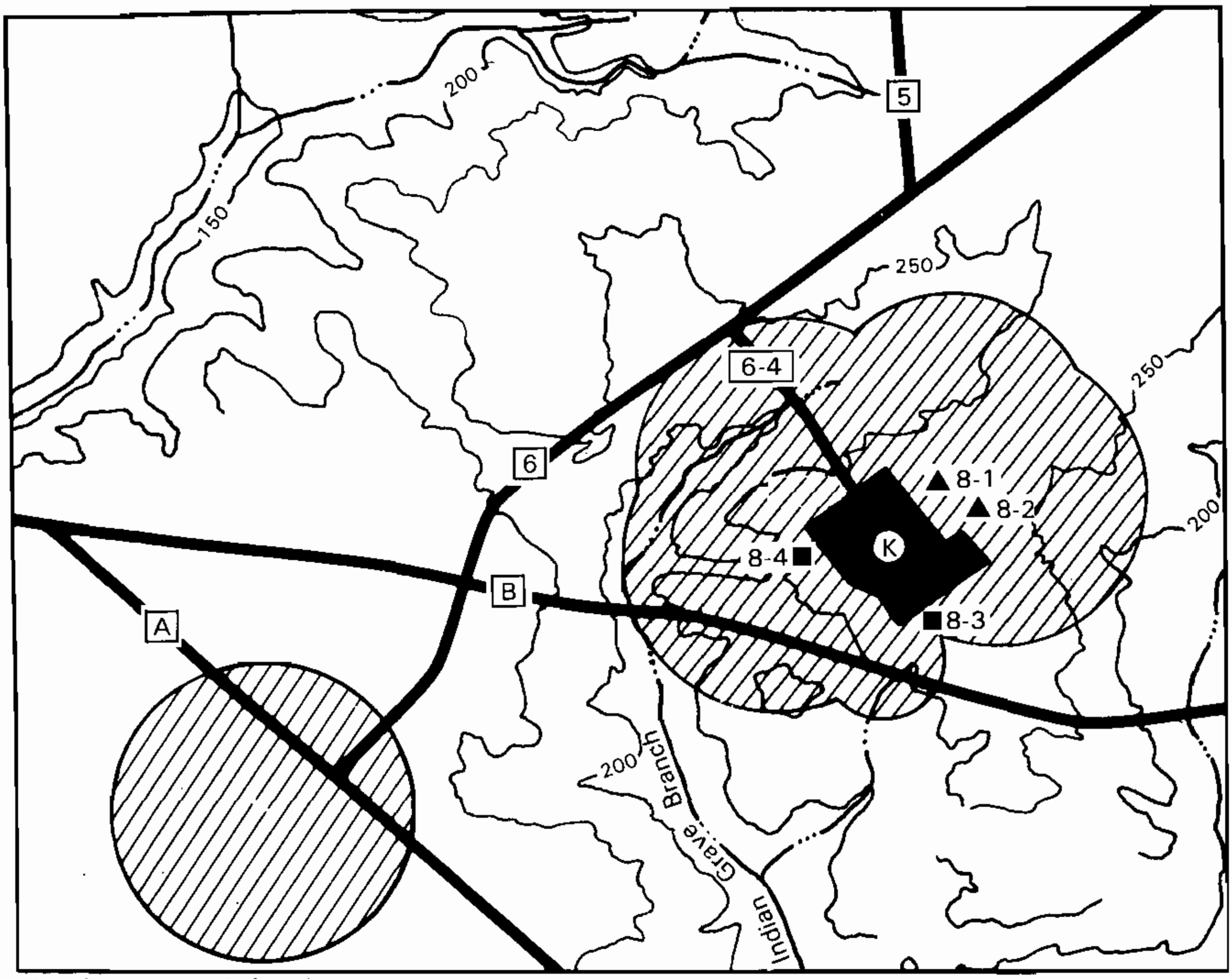
Figure B-15. Drillers Log for Monitoring Well XSB-3T



Number	Potential Waste Type	Site Name	Building Number
7-1	●	Road A Chemical Basin*	904-111G

*Indicates that waste type may be contained in the waste site
● —Mixed

Figure B-16. Road A Area Chemical Basin Waste Site



Note: Elevations are in feet above
mean sea level
1.0 foot = 0.3048 meter
K Reactor Area

Scale (kilometers)
0 1 2

Number	Potential Waste Type	Site Name	Building Number
8-1	▲	K-Area Burning/Rubble Pit*	131-K
8-2	▲	K-Area Acid/Caustic Basin*	904-80G
8-3	■	K-Area Bingham Pump Outage Pit*	643-1G
8-4	■	K-Area Reactor Seepage Basin	904-65G

*Indicates that waste type may be contained in the waste site
▲—Hazardous
■—Low-level radioactive

Figure B-17. K-Area Waste Sites

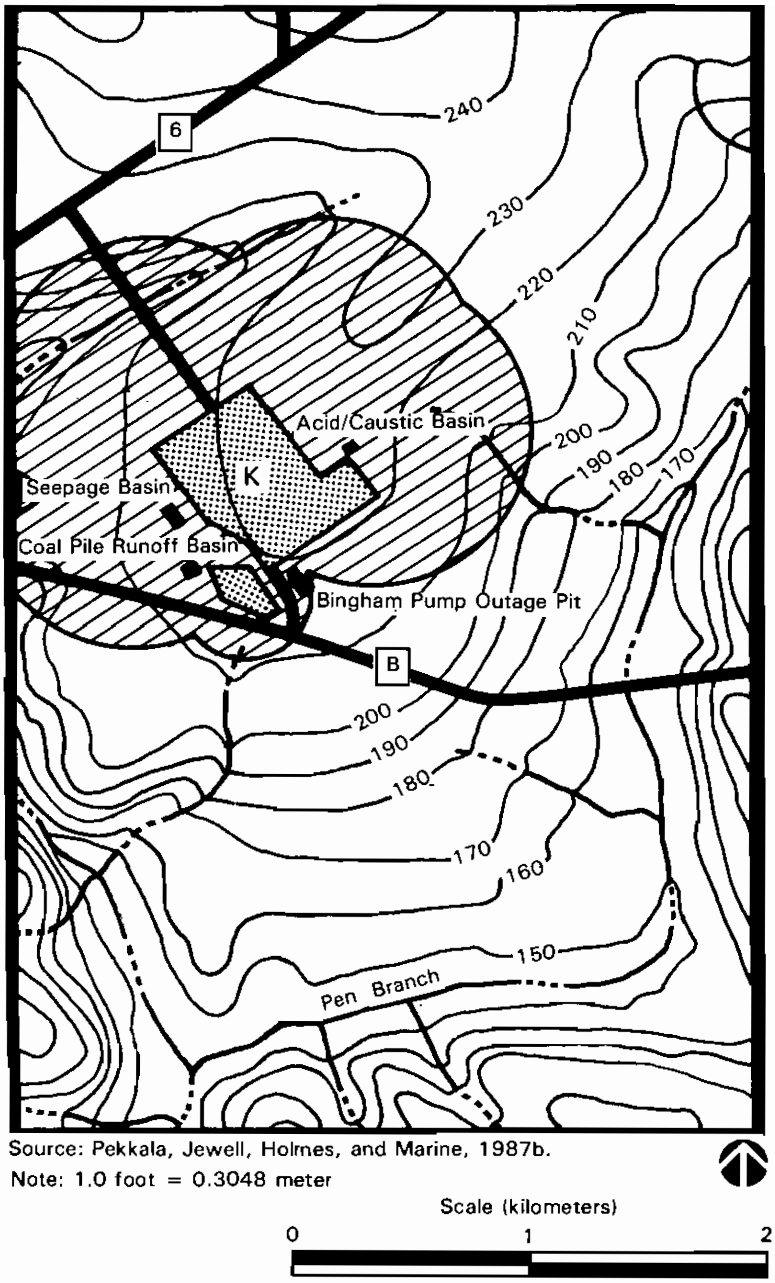


Figure B-18. Map of Water Table Near K-Area Showing Locations of Reactor Seepage Basin and Other Waste Sites (contours are expressed in feet above mean sea level)

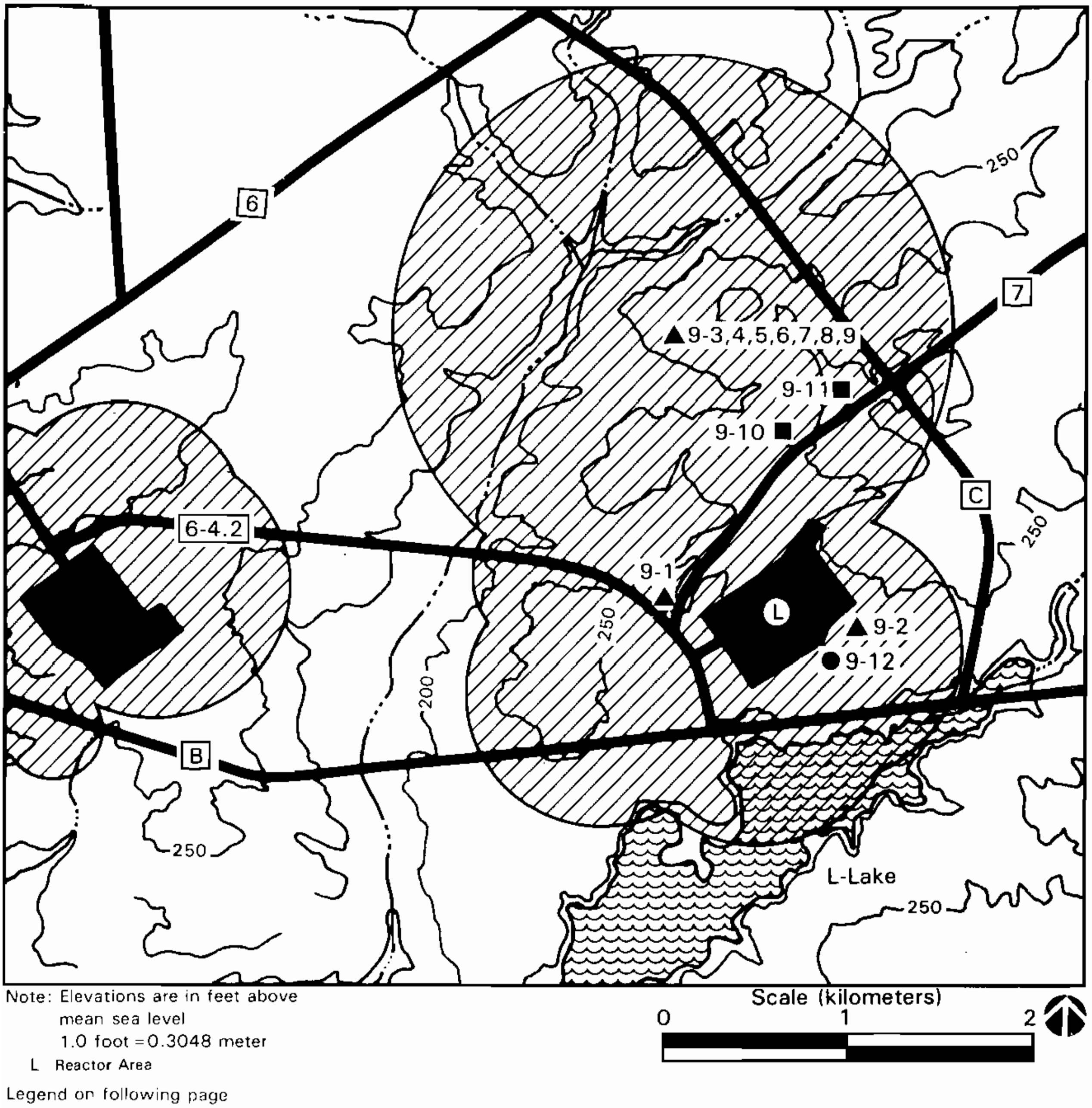
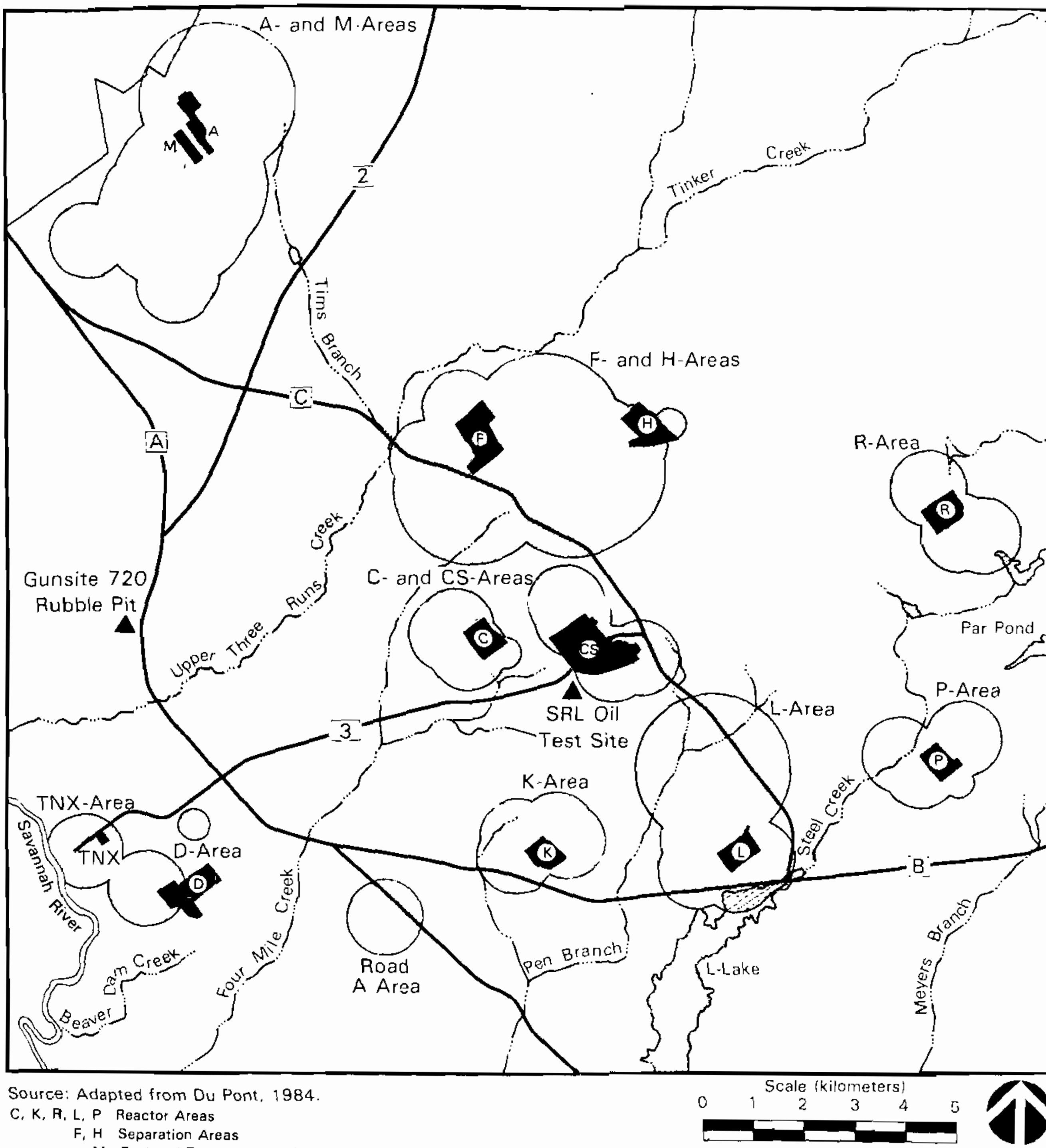


Figure B-19. L-Area Waste Sites

Number	Potential Waste Type	Site Name	Building Number
9-1	▲	L-Area Burning/Rubble Pit*	131-L
9-2	▲	L-Area Acid/Caustic Basin*	904-79G
9-3	▲	CMP Pit	080-17G
9-4	▲	CMP Pit	080-17.1G
9-5	▲	CMP Pit	080-18G
9-6	▲	CMP Pit	080-18.1G
9-7	▲	CMP Pit	080-18.2G
9-8	▲	CMP Pit	080-18.3G
9-9	▲	CMP Pit	080-19G
9-10	■	L-Area Bingham Pump Outage Pit*	643-2G
9-11	■	L-Area Bingham Pump Outage Pit*	643-3G
9-12	●	L-Area Oil and Chemical Basin*	904-83G

*Indicates that waste type may be contained in the waste site
▲—Hazardous
■—Low-level radioactive
●—Mixed

Figure B-19. L-Area Waste Sites (continued)



Source: Adapted from Du Pont, 1984.

C, K, R, L, P Reactor Areas
F, H Separation Areas
M Fuel and Target Fabrication
D Steam and Power Plant, Heavy Water Production (on standby)
A Savannah River Laboratory and Administration Area
CS Central Shops
TNX Pilot Scale Chemical Processing Facility

Figure B-1. Geographic Groupings of Waste Sites

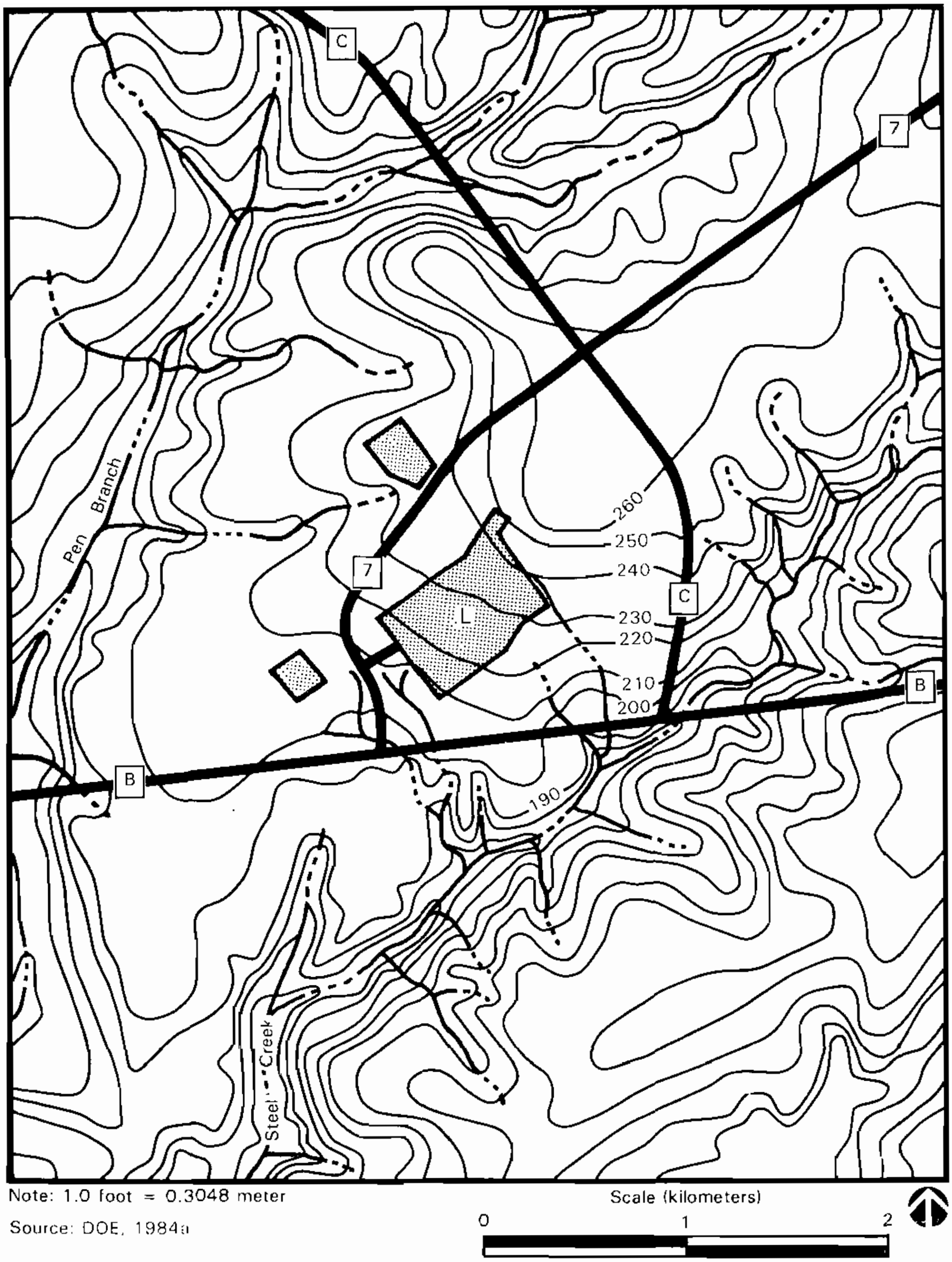
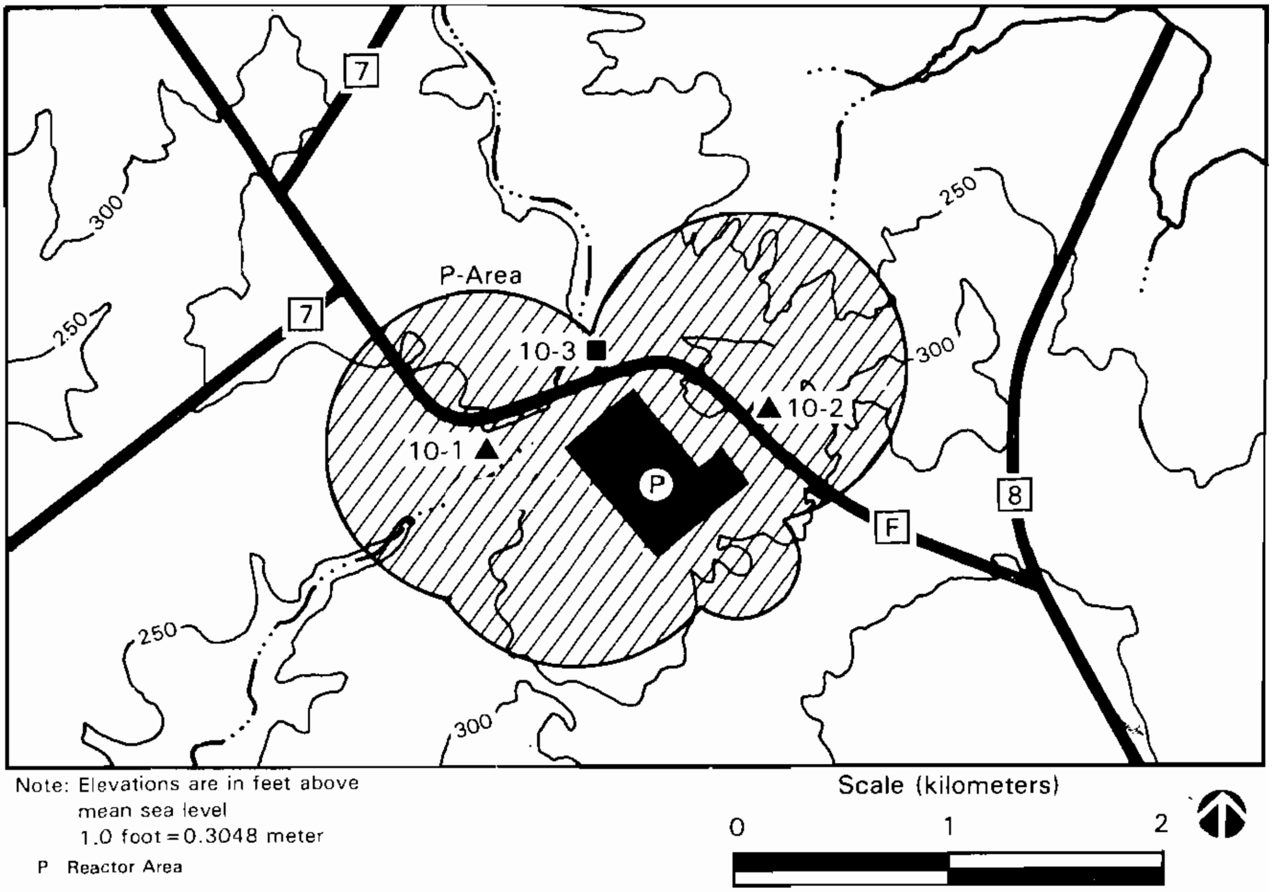


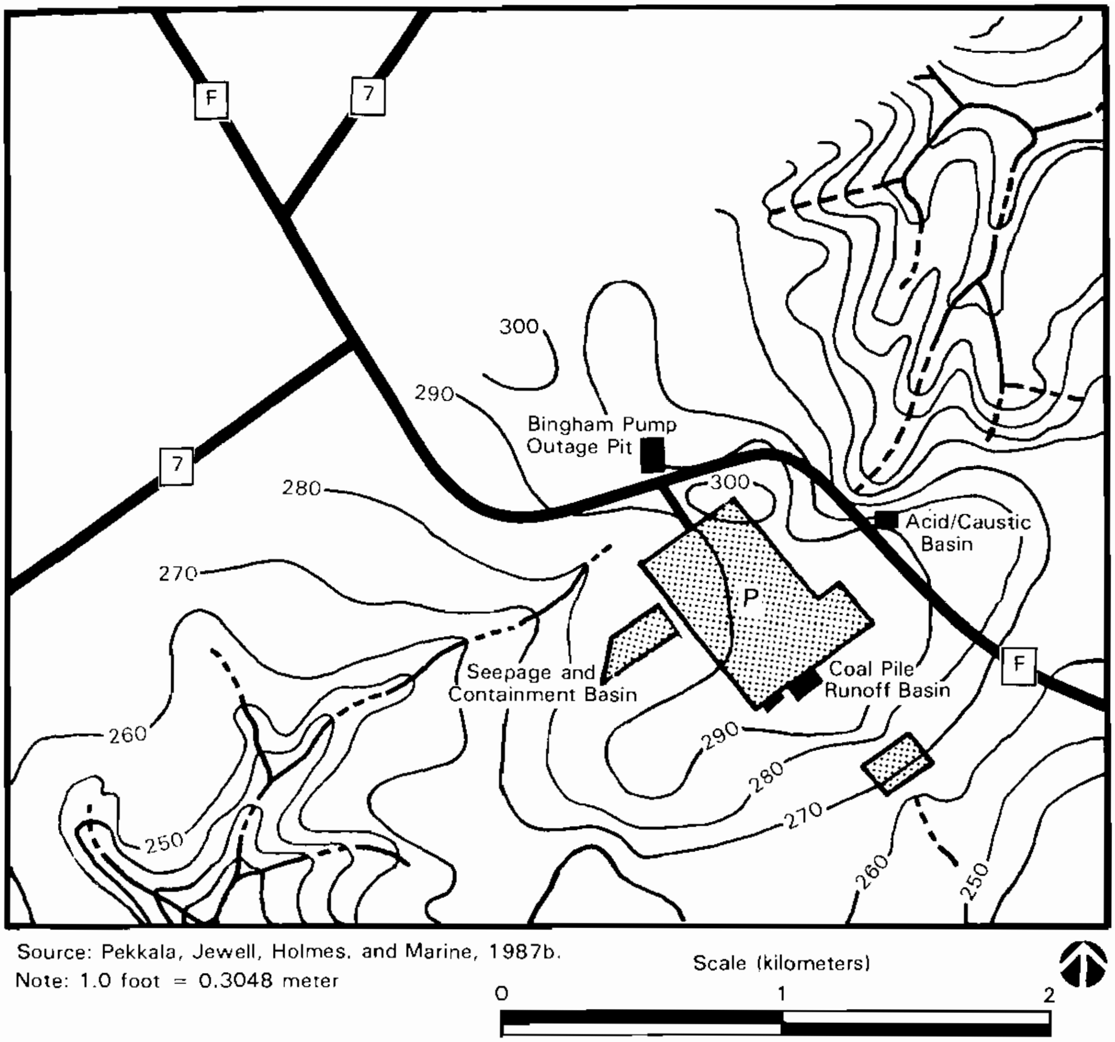
Figure B-20. Water Table Contours in Vicinity of L-Area (Feet Above Mean Sea Level)



Number	Potential Waste Type	Site Name	Building Number
10-1	▲	P-Area Burning/Rubble Pit*	131-P
10-2	▲	P-Area Acid/Caustic Basin*	904-78G
10-3	■	P-Area Bingham Pump Outage Pit*	643-4G

*Indicates that waste type may be contained in the waste site
▲—Hazardous
■—Low-level radioactive

Figure B-21. P-Area Waste Sites



Source: Pekkala, Jewell, Holmes, and Marine, 1987b.
Note: 1.0 foot = 0.3048 meter

Figure B-22. Map of Water Table Near P-Area Showing Location of Seepage Basins and Other Waste Sites (contours expressed in feet above mean sea level)

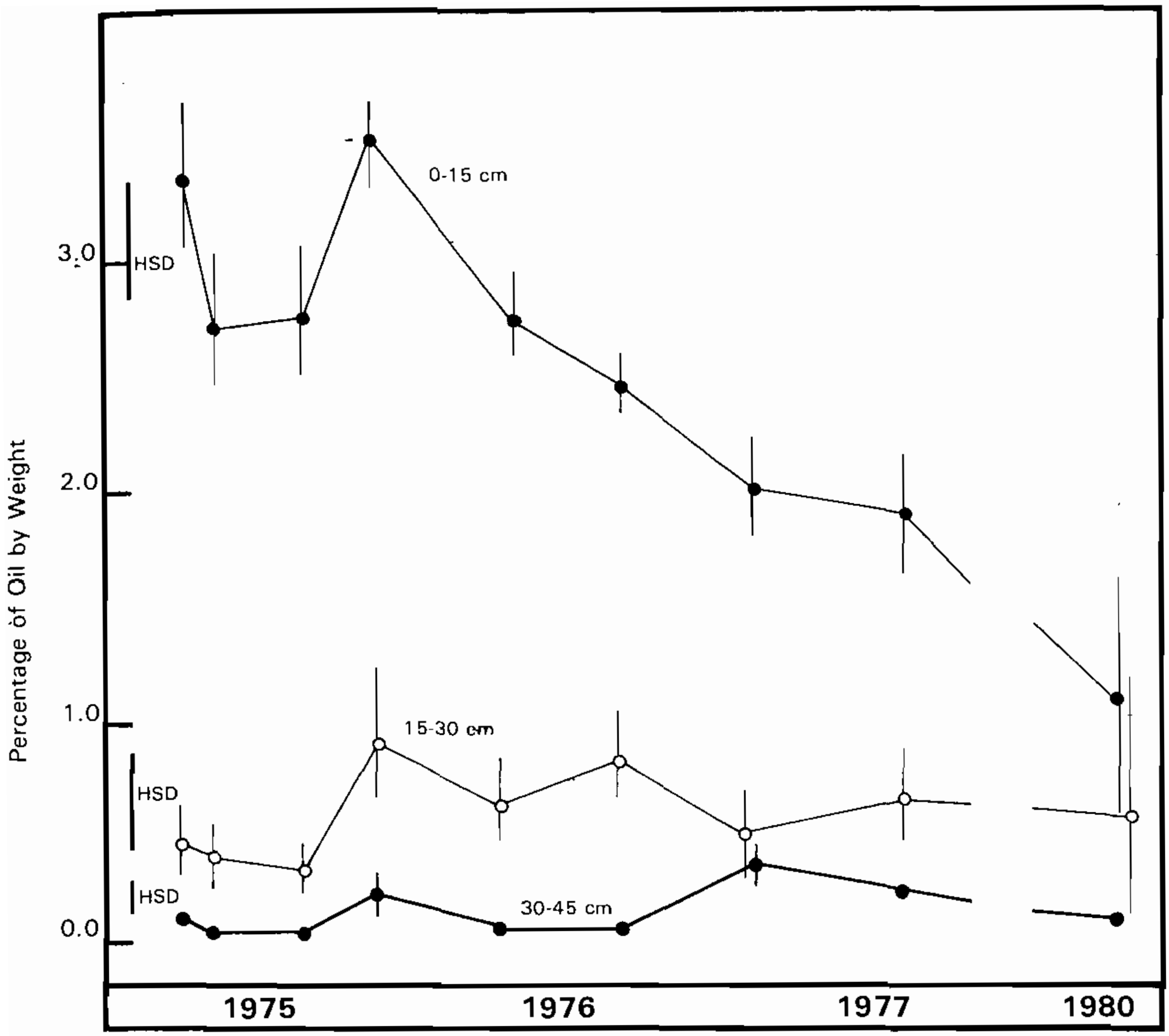
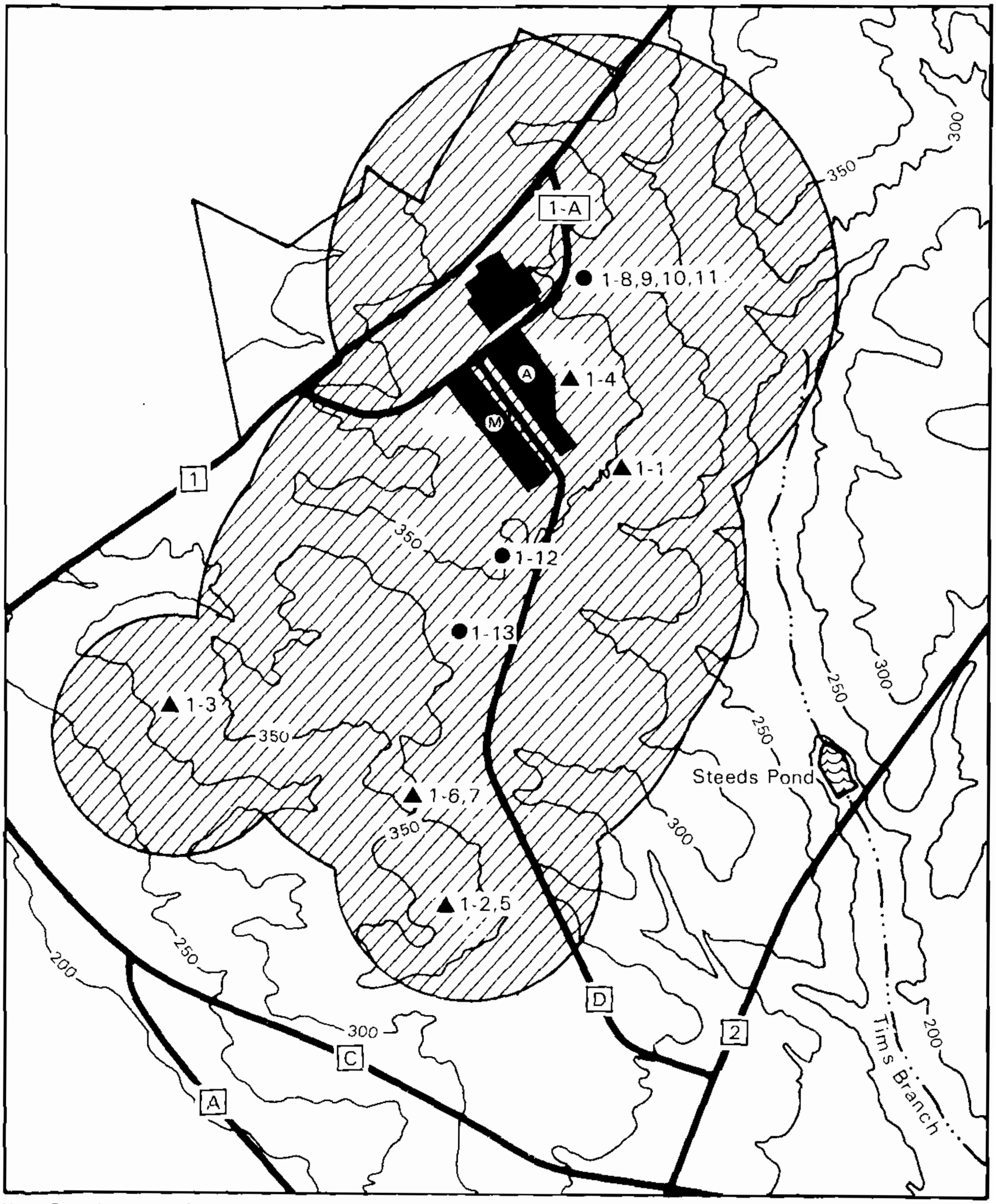


Figure B-23. Oil Content of Soil as a Function of Time for Three Soil Depths (The bars on the means are ±2 standard errors. Honestly significant differences (HSD) shown along the y-axis for each of the three soil depths.)



Note: Elevations are in feet above mean sea level 1.0 foot = 0.3048 meter

A *Savannah River Laboratory and Administration Area*

M *Fuel and Target Fabrication*

Legend on following page

Scale (kilometers) 0 1 2

Figure B-2. A- and M-Area Waste Sites

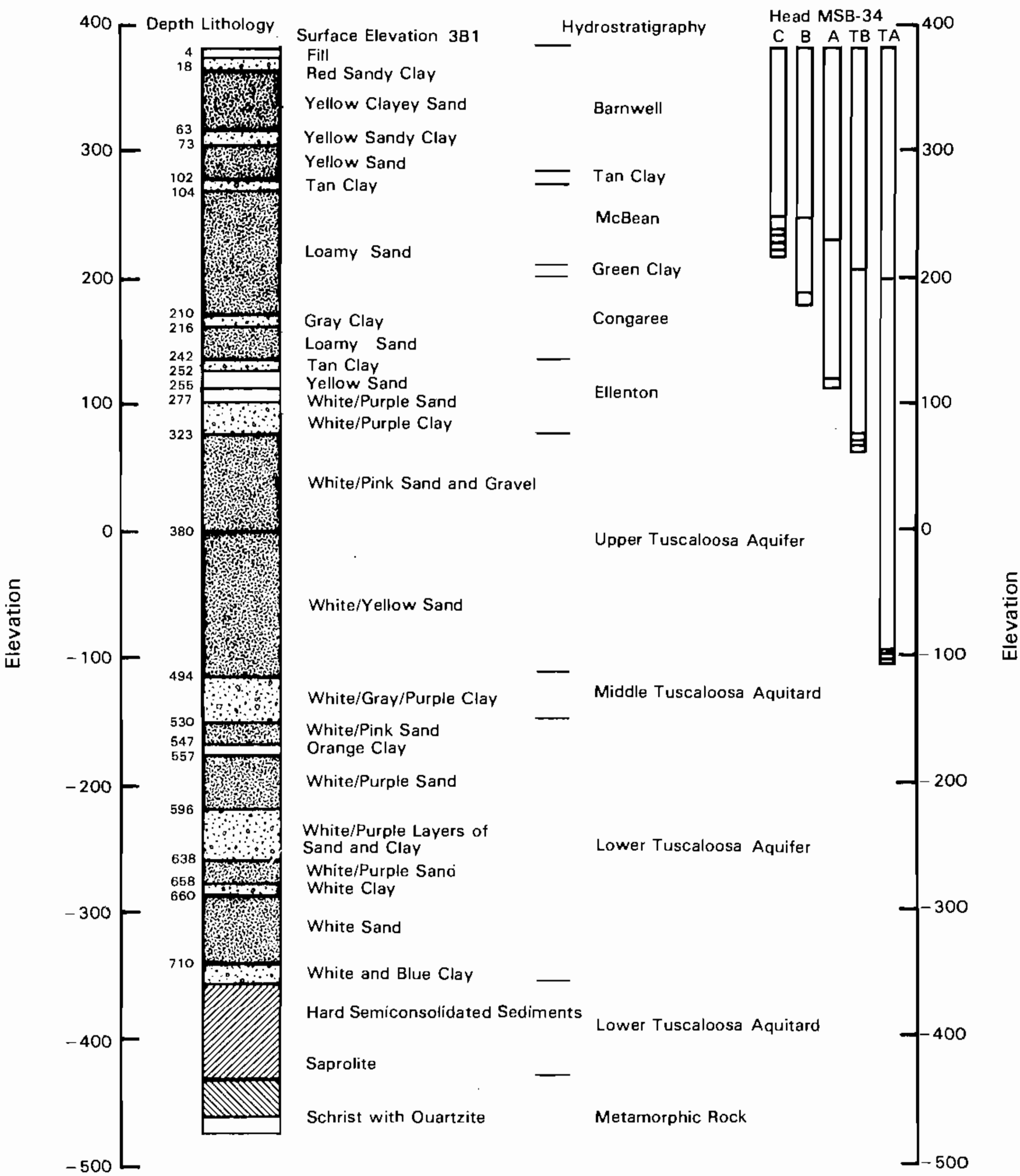
Number	Potential Waste Type	Site Name	Building Number
1-1	▲	716-A Motor Shop Seepage Basin	904-101G
1-2	▲	Metals Burning Pit	731-4A
1-3	▲	Silverton Road Waste Site	731-3A
1-4	▲	Metallurgical Laboratory Basin*	904-110G
1-5	▲	Miscellaneous Chemical Basin*	731-5A
1-6	▲	A-Area Burning/Rubble Pit*	731-A
1-7	▲	A-Area Burning/Rubble Pit*	731-1A
1-8	●	SRL Seepage Basin	904-53G
1-9	●	SRL Seepage Basin	904-53G
1-10	●	SRL Seepage Basin	904-54G
1-11	●	SRL Seepage Basin	904-55G
1-12	●	M-Area Settling Basin	904-51G
1-13	●	Lost Lake	904-112G

*Indicates that waste type may be contained in the waste site

▲—Hazardous

●—Mixed

Figure B-2. A- and M-Area Waste Sites (continued)



Note: 1.0 foot = 0.3048 meter

Figure B-3. Geology and Hydrology Near the Center of A- and M-Area (Geology and heads for elevations above −280 ft. were determined at MSB-34TA; those for −280 to −355 ft. at 905-20A; and those for elevations below −355 ft. at well P8R located at MSB-17)

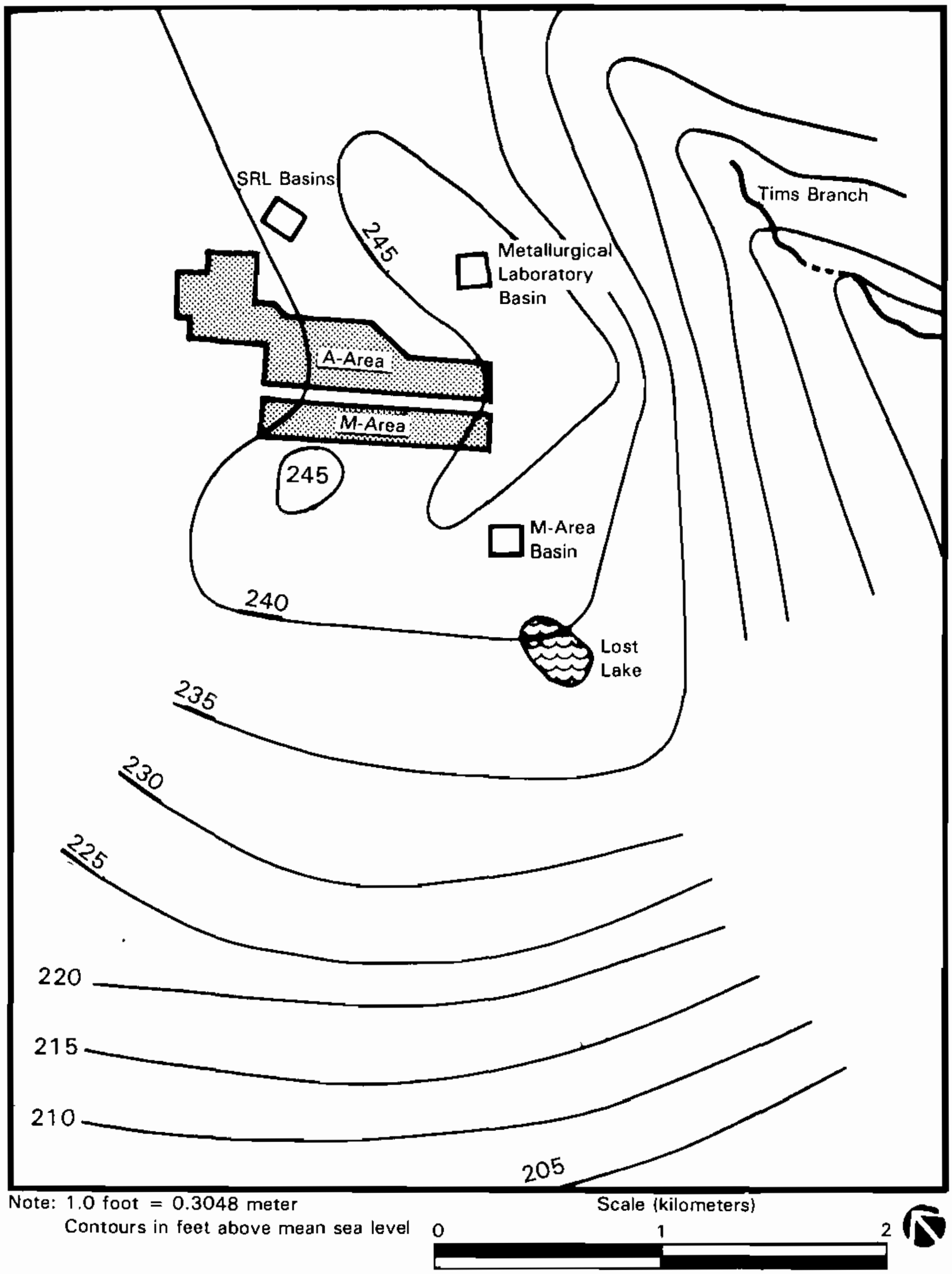
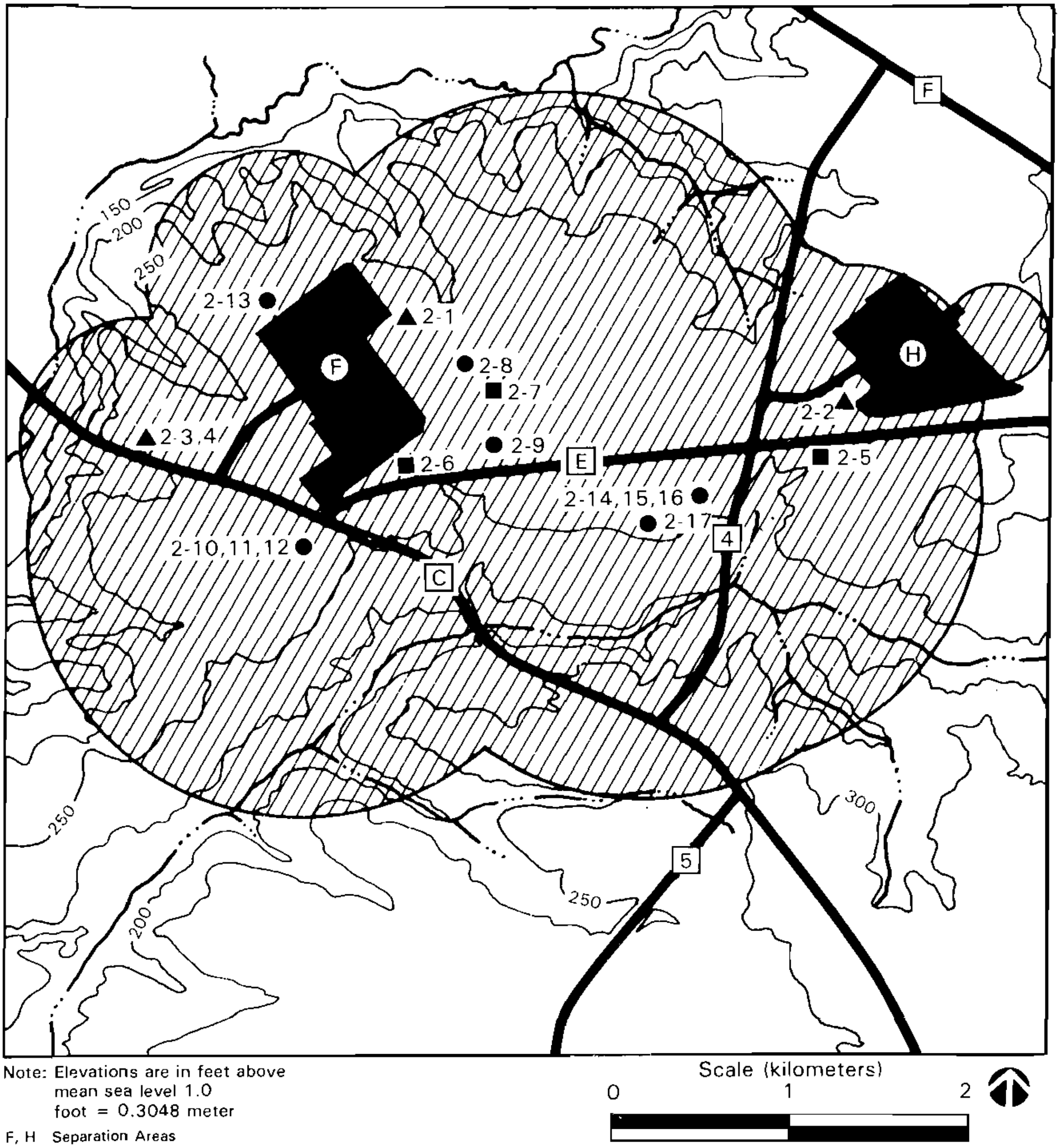


Figure B-4. Water Table Map for July 1984, A/M-Areas and Vicinity



Note: Elevations are in feet above mean sea level 1.0 foot = 0.3048 meter

F, H Separation Areas

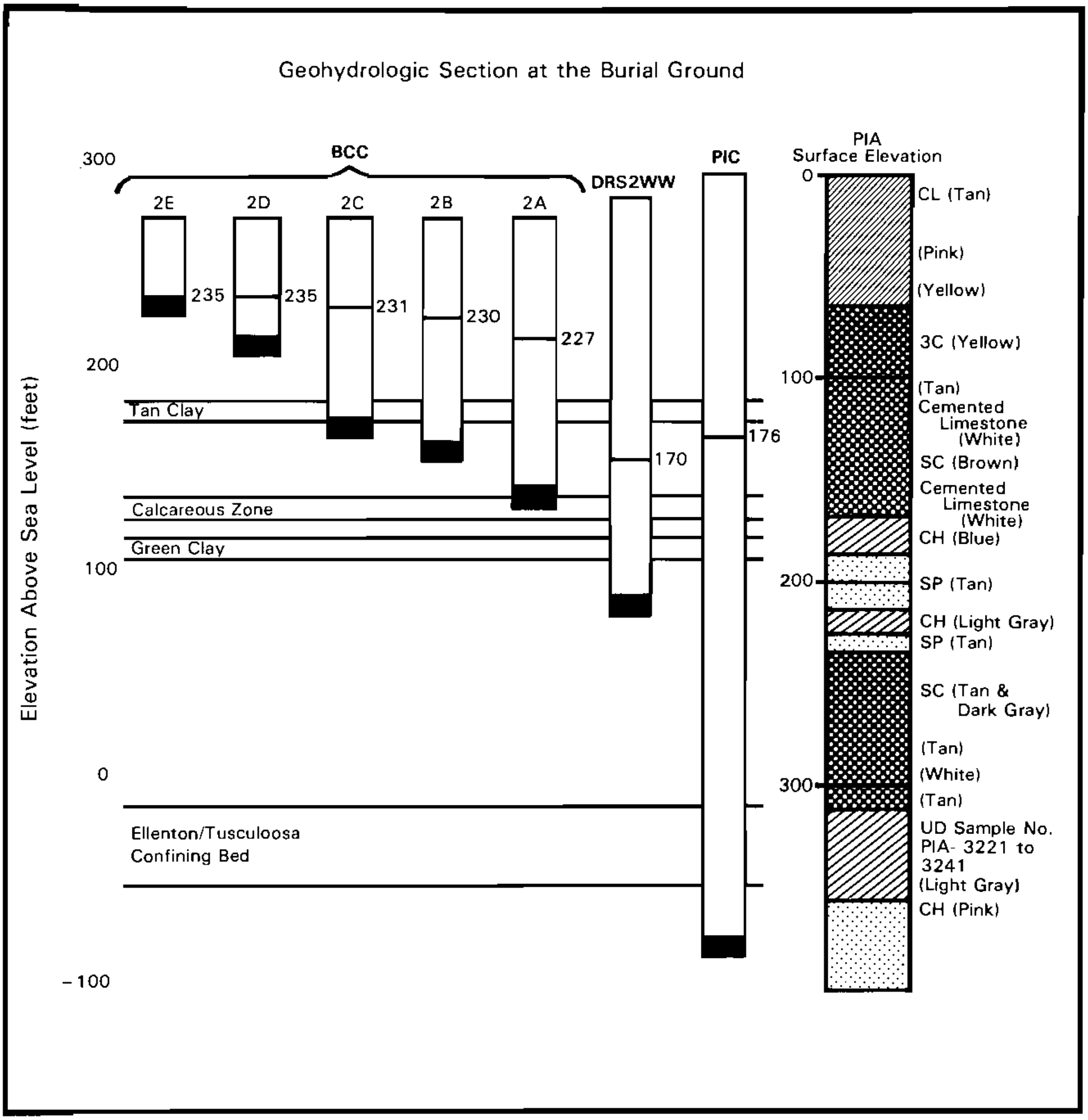
Legend on following page

Figure B-5. F- and H-Area Waste Sites

Number	Potential Waste Type	Site Name	Building Number
2-1	▲	F-Area Acid/Caustic Basin*	904-74G
2-2	▲	H-Area Acid/Caustic Basin*	904-75G
2-3	▲	F-Area Burning/Rubble Pit*	231-F
2-4	▲	F-Area Burning/Rubble Pit*	231-1F
2-5	■	H-Area Retention Basin	281-3H
2-6	■	F-Area Retention Basin	281-3F
2-7	■	Radioactive Waste Burial Ground	643-7G
2-8	●	Mixed Waste Management Facility	643-28G
2-9	●	Radioactive Waste Burial Ground	643-G
2-10	●	F-Area Seepage Basin	904-41G
2-11	●	F-Area Seepage Basin	904-42G
2-12	●	F-Area Seepage Basin	904-43G
2-13	●	F-Area Seepage Basin (old)	904-49G
2-14	●	H-Area Seepage Basin	904-44G
2-15	●	H-Area Seepage Basin	904-45G
2-16	●	H-Area Seepage Basin	904-46G
2-17	●	H-Area Seepage Basin	904-56G

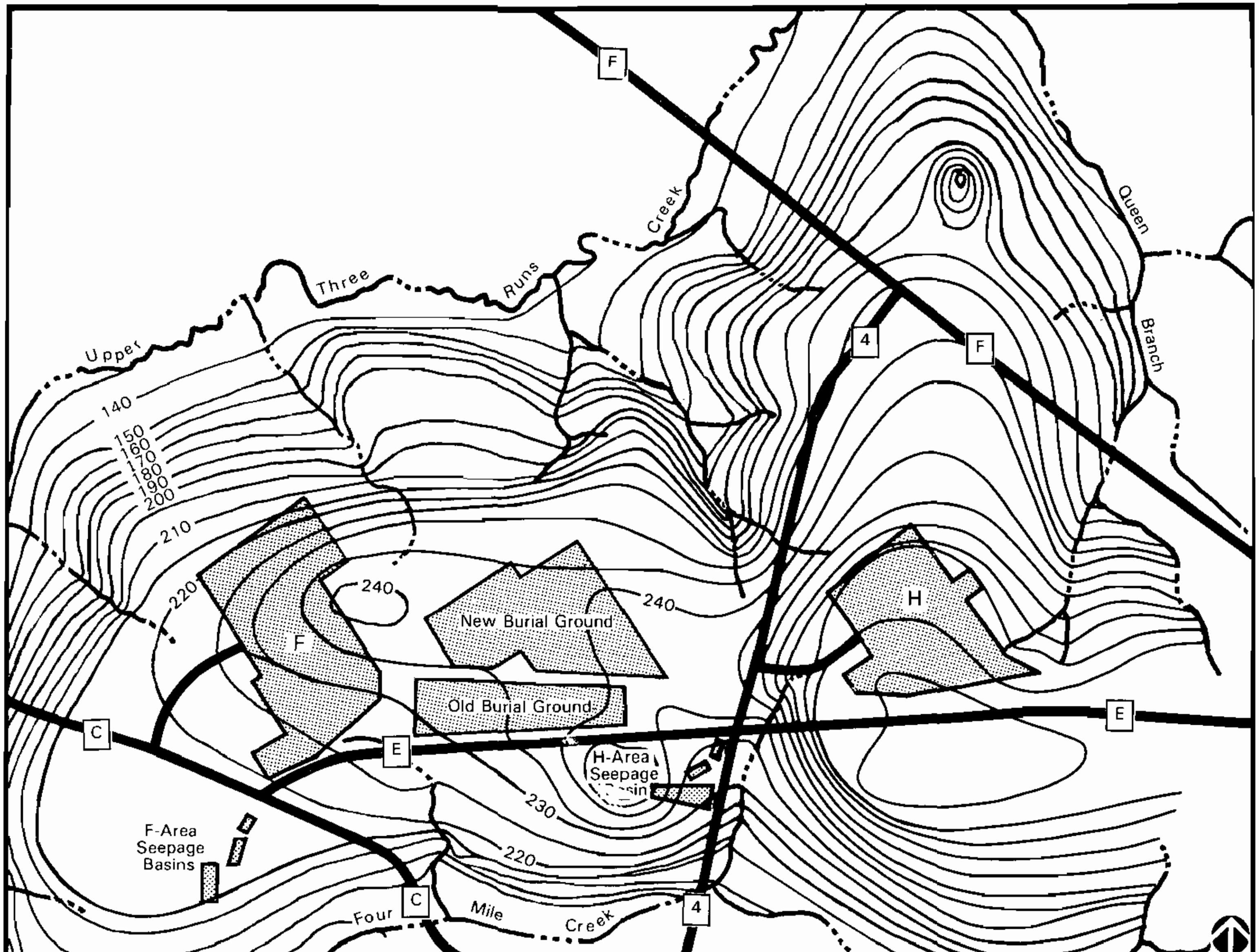
*Indicates that waste type may be contained in the waste site
▲—Hazardous
■—Low-level radioactive
●—Mixed

Figure B-5. F- and H-Area Waste Sites (continued)



Source: Jaegge *et al.* (1986)
Note: 1.0 foot = 0.3048 meter

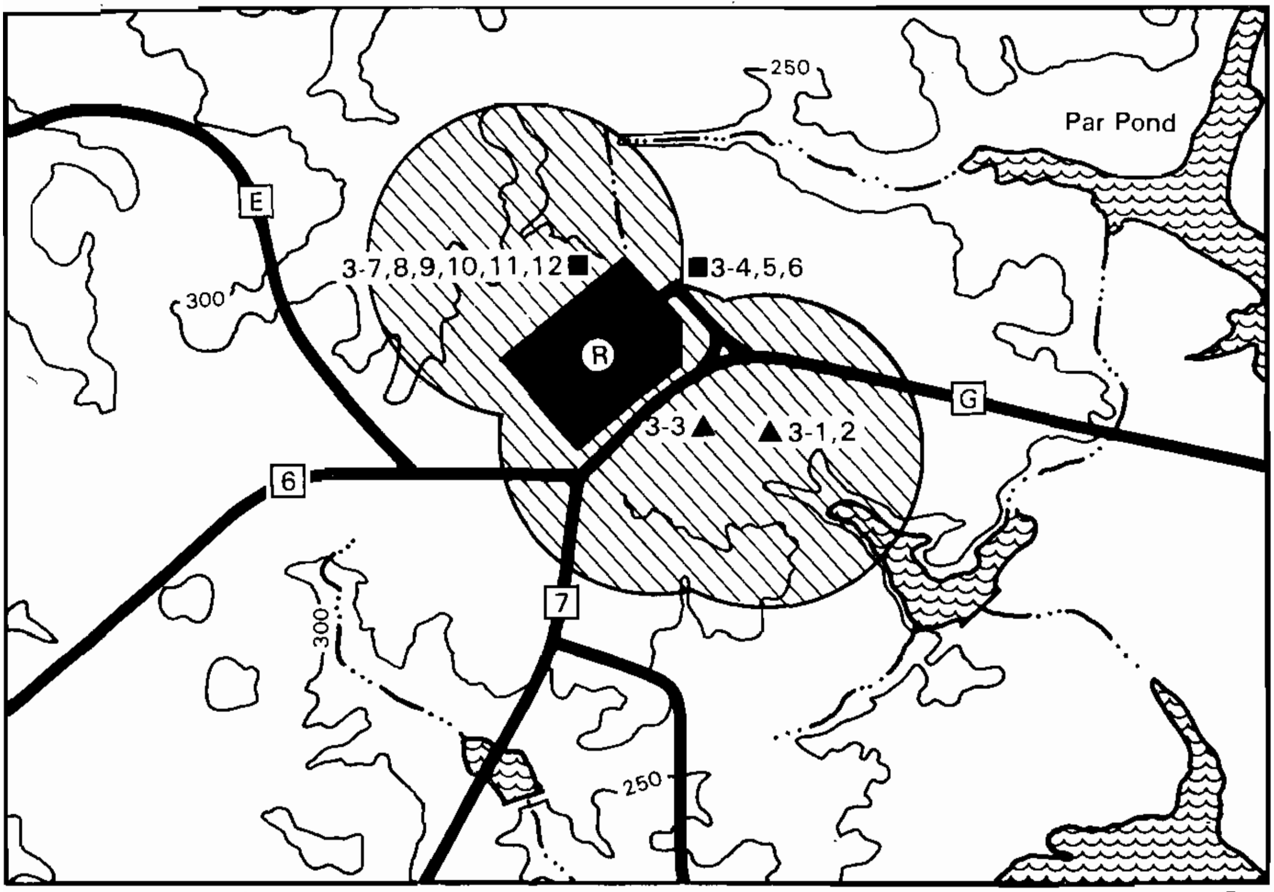
Figure B-6. Vertical-Head Relationships Around Log for Burial Ground Wells



Source: Jaegge *et al.*, 1987.
Note: 1.0 foot = 0.3048 meter
Contours are in 10 foot intervals below 200 feet and 5 foot intervals above 200 feet.

Scale (kilometers)
0 1 2

Figure B-7. Water Table, F- and H-Areas, 1982



Note: Elevations are in feet above mean sea level 1.0 foot = 0.3048 meter

R Reactor Area

Scale (kilometers) 0 1 2

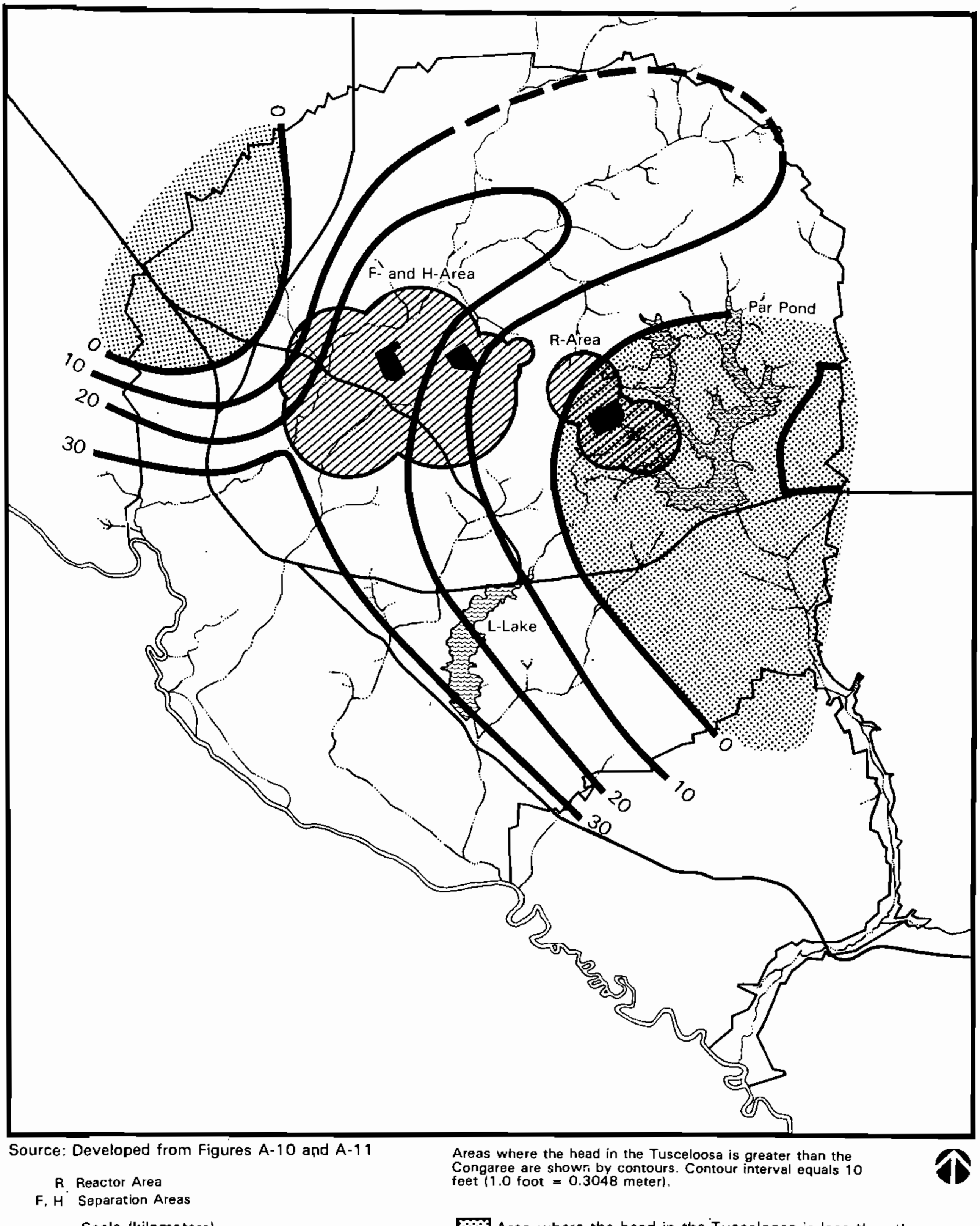
Number	Potential Waste Type	Site Name	Building Number
3-1	▲	R-Area Burning/Rubble Pit*	131-R
3-2	▲	R-Area Burning/Rubble Pit*	131-1R
3-3	▲	R-Area Acid/Caustic Basin*	904-77G
3-4	■	R-Area Bingham Pump Outage Pit*	643-8G
3-5	■	R-Area Bingham Pump Outage Pit*	643-9G
3-6	■	R-Area Bingham Pump Outage Pit*	643-10G
3-7	■	R-Area Reactor Seepage Basin	904-57G
3-8	■	R-Area Reactor Seepage Basin	904-58G
3-9	■	R-Area Reactor Seepage Basin	904-59G
3-10	■	R-Area Reactor Seepage Basin	904-60G
3-11	■	R-Area Reactor Seepage Basin	904-103G
3-12	■	R-Area Reactor Seepage Basin	904-104G

*Indicates that waste type may be contained in the waste site

▲—Hazardous

■—Low-level radioactive

Figure B-8. R-Area Waste Sites



Source: Developed from Figures A-10 and A-11

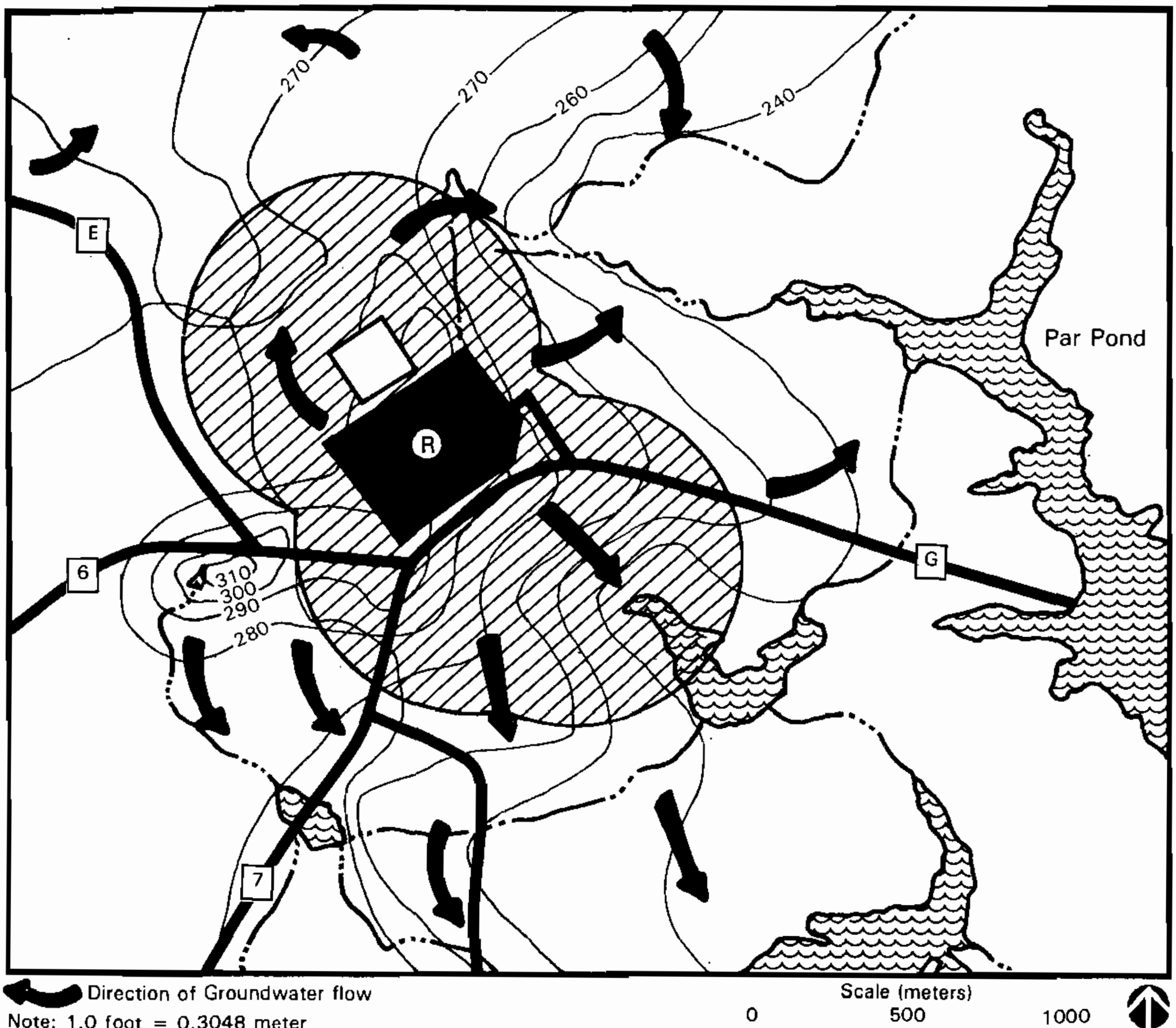
R Reactor Area
F, H Separation Areas

Scale (kilometers)
0 2 4 6 8 10

Areas where the head in the Tusceloosa is greater than the Congaree are shown by contours. Contour interval equals 10 feet (1.0 foot = 0.3048 meter).

Area where the head in the Tuscaloosa is less than the head in the Congaree

Figure B-9. Head Difference in Feet Between Tuscaloosa and Congaree Formations at Savannah River Plant (1982)



Note: 1.0 foot = 0.3048 meter

Source: Pekkala, Jewell, Holmes, and Marine, 1987b.

R Reactor Area

Figure B-10. Water Table Elevation (in feet above mean sea level) at R-Area During the Period 1961-1967

Table B-12. Site Investigations and Monitoring at Waste Management Facilities in the F- and H-Area Geographic Grouping[a]

TE

Facility	RCRA monitoring well[b]	Site investigations[c]	Monitoring results
		HAZARDOUS WASTE SITES	
F-Area acid/caustic basin (904-74G)	FAC 1 FAC 2 FAC 3 FAC 4	Wells monitored quarterly for RCRA and SCHWMR parameters. Waste site characterization program completed in 1985.	Statistical analysis of groundwater monitoring data shows the following to be present: • pH • Conductivity • Manganese • Sodium • Sulfate • Barium Sediment samples showed elevated levels of metals and other inorganics.
H-Area acid/caustic basin (904-75G)	None	Waste site characterization program, completed in 1985, consists of water, sediment, and soil sample analysis.	None.
F-Area burning/rubble pits (231-F, 231-1F)	FBP 1A FBP 2A FBP 3A FBP 4	Wells monitored quarterly for RCRA and SCHWMR parameters. Waste site sediment characterization program to be conducted.	Statistical analysis of groundwater monitoring data shows the following to be present: • Conductivity • Total organic carbon • Total organic halogen • pH • Sodium • Chloride
		LOW-LEVEL WASTE SITES	
H-Area retention basin (281-3H)	281-3H-11[d] 281-3H-13[d]	Core samples of basin sediments taken in 1973. Radiological survey (1977) of soil and vegetation found elevated levels of radioactivity. Wells monitored for tritium, gross alpha, and gross nonvolatile beta.	Soil constituents include: • Cesium-137 • Strontium-89, -90 • Plutonium-238 Radiation measured at 90 mrad/hr. Vegetation exhibited levels of • Cesium-137 at 8200-8900 pCi/g • Strontium-89, -90 at 58,000 pCi/g Groundwater monitoring data shows elevated levels of tritium.
F-Area retention basin (281-3F)	None	In late 1978, 994 m^3 of contaminated soil removed. Core samples taken at that time.	Soil constituents include: • Cesium-137 • Strontium-89, -90

Footnotes on last page of table.

Table B-12. Site Investigations and Monitoring at Waste Management Facilities in the F- and H-Area Geographic Grouping[a] (continued) | TE

Facility	RCRA monitoring well[b]	Site investigations[c]	Monitoring results
		LOW-LEVEL WASTE SITES (continued)	
Radioactive waste burial ground (643-7G)	15 wells directly associated with 643-7G[c]	Wells monitored for: • Tritium • Gross alpha • Gross nonvolatile beta • Mercury • Lead • Cadmium	Groundwater constituents include: • Gross beta • Tritium • Strontium-90 • Technetium-99 • Cesium-137 • Cobalt-60 • Plutonium-238 • Curium-244 • Mercury • Lead • Cadmium
		MIXEO WASTE SITES	
Radioactive waste burial ground (643-G)	125 single wells and 3 well clusters directly associated with 643-G[d]	Groundwater wells monitored for: • Tritium • Gross alpha • Gross nonvolatile beta • Mercury • Lead • Cadmium Following parameters measured for wells with history of gross alpha or gross nonvolatile beta activity • Cobalt-60 • Strontium-90 • Cesium-137 • Plutonium-23B, -239 Dry boreholes used for in-situ gamma radiation measurements. Additional soil coring planned.	Groundwater constituents include: • Gross alpha • Gross beta • Tritium • Mercury • Lead • Cadmium • Strontium-90 • Technetium-99 • Cesium-137 • Cobalt-60 • Plutonium-238 • Curium-244 Tritium plume defined east of facility.
Mixed waste management facility (643-28G)	38 wells are associated with 643-28G[d]	27 new RCRA monitoring wells located in clusters of 3 will be installed with RCRA monitoring proposed as part of postclosure detection and compliance point monitoring. A compaction study will determine the physical characteristics of the waste and overburden. A borrow study will identify sources of material for the final cover.	The presence of hazardous constituents in the groundwater at the boundary of 643-28G has not been established.

Footnotes on last page of table.

 TE

Facility	RCRA monitoring well[b]	Site investigations[c]	Monitoring results
		MIXED WASTE SITES (continued)	
F-Area seepage basins (904-41G, 904-42G, 904-43G)	FSB 76, 76A, B, C FSB 77 FSB 78, 78A, B, C FSB 79, 79A, B, C FSB 87A, B, C, D	Wells monitored quarterly for RCRA and SCHWMR parameters. 13 plume-definition wells installed in fall 1984. Soil samples from seepage basin collected during several studies (1971 and 1984). Terrain conductivity survey completed. As of 11/5/87, 28 RCRA compliance wells have been installed.	Statistical analysis of groundwater monitoring data shows the presence of: • Conductivity • Total dissolved solids • Turbidity • Sodium • Zinc • Nitrate • pH • Cadmium • Copper • Lead • Mercury • Manganese • Nickel • Gross beta • Radium • Chromium • Fluoride (Sampling techniques or well construction may bias results.) Additional probable groundwater contaminants include • Gross alpha • Tritium • Strontium-90 • Selenium • Barium Probable soil contaminants include • Americium-241 • Cobalt-60 • Cesium-137 • Tritium • Iodine-129 • Niobium-95 • Promethium-147 • Ruthenium-106 • Strontium-89, -90 • Uranium-234, -235, -238 • Zirconium-95 • Chromium • Sodium • Zinc • Tin • Mercury

F-22

Footnotes on last page of table.

Table B-12. Site Investigations and Monitoring at Waste Management Facilities in the F- and H-Area Geographic Grouping[a] (continued) | TE

Facility	RCRA monitoring well[b]	Site investigations[c]	Monitoring results
		MIXED WASTE SITES (continued)	
F-Area seepage basin (904-49G)	FNB 1 FNB 2 FNB 3 FNB 4	Wells monitored quarterly for RCRA and SCHWMR parameters. Sediment samples collected from basin in June 1955. Wastewater samples collected in February 1985.	Statistical analysis of groundwater monitoring data indicates the presence of: • Conductivity • Nitrate • pH • Barium • Manganese • Sodium • Gross alpha • Gross beta • Radium • Lead Constituents present in groundwater include: • Mercury • Lead • Total dissolved solids
H-Area seepage basins (904-44G, 904-45G, 904-46G, 904-56G)	HSB 65, 65A, B, C HSB 66 HSB 67 HSB 68, 68A, B, C HSB 69 HSB 70 HSB 71 HSB 83A, B, C, D HSB 84A, B, C, D HSB 85A, B, C HSB 86A, B, C, D	Wells monitored quarterly for RCRA and SCHWMR parameters. 21 plume-definition wells installed in fall 1984. 0.9-m cores collected from bottoms of H-Area basins in 1984. Terrain conductivity survey completed. As of 11/5/87, 27 of 42 RCRA compliance wells were installed.	Statistical analysis of groundwater monitoring data indicate the following to be present: • pH • Conductivity • Total dissolved solids • Manganese • Sodium • Fluoride • Nitrate • Mercury • Gross beta • Cadmium • Radium • Chloride Additional constituents present: • Gross alpha • Tritium • Strontium-90 • Lead • Barium • Antimony

TC

Footnotes on last page of table.

Table B-12. Site Investigations and Monitoring at Waste Management Facilities in the F- and H-Area Geographic Grouping[a] (continued) TE

Facility	RCRA monitoring well[b]	Site investigations[c]	Monitoring results
		MIXED WASTE SITES (continued)	
			Soil column constituents include: • Plutonium-238 • Plutonium-239, -240 • Americium-241 • Cerium-144 • Curium-244 • Cobalt-60 • Cesium-134, -137 • Tritium • Iodine-129 • Promethium-147 • Strontium-89, -90 • Ruthenium-106 • Technetium-99 • Uranium-234, -235, -238 • Zirconium-95 • Barium • Chromium • Sodium • Lead • Zinc • Mercury

[a]Sources: Ward, Johnson, and Marine, 1987; Huber, Johnson, and Marine, 1987; Scott, Killian, Kolb, Corbo, and Marine, 1987; Jaegge et al., 1987; DOE, 1985; Killian et al, 1987a,b; Du Pont, 1985b; Odum et al., 1987. TC
[b]Monitored hydrogeologic units for these wells are the Barnwell and McBean.
[c]See page B-1.
[d]Not RCRA monitoring wells.

Table B-1B. Site Investigations and Monitoring at Waste Management Facilities in the R-Area Geographic Grouping[a] | TE

Facility	RCRA monitoring well[b]	Site investigations[c]	Monitoring results
		HAZARDOUS WASTE SITES	
R-Area burning/rubble pits (131-R, 131-1R)	RRP 1 RRP 2 RRP 3 RRP 4	Wells monitored quarterly for RCRA and SCHWMR parameters. Waste sediment characterization program to be conducted.	Statistical analysis of groundwater monitoring data indicates the following parameters to be present: • Sodium • Copper
R-Area acid/caustic basin (904-77G)	RAC 1 RAC 2 RAC 3 RAC 4	Wells monitored quarterly for RCRA and SCHWMR parameters. Waste site characterization program completed by third quarter of 1985.	Statistical analysis of groundwater monitoring data indicates the following to be present: • Conductivity • Chloride • Total dissolved solids • Sodium Sediment samples showed metals and other inorganics to be present.
		LOW-LEVEL WASTE SITES	
R-Area Bingham Pump outage pits (643-8G, G43-9G, 643-10G)	None	No monitoring wells exist at outage pits, and records yield no evidence of core-sampling activity there. Radioactivity in vegetation measured in 1970.	Vegetation growing above outage pits shows little or no elevation in activity levels.
R-Area seepage basins (904-57G, 904-58G, 904-59G, 904-60G, 904-103G, 904-104G)	48 monitoring wells associated with R-Area reactor seepage basins[d]	Wells typically monitored for gross alpha, gross nonvolatile beta, and tritium. Soil borings were analyzed from sediment in and beneath backfilled basins in 1978.	Groundwater constituents include • Strontium-90 • Gross alpha • Gross beta Soil contaminants include • Cesium-137 • Strontium-90

[a]Sources: Huber, Johnson, and Marine, 1987; Ward, Johnson, and Marine, 1987; Pekkala, Jewell, Holmes, and Marine, 1987a, b. | TC
[b]The monitored hydrolgeologic unit for these wells is the Barnwell.
[c]See page B-1.
[d]Not RCRA monitoring wells.

Table B-20. Site Investigations and Monitoring at Waste Management Facilities in the C- and CS-Area Geographic Grouping[a]

TE

Facility	RCRA monitoring well[b]	Site investigations[c]	Monitoring results
		HAZARDOUS WASTE SITES	
CS-Area burning/rubble pits (631-1G, 631-5G, 631-6G)	CSR 1 CSR 2 CSR 3 CSR 4 No wells at pit 631-6G	Wells monitored quarterly for RCRA and SCHWMR parameters. Waste site sediment characterization program to be conducted.	Statistical analysis of groundwater monitoring data indicates the following to be present: • Conductivity • Sodium
C-Area burning/rubble pit (131-C)	CRP 1 CRP 2 CRP 3 CRP 4	Wells monitored quarterly for RCRA and SCHWMR parameters. Waste site sediment characterization program to be conducted.	Statistical analysis of groundwater monitoring data indicates the following to be present: • pH • Conductivity • Lead • Manganese • Sodium • Total organic halogen • Nitrate
Hydrofluoric-acid spill area (631-4G)	CSA 1 CSA 2 CSA 3 CSA 4	Wells monitored quarterly for RCRA and SCHWMR parameters. No soil-sample analyses performed.	Groundwater-monitoring results indicate the presence of: • Barium • Manganese
		LOW-LEVEL WASTE SITES	
Ford Building waste site (643-11G)	None	None	None

Footnotes on last page of table.

Table B-20. Site Investigations and Monitoring at Waste Management Facilities in the C- and CS-Area Geographic Grouping[a] (continued) | TE

Facility	RCRA monitoring well[b]	Site investigations[c]	Monitoring results
		MIXED WASTE SITE	
Ford Building seepage basin (904-91G)	HXB 1 HXB 2 HXB 3	Wells monitored quarterly for RCRA and SCHWMR parameters. Basin-characterization study completed in 1985.	Groundwater monitoring indicates the presence of: • Nitrate • Mercury • Lead Soil characterization data indicate the presence of: • Cesium-137 • Cobalt-60 • Strontium-90 • Aluminum • Arsenic • Cadmium • Chromium • Copper • Iron • Mercury • Nickel • Selenium • Zinc • Ammonia • Fluoride • Sulfate • Phosphate

[a]Sources: Huber, Johnson, and Marine, 1987; Huber and Bledsoe, 1987a; Huber et al., 1987; Pekkala, Jewell, Holmes, and Marine, 1987b; Pekkala, Jewell, Holmes, Simmons, and Marine, 1987. | TC
[b]The monitored hydrogeologic unit for these wells is the Barnwell.
[c]See page B-1.
[d]Not RCRA monitoring wells.

Table B-25. Site Investigations and Monitoring at Waste Management Facilities in the TNX-Area Geographic Grouping[a]

Facility	RCRA monitoring well[b]	Site investigations	Monitoring results
		HAZARDOUS WASTE SITES	
D-Area burning/rubble pits (431-D, 431-1D)	DBP 1 DBP 2 DBP 3 DBP 4	Wells monitored quarterly for RCRA and SCHWMR parameters. Sediment samples to be taken from facilities with similar inventories. If contamination is indicated, all burning/rubble pits with similar inventories will be tested.	Statistical analysis of groundwater monitoring data indicates the following to be present: • pH • Lead • Nitrate • Conductivity • Manganese • Sulfate • Copper
		LOW-LEVEL WASTE SITES	
TNX burial ground (643-5G)	None	No groundwater monitoring wells exist in immediate vicinity of TNX burying ground. No soil samples from burial area have been analyzed.	Uranyl nitrate is possible soil constituent.
		MIXED WASTE SITES	
TNX seepage basin, old (904-76G)	XSB 1[c] XSB 2[c] XSB 3A[c] XSB 4[c] XSB 5, 5A[c] XSB 3T[c]	Wells monitored quarterly for RCRA and SCHWMR parameters. Basin-sediment and swamp-sediment characterization program completed in 1984.	Statistical analysis of groundwater monitoring data indicates the following are present: • pH • Conductivity • Barium* • Chromium* • Manganese* • Zinc* • Gross beta • Gross alpha • Radium • Total organic halogen • Total dissolved solids • Cadmium* • Copper* • Iron* • Sodium *Probable sampling artifacts.

Footnotes on last page of table.

Table B-25. Site Investigations and Monitoring at Waste Management Facilities in the TNX-Area Geographic Grouping[a] (continued)

TE

Facility	RCRA monitoring well[b]	Site investigations	Monitoring results
		MIXED WASTE SITES (continued)	
			• Nickel • Nitrate • Total organic carbon • Beryllium • Lead Basin-sediment samples contained: • Curium-243, -244 • Plutonium-239, -240 • Radium-228 • Thorium-228 • Uranium-235 • Silver • Chromium • Copper • Nickel • Mercury • Cyanide Swamp-sediment samples contain: • Radium-228 • Thorium-228 • Tritium • Uranium-235 • Chromium • Mercury Swamp water constituents include: • Gross alpha • Gross beta • Radium • Silver • Chromium • Copper • Mercury • Cyanide
TNX seepage basin, new (904-102G)	YSB 1A YSB 2A YSB 3A YSB 4A	Wells monitored quarterly for RCRA and SCHWMR parameters. Sediment-sampling program (1.5-m cores) conducted in fourth quarter of 1985.	Monitoring indicates little if any groundwater contamination. Soil characterization indicates no significant organic contamination. EP toxicity tests show basin sediments to be nonhazardous.

Footnotes on last page of table.

Table B-25. Site Investigations and Monitoring at Waste Management Facilities in the TNX-Area Geographic Grouping[a] (continued) | TE

Facility	RCRA monitoring well[b]	Site investigations	Monitoring results
		MIXED WASTE SITES (continued)	
			The following constituents are found in soils and groundwater: • Barium • Nickel • Chromium • Lead • Nitrate • Phosphate • Sodium

[a]Sources: Huber, Johnson, and Marine, 1987; Dunaway, Johnson, Kingley, Simmons, and Bledsoe, 1987a,b; Dunaway, Johnson, Kingley, Simmons, Bledsoe, and Smith, 1987. | TC

[b]The monitored hydrogeologic unit for these wells is the Pleistocene alluvium.

[c]Non-RCRA wells.

Table B-26. Site Investigations and Monitoring at Waste Management Facility in the D-Area Geographic Grouping[a] TE

Facility	RCRA monitoring well[b]	Site investigations	Monitoring results
D-Area waste oil basin (631-G)	DOB 1 DOB 2 DOB 3 DOB 4	Wells monitored quarterly for RCRA and SCHWMR parameters. Sediments beneath waste-oil basin to be characterized. Following parameters to be measured: • EP toxicity-metals • Acid-base and neutral organics • Volatile organics • Oil and grease	Statistical analysis of groundwater monitoring data shows that lead is the only constituent that is significantly elevated in a down-gradient well. TC

[a]Source: Huber, Johnson, and Bledsoe, 1987.
[b]The monitored hydrogeologic unit for these wells is the Pleistocene alluvium. TC

Table B-27. Site Investigations and Monitoring at the Road A Area Geographic Grouping[a] TE

Facility	RCRA monitoring well[b]	Site investigations	Monitoring results
Road A chemical basin (904-111G)	BRD 1 BRD 2 BRD 3 BRD 4	Wells monitored quarterly for RCRA and SCHWMR parameters. No soil or sediment characterization studies have been performed.	Elevated levels of lead are evident in a downgradient well.

TC

[a]Source: Pickett, Muska, and Bledsoe, 1987.
[b]The monitored hydrogeologic unit for these wells is the McBean. TC

Table B-30. Site Investigations and Monitoring at Waste Management Facilities in the K-Area Geographic Grouping[a]

TE

Facility	RCRA monitoring well[b]	Site investigations[c]	Monitoring results
		HAZARDOUS WASTE SITES	
K-Area burning/rubble pit (131-K)	KRP 1 KRP 2 KRP 3 KRP 4	Wells monitored quarterly for RCRA and SCHWMR parameters. Waste site characterization program to be conducted.	Statistical analyses of ground-water monitoring data indicate the following are present: • Nickel • Conductivity • Manganese • Sodium • Total organic halogen • Sulfate
K-Area acid/caustic basin (904-80G)	KAC 1 KAC 2 KAC 3 KAC 4	Wells monitored quarterly for RCRA and SCHWMR parameters. Waste site characterization program completed third quarter of 1985.	Statistical analysis of ground-water monitoring data indicates the following are present: • pH • Conductivity • Chloride • Sulfate • Sodium • Total organic halogen Sediment samples showed the presence of metals and other inorganics.
		LOW-LEVEL WASTE SITES	
K-Area Bingham Pump outage pit (643-1G)	None	No monitoring wells exist at outage pits, and records yield no evidence of core-sampling activity there. Radioactivity in vegetation measured in 1970.	Vegetation growing above outage pits shows little elevation in activity levels above background.

Footnotes on last page of table.

Table B-30. Site Investigations and Monitoring at Waste Management Facilities in the K-Area Geographic Grouping[a] (continued) TE

Facility	RCRA monitoring well[b]	Site investigations[c]	Monitoring results
		LOW-LEVEL WASTE SITES (continued)	
K-Area seepage basin (904-65G)	KSB 1[d] KSB 2[d] KSB 3[d] KSB 4A[d]	Wells typically monitored for gross alpha, gross nonvolatile beta, and tritium. Analyses of soils beneath reactor-area seepage basin conducted in 1978.	Groundwater monitoring results show little evidence of contamination. Basin soils contain: • Cesium-137 • Strontium-90 • Cobalt-60

[a]Sources: Huber, Johnson, and Marine, 1987; Ward, Johnson, and Marine, 1987; Pekkala, Jewell, Holmes, and Marine, 1987a, b. TC
[b]The monitored geohydrologic unit for these wells is the Barnwell.
[c]See page B-1.
[d]Not RCRA monitoring wells.

TE

Table B-32. Site Investigations and Monitoring at Waste Management Facilities in the L-Area Geographic Grouping[a]

Facility	RCRA monitoring well[b]	Site investigations[c]	Monitoring results
		HAZARDOUS WASTE SITES	
L-Area burning/rubble pit (131-L)	LRP 1 LRP 2 LRP 3 LRP 4	Wells monitored quarterly for RCRA and SCHWMR parameters. Waste site sediment characterization program to be undertaken.	Groundwater monitoring indicates no contaminants present.
L-Area acid/caustic basin (904-79G)	LAC 1 LAC 2 LAC 3 LAC 4	Wells monitored quarterly for RCRA and SCHWMR parameters. Waste site characterization program completed third quarter of 1985.	Statistical analysis of groundwater monitoring data indicates the following are present: • pH • Conductivity • Sulfate • Sodium Sediment samples showed presence of metals and other inorganics.

CMP pits (080-17G, 080-17.1G, 080-18G, 080-18.1G, 080-18.2G, 080-18.3G, 080-19G)	CMP 8A, B, C
	CMP 9B, C
	CMP 10B, C
	CMP 11B, C, TA
	CMP 12A, B, C
	CMP 13B, C
	CMP 14B, C
	CMP 15A, B, C
	CMP 16B
		Wells monitored quarterly for RCRA and SCHWMR parameters.
		Soil borings taken and contaminated soil excavated from pits (1984).
		Area capped with impermeable plastic and soil cover.
			Statistical analysis of groundwater data shows the following are present:
			• Conductivity
			• Zinc
			• Nitrate
			• Sulfate
			• pH
			• Sodium
			Groundwater constituents include:
			• Benzene
			• Methylene chloride
			• Tetrachloroethylene
			• Toluene
			• Bisphthalate
			• Lead
			• Mercury
			• Zinc
			• Copper

TC

Footnotes on last page of table.

Table B-32. Site Investigations and Monitoring at Waste Management Facilities in the L-Area Geographic Grouping[a] (continued)

TE

Facility	RCRA monitoring well[b]	Site investigations[c]	Monitoring results
		LOW-LEVEL WASTE SITES	
L-Area Bingham pump outage pits (643-2G, 643-3G)	None	No monitoring wells exist at outage pits, and records yield no evidence of core-sampling activity there. Radioactivity in vegetation measured in 1970.	Vegetation growing above outage pits shows little activity.
		MIXED WASTE SITES	
L-Area oil and chemical basin (904-83G)	LCO 1 LCO 2 LCO 3 LCO 4	Wells monitored quarterly for RCRA and SCHWMR parameters. Basin water, basin sediment, and soil under basin sampled in early 1985.	Groundwater constituents include: • Cadmium • Chromium • Mercury • Nickel • Lead • Tetrachloroethylene Possible basin-soil contaminants include • Americium-241 • Antimony-125 • Cesium-137 • Cobalt-60 • Europium-152 • Europium-154 • Europium-155 • Plutonium-238 • Plutonium-239, -240 • Promethium-147 • Strontium-90 • Tritium • Uranium-235 • Uranium-238

[a]Sources: Huber, Johnson, and Marine, 1987; Ward, Johnson, and Marine, 1987; Scott, Kolb, Price, and Bledsoe, 1987; Pekkala, Jewell, Holmes, and Marine, 1987b; Pekkala, Jewell, Price, and Bledsoe, 1987. TC

[b]The monitored hydrogeologic unit is the Barnwell.

[c]See page B-1.

Table B-33. Site Investigations and Monitoring at Waste Management Facilities in the P-Area Geographic Grouping[a] TE

Facility	RCRA monitoring well[b]	Site investigations[c]	Monitoring results
		HAZARDOUS WASTE SITES	
P-Area burning/rubble pit (131-P)	PRP 1A PRP 2 PRP 3 PRP 4	Wells monitored quarterly for RCRA and SCHWMR parameters. Waste site sediment characterization to be performed.	Statistical analysis of monitoring data indicates the following to be present: • pH • Barium • Lead • Conductivity • Magnesium • Sodium • Total organic carbon • Total organic halogen
P-Area acid/caustic basin (904-78G)	PAC 1 PAC 2 PAC 3 PAC 4	Wells monitored quarterly for RCRA and SCHWMR parameters. Waste site characterization program completed third quarter of 1985.	Statistical analysis of groundwater monitoring data indicates the following are present: • pH • Conductivity • Sodium • Zinc • Sulfate • Total dissolved solids • Chloride Sediment samples showed metals and other inorganics to be present.
		LOW-LEVEL WASTE SITES	
P-Area Bingham pump outage pit (643-4G)	None	No monitoring wells exist at outage pits, and records yield no evidence of core-sampling activity there. Radioactivity in vegetation measured in 1970.	Vegetation growing above outage pits shows elevated but low levels of activity. TC

[a]Sources: Huber, Johnson, and Marine, 1987; Ward, Johnson, and Marine, 1987; Pekkala, Jewell, Holmes, and Marine, 1987a, b. TC
[b]The monitoring hydrogeologic unit for these wells is the Barnwell.
[c]See page B-1.
[d]Non-RCRA wells.

Table B-34. Site Investigations and Monitoring at Miscellaneous Area Waste Management Facilities[a] TE

Facility	RCRA monitoring well	Site investigations	Monitoring results
SRL oil-test site (080-16G)	None	Soil beneath oil test site plots characterized at depths of 0-15, 15-30, and 30-45 cm.	Constituents present in soil include waste oil.
Gunsite 720 rubble pit	None	No studies on soil surrounding site have been performed to date.	None.

[a]Sources: Johnson, Pickett, and Bledsoe, 1987; Huber and Bledsoe, 1987b. TC

Table B-6. Site Investigations and Monitoring at Waste Management Facilities in the A- and M-Area Geographic Grouping[a] | TE

Facility	RCRA monitoring well[b]	Site investigations[c]	Monitoring results
		HAZARDOUS WASTE SITES	
Motor-shop seepage basin (904-110G)	AOB 1 AOB 2	Wells monitored quarterly for RCRA and SCHWMR parameters. Liquid sample from basin has been analyzed. Sediment beneath basin to be characterized.	Trace quantities of following materials present in the basin liquid: • Ethylene glycol • Kerosene • Motor oil • Grease
Metals-burning pit (731-4A)/miscellaneous chemical basin (731-5A)	ABP 1A ABP 2A ABP 3 ABP 4	Wells monitored quarterly for RCRA and SCHWMR parameters. Surface soil analysis conducted in January 1986.	Trichloroethylene and tetrachloroethylene found in wells ABP-2A and ABP-3. Surface soil analysis indicates presence of: • Tetrachloroethylene • Trichloroethylene • Trans, 1,2-dichloroethylene
Silverton Road waste site (731-3A)	SRW 1 SRW 2, 2A, 2B SRW 3A SRW 4 SRW 5 SRW 6 SRW 7 SRW 8 SRW 9, 9A, 9B SRW 10 SRW 11 SRW 12A, 12B, 12C SRW 13A, 13B, 13C SRW 14A, 14B, 14C SRW 15A, 15B, 15C SRW 16A, 16B, 16C	Wells monitored quarterly for RCRA and SCHWMR parameters. Waste-site sediment characterization program completed in 1983. Conductivity survey completed.	Groundwater constituents include: (TC) • Trichloroethylene • Tetrachloroethylene • 1,1,1-trichloroethane • Chloroform • Barium (Metals not observed • Cadmium in recent surveys) • Chromium • Lead • Iron Waste sediment analysis inconclusive. Soil constituents might include: (TC) • Trichloroethylene • Tetrachloroethylene • 1,1,1-trichloroethane Conductivity anomalies most likely due to increased clay content or metal objects (TC)
Metallurgical-Lab basin (904-110G)	AMB 1A AMB 2 AMB 3A	Wells monitored quarterly for RCRA and SCHWMR parameters. Soil and basin-water characterization program completed in 1985.	Sediment samples contain no organic compounds or metals above EPA guidelines. Basin-water samples pass all drinking-water standards except those for pH and iron

Footnotes on last page of table.

Table B-6. Site Investigations and Monitoring at Waste Management Facilities in the A- and M-Area Geographic Grouping[a] (continued) TE

Facility	RCRA monitoring well[b]	Site investigations[c]	Monitoring results
		HAZARDOUS WASTE SITES (continued)	
Burning/rubble pits (731-A, 731-1A)	ARP1A ARP2 ARP3 ARP4	Wells monitored quarterly for RCRA and SCHWMR parameters. Waste-site sediment characterization program to be initiated.	Statistical analysis of groundwater monitoring data shows the following to be present: • Manganese • Sodium • Sulfate • Nitrate • Iron
		LOW-LEVEL WASTE SITES	
SRL seepage basins [904-53G (two basins), 904-54G, 904-55G]	ABS 1A ABS 2A ABS 3 ABS 4 ABS 5A	Wells monitored quarterly for RCRA and SCHWMR parameters. Seepage basin sediment characterization program completed in 1983.	Statistical analysis of groundwater data indicates the following are present: • Manganese • Sodium • Chloride Trichloroethylene and tetrachloroethylene present in groundwater but might be from another source. Analysis of sediment cores showed the following to be present: • Arsenic • Cadmium • Chromium • Copper • Fluoride • Lead • Mercury • Nickel • Silver • Sodium • Americium-241 • Cesium-137 • Cobalt-60 • Curium-243, -244 • Plutonium-238 • Plutonium-239, -240 • Strontium-90 • Uranium-235, -238 • Tritium

TC

TC

TC

Footnotes on last page of table.

Table B-6. Site Investigations and Monitoring at Waste Management Facilities in the A- and M-Area Geographic Grouping[a] (continued) TE

Facility	RCRA monitoring well[b]	Site investigations[c]	Monitoring results
		MIXED WASTE SITES	
M-Area settling basin (904-51G) Lost Lake (904-112G)	MSB 1A MSB 2A MSB 3A MSB 4A MSB 5A MSB 6A MSB 7A MSB 8A Additional wells to be installed	Wells monitored quarterly for RCRA and SCHWMR parameters. Initial (1981-1982) waste-site characterization studies examined waste liquid and sludge, as well as soil under basin and in overflow ditch, seepage area, and Lost Lake. Extended characterization program (1984-1985) sought to confirm results of 1981-1982 study and provide additional data to support closure activities.	Statistical analysis of groundwater monitoring data indicates the following are present: • Conductivity • Total dissolved solids • Gross beta • Total organic halogen • pH • Gross alpha • Radium • Chromium • Manganese • Sodium • Nickel • Chloride • Cyanide • Fluoride • Nitrate • Sulfate • Dissolved organic carbon • Phenols • Total organic carbon • Zinc Soil constituents include: • Bisphthalate • Tetrachloroethylene • 1,1,1-trichloroethane • Di-n-octylphthalate • Toluene • Tetrachlorobiphenyl • Pentachlorobiphenyl • Hexachlorobiphenyl • Trichloroethylene • Methylene chloride • Uranium • Lead • Nickel • Copper • Chromium • Barium

[a]Sources: Huber, Johnson, and Bledsoe, 1987; Pickett, Muska, and Marine, 1987; Scott, Killian, Kolb, Corbo, and Bledsoe, 1987; Geraghty and Miller, 1985; Michael, Johnson, and Bledsoe, 1987; Huber, Johnson, and Marine, 1987; *Fowler et al., 1987; Pickett, Colven, and Bledsoe, 1987.* TC
[b]The monitored hydrogeologic unit for these wells is the McBean.
[c]See discussion on page 8-1.

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APPENDIX C

REMEDIAL, TREATMENT, AND CLOSURE TECHNIQUES

This appendix describes potential remedial, treatment, and closure action techniques and their applicability to existing waste sites on the Savannah River Plant (SRP). It also provides the basis for identification of remedial and closure actions associated with the existing waste site alternatives described in Sections 2.2.2 and 4.1 and assessed in this environmental impact statement (EIS).

The alternatives for the modification of waste management activities at existing waste sites are as follows:

- Removal of waste to the extent practicable at all waste sites, and remedial and closure actions, as required

- Removal of waste to the extent practicable at selected sites, and remedial and closure actions, as required

- No removal of wastes, but remedial and closure actions, as required

- No action; that is, no removal of wastes and no remedial and closure actions

The principal remedial, treatment, and closure actions potentially associated with these alternatives are the following:

- Groundwater pumping and possible chemical or physical treatment of recovered groundwater

- Treatment of hazardous waste as a limited treatment application

- Surface sealing and capping as a closure action

Hundreds of engineering concepts and actions are available for the treatment of wastes, for the remediation of waste sites, and for closure actions, although their feasibility has not been determined. The techniques described in this appendix either have been initiated or are considered to be both technically and economically attractive to the U.S. Department of Energy (DOE) for existing waste site remediation. The descriptions of techniques for potential remedial actions are derived from two handbooks published by the U.S. Environmental Protection Agency (EPA, 1982; 1985). This EIS does not select any specific remedial, treatment, or closure technique. DOE plans to conduct studies involving groundwater monitoring and modeling and the feasibility of approaches to establish firm remedial actions; the basis for these studies will be an alternative strategy selected by DOE.

Section C.1 describes corrective (remedial) actions, including permeable bed treatment, groundwater pumping, and impermeable barriers, and their applicability. Section C.2 describes the direct treatment of wastes and includes general information on biological, chemical, and mechanical techniques for waste treatment; it also addresses the applicability of these techniques to

SRP waste types. Section C.3 addresses closure actions, such as surface sealing and capping, water diversion and control systems, and leachate control systems. Section C.3 also describes the applicability of the closure actions to existing SRP waste sites.

C.1 CORRECTIVE ACTIONS

Corrective actions for dealing with groundwater contaminated by waste disposal sites are complex and dependent upon many variables. Many variables are site-specific, including local topography, geology, surface-water and groundwater hydrology, and existing and proposed future site development.

Corrective actions for dealing with contaminated groundwater include the following: (1) in situ treatment; (2) groundwater pumping; and (3) containment or diversion. In situ treatment is a method by which contaminated groundwater is allowed to flow through permeable treatment beds (e.g., activated carbon). The beds are installed vertically below the ground surface and are designed to filter contaminants. Groundwater pumping is used to remove contaminated groundwater for treatment, contain a groundwater plume, or lower the groundwater so it does not contact the waste disposal area and become contaminated. Containment or diversion is the installation of impermeable barriers. These barriers are positioned below the ground surface to either prevent groundwater from migrating away from the site (containment) or divert groundwater and prevent contact with waste materials (diversion). Although the following paragraphs describe the corrective actions individually, an effective design often combines two or more actions.

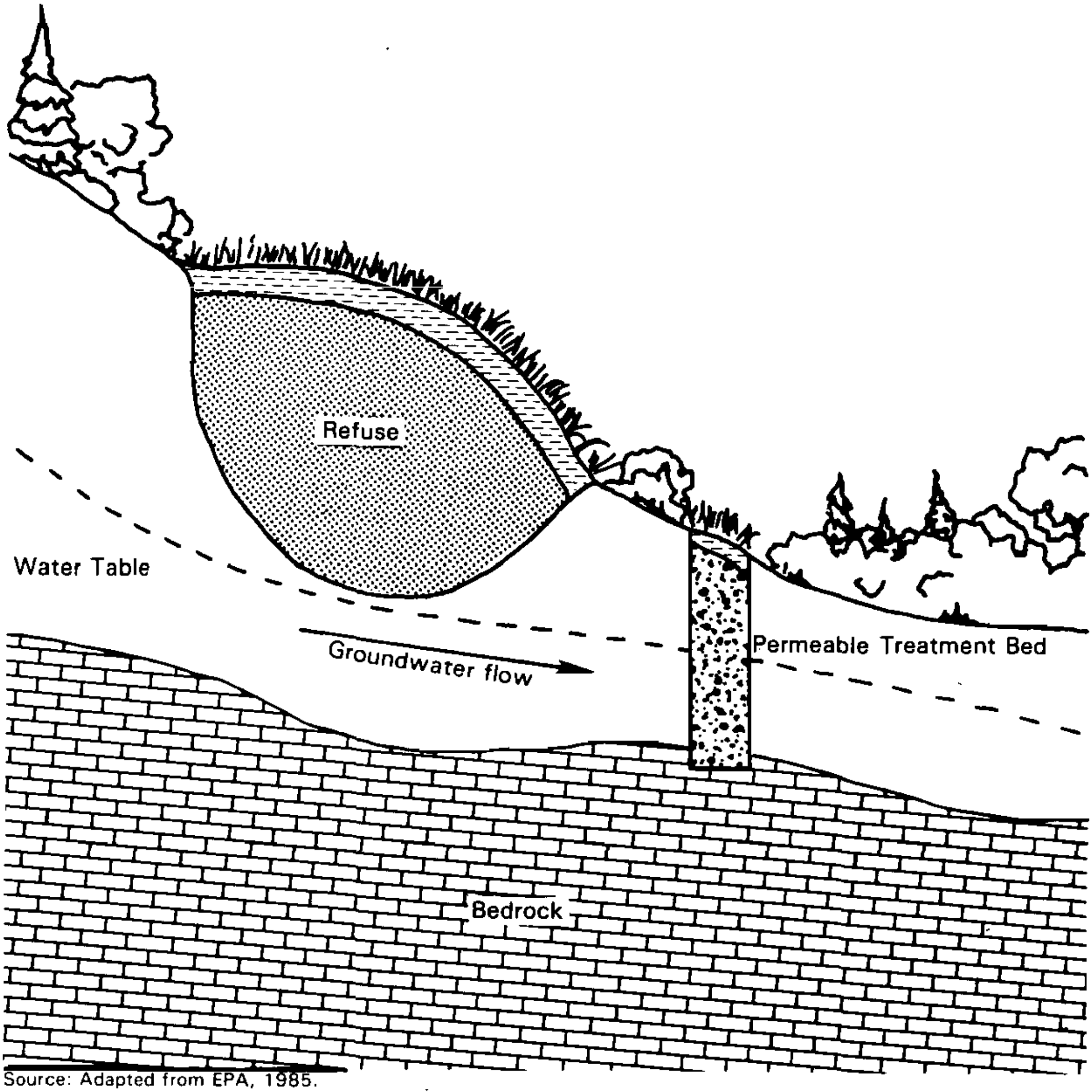
C.1.1 PERMEABLE TREATMENT BEDS

C.1.1.1 Description

Permeable treatment beds are sections of porous media through which contaminated groundwater passes and which remove the contaminants through physicochemical processes. Installed vertically below the ground surface in a manner similar to, and often with, slurry walls, permeable treatment beds are a viable means of in situ treatment (see Figure C-1).

Construction of a permeable treatment bed entails excavating a trench to intercept the flow of contaminated groundwater, filling the trench with the appropriate materials, and capping it. The trench extends to a confining layer at some depth below the ground surface. Permeable treatment beds are economical where the water table is close to the surface, and the aquifer is shallow with bedrock or a confining layer limiting the depth to which the fill must be placed. The width of the trench is determined by the velocity of the groundwater flow, and the contact time required for effective treatment. Finally, the trench must be long enough to contain the plume and prevent it from circumventing the treatment beds.

The following materials are used in permeable beds to remove contaminants from groundwater: (1) crushed limestone or crushed shell; (2) activated carbon; (3) glauconitic greensands or zeolite; and (4) synthetic ion exchange resins. Each of these materials is effective for the removal of specific contaminants;



Source: Adapted from EPA, 1985.

Figure C-1. Installation of a Permeable Treatment Bed

however, they are limited in service life to varying degrees and must eventually be replaced or regenerated.

Crushed Limestone

Permeable treatment beds of crushed limestone contain granular materials varying from gravel- to sand-size particles. The particle size used depends on the results of the analysis of the type of soil in which groundwater flows and the level of groundwater contamination. Limestone is used to neutralize acidic flow. It also can be used to remove metallic contaminants such as cadmium, iron, and chromium from groundwater.

Activated Carbon

Activated carbon is a carbon compound that has been heated without oxygen to activate its pores. This material, which generally is derived from coal or wood, varies from pebble to sand size; it is also available in powder form. Activated carbon is used to remove organic contaminants, such as carbon tetrachloride and polychlorinated biphenyls.

Glauconitic Greensands

Glauconite is a hydrous aluminosilicate clay mineral, rich in ferric iron and potassium. Glauconite occurs as dark, light, or yellowish-green pellets 0.9 to 1 millimeter long, as casts of fossil shells, as coatings and other grains, and as a clayey matrix in coarser-grained sediments. Glauconitic greensand deposits of the Atlantic Coastal Plain have a high potential for the removal of heavy metals from contaminated water. High removal efficiencies are reported for copper, mercury, nickel, arsenic, and cadmium.

Other Materials

Other materials that are used for removing contaminants from groundwater are zeolite and synthetic ion-exchange resins. These materials are effective in the removal of heavy metal contaminants but are seldom economical for permeable beds because of problems with short life, high cost, and regeneration.

C.1.1.2 Applicability

Permeable treatment beds have limited applicability on the SRP. The depth to groundwater at most of the waste sites is from 12 to 30 meters. The "green clay" is the first effective confining layer. It generally lies about 30 to 61 meters below the surface, except near Upper Three Runs Creek where it outcrops (see Sections 3.4.1 and 3.4.2).

C.1.2 GROUNDWATER PUMPING

C.1.2.1 Description

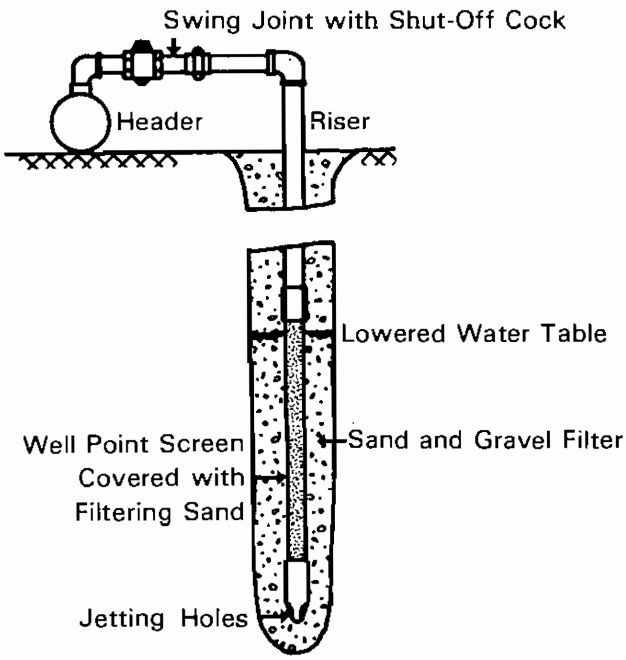
Groundwater pumping alters the elevation of the groundwater through the development of a cone of depression around the well. If wells are placed closely together, the combined cones of depression result in a depression network, which can lower the effective elevation of the groundwater over a large area. Groundwater pumping serves two purposes: it retrieves contaminated groundwater for treatment (Section C.2) and reduces further migration of the contaminants.

Groundwater pumping uses pumps to draw the groundwater to the surface through a series of wells. An adequate well system requires a careful evaluation of site conditions; a knowledge of seepage and groundwater flow to wells or wellpoints; and an understanding of wells, wellpoints, and pumping equipment. Any groundwater lowering (also referred to as dewatering) technology requires careful consideration of the possible effects of its implementation.

Wellpoints

Wellpoints are small well screens approximately 5.1 to 7.6 centimeters in diameter and 0.3 to 1.1 meters long. They are manufactured with brass or stainless-steel screens and with closed ends, drive-point tips, or self-jetting tips. Self-jetting-type wellpoints are installed in the ground with water flowing out the tip under high pressure. Closed end or plain tip wellpoints are installed into predrilled boreholes. Drive-point tips are installed directly via drop hammer and are suitable for some soils. Lines or rings of wellpoints installed on 0.9- to 3.6-meter centers and attached to a common header pipe (15 to 30 centimeters in diameter) and connected to a wellpoint pump (a combined vacuum and centrifugal pump) are called a wellpoint system (see Figure C-2).

Wellpoints are a common method of dewatering for construction purposes. They are applicable where the required depth of drawdown is no greater than 4.6 to 6.1 meters below the center of the header. Discharge capacity is generally on the order of 0.95 to 1.9 liters per second.



Source: Adapted from EPA, 1985.

Figure C-2. Well Point

Deep Wells

Deep wells differ from wellpoints by their function, which is to pump heavy flows over large vertical distances. These are typically large-diameter wells with diameters that range from 15 to 51 centimeters. Well screens typically range in length from 6 to 23 meters. Screens consist of a commercial-type water well screen or a perforated metal pipe often surrounded with a properly graded sand and gravel filter. Deep wells need 6- to 61-meter centers, depending on conditions. Pumping is performed with a submersible or vertical turbine pump installed near the bottom of the well. Well pumps are available in sizes from 0.3 to 379 liters per second, with head capabilities up to 183 meters.

Jet-Eductor Wells

Jet-eductor wells are wellpoints modified to provide lifts in excess of the typical 5- to 6-meter physical limits of standard wellpoints. Such a well is a wellpoint attached to the bottom of a jet-eductor pump, with one pressure pipe and a slightly larger return pipe.

Vacuum Wells

Vacuum wells are modified wellpoints or deep wells. The screen and riser pipe of a vacuum well are surrounded with a free-draining sand filter extending to within a few feet of the surface. The remainder of the soil is sealed with bentonite or impervious soil. The vacuum within the well effectively increases the hydraulic gradient toward the well or wellpoints.

Vertical Sand Drains with Wellpoints or Deep Wells

Vertical sand drains are used with deep wells and wellpoints to drain stratified soils where impermeable strata lay on top of more pervious strata. The drains are constructed by drilling vertical boreholes through the impermeable layers and are extended to underlying impermeable layers where wellpoints are placed. The boreholes, usually 41 to 51 centimeters in diameter, are continuously cased during advancement. The borings are filled with sand or other appropriate pervious material and the casings removed. A system of vertical sand drains is installed on 1.8- to 3.0-meter centers.

Sand drains with wellpoints or deep wells are applicable where a less permeable zone above a more pervious zone needs to be drained. The sand drains intercept the flow in the upper zone and drain it to the lower zone where the pressure is kept reduced by pumping from deep wells.

C.1.2.2 Applicability

Groundwater pumping is considered a viable method for recovering certain types of contaminated groundwater for treatment at the SRP based on previous experience with groundwater contaminants. Generally, deep wells with submersible pumps would be required. The capacity of each well is limited due to the rather low transmissivity of the tertiary aquifer in areas where contaminated groundwater has been identified. In the M-Area, for example, a system of 11 recovery wells is in operation. The recovered groundwater is routed to a 25-liter-per-second air stripper that removes volatile organic compounds.

In addition to this ongoing application, all potential groundwater remedial actions identified in Appendix F would apply such pumping to recover the groundwater for treatment. Groundwater pumping would also be used to prevent further migration of contaminants.

C.1.3 IMPERMEABLE BARRIERS

Impermeable barriers are underground structures designed to restrict groundwater. The term "impermeable" is used in the context that most common types of barriers are more appropriately labeled "low permeability" barriers. The subject of impermeable barriers is readily divided into two broad categories, configurations (Section C.1.3.1) and types (Section C.1.3.2).

C.1.3.1 Barrier Configuration

The configuration of the impermeable barrier is its vertical or horizontal position relative to the waste site. Configurations are called upgradient, downgradient, circumferential, keyed (fully penetrating), or hanging (partially penetrating). Impermeable barriers in use today include slurry walls, grout curtains, and sheetpiles. Table C-1 summarizes the configurations for impermeable barriers.

Keyed or Fully Penetrating

Keyed impermeable barriers are designed to block flow from passing through the area in which they are located. They are vertical structures that are carried from the ground surface to a confining stratum or impervious layer at some depth. The barrier structure is "keyed" into the confining stratum, as shown in Figure C-3.

Hanging or Partially Penetrating

Hanging impermeable barriers are not keyed into a low permeability confining stratum. This configuration is generally used to control lighter-than-water contaminants such as petroleum products, which float on the top of the groundwater. The depth of the barrier depends on several variables, including the thickness of the floating contaminant layer and the anticipated lowest possible water table elevation.

Circumferential Placement

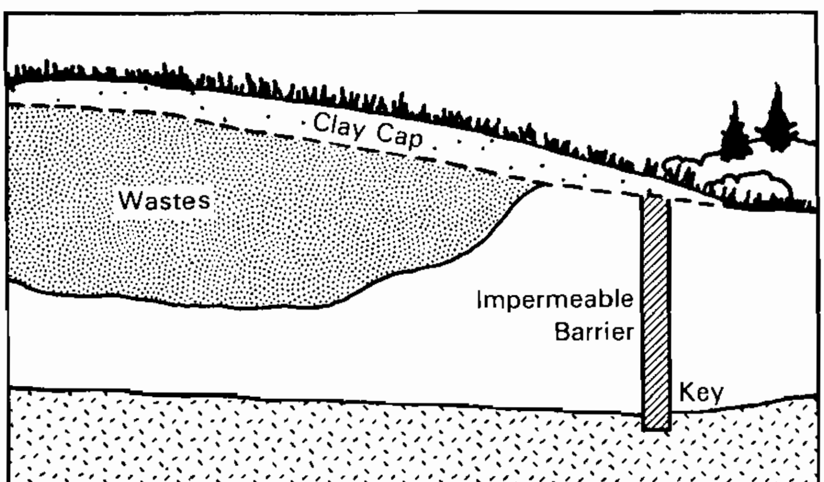
In circumferential placement, an impermeable barrier is installed completely around a waste site. With a cap and a leachate collection system, this barrier can reduce or eliminate the migration of contaminants.

Upgradient Placement

Upgradient placement is the positioning of the wall on the groundwater source side of a waste site. This type of placement is used to divert contaminated groundwater around the wastes where there is a relatively steep gradient across the site. Therefore, clean groundwater is prevented from becoming contaminated and leachate generation is reduced (see Figure C-4).

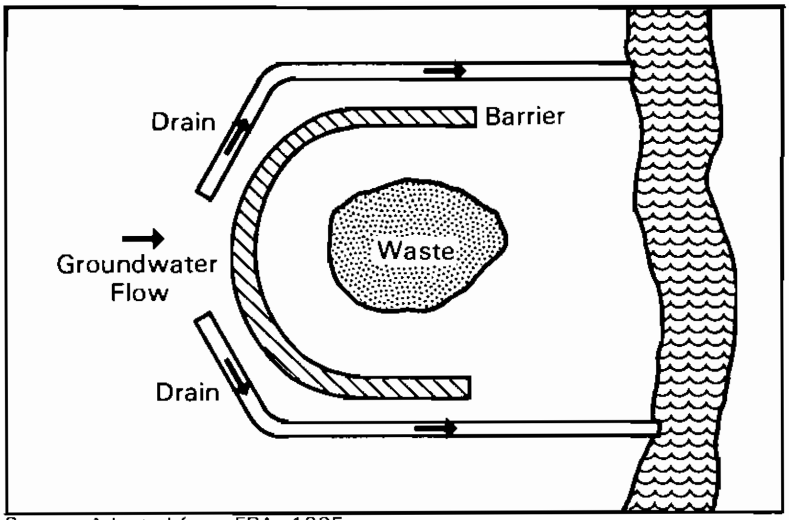
Table C-1. Summary of Configurations for Impermeable Barriers

Vertical Configuration	Horizontal Configuration: Circumferential	Upgradient	Downgradient
Keyed-in	• Most common and expensive configuration to use • Most complete containment • Vastly reduced leachate generation	• Not common • Used to divert groundwater around site in steep gradient situations • Can reduce leachate generation	• Used to capture miscible or sinking contaminants for treatment or use • Inflow not restricted, may raise water table
Hanging	• Used for floating contaminants moving in more than one direction (such as on a groundwater divide)	• Very rare • May temporarily lower water table behind it • Can stagnate leachate but not halt flow	• Use to capture floating contaminants for treatment or use • Inflow not restricted, may raise water table



Source: Adapted from EPA, 1985.

Figure C-3. Fully Penetrating Impermeable Barrier



Source: Adapted from EPA, 1985.

Figure C-4. Plan of Upgradient Placement with Drain

The design of upgradient barriers depends on site-specific variables. The actual site setting and the contaminants involved determine whether an upgradient wall can be keyed or hanging. Drainage and diversion structures might be needed to alter the flow of clean groundwater (see Figure C-5).

Downgradient Placement

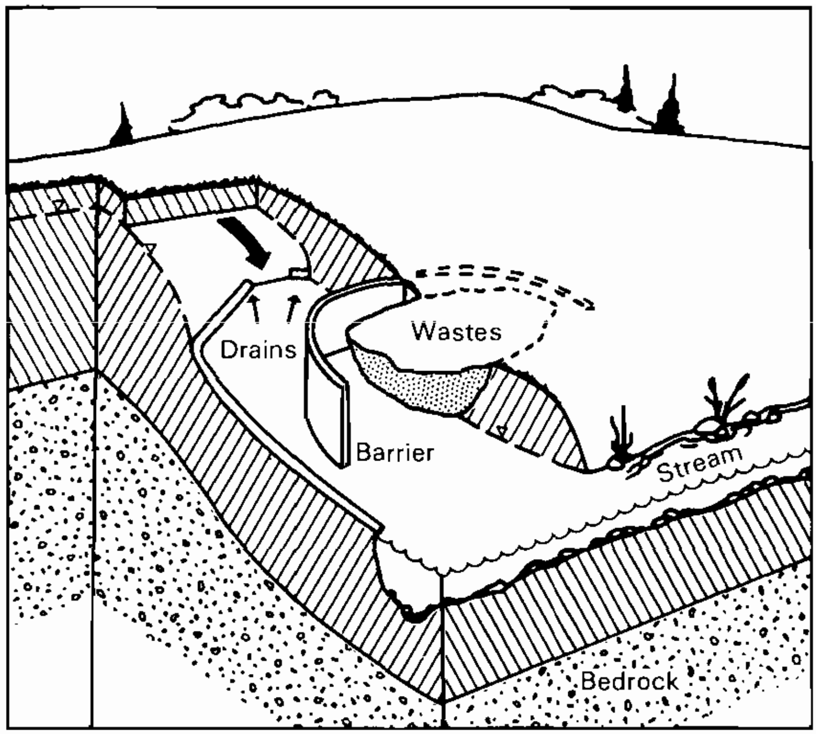
Installation of an impermeable barrier at a waste site at the side opposite the groundwater source is referred to as downgradient placement (see Figure C-6). The barrier serves as a temporary container of leachate and facilitates its easy recovery. Because it does not reduce the amount of groundwater entering the site, it is practical only in situations, such as near drainage divides, where there is a limited flow of groundwater. Without a means of recovery (i.e., deep wells or wellpoints), the volume of the barrier as a container would eventually be exceeded and contaminated groundwater would flow around the barrier and continue downgradient. Downgradient placement can use keyed- or hanging-type construction.

C.1.3.2 Barrier Types

The type of barrier chosen is a function of many variables, such as availability of materials, costs, required strength, and required permeability. Type and configuration are considered simultaneously and depend on the overall characteristics of each site.

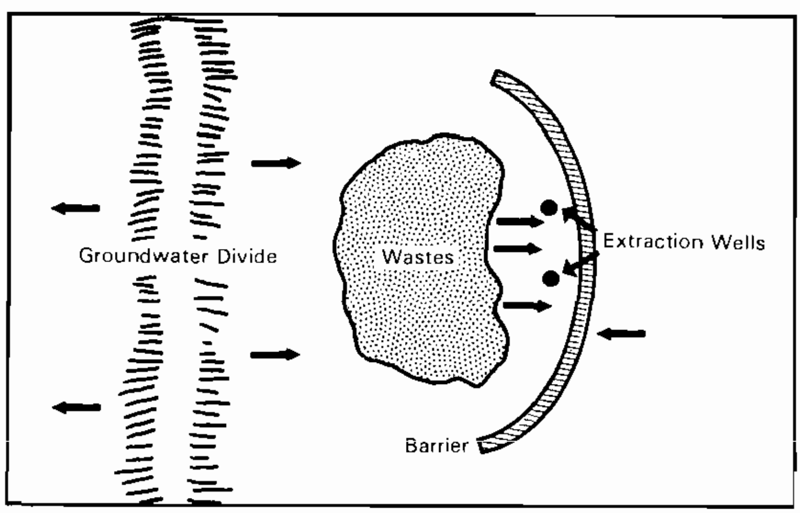
Slurry Walls

Slurry trench construction developed in the mid-1940s from the technology of clay-mud suspensions pioneered in oil well drilling operations in the early 1900s. Today, this practice covers a range of construction techniques from



Source: Adapted from Spooner *et al.*, 1985.

Figure C-5. Cut-away Cross-section of Upgradient Placement with Drain



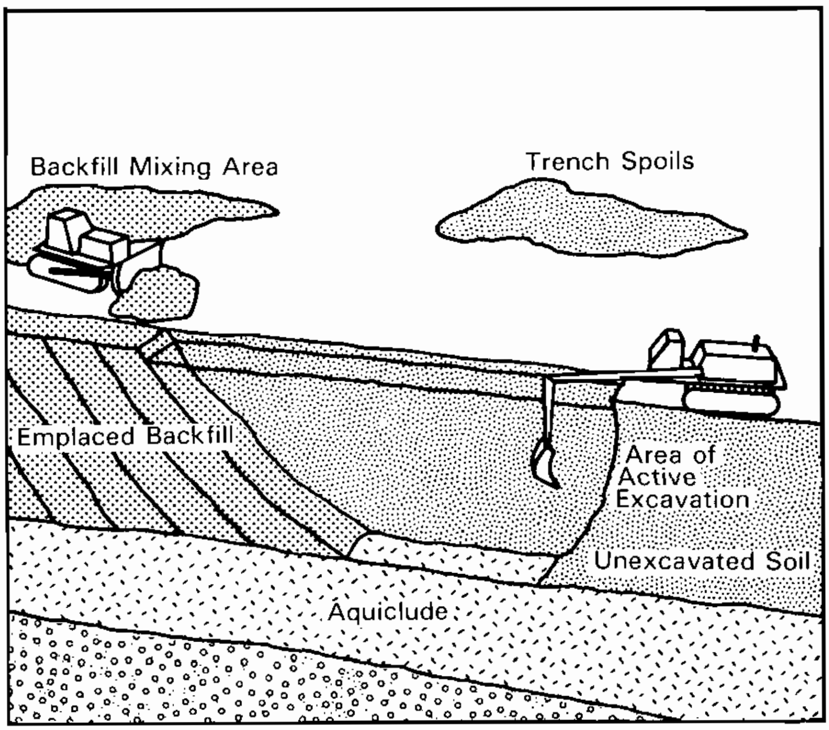
Source: Adapted from Spooner *et al.*, 1985.

Figure C-6. Plan of Downgradient Placement

simple to complex. In recent years, engineers and contractors have become aware of the low cost and nearly universal success of slurry wall cutoffs. This technique has largely replaced such methods as grout curtain and sheet piling cutoffs.

Two principal types of slurry walls, soil-bentonite (SB) and cement-bentonite (CB), are in common use. The names are derived from the key ingredients in the slurries used to construct each respective wall. Bentonite is a clay mineral that is highly expansive when combined with water; it can swell 10 to 12 times its original volume.

Slurry walls are constructed by excavating a trench to the desired depth; mixing a slurry of soil, bentonite, and water or of cement, bentonite, and water; and backfilling layers of the slurry (see Figure C-7). As the backfilling continues, the trench becomes completely filled with a monolith of soil or cement and bentonite of extremely low permeability.



Source: Adapted from Spooner *et al.*, 1985.

Figure C-7. Construction of a Slurry Wall

Grout Curtains

Grouting is the pressure injection of one of a variety of special fluids into a rock or soil body. These fluids set or gel into the rock or soil voids, greatly reducing permeability and increasing the strength of the previously ungrouted mass. Grouting of both soil and rock is a technology that has been used successfully for decades in the field of dam design and construction. The major use of curtain grouting is to seal voids in porous or fractured rock where other methods of groundwater control are impractical or likely to be ineffective.

Grouts can be divided into two main categories, suspension and chemical grouts. Suspension grouts contain cement mixed with fine particle materials, such as sand, clay, or bentonite. Chemical grouts consist of newtonian-type fluids, either natural or synthetic, manufactured and marketed under various trade names. Examples of chemical grouts include bituminous emulsions and sodium silicate with settling agents, accelerators, or hardeners.

The grouting process involves drilling holes to a predetermined depth below the ground surface and injecting grout with special equipment. A line of holes in single, double, or triple staggered rows is advanced vertically into the subsurface area. Grout is injected into every other hole to a predetermined depth; this is done until grout has been injected into each hole and the hole is filled (see Figure C-8).

Few data are available on the ability of the grouts to resist chemical degradation when contacted by contaminants. Special consideration should be given to the reaction of chemical grouts with the leachate. Testing should be conducted to determine these reactions before this grouting is used.

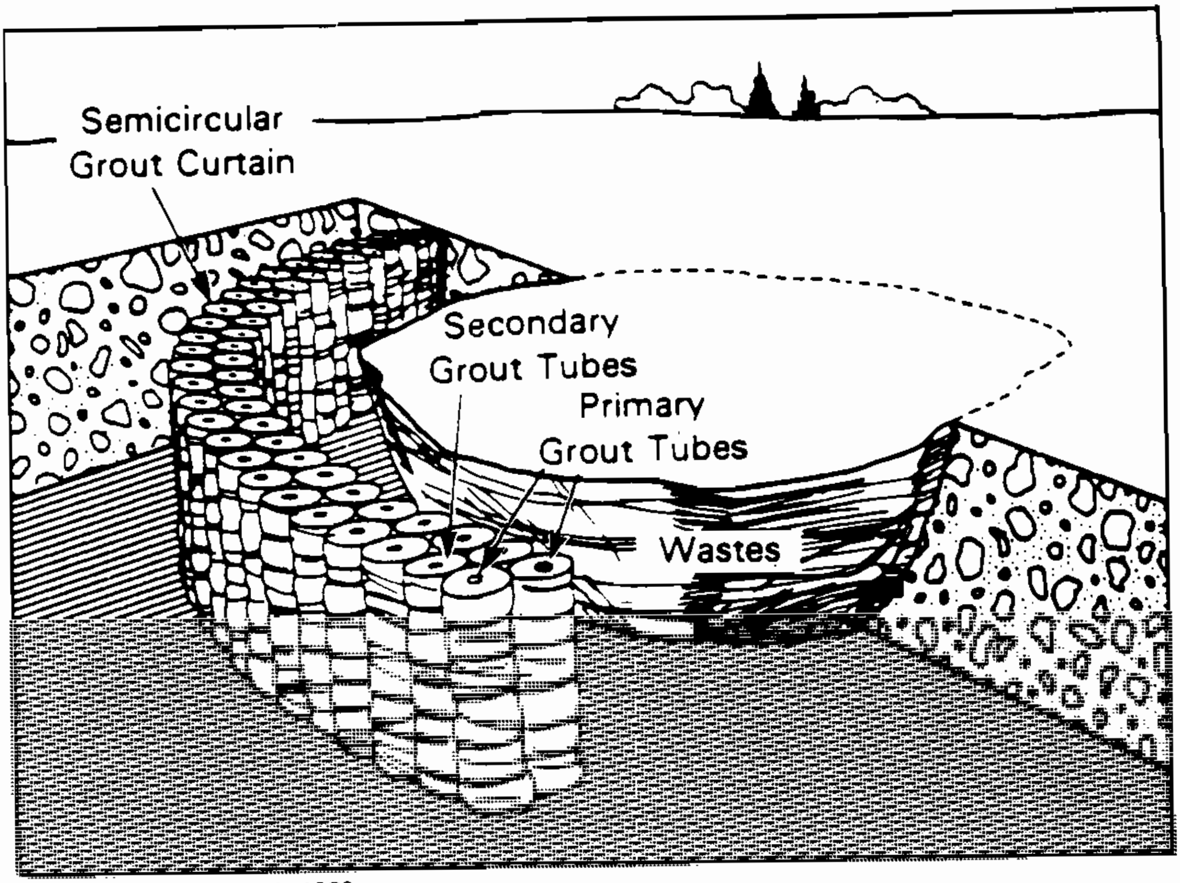
Sheetpile Walls

Sheetpile walls are narrow structural members that are driven below the ground surface mechanically to a desired depth. Sheetpiles, which are made of wood, concrete, or steel, serve a variety of functions in the construction industry. Wood is an ineffective water barrier; concrete is used primarily where great strength is required; and steel, which is an adequate sheetpile wall when used for groundwater cutoff, is the most cost-effective material available.

Steel sheetpiles are thin-walled, interlocking sections that are driven into the ground by pneumatic, steam, or vibratory piledrivers. They are manufactured in a variety of shapes and steel strengths. Lengths of the piles vary from 1.2 to 12 meters, while typical widths range from 38 to 51 centimeters. Longer lengths are available by special order.

C.1.3.3 Applicability

Barrier walls might be appropriate as a possible corrective action at the Savannah River Laboratory (SRL) seepage basins, the Separations Area retention basins, the radioactive waste burial grounds, the F-Area seepage basins and



Source: Adapted from EPA, 1982.

Figure C-8. Grout Curtain

the H-Area seepage basins. The following factors limit their applicability to other SRP waste sites:

- Many SRP waste sites are located over groundwater divides. This precludes the application of upgradient barriers and generally requires the use of expensive circumferential barriers.

- Great depths would be required to reach an effective confining stratum for the application of fully penetrating barrier walls. For example, a cutoff wall approximately 46 meters deep, anchored into the Congaree Formation, was required to prevent seepage through the recently constructed L-Reactor cooling lake.

- Generally, partially penetrating barriers are applied to control lighter-than-water contaminants, especially oil. SRP sites that have received oil, such as the waste oil basins, the L-Area oil and chemical basin, and the SRL oil test site, are not likely to require any groundwater remedial action.

C.1.3.4 Summary

Groundwater pumping appears to be a more applicable corrective action at the SRP than either permeable treatment beds or barrier walls for the following reasons:

- Groundwater pumping has already been demonstrated to be effective in containment and subsequent treatment of M-Area groundwater.
- Depths to confining layers (aquitards) are great over most of the SRP, thus requiring extensive excavation and disposal of potentially contaminated soil around certain existing waste sites.
- Permeable treatment beds of several different materials would be required to treat groundwater at many sites because of the mixed composition of the groundwater (i.e., sites that have demonstrated a migration of contaminants usually contain more than a single contaminant). A single bed usually is not effective in removing more than one kind of contaminant.
- The capacity of permeable treatment materials eventually becomes exhausted. In situ regeneration is not feasible. The replacement of an exhausted bed requires the subsequent disposal of the bed.

C.2 DIRECT TREATMENT OF WASTES

C.2.1 BIOLOGICAL TREATMENT

C.2.1.1 Description

An effective way to treat large quantities of contaminated water is biological treatment, which involves the use of microorganisms to digest organic materials. Principal application of this treatment is for aqueous waste streams; however, some organic liquid-phase treatment is possible. Biological treatment is accomplished by the use of one or two types of microorganisms, aerobic or anaerobic. Treatment is conducted in large lagoons or small reaction vessels or tanks. Contaminated water can be spread over land, which is known as landfarming, or treated in place (as with groundwater).

Biological treatment is a versatile treatment process, although many factors can affect its performance, such as:

- Hazardous or toxic substances that inhibit biodegradation reactions
- Retention time
- Temperature; the ideal range is 10° to 38°C
- Sensitivity to organic loading
- Bioaccumulation

Post-Extraction Technologies

The following sections describe technologies that are appropriate for the treatment of waste streams that have been extracted from the groundwater, have been pumped from a lagoon or surface impoundment, or will be received directly as a process waste stream. Treatment can be done by many small units located throughout the site, or can be treated in a large centralized facility. The latter option is less likely to be affected adversely by a single-source shock loading.

Aerobic treatment of waste depends on the use of aerobic microorganisms supplied with sufficient air or oxygen to digest organic wastes. The reactions occur naturally in stabilization ponds, under controlled conditions in specially designed reaction vessels (digestors), or in lagoons with forced aeration.

Activated Sludge

Activated sludge treatment is a continuous-flow treatment process where microorganisms suspended in the aqueous phase metabolize the organic constituents in the presence of oxygen and nutrients. Digestion of the contaminant results in the conversion of organic molecules into carbon dioxide and water. This process is the most widely used and best-understood biological treatment process.

An activated sludge process is designed according to one of three process types: high rate, conventional, or extended aeration. High-rate systems are used for low-strength waste streams, while conventional systems are used to treat higher levels of BOD and more resistant wastes. Aerated lagoons are used when low BOD levels are accompanied by difficult-to-treat wastes, which require a longer contact time.

Aerated Lagoon

Although primarily an aerobic treatment process, both aerobic and anaerobic processes occur simultaneously in an aerated lagoon. Similar to the activated sludge process, this system uses a continuous-flow aerated basin; however, aeration and mixing are incomplete. Thus, the microorganisms are not entirely suspended throughout the lagoon. Incoming material is treated aerobically; however, as the undigested organics and dying microorganisms settle to the bottom where dissolved oxygen levels are low, anaerobic organisms complete the decomposition.

Trickling Filter

The trickling filter is a fixed bed of rock or plastic used as a support for the growth of a biological film. The film or slime accumulates on the medium as organic wastes are metabolized. As the microorganisms grow, the thickness of the slime layer increases and the oxygen transfer to the inner layers decreases. The microorganisms near the surface enter an endogenous growth phase. The biomass near the surface of the medium begins to lose its ability to attach itself. The flow of water eventually detaches the heavier growths. Treated water and excess biomass are removed by an underdrain system and separated downstream by clarification.

Activated Biofilters

Activated biofilters (ABFs) operate as both attached and suspended growth treatment systems. The filter medium is used to support the attached biofilm, while periodic recirculation allows for a mixing of the biomass and the waste stream. The intermittent aeration serves two purposes: to support the growth of the aerobic organisms and to remove the excess biofilm.

Biological Activated Carbon

Biodegradation on biological activated carbon is a relatively new application of two well-established technologies. This process can be used on waste streams that cannot be treated effectively by either process individually. The process begins with the addition of activated carbon to an activated sludge system.

This system is a combination of fixed film and suspended growth systems (similar to the biofilter). The biomass is suspended in the mixed liquor and also attached to the powdered carbon particles. Adsorption and degradation take place within the same basin. The underflow of settled carbon and biomass is sent to a thermal regenerator where the carbon is regenerated, and the excess sludge is destroyed. The regenerated carbon is then returned to the system for further use.

This treatment system has been effective on waste streams with even significant levels of priority pollutants. Heavy metals removal has also been enhanced.

Anaerobic Treatment Technologies

Anaerobic treatment of waste streams uses faculative and anaerobic microorganisms in an enclosed reaction vessel to achieve organic contaminant digestion. This process is applicable to wastewater treatment; however, it generally is used to treat the heavy organic loadings associated with wastewater sludges.

In-Situ Treatment

Biological treatment processes have been developed that permit the decontamination of contaminated groundwater in place. Bioreclamation is a process in which naturally occurring microorganisms are used to degrade the contaminants in the aquifer. To promote the in situ degradation, constant amounts of oxygen and nutrients must be supplied to the microorganisms. Injection wells normally are used to supply these reactants.

C.2.1.2 Applicability

The biological treatment of groundwater or hazardous waste streams has limited applicability at the SRP. The major organic contaminants observed on the Plant are chlorinated aliphatic compounds, which are among the most refractory to aerobic or anaerobic degradation. The ease with which chlorinated materials are volatilized or sorbed on activated charcoal makes such processes more attractive technically.

Treatment of contaminated water by biological systems can be done under a variety of conditions and contaminant concentrations. Systems are available that will decontaminate water in place by biodegradation, in a centralized treatment facility using aerobic and/or anaerobic organisms, or in a combination of these systems.

C.2.2 CHEMICAL TREATMENT

C.2.2.1 Description

Chemical treatment, the use of chemicals to achieve a desired contaminant removal, detoxification, separation, destruction, or neutralization, is achieved by many commercially available processes. Many waste-specific processes are available; most fall into the following basic categories:

- Oxidation/reduction
- Precipitation
- Liquid/liquid extraction
- Neutralization
- Ion exchange

Oxidation/Reduction

Chemical oxidation and reduction are processes for waste detoxification and destruction. Oxidation is applicable to wastes that are oxidized by chlorine, ozone, hydrogen peroxide, potassium permanganate, and chlorine dioxide. Chemical dechlorination, a specific example of chemical oxidation, can be achieved by ozonation.

Chemical reduction is a process in which the oxidation state of a substance is lowered specifically to treat certain soluble metal ions. The reduction of hexavalent chromium to the trivalent state before precipitation with lime or caustic is an example of one application of reduction technology.

Neutralization

The discharge of extremely alkaline or acidic waste streams can pose a significant threat to the environment. Such streams can be neutralized by many available methods. The goal of such a process is to obtain an effluent that has a pH suitable for discharge within regulatory guidelines and standards, or that will not have a detrimental effect on downstream treatment processes, such as biological treatment.

Precipitation

Chemical precipitation is a well-established process for the removal of inorganic compounds. There are three basic types of precipitation systems: carbonate, hydroxide, and sulfide. Of these, the hydroxide system has found the greatest use. Hydrated lime or sodium hydroxide is used to achieve an alkaline pH.

Precipitation can be used to remove both cations and anions; however, the bulk of its use has been for cation removal. The lime-soda softening process is a typical example of a cation precipitation process. This process is also a good example of the carbonate process.

Hydroxide system precipitation can be used to remove a significant number of soluble metal ions. Metals that form insoluble hydroxide precipitates include iron, aluminum, manganese, trivalent chromium, lead, zinc, copper, mercury, silver, cadmium, and nickel. The hydroxides of these metals are normally precipitated at alkaline pH.

Sulfide precipitation has come into common use only recently in wastewater treatment. It is becoming more widely accepted due to the recent discovery that many metal sulfides are less soluble than the corresponding hydroxides. Two sources of the sulfide are sodium sulfide and ferrous sulfide.

Liquid-Liquid Extraction

Liquid-liquid extraction is a chemical separation process that is used widely to separate two immiscible liquid phases. It has, in the waste treatment field, also been used to treat contaminated soils. The basis of either process involves the use of a solvent to separate a contaminant or group of contaminants selectively from an aqueous phase or soil. In cases of gross water contamination, liquid-liquid extraction is best suited for use when distillation would be difficult because the boiling points of the mixture are too close to permit adequate separation. Following the actual separation, distillation is used (if possible) to separate the contaminate. This permits solvent reuse and the disposal of small volumes of hazardous waste.

Ion Exchange

Ion exchange is a process used to remove ionic species from an aqueous solution. In the process, the ionic species are replaced by ions on the ion-exchange resin. A hydrogen ion is exchanged for a cation, or a hydroxide group for an anion. In many applications, a toxic ion will be present in small amounts with large amounts of a relatively innocuous ion of the same or higher valence. Specific ion-exchange resins have been developed for the removal of specific ions, and the use of these resins should be considered to avoid high resin regeneration costs.

Ion exchange is considered applicable for removal of the following:

- All soluble metallic elements
- Inorganic anions such as halides, sulfates, nitrates, and cyanide
- Carboxylic and sulfonic acids, and some phenols at alkaline pH
- Radionuclides such as cobalt-60, yttrium-90, strontium-90, cesium-134 and -137, plutonium-238 and -239, and uranium-238

The ion-exchange resins, which eventually will become exhausted, can be regenerated or disposed of. The costs of onsite regeneration can be prohibitively high, especially when the site is remote. A system with replacement modules might be desirable so the resins can be regenerated offsite. In addition, the regenerant wastes will contain the removed ions at much higher concentrations than the influent and must be treated further or disposed of properly.

C.2.2.2 Applicability

Chemical treatment methods are effective measures for the remediation of contaminated waters and soils. Table C-2 lists some chemical treatment processes and summarizes their possible applications as remedial actions.

Table C-2. Applicability of Chemical Treatment at SRP

Treatment method	Application
• Oxidation/reduction	Groundwater and surface-water decontamination - Metals - Organic contaminants - Radionuclides
• Neutralization	Process waste streams with extreme pH values
• Precipitation	Groundwater and surface water - Metals - Radionuclides
• Liquid-liquid extraction	Grossly contaminated water and soils
• Ion Exchange	Groundwater and surface water - metals, dissolved solids, inorganic anions, carboxylic and sulfonic acids, radionuclides

TC

C.2.3 PHYSICAL TREATMENT

C.2.3.1 Description

Most of the physical treatment processes are concentration technologies. Large wastewater streams contaminated with small concentrations of wastes are treated to produce a cleaner product and a waste stream. The product stream, or effluent, is a high-flow stream with little residual contamination, while the waste stream is a low-flow stream with high concentrations of contaminants. The effluent should be clean enough for discharge, while the waste stream must be taken to a landfill for disposal or treated and rendered nonhazardous.

Flocculation, Sedimentation

Suspended solids in waste streams inherently contain a wide distribution of particle sizes depending on the type and amount of pretreatment that has occurred. Influent streams can contain particles large enough to be visible, or small enough to be submicroscopic. These particles generally carry an electrical charge (usually negative) which can be used advantageously in removal.

Flocculation and a similar process, coagulation, are physical processes which accomplish removal by agglomerating these similarly charged particles into large settleable particles.

Activated Carbon Adsorption

Activated carbon adsorption is a physical treatment process that has demonstrated efficient chemical removal from aqueous streams by chemical processes. The adsorption process involves the concentration of contaminants on the surface of the carbon by physical and chemical means. Attractive forces that predominate at the carbon surface are the basis for the contaminant removal. Materials that have a relatively low solubility in water, or have large molecules, exhibit good adsorption rates. Pesticides and PCBs are examples of contaminants that fit this description. Compounds that are adsorbed readily by activated carbon include aromatics, ethers, esters, and the larger ketones. Alcohols (except for hexanols), amines, aldehydes, and glycols are not adsorbed readily. Radionuclides such as cobalt-60 and cesium-137 can be removed successfully by this process.

Air Stripping

Volatile organic contaminants are removed readily from contaminated aqueous streams by air stripping. This simple, inexpensive process strips the volatile compounds from the water using air as the transfer medium. Contaminated water is charged into the top of a packed column and cascades over the packing while large volumes of air are forced upward through the column.

This treatment technology is well suited to the treatment of solvents and other volatile compounds that have migrated into aquifers beneath the SRP. Water extracted by wells from the water-bearing zones is treated after collection in an air-stripping tower nearby. Such remedial actions are under way in the A/M-Area.

Filtration

Both radioactive and nonradioactive solids can be separated from a liquid by one of three filtration processes: cake, depth, and surface filtration.

Cake filtration involves the separation of solids from the aqueous phase by passing the liquid through a porous filter medium, such as a cloth filter. This medium allows liquids, but not solid particles, to pass. The process yields a thick filter cake. When the operating pressure of the system increases significantly, the medium must be cleaned or replaced. The concentrated waste is then sent to disposal.

In depth filtration, a bed of porous material is used as the filtration medium. A waste stream passes through the filter, where the solid particles become trapped between the small particles of the bed. Operating pressure is also critical for this filtration type. At a certain pressure the bed must be back-washed to return the bed to its original porosity.

In surface filtration, the liquid is strained. This process is similar to the cake filtration process; however, it differs in that the matrix used for filtration becomes clogged at a much higher rate than that used for cake filtration.

Filtration can be used to remove radioactive and nonradioactive suspended solids. This technology can remove radionuclides that have lower solubilities, that tend to absorb to suspended particles, or that can be coprecipitated with other cations. Alpha emitters, such as uranium-238 and plutonium-238, are radionuclides that might be removed by filtration.

Membrane Filtration

Three filtration processes fall under this heading: microfiltration, ultrafiltration, and reverse osmosis. The applicability of each process is as follows:

- Microfiltration and ultrafiltration - High-molecular-weight inorganic and organic contaminants, uranium-238 and plutonium-238

- Reverse osmosis - Metal ions, low molecular weight organic contaminants, strontium-90, cobalt-60, and cesium-134 and -137

Evaporation

Evaporation is a process in which heat is added to a liquid (usually water) to vaporize it, resulting in the concentration of dissolved or suspended solids or the removal of volatile substances. The concentrated materials must be treated further or disposed of, and the vaporized liquid is released to the atmosphere. Three types of evaporation methods are classified by the mode of heat transfer:

- Indirect - heat source is separated from the solution by physical barrier

- Direct - heat source is applied directly to the solution

- Natural - solar energy or natural diffusion of the solution to air are used to induce evaporation

Evaporation methods are more effective for heavier radionuclides, such as cesium-134 and -137, uranium-238, and plutonium-238. Evaporation is an effective way to reduce tritium concentrations in basins.

Electrodialysis

This process is used to transfer an ionic species from one stream of liquid, through a semipermeable membrane, into another stream of liquid under the influence of an applied electrical potential. The process depends on special synthetic membranes that are permeable to a single type of ion. Cation exchange membranes permit passage only of positively charged ions, and anion exchange membranes permit the passage only of negatively charged ions, under the influence of the electrical field.

C.2.3.2 Applicability

Physical or chemico-physical treatment processes have limited applicability for the treatment of contaminated groundwater at the SRP. Air stripping of volatile organic compounds, already in use in the A/M-Area, ion exchange for the removal of soluble metals and radionuclides, and carbon adsorption for the removal of volatile and semivolatile organic compounds offer the greatest feasibility. Centralized treatment facilities might be advantageous.

C.3 CLOSURE

Site closure techniques and methods are designed to reduce surface-water infiltration, to control runoff at waste disposal sites, to reduce erosion, to stabilize the surface of covered sites, and to control leachate generation. Closure techniques include capping, grading and revegetation, runoff diversion and collection, and leachate control systems.

C.3.1 SURFACE SEALERS AND CAPS

C.3.1.1 Description

Surface sealing or capping is used to cover or close a waste site. It prevents surface-water infiltration, isolates contaminated wastes and gases, controls erosion due to surface-water runoff, and provides a surface for vegetation. The process of surface sealing consists of covering the site with a layer or system of layers of natural soils, modified soils, and synthetic membranes. Other techniques use chemical sealants and stabilizers. The choice of the covering material is influenced by such site-specific variables as type of soils, availability and costs of materials, climate and hydrogeology, designed function of the cap, nature of the covered wastes, reliability of the covering material, and projected future life of the site.

Clay

Compacted soils are used commonly for surface sealing or capping. The capacity of a soil cap to resist fluid infiltration is primarily a function of the permeability of the soil material. Clays consist of fine particles with low permeabilities. Clays are susceptible to cracking and dessication, which can reduce their capacity to resist penetration. Therefore, they often are installed as caps in conjunction with covers comprised of other soils or materials (see the paragraph on Multimedia Cap below).

Synthetic Membranes

Synthetic membranes are manufactured covers, commonly made of plasticized polyvinyl chloride (PVC), polyethylene, and butyl rubber. They consist of a raw polymer and carbon black, pigments, fillers, plasticizers, chemicals, and processing aids.

Admixed Materials

Various admixtures can be combined with soil *in situ* to be used as covers for hazardous waste sites. Admixtures include such materials as Portland cement, bituminous concrete, soil cement, soil asphalt, and blown asphalt. All these types of covers are relatively expensive and usually require special mixing or spreading techniques.

Chemical Sealants/Stabilizers

Chemical sealants and stabilizers can be added to soils to form strong and less permeable covers for waste sites. The most common sealant/stabilizers are cement, fly ash, lime, soluble salts, and freeze-point suppressants. Portland cement can be added to sandy soils in quantities as small as 1 percent to stabilize and reduce the permeability of the soils. Soil is treated chemically by the addition of lime. The addition of 2 to 8 percent lime will strengthen fine cohesive soils over time due to the chemical reaction of the lime with clay minerals. Lime also will increase the cementing properties of the clay and reduce shrinking and swelling.

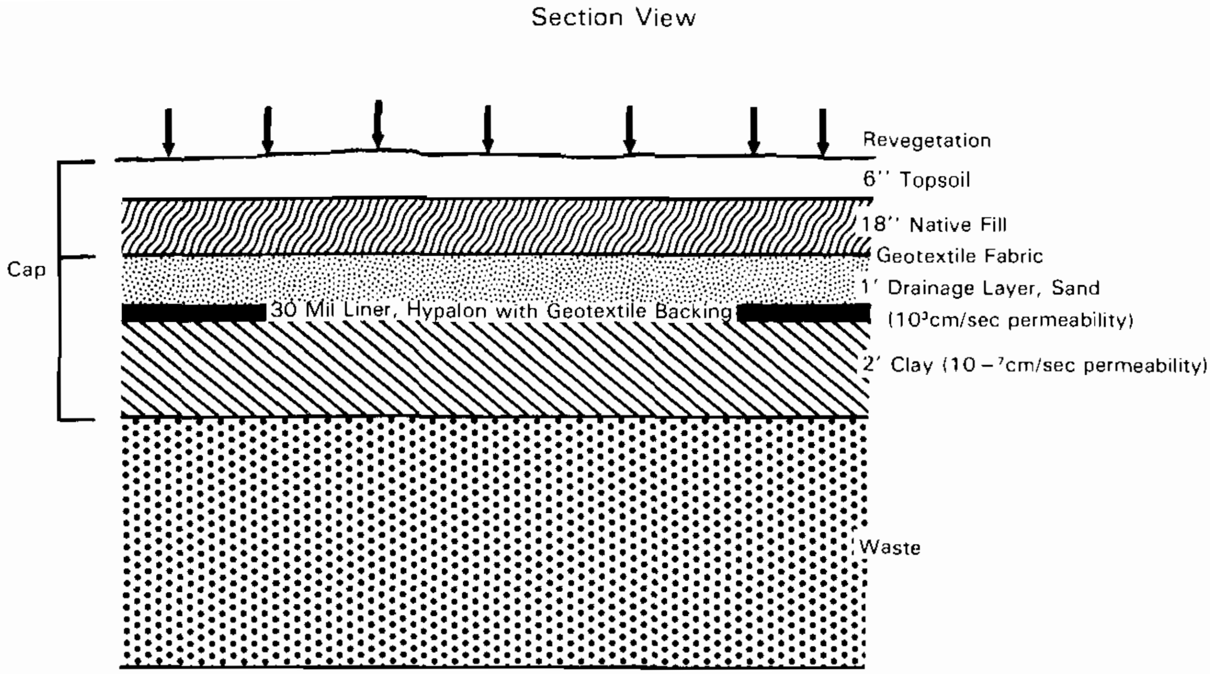
The combination of fly ash, lime, and water forms a cementing compound that can be added to sands and gravels for strengthening and stabilizing effects. It optimizes grain size distribution and reduces shrinking and swelling. Soluble salts like sodium chloride and tetra-sodium pyrophosphate are added to fine-grained soils containing clay minerals to act as dispersing agents. They can break down the clayey aggregates into separate particles (deflocculate) and thereby increase density, facilitate compaction, and lower the permeability of the soil. A freeze-point suppressant such as calcium chloride can be very effective in solution or in dry, flaked form. A suppressant is used on poorly compacted soils during cold weather operations to reduce the potential of the pore water from freezing.

Multimedia Cap

A multimedia cap combines two or more distinct materials in multiple layers that perform specific functions. This cover is the preferred option under the Resource Conservation and Recovery Act (RCRA) and is sometimes called a RCRA-type cap.

A RCRA cap has a top soil layer to support vegetation; a water drainage channel or layer to provide an exit for water; a barrier layer or membrane to prevent infiltration and percolation of water; a buffer layer to protect the barrier by providing a smooth base; a filter layer to control the clogging of coarse layers; and a gas drainage layer. Figure C-9 shows typical layered or multimedia cover systems.

The barrier layer is the most important feature in a multimedia cap. This layer or membrane, which controls the passage of water and gases, is usually a clayey soil with low permeability or a synthetic membrane. The principal purpose of a buffer layer is to protect the barrier layer, shielding it from tears, cracks, offsets, and punctures. The water drainage channel or blanket provides a path for water to exit quickly; recommended soils for this layer are poorly graded sands and gravels. This channel is sometimes combined with a system of buried pipe drains. Filters are used to reduce the clogging of pores in the drainage layer by fine particles of another layer; the selection of a filter material depends on the nature of material being filtered. A gas drainage layer has a structure and function very similar to the water drainage layer; the gas layer is below the barrier layer so it can collect gases rising



Source: Adapted from EPA, 1985. Not to Scale

Figure C-9. Multimedia (RCRA) Cap

from the wastes, while the water layer is above the barrier layer to intercept water migrating from the surface.

C.3.1.2 Applicability

The waste sites on the SRP, where modeling results indicate a delay or reduction in peak contaminant concentrations, could be retrofitted with one of the surface sealers or caps described above. The particular system used would be considered on a site-by-site basis. The multimedia cap might make an excellent cover for use on the SRP.

C.3.2 SURFACE-WATER DIVERSION AND COLLECTION SYSTEMS

C.3.2.1 Description

Surface-water diversion structures and collection systems provide either temporary or permanent measures to control surface flows into a hazardous or radioactive waste site. They control flooding and surface-water infiltration. The types of diversions and collectors include dikes and berms, open channels, terraces and drainage benches, chutes, and seepage basins.

Dikes and Berms

A dike or berm (these names are interchangeable) is a well-compacted earthen embankment of low-permeability, erosion-resistant, fine-grained soils. It is positioned above, below, or around the perimeter of a disposal site to intercept and divert surface water. An effective dike or berm thereby reduces erosion potential and prevents excess runoff from entering the site and infiltrating the fill.

Open Channels, Diversions, Waterways

An open channel or swale is an excavated drainageway used to intercept and divert surface water. Such a structure is usually temporary and typically stays in place until the site is sealed and stabilized. A channel upslope of the site can intercept surface water and divert flow; a channel below the site can collect and transport sediment-laden flow to holding basins.

Diversions are shallow drainageways excavated along a contour of graded slopes, with a dike along the downhill edge of the drain. In essence, a diversion is a combination of a dike and a channel that is designed to provide a more permanent control of erosion on long slopes that are exposed to heavy surface water flows. It can be at the top or at the base of long graded slopes of a site to intercept and carry flow. Diversions should be used only for slopes of 15 degrees or less.

A grassed waterway is a wide drainageway that has been stabilized with vegetation or stone riprap. It is usually positioned along the perimeter of a disposal site located within the natural slopes. A waterway is designed to collect and transfer surface water diverted from berms or diversions. A grassed waterway can be part of the final grading design for a capped and revegetated site.

Terraces or Drainage Benches

Terraces or drainage benches are located along the contours of long and steep slopes. They slow down the surface water and divert it to channels or diversions. These benches are considered to be "slope-reducing devices." They should be compacted and stabilized with vegetation.

A terrace is capable of isolating a site hydrologically, reducing erosion on covers, and containing contaminated sediments eroded from the site. An upslope terrace can slow and divert stormwater; a downslope terrace can intercept sediments and divert them to basins.

Chutes and Downpipes

Chutes and downpipes are drainage structures located downslope from dikes. They transfer concentrated runoff from an upper level to a lower level while controlling erosion.

Chutes (or flumes) are open channels lined with bituminous concrete, Portland cement, or grouted riprap. They should be on undisturbed soil or well-compacted fill.

Downpipes, also called downdrains or pipe-slope drains, are located downslope of a site. They are made of corrugated metal pipe or flexible plastic tubing. They collect discharge and transport the flow to stabilized outlets or traps. Because they have limited capacities, they can accommodate only low discharges. A downpipe can collect and transfer surface water from long, isolated outslopes or from small sites along steep slopes.

Seepage Basins and Seepage Ditches

Seepage basins and ditches intercept water from surface-water diversions or groundwater pumps and discharge it back to the groundwater by letting it seep through the ground. Such structures have a basin or ditch, a sediment trap, a bypass for excess surface water, and an emergency overflow. They are lined with gravel at the bases and have pervious material for the side walls. A seepage basin is uncovered, while a seepage ditch is backfilled with gravel or topsoil. Seepage ditches are used in parallel to increase seepage, and they can distribute water over a larger area than basins. Seepage basins use gabions for vertical side walls and dense turf for the side slopes to prevent erosion and allow infiltration.

C.3.2.2 Applicability

Any of the surface-water diversion and collection systems described above could be implemented readily on the SRP. The relatively gentle slope found throughout the Plant has the effect of reducing runoff velocities and concentrations. At most sites, a properly designed and installed cover or cap should be sufficient to minimize the infiltration of water into a waste site. The need for additional protection measures such as surface-water diversion and collection systems would be reviewed during the predesign phase.

C.3.3 LEACHATE CONTROL SYSTEMS

C.3.3.1 Description

Leachate control systems prevent surface-water seepage and leachate from percolating to the groundwater. Leachate is the contaminated liquid that results when surface water migrates down through layers of a landfill and contacts the wastes. The leachate travels to the ground below or seeps from the sides of the fill. A control system intercepts the leachate before it becomes a contamination problem. A system is a series of drains that intercept and channel the leachate to a sump, a wetwell, or a collection basin.

Subsurface Drains

Subsurface drains intercept leachate and transport it away from a site. They are constructed by excavating a trench and laying underground tile or perforated piping from end to end. The pipe is surrounded with an envelope of sand, gravel, and straw, woodchips, or fiberglass. The envelope is lapped with a filter fabric to prevent fine soil from clogging the drain. The trench is closed by a backfill of topsoil or clay.

Drainage Ditches

Drainage ditches are open ditches 1.8 to 3.6 meters deep that can be trapezoidal in cross-section. They collect surface-water runoff, and are collectors leading from subsurface drains or interceptor drains.

Drainage ditches might be required for flat or gentle rolling landfills that have impermeable soils underneath, thereby making the use of subsurface drainage impractical. In some cases, these open drains are used to intercept subsurface collectors and transfer the leachate to a discharge point. Open ditches can collect lateral surface seepage from a disposal site and prevent it from seeping into the groundwater or from flowing into protected areas.

Liners

Liners are used in new or existing sites to intercept leachate before it reaches the groundwater. They are located beneath the fill and act as impermeable barriers. Prefabricated liners, pressure-injected grouts, and bentonite slurry can all be used as bottom sealants, but prefabricated liners are used only in new sites.

C.3.3.2 Applicability

Leachate control systems and components are applicable primarily to new disposal facilities.

C.3.4 SUMMARY

All the closure techniques, both surface-water controls and leachate controls, described in the previous sections can be summarized in terms of functions. These methods primarily reduce surface-water infiltration, control runoff, reduce erosion, discharge water, and intercept leachate. Table C-3 summarizes the individual techniques with their functions.

Table C-3. Closure Techniques and Functions

Technique	Function						
	Minimize runoff	Minimize infiltration	Control erosion	Isolate & contain wastes	Collect & transfer water	Discharge water	Intercept & transport leachate
Surface seals & caps		X	X	X			
With vegetation	X	X	X				
Dikes/berms	X	X	X				
Ditches/diversions/ waterways	X	X	X				
Terraces/benches	X		X				
Chutes/downpipes			X		X		
Leachate controls							X
Seepage basins & seepage ditches						X	

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APPENDIX D

PREDISPOSAL TREATMENT TECHNOLOGIES

The U.S. Environmental Protection Agency (EPA) broadly defines "treatment" as "any method, technique, or process, including neutralization, designed to change the physical, chemical, or biological character or composition of any hazardous waste so as to neutralize such waste, or so as to recover energy or material resources from the waste, or so as to render such waste nonhazardous, or less hazardous; safer to transport, store, or dispose of; or amenable for recovery, amenable for storage, or reduced in volume" (40 CFR 260).

For the purposes of this EIS, "predisposal treatment" is treatment provided to wastes before storage or disposal to reduce their volume or alter their chemical or physical characteristics to render them less toxic or more stable. This appendix categorizes, lists, and defines various predisposal technologies; discusses their applicability to hazardous, low-level radioactive, and mixed wastes generated at the Savannah River Plant (SRP); and describes how the applicable technologies could be employed and the results that might be expected.

D.1 APPLICABLE WASTES

The SRP generates appreciable quantities of hazardous, low-level radioactive, and mixed wastes (Appendix E). Except for nonradioactive polychlorinated biphenyls (PCBs), all such wastes generated on the Plant are recycled, stored | TC for ultimate disposal, or deposited in an onsite waste disposal facility. The Plant does not receive hazardous waste or nonbyproduct mixed waste from offsite sources.

In the context of this appendix, predisposal technologies apply only to hazardous, low-level radioactive, and mixed wastes generated by ongoing SRP operations, by existing waste site closure actions, and by offsite, defense-related generators of low-level radioactive wastes.

All hazardous wastes currently being generated either are stored in storage facilities (buildings) or are recovered and recycled. Mixed wastes, such as scintillation solutions and tritiated waste lubricating oils, are stored either at the mixed waste storage facility or at the tritium facility, depending on their levels of radioactivity.

Virtually all hazardous, low-level radioactive, and mixed wastes generated on the Plant are candidates for the application of one or more predisposal treatment technologies. These wastes include the following:

- Hazardous and mixed waste combustible oils, solvents, and solids
- Mixed and low-level radioactive solvents, scintillation solutions, contaminated equipment, razed-building rubble, and job control wastes
- Mixed waste sludges generated at effluent treatment facilities (ETFs)

- Hazardous, mixed, and low-level radioactive ash and scrubber blowdown from incinerators

- Hazardous, mixed, and low-level radioactive waste, including contaminated soil.

D.2 AVAILABLE TECHNOLOGIES

D.2.1 VOLUME REDUCTION

During the past few years, there has been an industry-wide shift from limited waste volume reduction to maximum reduction before disposal. This shift has occurred for a number of reasons. The strongest is the realization that adequate disposal sites are a diminishing resource and, therefore, that future disposal capacity is uncertain and will be more expensive to develop (Voss and Guilbeault, 1984). The stated objectives of the Savannah River Interim Waste Management Program include the implementation of a sitewide effort to reduce the volume of waste generated and to demonstrate the technology for incinerating beta-gamma waste (DOE-SR, 1985). The technologies designed to reduce the volume of wastes for disposal fall into two general categories: (1) incineration; and (2) concentration, which includes compaction and physical treatment methods (Beamer, 1984; DOE, 1985; Enegess, 1984; Giuffre et al., 1984; NRC, TE 1981; OTA, 1985; Rutland, Papaiya, and Naughton, 1984).

D.2.1.1 Incineration

As a volume reduction technique, incineration is applicable primarily to organic wastes, which combine with oxygen in the air through combustion at high temperatures to form carbon dioxide, water vapor, minor quantities of other waste gases, particulates, and residual ash. The residuals from this process consist of inorganic material (ash) and possibly scrubber blowdown from exhaust gas pollution control devices. Usually, these residuals are sent to a landfill for disposal, often after they have been solidified (see Section D.2.3.4).

D.2.1.2 Compaction

Compaction includes several processes that achieve volume reduction by compression and crushing to reduce interstitial air space within the bulk material. Compaction is much more efficient in terms of disposal capacity; it improves the stability of landfills after closure; and it decreases leachate generation and contaminant migration by minimizing the conduits within which liquids can percolate through the waste. Solid and semisolid waste materials, particularly noncombustibles, can be compacted before disposal to achieve volume reduction if other methods are not possible or feasible.

The nuclear industry has used several compaction techniques to reduce the volume of noncombustible solid wastes before storage, shipping, and disposal (NRC, 1981):

- Compactors - compress material into final storage, shipping, or disposal containers

- Balers - compress material into bales to maintain volume reduction
- Baggers - compress material into slugs that are injected into bags, metal containers, etc.

Supercompactors substantially reduce the volume of large metal objects and other pieces of equipment.

As a predisposal treatment technology, compaction could be applied to a variety of hazardous, low-level radioactive, and mixed wastes, particularly solid noncombustible wastes. It is most applicable in the treatment of laboratory and job control wastes; under special conditions, it would be useful in the predisposal treatment of unincinerated, unsolidified wastes exhumed from existing SRP waste sites. Developmental research might show that supercompactors are applicable to materials from renovations and from decommissioning and decontamination projects. In some instances, compacting wastes as they are placed in above- or below-ground landfills might be desirable. Standard geotechnical techniques using sheepsfoot, rubber-tired, smooth, or vibratory rollers can achieve desired compaction results.

D.2.1.3 Shredding

The shredding of solid wastes containing hazardous or radioactive contaminants not only reduces the size of the particles to be placed in a container, incinerator, or landfill, but also provides a uniform particle size distribution. When applied before incineration or compaction, shredding produces a more uniform burn or a greater, more uniform density of compacted waste.

A number of types of size reduction (shredding) machines are used to handle industrial solid waste; these include the hammer mill, knife-cutters, jaw crusher, and bulky waste crusher. The actual size of the reduction depends on the waste type, feed rate, and type of shearing. Generally, small shredders (7 to 45 horsepower) are used to prepare combustible waste for incineration, while large shredders (160 horsepower) are used to reduce noncombustible wastes for compaction or disposal (Charlesworth, 1985).

Shredders might be installed on some SRP incinerators in the 1994 timeframe. Further research might identify other applications of shredding technology on the Plant.

D.2.2 CONTAINMENT

Containment technologies use fairly inert materials to reduce the leachability of a waste and to improve its stability before disposal. They have been applied successfully to hazardous and low-level radioactive wastes (COE, 1984; DOE, 1985; EPA, 1982a; NRC, 1981). TE

D.2.2.1 Solidification/Stabilization

Wastes can be mixed with a binding agent and cured to form a solid. This usually reduces leachability because the binding agent (1) complexes or binds the hazardous contaminants in a stable, insoluble form, or (2) entraps the waste material in a crystalline matrix.

Typical processes used to solidify low-level radioactive and mixed wastes include the following:

- Cement-based
- Pozzolanic (lime-based)
- Thermoplastic (including bitumen, paraffin, and polyethylene)
- Organic polymer
- Self-cementation
- Glassification

In general, each process has features that make it particularly useful for the treatment of specific kinds of waste. Similarly, each process has limitations that restrict or even preclude its use on certain wastes. Thus, solidification processes tend to be waste-specific. Table D-1 summarizes the compatibility of these processes with various types of hazardous, mixed, and low-level radioactive wastes.

Cement-based and pozzolanic processes are used commonly to solidify hazardous and low-level radioactive wastes, although some of these processes might not be effective in the immobilization of heavy metals and fairly mobile isotopes such as cesium (COE, 1982; Clark, Perry, and Poon, 1985; Croney, 1985; Kalb and Columbo, 1984; Miller et al., 1984). However, the U.S. Army Corps of Engineers (COE, 1984) has found Sealosafe (registered trademark of the Stablex Corporation) to be effective in preventing excessive leaching of heavy metals from a solidified waste. Similarly, a lime/bentonite/cement mixture effectively fixes metals within the solidified mass (Escher and Newton, 1985). The gypsum cement, Envirostone (a registered trademark of United States Gypsum), produces solidified waste forms meeting all the criteria recommended by the U.S. Nuclear Regulatory Commission (NRC) (Phillips, 1984) for compliance with
TE | 10 CFR 61 (Rosenstiel and Lange, 1984; Rosenstiel, Bodet, and Lange, 1984).

Solidification technology is applicable to the predisposal treatment of a variety of hazardous, low-level radioactive, and mixed wastes. These include material exhumed from SRP waste sites, incinerator wastes, low-level radioactive and mixed organic and evaporator bottom wastes from the Naval Fuel Material Facility, lead smelter and associated wastes, low-level radioactive contaminated equipment, renovation decommissioning waste, and mixed waste ETF sludges. Because this technology provides a "universally acceptable" waste product, it allows the widest choice of disposal sites (DiSalvo, 1984). In addition, the solidification of radioactive wastes reduces exposure rates associated with transportation and disposal.

Solidification processes, particularly those that are cement based, produce as much as a two-fold increase in the amount (i.e., weight and volume) of waste material to be disposed of (EPA, 1982b). Consideration of this effect is essential for an accurate determination of future disposal capacity needs.

D.2.2.2 Encapsulation

The encapsulation process involves enclosing wastes in a jacket or membrane of impermeable, chemically inert, water-resistant material to facilitate transport, storage, or disposal. It can be applied to solid hazardous wastes

Table D-1. Compatibility of Selected Waste Categories with Different Containment Technologies[a]

Waste component	Cement-based	Lime-based	Thermoplastic-solidification	Organic polymer (UF)[b]	Self-cementing techniques	Glassification and synthetic mineral formulation	Surface encapsulation
				ORGANICS			
Organic solvents and oils[c]	Many impede setting; can escape as vapor	Many impede setting; can escape as vapor	Organics can vaporize on heating	Can retard set of polymers	Fire danger on heating	Wastes decompose at high temperatures	Must first be absorbed on solid matrix
Solid organics (e.g., plastics, resins, tars)[d]	Good; often increases durability	Good; often increases durability	Possible use as binding agent	Can retard set of polymers	Fire danger on heating	Wastes decompose at high temperatures	Compatible; many encapsulation materials are plastic
				INORGANICS			
Acid wastes[c]	Cement will neutralize acids	Compatible	Can be neutralized before incorporation	Compatible	Can be neutralized to form sulfate salts	Can be neutralized and incorporated	Can be neutralized before incorporation
Oxidizers[c]	Compatible	Compatible	Can cause matrix breakdown, fire	Can cause matrix breakdown	Compatible if sulfates are present	High temperatures can cause undesirable reactions	Can cause deterioration of encapsulating materials
Sulfates[d]	Can retard setting and cause spalling unless special cement is used	Compatible	Can dehydrate and rehydrate, causing splitting	Compatible	Compatible	Compatible in many cases	Compatible

Footnotes on last page of table.

Table D-1. Compatibility of Selected Waste Categories with Different Containment Technologies[a] (continued)

Waste component	Cement-based	Lime-based	Thermoplastic-solidification	Organic polymer (UF)[b]	Self-cementing techniques	Glassification and synthetic mineral formulation	Surface encapsulation
Halides[d]	Easily leached from cement; can retard setting	Can retard set; most are easily leached	Can dehydrate	Compatible	Compatible if sulfates are present	Compatible in many cases	Compatible
Heavy metals[c]	Compatible	Compatible	Compatible	Acid pH solubilized metal hydroxides	Compatible if sulfates are present	Compatible in many cases	Compatible
Radioactive materials[c]	Compatible	Compatible	Compatible	Compatible	Compatible if sulfates are present	Compatible	Compatible

[a]Source: DOE, 1985.
[b]Urea-formaldehyde resin.
[c]Some waste streams on SRP frequently contain these components.
[d]Not usually generated on SRP; seldom observed in the groundwater.

in bulk or particulate form (e.g., contaminated demolition debris), containerized wastes, wastes in damaged or corroded drums, and wastes that have been previously stabilized by solidification.

Ideally, the jacket is bonded to the external surface of the waste. As long as the jacket is intact, the potential for leaks is low. However, this technology is in a developmental stage and few data are available on the long-term stability and integrity of covering materials or the costs of a full-scale facility (Ehrenfeld and Bass, 1983; OTA, 1985). TE

D.2.3 OTHER TREATMENT

D.2.3.1 Physical Treatment

Physical treatment processes concentrate semisolid or liquid wastes to render them more suitable for additional treatment or disposal. These processes include carbon adsorption, sedimentation/filtration, evaporation, air stripping, ion exchange, flotation, and reverse osmosis. They are seldom used in a single operation (DOE, 1985), but rather are combined with other technologies (often chemical or biological processes) to provide complete treatment of the waste stream. For example, many processes are employed in the M-Area ETF.

Physical treatment technologies have been proven to be effective and reliable; however, they are most likely to be used in connection with ETFs and generally are not applicable for the predisposal treatment of the types of hazardous, low-level radioactive, and mixed wastes described in this EIS. An exception is evaporation, which could be applied to ETF sludges for volume reduction and the stabilization of semisolid sludge to a dry salt form. TE

D.2.3.2 Chemical Treatment

Chemical treatment processes involve conditioning wastes to enhance sedimentation or filtration. These methods include precipitation, chelation, and flocculation. Other chemical technologies - for example neutralization, oxidation, reduction, solvent extraction, chlorination, and ozonation - destroy or detoxify wastes.

Chemical treatment technologies, particularly neutralization and precipitation, are applicable to the predisposal treatment of certain hazardous and mixed wastes (contaminated water, sludges, and soils from specific seepage and settling basins), but are used most commonly in ETFs.

D.2.3.3 Biological Treatment

Biological treatment technologies involve the use of oxidizing bacteria, algae, fungi, and microorganisms to destroy, stabilize, or alter organic wastes in aqueous streams. They are generally applied to process or domestic wastewaters, leachates, and other contaminated waters. Biological treatment technologies include activated sludge, stabilization ponds, trickling filters, rotating biological contactors, and land treatment.

Although these technologies are used extensively for waste treatment (including land treatment/disposal of certain oil wastes on the SRP), they generally are not applicable to the treatment of highly toxic hazardous wastes or radioactive wastes before disposal and, therefore, are of limited use for predisposal treatment on the Plant. (For additional discussion of biological treatment technologies, refer to Appendix C.)

D.2.3.4 Thermal Destruction Treatment

Thermal destruction of organic wastes, regardless of volume reduction, requires specially designed incinerator facilities that produce high temperatures and, perhaps, long residence times. This controlled incineration uses temperatures typically higher than 800°C. Many incinerators have at least two chambers. The first can be fired under either oxygen-deficient conditions (pyrolysis) or oxygen-rich conditions at temperatures of approximately 700°C; residence times in this chamber are rather long (measured in minutes). The second chamber is usually an afterburner, where combustion of the hazardous contaminants and particulates from the first chamber occurs at high efficiency in an oxygen-rich environment; residence times are usually a few seconds, and temperatures are 1000°C or higher. The performance of the afterburner usually determines both the incinerator's efficiency in destroying the principal organic hazardous constituents and the identity and yield of particulates released to the emission control equipment and stack.

Hazardous waste incinerators must achieve destruction and removal efficiencies (DREs) of 99.99 percent, with the exception of dioxin incinerators, which must achieve a DRE of at least 99.9999 percent (40 CFR 264). Laboratory testing of incinerator performance under pyrolytic conditions on actual (or closely simulated) waste streams is the most effective and reliable method for predicting the emission of hazardous constituents (Dellinger et al., 1985; Mourningham and Olexsey, 1985).

Based on its assessment of incineration as a treatment method for organic hazardous wastes, the EPA (1985a) found incineration to be an environmentally sound technology that offers advantages over current disposal options under some circumstances. The EPA found little impact to health from incineration.

Thermal destruction by incineration does not destroy radionuclides. Therefore, when incineration is used to reduce the volume of wastes containing radioactivity, high-efficiency particulate air (HEPA) filters are needed to recover radioactive particulates from the exhaust gases. Both the recovered particulates and the residual ash, which contains solid radioactive particles, must be disposed of in a suitable disposal facility, usually after solidification.

Regarding its use for predisposal treatment, the Office of Technology Assessment (OTA, 1985) indicates that incineration is a proven, highly effective technology. It would, therefore, be applicable to a wide variety of hazardous, low-level radioactive, and mixed wastes, including those exhumed from existing SRP waste sites during closure actions. Table D-2 summarizes commonly used incineration technologies.

Table D-2. Commonly Used Incineration Technologies

Type	Process principle	Application	Combustion temperature (°C)	Residence time
Rotary kilns	Waste burns in a rotating, refractory cylinder	Any combustible solid, liquid, or gas	800–1650	Seconds for gases; hours for liquids and solids
Single chamber/ liquid injection	Wastes atomize in high-pressure air or steam and burn in suspension	Liquids and slurries that can be pumped	700–1650	0.1 to 1 second
Multiple hearth	Wastes descend through several grates to burn in increasingly hotter combustion zones	Sludges and granulated solid wastes	750–1000	Up to several hours
Fluidized-bed incineration	Waste is injected into an agitated bed of heated inert particles; heat transfers efficiently to wastes during combustion	Organic liquids, gases, and granular or well-processed solids	750–900	Seconds for gases and liquids; minutes for solids

Source: EPA, 1985b.

D.3 APPROPRIATE TECHNOLOGIES

D.3.1 SUMMARY OF PREDISPOSAL TREATMENT TECHNOLOGIES

Table D-3 summarizes the advantages, disadvantages, and limitations of common predisposal treatment technologies.

D.3.2 SUMMARY OF APPROPRIATE TECHNOLOGIES

The use of predisposal waste treatment technologies can produce a substantial change on the characteristics and volume of waste to be disposed of. These changes might preclude certain disposal technologies or limit disposal alternatives to one or two specific technologies. Also, the potential difference in waste volume will have a great influence on the design capacity of required disposal facilities. Therefore, predisposal treatment must be considered as an integral part of the disposal process; it has a major impact on the sizing, design, and operation of facilities.

Tables D-4, D-5, and D-6 summarize the applicability of five predisposal technologies to various hazardous, mixed, and low-level radioactive wastes generated by, or stored at, SRP facilities.

D.3.3 EXPECTED RESULTS OF APPLICATION

Tables D-4, D-5, and D-6 indicate that, potentially, predisposal treatment technologies, specifically incineration, compaction, evaporation, solidification, and encapsulation, can be applied to a wide variety of hazardous, low-level radioactive, and mixed wastes on the SRP. At present, the use of certain technologies is being planned.

The following subsections summarize the expected results of the application of these technologies and, if possible, estimate the potential results of broader applications.

D.3.3.1 Incineration

Because of the effectiveness of incineration technology for volume reduction or thermal destruction of hazardous waste constituents, and because of its relatively low operation and maintenance costs, its development is being pursued actively on the Plant. One demonstration incineration project, the beta-gamma low-level radioactive waste incinerator, and one pilot incineration project, the transuranic (TRU) waste incinerator, are in operation on the Plant.

The beta-gamma incinerator is a two-stage, ram-feed, air-controlled incinerator with a spray-quench tower, bag house, and high-efficiency particulate air (HEPA) filter. Waste in the first chamber is pyrolyzed at 900°C. Final combustion occurs with excess air in the second stage at 1000°C. This incinerator is achieving volume reductions of 95 to 99 percent (Weber, 1985).

The TRU waste pilot incinerator is an infrared, movable-grate type with a capacity of about 11 kilograms of solids per hour. Research conducted with this incinerator could be applied to low-level radioactive and mixed wastes

Table D-3. Advantages, Disadvantages, and Limitations of Common Predisposal Treatment Technologies[a]

Advantages	Disadvantages	Limitations	SRP applications
VOLUME REDUCTION/DESTRUCTION/DETOXIFICATION PROCESSES			
Incineration:			
• Onsite - Destroys organic wastes (99.99+%). - Long-distance transportation of wastes not required.	Onsite feedstock preparation required. Test burn would be required. Skilled operators required. Expensive.	Mobile units have low feed rate.	SRP currently generates and stores large quantities of organic wastes. BGI[c] demonstration facility. Consolidated Incineration facility is being designed for hazardous and radioactive waste
Biological treatment:			
• Conventional - Applicable to many organic waste streams. - High total organic removal. - Inexpensive. - Well understood and widely used in other applications.	Can produce a hazardous sludge that must be managed. Might require pretreatment before discharge.	Microorganisms sensitive to oxygen levels, temperature, toxic loading, inlet flow. Some organic contaminants are difficult to treat. Flow and composition variations can reduce efficiency.	SRP currently generates and stores large quantities of organic wastes. Organically contaminated waste sites generally not amenable to in situ biodegradation.
Chemical treatment:			
• Wet air oxidation - Good for wastes too dilute for incineration or too concentrated or toxic for biological treatment.	Oxidation not as complete as thermal oxidation or incineration. Might produce new hazardous species. Extensive testing is required. High capital investment. High-level operator skills required. Might require post-treatment.	Poor destruction of chlorinated organics. Moderate efficiencies of destruction (40-90%).	Generally not applicable to SRP organic wastes.
• Chlorination for cyanide - Essentially complete destruction. - Well understood and widely used in other applications.	Specialized for cyanide.	Interfacing waste constituents can limit applicability or effectiveness.	Generally, SRP does not produce cyanide wastes.

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TC

Table D-3. Advantages, Disadvantages, and Limitations of Common Predisposal Treatment Technologies[a] (continued)

Advantages	Disadvantages	Limitations	SRP applications
Chemical treatment *(continued)*:			
• Ozonation - Can destroy refractory organics. - Liquids, solids, mixes can be treated.	Oxidation not as complete as thermal oxidation or incineration. Might produce new hazardous species. Extensive testing is required. High capital investment; high O&M.	Limitations not as well understood.	
• Reduction for chromium - High destruction. - Well understood and widely used in other applications.		Interfering waste constituents can limit applicability or effectiveness.	Chromium wastes currently sent to H-Area seepage basin for disposal.
Physical treatment:			
• Compaction/shredding - Low technology. - Well understood and demonstrated.	Might require air pollution control.	Limited primarily to bulky solid wastes.	Compaction of low-level radioactive waste being used to conserve burial ground capacity. TC
SEPARATION/TRANSFER PROCESSES			
Chemical:			
• Neutralization/precipitation - Wide range of applications. - Well understood and widely used in other applications. - Inexpensive.	Hazardous sludge produced.	Complexing agents reduce effectiveness.	Widely used technology at SRP.
• *Ion exchange* - Can recover metals at high efficiency.	Generates sludge for disposal. Pretreatment to remove suspended solids might be required. Expensive.	Resin fouling. Removes some constituents but not others.	Used to treat disassembly-basin purge water before discharge into reactor seepage basins. To be a component of the F/H Effluent Treatment Facility. TC

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Table D-3. Advantages, Disadvantages, and Limitations of Common Predisposal Treatment Technologies[a] (continued)

Advantages	Disadvantages	Limitations	SRP applications
Physical treatment:			
• Carbon adsorption for aqueous streams - Well understood and demonstrated. - Applicable to many organics that do not respond to biological treatment. - High degree of effectiveness.	Regeneration or disposal of spent carbon required. Pretreatment might be required for suspended solids, oil, grease. High O&M cost.	Some organics are poorly adsorbed.	Currently used to remove chlorinated organics from drinking water in A/M-Area on an "as-needed" basis.
• Carbon absorption for gases - Widely used, well understood. - High removal efficiencies.	High capital and O&M costs.	More effective for low-molecular-weight polar species. Disposal or regeneration of spent carbon required.	
• Flocculation, sedimentation and filtration - Low cost. - Well understood.	Generates sludge for disposal.	--	
• Stripping - Well understood and demonstrated.	Air controls might be required.	Applicable only to relatively volatile organic components.	A 1.5-m^3/min air stripper is removing chlorinated organics from groundwater in A/M-Area.
• Flotation - Well understood and demonstrated. - Inexpensive.	Generates sludge for disposal.	--	
• Reverse osmosis - High removal potential.	Generates sludge for disposal. Pretreatment to remove suspended solids or adjust pH might be required. Expensive.	Variability in waste flow and composition affects performance.	To be a component of the F/H Effluent Treatment Facility. TC

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Table D-3. Advantages, Disadvantages, and Limitations of Common Predisposal Treatment Technologies[a] (continued)

Advantages	Disadvantages	Limitations	SRP applications
• Evaporation[b] - Well understood. - Low technology. - High degree of volume reduction.	Energy intensive.	Most effective with aqueous wastes of high solids content.	Currently being considered for drying ETF sludges to dry salt form.
	CONTAINMENT PROCESSES		
Solidification and stabilization • Improves containment performance. • High short-term effectiveness possible. • Waste material (e.g., fly ash, kiln dust) can be used as pozzolan.	Extensive testing might be required. Many processes developmental. Substantially increases volume of material to be disposed of.	Long-term integrity uncertain. Not useful for many organics.	Cement-fly ash matrix (CFM) is being performed at SRP. TC
Encapsulation: • Improve effectiveness of land disposal.	Developmental. Inefficient space utilization.	Long-term integrity uncertain. Requires solidification of bulk wastes.	Being used at greater confinement disposal demonstration in LLW burial ground.

[a]Source: OTA, 1985.
[b]Source: J. T. Baker Chemical Company, 1979.
[c]Beta-Gamma Incineration TC

Table D-4. Applicability of Predisposal Treatment Technologies to Hazardous Wastes[a]

Waste	Predisposal treatment technology				
	Incineration	Compaction	Evaporation	Solidification	Encapsulation
Organics, mercury and oil	3	5	5	4	5
Lathe coolant, oil	1	5	5	4	5
Oil with lead	3	5	5	4	5
Inorganic acids	3	5	5	4	5
Paint solvent	1	5	5	4	5
Other solvents	1	5	5	4	5
Toluene, xylene	1	5	5	4	5
Pesticides	1	5	5	4	5
CMP liquids	1	5	5	4	5
Sodium dichromate	1	5	5	4	5
Trichloroethane	1	5	5	4	5
Methylene chloride	1	5	5	4	5
Machine coolant	1	5	5	4	5
Naphtha-methylene chloride	1	5	5	4	5
Teargas concentrate	3	5	5	4	5
Toluene and isopropanol	1	5	5	4	5
Varnish and thinners	1	5	5	4	5
Waste paint	1	5	5	4	5
Laboratory chemicals	2, 3	5	5	3, 4	3
DWPF pilot plant sludge	5	5	1	1	3
Trichloroethylene sludge	1	5	5	4	4
Lead smelter waste	5	5	5	1	1
Beryllium-copper alloy	3	2	5	1	1
Alkalines	3	5	5	1	3
Nitrates	1	5	5	4	3
Mercury-contaminated material	1	2	5	4	1
Reactive metals	5	2	5	1	1
Contaminated soil	2	5	5	1	3

[a]Notations:
1. Broadly applicable
2. Moderately applicable
3. Limited to special conditions
4. Applicable when preceded by incineration to ash
5. Not applicable

generated on the Plant. In the first chamber, the waste is pyrolyzed at 870°C. Vaporized organic molecules and combustion products then enter an afterburner where the temperature reaches more than 1200°C for longer than 2 seconds. This type of incinerator has achieved a DRE of at least 99.9999 percent (Schreiber, 1985).

DOE plans a consolidated waste incineration facility (hazardous, mixed, and low-level) for the SRP. Current plans call for this facility to include two incinerators: one would use cyclonic, liquid injection incineration capable of destroying liquid organic wastes, including benzene from Defense Waste Processing Facility (DWPF) operations; the other would use rotary-kiln technology for the incineration of solid wastes (as much as 270 kilograms per hour) (DOE, 1985). Each unit would have spray-quench, wet-scrubber, and mist-eliminator systems. The liquid incinerator would also have a mercury absorption column. In the future, the conversion of this facility to a mixed waste facility might be desirable; if that were done, appropriate shielding and HEPA filters would be necessary.

The estimation of waste volumes in Appendix E includes assumptions for volume reduction by incineration. In general, it is assumed that liquid organics

Table D-5. Applicability of Predisposal Treatment Technologies to Mixed Wastes[a]

Waste	Predisposal treatment technology				
	Incineration	Compaction	Evaporation	Solidification	Encapsulation
Purex solvent	1	5	5	4	5
Scintillation fluid	1	5	5	4	5
Liquid organics	1	5	5	2, 4	5
Tritiated mercury	5	5	5	1	3
Tritiated oil	1	5	5	3, 4	5
PCB contaminated oil	1	5	5	4	5
FMF WWTF sludge	5	5	1	1	3
M-Area ETF sludge	5	5	1	1	3
F- & H-Area ETF sludge	5	5	1	1	3
FPF ETF sludge	5	5	1	1	3
Mercury-contaminated waste	1	3	5	4	3
Job control waste	1	1	5	4	3
Lead shielding	5	5	5	5	1
Mercury-contaminated equipment	5	3	5	5	1
Contaminated soil	3	5	5	1	3

[a]Notations:
1. Broadly applicable
2. Moderately applicable
3. Limited to special conditions
4. Applicable when preceded by incineration to ash
5. Not applicable

Table D-6. Applicability of Predisposal Treatment Technologies to Low-Level Radioactive Wastes[a]

Waste	Predisposal treatment technology				
	Incineration[b]	Compaction	Evaporation	Solidification	Encapsulation
Low-level radwaste solvents	1	5	3	1	5
Tritiated oil	1	5	5	3, 4	5
Purex solvent	1	5	5	4	5
Job control waste	1	1	5	4	1
Targets, equipment, hardware	3	3	5	4	1
Contaminated soil & radwaste	5	3	5	1	1

[a]Notations:
1. Broadly applicable
2. Moderately applicable
3. Limited to special conditions
4. Applicable when preceded by incineration to ash
5. Not applicable

[b]Incineration does not destroy or reduce radionuclides but can be used to reduce the volume, change the physical state, and chemically stabilize low-level radioactive wastes.

would be reduced by 97.5 percent, but that circumstances could reduce that to 95 or 92.5 percent. It is also assumed that combustible solids would be reduced by 92.5 percent and that the incineration of contaminated soils would result in no reduction in volume. The residuals are assumed to include both ash and exhaust gas scrubber blowdown.

D.3.3.2 Compaction

Compactor demonstration programs at the SRP and other DOE facilities (e.g., Oak Ridge and the Fuel Materials Production Facility) are reducing the volume of low-level radioactive waste. The Reactor Department and the Savannah River Laboratory (SRL) both use small (0.15-cubic-meter) box compactors. These units reduce the volume of job-control wastes by approximately 67 percent. Data from these demonstrations will provide the basis for the installation of additional compactors by the Reactor Department.

The Separations Department and Waste Management have installed a large box compactor in H-Area. TC This unit compacts wastes into 2.6-cubic-meter, carbon-steel boxes. As waste items are received in cardboard boxes, radiation levels are verified and the waste is fed manually to the compactor. Volume reductions of greater than 80 percent have been achieved. This demonstration will permit the evaluation of (1) volume reduction achievable for TC low-level radioactive waste, (2) the classification of compactible material, (3) loading techniques, and (4) ventilation control requirements. Appendix E assumes a volume reduction of 75 percent through the use of this technology.

Shredding technology is a subset of compaction. As discussed in Section D.2.1.3, shredding is particularly effective when applied before incineration or compaction. Currently, the SRP and SRL are testing two small shredders (15 and 45 horsepower) for use in preparing combustible, TRU-contaminated waste for incineration (Charlesworth, 1985).

A large (160-horsepower) shredder system that is expected to begin operation by 1990 will reduce decontaminated, noncombustible process equipment and other large items. Testing has determined that a 200-kilogram glove box can be reduced for disposal in a 208-liter drum.

The Raw Materials Department in M-Area has installed a large box compactor. That compactor presumably achieves volume reductions of 76 to 80 percent.

Collectively, these compaction programs should achieve a net reduction of about 2400 cubic meters of low-level waste annually (Mentrup, 1985). This amounts to a 9-percent reduction in the amount of low-level waste to be disposed of annually at the low-level waste burial grounds.

D.3.3.3 Evaporation

No significant research on or demonstration of evaporation technology for reducing ETF sludges to dry salt for disposal has been performed at the SRP in recent years. However, assuming a bulk density of 2400 kilograms per cubic meter of dry salt, the volume reductions would range from 87.5 percent for ETF sludges with 30 percent solids content by weight to 98.3 percent for sludges with 4 percent solids by weight.

D.3.3.4 Solidification

Research on cement/fly ash solidification of ETF sludges is under way at the SRP. The material produced by this method would be formed into monoliths in lined disposal facilities, where it would cure to a concrete-like substance.

Solidification is applicable to a variety of granular solid wastes such as incinerator ash and contaminated soil; semisolid sludges such as the M-Area ETF sludge; and liquids, including contaminated water. DOE has received permits for the construction and operation of facilities to solidify decontaminated DWPF supernate and to dispose of the waste in Z-Area.

Appendix E assumes that, because of the addition of substantial quantities of material to the waste using this technology, the waste form volume would be double the original waste volume. For soil/waste mixtures derived from the TC closure of existing waste sites, solidification should result in a volume increase of approximately 40 percent.

D.3.3.5 Encapsulation

The SRP has an active waste encapsulation program. At present, greater confinement disposal (GCD) techniques are being tested at instrumented facilities in the low-level waste burial ground. The goal of GCD is to dispose of Class B and C low-level radioactive wastes in a facility that would meet the NRC 500-year longevity guideline (10 CFR 61). Self-leveling cement grout is used to encapsulate the wastes as each "lift" is placed in a GCD demonstration borehole or trench (Cook et al., 1984). Such a use of this technology is considered to be disposal rather than pretreatment.

One predisposal alternative combines solidification and encapsulation technologies. It involves the use of a shell of concrete to contain saltstone or low-level waste grouted in place. The concrete containers can be shaped to fit tightly together in rows and columns, eliminating interstitial space and improving stability.

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APPENDIX E

NEW DISPOSAL FACILITY ALTERNATIVES

Chapter 2 of this environmental impact statement (EIS) defines four alternative waste management strategies (No Action, Dedication, Elimination, and Combination) for the modification of SRP waste management activities. In its Record of Decision, the U.S. Department of Energy (DOE) will select a strategy based on its evaluations of optional technologies that will conform to the objectives of the strategy and will achieve regulatory compliance. Section E.1 describes the various project-specific technologies being considered under each waste management strategy. Section E.2 describes the wastes that will require disposal. Section E.3 discusses the methodology through which candidate sites were identified to provide a basis for certain project-specific environmental analyses (e.g., groundwater modeling). Section E.4 identifies the project-specific technologies associated with each strategy and describes the advantages and disadvantages of implementation, the range of waste volumes currently anticipated, the range of potential costs associated with implementation, and the major analytical assumptions. TC

The objective of this appendix is to describe the technologies that could be used to implement each strategy to provide a basis for defining the range of environmental impacts expected (see Appendix G). This range, rather than specifically defined impacts, is intended to cover the potential project-specific actions that will be decided through planning and feasibility studies during the regulatory permitting process. These project-specific actions are associated with site selection, engineering design details, waste stream characteristics and volumes, closure of existing waste sites, predisposal treatment facilities, cost effectiveness, regulatory requirements, and judicial mandates. For the analysis of environmental impacts, this EIS makes conservative assumptions about project-specific actions to describe impacts that include all known reasonable waste management possibilities. TC

E.1 DESCRIPTION OF TECHNOLOGIES

This section describes the project-specific technologies being considered for the disposal and/or storage of hazardous, mixed, and low-level radioactive wastes. (Note: The term "disposal" refers to the permanent deposition of wastes in an engineered facility; the term "storage" presumes retrieval of the waste at some future time; the term "technology" means a project-specific technology or action; and the term "strategy" implies a means of achieving a specified waste management goal through the implementation of any of several optional project-specific technologies.) TE

E.1.1 HAZARDOUS OR MIXED WASTE

E.1.1.1 Applicable Regulations and Criteria

The management of hazardous waste and mixed (radioactive and hazardous) waste at the Savannah River Plant (SRP) is regulated by the Resource Conservation and Recovery Act (RCRA), the Hazardous and Solid Waste Amendments (HSWA), and

DOE Orders. Chapter 6 discusses these acts and amendments and other applicable regulations.

Predisposal treatment of these wastes might be required with all of the disposal technologies. TE Currently, RCRA prohibits the disposal of bulk or uncontainerized liquid waste or waste containing free liquids until they are treated chemically or physically (e.g., by mixing with a sorbent solid), such that free liquids are no longer present as defined by the regulations (i.e., the paint filter test).

Under the 1984 Amendments to RCRA (i.e., HSWA), the U.S. Environmental Protection TC Agency (EPA) will restrict or ban the land disposal of most untreated hazardous wastes over the next 5 years. These amendments require the treatment of hazardous wastes to remove their most toxic components, allowing only the treatment residue to be disposed of on land.

EPA's first action under this requirement applies to spent solvents and wastes that contain dioxin. Other materials to be affected include liquid hazardous waste containing cyanides, metals, and polychlorinated biphenyls (PCBs); corrosive wastes; and both liquid and solid hazardous wastes containing halogenated organic compounds (HOCs). To implement these requirements, EPA is establishing predisposal treatment standards based on actual performance of the best demonstrated treatment technologies available.

Under RCRA, EPA could consider a request from DOE for an exemption to the land disposal ban. EPA's approval would have to be based on its determination that no migration of hazardous constituents would occur from the waste management unit.

Predisposal treatment of hazardous or mixed waste for volume reduction, detoxification, and chemical or physical stabilization might be desirable and cost effective, regardless of the legal requirements. Appendix D describes the application of predisposal treatment, which will be determined specifically in the context of future advanced planning designed to carry out the selected waste management strategy.

E.1.1.2 <u>Belowground Vault Disposal (RCRA Waste)</u>

One technology being considered for shallow-land disposal of hazardous or mixed wastes is the double-lined, reinforced-concrete vault. A typical disposal vault would be a large, water-tight, reinforced-concrete box set below the surface of the ground on an exterior liner of compacted clay. Each vault would be divided into cells for the disposal of the different types of hazardous waste. A membrane liner in each cell would ensure containment of any leakage within that cell. A leachate (or leakage) collection system would be installed in each cell above the concrete liner (floor), and a leachate monitoring and collection system would be installed between the concrete floor and TC the compacted clay liner. Prior to closure, any rain or run-on would be collected and disposed of properly.

Hazardous or mixed wastes, delivered to the vaults in containers, would be placed in the cells in layers. As each layer in a cell was completed, voids would be filled with grout and the layer would be capped with about 0.3 meter of reinforced concrete. After capping, the cells would be sealed by a sloped, reinforced-concrete roof and covered with approximately 1 meter of soil. The closed facility would appear to be a mound at the ground surface. Space utilization efficiency would be about 66 percent.

Vaults for mixed waste would be nearly identical to those for hazardous waste, because no additional shielding would be required for radiation protection. However, intermediate-activity mixed waste (greater than 300 millirem per hour) would be handled by remote-controlled or shielded equipment and would be immediately grouted in place and covered by approximately 0.6 meter of concrete to provide the required occupational shielding.

This technology relies primarily on the design and integrity of the structure and its backup systems to ensure that hazardous or mixed waste constituents do not migrate from the facility into the surrounding soils or groundwater. The following features facilitate this objective:

- A water-tight concrete structure that prevents the entry of water into the facility and provides long-lasting stability
- Grouting of void spaces to improve stability and minimize channels through which water or liquids could percolate
- An interior synthetic-membrane (primary) liner that prevents the release of contaminated water or liquids from the facility
- A leachate collection system above the primary liner to provide a means of detecting and removing accumulated liquids
- A backup (secondary) liner consisting of at least 1.5 meters of compacted clay or the equivalent
- A secondary leachate collection system to provide a means of detecting and removing contamination outside the primary liner
- Placement below the surface of the ground to protect the structure and provide radiation shielding

E.1.1.3 Aboveground Vault Disposal (RCRA Waste)

The aboveground vault technology is similar to that of belowground vaults. This technology responds to the statement in the Notice of Intent to have the analysis of new disposal facility alternatives include an evaluation of aboveground disposal.

Section E.1.1.2 contains a description of the aboveground vault technology, except the aboveground vault is constructed at or near the natural surface of the ground with its concrete sides and roof protruding above the surface. A mixed waste facility could require allowances for additional radiation shielding or interior locational preferences for the disposal of intermediate-activity waste.

This technology relies on the design and integrity of the structure and its backup systems to ensure that hazardous and mixed waste constituents do not migrate from the facility into soils or groundwater. The features facilitating this objective are the same as those listed in Section E.1.1.2, except the vault is above the ground. A unique feature of this technology is its construction at the surface of the ground. This eliminates the need for substantial excavation and reduces the difficulty of monitoring, inspection, and repair, which could enhance its long-term reliability.

E.1.1.4 Vault Disposal (Cement/Flyash Matrix Waste)

A technology for the disposal of selected wastes involves predisposal treatment by solidification in a cement/flyash matrix (CFM) and discharge as a slurry directly into reinforced-concrete vaults, where it cures in-place to a hard, concrete-like substance. Currently, this technology is being considered for the disposal of mixed waste sludges from the M-Area effluent treatment facility (ETF), the F/H ETF, the Fuel Production Facility ETF, and the Naval Fuel Materials Facility wastewater-treatment plant, plus ash from the incineration of hazardous, mixed, and low-level radioactive wastes.

Treatment facility sludges and incinerator ash would be delivered to the treatment/disposal facility by tank truck and unloaded to a storage tank capable of holding 1 month's generated volume. Before disposal, the waste would be blended into a cement/flyash mixture that would be transported to disposal vaults for discharge and curing.

A typical disposal vault would be a large, reinforced-concrete box set either below the surface of the ground or at the surface. Each vault would be divided into cells to allow the pouring of discrete units of CFM waste and would have rain covers to help keep the chambers dry. Water that entered the facility before closure would be collected, monitored, and properly disposed of.

Closure of a filled vault would involve the placement of a concrete cover or roof, which would be either cast in place or precast in sections. A belowground vault would be covered with soil to grade; an aboveground vault would remain exposed or would be mounded with soil to protect the facility and provide added radiation shielding.

The vault technology for CFM disposal differs from the RCRA vaults (Sections E.1.1.2 and E.1.1.3) because it has no liners and no leachate collection systems. Rather, it relies on the solidification of the waste and the concrete structural barrier to prevent the release of waste constituents and to maintain environmental standards. The following features facilitate this waste management objective:

- Pretreatment by CFM solidification, which provides chemical and physical stability of the waste and resists leaching of constituents

- Direct discharge of the slurried mixture into the facility for curing in place, which eliminates channels into or through the waste and further resists leaching of constituents

TC

- Concrete vault containment, which provides a structural barrier between the solidified waste and the environment

- Limitation to specific wastes that are particularly suitable for solidification pretreatment

This technology relies extensively on the solidification pretreatment to prevent release of constituents and to render the waste potentially nonhazardous and eligible for delisting under RCRA. Without this pretreatment, RCRA technology standards would apply. Any future evaluations of this technology should include the predisposal treatment facilities as an integral component.

E.1.1.5 RCRA-Type Landfill Disposal

A RCRA-type landfill facility for hazardous or mixed waste consists of double-lined trenches, cells, or pits with double leachate collection systems. The first liner would be of clay compacted on the bottom and sides of the trench. This would be overlain by a leachate collection system consisting of a permeable material such as sand or crushed stone. An impermeable synthetic membrane liner would be placed above this, followed by another leachate collection system. The final layer would be a working surface of crushed stone. The waste containers would be unloaded and stacked on this surface. TC

Mixed waste emitting radioactivity of more than 300 millirem per hour (intermediate-activity waste) would be handled remotely or with shielded equipment. Containers of such waste would be placed at the bottom level and shielded horizontally and vertically with containers of material emitting less than 300 millirem per hour (low-activity waste).

As a trench was filled, closure would consist of filling void spaces with sand, covering the facility with a low-permeability synthetic membrane, and protecting that membrane with layers of sand, a low-permeability clay cap, and soil. The cover membrane would be fused to the base membrane to provide a water-tight enclosure for the waste. Total space utilization efficiency in the trench would be about 49 percent.

After closure, the ground surface above the facility would be contoured to channel surface runoff away from the landfill and would be seeded with grass or other shallow-rooted vegetation to stabilize the soil and mitigate erosion.

During the operation of the facilities, run-on and leachate water would be collected and monitored. This water would be disposed of in accordance with RCRA regulations. C-114

As with other RCRA facilities, this landfill relies largely on the design and structural integrity of the facility and its backup systems to ensure that hazardous or mixed waste constituents do not migrate from the facility into the surrounding soils or groundwater. The following features facilitate this objective:

- A water-tight sealed membrane that completely surrounds the waste to prevent the entry of water into the facility or the release of potentially contaminated water from the facility
- Sand-filled void spaces to improve stability
- A leachate collection system above the primary (synthetic-membrane) liner to provide a means of detecting and removing accumulated liquids

TE

- A backup (secondary) liner consisting of at least 1.5 meters of compacted clay or the equivalent (40 CFR 264.301)

- A secondary leachate collection system to provide a means of detecting and removing contamination outside the primary liner

- Placement below the surface of the ground to provide structural support, protect the liners, and provide radiation shielding of mixed waste

E.1.1.6 Retrievable-Storage Buildings

The buildings being considered for the retrievable storage of hazardous or mixed wastes would be of metal and/or concrete construction, designed and operated to prevent releases of hazardous or radioactive wastes. Wastes would be delivered to the buildings in containers (e.g., 208-liter drums or 2.5-cubic-meter steel boxes) for storage. Interior partitions would segregate noncompatible wastes. The design of mixed waste facilities would include varying degrees of radiation shielding. Access aisles would facilitate the handling and periodic inspection of the waste containers. Due to the space devoted to items other than waste storage, the estimated space utilization efficiency of such a storage building is 15 to 20 percent.

The long-term storage of hazardous and mixed wastes in a safe and secure manner depends on the design and reliability of the storage facilities and a cognitive operational program. The building design would include the following specific features:

- Separate drains and alarmed sumps for the recovery of any liquids from each partitioned area

- Smoke and fire detection, and automatic foam fire control systems

- Ventilation systems with vapor and radiation detectors to provide occupational protection and warning of potential leakage

- In mixed waste facilities, the routing of ventilated air through high-efficiency particulate filters to preclude the release of radioactive particles

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Operations would include waste analysis, site security, periodic inspections of the waste containers and the facility, personnel training, emergency preparedness and procedures, SPCC plans, recordkeeping, and reporting.

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The objective of the retrievable-storage technology is to store waste temporarily in anticipation of the development of improved technologies for destruction, detoxification, recycling, or disposal. Pretreatment prior to storage might foreclose future options. Therefore, pretreatment generally is neither required nor desired, with the exception of some forms of volume reduction (e.g., compaction, shredding) to reduce bulk, usually by eliminating air spaces.

TC

The retrievable-storage technology has a major disadvantage; that is, by itself it could not provide a permanent waste management solution. Future expenditures for construction of treatment or disposal facilities, retrieval of the stored waste, decontamination of the storage facilities, and operation of those treatment or disposal facilities would be required. TC

E.1.2 LOW-LEVEL RADIOACTIVE WASTE

E.1.2.1 Applicable Regulations and Criteria

DOE has published general guidelines and policies for the management of low-level radioactive waste in the form of DOE Orders; these are summarized in Chapter 6.

E.1.2.2 Engineered Low-Level Trench Disposal

The engineered low-level trench (ELLT) is a technology for the disposal of low-activity (less than 300 millirem per hour) waste. A typical ELLT disposal facility would consist of an open trench, 40 to 50 meters wide and 150 to 170 meters long, with a floor of crushed stone. Low-activity waste in steel containers would be delivered to the trench, unloaded, and stacked on the crushed stone base. The trench would be closed as it was filled. Sand, soil, or other suitable material would be used to fill void spaces; it would be overlain by a cap of clay, fill, and topsoil. The ground surface would be seeded, and surface water would be channeled away from the facilities to minimize infiltration of the water and erosion of the cap. Subsidence that occurred after closure would be corrected as necessary to eliminate ponding above the trench. The use of metal containers should delay subsidence for some time. TC

Because the ELLT technology includes no engineered barriers or leachate collection, it relies on site selection, a well-constructed low-permeability cap, and postclosure maintenance to minimize the intrusion of water into the closed trench and prevent excessive migration of waste constituents.

E.1.2.3 Vault Disposal

DOE is considering the use of vaults for the disposal of low- and intermediate-activity waste. A typical low-activity disposal vault is a large, reinforced-concrete box set either below or at the surface of the ground. The interior can be open or divided into cells, as appropriate, to accommodate facility operations and waste handling.

Typically, waste would be delivered to the facility in metal containers, which would be packed closely in the vault to minimize void spaces. When it was filled, the vault would be closed with a concrete cap or roof to seal the waste inside. A belowground vault would be covered with soil to grade and the surface would be contoured to channel runoff away from the facility. An aboveground design would remain exposed or would be mounded with soil to protect the vault from weathering or to provide additional radiation shielding.

Due to the relatively low concentration of contaminants in the low-activity waste fraction, this technology requires no additional clay or membrane liners and no leachate collection systems. The low-activity vault relies largely on the sealed concrete structural barrier, the siting, and the surface drainage to minimize the intrusion of water, which could leach waste constituents into underlying soils and groundwater.

The vault design for intermediate-activity waste is similar structurally to that for the low-activity vault; however, due to the higher concentration of radionuclides, the design may contain a complete exterior leachate collection system and a secondary barrier of compacted clay or other suitable material. Containerized or bulk intermediate-activity wastes could be grouted in place to fill void spaces and add stability, or added stability could be incorporated into the structure. Closure would be similar to that described for the low-activity vault.

TE

The vault technology for intermediate-activity, low-level waste differs from that for the RCRA vault; it may contain a single leachate collection system and exterior liner rather than the double (interior and exterior) leachate collection systems and liners required for RCRA facilities. On the other hand, the intermediate-activity vault design requires added stability by either in-place grouting or structural design to minimize the possibility of subsidence and the intrusion of water to ensure that radionuclides are contained within the facility.

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DOE Orders require predisposal treatment (i.e., solidification) prior to disposal of liquid low-level waste using vault technologies. Other pretreatments (i.e., volume reduction) are not required but might be desirable to enhance stability or improve the efficiency and cost effectiveness of space utilization.

E.1.2.4 Abovegrade Operations

DOE is considering an abovegrade operation (AGO) for the disposal of low-activity, low-level radioactive waste; however, this technology can be used for the disposal of both low- and intermediate-activity wastes. An AGO consists of a stable stack of waste-filled containers, surrounded by a low-permeability synthetic membrane. Typically, an AGO facility includes a subbase of compacted clay covered by the membrane. A layer of sand protects the membrane and facilitates a leachate-collection field. A geotextile layer separates the sand from the final layer of crushed stone. The subbase is sloped to aid in the collection of run-on water and leachate during operation and after closure.

Wastes would be delivered to the AGO in steel containers, which would be unloaded and stacked on the crushed stone base mat. Intermediate-activity (greater than 300 millirem per hour), low-level wastes that require added shielding would be handled by remotely controlled equipment and placed in specially prepared precast reinforced-concrete casks near the center of the pile.

The AGO would be closed with sand to fill void spaces and clay, a low-permeability synthetic membrane, and a final cover of soil. The cover membrane would be fused to the base membrane to form a water-tight sealed envelope around the stacked waste containers. This should prevent the generation of leachate from the facility; however, any water collected from beneath the facility would be tested and, if contaminated, would be solidified in concrete and disposed of as low-level waste.

An AGO unit typically measures 50 to 60 meters wide by 150 to 160 meters long at the base; following closure, it would be about 9 meters high.

AGO technology relies primarily on a stable soil base and the waste containers for structural stability and on the synthetic membrane to minimize the intrusion of water and prevent excessive migration of waste constituents. The leachate collection system provides early warning of a leakage and a means to remove contaminated liquids. The aboveground design provides relatively easy access to the facility to conduct appraisals and effect necessary repairs.

As with other low-level waste disposal technologies, liquid wastes must be pretreated (i.e., solidified) before disposal. Other pretreatments might be desirable to enhance stability or improve space utilization.

E.1.2.5 Greater Confinement Disposal

DOE is considering greater confinement disposal (GCD) technologies for the disposal of intermediate-activity, low-level wastes that require a greater degree of isolation from the environment than low-activity wastes. GCD technology involves deeper burial, and hence more shielding, than the ELLT technology; encapsulation of the waste forms after emplacement with grout; and closure to prevent root intrusion and minimize the percolation of water to the waste.

The SRP could use either of two types of GCD facilities - boreholes and trenches. In a typical GCD borehole design, waste is placed in a liner that is 2.1 meters in diameter and 6.1 meters high; the liner rests on a 0.3-meter-thick concrete pad in an augered hole with a diameter of 2.7 meters. The top TE
of the base pad is generally 9 meters below grade and at least 3 meters above the expected high water table. The top of the waste placed in the liner is typically at least 3 meters below grade. The liner is surrounded by a 0.3-meter-thick annulus of grout. TE Waste in 208-liter drums would be placed in the liner in layers six drums deep and the void space would be filled with grout. The liner would be capped with 0.3 meter of concrete and overlain with a cap of clay, sand, and topsoil. The surface would be seeded and surface water would be channeled away from the holes to eliminate infiltration of the water and erosion of the cap.

GCD trenches have the same shielding objectives as GCD boreholes. Typically, a facility would consist of a concrete-lined trench with a low-permeability membrane liner. A typical trench might be 7 meters wide, 122 meters long, and 7.5 meters deep. Waste in steel containers or bulky, uncontainerized wastes would be placed in the trench in layers about 0.3 meter from the walls. The void spaces would be filled with grout and the trench would be capped with 0.6 TE
meter of reinforced concrete overlain by a cap of clay, sand, and topsoil. The surface would be seeded and surface water would be channeled away from the trench to eliminate infiltration of the water and erosion of the cap.

Total space utilization efficiency would be about 50 percent for trenches and about 40 percent for boreholes. Monitoring wells and leachate collection systems are included in the design of both types of GCD facilities to detect and recover any contaminated water.

GCD technology relies on the following design features to ensure that low-level waste constituents are not released:

- Proper siting to provide adequate depth of disposal, and at least 3 meters between the waste and the expected high water table to prevent contact of the waste with groundwater

- A concrete structure to prevent the intrusion of water into the facility or the release of potentially contaminated water from the facility

- A low-permeability clay cap to divert downward percolating water away from the facility

- Grout encapsulation of the waste after emplacement to improve stability and eliminate channels through which water could flow in contact with the waste

- Backup leachate monitoring and collection systems to provide warning of a release and a means of recovering contaminated liquids

This technology requires predisposal treatment of any liquid wastes (e.g., solidification). Other pretreatments to enhance stability or improve space utilization might be desirable and cost effective.

E.1.2.6 Engineered Storage Buildings

The retrievable-storage alternative for low-level waste involves the segregation of low-activity from intermediate-activity material. The low-activity material is stored in unshielded or lightly shielded facilities. Intermediate-activity material requires heavier radiation shielding and remote handling.

The storage facilities for low-activity wastes would be concrete or metal buildings. The use of concrete block as lining of the walls provides some additional shielding in some buildings.

The building design includes floor drainage sufficient to recover any liquids; heating and ventilation; and fire, smoke, vapor, and radiation detection systems and automatic fire extinguishing systems. Low-activity wastes would

TE be stored in steel containers in racks to facilitate handling and inspection.

Storage of intermediate-activity wastes would occur in concrete buildings or vaults, either above or below the ground, to provide adequate radiation shielding. Each facility would be water-tight and have drainage collection; heat and ventilation; fire, smoke, vapor, and radiation detection, and fire extinguishing systems as required. Intermediate-activity wastes would be stored in steel containers that are handled and inspected remotely.

The objectives of the retrievable-storage technology for low-level radioactive waste are to (1) store waste temporarily in anticipation of the development of

TE more advanced technologies for suitable disposal, and (2) store waste until the radionuclides have decayed to such a point that its disposal using available technology would not violate applicable standards.

This technology requires no pretreatment of wastes other than the immobilization of liquids. Other pretreatments might be desirable (e.g., compaction, shredding) to enhance space utilization efficiency.

The major disadvantage of retrievable storage for low-level waste is the need for future expenditures for retrieval, decontamination, treatment, and/or disposal facilities.

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E.2 WASTES REQUIRING DISPOSAL

The planning and design of new disposal facilities rely to a great extent on the ability to forecast the volume and the important characteristics of the wastes (i.e., physical state, chemical composition, etc.) to be disposed of. SRP operations generate five basic classes of waste [hazardous, low-level radioactive, mixed, high-level radioactive (including TRU waste), and nonhazardous/nonradioactive]. Some of these wastes can be treated before disposal and some cannot. Some wastes are stored and others are disposed of. Further, the storage or disposal technology that is chosen might require or prevent certain kinds of waste treatment that, in turn, can greatly affect both the volume and the characteristics of the waste. This EIS is concerned only with hazardous, mixed, and low-level radioactive waste; it does not consider high-level radioactive and nonhazardous/nonradioactive wastes, which have been covered by earlier planning efforts and documentation.

Figure E-1 shows a conceptual model of the various waste streams related to the disposal technologies. This model assumes that all wastes are at, or in transit between, any of four types of facilities: waste generators, waste treatment facilities, interim-storage facilities, or waste disposal facilities (including long-term storage). It also assumes that waste generators are the only facilities that produce waste; generally, such generators can be categorized as plant operations, closure actions at existing waste sites, and offsite governmental generators. Waste treatment facilities might change the volume and character of the waste, but they do not create appreciable volumes of new waste except that resulting from the operation of the facility. Interim-storage facilities are used to store wastes until new disposal or reclamation facilities are available. Disposal facilities are engineered repositories for the permanent placement of wastes. Thus, the total volume of waste to be disposed of and the design capacity of disposal facilities are functions of the time during which the facilities are actively used, the volume of waste generated during that time, and the predisposal and disposal technologies employed.

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The estimate of waste volumes was based on an operational planning period of 20 years and the use of existing facilities, including interim storage, between the present and the startup of new facilities. For hazardous and mixed wastes, the assumed startup date of new facilities is 1992. For low-level radioactive wastes, an assumed startup date is 1989.

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At present, site-specific actions at existing waste sites that can have a substantial effect on the volume of waste to be disposed of in the future are:

- A determination of those existing waste sites that ultimately will require removal of waste and/or contaminated soil prior to closure

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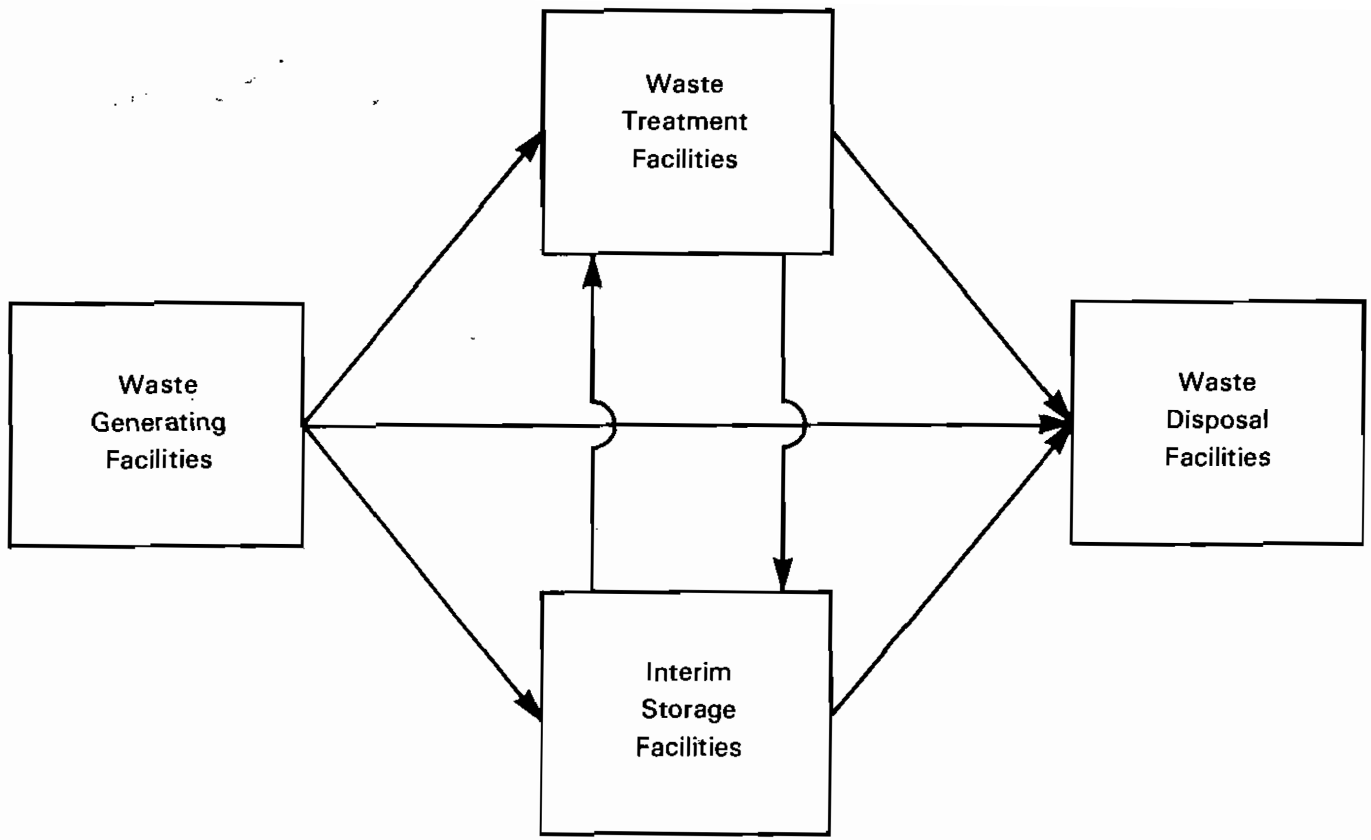

Figure E-1. Integrated Waste Disposal Model

- A determination, based on field testing and examination, of the quantity of waste or contaminated soil to be removed at existing waste sites

- The availability or integration of various predisposal treatment technologies into the management of SRP wastes (see Appendix D)

For the purposes of this EIS, waste volumes are described in terms of a range bounded by upper and lower limit volume figures that are based on current information and certain assumptions. The following assumptions define the upper limit: TC

- Suitable predisposal treatment technologies were assumed if they expand the untreated waste volume, unless a disposal technology requires a specific predisposal treatment (i.e., cement/flyash matrix vault disposal). TE

- Due to the magnitude of waste and contaminated soil at the radioactive waste burial grounds and the mixed waste management facility, total volumes were shown with and without consideration of these sites. TC

The following assumption defines the lower limit:

- Suitable predisposal treatment technologies were assumed if they reduce the untreated waste volume, unless a disposal technology requires a specific predisposal treatment.

These assumptions represent the extreme situations that probably would result in a volume range that bounds the estimated 20-year volumes of hazardous, mixed, and low-level radioactive wastes. TE

Tables E-1 through E-3 summarize available information on SRP waste streams. The first three columns identify the sources or type of facility, the facility, and the waste. The fourth column defines the waste as solid, semisolid, or liquid. Column five lists the untreated volumes of waste estimated for the 20-year period. The sixth column presents the estimated 20-year volume of waste following predisposal treatment by incineration or evaporation (i.e., volume reduction). The seventh column lists the estimated 20-year volume of waste following predisposal treatment by solidification or incineration and solidification. The waste volume ranges provided in Section E.3 were derived from Tables E-1 through E-3, based on the upper and lower limit assumptions previously defined. TC

E.3 SITING OF FACILITIES

For the purpose of providing a basis for particular environmental evaluations in this EIS (e.g., groundwater modeling), the identification of specific sites was necessary. Based on the information currently available, the most likely candidate sites for the construction of new waste management facilities were identified and used. However, at the current stage of planning, detailed site-specific analyses and final site selection have not been completed. This section describes the process by which candidate sites were identified and ranked, the rationale for selecting sites for EIS evaluation purposes, and the continuing process by which the detailed site-specific analyses and final site selection will be carried out. TC

Table E-1. Hazardous Waste Volumes[a] (cubic meters)

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Source	Facility[b]	Waste	Physical state[c]	Untreated volume	Treated volume	Solidified volume[d]
Operations	Lab	Organics, Hg, oil	LD	375	9.5[e]	13.3
Operations	Maintenance	Lathe coolant, oil	LD	83	2.0[e]	2.8
Operations	Raw materials	Li-Al dross	SD	291	-	-
Operations	Raw materials	Oil with lead	LD	541	-	-
Operations	Raw materials	TCE sludge	SS	125	9.0[f]	12.6
Operations	Monitoring	Inorganic acids	LD	4	-	-
Operations	Construction	Paint solvent	LD	833	21.0[e]	29.4
Operations	Engineering	Solvents	LD	125	3.0[e]	4.2
Operations	Health protection	Toluene, xylene	LD	4	0.5[e]	0.7
Operations	Forest Service	Pesticides	LD	4	0.5[e]	0.7
Operations	Miscellaneous	Misc. HW	SD	112	9.0[f]	12.6
Storage	HWSF	CMP pit soil similar	SD	1,062	1062.0[g]	1,486.8
Storage	HWSF	CMP pit liquids	LD	33	2.5[f]	3.5
Storage	HWSF	Sodium dichromate	LD	1	0.1[f]	0.14
Storage	HWSF	Trichloroethane	LD	39	2.9[f]	4.06
Storage	HWSF	Methylene chloride	LD	1	0.1[f]	0.14
Storage	HWSF	Hg-contaminated mat'l.	SD	4	0.3[f]	0.42
Storage	HWSF	Machine coolant	LD	16	1.2[f]	1.68
Storage	HWSF	Misc. solvents	LD	1	0.1[f]	0.14
Storage	HWSF	Naphtha-methylene cl	LD	1	0.1[f]	0.14
Storage	HWSF	Nitrates	SD	10	0.8[f]	1.12
Storage	HWSF	Pesticides	LD	2	0.2[f]	0.28
Storage	HWSF	Paint solvents	LD	90	6.8[f]	9.52
Storage	HWSF	Teargas concentrate	LD	1	0.1[f]	0.14
Storage	HWSF	Toluene-isopropanol	LD	12	0.9[f]	1.26
Storage	HWSF	Varnish and thinners	LD	5	0.4[f]	0.56
Storage	HWSF	Waste oil with lead	LD	61	-	-
Storage	HWSF	Waste paint	LD	5	0.4[f]	0.56
Storage	HWSF	Alkalies	SD	7	-	-
Storage	HWSF	Be-Cu alloy	SD	1	-	-
Storage	HWSF	Lead smelter waste	SD	10	-	-
Storage	HWSF	Lab chemicals	LD	2	-	-
Storage	HWSF	Reactive metals	SD	9	-	-
Storage	HWSF	DWPF pilot plant sludge	SS	5	-	-
Storage	HWSF	Misc. HW - incinerable	-	500	25.0[h]	35
Storage	HWSF	Misc. HW - nonincinerable	-	373	-	-
Closure	716-A motor shop S.D.	Cont. soil and waste	SD	900	900[g]	1,260
Closure	Metals burning pit Misc. Chemical Basin	Cont. soil and waste	SD	21,700	21,700[h]	30,380
Closure	Silverton Road waste site	Cont. soil and waste	SD	39,800	39,800[g]	55,720
Closure	Met. lab. basin	Cont. soil and waste	SD	340	340[g]	476
Closure	Burning rubble pits (15)	Cont. soil and waste	SD	25,260	25,260[g]	35,364
Closure	Acid/caustic basins (6)	Cont. soil and waste	SD	3,080	3,080[g]	4,312
Closure	Hydrofluoric acid spill area	Cont. soil and waste	SD	230	230[g]	322
Closure	0-Area oil seepage basin	Cont. soil and waste	SD	5,900	5,900[g]	8,260
Closure	CMP pits (7)	Cont. soil and waste	SD	1,500	1,500[g]	2,100
Closure	SRL oil test site	Cont. soil and waste	SD	150	150[g]	210
Closure	Gunsite 720 rubble pit	Cont. soil and waste	SD	40	40[g]	56

[a]Adapted from Cook, Grant, and Towler, 1987a; and Moyer, 1987.
[b]Number in parentheses indicates number of separate facilities where more than 1 exist.
[c]SD-Solid, LD-Liquid, SS-Semi-solid (sludge).
[d]Solidification of ash or residue with volume increase of 40 percent.
[e]Assumes incineration with volume reduction of 97.5 percent.
[f]Assumes incineration with volume reduction of 92.5 percent.
[g]Assumes incineration for destruction of organics with no volume reduction.
[h]Assumes incineration with volume reduction of 95.0 percent.

Table E-2. Mixed Waste Volumes[a] (cubic meters)

Source	Facility[b]	Waste	Physical state[c]	20-year untreated volume	Treated volume	Solidified volume
Operations	Separations	Hg-contaminated waste	LD	2,266	56.7[d]	79.3[e]
Operations	SRL, SREL	Scintillation fluid	LD	6	0.2[d]	0.2[e]
Operations	H-3 facility	Tritiated oil	LD	170	4.3[d]	6.0[e]
Operations	DWPF	Benzene	LD	3,965	99.1[d]	138.8[e]
Operations	Separations	Hg-contaminated equip.	SD	680	-	-
Operations	H-3 facility	Tritiated mercury	LD	6	-	-
Operations	SRL, H-3 facility	Lead shielding	SD	11	-	-
Operations	FMF	WWTF sludge	SS	6,435	107.3[f]	12,870.0[g]
Operations	F- & H-Area	ETF sludge	SS	39,743[h]	4,967.9[f]	79,486.0[g]
Operations	M-Area	ETF sludge	SS	27,252	3,293.0[f]	5,4504.0[g]
Operations	FPF	ETF sludge	SS	14,534	3D2.8[f]	29,068.0[g]
Storage	DWPF	8enzene	LD	396	9.9[d]	13.9[e]
Storage	Separations	Hg-contaminated waste	LD	113	2.8[d]	4.0[e]
Storage	Storage tanks	Scintillation fluid	LD	5	0.4[d]	0.5[e]
Storage	H-3 facility	Tritiated oil	LD	119	8.9[d]	12.5[e]
Storage		PC8-contaminated oil	LD	6	-	-
Storage	SRL, H-3 facility	Lead shielding	SD	4	-	-
Storage	H-3 facility	Tritiated mercury	LD	2	-	-
Storage	Separations	Hg-contaminated equip.	SD	227	-	-
Storage	M-Area stg.	ETF sludge (9 mo.)	SS	1,022	123.5[f]	2,044.0[g]
Closure	SLR seepage basins (4)	Cont. soil and waste	SD	2,000	2,000[i]	2,800[e]
Closure	M-Area settling basin	Cont. soil and waste	SD	46,300	46,300[i]	64,820[e]
Closure	Mixed Waste B.G.	Cont. soil and waste	SD	1,477,920	1,477,920[i]	2,069,088[e]
Closure	F-Area seepage basins (3)	Cont. soil and waste	SD	9,410	9,410[i]	13,174[e]
Closure	Old F-Area S.B.	Cont. soil and waste	SD	5,370	5,370[i]	7,518[e]
Closure	H-Area seepage basins (4)	Cont. soil and waste	SD	24,950	24,950[i]	34,930[e]
Closure	Ford Bldg. seepage basin	Cont. soil and waste	SD	170	170[i]	238[e]
Closure	Old TNX basin	Cont. soil and waste	SD	670	670[i]	938[e]
Closure	New TNX basin	Cont. soil and waste	SD	470	470[i]	658[e]
Closure	Road A chem. basin	Cont. soil and waste	SD	1,070	1,070[i]	1,498[e]
Closure	L-Area oil & chem. basin	Cont. soil and waste	SD	740	740[i]	1,036[i]

TC

[a]Adapted from Cook and Grant, 1987; Cook, Grant and Towler, 1987a; and Moyer, 1987.
[b]Number in parentheses indicates number of separate facilities where more than 1 exist.
[c]SD - Solid, LD - Liquid, SS - Semisolid (sludge).
[d]Assumes incineration with volume reduction of 97.5 percent.
[e]Assumes solidification of ash or residue with volume increase of 40 percent.
[f]Assumes pretreatment by evaporation to dry salt form.
[g]Assumes solidification of untreated sludge using Cement/Flyash Matrix with volume increase of 100 percent.
[h]Average estimated 20-year volume.
[i]Assumes incineration for destruction of organics with no volume reduction.

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Table E-3. Low-Level Waste Volumes[a] (cubic meters)

Source	Facility[b]	Waste	20-year untreated volume	Treated volume[c]	Solidified volume[d]
Operations	Tritium	Combustible	20,676	1,034	1,447
Operations	Tritium	Noncombustible	13,784	-	-
Operations	Raw Materials	Combustible	35,806	1,790	2,506
Operations	Raw Materials	Noncombustible	23,870	-	-
Operations	Reactors	Combustible	29,566	1,478	2,070
Operations	Reactors	Noncombustible	19,711	-	-
Operations	Separations	Combustible	125,727	6,286	8,801
Operations	Separations	Noncombustible	83,818	-	-
Operations	Waste Management	Combustible	74,058	3,703	5,184
Operations	Waste Management	Noncombustible	49,372	-	-
Operations	Laboratories	Combustible	24,142	1,207	1,690
Operations	Laboratories	Noncombustible	16,095	-	-
Operations	Services	Combustible	3,711	186	260
Operations	Services	Noncombustible	2,474	-	-
Operations	SRL	Combustible	26,426	1,321	1,850
Operations	SRL	Noncombustible	17,617	-	-
Operations	Other	Combustible	19,534	977	1,367
Operations	Other	Noncombustible	13,023	-	-
Operations	Offsite sources	Combustible	28,302	1,415	1,981
Operations	Offsite sources	Noncombustible	18,868	-	-
Closure	H-Area ret. basin	Cont. soil and waste	6,200	-	8,680
Closure	F-Area ret. basin	Cont. soil and waste	9,200	-	12,880
Closure	Rad. waste burial ground	Cont. soil and waste	1,524,080	-	2,133,712
Closure	R-Area BPOPs (3)	Cont. soil and waste	7,130	-	9,982
Closure	R-Area seepage basins (6)	Cont. soil and waste	8,430	-	11,802
Closure	Ford Building waste site	Cont. soil and waste	400	-	560
Closure	TNX burying ground	Cont. soil and waste	1,220	-	1,708
Closure	K-Area BPOP	Cont. soil and waste	7,700	-	10,780
Closure	K-Area seepage basin	Cont. soil and waste	590	-	826
Closure	L-Area BPOPs (2)	Cont. soil and waste	8430	-	11,802
Closure	P-Area BPOP	Cont. soil and waste	3,870	-	5,418

[a]Adapted from Cook, Grant and Towler, 1987b and Moyer, 1987.
[b]Number in parentheses indicates number of separate facilities where more than 1 exist.
[c]Assumes incineration with average volume reduction of 95 percent.
[d]Assumes solidification of ash volume increase of 40 percent.

E.3.1 GENERAL METHODOLOGY

Currently, the only criteria in RCRA/HSWA or the South Carolina Hazardous Waste Management Regulations (SCHWMR) that govern site selection for hazardous and mixed waste facilities relate to seismic considerations, floodplains, and recharge zones (40 CFR 264.18). There are no specific criteria under DOE Orders for siting low-level radioactive waste facilities (DOE Order 5820.2, Chapter III, Section 3.c). Criteria used in the initial identification and ranking of candidate sites implicitly encompass facility siting criteria established by Executive Orders (i.e., wetlands and floodplains), the Nuclear Regulatory Commission's Licensing Requirements for Land Disposal of (Commercial) Radioactive Waste (10 CFR 61.50) and DOE Orders 5480.2 (Hazardous and Radioactive Mixed Waste Management) and 5820.2 (Radioactive Waste Management).

The general methodology for SRP site selection consisted of three levels of evaluation. Level 1 of the site screening process involved the identification, using topographic maps, of 17 candidate sites that were located on hilltops and ridge-tops.

Level 2 of the analysis employed limited screening criteria, a ranking system, and available site-specific data to rate and rank the 17 sites numerically. It is at this level of the siting methodology that the EIS required site-specific data for evaluation purposes. Therefore, based on the site rankings from the Level 2 analysis plus the professional judgment of the evaluation team, the most likely candidate sites were selected for this purpose.

The ongoing Level 3 analysis consists of the site-specific characterization of the five top-ranked candidate sites in relation to surface water, groundwater, geology, geomechanics, meteorology, air quality, ecology, land use, and cultural resources. The prime objective of this characterization is to develop the technical information eventually needed to select and permit suitable sites for construction of new waste management facilities. F-12 J-8 TE

E.3.2 LEVEL 1 SITE SELECTION PROCEDURE

The first major criterion used in the identification of suitable candidate sites for the construction of waste management strategies was to restrict the site to the 780-square-kilometer area of the SRP. This criterion eliminates all areas outside the SRP boundary including potential sites where "projected population and future development" in close proximity could be a major site selection issue (i.e., 10 CFR 61.50(a) Criterion No. 3). Also, the SRP area provides many excellent opportunities to identify sites that will result in the "isolation of wastes" (i.e., 10 CFR 61.50(a) Criterion No. 1).

In consideration of the screening criteria to be applied at the Level 2 analysis (i.e., distance to the public, depth to water table, distance to the nearest stream, available surface area, topography/slope, and distance to waste generators), 17 candidate sites were delineated by identifying specific hilltops and ridgetops using topographic maps. The identification of hilltops and ridgetops implicitly eliminates flood-prone areas (i.e., 40 CFR 264.18(b) Criterion No. 5, and E.O. 11988) and wetlands (E.O. 11990), and includes areas that generally exhibit the greatest depth to groundwater (i.e., 10 CFR 61.50(a) Criterion No. 7), relatively flat topography (i.e., 10 CFR 61.50(a) Criterion No. 10) and minimal upstream drainage area (i.e., 10 CFR 61.50(a)

Criterion No. 6). Locations of the 17 candidate sites, designated A through Q, are shown in Figure E-2.

E.3.3 LEVEL 2 SITE SELECTION PROCEDURE

Level 2 of the site selection procedure involved screening the 17 sites in relation to specific characteristics important in the disposal of hazardous or mixed waste and low-level radioactive waste. Each characteristic was assigned a weighting factor in a range from 1 to 6 representing increasing importance in achieving maximum performance of the site for waste disposal. Also, a table was devised for each characteristic to provide a basis for evaluating available site-specific data and assigning a rating factor. Each candidate site was evaluated in relation to each characteristic by multiplying its rating by the respective weighting value. The scores for all characteristics were summed and ranked from highest to lowest indicating relative "best" to "worst." Because the weighting and rating values are highly subjective and a full range of evaluation data was not available for analysis, the procedure was used only to identify a group of the "best" sites (rather than a single site) that would be subjected to the Level 3 (site-specific) analysis.

E.3.3.1 Hazardous or Mixed Waste Disposal

Three characteristics were used to rank the candidate sites for hazardous or mixed waste disposal; (1) depth to water table, (2) available area, and
F-12 (3) surface topography.
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Depth to Water Table

Depth to water table was considered to be the most important characteristic and was given a weighting factor of 6. The development of the rating table considered that at least one of the alternative disposal technologies required wastes to be a minimum of 5 meters deep and at least 1.5 meters above the water table. To meet these requirements and provide sufficient depth for construction of the facility, the groundwater table would have to be a minimum of 14 meters below the surface. Sites exhibiting greater depth to groundwater would receive a higher rating in accordance with the following:

Depth to water table

Depth (meters)	Rating factor
>24	5
22 - 24	4
19 - 21	3
14 - 18	2
<14	0

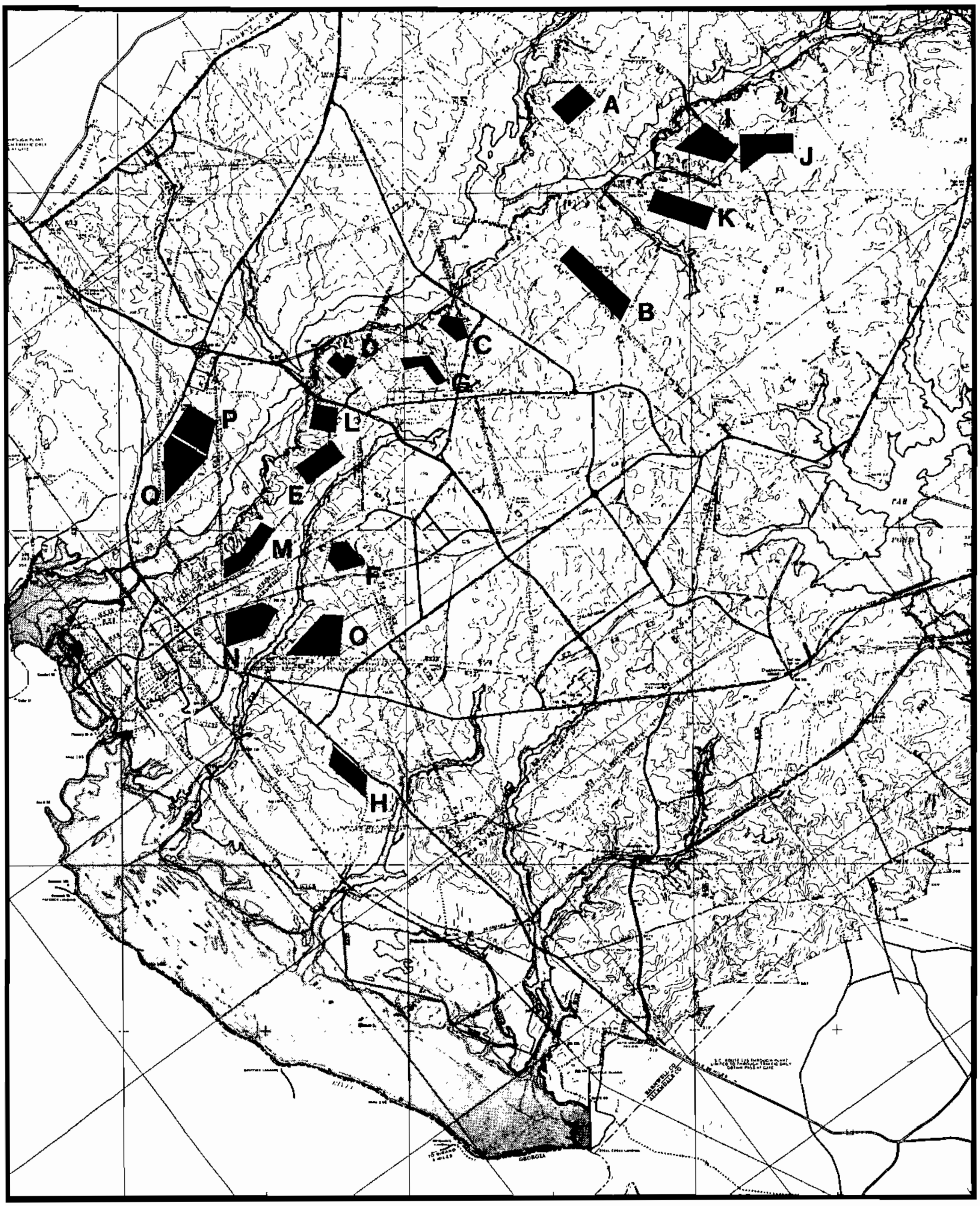

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Figure E-2. Candidate Sites for New Waste Management Facilities

Available Area

Available area was given a weighting factor of 4 to indicate its intermediate importance as a siting characteristic. Its importance is derived from the need to identify sites with sufficient space for disposal/storage facilities, service facilities, and buffer zones. The following ratings were devised for hazardous or mixed waste disposal sites:

Available Area

Size (acres)	Rating factor
>90	4
80 - 90	3
70 - 79	2
60 - 69	1
<60	0

Surface Topography

F-12 J-8 The forces of erosion by precipitation runoff are directly proportional to the slope of the land surface. Because a low slope will erode more slowly than a steep slope, it is rated higher. This characteristic was given a weighting factor of 2 because it is subject to alteration as required by the design.

Surface Topography

Maximum slope (%)	Rating factor
0 - 1.2	4
1.2 - 2.5	3
2.5 - 3.7	2
3.7 - 5.0	1
>5.0	0

E.3.3.2 Low-Level Radioactive Waste Disposal

Six characteristics were used to rank the candidate sites for low-level radioactive waste disposal facilities: (1) depth to water table, (2) distance to the public, (3) distance to waste generators, (4) distance to nearest stream, (5) available surface area, and (6) surface topography.

Depth to Water Table

Depth to water table was considered to be among the most important characteristics in the selection of sites for low-level radioactive waste disposal and was given a weighting factor of 6. As discussed above for hazardous/mixed waste siting, the minimum acceptable depth was determined to be 14 meters, with greater depths rated more highly in accordance with the table in Section E.3.3.1.

Distance to the Public

Another important characteristic in the siting of low-level waste disposal facilities was distance to the public, which was given a weighting factor of 6. The rating of this characteristic assumes that the more distant the site is from public lands or public access areas, the lower the probability is of an accidental exposure and contamination of public drinking-water supplies. The following rating factors were devised:

Distance to the Public

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Distance (kilometers)	Rating factor
>6.4	4
4.8 - 6.4	3
3.2 - 4.8	2
1.6 - 3.2	1
0 - 1.6	0

Distance to Waste Generators

The volume of waste and the distance it must be transported impacts the dose to waste transport personnel, the probability of a transportation accident, and the economics of waste management. Accordingly, this characteristic was given a weighting factor of 6. At the SRP, the multiple waste generators are widely dispersed, so a volume-of-waste weighted method was used to rate the potential sites. The distance from each potential site to each operating area was rated using the following table, weighted by the percentage of waste produced by each operating area, and multiplied by the weighting factor.

Distance to Waste Generators

Distance (kilometers)	Rating factor
<3.2	4
3.2 - 6.3	3
6.4 - 9.6	2
9.7 - 12.9	1
>12.9	0

Distance to Nearest Stream

Surface water in the humid southeastern United States generally represents areas of groundwater discharge, and transport by surface water is much more rapid than by groundwater. The desirability of maximizing the distance from the waste to surface water received the relatively high weighting factor of 5. The following ratings were developed for distances of less than 152 meters
F-12 J-8 to more than 610 meters:

Distance to Nearest Stream

Distance (meters)	Rating Factor
>610	4
457 - 610	3
305 - 457	2
152 - 305	1
<152	0

Available Area

Available area was considered to be of intermediate importance in the siting of low-level radioactive waste facilities, with a weighting factor of 4. Its importance stems from the need to identify sites with sufficient space for all facilities and buffer zones. The following ratings were devised for evaluating candidate sites for low-level waste facilities:

Available Area

Area (acres)	Rating factor
>200	4
100 - 200	3
50 - 100	2
25 - 50	1
<25	0

Surface Topography

Surface topography, with a weighting factor of 2, was considered to be among the less important characteristics, but it is worthy of evaluation because of its effect on erosion. The surface topography rating table in Section E.3.3.1 also applies to low-level waste facility siting evaluations.

Tables E-4 and E-5 list the available data used in the ranking of the candidate sites. Each of the candidate sites was evaluated in accordance with F-12
the procedures described above, in relation to the hazardous/mixed waste J-8
facility siting characteristics and the low-level radioactive waste facility siting characteristics. Table E-6 lists 15 of the 17 candidate sites in the order of their ranking for each evaluation and provides the corresponding ranking scores. Two sites, K and I, were eliminated from consideration because of a potential conflict with SRP security operations. Due to the subjectivity of the weighting and rating values and the limited available data on a relatively few siting characteristics, a group of five of the top-rated candidate sites was selected for additional site-specific analysis (Level 3). These candidate sites are B, G, L, P, and Q.

At this stage of the siting process, the EIS modeling effort required site-specific input data. Because final siting had not been completed, it became necessary to select sites for EIS evaluation purposes. The objective was to select the most likely candidate site for each of the new waste management facilities assuming the most site-stringent technology (i.e., shallow land disposal). Based on the professional judgment of the siting team, the evaluation of hazardous and mixed waste facilities, cement/flyash matrix facilities, and low-level radioactive waste facilities would be carried out using data from candidate sites B, L, and G, respectively, as shown in Figure E-3. If, as a result of the additional site-specific (Level 3) analysis, the final chosen sites are different than those selected for the EIS analysis, an additional evaluation will be conducted to demonstrate that the chosen sites will result in facilities performance that is equal or superior to that documented in the EIS evaluations.

Table E-4. Available Candidate Site Data[a]

	Candidate site	Available area (acres)	Distance to stream (m)	Depth to water table (meters)	Topography (% slope)	Distance to public (km)
	A	135	762	N/A[b]	0.0 to 1.2	3.9
	B	200	762	16.8 to 19.8	1.2 to 2.5	8.0
	C	90	152	16.8	1.2 to 2.5	8.4
	D	80	457	12.2 to 21.3	Greater than 5.0	5.8
	E	185	762	13.7 to 19.8	0.0 to 1.2	4.3
	F	115	457	12.2 to 18.3	1.2 to 2.5	4.0
	G	200	610	13.7 to 18.3	0.0 to 1.2	7.7
	H	135	1067	15.2 to 18.3	1.2 to 2.5	0.6
	I	215	610	12.2 to 25.9	0.0 to 1.2	4.8
F-12	J	220	152	N/A	0.0 to 1.2	5.5
J-8	K	220	610	19.8	0.0 to 1.2	6.6
	L	100	518	12.2 to 24.4	0.0 to 1.2	4.8
	M	160	610	N/A	2.5 to 3.7	2.3
	N	210	457	N/A	1.2 to 2.5	1.1
	O	225	305	N/A	2.5 to 3.7	1.1
	P	240	1524	18.3 to 24.4	1.2 to 2.5	1.6
	Q	255	1524	13.7 to 27.4	1.2 to 2.5	1.0

[a]Source: Cook, Grant, and Towler, 1987a.
[b]Not available.

E.3.4 LEVEL 3 SITE SELECTION PROCEDURE

Level 3 of the siting methodology, which is currently under way, is intended to provide a complete site-specific characterization of the five "best" candidate sites. This characterization addresses surface water, groundwater, geology, geomechanics, meteorology, air quality, ecology, land use, and cultural resources. The primary objective is to develop the site-specific technical information needed to select and permit the best overall sites for

Table E-5. Distance to Generators (kilometers)

Candidate Sites	SRP operating area							
	A	C	F	H	K	L	M	P
A	11.1	13.0	9.3	7.7	16.4	15.9	11.4	14.3
B	11.6	9.3	6.4	3.9	12.2	11.4	12.1	9.8
C	9.3	6.3	2.7	1.4	10.0	10.3	9.2	10.1
D	7.7	4.7	1.0	3.9	8.9	10.5	7.4	11.7
E	9.7	2.4	2.1	4.3	6.6	8.7	9.2	10.6
F	12.2	0.8	4.7	6.1	4.0	6.8	11.6	9.7
G	9.0	4.8	1.3	1.9	8.7	9.5	8.9	10.3
H	17.9	6.6	10.8	11.6	2.9	6.1	17.2	10.3
I	14.5	14.2	11.1	8.9	16.9	15.8	14.8	13.2
J	15.9	14.8	12.1	9.5	17.4	15.8	16.1	12.9
K	14.2	12.4	9.7	7.1	15.1	13.7	14.3	11.3
L	8.9	3.2	1.4	4.2	7.6	9.5	8.4	11.1
M	11.7	4.2	6.6	8.9	6.0	9.7	11.1	12.9
N	13.4	4.8	8.0	10.1	5.5	9.3	12.6	13.0
O	14.8	3.9	7.9	9.2	2.4	6.4	14.3	10.1
P	7.7	5.8	5.3	8.2	9.3	12.4	7.1	14.8
Q	8.7	5.6	5.8	8.7	8.9	12.1	7.9	14.6
Percentage of waste	7.8	3.3	33.2	28.9	2.0	2.8	8.2	2.1

Source: Cook, Grant, and Towler, 1987b.

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construction of the new waste management facilities. Specifically, the information will be used to:

- Demonstrate that the performance objectives and minimum technical requirements on site suitability will be achieved

Table E-6. Ranking of Candidate Sites

Hazardous or mixed waste facilities[a]		Low-level rad waste facilities[b]	
Site	Score	Site	Score
P	46	G	98
Q	46	B	97
L	42	L	88
B	40	P	84
J	36	E	80
G	36	Q	78
C	34	D	75
D	34	C	72
F	34	F	71
H	34	J	66
A	28	A	60
E	28	H	55
N	22	M	55
M	20	N	45
O	20	O	37

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[a]Source: Cook, Grant, and Towler, 1987a.
[b]Source: Cook, Grant, and Towler, 1987b.

- Evaluate the capability of site characteristics to contribute to the isolation of wastes

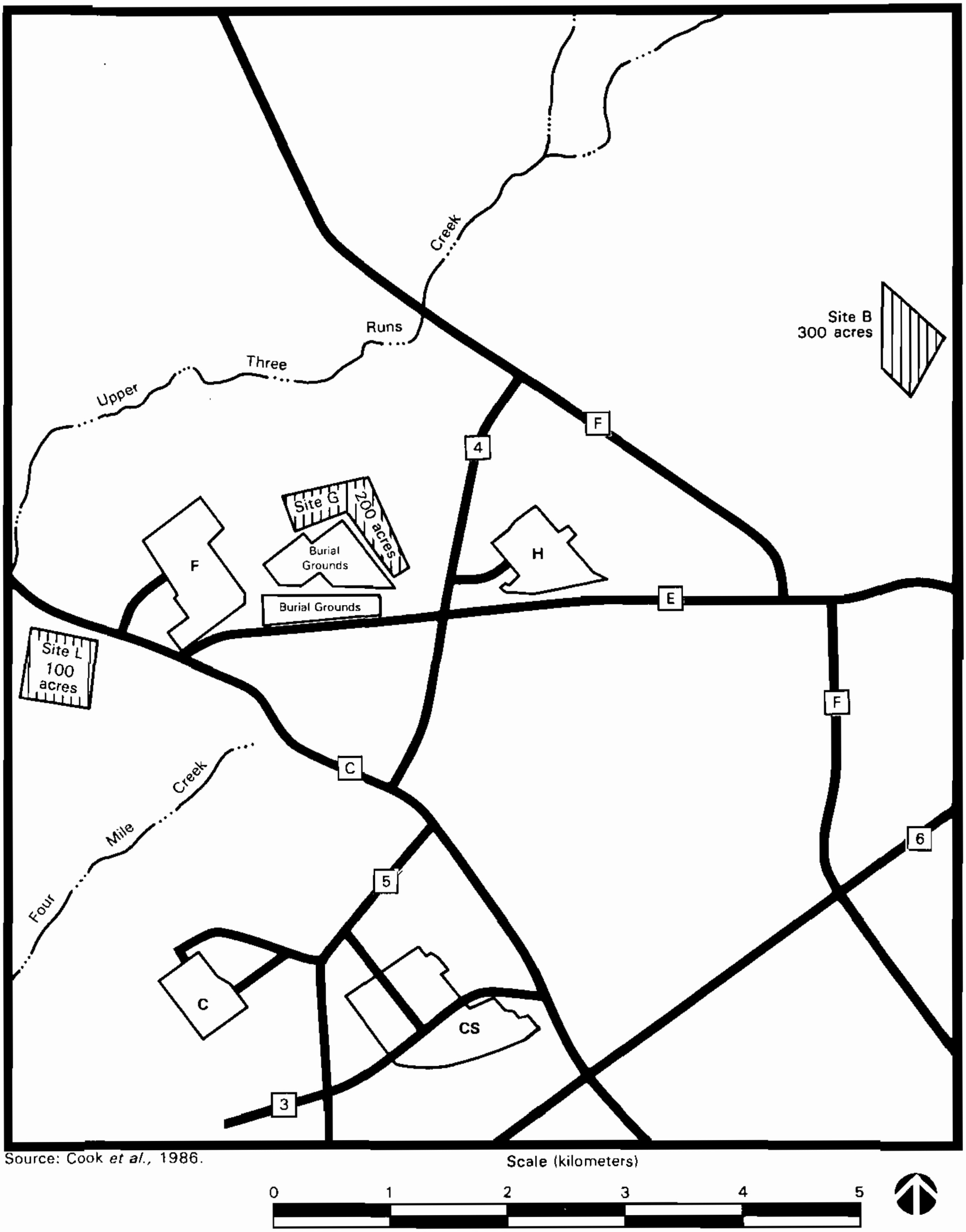
- Identify interactions between low-level radioactive wastes/containers and various site characteristics

- Identify and prevent potential adverse environmental impacts resulting from construction, operation, and closure/decontamination of the facilities

- Establish data collection points and an environmental baseline for the sites

- Provide the basis for site-specific design of the facilities (Cook, 1985)

The general plan for the geologic and hydrologic characterizations is to obtain hydrologic and chemical data from 10 water-table piezometers and one piezometer cluster within each of the selected candidate sites. Continuous core samples are to be taken at each new boring to provide the data necessary to produce site-specific geologic profiles.



Source: Cook *et al.,* 1986.

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Figure E-3. Candidate Sites Selected for Environmental Analysis

Information from the Level 3 site selection procedure, together with the results of advanced planning to define specific technologies for implementing the chosen strategy, will provide the basis for a future decision on the locations of new waste management facilities.

E.4 WASTE DISPOSAL/STORAGE ALTERNATIVES

The waste management strategies - No Action, Dedication, Elimination, and Combination - could be implemented in a number of ways using a number of technologies. To provide a basis for determining the magnitude of environmental impacts, analyses herein identify the implementation technologies and explain their use. If DOE intends the concurrent use of more than one technology, the description uses the word "and" (e.g., storage buildings and RCRA landfill). If there is to be a future choice between two or more technologies, the description uses the word "or" (e.g., RCRA landfill or vaults). Table E-7 lists the technologies being considered for inclusion in each of the four waste management strategies. Cost reported herein were based on the range of waste volumes estimated and unit costs derived from the Venture guidance appraisal (Moyer, 1987). The following subsections provide additional detail for evaluation of waste management strategies.

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E.4.1 NO-ACTION STRATEGY

The No-Action strategy provides an assessment of the consequences of implementing a waste management strategy that would require that no new facilities be constructed to accommodate future needs. Facilities include sites, buildings, landfills, vaults, engineered trenches, boreholes, and appurtenances. For the purposes of comparative analysis, DOE assumed that SRP would continue to operate and generate wastes and that the applicable regulations and criteria would continue to remain in force.

E.4.1.1 Hazardous or Mixed Waste

The No-Action strategy for hazardous or mixed waste would continue current operating practices, using existing interim storage facilities until reaching full capacity in 1992. After 1992, the No-Action strategy assumes that hazardous or mixed waste would be stored in existing structures, on existing concrete pads, or, if these were not available, on prepared areas at existing waste sites. As much as possible, mixed waste with radioactivity greater than 300 millirem per hour would be stored in unused existing shielded structures, such as the R-Reactor building. No new (undeveloped) sites would be used to store wastes under this strategy.

Before storage, wastes would be placed in steel containers (i.e., 208-liter drums, 2.5-cubic-meter boxes). Noncompatible wastes would be segregated administratively by storing them at different locations. All stored material, except intermediate-activity wastes, would be accessible for inspection. Inspections would be conducted on a regular basis. Damaged or deteriorated containers would be replaced and any spillage or leakage would be attended to expeditiously.

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Table E-7. New Disposal/Storage Facility Implementation Technologies

Waste management strategy	Disposal/storage project alternative	Disposal/storage technologies		
		Hazardous waste	Mixed waste	Low-level waste
No Action	No new facilities	Storage at existing facilities and at other available structures, pads, and areas	Storage at existing facilities and at other available structures, pads, and areas	Disposal at existing facilities and storage at other available structures, pads, and areas
Dedication	Disposal facilities	RCRA landfill or vaults[a]	RCRA landfill or shielded vaults[a], with or without CFM[b] vaults	ELLT[c], vaults[a], or AGO[d], for low-activity waste; and vaults or GCD[e] for intermediate activity waste
Elimination	Retrievable storage facilities	Storage buildings	Shielded storage buildings	Engineered storage buildings
Combination	Disposal/storage combination	Storage buildings and RCRA landfill or vaults[a]	Shielded storage buildings and RCRA landfill or shielded vaults[a], with or without CFM[b] vaults	Engineered storage buildings; and ELLT[c], vaults[a], or AGO[d], for low-activity waste; and vaults[a] or GCD[e] for intermediate-activity waste

[a]Vaults may be above or below the ground.
[b]Cement/flyash matrix.
[c]Engineered low-level trench disposal.
[d]Abovegrade operation disposal.
[e]Greater confinement disposal.

TE

The No-Action strategy assumes that hazardous and mixed wastes would receive no pretreatment prior to storage (e.g., no new facilities). Table E-8 lists the estimated 20-year volumes for hazardous and mixed waste, as calculated from Tables E-1 and E-2.

Table E-8. Estimated Hazardous and Mixed Waste 20-Year Storage Volumes Under the No-Action Strategy (cubic meters)

TC

Waste type	Estimated waste volume[a]
Hazardous waste	4,700
Mixed waste	97,000

[a]Rounded to the nearest 100 cubic meters.

TE

Cost estimates associated with the management of hazardous and mixed wastes under this strategy are listed in Table E-9.

TE

Table E-9. Estimated Costs for Hazardous and Mixed Waste Management Under the No-Action Strategy[a]

TC

Item	Hazardous waste	Mixed waste
Site preparation	251	3,301
Operations	2,929	22,863
Total (20 years)[b]	3,180	26,164

[a]Cost in thousands of 4th Quarter 1985 dollars for 20-year planning period.
[b]Does not include costs of waste retrieval, decontamination, any subsequent treatment, or disposal.

TE

The primary advantages of the No-Action strategy for hazardous or mixed waste would be the delay of expenditures associated with the construction of disposal/storage facilities and, perhaps, the use of existing available structures for storage, which otherwise would have remained unused.

The No-Action strategy has many disadvantages. As described above, hazardous or mixed wastes would be placed in sealed containers, segregated, and stored in a manner that would facilitate periodic inspection. Further, inspections would be performed on a regular basis; damaged or deteriorated containers would be replaced; and any spillage or leakage would be corrected expeditiously. Under this strategy, the release of hazardous or radioactive waste and the associated health and environmental effects would be insignificant as long as no substantial leakage or spills occurred due to any cause (e.g., fire, explosion, container deterioration, containers breached by an impact).

Because this type of storage is not designed and constructed specifically to include the backup systems and safety equipment required in a RCRA facility (i.e., double liners, leachate collection, special fire protection, automatic vapor detection, leakage recovery), the risk of a serious accidental release of hazardous or mixed waste and the associated effects would be much greater than with any of the "action" strategies. The magnitude of a potential performance failure of the No-Action strategy could range from zero (no releases from any cause) to release and dispersion of all waste stored in this manner. Because there are no backup systems and built-in safety equipment, the risk of a mixed waste release, including a catastrophic release, would be higher than with any other strategies. Although this higher risk cannot be quantified, it is unacceptable under RCRA.

In addition, the No-Action strategy would result in noncompliance with RCRA, HSWA, the Safe Drinking Water Act, DOE Orders, and the Clean Water Act; would involve the use of unpermitted facilities; and could result in noncompliance with other permits or applicable laws. Finally, because no action only delays future expenditures for waste management, the life-cycle cost of the No-Action strategy could exceed that of the other strategies, particularly in the event of an accidental release of wastes.

E.4.1.2 Low-Level Radioactive Waste

The No-Action strategy for low-level radioactive waste also consists of a continuation of current operating practices using shallow-land and greater confinement disposal at the existing burial facility until its capacity is reached in 1989. After 1989, this strategy assumes that low-level waste would be stored in existing structures, on existing concrete pads, or, if these are not available, on prepared areas at the current burial facility. As much as possible, low-level waste with radioactivity greater than 300 millirem per hour would be stored in unused existing shielded structures, such as the R-Reactor building. No new (undeveloped) sites would be used for the storage of wastes.

This EIS assumes that low-level waste would be stored in sealed steel containers. The intermediate-activity wastes would be segregated and handled with shielded equipment. All stored material, except the intermediate-activity waste, would be accessible for inspection, which would be conducted on a regular basis. Damaged or deteriorated containers would be replaced, and any spillage or leakage would be collected or recovered expeditiously.

Because the No-Action strategy requires "no new facilities," low-level waste would be stored without pretreatment. The 20-year volume, therefore, is estimated at 646,500 cubic meters. TC

Estimated costs for the management of low-level waste under the No-Action strategy are listed in Table E-10 and are directly related to the waste volume estimated above. TE

The advantages and disadvantages of the No-Action strategy for low-level radioactive waste management are the same as those discussed for hazardous and mixed waste. TE

TE

Table E-10. Estimated Cost for Low-Level Waste Management Under No-Action Strategy[a]

Item	Estimated cost
Site preparation	11,632
Operations	60,529
Total (20 years)[b]	72,161

TC

[a]Cost in thousands of 4th Quarter 1985 dollars for 20-year planning period.

TE [b]Does not include costs of waste retrieval, decontamination, any subsequent treatment, or disposal.

E.4.2 DEDICATION STRATEGY

The Dedication strategy involves the construction of hazardous, mixed, and low-level radioactive waste disposal facilities.

E.4.2.1 Hazardous or Mixed Waste

The technologies for implementing the Dedication strategy for hazardous waste are belowground or aboveground vaults or RCRA landfills. For mixed waste, the disposal technologies are belowground vaults, aboveground vaults, RCRA landfills, belowground vaults with CFM vaults, aboveground vaults with CFM vaults, or RCRA landfills with CFM vaults.

Hazardous or mixed waste disposal using above- or belowground vaults or RCRA landfills (i.e., CFM vaults not used for any portion of mixed waste) would require some specific predisposal treatment. Treatment for volume reduction and detoxification would be in accordance with new HSWA regulations. The three mixed waste alternatives, which include cement/flyash matrix disposal for a portion of the waste, require that this portion be solidified to a concrete-like material to render the waste nonhazardous under RCRA. The remainder of the mixed waste under these alternatives would be disposed of in above- or belowground vaults or RCRA landfills.

TE Under the Dedication strategy, the site-specific actions regarding predisposal treatment (i.e., volume reduction, detoxification, solidification) lead to a range of possible hazardous and mixed waste disposal volumes. Table E-11 lists the estimated volume ranges, as calculated from the values in Tables E-1 and E-2. Under the Dedication strategy, no wastes would be generated by removal/closure of existing waste sites.

TE Estimated costs associated with the management of hazardous and mixed wastes under the Dedication strategy were prepared for this EIS; these costs attempt to bracket site-specific actions regarding technologies, design details, and predisposal treatment effects. Table E-12 indicates the relative magnitude of the costs associated with the implementation of the Dedication strategy for hazardous and mixed waste. These costs are not complete (e.g., those for most predisposal treatment considerations have not been included), and no cost-effectiveness analysis has been performed.

Table E-11. Estimated Range of Hazardous and Mixed Waste 20-Year Disposal Volumes Under the Dedication Strategy (cubic meters)[a] TE

Waste type	Lower limit[b]	Upper limit
Hazardous waste	2,500	5,200[c]
Mixed waste	9,900	185,900[d]

TC

[a]Rounded to the nearest 100 cubic meters.
[b]Maximum volume reduction.
[c]No volume reduction for hazardous waste.
[d]Volume expansion of mixed waste caused by CFM solidification of ETF sludges.

The major advantages of the Dedication strategy for the future management of SRP wastes are the following:

- During the 20-year operation period, wastes would be disposed of permanently.

- The disposal of waste would comply with all applicable Federal and state regulations.

- Facilities would be capable of achieving compliance with environmental standards (e.g., groundwater, surface water).

The Dedication strategy has the following disadvantages:

- Facilities would be costly to construct and operate.

- Land would be dedicated to use as a waste repository in perpetuity.

- In the event of a failure that released waste constituents, retrieval of the waste packages could be difficult where certain practices were employed (e.g., grouting in place).

E.4.2.2 Low-Level Radioactive Waste

The technologies for implementing the Dedication strategy are ELLTs, AGOs, or vaults (above or below the ground) for the disposal of low-activity waste (i.e., less than 300 millirem per hour); and vaults (above or below the ground) or GCD trenches/boreholes for the disposal of intermediate-activity waste (i.e., greater than 300 millirem per hour).

Low-level waste disposal using any of the optional technologies would not require predisposal treatment other than liquid immobilization (e.g., by sorbents or solidification); however, treatments that provide volume reduction could be cost-effective and desirable.

Table E-12. Estimated Cost Range for Hazardous and Mixed Waste Management Under Dedication Strategy[a, b]

Item	Hazardous waste		Mixed waste	
	Lower limit	Upper limit	Lower limit	Upper limit[c]
Site Preparation	0.9	0.7	3.5	1.1
Construction[d]	3.0	18.2	12.1	181.1
Operation	3.0	9.2	12.1	111.5
Closure	1.4	0.2	5.5	0.3
Subtotal, 20 years	8.2	28.3	33.2	294.0
Maintenance	0.6	1.3	2.5	7.9
Monitoring[e]	1.2	2.6	5.0	27.7
Subtotal, 100 years	1.9	3.9	7.5	35.6
Total, 120 years	10.1	32.2	40.7	329.6

TC

[a]Adapted from Cook and Grant, 1987; Cook, Grant, and Towler, 1987a; and Moyer, 1987.
[b]Cost in millions of 4th Quarter 1985 dollars.
[c]Includes estimated costs for predisposal treatment of ETF sludges by CFM solidification.
[d]Includes monitoring well installations assuming an average cost of about $8,000 per well for an average depth of 42.7 meters using PVC materials.
[e]Includes sampling, analysis, and reporting of data assuming annual sampling for 31 parameters, plus 3 quarterly samples costing about $1,200/well/year for the first 5 years, and annual sampling for 31 parameters thereafter, costing about $700/well/year.

Under the Dedication strategy, project-specific actions regarding predisposal treatment lead to a range of possible low-level disposal volumes. Based on the values in Table E-3, this range extends from a low of 278,000 cubic meters to an upper limit of 646,600 cubic meters. The low end of this range assumes maximum volume reduction through predisposal treatment; the upper limit assumes no volume reduction, and solidification where applicable. Under the Dedication strategy, no wastes would be generated by removal/closure of existing waste sites. TC

Estimated costs associated with the management of low-level wastes under the Dedication strategy were prepared for this EIS; they bracket project-specific actions regarding specific technologies, design details, and predisposal treatment effects. The cost ranges listed in Table E-13 indicate the relative magnitude of costs associated with implementing this strategy for low-level waste. TE However, these costs are not complete (e.g., they do not contain costs for predisposal treatment considerations); also, cost effectiveness has not been analyzed. Thus, the ranges should not be used for a direct comparative analysis or as a basis for decisionmaking.

Table E-13. Estimated Cost Range for Low-Level Radioactive Waste Management Under Dedication Strategy[a, b]

Item	Lower limit	Upper limit
Site preparation	5.5	5.6
Construction[c]	86.8	412.2
Operation	35.8	137.0
Closure	24.5	18.3
Subtotal, 20 years	152.6	573.1
Maintenance	2.9	6.8
Monitoring[d]	14.7	34.2
Subtotal, 100 years	17.7	41.1
Total 120 years	170.3	614.2

[a]Adapted from Cook, Grant, and Towler, 1987b; and Moyer, 1987.
[b]Cost in millions of 4th Quarter 1985 dollars.
[c]Includes monitoring well installations assuming an average cost of about $8,000 per well for an average depth of 42.7 meters using PVC materials.
[d]Includes sampling, analysis, and reporting of data.

TC

E.4.3 ELIMINATION STRATEGY

The Elimination strategy for new waste management facilities involves the construction of hazardous, mixed, and low-level radioactive waste storage facilities. The technology for implementing this strategy uses retrievable-storage buildings, which are described in Section E.1.1.6 for hazardous and mixed wastes, and in Section E.1.2.6 for low-level radioactive waste.

RCRA regulations define "storage" as "the holding of hazardous waste for a temporary period, at the end of which the waste is treated, disposed of, or stored elsewhere" (40 CFR 260.10). The term "temporary" is not defined by a specific time period, rather it is taken to mean "not permanent" and implies
TC an intention to retrieve the waste for future treatment and/or disposal. Facilities which accumulate hazardous waste for more than 90 days, such as those proposed under the Elimination strategy, are considered storage facilities under RCRA and can be permitted and operated in accordance with 40 CFR 270 and 40 CFR 264, respectively (40 CFR 262.34).

Because a major objective of retrievable storage is a delay of permanent deposition of wastes in anticipation of advanced methods of treatment, recycling, or disposal, the predisposal treatment of waste could close out future waste management options. Thus, the only predisposal techniques considered applicable are liquid immobilization by sorption techniques and compaction of bulky wastes to reduce volume. Under the Elimination strategy, wastes would be generated from the removal/closure of all existing waste sites.

On this basis, Table E-14 lists the estimated retrievable-storage volumes of hazardous, mixed, and low-level waste as calculated from Tables E-1 through E-3, with and without consideration of the mixed and low-level radioactive waste burial grounds.

TC

Table E-14. Estimated Hazardous, Mixed, and Low-Level Waste 20-Year Storage Volumes Under the Elimination Strategy (cubic meters)[a]

	Estimated waste volumes	
Waste type	Without burial grounds	With burial grounds
Hazardous	103,600	103,600
Mixed	188,100	1,666,000
Low-level radioactive	699,800	2,223,800

[a]Rounded to the nearest 100 cubic meters.

The estimated costs of implementing the Elimination strategy bracket project-specific actions associated with specific regulatory requirements and design
TE details. Therefore, the costs listed in Table E-15 indicate the relative magnitude of cost associated with the strategy; they should not be used for direct comparative analysis or as a basis for decisionmaking. Unlike disposal alternatives, the Elimination strategy contains no closure or
TC postclosure costs because the intent is to retrieve the waste at some future time during the 20-year operational period.

Table E-15. Estimated Costs for Hazardous, Mixed, and Low-Level Waste Management Under Elimination Strategy[a, b]

Item	Hazardous waste	Mixed waste[c]		Low-level waste[d]	
		Without MWBG	Including MWBG	Without LLBG	Including LLBG
Site preparation	22.8	24.7	349.5	7.6	24.0
Construction	119.2	158.1	1857.2	387.8	1205.5
Operation	126.2	137.1	1936.1	106.7	336.1
Retrieval/decontamination	NA[e]	NA	NA	NA	NA
Total, 20 years	268.2	319.9	4142.8	502.0	1565.6

TC

[a]Adapted from Cook, Grant, and Towler, 1987a; Cook, Grant, and Towler, 1987b; Cook and Grant, 1987; and Moyer, 1987.
[b]Cost in millions of 4th Quarter 1985 dollars.
[c]Without Mixed Waste Burial Ground and including Mixed Waste Burial Ground.
[d]Without Low-level Waste Burial Ground and including Low-level Waste Burial Ground.
[e]NA - Not available.

The major advantages of the Elimination strategy with regard to future waste management facilities are the following:

TE

- No SRP land would be dedicated in perpetuity as a hazardous, mixed, or low-level waste repository.

- In the event of a failure in which wastes are spilled or leaked from their containers, facilities, equipment, and procedures would provide a rapid and efficient retrieval of the waste, such that no leakage outside the facility would occur.

TC

- Storage of the wastes would comply with applicable Federal and state regulations, presuming the necessary permits for long-term storage of hazardous and mixed wastes were granted by the regulatory agencies.

- Facilities would be capable of achieving compliance with all environmental standards (e.g., groundwater, surface water).

The Elimination strategy has the following disadvantages:

- Storage facilities would be costly to construct and operate.

TE

- Additional future costs for retrieval of the waste, decontamination of the storage facilities, and construction and operation of treatment or disposal facilities would be inevitable and substantial.

E.4.4 COMBINATION STRATEGY

The Dedication and Elimination strategies would provide adequate management of all SRP hazardous, mixed, and low-level wastes. However, the management of specific wastes might be more economical, technologically feasible, or environmentally reliable under one or the other strategy. Thus, the objective of the Combination strategy is to identify and implement the best mix of disposal (Dedication) and storage (Elimination) technologies based on specific hazardous, mixed, and low-level waste volumes and characteristics.

E.4.4.1 Hazardous or Mixed Waste

The Combination strategy for hazardous waste includes retrievable-storage buildings, and belowground or aboveground vaults or RCRA landfills for disposal. The Combination strategy for mixed waste consists of retrievable-storage buildings and belowground or aboveground vaults or RCRA landfills, below-ground vaults with CFM vaults, aboveground vaults with CFM vaults, or RCRA landfills with CFM vaults.

TE

Under this strategy, project-specific actions regarding predisposal treatment (i.e., volume reduction, detoxification, solidification) lead to a wide range of possible hazardous and mixed waste disposal volumes. Removal and closure of existing hazardous and mixed waste sites have been specified to occur only at the old F-Area seepage basin. Table E-16 lists the estimated 20-year volume ranges, calculated from the values in Tables E-1 and E-2.

Table E-16. Estimated Range of Hazardous and Mixed Waste 20-Year Disposal/Storage Volumes Under the Combination Strategy (cubic meters)[a] TE

Waste Type	Lower limit[b]	Upper limit
Hazardous waste	2,500	5,200[c]
Mixed waste	15,600	191,300[d]

TC

[a]Rounded to the nearest 100 cubic meters.
[b]Maximum volume reduction.
[c]No volume reduction.
[d]Volume expansion caused by CFM solidification of ETF sludges.

The estimated cost ranges in Table E-17 bracket site-specific actions regarding the mix of specific technologies, design details, and volume capacity. These ranges indicate the relative magnitude of potential costs associated with the implementation of the Combination strategy for hazardous and mixed waste; they should not be used for direct comparative analysis or as a basis for decisionmaking. TE

In addition to the advantages and disadvantages of Dedication and Elimination described in Sections E.4.2.1 and E.4.3, the Combination strategy would allow the selection of a mix of technologies that would optimize performance and minimize cost.

E.4.4.2 Low-Level Radioactive Waste

The technologies for implementing the Combination strategy for low-level waste are engineered storage buildings, and ELLTs or vaults or AGOs for the disposal of low-activity waste (i.e., less than 300 millirem per hour); and vaults or GCD for the disposal of intermediate-activity waste (i.e., greater than 300 millirem per hour).

Site-specific actions regarding predisposal treatment (i.e., volume reduction, solidification, encapsulation) lead to a range of possible low-level waste disposal volumes. Also, removal and closure of existing low-level waste sites have been specified to occur only at the R-Area Seepage Basins. Based on the values listed in Table E-3, this range extends from a lower limit of 286,500 cubic meters to an upper limit of 658,400 cubic meters. The lower limit assumes maximum volume reduction, whereas the upper limit assumes no volume reduction and some volume expansion by solidification of closure action wastes. TC

Table E-18 lists cost ranges associated with low-level waste management under the Combination strategy. These ranges bracket the site-specific actions regarding the technological mix, design details, and volume capacity. They indicate the relative magnitude of potential costs associated with the implementation of this strategy for low-level waste; they should not be used for direct comparative analysis or as a basis for decisionmaking. TE

Table E-17. Estimated Cost Range for Hazardous and Mixed Waste Management Under the Combination Strategy[a, b]

Item	Hazardous waste		Mixed waste	
	Lower limit	Upper limit	Lower limit	Upper limit[c]
Site preparation	1.1	1.3	6.9	3.4
Construction[d]	4.5	20.8	29.2	207.1
Operation	3.2	9.8	21.2	123.4
Closure/retrieval[e]	2.0	0.3	12.4	0.8
Subtotal, 20 years	10.7	32.2	69.7	334.7
Maintenance	1.3	2.1	8.2	5.2
Monitoring[f]	2.6	4.9	16.4	12.2
Subtotal, 100 years	4.0	6.9	24.5	17.5
Total, 120 years	14.7	39.1	94.2	352.2

[a]Adapted from Cook, Grant, and Towler, 1987a; Cook and Grant, 1987; and Moyer, 1987.
[b]Cost in millions of 4th Quarter 1985 dollars.
[c]Includes estimated costs for predisposal treatment of ETF sludges by CFM solidification.
[d]Includes monitoring well installations assuming an average cost of about $8,000 per well for an average depth of 42.7 meters using PVC materials.
[e]Includes costs of decontaminating the storage facilities.
[f]Includes sampling, analysis, and reporting of data assuming annual sampling for 31 parameters, plus 3 quarterly samples costing about $1,200/well/year for the first 5 years, and annual sampling for 31 parameters thereafter, costing about $700/well/year.

TC

Table E-18. Estimated Cost Range for Low-Level Radioactive Waste Management Under the Combination Strategy[a]

Item	Lower limit	Upper limit
Site preparation	3.4	0.0
Construction[b]	114.6	424.7
Operation	48.8	139.5
Closure/retrieval and decontamination	33.5	35.8
Subtotal, 20 years	200.0	600.0
Maintenance	9.4	7.0
Monitoring[c]	14.1	35.2
Subtotal, 100 years	23.5	42.2
Total, 120 years	223.8	642.2

[a]Cost in millions of 4th Quarter 1985 dollars
[b]Includes monitoring well installations assuming an average cost $8,000 per well for an average depth of 42.7 meters using PVC material.
[c]Includes sampling analysis and reporting of data.

TC

The advantages and disadvantages of the Combination strategy are discussed in Section E.4.4.1.

E.5 SUMMARY

Tables E-19 through E-22 summarize the four strategies for the modification of SRP waste management practices with regard to new disposal/storage facilities. TE

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Table E-19. No-Action Strategy

Item	Description	
Objective	Waste management with no new facilities	
Technologies	Indefinite storage of hazardous and mixed waste at existing facilities, then at other available structures, pads, or areas	
	Disposal of low-level waste at existing burial grounds, then indefinite storage at other available structures, pads, or areas	
Limitations	No new facilities, including pretreatment	
Volume (m^3)	Hazardous	4,700
	Mixed	97,000
	Low-level	646,500
	Total	748,200
Cost range ($Mil)[a]	Hazardous	3.2
	Mixed	26.2
	Low-level	72.2
	Total	101.6
Cost uncertainties	Total and types of storage capacity available	
	No specific existing facilities identified	
Advantages	Would delay expenditures for waste management facilities	
	Would make use of structures that otherwise would remain unused	
Disadvantages	Unquantified higher risk of environmental releases of waste and the associated occupational, public health, and environmental impacts	
	Noncompliance with RCRA, DOE Orders, and other regulations eliciting enforcement actions	
	Probable judicial intervention	
	Inevitable future expenditures for waste treatment/disposal	

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[a]Costs through the 20-year period. (Note: Site-specific actions prevent costs from being used for direct comparative analysis).

Table E-20. Dedication Strategy

TE

Item	Description		
Objective	Waste management by disposal		
Technologies	Hazardous - Belowground vaults, aboveground vaults, or RCRA landfills		
	Mixed - Belowground vaults, aboveground vaults, or RCRA landfills with or without CFM vaults		
	Low-level - ELLTs, AGOs, or vaults for low-activity waste; vaults or GCD for intermediate-activity waste		
Limitations	Mixed waste options using CFM vaults require pre-disposal treatment by cement/flyash solidification		
Volume range (m^3)	Hazardous	2,500 to	5,200
	Mixed	9,900 to	185,900
	Low-level	278,000 to	646,600
	Total	290,400 to	837,700
Volume uncertainties	Volume reduction by predisposal treatment		
	Volume expansion by solidification		
Cost range ($Mil)[a]	Hazardous	10.1 to	32.2
	Mixed	40.7 to	329.6
	Low-level	170.3 to	614.2
	Total	221.1 to	976.0
Cost Uncertainties	Total disposal capacity required		
	Optional disposal technologies		
	Pretreatment technologies and capacities		
	Pretreatment costs not included except with CFM portion		
	Postclosure requirements		
Advantages	Final placement of waste		
	Compliance with applicable regulations		
	Compliance with environmental standards		

TC

TC

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TE

Table E-20. Dedication Strategy (continued)

Item	Description
Disadvantages	Facilities costly to construct and operate
	Land dedicated in perpetuity
	Waste retrieval difficult in a failure

TC

[a]Costs for 20-year period through closure plus postclosure maintenance for 100 years.

Table E-21. Elimination Strategy TE

Item	Description		
Objective	Waste management by retrievable storage		
Technologies	Storage buildings for hazardous, mixed, and low-level wastes		
Limitations	Prestorage treatments limited to liquid sorption and compaction		
Volume (m^3)		Without Burial Grounds	Including Burial Grounds
	Hazardous	103,600	103,600
	Mixed	188,100	1,666,000
	Low-level	699,800	2,223,800
	Total	991,500	3,993,400
Volume uncertainties	Removal volume from existing waste sites		
	Volume reduction by compaction		
Cost range ($Mil)[a]		Without Burial Grounds	Including Burial Grounds
	Hazardous	268.2	268.2
	Mixed	319.9	4,142.8
	Low-level	502.0	1,565.6
	Total	1,090.1	5,976.6
Cost uncertainties	Total storage capacity required		
	Compaction capacity and cost (not included)		
Advantages	No land dedicated in perpetuity		
	Waste retrieval relatively simple in a failure		
	Compliance with applicable regulations, presuming waivers are granted		
	Compliance with environmental standards		
Disadvantages	Facilities costly to construct and operate		
	Inevitable future expenditure for continued storage or waste retrieval, treatment, and/or disposal		

TC (Volume) TC (Cost range)

[a]Costs through the 20-year period; does not include waste retrieval, treatment, or disposal. (Note: Site-specific actions prevent costs from being used for direct comparative analysis.)

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Table E-22. Combination Strategy

Item	Description			
Objective	Waste management by combination of storage and disposal			
Technologies	Storage buildings for storage of hazardous, mixed, and low-level wastes; vaults or RCRA landfills for hazardous waste; vaults or RCRA landfills with or without CFM vaults for mixed waste; ELLTs, AGOs, or vaults for low-activity low-level waste; vaults or GCD for intermediate-activity low-level waste.			
Limitations	Mixed waste options using CFM vaults require predisposal treatment by cement/flyash solidification. Prestorage treatments limited to liquid sorption and compaction.			
Volume range (m^3) (TC)	Hazardous	2,500	to	5,200
	Mixed	15,600	to	191,300
	Low-level	286,500	to	658,400
	Total	304,600	to	854,900
Volume uncertainties	Removal volume from existing waste sites			
	Volume reduction by pretreatment			
	Volume expansion by solidification			
Cost range ($Mil)[a] (TC)	Hazardous	14.7	to	39.1
	Mixed	94.2	to	352.2
	Low-level	223.8	to	642.2
	Total	332.7	to	1,033.5
Cost uncertainties	Total storage and disposal capacities required			
	Optional disposal technologies			
	Pretreatment technologies and capacities			
	No pretreatment costs, except CFM solidification			
	Postclosure requirements on disposal facilities			

Footnote on last page of table.

Table E-22. Combination Strategy (continued)

TE

Item	Description
Advantages	Allows selection of a mix of disposal and storage technologies that would optimize performance and minimize cost Other advantages are the same as those for the Dedication and Elimination strategies
Disadvantages	Same as those for the Dedication and Elimination strategies

[a]Costs for 20-year period through closure including postclosure maintenance or retrieval and disposal of stored wastes. (Note: Site-specific actions prevent costs from being used for direct comparative analysis.)

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APPENDIX F

ASSESSMENT OF ACTIONS AT EXISTING WASTE SITES

This appendix describes removal, remedial, and closure actions considered feasible for the existing waste sites characterized in Appendix B and listed in Table B-2. TE Cumulative (i.e., over all the sites) environmental consequences of the actions are presented in Section 4.2 and summarized in Section 2.2. The assessments in this appendix are presented by individual waste site and are based largely on the results of contaminant transport modeling. TE

This appendix consists of 11 major sections, each of which covers existing TE waste sites in a particular geographic group (see Section B.1.2 in Appendix B). For example, Section F.1 assesses the actions at the waste sites in the first geographic grouping (i.e., the A- and M-Areas). Each geographic-grouping section is further divided into a section for each waste site. For example, Sections F.1.1-F.1.13 deal with the 13 waste sites in the A- and M-Areas. These sections discuss the actions, releases, and other impacts associated with the waste sites for each of the three project-specific alternatives (no action, closure with no removal of waste, and closure with TE removal of waste). Finally, for each alternative at each waste site, three major topics (description of action, comparison of expected releases to applicable standards, and impacts other than releases) are presented.

To accommodate this extensive scope, many essentially equivalent discussions of similar sites and groups of sites have been combined. Similarly, to minimize repetition, the specific waste site sections are usually followed by a section that discusses those factors related to biological impacts that apply generically to all the waste sites within a particular geographic group.

The assessments in this appendix are supported by detailed modeling of contaminant transport and health risk analyses; the models used are described in Appendixes H and I.

Appendix I also presents criteria for the selection of chemical and radioactive constituents and sites for evaluation based on risks to human health. These selection criteria, corresponding to maximum contaminant levels (MCLs) or less, or to proposed de minimis radioactivity values, have been TE applied to chemical and radioactive constituents found in the waste sites, soil, and groundwater at the Savannah River Plant (SRP). If the quantities or concentrations are below the selection criteria values, no pathway modeling calculations and, consequently, no environmental assessments are made. Such cases will be noted in those sections of this appendix addressing sites with insignificant or no measurable concentrations of constituents in groundwater or soil at and near the waste sites.

Environmental assessments of alternative actions at existing waste sites are based on data and methodologies presented in the Environmental Information Documents (EIDs) referenced herein. The methodologies employ several pathway models for assessing the effects of releases on human health and the environment (aquatic and terrestrial ecology, endangered species, and wetlands).

Water pathways include groundwater movement to water wells, groundwater movement to surface streams, erosion of waste materials and movement to a surface stream, consumption of food produced from farmland reclaimed over a waste site, consumption of crops produced through natural biointrusion of land over a waste site, and direct exposure to gamma radiation. Atmospheric pathways for human exposure are inhalation of waste particulates or gases in air, ingestion of foods containing waste materials from deposition of air TC particulates on the ground surface. Additionally, a direct gamma radiation exposure to occupant of reclaimed land over a waste site is evaluated. Detailed descriptions of the pathway analysis methodology are included in the EIDs and Appendix H of this document.

Two assumptions are made regarding the time periods of analysis for potential environmental consequences. First, it is assumed that the Department of Energy (DOE) will maintain institutional control over the SRP site for 100 years beyond 1985. This is a reasonable assumption, in light of current production planning and projected scheduling for site decommissioning. Second, the basic time period for the long-term analyses extends up to 1000 years beyond 1985. Guidelines issued by the U.S. Environmental Protection Agency (EPA) and the U.S. Nuclear Regulatory Commission (NRC) specify 1000 years as a reasonable time for calculations of projected effects of waste disposal activities.

Public exposures attributed to the surface and subsurface pathways for various waste sites are based on exposure assessments for the years in which peak concentrations occur in surface water and groundwater, and for future years (100, 200, 300, 400, 500, 700, and 1000 years from 1985). Results are reported at hypothetical wells assumed to be located 1 and 100 meters downgradient from each waste site and in the Savannah River.

Groundwater concentrations of constituents that exceed health-based regulatory standards are identified in this appendix. These exceedances are reported for measured concentrations at downgradient monitoring wells and modeling predictions at the hypothetical 1- and 100-meter wells. Some constituents that were modeled are not reported because applicable standards are not available or because the standard is not based on risk to human health and the environment. These include miscellaneous organic compounds, sodium, and phosphate.

The evaluations of alternatives in this appendix are based on groundwater and surface-water concentrations at individual waste sites that are predicted by the PATHRAE code. These results are not directly comparable to monitoring results for these sites. Predicted exceedance of standards for all closure actions indicates that further action may be required. This could range from taking remedial action (e.g., groundwater cleanup) to monitoring and assuring protection of human health and the environment in close cooperation with regulatory agencies [e.g., the South Carolina Department of Health and Environmen- TE tal Control (SCDHEC)]. Also, any action would be designed to ensure compliance with applicable regulations. These modeling predictions represent a very preliminary indication that some action may be required. In practice, implementation of any action would be based on this work and additional site-specific modeling and actual monitoring results.

Public exposure and risk attributed to the atmospheric pathway for various waste sites include risk assessment for every year for the period 1986-1990, for every fifth year for the period 1990-2085, and for every one-hundredth year for the period 2085-2985. Risks for a maximally exposed individual are estimated for 3 selected years: 1985 (assumed start of closure actions), 2085 (assumed start of public occupation of the SRP area), and 2985 (end of 1000-year period).

Risk assessments are presented in this appendix in their originally calculated form (King et al., 1987) as follows:

- Carcinogenic risks from radioactive and nonradioactive waste constituents are the product of exposure (either chemical or radioactive) and the cancer risk per unit exposure [unit cancer risk (UCR)]. These risk estimates are expressed as the increase in probability of fatal cancer in an individual (with a value between 0 and 1). TE In these evaluations, risks from chemical carcinogens have been determined as lifetime risks from exposure over a period of 50 years that encompasses the year of peak exposure. Radiological risks, however, were calculated for an exposure period of the peak year only. The radiological risk values presented in this appendix are multiplied by 50 in Chapter 4 to produce a conservative estimate of lifetime-exposure risks comparable to those originally calculated for chemical carcinogens.

- Noncarcinogenic risks from chemical constituents are presented as the ratio of the average daily dose to the acceptable daily intake (ADI) for chronic exposure. Because noncarcinogenic effects are assumed to occur only if the exposure exceeds a threshold value defined by the ADI, any value of calculated risk less than 1 means that no health effect is likely; the smaller the value, the greater the margin of safety. Individual noncarcinogenic risk values are summed to form a Hazard Index that also is compared conservatively to a threshold of 1.

F.1 ASSESSMENT OF ACTIONS AT A- AND M-AREA WASTE SITES

This geographic grouping of waste sites is located along the northwest edge of the SRP where Road 1 leads to the Administration Area (700-A). Figure F-1 shows the boundaries of this geographic grouping and the locations of the waste sites within it.

Sections F.1.1 through F.1.13 contain (or reference the section that contains) a discussion of sites 1-1 through 1-13, respectively. Section F.1.14 discusses biological impacts that are generically applicable to the A- and M-Area geographic grouping.

F.1.1 716-A MOTOR SHOP SEEPAGE BASIN, BUILDING 904-101G*

F.1.1.1 Assessment of No Action (No Removal of Waste, and No Remedial or Closure Actions)

Under no action, the motor shop seepage basin would remain uncovered and open to receive rainwater. TC Groundwater monitoring would continue on a quarterly

*The reference source for the information in this section is Huber, Johnson, and Bledsoe, 1987.

TC basis for the first year, then annually for 29 years. Site maintenance would continue for the entire 30-year period.

Expected Environmental Releases

No environmental releases are expected at this site for this action.

Comparison of Expected Environmental Releases with Applicable Standards

The environmental impact and health risks associated with the motor shop seepage basin were not determined because chemical constituents at the site were below the threshold selection criteria.

Potential Impacts (Other Than Releases)

TE Section F.1.14.1 describes general impacts to biological resources from no action. Aquatic impacts would be unlikely.

The 716-A motor shop seepage basin might have an impact on the wildlife and vegetation that come into contact with its standing surface waters. Based on the available chemical analysis data on the standing surface water of the seepage basin, pH, cadmium, lead, and mercury do not fall within the EPA freshwater aquatic life criteria. However, cadmium, lead, and mercury meet
TC EPA drinking-water criteria. Thus, wildlife that consume the water should not receive adverse impacts.

In addition, food-chain uptake calculations based on the bioconcentration of heavy metals from the standing water by nonrooted aquatic macrophytes indicate that the predicted concentrations of heavy metals would be well below the concentrations considered toxic to herbivorous wildlife.

F.1.1.2 Assessment of No Removal of Waste and Implementation of Cost-Effective Remedial and Closure Actions as Required

Description of Action

TE Under the no-removal-and-closure action, the motor shop seepage basin would be backfilled to grade and seeded. This action would require approximately 1350 cubic meters of soil. Groundwater would continue to be monitored on a quar-
TC terly basis for 1 year, then annually for 29 years. Site maintenance would continue for the entire 30-year period.

Comparison of Expected Environmental Releases with Applicable Standards

No chemical constituents at or above threshold selection criteria were identified for this waste site; thus, expected environmental releases were not determined. However, closure of the basin by backfilling would reduce the possibility that the free liquid might be transported by surface runoff or flooding.

No environmental risks due to atmospheric chemical releases from the motor shop seepage basin are expected for this action.

Potential Impacts (Other Than Releases)

Section F.1.14.2 describes general impacts to biological resources. Aquatic impacts resulting from the discharge of standing basin water should be minimal because the water would be drained through a permitted discharge. This action would eliminate any potential for impacts on wildlife coming into contact with basin water.

F.1.1.3 Assessment of Removal of Waste to the Extent Practicable, and Implementation of Cost-Effective Remedial and Closure Actions as Required

Description of Action

Under the waste-removal-and-closure action, all waste would be removed from the motor shop seepage basin. The liquid would be drummed and removed to a waste storage/disposal facility. The basin would be excavated to a depth of 1 meter. Approximately 675 cubic meters of soil would be removed to the SRP sanitary landfill. The basin would be backfilled to grade, requiring approximately 2025 cubic meters of soil, and seeded. Groundwater monitoring would continue on a quarterly basis for 1 year and thereafter on an annual basis for 29 years. Site maintenance would continue for the entire 30-year period. TC

Comparison of Expected Environmental Releases with Applicable Standards

As stated above, no chemical constituents at or above threshold criteria were identified for this waste site; therefore, no environmental releases were determined. However, removal of the waste and backfilling of the basin should reduce the possibility of future environmental releases.

Potential Impacts (Other Than Releases)

Section F.1.14.3 describes general impacts to biological resources. No aquatic impacts are expected, as discussed in Section F.1.1.2. Potential impacts on wildlife as a result of coming into contact with basin water would be eliminated.

F.1.2 METALS BURNING PIT, BUILDING 731-4A*

F.1.2.1 Assessment of No Action (No Removal of Waste, and No Remedial or Closure Actions)

Description of Action

Under no action, the site would be left in its present condition, and a site identification sign would be installed. Groundwater monitoring at the existing wells would occur quarterly for 1 year, then annually for 29 years. Upkeep would include maintaining the groundwater monitoring wells. A U.S. Forest Service experimental study would continue, with weed and underbrush control conducted consistent with the pine tree growth study. Site maintenance would continue for the entire 30-year period. TC

*The reference source of the information in this section is Pickett, Muska, and Marine, 1987.

Comparison of Expected Environmental Releases with Applicable Standards

The waste constituents selected for assessment of the environmental impacts and health risks at the metals burning pit are tetrachloroethylene and trichloroethylene. Both of these compounds were found in the groundwater at levels higher than the selection criteria (Looney et al., 1987).

Table F-1 lists the predicted maximum concentrations of tetrachloroethylene and trichloroethylene based on results of constituent transport modeling for all of the closure actions and for no action. The table also lists the applicable standard, criterion or proposed MCL for each constituent and, in parentheses, the years in which the maximum concentration is expected to be reached. For no action, the table indicates maximum concentrations of tetrachloroethylene and trichloroethylene at levels in excess of the applicable standards at the 1- and 100-meter wells. Table F-1 also shows monitoring data for these two organics and for cadmium, which slightly exceeded its applicable standard but was not selected for the modeling assessment. Surface-water quality would not be significantly affected by the addition of potential contaminants from the groundwater pathway from this site, as the resulting concentrations of constituents in the Savannah River are projected to be below drinking-water standards.

Environmental risks due to atmospheric chemical releases from the metals burning pit were calculated. The risk values are conservative because they are based on emissions from two sites: the metals burning pit and the miscellaneous chemical basin. The carcinogenic risks are very low (the highest risk to the maximally exposed individual is less than 10^{-14} excess cancers) and are not considered significant. Non-carcinogenic atmospheric releases are predicted to produce insignificant risks (i.e., EPA Hazard Index is less than 1×10^{-2}).

The expected concentrations for the erosion, reclaimed farmland, and biointrusion pathways are zero. That is, the erosion rate is such that no waste erodes during the first 1000 years of the simulation; waste materials are leached from the zone of excavation before a farming operation could begin, due to the 100 years of institutional control; and the 1 meter of existing soil cover equals or exceeds the root penetration assumed for the biointrusion pathway.

Potential Impacts (Other Than Releases)

Section F.1.14.1 describes the ecological impacts of no action. PATHRAE modeling was performed on tetrachloroethylene and trichloroethylene, which were considered to have a potential impact on the aquatic system. The results of this analysis indicate that these particular constituents should not cause significant impacts to water quality. Neither aquatic species nor terrestrial wildlife, which could consume water at the outcrop, should be affected
TE adversely under closure actions. Because of rapid leaching of mobile contaminants at the site, uptake by vegetation is not expected to be a problem. Thus, impacts to vegetation and herbivorous wildlife are not expected.

F.1.2.2 Assessment of No Removal of Waste and Implementation of Cost-Effective Remedial and Closure Actions as Required

Description of Action

TE Under the no-removal-and-closure action, a low-permeability cap (Figure F-2) would be placed atop the existing backfill. The exact location of the area involved in the burning and disposal of the metal and debris is not known, but soil sampling to define the specific location of the metals and/or organically contaminated soil is planned to occur before closure. This could significantly reduce the amount of area requiring capping. For the purpose of this document, however, the cost analysis will be made on the assumption that the entire waste site, about 3.6 acres, would be capped. The cap would be graded and revegetated in a manner similar to the current status of the site. Because the materials that were disposed of at the site would be left in place, groundwater monitoring would continue quarterly for 1 year, and then (TE) annually for 29 years. Site maintenance would continue for the entire 30-year period.

Additional corrective actions, such as groundwater extraction and treatment, might be needed to reduce the levels of trichloroethylene and tetrachloroethylene in the groundwater (see Table F-1).

Comparison of Expected Environmental Releases with Applicable Standards

The consequences of environmental releases include the relative risk to human health and the potential impact on aquatic and terrestrial ecosystems of tetrachloroethylene and trichloroethylene. TE The pathways that might have an impact on human health are the same as those described in Section F.1.2.1.

Table F-1 lists the predicted maximum concentrations of the chemical constituents based on results of groundwater modeling. The table also lists the applicable standard for each constituent and, in parentheses, the years in which the maximum concentration is expected to be reached. For the no-removal-and-closure action, the table indicates maximum concentrations of trichloroethylene and tetrachloroethylene at levels in excess of the applicable standards in the future at the 1- and 100-meter wells. Surface-water quality would not be significantly affected by the addition of potential contaminants from the groundwater pathway from this site, as the resulting concentrations of constituents in the Savannah River are projected to be below drinking-water standards.

TC Additional corrective actions might be needed to reduce the levels of constituents already in the groundwater. Decisions regarding the precise actions to be taken would be based on site-specific studies and discussions with the regulatory agencies concerned.

TE The expected concentrations for the erosion, reclaimed farmland, and biointrusion pathways are zero. Maximum concentrations were not developed for the other pathways.

TE Environmental risks due to atmospheric releases from the metals burning pit are conservative for the reason discussed in Section F.1.2.1. Carcinogenic risks would be zero for 1986 and the same as those for no action 100 years later, due to the diffusion of the volatile contaminants through the backfill soil. The carcinogenic risk value is calculated to be very low (the highest risk to the maximally exposed individual is less than 10^{-8} excess cancers) and is considered not significant. The non-carcinogenic risk value is also calculated to be low (i.e., the EPA Hazard Index is less than 1×10^{-2}).

Potential Impacts (Other Than Releases)

The potential ecological impacts of no waste removal and closure for the metals burning pit are similar to those addressed in Sections F.1.2.1 and F.1.14.2.

F.1.2.3 Assessment of Removal of Waste to the Extent Practicable, and Implementation of Cost-Effective Remedial and Closure Actions as Required

Description of Action

TE Under the waste-removal-and-closure action, soil sampling to define the specific location of the metals and/or organics would be performed prior to closure. It is expected that this would significantly reduce the amount of soil to be excavated and/or treated. However, for the purposes of this document, the cost analysis will be made on the total volume of soil which could contain these constituents.

Photographs taken in 1974 indicate that the total pit depth was 1.0 to 1.5 meters. To remove the waste materials, therefore, an assumed depth of 1.5 meters over the 120 meter by 120 meter area would have to be excavated and
TE backfilled (21,700 cubic meters). The excavated materials would be transported in metal boxes or containers and disposed of in a waste storage/disposal facility. The site would be backfilled with clean material, regraded, vegetated, and allowed to return to its natural state. Groundwater monitoring would continue quarterly for 1 year and then annually for 29 years. Site maintenance would continue for the entire 30-year period.

Additional corrective actions, such as groundwater extraction and treatment, might be needed to reduce the levels of tetrachloroethylene and trichloroethylene in the groundwater (see Table F-1).

Comparison of Expected Environmental Releases with Applicable Standards

The consequences of environmental releases include the relative risk to human health and the potential impact on aquatic and terrestrial ecosystems. The pathways that may have an impact on human health are the same as those for no action.

Closure was not modeled because the constituents of concern were assumed to have leached beyond the zone of excavation by the time remedial actions would occur. Therefore, this site would behave in the same manner as it would for no action. Table F-1 lists the predicted maximum concentrations of the chemical constituents based on results of groundwater modeling for this action and for no action.

Additional actions might be required to reduce the constituent levels in the groundwater to meet applicable standards. The exact measures to be initiated would be defined on the basis of site-specific studies and interaction with regulatory agencies.

Environmental risks due to atmospheric releases from the metals burning pit are conservative for the reason discussed in Section F.1.2.1. The carcinogenic risk value is calculated to be very low (the highest risk to the maximally exposed individual is less than 10^{-8} excess cancers) and is considered not significant. The noncarcinogenic risk value is also calculated to be low (i.e., the EPA Hazard Index is less than 1×10^{-2}).

Estimated environmental risks due to atmospheric chemical releases from the metals burning pit for this action are very low (the highest public and occupational risks to the maximally exposed individual are, respectively, less than 10^{-14} and 10^{-16} excess cancers) and are considered not significant.

The expected concentrations for the erosion, reclaimed farmland, and biointrusion pathways are zero for closure. Maximum concentrations for the other pathways were not developed.

The occupational risks to protected workers due to excavation is less than 1×10^{-8} health effects per lifetime. This level is considered to be insignificant.

Potential Impacts (Other Than Releases)

The potential ecological impacts of waste removal and closure for the metals burning pit would be similar to those addressed in Sections F.1.2.1 and F.1.14.3.

F.1.3 SILVERTON ROAD WASTE SITE, BUILDING 731-3A*

F.1.3.1 Assessment of No Action (No Removal of Waste, and No Remedial or Closure Actions)

Description of Action

Under no action, the site would be left in its present condition; groundwater would be monitored quarterly for 1 year, then annually for 29 years. Site maintenance would consist of installing and maintaining a fence and signs around the basin, cutting weeds periodically, and filling depressions at the site with topsoil and seeding for the entire 30-year period.

Comparison of Expected Environmental Releases with Applicable Standards

The chemical constituents selected for assessment of environmental impact and health risks associated with the Silverton Road waste site are lead, tetrachloroethylene, trichloroethylene, and trichloromethane. These were selected because they were found in the groundwater at levels higher than the threshold selection criteria.

*The reference source of the information in this section is Scott, Killian, Kolb, Corbo, and Bledsoe, 1987.

Table F-2 lists the predicted maximum concentrations of those constituents predicted to exceed applicable standards based on groundwater modeling for no action. The table also lists the applicable standard for each constituent and, in parentheses, the year in which the maximum concentration is estimated to occur. A comparison of predicted maximum concentrations to applicable standards for no action indicates that the peaks have already occurred at the 1- and 100-meter wells. However, recent sampling data at the site indicate that trichloroethylene and tetrachloroethylene remain in excess of applicable standards.

Surface-water quality would not be significantly affected by the addition of potential contaminants from the groundwater pathway from this site, as the resulting concentrations of constituents in the Savannah River are projected to be below drinking-water standards.

Estimated environmental risks due to atmospheric releases from the Silverton Road waste site are very low and are considered not significant. For example, the highest carcinogenic risk to the maximally exposed individual is less than 10^{-15} excess cancer. The EPA Hazard Index for noncarcinogens is 1.4 x
TC 10^{-6}.

The expected concentrations for the erosion pathways are zero because the length of time that it takes for the contaminants to start eroding is well over 1000 years. Maximum concentrations for the other pathways were not developed.

Potential Impacts (Other Than Releases)

Section F.1.14.1 describes ecological impacts of no action. Modeling was performed on lead, tetrachloroethylene, trichloroethylene, and trichloromethane, which were considered to have potential impacts on the aquatic system. The results indicate that these waste materials would not alter the present water
TE quality of the receiving stream under any closure actions. However, lead in the Savannah River is presently above the EPA criteria for aquatic life. The levels of groundwater outcrop contamination predicted by the PATHRAE model are
TE ecologically insignificant for all closure actions, indicating no potential for adverse effects on the aquatic biota of the Savannah River or adjacent wetlands and no adverse effects on wildlife consuming the undiluted groundwater at the outcrop.

Based on the available data, no adverse terrestrial impacts are expected for
TE any closure action. The PATHRAE model predicts that all constituents, with the exception of lead, have moved out of the unsaturated zone by Year 1, making them unavailable for uptake by vegetation. No soil monitoring data are currently available; therefore, the potential terrestrial effects due to lead concentrations cannot be evaluated. However, the relatively small amounts of lead disposed of at the site, the length of time the site has been out of service (since 1974), and the low groundwater concentrations for lead indicate that any effects should be negligible. If terrestrial impacts due to elevated lead concentrations should occur, they would be limited to the area of the waste site.

F.1.3.2 <u>Assessment of No Removal of Waste and Implementation of Cost-Effective Remedial and Closure Actions as Required</u>

<u>Description of Action</u>

TE Under the no-removal-and-closure action, the 3.25-acre site would be covered with 0.6 meter of borrow fill (7,890 cubic meters) and capped as described in Section F.1.2. The cap would be covered with topsoil and seeded with grass. Groundwater would be monitored quarterly for 1 year, then annually for 29 years. Site maintenance would be provided for the entire 30-year period.

Additional corrective actions, such as groundwater extraction and treatment, might be needed to reduce the constituent levels in the groundwater.

<u>Comparison of Expected Environmental Releases with Applicable Standards</u>

The chemical constituents, the consequences of environmental releases, the exposure pathways, and the potential human health risks would be the same as those described under Section F.1.3.1. Table F-2 presents the predicted maximum concentrations for the chemical constituents of concern at this site. It lists predicted maximum concentrations of contaminants that peaked prior to 1985 at the 1- and 100-meter wells and that appear to be receding. However, recent sampling data at the site indicate concentrations in excess of applicable standards.

Additional actions might be required to reduce the concentrations of constituents in the groundwater to meet the applicable standards. The precise actions to be taken would be decided on the basis of site-specific investigations and interactions with the regulatory agencies concerned.

Environmental risks due to atmospheric releases from the Silverton Road waste site for this action are estimated to be very low (the highest carcinogenic risk to the maximally exposed individual is less than 10^{-15} excess cancers)
TC and are considered not significant. The EPA Hazard Index for noncarcinogens is zero.

<u>Potential Impacts (Other Than Releases)</u>

The potential ecological impacts of no waste removal and closure for the Silverton Road waste site are similar to those addressed in Sections F.1.3.1 and F.1.14.2.

F.1.3.3 <u>Assessment of Removal of Waste to the Extent Practicable, and Implementation of Cost-Effective Remedial and Closure Actions as Required</u>

<u>Description of Action</u>

TE Under the waste-removal-and-closure action, the waste would be excavated and treated in an approved incinerator and the residual ash disposed of in a waste storage/disposal facility. The volume to be excavated is 26,288 cubic meters. The area would be backfilled with the same quantity of borrow fill and covered with a low-permeability cap (see Figure F-2). Rainwater infiltration would be reduced at least 99 percent. The cap would be covered with topsoil and seeded with grass. Groundwater would be monitored quarterly for 1 year, then annually for 29 years. Site maintenance would be provided for the entire 30-year period.

Additional corrective actions, such as groundwater extraction and treatment, might be needed to reduce the levels of constituents in the groundwater.

Comparison of Expected Environmental Releases with Applicable Standards

Closure was not modeled, as the contaminants of concern were assumed to have leached beyond the zone of excavation by the time remedial actions would occur. Therefore, the concentrations are expected to be similar to those associated with no action and discussed in Section F.1.3.1.

Estimated environmental and occupational risks due to atmospheric releases from the Silverton Road waste site for this action are very low and are considered not significant. For example, the highest public and occupational risks to the maximally exposed individual both are estimated to be less than 10^{-15} excess cancers. Except for 1986, the excavation year, the EPA Hazard Index due to noncarcinogenics would be less than 10^{-19}. The occupational noncarcinogenic Hazard Index to the maximally exposed individual has a maximum value of 3×10^{-5}, and there are less than 10^{-15} health effect per lifetime, which is considered to be insignificant. TC

Potential Impacts (Other Than Releases)

The potential ecological impacts of waste removal and closure for the Silverton Road waste site would be similar to those addressed in Sections F.1.3.1 and F.1.14.3.

F.1.4 METALLURGICAL LABORATORY BASIN, BUILDING 904-110G*

F.1.4.1 Assessment of No Action (No Removal of Waste, and No Remedial or Closure Actions)

Description of Action

Under no action, groundwater monitoring would continue quarterly for 1 year, then annually for 29 years. Site maintenance would be provided for the entire 30-year period. TE

Comparison of Expected Environmental Releases with Applicable Standards

Several chemical constituents were evaluated at this site because they were identified in groundwater sampling or were implicated as potentially significant in available records. The chemical constituents selected for evaluation of the environmental impacts and health risks associated with the metallurgical laboratory basin were chromium, lead, mercury, tetrachloromethane, 1,1,1,-trichloroethane, and trichloroethylene.

*The reference source of the information in this section is Michael, Johnson, and Bledsoe, 1987.

Table F-3 summarizes the predicted maximum concentrations of tetrachloromethane, 1,1,1-trichloroethane, and trichloroethylene based on groundwater modeling for all the closure actions and for no action. The table also lists the applicable standard for each of these constituents and, in parentheses, the year in which the maximum concentration is expected to be reached. For no action, the table indicates maximum concentrations of tetrachloromethane, 1,1,1-trichloroethane, and trichloroethylene at levels in excess of the applicable standards at the 1- and 100-meter wells. Table F-3 also lists monitoring data for tetrachloroethylene, nickel, gross alpha, gross beta, and radium, which exceeded applicable standards but were not modeled.

Surface-water quality is not significantly affected by the addition of potential contaminants from the groundwater pathway from this site, as the resulting concentrations of constituents in the Savannah River are projected to be below drinking-water standards.

Expected atmospheric releases of chemicals from the metallurgical laboratory basin for this action are minimal. For example, lead and mercury releases are less than 1 percent of the significant emission rates under the Prevention of Significant Deterioration (PSD) regulations and are considered insignificant.

Estimated environmental risks due to atmospheric chemical releases from the metallurgical laboratory basin for this action are small and are not consid-
TC ered significant. The highest carcinogenic risks to the maximally exposed individual are less than 10^{-9}. The peak EPA Hazard Index for noncarcinogens is less than 10^{-5}.

The concentrations for the erosion pathway are zero, because the length of time for the constituents to start eroding is well over 1000 years. Maximum concentrations for other pathways were not developed.

Potential Impacts (Other Than Releases)

A general description of the ecological impacts of no action is provided in Section F.1.14.1. Chromium, lead, mercury, tetrachloromethane, 1,1,1-trichloroethane, and trichloroethylene were identified as having a potential impact on aquatic systems. The PATHRAE modeling results indicate that these waste materials would not alter the present water quality of the Savannah
TE River under any closure action. Because the levels of modeled contaminants are ecologically insignificant, impacts to aquatic biota of the Savannah River or adjacent wetlands should not occur. In addition, impacts to wildlife consuming undiluted groundwater at the outcrop should not occur. However, the
TE levels of lead and mercury from unknown sources in the Savannah River, both upriver and downriver from the SRP, are presently above the aquatic biota criteria.

Because the metallurgical laboratory basin contains contaminated standing surface water and soil, there could be impacts on the wildlife and vegetation that come into contact with the waters. However, contaminant levels in the water are below drinking-water standards; thus, consumption by wildlife should not cause adverse impacts. In addition, the contaminants in basin soils are below levels considered toxic to vascular plants. Food-chain calculations indicate that predicted vegetation concentrations are below levels considered toxic to herbivorous wildlife.

F.1.4.2 Assessment of No Removal of Waste and Implementation of Cost-Effective Remedial and Closure Actions as Required

Description of Action

TE The waste-removal-and-closure action for the metallurgical laboratory basin includes batch neutralization of the 453,072 liters of basin water with caustic soda, hydrated lime, or limestone, release of the water to Tims Branch through NPDES Outfall A-11, backfill of the basin, and continuation of groundwater monitoring.

Following the release of the water to Outfall A-11, the basin would be backfilled with approximately 550 cubic meters of soil, covered with a low-permeability cap (see Figure F-2), and seeded. Groundwater monitoring would continue quarterly for 1 year and then annually for 29 years. Site maintenance would be provided for the entire 30-year period.

Additional corrective actions might be needed to reduce concentrations of constituents already in the groundwater.

Comparison of Expected Environmental Releases with Applicable Standards

The chemical constituents, the consequences of environmental releases, and the pathways are the same as those discussed in Section F.1.4.1.

Table F-3 presents the applicable standards and the predicted maximum concentrations for the chemical constituents for the groundwater-to-river pathway and the groundwater-to-wells pathway. For the no removal/closure action, the table indicates maximum concentrations of tetrachloromethane, 1,1,1-trichloroethane, and trichloroethylene at levels in excess of the applicable standards at the 1- and 100-meter wells.

Surface-water quality would not be significantly affected by the addition of potential contaminants from the groundwater pathway from this site, as the resulting concentrations of constituents in the Savannah River are projected to be below drinking-water standards.

Expected atmospheric releases of chemical constituents from the metallurgical laboratory basin for this action are very small (0 to 6.7×10^{-5} kilograms per year). They are considered insignificant for the reason discussed in Section F.1.4.1. Estimated environmental risks due to atmospheric releases of carcinogens from the metallurgical laboratory basin are equal to or less than
TC the risks for no action. The risk values are extremely small and are considered not significant. The EPA Hazard Index value for noncarcinogens for the no-removal action is less than that for no action.

Potential Impacts (Other Than Releases)

Sections F.1.4.1 and F.1.14.2 describe the ecological impacts of the no-waste-removal-and-closure action. The liquid contents of the basin would be neutralized and released into Tims Branch, eliminating any uptake of basin water by wildlife. All such releases would comply with National Pollutant Discharge Elimination System (NPDES) permit requirements; therefore, no impact to the stream environment is anticipated.

F.1.4.3 Assessment of Removal of Waste to the Extent Practicable, and Implementation of Cost-Effective Remedial and Closure Actions as Required

Description of Action

The waste-removal-and-closure action for the metallurgical laboratory basin includes batch neutralization of the basin water as described above, release of the water through Outfall A-11, removal of approximately 1 meter of basin bottom sediment, backfill of the basin, and continuation of groundwater monitoring. TE

Following neutralization, the basin water would be sent to Outfall A-11. Approximately 340 cubic meters of the sediment would then be removed from the basin, placed in metal boxes, and sent to a waste storage/disposal facility. The basin would be backfilled with approximately 900 cubic meters of soil and seeded to complete closure. Groundwater monitoring would continue quarterly for 1 year and then annually for 29 years. Site maintenance would continue for the entire 30-year period.

Additional corrective actions might be needed to reduce the levels of groundwater constituents to meet applicable standards.

Comparison of Expected Environmental Releases with Applicable Standards

The chemical constituents of concern are tetrachloromethane, 1,1,1-trichloroethane, and trichloroethylene. The pathways that may have an impact on human health are the same as those for no action.

For closure with waste removal, Table F-3 lists the predicted maximum concentrations of the chemical constituents based on results of groundwater modeling. The table also lists the applicable standard for each contaminant and, in parentheses, the year in which the maximum concentration is expected to be reached. As in the case of no removal and closure, maximum concentrations of tetrachloromethane, 1,1,1-trichloroethane, and trichloroethylene are in excess of applicable standards at the 1- and 100-meter wells and below applicable standards at the river. TE

In all cases, the expected atmospheric releases of chemical contaminants from the metallurgical laboratory basin would be less than for no action. They are considered insignificant for the reason discussed under Section F.1.4.1 for no action. Estimated environmental and occupational risks due to atmospheric chemical releases from the metallurgical laboratory basin are extremely small and are considered not significant. The highest public and occupational carcinogenic risks to the maximally exposed individual would be, respectively, less than 10^{-12} and 10^{-9}. The EPA Hazard Index values for noncarcinogens are less than 10^{-9} for public exposure and 5.41×10^{-3} for occupational exposure. TC

The concentrations for the erosion and biointrusion pathways are estimated as zero because the cover thickness, erosion rate, and plant-root depth would be such that erosion of the waste material would never take place within the 1000-year study period, and the roots of the plants in the biointrusion pathway would never extend into the remaining waste material.

Potential Impacts (Other Than Releases)

Sections F.1.4.1 and F.1.14.3 describe the ecological impacts of waste removal and closure. The contents of the basin would be released into Tims Branch, eliminating any uptake of basin water by wildlife. All such releases would comply with NPDES permit requirements; therefore, no impact on the stream environment is anticipated. Closure would remove soils from the waste site and thus reduce the potential impact of plant uptake of wastes. In addition, it would eliminate the possibility of consumption of basin water by wildlife.

F.1.5 MISCELLANEOUS CHEMICAL BASIN, BUILDING 731-5A*

F.1.5.1 Assessment of No Action (No Removal of Waste, and No Remedial or Closure Actions)

TE

Description of Action

Under no action, five groundwater monitoring wells and a site identification sign would be installed. Otherwise, the site would be left in its present condition. The site would be mowed periodically and the groundwater monitoring wells would be maintained.

The groundwater would be monitored quarterly for the first year and then annually for 29 years. Site maintenance would continue for the entire 30-year period.

Comparison of Expected Environmental Releases with Applicable Standards

The chemical constituent selected for consideration of the environmental impact and health risks for the miscellaneous chemical basin is tetrachloroethylene. This compound was detected in soil gas samples at levels higher than the selection criteria.

The consequences of environmental releases include the relative risk to human health resulting from potential exposure to waste materials transported through groundwater or atmospheric pathways and the potential impact on the aquatic and terrestrial ecosystems due to transport of waste materials into these ecosystems.

Table F-4 lists the predicted maximum concentrations of tetrachloroethylene for all closure actions and for no action. These data indicate concentrations above the applicable standard at the 1- and 100-meter wells, but not at the river.

Surface-water quality would not be significantly affected by the addition of potential contaminants from the groundwater pathway from this site, as the resulting concentrations of constituents in the Savannah River are projected to be below drinking-water standards.

*The reference source of the information in this section is Pickett, Muska, and Marine, 1987.

Estimated environmental risks due to atmospheric chemical releases from the miscellaneous chemical basin are conservatively considered the same as for the metals burning pit (Section F.1.2.1). As discussed in that section, the risks are very low and are considered not significant.

The concentrations for the erosion, reclaimed farmland, and biointrusion pathways are expected to be zero.

Potential Impacts (Other Than Releases)

Section F.1.4.1 describes the ecological impacts of no action. Potential impacts on the aquatic biota of outcropping streams were determined for tetrachloroethylene and trichloroethylene, which were considered to have potential impacts on the aquatic system. The results of the PATHRAE model analysis indicate that these particular compounds should not cause adverse effects to the water quality in Tims Branch and to aquatic biota under any closure action. Due to the rapid leaching of the mobile contaminants and the low level of soil contamination, vegetation and herbivorous wildlife should not receive adverse impacts.

F.1.5.2 Assessment of No Removal of Waste and Implementation of Cost-Effective Remedial and Closure Actions as Required

Description of Action

The 1974 photographs of this site indicated that it was a small, shallow depression - approximately 6 meters by 6 meters by 0.3 meter deep. The specific location would be confirmed by shallow soil core sampling. A low-permeability cap (Figure F-2) would be placed on top of the miscellaneous chemical basin. The area of the cap would be about 2000 square meters (approximately 45 by 45 meters) to cover the impacted area completely. The cap would be graded and revegetated in a manner similar to the current status of the site. Five new monitoring wells would be installed; they would be monitored quarterly for 1 year, and then annually for 29 years. Site maintenance would continue for the entire 30-year period.

To reduce the concentration of tetrachloroethylene in the groundwater to levels below the applicable standards in the vicinity of the basin, additional corrective actions, such as groundwater extraction and treatment, might be needed.

Comparison of Expected Environmental Releases with Applicable Standards

The chemical constituent of concern at this site is tetrachloroethylene. The concentrations of tetrachloroethylene in the groundwater are shown on Table F-4. This table lists the applicable standard for the contaminant, the predicted concentrations, and, in parentheses, the year in which the maximum concentration is expected to be reached. In the vicinity of the site wells at 1 and 100 meters, the concentrations exceed the applicable standard.

Surface-water quality would not be significantly affected by the addition of potential contaminants from the groundwater pathway from this site, as the resulting concentrations of constituents in the Savannah River are projected to be below drinking-water standards.

Estimated environmental risks due to atmospheric chemical releases from the miscellaneous chemical basin were added to those from the nearby metals burning pit (Section F.1.2.1). The risks are very low and are considered not significant.

The expected concentrations for the erosion, reclaimed farmland, and the biointrusion pathways are estimated as zero.

Potential Impacts (Other Than Releases)

The potential ecological impacts of waste removal and closure for the miscellaneous chemical basin are expected to be similar to those addressed in Sections F.1.5.1 and F.1.14.2.

F.1.5.3 Assessment of Removal of Waste to the Extent Practicable, and Implementation of Cost-Effective Remedial and Closure Actions as Required

Description of Action

Analyses of soil samples collected during the installation of the proposed groundwater monitoring well (at the center of the site) would determine a depth-contamination profile. However, for purposes of estimating the disposal costs, the soil would be excavated to an assumed depth of 2 meters. The total excavated volume would be 72 cubic meters. The excavated material would be placed in metal boxes and transported to a waste storage/disposal facility. The site would be backfilled with clean material, regraded, vegetated, and then allowed to return to its natural state. Five new monitoring wells would be installed; they would be monitored quarterly for 1 year, then annually for 29 years. Site maintenance would continue for the entire 30-year period.

Additional corrective actions, such as groundwater extraction and treatment, might be needed to address the constituents already in the groundwater. The exact action to be taken would be determined by site-specific studies and by interactions with regulatory agencies.

Comparison of Expected Environmental Releases with Applicable Standards

This closure action was not modeled, as the constituent of concern was assumed to have leached beyond the zone of excavation by the time remedial actions would occur. Therefore, the site would behave in the manner as described in Section F.1.5.1. Table F-4 lists the estimated maximum concentrations of the chemical constituents based on results of groundwater modeling.

Estimated environmental and occupational risks due to atmospheric chemical releases from the miscellaneous chemical basin are conservatively considered the same as for the metals burning pit. As discussed in Section F.1.2.3, the risks are very low and are considered insignificant.

The expected concentrations for the erosion, reclaimed farmland, and biointrusion pathways are zero for this closure action.

Potential Impacts (Other Than Releases)

The potential ecological impacts of waste removal and closure for the miscellaneous chemical basin are expected to be similar to those addressed in Sections F.1.5.1 and F.1.14.3.

F.1.6 BURNING/RUBBLE PITS*

There are 15 burning/rubble pits on the SRP, located in A-, F-, R-, CS-, C-, D-, K-, L-, and P-Areas, as follows:

Area	Building	Area	Building
A	731-A	CS	631-6G
A	731-1A	C	131-C
F	231-F	D	431-D
F	231-1F	D	431-1D
R	131-R	K	131-K
R	131-1R	L	131-L
CS	631-1G	P	131-P
CS	631-5G		

TE All of these pits operated over essentially the same time period and received similar waste. Consequently, the closure actions, potential releases, and associated environmental effects would be expected to be similar. Therefore, the actions, releases, and impacts described in this section would be applicable to each of the burning/rubble pits.

The assessments of groundwater and surface-water releases presented here are based on the C-Area burning/rubble pit, which is assumed to be representative of groundwater and surface-water releases of all the burning/rubble pits at the SRP. To provide a relative scale for the burning/rubble pits, the estimated disposal mass of contaminants selected for environmental assessment is listed in Table F-5.

A similar scenario was developed for atmospheric releases. The two pits in A-Area (Buildings 731-A and 731-1A) and the pit in C-Area were analyzed as a single site for purposes of assessment of the atmospheric releases from the three pits. Atmospheric releases from each of the remaining 12 pits in F-, R-, CS-, D-, K-, L-, and P-Areas were assessed on the basis of a single site containing a combination of the wastes deposited in those 12 pits.

*The reference source of the information in this section is Huber, Johnson, and Marine, 1987.

Table F-5. Estimated Disposal Mass of Contaminants in the Burning/Rubble Pits

	Estimated Disposal Mass		
Area	Lead (kg)	Chromium (kg)	Chlorinated hydrocarbons (kg)
A	-	-	1.2[a]
F	-	-	16.4[a,b]
C	38	160	54[a]
CS	-	-	-
D	2.2	-	0.099[b]
K	-	-	3.71[a,b]
L			-
P	30	-	26.2[a,b,c]
R	-	-	1.5[b]

TC

[a]Trichloroethylene.
[b]Tetrachloroethylene.
[c]1,1,1-trichloroethane, trans-1,2-dichloroethylene, 1,1-dichloroethylene.

F.1.6.1 Assessment of No Action (No Removal of Waste, and No Remedial or Closure Actions)

Description of Action

Under no action, the burning/rubble pits would be left in their current status. Groundwater monitoring would continue quarterly for 1 year, then annually for 29 years. Site maintenance would continue for the entire 30-year period. TE

Comparison of Expected Environmental Releases with Applicable Standards

The chemical constituents and waste materials selected for consideration of the environmental impact and health risks associated with burning/rubble pits are chromium, lead, and trichloroethylene. These constituents were selected because they were found in the groundwater at the pit sites at levels higher than the threshold selection criteria.

The pathways associated with this site that may have an impact on human health include those cited in Subsection F.1.2.1 and, in addition, direct gamma radiation.

The groundwater contaminant transport analysis of the burning/rubble pits was performed only for the C-Area burning/rubble pit. The results of this analysis are summarized in Table F-6, which presents the expected maximum concentrations of trichloroethylene, based on results of groundwater modeling as TC determined for the C-Area burning rubble pit for all of the closure actions and for no action. The table also lists the applicable standard and the year in which the maximum concentration is expected to occur. The table indicates that the maximum concentrations of trichloroethylene at the 1- and 100-meter wells are in excess of the applicable standard. Table F-6 also lists monitoring data for cadmium, lead, mercury, nitrate, gross alpha, gross beta, and radium, which exceeded applicable standards. Peak values of chromium and lead are predicted to be below their applicable standards. Peak concentrations of the three modeled constituents (chromium, lead, and trichloroethylene) are predicted to be the same. TC

Surface-water quality would not be significantly affected by the addition of potential contaminants from the groundwater pathway from these sites, as the resulting concentrations of constituents in onsite streams and the Savannah River are projected to be below drinking-water standards.

As indicated above, estimated environmental risks due to atmospheric chemical releases from the burning/rubble pits within each geographic grouping are conservative because they are based on emissions from several burning/rubble pits. Risks are still quite low for these worst-case scenarios. For example, the highest reported chemical carcinogenic risk to the maximally exposed individual is less than 10^{-8}. The EPA Hazard Index for noncarcinogens is less than 10^{-5}. These risks are considered not significant. TC

The predicted maximum concentration for the erosion pathway is zero because the length of time that it takes the constituents to start eroding is well over 1000 years.

Potential Impacts (Other Than Releases)

Section F.1.14.1 describes the ecological impacts under no action. Results from the C-Area PATHRAE analysis indicate no impact on existing in-stream concentrations of chromium, lead, and trichloroethylene under any of the closure actions. Therefore, no aquatic impacts would be expected. Impacts from root uptake of wastes are expected to be negligible for all closure actions because PATHRAE modeling indicates that contaminants have already migrated vertically out of the soil profile. Because the C-Area burning/rubble pit has the largest estimated waste inventory, aquatic and biointrusion impacts are not expected at other burning/rubble pits.

F.1.6.2 Assessment of No Removal of Waste and Implementation of Cost-Effective Remedial and Closure Actions as Required

Description of Action

Under the no-removal-and-closure action, all waste would be left in its present location. Since all burning/rubble pits have been backfilled, no further backfill would be required. Groundwater monitoring would continue on a quarterly basis for 1 year, then annually for 29 years. Site maintenance would continue for the entire 30-year period. TE

Additional corrective actions, such as groundwater extraction and treatment, might be needed to reduce the concentration of chlorinated hydrocarbons in the groundwater.

Comparison of Expected Environmental Releases with Applicable Standards

The chemical constituents, the consequences of environmental releases, and the pathways associated with this action are the same as those for no action (see Section F.1.6.1) because the pit has been backfilled and is considered closed.

Potential Impacts (Other Than Releases)

Sections F.1.6.1 and F.1.14.2 describe the ecological impacts of no waste removal and closure for the A-Area burning/rubble pits.

F.1.6.3 Assessment of Removal of Waste to the Extent Practicable, and Implementation of Cost-Effective Remedial and Closure Actions as Required

Description of Action

TE Under the waste-removal-and-closure action, all waste deposited in the burning/rubble pits would be excavated, as would any contaminated soil, to a depth of 1 meter below the base of the pits. The waste and contaminated material would be placed in metal boxes and sent to a waste storage/disposal facility. The pits would be backfilled with clean excavated backfill and additional clean soil, compacted as necessary to prevent settling, and seeded. The amount of soil required to backfill and the amount of waste to be removed at each pit are as follows:

Building	Soil (m^3)	Waste (m^3)	Building	Soil (m^3)	Waste (m^3)
731-A	22,140	5,460	631-6G	3,298	804
731-1A	6,683	1,630	131-C	3,325	811
231-F	6,494	1,584	431-D	5,166	1,260
231-1F	10,889	2,606	431-1D	3,510	856
131-R	1,902	466	131-K	2,615	638
131-1R	2,948	719	131-L	2,529	617
631-1G	2,276	555	131-P	4,802	1,171
631-5G	5,146	1,255			

Groundwater would continue to be monitored on a quarterly basis for 1 year, then annually for 29 years. The sites would be maintained on a basis similar to the surrounding grounds for 30 years.

Additional corrective actions, such as groundwater extraction and treatment, might be needed to reduce the concentration of chlorinated hydrocarbons in the groundwater.

Comparison of Expected Environmental Releases with Applicable Standards

The chemical constituents, the consequences of environmental releases, and the pathways are the same as those for no action. The predicted maximum concentrations of the chemical constituents for this action are the same as those for no action as the constituents are assumed to have leached beyond the zone of control (see Section F.1.6.1).

Expected environmental risks to the maximally exposed individual due to atmospheric releases of chemical carcinogens from these burning/rubble pits for this action are about 20 to 100 times less than those for no action and are considered not significant. The peak EPA Hazard Index value for noncarcinogens is 3.37×10^{-8}.

Occupational risks associated with this action were also calculated. They are very low (carcinogenic risk of 5.24×10^{-9}; EPA Hazard Index for noncarcinogens of 1.0×10^{-4}) and are considered not significant, particularly when the conservatism built into the emissions is accounted for. TC

The predicted maximum concentrations for the erosion pathways are zero for this closure action.

Potential Impacts (Other Than Releases)

The potential ecological impacts of waste removal and closure for the A-Area burning/rubble pits are discussed in Sections F.1.6.1 and F.1.14.3.

F.1.7 A-AREA BURNING/RUBBLE PIT, BUILDING 731-1A

This burning/rubble pit is discussed in conjunction with the other pits in Section F.1.6. The ecological effects of this site that relate specifically to the A- and M-Area geographic grouping are discussed in Section F.1.14.

F.1.8 SRL SEEPAGE BASINS*

The Savannah River Laboratory (SRL) seepage basins [Buildings 904-53G (Basins 1 and 2), 904-54G (Basin 3), and 904-55G (Basin 4)] stopped receiving wastes in October 1982. Background information on the history of waste disposal, waste characteristics, and evidence of contamination are presented in Appendix B, Section B.2.2.

F.1.8.1 Assessment of No Action (No Removal of Waste, and No Remedial or Closure Actions)

Description of Action

Under no action, the site would be left in its present condition. Groundwater monitoring at existing wells would continue quarterly for 1 year and then annually for 29 years. Upkeep would consist of maintaining a fence and signs around the basin area and cutting the weeds periodically for the entire 30-year period. TE

Comparison of Expected Environmental Releases with Applicable Standards

PATHRAE predicts that arsenic will exceed groundwater standards during the first 200 years of the modeled period. Table F-7 lists these parameters, the TC

*The reference source of the information in this section is Fowler et al., 1987.

corresponding regulatory standards, and the maximum concentrations predicted to be found in the groundwater near the basins. All other constituents modeled were predicted to be below applicable standards. Table F-7 also shows monitoring data for nickel, which exceeded the applicable standard but was not selected for modeling.

Surface-water quality would not be significantly affected by the addition of potential contaminants from the groundwater pathway from this site, as the resulting concentrations of constituents in the Savannah River are projected to be below drinking-water standards.

The nonradioactive constituents were analyzed, using the methodology discussed in the introduction to Appendix F and in Appendix I, to estimate public exposure and risk attributable to constituents released to the atmosphere from the SRL seepage basins. Releases to the maximally exposed individual are due to the volatilization of the contaminants and wind erosion. Risks attributable to releases of carcinogens are less than 10^{-7}. Environmental risks due to atmospheric chemical releases were calculated. The carcinogenic risks to the maximally exposed individual are less than 1.0×10^{-7} with a value of 2.31×10^{-8} for 1985 and 1.61×10^{-8} for 2085. The EPA Hazard Index for noncarcinogens is 5.24×10^{-5}. TC TC

Environmental doses and risks to the maximally exposed individual due to radiological releases from SRL seepage basins were calculated using the methodology presented in the introduction to this appendix and in Appendix I. The calculated doses are less than 3 percent of the DOE limit of 25 millirem. The risks associated with these doses would be less than 2.0×10^{-7}.

Potential Impacts (Other Than Releases)

Section F.1.14.1 describes the ecological impacts of no action. PATHRAE modeling was performed on arsenic, cadmium, chromium, copper, fluoride, lead, mercury, nickel, phosphate, silver, zinc, sodium, tritium, cobalt-60, strontium-90, yttrium-90, cesium-137, uranium-235 and -238, plutonium-238 and -239, americium-241, and curium-244. The four SRL seepage basins were modeled as a single unit to estimate cumulative effects resulting from the closure actions. The results of the PATHRAE analysis indicate that these elements would not alter the present water quality of the Savannah River under any of the closure actions. Because the levels of groundwater outcrop contamination are ecologically insignificant for all closure actions, no impacts are expected to aquatic biota of the river or the adjacent wetlands. In addition, wildlife consuming undiluted groundwater at the outcrop would not receive adverse effects. TE

Because the SRL seepage basins have standing surface water, there could be impacts on the wildlife that consume this water. Based on the available chemical analysis data on the standing surface water of the seepage basins, pH, iron, manganese, mercury, gross alpha, and gross beta exceed either primary or secondary drinking-water standards; thus, impacts are possible under no action.

No action would produce limited terrestrial impacts. The maximum concentrations in the basin soils for americium-241, curium-244, cobalt-60, cesium-137, tritium, plutonium-238, -239, and -240, strontium-90, and uranium-235 and -238 exceed DOE's Threshold Guidance Limits, which are based on human health concerns and are conservative. The maximum concentrations in the basin soils for cadmium, chromium, copper, mercury, nickel, and silver exceed the phytotoxic benchmarks, indicating that these concentrations could cause such vegetation impacts as reduced plant growth and increased plant mortalities via the biointrusion pathway. However, food-chain uptake calculations indicate that the predicted vegetation concentrations are below the levels considered toxic to consuming wildlife. Any terrestrial impacts would be limited to the area occupied by the basins (approximately 2.15 acres).

F.1.8.2 Assessment of No Removal of Waste and Implementation of Cost-Effective Remedial and Closure Actions as Required

Description of Action

TE Under the no-removal-and-closure action, approximately 2500 cubic meters of standing water in basins 1, 2, and 3 would be moved to basin 4, where it would be removed by continuing seepage, supplemented by accelerated evaporation, if required. There would be no excavation. The basins would be backfilled and capped. The fill would consist of 61 to 122 centimeters of crushed stone or washed gravel covered by a geotextile filter fabric and a minimum of 61 centimeters of common borrow fill. This would be covered by a low-permeability cap (see Figure F-2). Basins 1, 2, and 3 would be restored to the original ground surface (Figure F-3). Basin 4 would be filled and graded to remain above the original ground surface to ensure that the bottom sediments were covered (Figure F-4). Groundwater would be monitored quarterly for 1 year and then annually for 29 years. Site maintenance would continue for the entire 30-year period.

TE Corrective action might be required since results of PATHRAE modeling predict that the concentrations in the groundwater of arsenic would remain above the MCLs (see Table F-7). The precise actions to be taken would be decided on the basis of site-specific studies and interactions with regulatory agencies. Appendix C describes some possible treatment technologies.

Groundwater cleanup would consist of the removal of water from wells placed to contain the contaminant plume, and the physical or chemical treatment of this water to remove contaminants to concentrations that meet applicable health-based standards. Possible treatment technologies are discussed in Appendix C.

Comparison of Expected Environmental Releases with Applicable Standards

TC The implementation of this closure action, plus remedial action, would reduce all environmental releases of arsenic to below MCLs or other health-based standards (see Table F-7 for a listing of applicable standards). All other environmental releases are projected to be below regulatory standards.

TC The analysis described in the air release portion of Section F.1.8.1 was also performed for the no waste removal and closure action. Risks attributable to the release of carcinogens were calculated to be less than 10^{-20}. The hazard index attributable to the release of noncarcinogens was calculated to be less than 1, with the maximum fraction of the ADI of less than 6.5×10^{-9}. The implementation of this closure action will reduce carcinogenic releases to zero. Noncarcinogenic risks to the maximally exposed individual are due to the volatilization of mercury. The associated EPA Hazard Index is less than

1.0×10^{-8}. The radionuclide dose is calculated to be 1.1×10^{-14} percent of the DOE limit of 25 millirem or less for each of the 3 years. The risk associated with this dose would be less than 8×10^{-22}.

Potential Impacts (Other Than Releases)

Sections F.1.8.1 and F.1.14.2 describe the ecological impacts of no waste removal and closure. The contaminated water would be processed to meet NPDES standards before discharge. Therefore, no significant biological impacts on surface waters are expected. This would also eliminate possible impacts due to wildlife consumption of basin waters. Closure of the basins would remove terrestrial impacts due to biointrusion.

F.1.8.3 Assessment of Removal of Waste to the Extent Practicable, and Implementation of Cost-Effective Remedial and Closure Actions as Required

Description of Action

Under the waste-removal-and-closure action, the basin water would be removed as described in Section F.1.8.2. The basins would be excavated of waste, and the waste would be transported to a storage/disposal facility. Approximately 31 centimeters would be excavated each from basins 1 and 2, 16 centimeters would be excavated from basin 3, and 8 centimeters from basin 4. A total of 1900 cubic meters would be excavated from the four SRL seepage basins. The basins would be backfilled and the site would be capped as described in Section F.1.8.2. Groundwater would be monitored quarterly for 1 year and then annually for 29 years. Site maintenance would continue for the entire 30-year period. TE

Corrective actions might be required because the results of PATHRAE modeling indicate that the concentrations of arsenic in the groundwater would remain above the MCLs (see Table F-7). The exact actions to be taken would be determined after site-specific studies and interactions with regulatory agencies. Some of the possible treatment technologies are discussed in Appendix C.

Comparison of Expected Environmental Releases with Applicable Standards TE

The implementation of this closure action, plus remedial action, would reduce all environmental releases to below MCLs or other health-based standards (see Table F-7 for a listing of applicable standards). All other environmental releases are projected to be below regulatory standards.

The analysis of atmospheric releases described in Section F.1.8.1 was also performed for the waste-removal-and-closure action. Releases are due to the volatilization of the constituents and earth-moving activities in 1986 and to volatilization in other years. Risks attributable to releases of carcinogens are less than 1.2×10^{-11}. The EPA Hazard Index for releases of noncarcinogens is less than 2.3×10^{-8}. TC

The calculated dose to the maximally exposed individual at the SRP boundary for each of the 3 years is less than 0.06 percent of the DOE limit of 25 millirem. The risk associated with this dose would be less than 3.8×10^{-9}.

TC An analysis of the average individual worker health risks attributable to occupational exposure to carcinogens (both nonradioactive and radioactive) and noncarcinogens was performed using the methodology presented in Appendix I. The risk to a worker from nonradioactive carcinogens was calculated as less than 1.8×10^{-7}. The Hazard Index from noncarcinogens to a worker would be 1.23×10^{-2}. The total dose to the worker was calculated as 9.9 millirem, which is equivalent to a risk of 2.8×10^{-6}. The total dose to the worker transporting the waste was calculated to be 18 millirem, equivalent to a risk of 5.1×10^{-6}.

Potential Impacts (Other Than Releases)

Impacts associated with waste removal and closure would be similar to those described in Sections F.1.8.2 and F.1.14.3.

F.1.9 SRL SEEPAGE BASIN, BUILDING 904-53G (BASIN 2)

This seepage basin is discussed in conjunction with the other SRL seepage basins in Section F.1.8.

F.1.10 SRL SEEPAGE BASIN, BUILDING 904-54G (BASIN 3)

This seepage basin is discussed in conjunction with the other SRL seepage basins in Section F.1.8.

F.1.11 SRL SEEPAGE BASIN, BUILDING 904-55G (BASIN 4)

This seepage basin is discussed in conjunction with the other SRL seepage basins in Section F.1.8.

F.1.12 M-AREA SETTLING BASIN AND VICINITY*

The M-Area settling basin (Building 904-51G) and its associated areas have been designated as the M-Area Hazardous Waste Management Facility (HWMF). The areas included in the HWMF include the settling basin, overflow ditch, natural seepage area, a Carolina bay known as "Lost Lake" (Building 904-112G), and the inlet process sewer line. The HWMF received process effluents between 1958 and 1985. Background information on the history of waste disposal, waste characteristics, and evidence of contamination are presented in Appendix B, Section B.2.3.

F.1.12.1 Assessment of No Action (No Removal of Waste, and No Remedial or Closure Actions)

Description of Action

TE Under no action, the liquid in the settling basin would be allowed to infiltrate or evaporate. The soils in the overflow ditch, seepage area, and Lost Lake would remain in place. General maintenance of the area around the basin, including vegetation control and maintenance of the exclusion fence, would continue. Monitoring of the groundwater would continue quarterly for 1 year,

*The reference source of the information in this section is Pickett, Colven, and Bledsoe, 1987.

then annually for 29 years. The existing groundwater treatment facility would continue to process recovered groundwater contaminated with varying amounts of chlorocarbons. The treatment facility consists of an air stripper that is supplied with feed water from 11 groundwater withdrawal wells. The system is capable of treating a maximum flow of 1250 liters per minute. Treat ' ᶠᶠ¹ -ent from the air stripper is discharged to a tributary of Tims Branch Creek at existing NPDES Outfall A-14. No additional remedial action is planned for no action.

Comparison of Expected Environmental Releases with Applicable Standards

Current groundwater monitoring data indicate that concentrations of nitrate, nickel, gross alpha, gross beta, radium, tetrachloroethylene, 1,1,1-trichloroethane, and trichloroethylene exceed actual or proposed regulatory standards. PATHRAE modeling results indicate that groundwater concentrations of barium, cadmium, lead, nickel, nitrate, tetrachloroethylene, 1,1,1-trichloroethane, and trichloroethylene will exceed standards at various times in the future. However, the PATHRAE model does not account for removal of the chlorocarbons by the existing groundwater treatment facility. | TC

Table F-8 lists all constituents in the groundwater that currently exceed or are projected to exceed regulatory standards for the no-action alternative. The PATHRAE simulation indicates that future concentrations of modeled constituents in Tims Branch (due to outcrop of contaminated groundwater) will be below drinking-water standards.

The nonradioactive constituents were analyzed, using the methodology discussed in the introduction to Appendix F and in Appendix I, to estimate public and maximum individual exposure and risk attributable to releases of constituents to the atmosphere from the M-Area HWMF. The analysis was performed for each of the subareas: M-Area settling basin, the overflow ditch and seepage area, Lost Lake, and the air stripper. | TC | TC

Releases are due to the volatilization of the constituents and to wind erosion. Risks to the maximally exposed individual attributable to releases of carcinogens are less than 5×10^{-8} for each subarea for each of the 3 selected years (the air stripper will operate for a period of 30 years). The Hazard Index attributable to releases of noncarcinogens are calculated to be below 1, with a maximum value less than 2×10^{-4} for each of the 3 years. | TC

Environmental doses and risks to the maximally exposed individual due to radiological releases from the M-Area HWMF were calculated using the methodology presented in the introduction to this appendix and in Appendix I. The calculated doses are less than 1 percent of the DOE limit of 25 millirem for each of the 3 years. The risks associated with these doses would be less than 3×10^{-8}. | TC

Potential Impacts (Other Than Releases)

Section F.1.14.1 describes the ecological impacts of no action. For the M-Area Settling Basin, PATHRAE modeling was performed on bis (2-ethylhexyl) phthalate, barium, cadmium, chromium, copper, cyanide, 1,1-dichloroethylene, lead, mercury, nickel, nitrate, tetrachlorobiphenyl, phosphate, silver, sodium, tetrachloroethylene, 1,1,1-trichloroethane, trichloroethylene, zinc, | TE and uranium-238 because each was identified as having potential impacts on the aquatic system. The results indicate that none of these materials would, after mixing, alter the present water quality of Upper Three Runs Creek under any closure action; thus aquatic biota in the stream would not be affected. TE

Levels of lead, nitrate, and tetrachloroethylene would exceed EPA water-quality criteria under no action at year 200 in the relatively unmixed waters of wetlands adjacent to the groundwater outcrop, indicating the potential for aquatic impacts. The groundwater outcrop concentration of tetrachloroethylene would exceed drinking-water standards under all closure actions, indicating a potential for impacts to wildlife that consume the undiluted groundwater. However, a comparison of the outcrop concentration with that considered toxic for wildlife revealed that wildlife should not receive adverse impacts.

Based on available data, the contaminant levels in basin waters of cadmium, lead, nitrate, phosphate, sodium, tetrachloroethylene, trichloroethylene, and trichloroethane exceed EPA drinking-water standards. Comparisons of these levels with levels considered toxic to wildlife revealed that no adverse effects on wildlife are expected. Food-chain uptake calculations based on the bioconcentation by aquatic macrophytes of heavy metals from the standing water indicate that the predicted concentrations of heavy metals from the standing water are well below the concentrations considered toxic to herbivorous wildlife.

The maximum contaminant concentrations in the settling basin soil for chromium, copper, lead, mercury, nickel, silver, and zinc exceed the phytotoxic concentrations, indicating that such adverse impacts as reduced plant growth and increased plant mortalities are probable. The maximum contaminant concentration in the settling basin and Lost Lake soils for bis (2-ethylhexyl) TE phthalate exceeds the no-effect concentration, indicating the potential for adverse effects on vegetation. However, food-chain uptake calculations indicate that the predicted vegetation concentrations are below the levels considered toxic to herbivorous wildlife at both the settling basin and Lost Lake. Terrestrial impacts would be limited to the general area occupied by the settling basin and Lost Lake.

Although no endangered species have been observed at Lost Lake, an alligator has been observed living in the M-Area settling basin since 1985. No action would not displace this animal; the long-term impacts to the alligator from TE residing in the basin are not known.

Under no action, heavy metals and salts would be deposited in the soil of the M-Area settling basin and Lost Lake as the water evaporated. Small temporary TE pools would concentrate wastes, which could result in the pools being unsuitable habitat for the reproduction of amphibians and reptiles. Waste concentrations could also affect revegetation; thus, the utility of Lost Lake for reestablishment as a typical Carolina Bay is unlikely under no action.

F.1.12.2 Assessment of No Removal of Waste and Implementation of Cost-Effective Remedial and Closure Actions as Required

Description of Action

The steps involved in cleanup of the M-Area settling basin and vicinity by closure without waste removal are as follows:

- The remaining liquid in the basin would be decanted by being pumped into the overflow areas and Lost Lake, where enhanced evaporation and infiltration would occur. Pumping rates would not exceed historical overflow rates (750 to 1100 liters per minute), so as not to disturb the underlying sludge layer or overwhelm the retention capacity of the seepage and Lost Lake areas. Entrainment would be minimized by the design of pumping apparatus. Any suspended or dissolved materials carried over during this process would be retained in the shallow sediments after natural evaporation of the water.

- The gelatinous sludge layer in the basin would be stabilized to produce a solid material capable of supporting heavy equipment operation and the overburden load produced by fill and cap materials. A chemically suitable stabilization agent (Type I Portland cement) has been tested and was demonstrated to provide sufficient load-bearing capacity. The stabilization process would be performed in situ by mixing the agent directly with the sludge. The mixture ratio that demonstrated acceptable performance was 0.5 kilogram of agent per liter of sludge. The resulting product would be a layer of solid material covering the basin floor.

- A recharge network would be installed beneath the basin to flush organic contamination in the vadose zone to the groundwater, where in-place recovery systems would remove and treat the water.

  The recharge network would consist of a series of 15-centimeter-diameter perforated PVC pipe placed at 6-meter spacings lengthwise in the basin, connected by nonperforated pipe to a manhole at each end of the basin. This perforated pipe would be laid in 2.5-meter-deep trenches, which would then be backfilled with 0.3 meter of gravel and 2.2 meters of original soil. The 2.5-meter depth would put the recharge system below the metal contamination in the soil to prevent dissolution and migration of waste material.

  The purpose of the recharge network would be to replace the natural infiltration of rainwater, which would be cut off by the low-permeability cover. Clean water would be introduced to the system through a manhole at an infiltration rate of 8 liters per minute. At this rate, the network would simulate a natural recharge that serves to flush vadose zone organic contamination.

- The soils and dried sludge contaminated with metals from the overflow ditch, seepage area, and Lost Lake would be excavated. Also, the process sewer line and manholes would be removed, as would 0.6 meter of soil beneath the sewer line between the basin and manhole No. 1 inside the M-Area exclusion perimeter. The total volume of soil to be excavated is shown below:

Soil/sludge from overflow ditch adjacent seepage area		5,150 cubic meters
Remainder of seepage area		7,500
Lost Lake		16,900
Process sewer, manholes, and soil		840
	Total	≈30,400 cubic meters

All excavated soil and rubble would be placed in the basin and compacted to support the basin cap. Fill dirt would be added if required to level the material at the top of the berm.

- A low-permeability cap would be emplaced (Figure F-2). The cap would be designed and constructed to provide a maximum permeability of 1×10^{-7} centimeter per second. A layer of more permeable material would be placed on top of the cap, and a 0.6-meter-thick layer of topsoil would be added. The cap would be graded and planted to minimize erosion.

- Routine site maintenance would be carried out and a groundwater monitoring program would be maintained quarterly for 1 year and then annually for 29 years.

The current groundwater remedial action program for treatment of chlorocarbons would continue. The recharge network would flush chlorocarbons in the vadose zone to the water table, where the in-place groundwater recovery wells would remove and treat the water.

Additional remedial action may be taken to reduce concentrations of barium, cadmium, nickel, and nitrate constituents that PATHRAE simulations predict would exceed MCLs or other health-based standards in the future under this action (see Table F-8).

Comparison of Expected Environmental Releases with Applicable Standards

The PATHRAE model predicts that the closure actions described above would maintain the groundwater concentration of lead within its MCL. The current groundwater treatment facility is designed to reduce concentrations of chlorocarbons to within MCLs, and the potential additional groundwater treatment is expected to reduce concentrations of nitrate, cadmium, nickel, and barium to within MCLs or other health-based standards. In addition, gross alpha and gross beta constituents, which include radium and most alpha and beta radionuclides, would be reduced to levels within MCLs or ACLs by means of additional treatment. The PATHRAE simulation predicts that concentrations of inorganic constituents in the groundwater outcrop at Tims Branch would be below drinking-water standards. Treated effluent from the in-place groundwater treatment facility would be discharged to a tributary of Tims Branch and would be in compliance with NPDES permit limitations.

The analysis of atmospheric releases described in Section F.1.12.1 was also performed for this action. Releases of carcinogens would be caused by the volatilization of contaminants through the cap on each basin. Risks to the TC

TC maximally exposed individual attributable to these releases were calculated to be less than 1.6 x 10^{-8} for each of the 3 years for each subarea. The hazard index attributable to releases of noncarcinogens was calculated to be much less than 1, with a maximum value less than 1.7 x 10^{-6} for each of the 3 selected years for each subarea. The calculated radionuclide dose is less than 2 x 10^{-2} percent of the DOE limit of 25 millirem for each of the 3 years. The risk associated with this dose would be less than 8 x 10^{-10}.

Potential Impacts (Other Than Releases)

Section F.1.14.2 describes the ecological impacts of no waste removal and closure. Backfilling and capping the M-Area settling basin would eliminate potential impacts associated with exposure to standing basin water and soils. The water in the M-Area settling basin would be pumped into Lost Lake, where it would evaporate and infiltrate. Decreases in groundwater contamination would occur.

After liquids were evaporated from Lost Lake and the top several centimeters of soil were removed, the potential for the direct contamination of wildlife would be reduced. The area would be regraded and planted in either moisture-tolerant trees or pine, depending on elevation. Moisture-tolerant species would include sycamore, red maple, or tulip poplar. After revegetation, the area would be allowed to return to a wetlands environment. Reinvasion by wildlife such as amphibians and turtles should occur.

F.1.12.3 Assessment of Removal of Waste to the Extent Practicable, and Implementation of Cost-Effective Remedial and Closure Actions as Required

Description of Action

The steps involved in cleanup of the M-Area settling basin and vicinity by waste removal and closure are as follows:

- The remaining liquid portion in the basin would be decanted in a manner identical to that described in Section F.1.12.2.

- The gelatinous sludge layer in the basin would be stabilized to facilitate removal and handling. The sludge would be treated with adsorbents or drying agents to produce a material which could be removed by normal excavation methods.

- Soil and sludge contaminated with metals from the basin, overflow ditch, seepage area, and Lost Lake would be removed, as would the process sewer line, manholes, and 0.6 meter of soil beneath the sewer line between the basin and manhole No. 1 inside M-Area. The extent to which soil removal for metals contamination would be required would depend on results of soil and sludge characterization studies. In general, the depth of soil removal would range from a few centimeters in Lost Lake to 2 meters beneath the basin to remove metal contamination significantly above background levels. Estimates of the total volume of material to be removed in this step are as follows:

Sludge/soil beneath basin		11,000 cubic meters
Stabilized sludge		4,500
Overflow ditch and adjacent seepage area		5,150
Remainder of seepage area		7,500
Lost Lake		16,900
Process sewer, manholes, and soil		840
	Total	45,890 cubic meters

- The soil and sludge removed from the M-Area basin and vicinity would be transported to a waste storage/disposal facility.

- The basin and vicinity would be backfilled and regraded with clean onsite fill material. No cap would be required. An estimated 30,000 cubic meters of fill material would be required. The area would be revegetated with grass and trees to restore the natural state.

- Postclosure monitoring would begin and the cleanup of organic contamination in the groundwater and vadose zone would continue. In-place monitoring wells would be used to define the extent of contamination and evaluate the effectiveness of cleanup activities. These wells would also be used to determine the point at which groundwater cleanup activities could be discontinued.

- Groundwater treatment for removal of organic contamination would be accomplished by means of the in-place recovery well network and air stripping system. Vadose zone contamination would be allowed to migrate via natural recharge to the groundwater, where in-place recovery systems would remove and treat the water.

- Routine site maintenance would be carried out, and a groundwater monitoring program would be maintained quarterly for 1 year and then annually for 29 years.

Potential additional remedial action, as described in Section F.1.12.2, may be required to reduce groundwater concentrations of barium, cadmium, lead, nickel, and nitrate to levels within MCLs. As shown in Table F-8, PATHRAE simulations predict that these constituents will exceed regulatory standards at various times in the future for waste removal and closure.

Comparison of Expected Environmental Releases with Applicable Standards

The discussion presented in Section F.1.12.2 is also relevant to waste removal and closure.

The analysis of atmospheric releases described in Section F.1.12.1 was also performed for this action. Releases in the first year are due to excavation and backfilling. In future years, releases would be caused by volatilization of contaminants. Releases due to emissions from the air stripper are zero for the years 2085 and 2985 since the facility will only operate 30 years. Risk to the maximally exposed individual attributable to releases of carcinogens TC was calculated to be less than 1.6×10^{-8}. The maximum EPA Hazard Index for noncarcinogens was calculated to be less than 1.7×10^{-6}.

The calculated radioactive dose to the maximally exposed individual at the SRP boundary for each of the 3 years is less than 3×10^{-6} percent of the DOE limit of 25 millirem. The risk associated with this dose would be less than 1.4×10^{-9}.

TC An analysis of the average individual worker health risks attributable to occupational exposure to carcinogens (both nonradioactive and radioactive) and noncarcinogens was performed using the methodology presented in Appendix I. The risk due to nonradioactive carcinogens to a worker was calculated to be less than 3.2×10^{-9}. The EPA Hazard Index due to noncarcinogens to a worker was calculated to be 8.7×10^{-4}. The total radioactive dose to the worker was calculated as 47 millirem, which translates to a risk of 1.3×10^{-5}. The total dose to the worker transporting the waste would be 23.3 millirem, which translates to a risk of 6.5×10^{-6}.

Potential Impacts (Other Than Releases)

TE Because of the similarity of this action and the no-waste-removal-and-closure action, impacts would be similar to those described in Section F.1.12.2.

F.1.13 LOST LAKE, BUILDING 904-112G

Lost Lake is discussed in conjunction with the M-Area settling basin and vicinity in Section F.1.12.

F.1.14 POTENTIAL IMPACTS ON BIOLOGICAL RESOURCES IN A- AND M-AREA

This section discusses those generic impacts related to aquatic and terrestrial ecology, as well as endangered species and wetlands, for each closure action. A discussion of site-specific data is presented in the appropriate section above.

There are 13 waste sites located within the A- and M-Area. The motor shop seepage basin contains surface waters, as do the metallurgical laboratory basin, the four SRL seepage basins, the M-Area settling basin, and Lost Lake. The remaining waste sites, the metals burning pit, Silverton Road waste site, miscellaneous chemical basin, and the two A-Area burning/rubble pits are presently backfilled or covered with soil and vegetation. All waste sites within this geographic grouping are either abandoned or inactive.

F.1.14.1 Assessment of No Action (No Removal of Waste and No Remedial or Closure Actions)

Aquatic Ecology

A potential aquatic impact for the A- and M-Area is the release to surface water of groundwater containing materials from the various waste sites in the A- and M-Area. Table F-9 lists those materials in the groundwater that were not modeled using the PATHRAE analysis but do exceed the freshwater biota criteria for each of the waste sites.

Where data are available, it can be determined that the materials listed in Table F-9 are not expected to create new or enhance existing impacts on the aquatic biota of nearby streams. This conclusion was based on the estimated dilution factors (Table F-9), which were calculated by dividing the groundwater flux by the flow rate of the receiving stream. The dilution factor indicates that these materials will be diluted so as not to affect the present water quality of the receiving stream.

Terrestrial Ecology

The potential terrestrial impacts for the waste sites of the A- and M-Areas include the exposure of wildlife and vegetation to surface waters within waste sites, the toxic effects on vegetation of soils containing waste materials, and the consumption of undiluted groundwater at the outcrop. Terrestrial impacts related to these sources of contamination have been addressed on an individual basis above.

Endangered Species

No endangered species were identified in the vicinity of the waste sites of the A- and M-Areas during previous surveys at the SRP, with the exception of an alligator that lives in the M-Area settling basin (Section F.1.12) (see Table F-9). With the exception of the M-Area settling basin, the habitats in the immediate vicinity of the waste sites are not suitable for any Federally endangered species previously reported on the SRP. Therefore, none of the actions proposed for the waste sites of A- and M-Areas would have an effect on endangered species.

Wetlands

The nearest wetlands to the waste sites of the A- and M-Areas are associated with Tims Branch and Upper Three Runs Creek. These wetlands consist primarily of bottomland hardwoods. Table F-9 provides the distances between the waste sites and the wetlands. Potential impacts to wetlands biota are discussed on an individual basis above.

F.1.14.2 Assessment of No Removal of Waste and Implementation of Cost-Effective Remedial and Closure Actions as Required

Aquatic Ecology

TE

The potential aquatic impacts for the waste sites of the A- and M-Areas include direct and indirect contamination of surface water. In some cases, this action proposes to drain the surface water of a waste site directly into a stream. Potential impacts of PATHRAE-modeled wastes are addressed above on an individual basis. Indirect contamination of surface water by non-PATHRAE-modeled wastes from the various waste sites would not create an impact on the existing stream water quality due to the dilution factor, as described in Section F.1.14.1. Also, some closure actions involve backfilling the basin with uncontaminated fill and the use of a low-permeability cap over the waste site. The cap would retard the leaching of soil contaminants into the groundwater, although wastes previously leached to the groundwater would continue to enter streams.

Terrestrial Ecology

The potential terrestrial impacts for the waste sites of the A- and M-Areas include toxic effects on vegetation caused by contaminated soil and temporary disturbance of the wildlife due to noise and habitat loss created by the closure plan. Closure actions, including use of a clay cap and mowing, would help prevent the establishment of deep-rooted plants and, hence, root penetration into the waste zone. | TE

Endangered Species

With the exception of the M-Area settling basin, none of the actions proposed for the waste sites of the A- and M-Areas would have any effect on endangered species. See Section F.1.14.1.

Wetlands

As described in Section F.1.14.1, most of the waste sites of the A- and M-Areas are sufficiently removed from the wetlands that they are not affected by any of the closure actions. However, for those waste sites that are near wetlands, proper erosion control to prevent runoff of sedimentation into the wetlands would prevent significant impacts. | TE

F.1.14.3 Assessment of Removal of Waste to the Extent Practicable, and Implementation of Cost-Effective Remedial and Closure Actions as Required

Aquatic Ecology

The potential ecological impacts of waste removal and closure for the waste sites of the A- and M-Area would be similar to those described in Section F.1.14.2, except that the removal of waste material and contaminated soils should further reduce the potential for impacts on aquatic ecosystems.

Terrestrial Ecology

Any potential for impact of plant toxicity would be significantly reduced by the proposed waste removal and closure. Disturbances to wildlife due to closure activities would be temporary.

Endangered Species

With the exception of the M-Area settling basin, none of the actions proposed for the waste sites of the A- and M-Areas would have any effect on endangered species. See description in Section F.1.14.1.

Wetlands

Section F.1.14.1 describes the wetlands that exist within the vicinity of the A- and M-Area. Remedial actions should include soil erosion control to protect those wetlands that are near a waste site.

F.2 ASSESSMENT OF ACTIONS AT F- AND H-AREA WASTE SITES

This geographic grouping of waste sites is about 10 kilometers southeast of A-Area. It is formed by waste sites associated with the Separations (200-F and -H) Areas, which are just north of Road E. Figure F-5 shows the locations of the waste sites within this grouping.

Sections F.2.1 through F.2.17 contain or reference the appropriate section for a discussion of sites 2-1 through 2-17. Section F.2.18 discusses biological impacts that are generically applicable to the F- and H-Area waste sites.

F.2.1 ACID/CAUSTIC BASINS*

There are a total of six acid/caustic basins on SRP, located as follows:

Area	Building
F	904-74G
H	904-75G
R	904-77G

Area	Building
K	904-80G
L	904-79G
P	904-78G

The acid/caustic basins on the SRP are nearly identical physically and received similar waste. Consequently, potential releases and associated environmental effects would be expected to be similar. Therefore, the actions, releases, and impacts described in this section would be applicable to each of these six basins.

The environmental analyses for the six acid/caustic basins were performed only for the L-Area acid/caustic basin (Building 904-79G). That basin has the largest inventory of contaminants and was, therefore, selected for the analysis. It is conservative to assume that the other five basins would behave similarly. To provide a relative scale for the six basins, the estimated disposal mass of contaminants selected for environmental assessment is listed in Table F-10.

F.2.1.1 Assessment of No Action (No Removal of Waste, and No Remedial or Closure Actions)

Description of Action

TE Under no action, the acid/caustic basins would be left in their current condition. The groundwater monitoring program would continue on a quarterly basis for 1 year, then annually for 29 years. Four monitoring wells would be

*The reference source of information for this section is Ward, Johnson, and Marine, 1987.

Table F-10. Estimated Disposal Mass of Contaminants Selected for Environmental Assessment

	Estimated Disposal Mass (Kilograms)					
	F-Area	H-Area	R-Area	K-Area	L-Area	P-Area
Constituent	(904-74G)	(904-75G)	(904-77G)	(904-80G)	(904-79G)	(904-78G)
Arsenic	-	-	-	-	-	0.6
Chromium	-	-	-	-	2.0	1.0
Copper	-	-	-	4.40	36.0	-
Lead	-	-	7.8	-	29.0	-
Mercury	0.3	-	0.1	-	0.3	-
Phosphate	-	-	-	1.20	-	-
Selenium	-	-	-	0.32	-	-
Sodium	-	-	33.0	4300.00	6200.0	-
Sulfate	-	-	-	9100.00	3300.0	-
Tetrachloro-ethylene	1.0	-	4.02	0.60	1.5	0.3

installed at the H-Area acid/caustic basin and monitored as described above. Site maintenance would be provided for the entire 30-year period. TC

Comparison of Expected Environmental Releases with Applicable Standards

The chemical constituents, or waste materials, selected for assessment at the acid/caustic basins were arsenic, chromium, copper, lead, mercury, phosphate, selenium, sodium, sulfate, and tetrachloroethylene. These constituents were selected because they were found in the groundwater or soil at levels higher than the threshold selection criteria. For the atmospheric pathway, the same 10 constituents were analyzed.

Table F-11 lists the predicted maximum concentration of lead and tetrachloroethylene and the year in which the maximum concentration is expected to occur, based on groundwater modeling. For no action, concentrations of these constituents are predicted to have exceeded applicable standards at the 1-meter and 100-meter wells in the early 1970s. Monitoring data indicate that tetrachloroethylene continues to exceed its health-based standard in the groundwater at the acid/caustic basins. Lead concentrations appear to be within drinking-water standards.

Surface-water quality would not be significantly affected by the addition of potential contaminants from the groundwater pathway from these sites. The resulting concentrations of constituents in L-Lake, calculated from the L-Area acid/caustic basin, are projected to be below drinking-water standards. TE

Estimated environmental risks due to atmospheric chemical releases from the acid/caustic basins for no action are based on the ten chemical constituents found in at least one but not all of the acid/caustic basins. Risks are very low. For example, the highest chemical carcinogenic risk to the maximally exposed individual is less than 1.6×10^{-10}, while the highest EPA Hazard Index value for noncarcinogens is 1.2×10^{-5}. These risks are considered not significant. TE TC

The concentrations for the erosion and biointrusion pathways are all zero, because the length of time that it takes for the constituents to start eroding is well over 1000 years and the depth of the cover material is such that roots of plants intruding onto the waste site will never penetrate the contaminated material.

Potential Impacts (Other Than Releases)

Section F.2.18.1 describes the ecological impacts of no action. PATHRAE analysis for no action at the L-Area acid/caustic basin indicates that the influent water concentrations of chromium, copper, lead, mercury, sodium, sulfate, and tetrachloroethylene would not exceed EPA water-quality criteria for the protection of aquatic life or equivalent numbers from the technical literature. Only lead would approach the water-quality criteria in the undiluted groundwater. On this basis, the contaminants attributable to the L-Area acid/caustic basin are not expected to impact the aquatic communities of the Steel Creek/L-Lake ecosystem and adjacent wetlands or to affect wildlife that use these habitats to drink and feed under any of the closure actions. Because the L-Area basin has the highest concentrations of the largest number of contaminants of the acid/caustic basins, similar conclusions can be assumed for the other basins that were not specifically analyzed. TE

F.2.1.2 Assessment of No Removal of Waste and Implementation of Cost-Effective Remedial and Closure Actions as Required

Description of Action TE

Under the no-removal-and-closure action, any liquid found in the basins would be neutralized, if required, and discharged. Approximately 500 cubic meters of soil would be required to backfill the basin to grade. The soil would be compacted to the appropriate density to prevent settling; the surface would be graded to preclude ponding of rainwater and seeded with suitable grass.

The groundwater monitoring program would continue on a quarterly basis for 1 year, then annually for 29 years. Four monitoring wells would be installed at the H-Area acid/caustic basin and monitored as described above. If required, groundwater remediation could be implemented to reduce the concentration of any contaminants to below applicable standards. Site maintenance would be provided for the entire 30-year period. TC

Comparison of Expected Environmental Releases with Applicable Standards

With the exception of air releases, the chemical constituents, the consequences of environmental releases, and the pathways associated with this action are the same as those for no action, since contaminants have presumably leached beyond the zone of control (see Table F-11).

TE The estimated environmental risks due to atmospheric releases from F-Area acid/caustic basin for this action are very small. For example, the maximum TC carcinogenic risk to the maximally exposed individual is less than 1.6 x 10^{-17}. The EPA Hazard Index value for noncarcinogens is also very low (less than 5.2 x 10^{-16}). These risks are considered insignificant.

Potential Impacts (Other Than Releases)

Sections F.2.1.1 and F.2.18.2 describe impacts on biological resources of this closure action at the F-Area acid/caustic basin.

F.2.1.3 Assessment of Removal of Waste to the Extent Practicable, and Implementation of Cost-Effective Remedial and Closure Actions as Required

Description of Action

TE Under the waste-removal-and-closure action, all basin liquids would be neutralized in place, if required, and discharged, and all sediment in the basins and any chemically contaminated soil to a depth of 0.9 meter (approximately 210 cubic meters) below the original sides and bottom of the basin would be removed prior to backfilling. Any chemically contaminated soil would be removed, placed in metal boxes, and transported to a waste storage/disposal facility. Approximately 700 cubic meters of soil would be required to backfill each basin to grade. The surface would be graded to preclude ponding of rainwater and seeded with a suitable grass.

The groundwater monitoring program already in place would be continued on a quarterly basis for 1 year; the wells would then be monitored annually for 29 years. Four monitoring wells would be installed at the H-Area acid/ TC caustic basin and monitored as described above. Site maintenance would be provided for the entire 30-year period. Additional corrective actions might be needed to address the constituents already in the groundwater. The choice of actions to be taken would be based on site-specific studies and interactions with relevant regulatory agencies.

Comparison of Expected Environmental Releases with Applicable Studies

The chemical constituents of concern, the consequences of environmental releases, and the pathways that may have an impact on human health are the same as for no action. The results of the PATHRAE analyses are listed in Table F-11. The contaminant concentrations in the groundwater for this action are the same as those for no action.

TC Estimated environmental risks due to atmospheric chemical releases from the acid/caustic basins are very low. For example, carcinogenic risk to the maximally exposed individual is less than 3.7 x 10^{-14}. In 1986 the carcinogenic risk is less than 10^{-12}, and the EPA Hazard Index value for noncarcinogens is less than 5.2 x 10^{-9}. The risks are considered not significant.

Occupational risks are also low. The calculated occupational carcinogenic risk is 2.2 x 10^{-9} and the EPA Hazard Index value for noncarcinogens is 2.2 x 10^{-2}. TC

The expected concentrations for the erosion and biointrusion pathways are zero. In addition, the expected concentrations for the reclaimed farm pathway are also zero because all of the contaminated material has been removed from the site.

Potential Impacts (Other Than Releases)

Sections F.2.1.1 and F.2.18.3 describe impacts on biological resources of this closure action at the F-Area acid/caustic basin.

F.2.2 H-AREA ACID/CAUSTIC BASIN, BUILDING 904-75G

This acid/caustic basin is discussed in conjunction with the other acid/caustic basins in Section F.2.1. However, four new groundwater monitoring wells would be installed and monitored at this site. The ecological effects of this site that relate specifically to the F- and H-Area geographic grouping are discussed in Section F.2.18. TC

F.2.3 F-AREA BURNING/RUBBLE PIT (BUILDING 231-F)

This burning/rubble pit is discussed in Section F.1.6 in conjunction with the other burning/rubble pits. Section F.2.18 describes the ecological effects of this site that relate to the F- and H-Area geographic grouping.

F.2.4 F-AREA BURNING/RUBBLE PIT, BUILDING 231-1F

This burning/rubble pit is discussed in Section F.1.6 in conjunction with the other burning/rubble pits. Section F.2.18 describes the ecological effects of this site that relate to the F- and H-Area geographic grouping.

F.2.5 H-AREA RETENTION BASIN, BUILDING 281-3H*

The H-Area retention basin is a low-level radioactive waste management facility that stopped receiving wastes in 1973. Background information on the history of waste disposal, waste characteristics, and evidence of contamination are presented in Appendix B, Section B.3.2. TC

F.2.5.1 Assessment of No Action (No Removal of Waste, and No Remedial or Closure Actions)

Description of Action

Under no action, the site would remain in its present condition. Two additional wells would be installed and all wells would be monitored quarterly for 1 year, then annually for 29 years. Site maintenance would be provided for the entire 30-year period. TC

*The reference source of the information in this section is Scott, Killian, Kolb, Corbo, and Marine, 1987.

Comparison of Expected Environmental Releases with Applicable Standards

PATHRAE predicts that strontium-90 and yttrium-90 will exceed groundwater standards during the 100-year institutional control period. Table F-12 lists these parameters, the corresponding health-based standards, and the maximum concentrations predicted to be found in the groundwater near the basins. All other constituents modeled were predicted to be below applicable standards.

Surface-water quality is not significantly affected by the addition of potential contaminants from the groundwater pathway from this site, as the resulting concentrations of constituents in Four Mile Creek are projected to be below drinking-water standards.

Environmental doses and risks to the maximally exposed individual due to radiological releases from the H-Area retention basin were calculated using the methodology presented in the introduction to this appendix and in Appendix I. The calculated doses were less than 1.6 percent of the DOE limit of 25 millirem per year for each of the 3 selected years. The risks associated with these doses would be 1.1×10^{-7} or less.

No nonradioactive constituents are released to the atmosphere in the H-Area retention basin.

Potential Impacts (Other Than Releases)

The maximum annual doses resulting from the reclaimed farm and direct gamma exposure pathways would occur 100 years from the present, at which time institutional control of the SRP is assumed lost. The doses are only 0.22 and 0.68 millirem per year for the farm and direct gamma exposure pathways, respectively. There would be no dose from the consumption of crops potentially contaminated as a result of biointrusion of subsurface sediments, due to the assumed limited plant-root depth.

Section F.2.18.1 describes the ecological impacts of no action. PATHRAE analysis has been performed on strontium-90, yttrium-90, cesium-137, and plutonium-238. PATHRAE-modeled groundwater outcrop concentrations and fluxes are identical for all closure actions. The results indicate that contaminants originating from the H-Area retention basin would not exceed freshwater biota water-quality criteria for any of the closure actions and would not impact the aquatic communities of Four Mile Creek and its associated wetlands or the wildlife that uses these waters to feed or drink.

The H-Area retention basin would contain standing water underlain by contaminated sediments under no action. Analysis of water currently in the H-Area retention basin indicates that cesium-134 and -137 are present at levels that exceed the EPA water-quality criteria for the protection of aquatic life or equivalent values from the technical literature. However, cesium at concentrations of 1×10^{7} picocuries per liter (50,000 times the comparison criterion) caused no effect on the development of fish embryos. Thus, aquatic organisms using the basin and wildlife visiting the waste site should not receive adverse impacts. However, calculated average basin sediment concentrations of cesium-137, strontium-90, and plutonium-238 exceed soil criteria by several orders of magnitude. Under no action, these contaminated sediments would be exposed at the basin surface, where they are readily available to plant roots. Thus, the possibility exists of biointrusion and subsequent food-chain transport after the onset of natural succession.

F.2.5.2 Assessment of No Removal of Waste and Implementation of Cost-Effective Remedial and Closure Actions as Required

Description of Action

TE

Under the no-removal-and-closure action, standing water would be removed and disposed of in the operating H-Area retention basin (281-3H). The basin would be backfilled to 0.3 meter above the land surface, with about 2.4 meters of
TE borrow fill. The amount of fill needed would be 5360 cubic meters. The fill would be covered with a low-permeability cap (Figure F-2). Two additional groundwater monitoring wells would be installed and all four wells would be monitored quarterly for 1 year, then annually for 29 years. Site maintenance
TC would be provided for the entire 30-year period. The modeling results indicate that remedial actions could be required.

Additional actions might be needed to address the constituents already in the groundwater. The choice of action would be based on site-specific studies and interactions with regulatory agencies. Some potential treatment technologies are discussed in Appendix C.

Comparison of Expected Environmental Releases with Applicable Standards

PATHRAE predicts that strontium-90 and yttrium-90 will exceed groundwater standards during the 100-year institutional control period. Table F-12 lists these parameters, the corresponding health-based standards, and the maximum concentrations predicted to be found in the groundwater near the basins. All other constituents modeled were predicted to be below applicable standards.

Appropriate treatment technologies would be employed to reduce the concentrations of radionuclides to below regulatory limits.

Releases to surface water associated with this action would not differ from those of no action (Section F.2.5.1).

There would be no releases to the atmosphere because the retention basin would be backfilled and capped.

Potential Impacts (Other Than Releases)

The maximum annual doses resulting from the reclaimed farm and direct gamma exposure pathways would occur 100 years from the present, at which time institutional control of the SRP is assumed lost. The doses are only 3.4×10^{-5} and 2.4×10^{-11} millirem per year for the farm and direct gamma exposure pathways, respectively. There is no dose from consumption of crops potentially contaminated as a result of biointrusion of subsurface sediments, due to the assumed limited plant-root depth.

Closure is expected to result in no adverse impacts on biological resources at the H-Area retention basin, as described in Sections F.2.5.1 and F.2.18.2. It also is expected to eliminate potential adverse impacts to organisms from standing water and biointrusion. TE

F.2.5.3 Assessment of Removal of Waste to the Extent Practicable, and Implementation of Cost-Effective Remedial and Closure Actions as Required

Description of Action

The basin, which is southwest of the H-Area perimeter fence, has been out of service since 1973. Under the waste-removal-and-closure action, standing water would be drained from the basin and removed to the operating H-Area retention basin (281-8H). The depth of soil to be excavated from the basin would be 2.6 meters. A 930-square-meter area outside the basin would be excavated to a depth of 0.3 meter. The soil removed from the basin and the 930-square-meter area would be transported in metal boxes and disposed of in a waste storage/disposal facility onsite. The basin would be backfilled to 0.3 meter above the ground surface with borrow fill. The amount of backfill required would be 11,500 cubic meters. The fill would be covered with a low-permeability cap (1900 cubic meters each of clay, sand, and topsoil) and seeded with grass over a 3160-square-meter area. Two additional groundwater monitoring wells would be installed and all wells would be monitored quarterly for 1 year, then annually for 29 years. TE

Comparison of Expected Environmental Releases with Applicable Standards

PATHRAE results for waste removal and closure of this site indicate that radionuclide concentrations would be reduced at the 1-meter well. PATHRAE predicts that strontium-90 and yttrium-90 will exceed groundwater standards during the 100-year institutional control period. Table F-12 lists these parameters, the corresponding health-based standards, and the maximum concentrations predicted to be found in the groundwater near the basins. All other constituents modeled were predicted to be below applicable standards.

Surface-water quality would not be significantly affected by the addition of potential contaminants from the groundwater pathway from this site, as the resulting concentrations of constituents in Four Mile Creek are projected to be below drinking-water standards.

The analyses described in Section F.2.5.1 were also performed for this action. Radionuclide releases to the atmosphere would take place only during the time that waste is being removed from the retention basin. The releases are associated with the excavation activities and are assumed to occur during the first year of waste removal and closure. TE

The annual dose to an individual resulting from the release of radionuclides to the atmosphere would be only 1.5×10^{-3} percent of the DOE limit of 25 millirem per year. The risk to the maximally exposed individual is 1.03×10^{-10}. TC

No nonradioactive constituents would be released to the atmosphere in the H-Area retention basin; therefore, no risk assessments were performed.

An analysis of the health risks to the average individual worker that would be attributable to occupational exposure to radioactive carcinogens was performed, using the methodology presented in Appendix I. The total dose to the worker was calculated to be 600 millirem, which would produce an incremental risk of 1.7×10^{-4}. The total dose to the worker transporting the waste was 240 millirem, producing an incremental risk of 6.7×10^{-5}.

Potential Impacts (Other Than Releases)

The maximum annual doses resulting from the reclaimed farm and direct gamma exposure pathways occur 100 years after waste removal and closure, at which time institutional control of the SRP is assumed lost. The doses would be only 9.8×10^{-6} and essentially 0 millirem per year for the farm and direct gamma exposure pathways, respectively. There would be no dose from the consumption of crops potentially contaminated as a result of biointrusion of subsurface sediments, due to the assumed limited plant-root depth.

TE DOE does not expect this action to produce adverse impacts on biological resources at the H-Area retention basin, as described in Sections F.2.5.1 and F.2.18.2. It should eliminate potential adverse impacts to organisms attracted to the wet-weather pond in the basin and biointrusion.

F.2.6 F-AREA RETENTION BASIN, BUILDING 281-3F*

TC The F-Area retention basin (Building 281-3F) is a low-level radioactive waste management facility that stopped receiving wastes in 1973. Background information on the history of waste disposal, waste characteristics, and evidence of contamination are described in Appendix B, Section B.3.2.

F.2.6.1 Assessment of No Action (No Removal of Waste, and No Remedial or Closure Actions)

Description of Action

TE For no action the site would remain in its present condition. Four groundwater monitoring wells would be installed and monitored quarterly for 1 year,
TC then annually for 29 years. Site maintenance would be provided for the entire 30-year period.

Comparison of Expected Environmental Releases with Applicable Standards

All environmental releases are projected to be below applicable standards for no action.

The releases are expressed in terms of radionuclide concentrations for both a well 1 meter downgradient of the retention basin and a well 100 meters downgradient. The PATHRAE predicts that groundwater quality would not be affected significantly by the addition of potential contaminants from this waste management unit. All constituents should be found at levels below applicable health-based standards.

*The reference source of the information in this section is Scott, Killian, Kolb, Corbo, and Marine, 1987.

Surface-water quality would not be significantly affected by the addition of potential contaminants from the groundwater pathway from this site, as the resulting concentrations of constituents in Four Mile Creek are projected to be below drinking-water standards.

There would be no releases to the atmosphere under no action, because the retention basin has been backfilled with dirt and covered with grass. TE

Potential Impacts (Other Than Releases)

The maximum annual doses resulting from the reclaimed farm and direct gamma exposure pathways would occur 100 years from the present. The doses would be only 9.1×10^{-7} and 7.0×10^{-13} millirem per year for the farm and direct gamma exposure pathways, respectively. The dose would be zero for the pathway which involves consumption of crops potentially contaminated as a result of biointrusion of subsurface sediments, since any such contamination is assumed to be precluded due to the limited plant root depth.

Section F.2.18.1 describes the ecological impacts of no action. PATHRAE analyses have been performed on cesium-137, strontium-90, and yttrium-90. PATHRAE-generated groundwater outcrop concentrations and fluxes are identical for all closure actions. None of the radionuclides modeled exceed the EPA water-quality criteria for the protection of aquatic life or equivalent numbers from the technical literature. These results, therefore, indicate that constituents originating from the F-Area retention basin would have no impact under any of the postulated closure actions on the aquatic communities of Four Mile Creek and its associated wetlands or wildlife that use these waters to feed or drink.

Analysis of soil cores taken after the basin was backfilled in 1979 indicate that cesium-137 and strontium-90 are present in sediments underlying the backfill at levels exceeding the soil criteria. Thus, biointrusion impacts via root penetration and subsequent food-chain transport after the onset of natural succession are possible under no action. TE

F.2.6.2 Assessment of No Removal of Waste and Implementation of Cost-Effective Remedial and Closure Actions as Required

Description of Action

Under the no-removal-and-closure action, the basin would be covered with a low-permeability cap (Figure F-2). TE Four groundwater monitoring wells would be installed around the basin and monitored quarterly for 1 year, then annually for 29 years. Site maintenance would be provided for the entire 30-year period. TC

PATHRAE analyses predict that all modeled constituents would be present in the groundwater at levels below MCLs for no waste removal and closure. Therefore, no further remedial action would be necessary.

Comparison of Expected Environmental Releases with Applicable Standards

All environmental releases are projected to be below applicable standards for the no-waste-removal-and-closure action. Releases to groundwater and surface water would not differ from these of no action (Section F.2.6.1).

There would be no releases to the atmosphere because the retention basin has already been backfilled.

Potential Impacts (Other Than Releases)

The maximum annual doses resulting from the reclaimed farm and direct gamma exposure pathways would occur 100 years from the present, at which time institutional control of the SRP is assumed lost. The doses are only 1.2×10^{-5} and 1.2×10^{-16} millirem per year for the farm and direct gamma exposure pathways, respectively. There would be no dose from the consumption of crops potentially contaminated as a result of biointrusion of subsurface sediments, due to the limited plant-root depth.

TC The ecological impacts of this closure action would be similar to those described in Sections F.2.6.1 and F.2.18.2. This action is expected to eliminate potential impacts of biointrusion.

F.2.6.3 Assessment of Removal of Waste to the Extent Practicable, and Implementation of Cost-Effective Remedial and Closure Actions as Required

Description of Action

TE Under the waste-removal-and-closure actions, the depth of the original backfill (2.1 meters) would be excavated along with 2 meters from the basin floor, for a total of 4.1 meters. The total volume of soil to be removed
TC would be 9153 cubic meters. The soil would be transported in metal boxes and disposed of in a waste storage/disposal facility. The basin would be backfilled to 0.3 meter above the ground surface with borrow fill. The amount of backfill required would be 9824 cubic meters. The fill would be covered with a low-permeability cap (1340 cubic meters each of clay, sand, and top soil) and seeded with grass over an area of 2233 square meters. Four groundwater monitoring wells would be installed around the basin and monitored
TC quarterly for 1 year, then annually for 29 years. Site maintenance would be provided for the entire 30-year period.

TE PATHRAE analyses predict that all modeled constituents would be present in the groundwater at levels below MCLs for the waste removal and closure action. Therefore, no further remedial action would be necessary.

Comparison of Expected Environmental Releases with Applicable Standards

TE All environmental releases are projected to be below applicable standards for the waste removal and closure action.

The peak concentrations for the 1-meter and 100-meter wells are the same as those presented in Section F.2.6.1. All constituents should be found at
TC levels below applicable health-based standards at the 100-meter well, but strontium-90 and yttrium-90 would exceed their respective MCL values.

Surface-water quality would not be significantly affected by the addition of potential contaminants from the groundwater pathway from this site, as the resulting concentrations of constituents in Four Mile Creek are projected to be below drinking-water standards.

Environmental doses and risks to the maximally exposed individual due to radiological releases from the F-Area Retention Basin were calculated using the methodology presented in the introduction to Appendix F and in Appendix I.

Radionuclide releases to the atmosphere would take place only during the time that waste was being removed from the retention basin. The releases would be associated with the excavation activities and are assumed to occur during the first year of waste removal and closure.

The calculated annual dose to an individual is less than 8.4×10^{-5} percent of the per year DOE limit of 25 millirem. The risk associated with this dose would be less than 6.0×10^{-12}.

No nonradioactive constituents would be released to the atmosphere in the F-Area Retention Basin, and therefore no risk assessments were performed.

An analysis of the average individual worker health risks from occupational exposure to radioactive carcinogens was performed using the methodology presented in Appendix I. The total dose to the worker was calculated to be 1 millirem, which would produce an incremental risk of 2.8×10^{-7}. The total dose to the worker transporting the waste was calculated as 0.52 millirem, producing an incremental risk of 1.5×10^{-7}.

Potential Impacts (Other Than Releases)

The maximum annual doses resulting from the reclaimed farm and direct gamma exposure pathways would occur 100 years after waste removal and closure, at which time institutional control of the SRP is assumed lost. The doses would be only 1.2×10^{-7} and essentially 0 millirem per year for the farm and direct gamma exposure pathways, respectively. There would be no dose from the consumption of crops potentially contaminated as a result of biointrusion of surface sediments, due to the assumed limited plant-root depth.

The ecological impacts of this closure action would be similar to those described in Sections F.2.6.1 and F.2.18.2. This action should eliminate potential impacts of biointrusion. TC

F.2.7 RADIOACTIVE WASTE BURIAL GROUNDS*

The radioactive waste burial grounds consist of three sites: the "new" (currently operating) low-level radioactive waste burial ground (643-7G), the mixed waste management facility (643-28G), and the "old" (inactive) radioactive waste burial ground (643-G). TE The latter site was used from 1952 to 1972 and is considered to be a mixed waste site; the former two sites began operation in 1972. The mixed waste management facility is no longer operating. TC The sites are essentially contiguous; accordingly, for the purposes of assessment analysis, they are considered as one. More information on the history of waste disposal, waste characteristics, and evidence of contamination is presented in Appendix B.

F.2.7.1 Assessment of No Action (No Removal of Waste, and No Remedial or Closure Actions)

Description of Action

No action is defined as continuing operations until SRP activities cease, followed by a period of institutional control generally considered to last for 100 years. Present operations of the filled portions of the solid waste
TE | disposal facility (burial grounds) consist of:

- Maintaining present fencing and surface drainage patterns
- Correcting trench subsidence as it occurs by backfilling with clean soil
- Reseeding as required with a shallow-rooted grass cover
- Frequently mowing to prevent onset of deep-rooted vegetation
- Monitoring for chemicals and radioactivity in the existing perimeter wells and well clusters
- Maintaining control of access to the facility (security)

The maintenance operations described above would be applied to the entire 195
TE | acres of the facility during the 100-year institutional control period. Further subsidence in the first-used section, 643-G, is expected to be infrequent.

Comparison of Expected Environmental Releases with Applicable Standards

Monitoring and analysis indicate that groundwater beneath and around the radioactive waste burial grounds is contaminated with radionuclides, metals, and organic chemicals. Table F-13 indicates the regulatory standards and the calculated maximum concentrations for constituents that exceed regulatory standards. Monitoring results are not presented, because data from protocol monitoring wells are not presently available. In most cases the peaks are modeled to have occurred in the past, after the inception of waste emplacement; however, because the site is continuing to receive wastes, they generally indicate present concentrations.

TC | The radionuclides tritium, nickel-63, cobalt-60, technetium-99, strontium-90, yttrium-90, cesium-134, cesium-137, neptunium-237, uranium-238, and plutonium-238 and -239 all are estimated to have exceeded their standards at the 1-meter well in 1957. PATHRAE results indicate that strontium-90 will exceed its standard again in 2185. Neptunium-237 should exceed its standard in 2420.

Of the chemical constituents, lead and mercury are estimated to have exceeded their standards at the 1-meter well in 1957. PATHRAE results also indicate

*The reference source of the information in this section is Jaegge et al., 1987.

that cadmium and xylene will exceed their standards at the 1-meter well in 2235 and 2056, respectively.

After 200 years, the groundwater concentrations would be below health-based standards except for the slow-moving neptunium-237, strontium-90, cadmium, and xylene. Because they move so slowly, these constituents would be out of compliance only in the immediate vicinity of the burial grounds.

The burial grounds waste constituents leave the aquifer at the groundwater outcrop and enter the site streams. Because the waste site straddles a groundwater divide, the waste would enter both Upper Three Runs Creek and Four Mile Creek. The calculations assume that all of the wastes are transported toward the groundwater outcrop nearest the waste site. This outcrop, 1000 meters downgradient from the site, results in waste entering Four Mile Creek and, ultimately, being transported to the Savannah River.

Incremental concentrations in Four Mile Creek can be calculated by multiplying the peak Savannah River concentrations by the ratio of Savannah River flow rate to Four Mile Creek flow rate (830). All Savannah River and Four Mile Creek concentrations would be well within the applicable standards for no action.

The nonradioactive constituents were analyzed, using the methodology discussed in the introduction to Appendix F and in Appendix I, to estimate public exposure and risk attributable to releases of constituents into the atmosphere from the radioactive waste burial grounds.

No releases of carcinogens are expected, because the waste site is capped. TE
Releases of noncarcinogens are associated with volatilization of constituents. The EPA Hazard Index values attributable to atmospheric releases are less than 10.4×10^{-7}. TC

Environmental doses and risks to the maximally exposed individual due to radiological releases from the radioactive waste burial grounds were calculated using the methodology summarized in the introduction to Appendix F and presented in Appendix I. The calculated doses were less than 8×10^{-8} TC
percent of the DOE limit of 25 millirem per year for each of the 3 years. The risks associated with these doses would be less than 5.2×10^{-15}. TC

Potential Impacts (Other Than Releases)

Section F.2.18.1 describes the ecological impacts of no action. Potential exists for adverse effects on the aquatic biota of Four Mile Creek and adjacent wetlands under all closure actions. The levels of groundwater outcrop contamination predicted by the PATHRAE model for year 100 for lead, mercury, tritium, and plutonium-238 exceed the EPA criteria for the protection of aquatic life or equivalent values from the technical literature by factors ranging from 1.2 for plutonium-238 to 232 for lead under no action. Dilution of the contaminated groundwater outcrop by Four Mile Creek yields contaminant concentrations for lead, mercury, and tritium that exceed EPA criteria by factors ranging from 5.4 (tritium) to 35 (lead). Dilution modeling indicates that the introduction of contaminated groundwater outcrops into Four Mile Creek will elevate existing stream concentrations for lead, mercury, and tritium. Studies on the biological effects of such contaminants revealed that tritium would be well below the no-effect concentration for developing fish embryos, while lead concentrations would be sufficient to produce adverse effects on zooplankton populations, but not to bluegill populations.

The groundwater outcrop concentrations for lead, tritium, and plutonium-238 exceed drinking-water standards under all closure actions, indicating a potential for effects on wildlife consuming the undiluted groundwater at the outcrop. However, any such effects should be negligible in view of the conservative nature of human drinking-water standards and the low probability
TC of significant numbers of wildlife consistently drinking water in the area of the undiluted groundwater outcrop.

Based on the calculated radioactivity concentrations in the disposed waste, the potential exists for limited terrestrial impacts such as reduced plant growth, increased plant mortalities, and food-chain transport to herbivorous wildlife under no action via the biointrusion pathway. Terrestrial impacts
TE would be limited to the general area surrounding the burial grounds.

F.2.7.2 Assessment of No Removal of Waste and Implementation of Cost-Effective Remedial and Closure Actions as Required

Description of Action

TE The no-removal-and-closure action consists of leaving the waste in place and closing the site using low-permeability caps on areas 643-G and 643-7G, which would cover approximately 200 acres. The caps would consist of:

- 0.6 meter of topsoil ($K = 7 \times 10^{-4}$ centimeters per second), over

TC

- 0.3 meter of sand (K greater than or equal to 1×10^{-3} centimeters per second)
- 0.15 meter of sand, over
- 20-mil (0.51 millimeters) membrane, over
- 0.15 meter of sand, over
- 0.6 meter of compacted clay (K less than 10^{-7} centimeters per second)

This cap (or equivalent) would be covered with shallow-rooted vegetation. The volumes of material that would be required are: 4.8×10^5 cubic meters of topsoil, 2.4×10^5 cubic meters of drainage sand, 2.4×10^5 cubic meters of buffer sand, 8×10^5 square meters of 20-mil plastic liner, and 4.8×10^5 cubic meters of compacted clay.

The site would remain fenced and current engineered drainage would continue. Reseeding and mowing would be carried out as needed. Grade would be reestablished and the cap repaired following any subsidence. Existing perimeter wells and well clusters would be used for monitoring groundwater. RCRA wells would be installed. Institutional control would continue for 100 years
TC following closure. Site maintenance and groundwater monitoring would continue for this entire period, as required.

As shown in Table F-13, further remedial action might be required for this action, since PATHRAE modeling predicts that the concentrations of several constituents would exceed regulatory standards. The radionuclides (other than tritium) and metals that exceed regulatory standards could be removed by pumping, and the contaminated groundwater could be treated to reduce concentrations to acceptable levels. The treated water could then be discharged to a site stream or reinjected into the ground.

The removal of tritium would be more difficult because the tritium (hydrogen) isotope is chemically part of the water. Four actions to consider are | TE
detritiation, evaporation, direct discharge to onsite streams, and reinjection. Detritiation would be extremely expensive; evaporation would change the dose pathway from the groundwater to the atmosphere.

Direct discharge to onsite streams (e.g., Four Mile Creek) would rely on dilution of the tritium to acceptable concentrations. The concentration due to the groundwater in the stream would depend on the flow rate of the discharge (essentially the flow rate of the extraction wells). Assuming discharge into Four Mile Creek (0.22 cubic meter per second) at the maximum groundwater concentration (2.9 curies per cubic meter), the maximum allowable discharge rate to meet the concentration standard of 8.7×10^{-5} curies per cubic meter would be only 6.7×10^{-6} cubic meters per second. Therefore, direct discharge to onsite streams could not meet regulatory criteria if a practical groundwater extraction rate (e.g., 0.02 cubic meter per second) were employed.

Reinjection would require the water (treated for all contaminants except tritium) to be reinjected into the ground. Tritium would then decay naturally in the shallow aquifers. The injection location would be chosen to maximize the efficiency of the extraction wells.

<u>Comparison of Expected Environmental Releases with Applicable Standards</u>

The no-waste-removal-and-closure action would not correct the groundwater-contaminant situation at the radioactive waste burial grounds; the contaminants are already in the water in concentrations that exceed regulatory standards. Closure would slow the rate at which contaminants enter the water table and would be effective in reducing concentrations of slow-moving constituents that had not yet reached the water table in significant concentrations (i.e., neptunium, cadmium, and xylene). This closure action | TE
would reduce concentrations of the constituents below the health-based standards (see Table F-13).

Strontium-90 and cadmium are slow-moving constituents that are predicted to exhibit secondary concentration peaks in the future for no action. This | TE
closure action would reduce these secondary peaks significantly below the concentration criteria.

As described in Section F.2.7.1, all Savannah River and Four Mile Creek incremental concentrations would be within applicable health-based standards.

The analysis described in Section F.2.7.1 was performed for this action. | TE
There would be no releases of carcinogens, since the facility would be capped. Releases of noncarcinogens would be due to volatilization of contaminants. Risks attributable to these releases are calculated to be below 1,

TC with a maximum value less than 7 x 10^{-12} for each of the years modeled. The calculated dose due to radiological releases was less than 2.8 x 10^{-23} percent of the DOE limit of 25 millirem for each of the 3 selected years. The risk associated with this dose would be less than 2.0 x 10^{-30}.

Potential Impacts (Other Than Releases)

TE The ecological impacts of the closure action would be similar to those described in Sections F.2.7.1 and F.2.18.2. Closure would eliminate the potential impacts of biointrusion.

F.2.7.3 Assessment of Removal of Waste to the Extent Practicable, and Implementation of Cost-Effective Remedial and Closure Actions as Required

Description of Action

TE Waste removal and closure of this site would include excavation of contaminated materials and capping of the area. Excavation of the waste disposal area would involve either removing the waste and soil from the waste trenches and placing it in another disposal/storage facility, or removing the waste from the waste trenches, processing it by sorting, size reduction, and stabilization, and redisposing of the treated waste at a mixed waste disposal/storage facility.

TE Excavation would proceed as follows: machines, operated either remotely or by personnel in shielded cabs, would excavate waste along known trench lines. The excavation would be larger and deeper than the original trench in order to assure that possibly contaminated adjacent soil would also be excavated. The entire area would be graded and covered to keep rainwater away from the excavated waste.

The estimated length of trench to be excavated is 64,000 meters, based on 50 percent utilization of the burial ground area. About 3 x 10^6 cubic meters of waste and contaminated soil would have to be excavated. Partial excavation would result in less waste removed, but current data and technologies are inadequate for determining how much less. Partial excavation, however, would leave residual radionuclide concentrations in excess of DOE guidelines for unrestricted sites.

After excavation, the waste-soil mixture would be sent to a process area where the mixture would be sorted, assayed, reduced, stabilized, and packaged for transport and disposal. The sorting process would take place on a number of conveyor belts and would be accomplished by remote sorting with manipulators. Small pieces and soil could be removed by a sorter such as a bouncing ball screen arrangement that is part of the conveyor system. Waste treatment would include processes such as incineration, shredding, compaction, and stabilization with grout. Waste and soil with very low levels of radioactivity could be returned to the original waste disposal area. The trigger value for the concentrations would have to be determined - a de minimis value for low-level waste does not currently exist.

TE Residual waste following treatment and sorting would be placed in metal disposal boxes and transported to an appropriate disposal/storage facility. The disposal volume to be evaluated should be 3 x 10^6 cubic meters; uncertainties regarding treatment and handling prevent estimation of any volume reduction. After excavation, the original waste disposal area would have to be closed, using a low-permeability cap as described above. The site would remain fenced and engineered drainage would continue. Reseeding and mowing would be carried out as needed. Grade would be reestablished and the cap repaired following any subsidence events. Existing perimeter wells and well clusters would be used for monitoring groundwater quarterly for 1 year and then annually for a minimum of 99 years. Institutional control would continue for 100 years following closure. Site maintenance would be provided for the entire institutional control period. TC

The possible corrective actions would be the same as those described for no waste removal and closure.

Comparison of Expected Environmental Releases with Applicable Standards

Groundwater and surface water releases would be the same as those for no waste removal and closure (Section F.2.7.2). TC

The analysis described in Section F.2.7.1 was performed for this action. Carcinogenic risks were calculated for 1986 due to wind erosion and excavation activities. These risks were calculated to be zero in future years, since the basin would be capped. Noncarcinogenic risks due to wind erosion and excavation activities were also calculated for 1986. Risks due to volatilization and seepage were calculated for 2085 and 2985. Risks due to carcinogen releases would be less than 1.5 x 10^{-12}. The EPA Hazard Index for noncarcinogenic releases would be less than 1.1 x 10^{-7} for each of the 3 years modeled. The calculated dose to the maximally exposed individual due to radiological releases is less than 2.8 percent of the DOE limit of 25 millirem for each of 3 years. The risk associated with this dose would be less than 2.0 x 10^{-7}. TC

An analysis of health risks to the the average individual worker attributable to occupational exposure to carcinogens (both nonradioactive and radioactive) and noncarginogens was performed using the methodology presented in Appendix I. The risk to a worker from nonradioactive carcinogens was calculated as less than 3.9 x 10^{-12}; the EPA Hazard Index for noncarcinogens was 3.8 x 10^{-7}. The total dose to the worker would be 4.2 x 10^3 millirem, producing an incremental risk of 1.2 x 10^{-3}. The total dose to the worker transporting the waste would be 2.2 x 10^3 millirem, producing an incremental risk of 6.2 x 10^{-4}. TC

Potential Impacts (Other Than Releases)

The ecological impacts of this action would be similar to those discussed in Sections F.2.7.1 and F.2.18.3. This action would eliminate the potential impacts of biointrusion. TE

F.2.8 MIXED WASTE MANAGEMENT FACILITY, BUILDING 643-28G

This site is discussed in conjunction with the other radioactive waste burial grounds in Section F.2.7.

F.2.9 RADIOACTIVE WASTE BURIAL GROUND, BUILDING 643-G

This site is discussed in conjunction with the other radioactive waste burial grounds in Section F.2.7.

F.2.10 F-AREA SEEPAGE BASINS*

F-Area seepage basins (Buildings 904-41G, 904-42G, and 904-43G) are mixed waste management facilities that are presently receiving waste. The three seepage basins were assumed to be a single operating unit for purposes of contaminant migration modeling and remedial action analyses. The history of waste disposal, evidence of contamination, and waste characteristics at the three basins are presented in Appendix B, Section B.3.3.

F.2.10.1 Assessment of No Action (No Removal of Waste, and No Remedial or Closure Actions)

Description of Action

No action would consist of allowing the basins to drain under natural conditions (i.e., infiltration and evaporation). Once the basins' residual bottom sediments dried sufficiently, the bottom and side slopes would be covered with 15 centimeters of topsoil and hydroseeded with an appropriate grass to protect the slopes from erosion. Approximately 4000 cubic meters of topsoil would be needed to cover the basin sides and bottoms, and approximately 26,200 square meters of seeding would be needed. The area would be fenced, and entrance would be allowed only for maintenance activities. Maintenance activities would consist of inspection for mowing and unacceptable erosion. Groundwater would be monitored quarterly for 1 year, then annually for 29 years.

Comparison of Expected Environmental Releases with Applicable Standards

TC Current groundwater monitoring data indicate that concentrations of chromium, lead, nickel, nitrate, tritium, strontium-90, radium, gross alpha, and gross beta exceed regulatory standards. PATHRAE modeling results indicate that concentrations of lead, nitrate, iodine-129, strontium-90, yttrium-90, americium-241, and uranium-238 would also exceed standards at various times in the future. Table F-14 lists all constituents that currently exceed or are TE projected to exceed regulatory standards under all closure actions and no action, the corresponding standard for each constituent, and the maximum concentration found or projected to be found in the groundwater near the three F-Area seepage basins.

PATHRAE modeling of surface-water impacts projects that the addition of constituents to Four Mile Creek via the groundwater pathway will not exceed drinking-water standards. Table F-14 indicates that the concentrations of these constituents in Four Mile Creek for no action, no waste removal, and waste removal are all below applicable health-based standards.

*The reference source of the information in this section is Killian et al., 1987a.

The nonradioactive constituents were analyzed, using the methodology discussed in the introduction to this appendix and in Appendix I, to estimate public exposure and risk attributable to atmospheric releases from the F-Area seepage basins.

Releases are associated with volatilization of contaminants and wind erosion. Risks due to carcinogenic releases were calculated to be less than 1.2×10^{-9} for each of the 3 selected years modeled. The EPA Hazard Index for noncarcinogenic releases would be less than 1×10^{-3} for each of the 3 years. TC

Environmental doses and risks to the maximally exposed individual due to radiological releases from the F-Area seepage basins were calculated using the methodology presented in the introduction to this appendix and in Appendix I. The calculated doses are less than 46 percent of the DOE limit of 25 millirem per year for each of the 3 selected years. The risks associated with these doses would be less than 3.3×10^{-6}. TC

Potential Impacts (Other Than Releases)

The maximum annual dose resulting from the reclaimed farm and direct gamma exposure pathways would occur 100 years from the present, at which time institutional control of the SRP is assumed lost. The doses would be 0.19 and 1000 millirem per year for the farm and direct gamma exposure pathways, respectively.

Section F.2.18.1 describes the ecological impacts of no action. The groundwater outcrop concentration for lead, mercury, nitrate, iodine-129, and tritium predicted by the PATHRAE model for year 0 under no action exceed EPA criteria by factors ranging from 1.1 for iodine to 129 for tritium, indicating that the potential exists for adverse effects on the aquatic biota in the relatively unmixed waters of the wetlands adjacent to the groundwater outcrop. Studies of the biological effects of these contaminants indicate that lead would not adversely affect zooplankton or bluegill populations and that tritium concentrations in the groundwater outcrop are well below the no-effect concentration for developing fish embryos; however, mercury would adversely affect fathead minnows and bluegill. No toxicity information is available for iodine-129; therefore, the potential aquatic effects due to the outcrop concentration of this contaminant cannot be assessed. The groundwater outcrop concentrations of nitrate are not expected to adversely affect the aquatic biota of Four Mile Creek or adjacent wetlands. TE

Water-quality parameters of downgradient wells were reviewed (Killian et al., 1987a) to identify those parameters that were higher than the water-quality criteria for aquatic life. Gross alpha concentrations were above the aquatic criteria, even after dilution. Therefore, adverse effects on aquatic biota could occur as a result of excessive concentrations of gross alpha in the relatively unmixed waters of wetlands adjacent to the groundwater outcrop. TE

The groundwater outcrop concentrations of nitrate and tritium exceed the drinking-water standards under all closure actions, indicating the potential for adverse impacts on wildlife consuming the undiluted groundwater outcrop. However, these impacts should be negligible in view of the conservative nature of applying human drinking-water standards to wildlife and the low probability of significant numbers of wildlife consistently drinking water in the area of the outcrop.

Based on available data, limited terrestrial impacts are anticipated for no action via the biointrusion and consumption of contaminated basin waters pathways. The contaminated levels in the basin waters for chromium, lead, tritium, cesium-137, plutonium-239, uranium-238, strontium-90, and yttrium-90 exceed the drinking-water standards, indicating a potential for adverse effects on wildlife consuming the basin waters. However, these effects should be minimal in view of the size of the basins, the conservative nature of human drinking-water standards when applied to wildlife, and the low probability of significant numbers of wildlife consistently drinking water from the basins. Food-chain uptake calculations based on the bioconcentration by aquatic macrophytes of heavy metals from the standing water indicate that the predicted concentrations of heavy metals are well below the concentrations considered toxic to herbivorous wildlife.

The maximum contaminant concentrations in the seepage basin soil for mercury, americium-241, cobalt-60, cesium-137, tritium, iodine-129, plutonium-238, -239, and -240, antimony-125, strontium-90, and uranium-238 exceed the soil criteria, in some cases by large factors, making adverse terrestrial effects probable. The maximum contaminant concentration in the seepage basin soil for mercury exceeds the phytotoxic concentration, indicating that a potential exists for such adverse vegetation impacts as reduced plant growth and increased plant mortalities. However, food-chain uptake calculations indicate that the predicted vegetation concentration for mercury is below the level considered toxic to herbivorous wildlife. Terrestrial impacts would be limited to the general area occupied by the seepage basins.

F.2.10.2 Assessment of No Removal of Waste and Implementation of Cost-Effective Remedial and Closure Actions as Required

Description of Action

TE Under the no-removal-and-closure action, backfilling and capping of the basin would consist of five phases:

1. Draining the basins' impounded liquids naturally, through infiltration and evaporation.

2. Stabilizing the sediment in the basins with cement.

3. Backfilling the basins with onsite soils to 0.6 meter above the surrounding ground surface, using controlled placement and compaction procedures. Approximately 114,000 cubic meters of backfill would be needed for the three basins.

TC 4. Covering the backfill with a low-permeability cap covering an area of 11.5 acres (Figure F-2).

TC 5. Hydroseeding the newly placed topsoil with an appropriate grass seed to minimize erosion. The seeding would cover an area of 11.5 acres.

The area would be fenced, and only maintenance activities would be allowed. Maintenance activities would consist of inspection for unacceptable erosion, mowing, and long-term groundwater monitoring quarterly for 1 year, then annually for 29 years. Site maintenance would be provided for the entire 30-year period. TC

Additional corrective actions (e.g., groundwater extraction and treatment) might be needed to address the constituents already in the groundwater. The selection of any such action would be based on site-specific studies and interactions with regulatory agencies. Some possible technologies are presented in Appendix C.

Comparison of Expected Environmental Releases with Applicable Standards

Levels of nitrate and tritium would not be affected by the described closure actions and would remain above standards (see Table F-14). Treatment by one or more of the technologies described in Appendix C is expected to reduce the PATHRAE-projected environmental releases of nitrate and tritium to within MCLs or ACLs. Lead and strontium-90 levels, although projected by PATHRAE to be within MCLs, currently exceed MCLs, as indicated by groundwater monitoring data. The levels of lead and strontium-90 would also be reduced to within MCLs by the treatment technology. In addition, the gross alpha and gross beta constituents, including radium, would be reduced to levels within MCLs. However, the levels of iodine-129 and uranium-238 might not be substantially reduced by the remedial action, due to the slow migration of these radionuclides through the vadose zone and aquifer.

The analysis described in the air release section of Section F.2.10.1 was also performed for this action. No risks due to carcinogens were calculated, since the seepage basin would be capped. TE Releases due to noncarcinogens in years 2085 and 2985 would result from the volatilization of mercury. The EPA Hazard Index is calculated to be less than 3.4×10^{-6}. No release of radiological constituents is projected, since the seepage basin would be capped. TE

Potential Impacts (Other Than Releases)

The doses due to reclaimed farm and gamma exposure pathways are negligible. TC

The impacts of the no-waste-removal-and-closure action on biological resources at the F-Area seepage basin are expected to be similar to those described in Sections F.2.10.1 and F.2.18.2. This action would eliminate the potential impacts of biointrusion. TE

F.2.10.3 Assessment of Removal of Waste to the Extent Practicable, and Implementation of Cost-Effective Remedial and Closure Actions as Required

Description of Action

The waste-removal-and-closure action would consist of the following five phases: TE

1. Draining the three basins' impounded liquids naturally, through infiltration and evaporation.

2. Excavating, transporting, and disposing of basin sediments. Based on a preliminary evaluation of soil-coring data, approximately 30 centimeters of material would be removed from all basins, for a total volume of 8000 cubic meters of soil. The materials would be transported in metal boxes and placed in a waste storage/disposal facility. TE

3. Backfilling the basins with on-site soils using controlled placement and compaction procedures to 60 centimeters above the surrounding ground surface elevations. Approximately 122,000 cubic meters of backfill would be needed for all three basins.

4. Capping the backfill with a low-permeability cap as described above.

TC 5. Hydroseeding the newly placed topsoil with an appropriate grass seed to minimize erosion (11.5 acres).

The area would be fenced, and only maintenance activities would be allowed. Maintenance activities would consist of inspection for unacceptable erosion and mowing. Groundwater would be monitored quarterly for 1 year and then annually for 29 years. Site maintenance would be provided for the entire 30-year period. TC

It might be necessary to take corrective actions to reduce levels of those constituents already present in the groundwater at these sites. Any such actions would be based on site-specific studies and interactions with regulatory agencies.

Comparison of Expected Environmental Releases with Applicable Standards

The comparison of expected environmental releases with applicable standards that is provided in Section F.2.10.2 is also relevant. However, the action under waste removal and closure, as projected by PATHRAE, would reduce the levels of uranium-238 to within regulatory standards.

The analysis described in the air release portion of Section F.2.10.1 was also performed. Releases of carcinogens are assumed to occur in the first year, 1986, due to earth-moving activities. No releases are assumed to occur in subsequent years since the seepage basin would be capped. Risks to the maximally exposed individual are calculated to be less than 1.8×10^{-13}. Releases of noncarcinogens are assumed to occur in the first year due to earth-moving activities and in future years due to volatilization of contaminants. However, the EPA Hazard Index is calculated to be less than 4.4×10^{-7} in each year modeled. TC

Releases of radiological constituents in the first year would be due to excavation activities and would be zero in future years, since the basin would be capped. The calculated annual dose to the maximally exposed individual would be less than 0.08 percent of the DOE limit of 25 millirem. The risk associated with this dose would be less than 1.6×10^{-9}. TC

An analysis of the health risks to the average individual worker attributable to occupational exposure to carcinogens (both nonradioactive and radioactive) and noncarcinogens was performed using the methodology presented in Appendix I. The risk to a worker due to nonradioactive carcinogens was calculated to be less than 2.0 x 10^{-11}. The risk due to noncarcinogens to a worker was calculated to be below 1, with a value of 5.0 x 10^{-4}. The total dose to the worker would be 940 millirem, which would produce an incremental risk of 2.6 x 10^{-4}. The total dose to the worker transporting the waste would be 340 millirem, producing an incremental risk of 9.5 x 10^{-5}. TC

Potential Impacts (Other Than Releases)

The waste-removal-and-closure action at the F-Area seepage basins is expected to have similar effects on biological resources as those discussed in Sections F.2.10.2 and F.2.18.3. This action would eliminate potential impacts of biointrusion. TE

F.2.11 F-AREA SEEPAGE BASIN, BUILDING 904-42G

This seepage basin is discussed in conjunction with the other F-Area seepage basins in Section F.2.10.

F.2.12 F-AREA SEEPAGE BASIN, BUILDING 904-43G

This seepage basin is discussed in conjunction with the other F-Area seepage basins in Section F.2.10.

F.2.13 F-AREA SEEPAGE BASIN (OLD), BUILDING 904-49G*

The old F-Area seepage basin, the first constructed in F-Area, was used for effluent disposal from Building 221-F beginning in November 1954 and ending in May 1955. The basin received a variety of wastewater, including evaporator overheads, laundry wastewater, and an unknown amount of chemicals. The history of waste disposal, evidence of contamination, and waste characteristics at the basin are presented in Appendix B, Section B.3.3. TE

F.2.13.1 Assessment of No Action (No Removal of Waste, and No Remedial or Closure Actions)

Description of Action

Under no action, the site would be left in its present condition. Groundwater monitoring with existing wells would be continued quarterly for 1 year, and then annually for 29 years. Upkeep would consist of maintaining a fence and signs around the basin area and controlling the vegetation. TE

Comparison of Expected Environmental Releases with Applicable Standards

Table F-15 lists all constituents in the groundwater that currently exceed or are projected to exceed regulatory standards for no action. Current groundwater monitoring data indicate that concentrations of lead, nickel, nitrate, trichloroethylene (TOH), radium, gross alpha, and gross beta exceed MCLs or health-based standards. Predictions by the PATHRAE model indicate that concentrations of uranium-238, strontium-90, and yttrium-90 will TC

*The reference source of the information in this section is Odum et al., 1987.

exceed standards at various times in the future, and that peak releases of nitrate and trichloroethylene exceeded MCLs from 1958 through 1965.

Surface-water quality would not be significantly affected by the addition of potential contaminants from the groundwater pathway from this site, as the resulting concentrations of constituents in Upper Three Runs Creek and the Savannah River are projected to be below drinking-water standards. TC

The nonradioactive contaminants were analyzed, using the methodology discussed in the introduction to this appendix and in Appendix I, to estimate public exposure and risk attributable to atmospheric contaminant releases from the old F-Area seepage basin. Releases of carcinogens and noncarcinogens are associated with volatilization and wind erosion. Risks attributable to atmospheric releases of carcinogens are calculated to be less than 1.3×10^{-11} for each of the 3 selected years. The EPA Hazard Index for noncarcinogens would be less than 8.6×10^{-7}. TC

Environmental doses and risks to the maximally exposed individual due to radiological releases from the old F-Area seepage basin were calculated using the methodology presented in the introduction to this appendix and in Appendix I. The calculated doses are less than 0.14 percent of the DOE limit of 25 millirem per year for each of the 3 years. The risks associated with these doses would be less than 9.2×10^{-9}.

Potential Impacts (Other Than Releases)

Section F.2.18.1 describes the ecological impacts of no action. PATHRAE analysis and simple dilution modeling have been performed on groundwater concentrations of barium, cadmium, chromium, lead, mercury, nitrate, sodium, trichloroethylene, strontium-90, yttrium-90, uranium-238, and plutonium-239. The results indicate that influent concentrations of these elements would be below EPA criteria for freshwater biota for all closure actions. Therefore, no adverse impacts would occur to the aquatic communities of the Upper Three Runs Creek ecosystem and adjacent wetlands, or to wildlife that use these habitats to drink or feed, including the species listed as threatened or endangered. TE

F.2.13.2 Assessment of No Removal of Waste and Implementation of Cost-Effective Remedial and Closure Actions as Required

Description of Action

Under the no-removal-and-closure action, the liquid in the basin would be allowed to dry by natural seepage and evaporation. The basin would then be backfilled and the site capped. There would be no excavation. The backfill would consist of 0.6 meter to 1.2 meters of crushed stone or washed gravel covered by a geotextile filter fabric and a minimum of 1.2 meters of common borrow fill. The low-permeability cap would be as shown in Figure F-2. A groundwater monitoring program would be maintained quarterly for 1 year and then annually for 29 years. Site maintenance would be provided for the entire 30-year period. TC TC

Additional corrective actions (e.g., groundwater extraction and treatment systems) might be needed to address the constituents already in the groundwater. The action selected would be based on site-specific studies and interactions with relevant regulatory agencies. The groundwater monitoring data in Table F-15 indicate that treatment processes would be required to reduce concentrations of lead, nickel, nitrate, trichloroethylene, radium, gross alpha, and gross beta to levels within regulatory standards. Uranium-238, strontium-90, and yttrium-90 are assumed to be the primary sources of gross alpha and gross beta, respectively. PATHRAE simulations (see Table F-15) indicate that expected peak releases of uranium-238 would exceed its MCL in 2370, and that peak releases of nitrate and trichloroethylene exceeded MCLs from 1956 through 1965.

Comparison of Expected Environmental Releases with Applicable Standards

Based on the results of the PATHRAE simulation, the closure actions described above would be expected to maintain levels of lead, strontium-90, and yttrium-90 within MCLs or ACLs. Levels of nitrate, trichloroethylene, and uranium-238 could be above standards after closure, but remedial actions would be expected to reduce them to within MCLs or ACLs.

TC The analysis described in the air release portion of Section F.2.13.1 was also performed. Releases are due to the volatilization of constituents. No other releases are assumed, since the seepage basin would be capped. The risks due to carcinogen releases would be less than 1.2×10^{-16} each of the 3 selected years. The EPA Hazard Index for noncarcinogens was calculated to be less than 2×10^{-15} for each of the years modeled.

The analysis for radiological releases described in Section F.2.13.1 was also performed. There are assumed to be no releases for all constituents because the basin would be capped.

Potential Impacts (Other Than Releases)

TE As discussed in Sections F.2.13.1 and F.2.18.2, no adverse impacts on biological resources are expected as a result of this closure action at the old F-Area seepage basin.

F.2.13.3 Assessment of Removal of Waste to the Extent Practicable, and Implementation of Cost-Effective Remedial and Closure Actions as Required

Description of Action

TC Under the waste-removal-and-closure action, before the site was excavated, the basin would be allowed to dry by natural seepage and evaporation. Contaminated soil would be excavated to a depth of appproximately 1 meter and transported in metal boxes to a waste storage/disposal facility. Approximately 1 meter would be excavated from the basin. It is estimated that no more than 5370 cubic meters of soil would be excavated and placed in containers. The basin would then be backfilled and capped. The backfill would consist of 0.6 meter to 1.2 meters of crushed stone or washed gravel covered TE by a geotextile filter fabric and at least 0.6 meter of borrow fill. This would be covered by a low-permeability cap, as described above and shown in Figure F-2.

The corners of the closed basin would be marked with identification pylons. Groundwater monitoring would be conducted quarterly for 1 year and then annually for 29 years. Vegetative growth above the basin would be controlled to protect the infiltration barrier. Site maintenance would be provided for the entire 30-year period. TC

Comparison of Expected Environmental Releases with Applicable Standards

Environmental releases to the groundwater would not be affected appreciably by waste removal, as the mobile chemicals and nuclides have been leached from the basin during the 29 years the basin has been receiving waste. Therefore, the discussion presented in Section F.2.13.2 is also applicable to waste removal and closure. TE

The analysis described in the air release portion of Section F.2.13.1 was also performed for this action. Releases are caused by volatilization of constituents and, in the first year, by wind erosion and excavation activities. Risks caused by releases of carcinogens were calculated as being less than 8.4×10^{-15} for each of the 3 years modeled. The EPA Hazard Index for noncarcinogenic releases would be less than 7.0×10^{-10}. TC

Radiological releases described in Section F.2.13.1 were also determined for 1986; they are due to normal excavation activities. These releases would be zero for future years since the basin would be capped. The dose to the maximally exposed individual at the SRP boundary would be less than 6.4×10^{-4} percent of the DOE limit of 25 millirem. The risk associated with this dose would be less than 4.5×10^{-11}. TE

An analysis of the health risks to the average individual worker attributable to occupational exposure to carcinogens (both nonradioactive and radioactive) and noncarcinogens was performed using the methodology presented in Appendix I. The risk due to nonradioactive carcinogens to a worker was calculated as 3.3×10^{-12}. The EPA Hazard Index for worker exposure to noncarcinogens was calculated as 1.4×10^{-5}. The total dose to the worker would be 3.1 millirem, which would produce an incremental risk of 8.7×10^{-7}. The total dose to the worker transporting the waste would be 1.6 millirem, producing an incremental risk of 4.5×10^{-7}. TC

Potential Impacts (Other Than Releases)

As discussed in Sections F.2.13.1 and F.2.18.3, no adverse impacts to biological resources are expected as a result of waste removal and closure at the old F-Area seepage basin.

F.2.14 H-AREA SEEPAGE BASINS*

The H-Area seepage basins (Buildings 904-44G, 904-45G, and 904-56G) are mixed waste management facilities that are presently receiving wastes; basin 904-46G

*The reference source of the information in this section is Killian et al., 1987b.

TE stopped receiving wastes in 1962. Background information on the history of waste disposal, waste characteristics, and evidence of contamination are presented in Appendix B, Section B.3.3.

F.2.14.1 Assessment of No Action (No Removal of Waste, and No Remedial or Closure Actions)

Description of Action

No action would consist of allowing the basins to drain under natural conditions (i.e., infiltration and evaporation). The area would be fenced, and only maintenance activities would be allowed. Maintenance activities would consist of mowing and inspection for unacceptable erosion. Groundwater TC would be monitored quarterly for 1 year, then annually for 29 years. Site maintenance would be provided for the entire 30-year period.

Comparison of Expected Environmental Releases with Applicable Standards

Monitoring has revealed that groundwater beneath the H-Area seepage basins is contaminated with heavy metals, inorganics, and radionuclides. In addition, PATHRAE predicts that a number of these constituents will exceed, or continue TE to exceed, groundwater standards. Table F-16 lists these parameters, the corresponding regulatory standards, and the maximum concentrations found, or predicted to be found, in the groundwater near the basins. Only contaminants that exceed, or are predicted to exceed, standards are listed. All other constituents are found at levels below applicable standards.

PATHRAE modeling of surface-water impacts predicts that concentrations of tritium and nitrate in Four Mile Creek will equal or exceed drinking-water standards because of the addition of those constituents from the groundwater pathway. Table F-16 presents concentrations of those constituents in Four Mile Creek for no action, no waste removal, and waste removal.

Nonradioactive constituents were analyzed to estimate public exposure and risk attributable to atmospheric releases from the H-Area seepage basins.

Releases are caused by the volatilization of constituents and by wind erosion. TC The risks due to releases of carcinogens would be less than 1.4×10^{-8}; the EPA Hazard Index for releases of noncarcinogens would be less than 3.7×10^{-3} for each of the 3 selected years. Environmental doses and risks to the maximally exposed individual due to radiological releases from the H-Area seepage basins were calculated using the methodology presented in the introduction to this appendix and in Appendix I. The doses are calculated to be less than 11.6 percent of the DOE limit of 25 millirem per year for each of the 3 years. The risks associated with these doses would be less than 8.2×10^{-7}.

Potential Impacts (Other Than Releases)

Section F.2.18.1 describes the ecological impacts of no action. A potential exists under all closure actions for adverse impacts on the aquatic biota of Four Mile Creek and adjacent wetlands due to elevated groundwater outcrop and diluted stream concentrations of lead, mercury, nitrate, tritium, and iodine-129. The groundwater outcrop concentrations for these constituents

predicted by the PATHRAE model for year 0 exceed the EPA criteria for the
protection of aquatic life or equivalent values from the technical literature
by factors ranging from 5.2 for nitrate to 200 for tritium. Dilution of the
groundwater outcrop by Four Mile Creek yields stream concentrations for these
constituents that exceed the same criteria by factors ranging from 1.3 for
nitrate to 53 for tritium.

Studies of the biological effects indicate that lead would not adversely
affect zooplankton and bluegill populations; mercury would not adversely TE
affect fathead minnow and bluegill populations; and tritium concentrations are
all below the no-effect concentration for developing fish embryos. No
toxicity information is available for iodine-129; therefore, the potential
aquatic effects due to the groundwater outcrop and diluted stream
concentrations of this constituent cannot be assessed. The groundwater
outcrop and diluted stream concentrations for nitrate are not expected to
adversely affect the aquatic biota of Four Mile Creek or adjacent wetlands.

To estimate potential impacts of other contaminants, water-quality parameters
of downgradient wells were reviewed to identify those that were higher than
the water-quality criteria for aquatic life. Zinc, gross alpha, and gross
beta revealed well and dilution concentrations greater than the criteria
(Table F-17). Therefore, adverse effects could occur on aquatic biota as a
result of excessive concentrations of these contaminants in the water of the
wetlands adjacent to the groundwater outcrop.

The groundwater outcrop concentrations of nitrate, sodium, tritium, and
iodine-129 exceed the drinking-water standards under all closure actions, TE
indicating the potential for adverse effects on wildlife consuming the
undiluted outcrop. However, these impacts should be negligible in view of the
conservative nature of human drinking-water standards when applied to
wildlife, and the low probability of significant numbers of wildlife TC
consistently drinking in the area of the groundwater outcrop.

Examinations of influent and sediment contamination levels indicate that,
because of elevated levels of heavy metals and radionuclides, a potential
exists for adverse effects on wildlife consuming the basin waters under no TE
action. However, these effects should be negligible in view of the limited
basin size and the low probability of significant numbers of wildlife
consistently drinking from this one location.

The maximum contaminant concentrations in the seepage basin soil for chromium,
lead, mercury, silver, americium-241, curium-244, cobalt-60, cesium-134, and
-137, tritium, iodine-129, plutonium-238 and -239, uranium-240, strontium-90,
technetium-99, thorium-233, and uranium-234, -235, and -238 exceed the soil
criteria, in some cases by large factors, making adverse terrestrial impacts
probable. The maximum contaminant concentrations in the seepage basin soil TE
for chromium, lead, mercury, and silver exceed the phytotoxic concentrations,
making such adverse vegetation impacts as reduced plant growth and increased
plant mortalities probable. However, food-chain uptake calculations indicate
that the predicted vegetation concentrations for these constituents are below
the levels considered toxic to herbivorous wildlife. Terrestrial impacts
would be limited to the general area occupied by the seepage basins.

F.2.14.2 Assessment of No Removal of Waste and Implementation of Cost-Effective Remedial and Closure Actions as Required

Description of Action

Under the no removal and closure action, backfilling and capping of the basin would consist of four phases: TE

1. Natural drainage of the basins' impounded liquids by infiltration and evaporation.

2. Backfilling of the basins with onsite soils using controlled placement and compaction procedures to 0.6 meter above the surrounding ground surface elevation. (This 0.6-meter layer is for the establishment of vegetation.) Approximately 244,000 cubic meters of backfill would be needed for the four basins.

3. Capping of the basins with a low permeability cap to reduce infiltration of precipitation (Figure F-2). TC

4. Hydroseeding of the newly placed topsoil with an appropriate legume seed to minimize erosion. The seeding would cover an area of 21.3 acres. The area would be fenced, and only maintenance activities would be allowed. Groundwater would be monitored quarterly for 1 year, then annually for 29 years. Site maintenance would be continued for the entire 30-year period. TC

Remedial actions could be required since results of PATHRAE modeling predict that concentrations in the groundwater of nitrate, tritium, iodine-129, neptunium-237, strontium-90, and yttrium-90 would remain above MCLs (see Table F-16). The precise action taken would be determined on the basis of site-specific studies and interaction with regulatory agencies. Some of the possible treatment technologies are presented in Appendix C.

Comparison of Expected Environmental Releases with Applicable Standards

The implementation of this closure/remedial action would reduce all environmental releases to below MCLs or ACLs. Inorganics and radionuclides would be removed from the groundwater to below applicable standards (see Table F-16). In addition, all other environmental releases are projected to be below regulatory concern. TE

The analysis described in the air release portion of Section F.2.14.1 was also performed for this action. There are no calculated risks due to carcinogenic releases since the seepage basin would be capped. The risks due to noncarcinogenic releases in each of the 3 years would be from the volatilization of mercury and phosphate seepage. The EPA Hazard Index associated with these releases was calculated as less than 9.7×10^{-12}. TC

The analysis for radiological releases described in Section F.2.14.1 was also performed. There are assumed to be no releases for any constituents since the basin would be capped.

Potential Impacts (Other Than Releases)

The impact of no waste removal and closure on aquatic resources at the H-Area seepage basins is expected to be similar to that described in Sections F.2.14.1 and F.2.18.2 and would eliminate the potential impacts of biointrusion.

TE

F.2.14.3 Assessment of Removal of Waste to the Extent Practicable, and Implementation of Cost-Effective Remedial and Closure Actions as Required

Description of Action

TE

The waste removal and closure action at all four basins in H-Area would consist of the following five phases:

1. Natural drainage of the basins' impounded liquids by infiltration and evaporation.

2. Excavation, transport, and disposal of basin sediments. Based on a preliminary evaluation of soil coring data, approximately 0.3 meter of material would be removed, for a total volume of 20,870 cubic meters of soil. The excavated material would be transported in metal boxes to a waste storage/disposal facility.

TC

3. Backfilling of all the basins with onsite soils to 0.6 meter above the surrounding ground surface, using controlled placement and compaction procedures. Approximately 237,150 cubic meters of backfill would be needed.

4. Capping of the basins with an impervious cap (synthetic geomembrane and low-permeability cap) to reduce precipitation infiltration. The cap would cover an area of 24.7 acres and be as described in Figure F-2.

TC

5. Hydroseeding of the newly placed cap with an appropriate grass seed to minimize erosion. The area would be fenced, and only maintenance activities would be allowed. Maintenance activities would include inspection for unacceptable erosion and mowing. Groundwater would be monitored quarterly for 1 year, and then annually for 29 years.

Remedial actions could be required because PATHRAE modeling shows concentrations of nitrate, tritium, iodine-129, neptunium-237, strontium-90, and yttrium-90 in the groundwater remaining above MCLs (see Table F-16).

Comparison of Expected Environmental Releases with Applicable Standards

Implementation of this closure/remedial action would reduce all environmental releases to below MCLs/ACLs. Contaminants would be removed from the groundwater to below applicable standards (see Table F-16 for a listing of standards). In addition, all other environmental releases are projected to be below regulatory concern.

The analysis for air releases described in Section F.2.14.1 was also performed. Releases would be caused by excavation activities and volatilization of constituents. Risks due to releases of carcinogens were calculated as being less than 2.2×10^{-12} for each of the 3 years modeled. The EPA Hazard Index values for noncarcinogenic releases were less than 1.7×10^{-6} for the 3 years. TC

Radiological releases described in Section F.2.14.1 were also determined and for 1986 are due to normal excavation activities. There would be no releases for future years since the basin would be capped. The dose to the maximum individual at the SRP boundary was calculated as being less than 0.03 percent of the DOE limit of 25 millirem. The risk associated with this dose would be less than 1.8×10^{-9}. TE

An analysis of the health risks to the average individual worker attributable to occupational exposure to carcinogens (both nonradioactive and radioactive) and noncarcinogens assuming the worker is in all basins was performed using the methodology presented in Appendix I. The risk due to nonradioactive carcinogens to a worker was calculated as less than 8.8×10^{-11}. The EPA Hazard Index for worker exposure to noncarcinogens was calculated as 2.4×10^{-5}. The total dose to the worker was calculated to be 1.1×10^{3} millirem, which would produce an incremental risk of 3.1×10^{-4}. The total dose to the worker transporting the waste was calculated to be 160 millirem, producing an incremental risk of 4.5×10^{-5}. TC

Potential Impacts (Other Than Releases)

This closure action at the H-Area seepage basins is expected to have similar effects on biological resources as discussed in Sections F.2.14.1 and F.2.18.3 and would eliminate the potential impacts of bioaccumulation. TE

F.2.15 H-AREA SEEPAGE BASIN, BUILDING 904-45G

This seepage basin is discussed in conjunction with the other H-Area seepage basins in Section F.2.14.

F.2.16 H-AREA SEEPAGE BASIN, BUILDING 904-46G

This seepage basin is discussed in conjunction with the other H-Area seepage basins in Section F.2.14.

F.2.17 H-AREA SEEPAGE BASIN, BUILDING 904-56G

This seepage basin is discussed in conjunction with the other H-Area seepage basins in Section F.2.14.

F.2.18 POTENTIAL IMPACTS ON BIOLOGICAL RESOURCES IN F- AND H-AREA

This section discusses those generic impacts related to aquatic and terrestrial ecology, as well as endangered species and wetlands for each closure and remedial action. Discussions of site-specific data are given in the appropriate section above. TE

There are 17 waste sites located within F- and H-Area. The F-Area acid/caustic basin is abandoned in place and is a wet-weather pond, as are the H-Area acid/caustic basin, the H-Area retention basin, the old F-Area seepage basin, and one of the H-Area seepage basins. Three F-Area seepage basins, three H-Area seepage basins, and the new radioactive waste burial ground (which includes the mixed waste management facility) are active waste sites. The four remaining sites, the two F-Area burning/rubble pits, the F-Area retention basin, and the old radioactive waste burial ground are backfilled or covered with soil.

F.2.18.1 Assessment of No Action (No Removal of Waste and No Remedial or Closure Action)

Aquatic Ecology

TE Impacts of no action on aquatic ecosystems could result from wastes entering TC the groundwater and subsequently outcropping to either Upper Three Runs Creek or Four Mile Creek. Table F-17 lists those contaminants identified in groundwater monitoring wells at the F- and H-Area waste sites not modeled TE using PATHRAE analyses which exceed EPA water quality criteria for aquatic life. A waste is listed in Table F-17 if the highest average measured value in any well exceeded the criterion. Since groundwater concentrations would be diluted upon entering the receiving water body, a dilution factor is also given in the table. In most cases the diluted concentrations were below the criteria, with the exception of gross alpha in the F-Area seepage basin and zinc, gross alpha, and gross beta in the H-Area seepage basin. These exceptions are discussed separately above in the appropriate sections.

Terrestrial Ecology

Potential terrestrial impacts for the waste sites of F- and H-Areas include exposure of wildlife and vegetation to surface waters within these sites and the toxic effects on vegetation of soils containing waste materials. The terrestrial impacts of those waste sites with standing surface waters and soils containing waste materials are discussed on an individual basis in previous sections.

Endangered Species

TC As indicated in Table F-17, no endangered species are known to reside in the vicinity of the F- and H-Area waste sites. Bald eagles have been sighted in flight near the H-Area waste sites, but this species should not be affected by TE no action. The waste sites, some of which are active, are all located near active facilities; as such, they represent highly disturbed habitats. The area is, therefore, not suitable for any of the endangered species known to occur on the Savannah River Plant. No action would have no impact on endangered species.

Wetlands

Wetlands are found within 1000 meters of each of the F- and H-Area waste sites, and as close as 100 meters from the H-Area seepage basins. Information on these wetlands is presented in Table F-17. Most wetlands are found along Four Mile Creek and its unnamed tributaries, and are more than 400 meters from the waste sites. No action would cause no impacts to wetlands other than those that may be occurring now. There are no surface discharges to wetlands, and no action would not result in any. TE

F.2.18.2 Assessment of No Removal of Waste and Implementation of Cost-Effective Remedial and Closure Actions as Required

Aquatic Resources

No removal of waste and implementation of cost-effective remedial and closure actions at the F- and H-Area waste sites would not cause additional adverse impacts on aquatic ecological resources. Erosion and sedimentation control measures would eliminate the potential for increased sedimentation. Where closure would eliminate open water at waste sites, no adverse effects to aquatic or semiaquatic organisms resulting from use of the open water areas would occur.

Terrestrial Resources

Closure would have no adverse impact on terrestrial ecological resources at the F- and H-Area waste sites. All of the sites are highly disturbed and closely associated with active operations areas, thus providing little or no habitat for terrestrial species. Construction activities associated with closure would not result, therefore, in significant impacts. Where closure would eliminate open water, adverse effects on wildlife resulting from use of the open-water areas would not occur. TE TE

Roots of deep-rooted plants could eventually penetrate the contaminant zone for sites if a low-permeability cap was used, thereby releasing wastes to the environment. However, site maintenance by mowing during the period of institutional control would prevent this potential impact.

Endangered Species

Closure would result in further disturbance of areas that are already highly disturbed and unsuitable as habitat for endangered species known to occur on the Savannah River Plant. With the exception of bald eagles, which have been observed in flight near H-Area, no endangered species are known to exist in the vicinity of F- and H-Area waste sites. Closure would have no significant impact on endangered species, although construction disturbance could temporarily discourage eagles from flying over a site undergoing cleanup. TE

Wetlands

As described in Section F.2.18.1, wetlands are found within 1000 meters of each of the F- and H-Area waste sites. Closure would cause no impacts on wetlands because they would not be disturbed by the action. The potential for increased sedimentation exists but would be checked by erosion and sedimentation control measures. TE

F.2.18.3 Assessment of Removal of Waste to the Extent Practicable and Implementation of Cost-Effective Remedial and Closure Actions as Required

Aquatic Ecology

TE In addition to wastewater removal and treatment, this action includes removal of contaminated waste material, sediment, and soil from the waste sites. Closure would be accomplished by backfilling and installation of a
TE low-permeability cap, eliminating the sources of contamination, and causing no additional adverse impacts to aquatic ecological resources. Closure of the waste site would eliminate adverse effects on organisms resulting from the use of open-water areas at the waste site.

Terrestrial Ecology, Endangered Species, and Wetlands

TE For the reasons described in Section F.2.18.2, there are no adverse impacts on terrestrial resources, endangered species, or wetlands.

F.3 ASSESSMENT OF ACTIONS AT R-AREA WASTE SITES

This geographic grouping is approximately 6 kilometers east of H-Area. As shown on Figure F-6, it contains R-Reactor and waste sites that are typical of the SRP reactor areas.

Sections F.3.1 through F.3.12 contain or reference the section that contains a discussion of sites 3-1 through 3-12. Section F.3.13 discusses biological impacts that are generically applicable to the waste sites in this geographic grouping.

F.3.1 R-AREA BURNING/RUBBLE PIT, BUILDING 131-R

This burning/rubble pit is discussed in conjunction with the other burning/rubble pits in Section F.1.6. The ecological effects of this site that relate to the R-Area geographic grouping are discussed in Section F.3.13.

F.3.2 R-AREA BURNING/RUBBLE PIT, BUILDING 131-1R

This burning/rubble pit is discussed in conjunction with the other burning/rubble pits in Section F.1.6. The ecological effects of this site that relate to the R-Area geographic grouping are discussed in Section F.3.13.

F.3.3 R-AREA ACID/CAUSTIC BASIN, BUILDING 904-77G

This acid/caustic basin is discussed in conjunction with the other acid/caustic basins in Section F.2.1. The ecological effects of this site that relate to the R-Area geographic grouping are discussed in Section F.3.13.

F.3.4 R-AREA BINGHAM PUMP OUTAGE PITS*

There are a total of seven Bingham pump outage pits located in four reactor areas:

Area	Building	Area	Building
R	643-8G	L	643-2G
R	643-9G	L	643-3G
R	643-10G	P	643-4G
K	643-1G		

The actions described in this section would be applicable to each of these outage pits.

Because the L-Area pits are situated closer to surface and subsurface waters, the total environmental releases and resulting impacts from the two L-Area pits would be greater than from the pits in the other areas. For this reason, the Bingham pump outage pits in the L-Area were chosen for detailed transport and pathway modeling and risk analysis. Environmental impacts associated with the L-Area outage pits are presented in this section. For purposes of this EIS, the total impacts from the pits in each reactor area are assumed to be the same as the total impacts from the two L-Area outage pits.

F.3.4.1 Assessment of No Action (No Removal of Waste, and No Remedial or Closure Actions)

Description of Action

The Bingham pump outage pits are currently receiving minimum control or upkeep. Annual inspections are made for signs of soil subsidence. Any sunken
TC areas would be filled as required. Radiation surveys have revealed slightly elevated although very low concentrations of radioactivity in vegetation above the outage pits. The natural growth of trees around and onto the site has continued since 1958 and would be permitted to do so under this closure action. Under no action, at least four groundwater monitoring wells would be
TC installed and groundwater monitoring would be conducted quarterly for 1 year and then annually for 29 years. Site maintenance would be continued for the entire 30-year period.

Comparison of Expected Environmental Releases with Applicable Standards

The two L-Area outage pits' contents were combined to define a single
TE effective pit. All environmental releases are projected to be below applicable standards for no action.

The PATHRAE predicts that groundwater quality would not be affected significantly by the addition of potential contaminants from this waste management unit. All constituents should be found at levels below applicable health-based standards.

*The reference source of the information in this section is Pekkala, Jewell, Holmes, and Marine, 1987a.

Surface-water quality would not be significantly affected by the addition of potential contaminants from the groundwater pathway from this site. The resulting concentrations of constituents in Pen Branch, calculated from the L-Area Bingham pump outage pits, are projected to be below drinking-water standards. TE

No radionuclides would be released to the atmosphere, because the pits have all been backfilled.

Potential Impacts (Other Than Releases)

The maximum annual doses resulting from the reclaimed farm and direct gamma exposure pathways occur 100 years from the present. The doses would only be 6.9×10^{-3} and 6.8×10^{-4} millirem per year for the farm and direct gamma pathways, respectively. The dose would be zero for the pathway involving consumption of crops potentially contaminated as a result of biointrusion of subsurface sediments, due to the assumed limited plant-root depth.

Section F.3.13.1 describes impacts to ecological resources from no action that could affect aquatic resources as a result of wastes entering the groundwater with subsequent outcrop to Par Pond. No groundwater monitoring data are available for the R-Area Bingham pump outage pits. PATHRAE analysis and simple dilution modeling performed on the two L-Area Bingham pump outage pits are considered to be representative of other pump outage pits. The levels of groundwater outcrop contamination predicted by PATHRAE and dilution modeling are ecologically insignificant for all closure actions, indicating no potential for adverse effects on the aquatic biota or adjacent wetlands and no adverse effects on wildlife that consume the undiluted groundwater at the outcrop. TE TE

Based on the small amounts of radioactivity disposed of at the outage pits, any terrestrial impacts should be negligible for all closure actions. The levels of radioactivity in the vegetation growing above the outage pits are ecologically insignificant, although these levels are slightly elevated in comparison to the vegetation growing at the SRP perimeter. Because of the depth at which the waste is buried (4 meters), any effects via the biointrusion pathway should be negligible. TE

F.3.4.2 Assessment of No Removal of Waste and Implementation of Cost-Effective Remedial and Closure Actions as Required

Description of Action

Because of the small amount of radioactivity buried at the Bingham pump outage pits, no activities would be needed other than site surveillance and groundwater monitoring, as described for no action.

Comparison of Expected Environmental Releases with Applicable Standards

All PATHRAE-modeled environmental releases are projected to be below applicable standards for closure. Because no-waste-removal-and-closure action would be the same as those for no-action, Section F.3.4.1 applies here. TE

Potential Impacts (Other Than Releases)

TE Because no action is the same as the no-waste-removal-and-closure action for the Bingham pump outage pits, Section F.3.4.1 also applies here.

TE As described in Sections F.3.4.1 and F.3.13.2, no significant adverse impacts to biological resources are expected as a result of closures at the R-Area Bingham pump outage pit (643-8G).

F.3.4.3 Assessment of Removal of Waste to the Extent Practicable, and Implementation of Cost-Effective Remedial and Closure Actions as Required

Description of Action

TE In the waste removal and closure action, the earthen cover would be removed from each waste site and retained for later use as backfill. The solid radioactive waste and surrounding soil would be excavated 0.3 meter below the original bottom of the outage pit. This excavation should reduce the residual contamination in the soil beneath the outage pit to near-background levels, so that no restrictions on site use would be needed after the pit was backfilled with clean soil, compacted, graded, and seeded for erosion control. Surveys would be made of the basin floor for residual radioactive contamination; the results might require additional excavation below the 0.3-meter depth in order to achieve acceptable results.

TE A total of approximately 27,000 cubic meters of exhumed waste would be excavated from the pits and placed in metal boxes or bagged as necessary and trucked to a waste storage/disposal facility. The bulky components of the waste (ladders, concrete, drums, pallets, piping, etc.) would require special TE care and equipment for exhumation, packaging, transport, and placement in the storage/disposal facility.

The corners of each closed outage pit would be marked with identification pylons. Should soil analyses show that elevated concentrations of waste remain in the soil after excavation, four groundwater monitoring wells (one upgradient, three downgradient) would be installed around the outage pits in each of the four areas. Groundwater would be monitored quarterly for 1 year and then annually for 29 years. Site surveillance would be maintained and vegetative growth above the waste sites would be controlled.

Comparison of Expected Environmental Releases with Applicable Standards

All environmental releases are projected to be below applicable standards for closure.

The PATHRAE model predicts that groundwater quality would not be affected significantly by the addition of potential contaminants from this waste management unit. All constituents should be found at levels below applicable health-based standards.

Surface-water quality would not be significantly affected by the addition of potential contaminants from the groundwater pathway from this site. The resulting concentrations of constituents in Pen Branch, calculated from the L-Area Bingham pump outage pits, are projected to be below drinking-water standards. TE

Radionuclide releases to the atmosphere would take place only during the time that waste is being removed from the outage pits.

The annual dose to an individual resulting from the release of these radionuclides to the atmosphere would be only 1.92×10^{-5} percent of the 25 millirem per year DOE limit. The risk associated with this dose would be 1.34×10^{-12}.

An analysis of the average individual worker health risks attributable to occupational exposure to radioactive carcinogens was performed using the methodology presented in Appendix I. The total dose to the worker was calculated to be 2.4 millirem, which would produce an incremental risk of 6.7×10^{-7}. The total dose to the worker transporting the waste was calculated as 1.2 millirem, producing an incremental risk of 3.4×10^{-7}.

Potential Impacts (Other Than Releases)

The maximum annual doses resulting from the reclaimed farm and direct gamma exposure pathways would occur 100 years after waste removal and closure, at which time institutional control of the SRP is assumed lost. The dose would be 1.4×10^{-8} millirem per year for the farm pathway. The dose from the direct gamma exposure would be essentially *zero* ($\sim 10^{-20}$ millirem per year). The dose would be zero for the pathway which involves consumption of crops potentially contaminated as a result of biointrusion of subsurface sediments. Such contamination is precluded due to the assumed limited plant-root depth. TC

For the reasons described in Sections F.3.4.1 and F.3.13.3, no adverse impacts on biological resources are expected as a result of closure at the R-Area Bingham pump outage pit (643-8G).

F.3.5 R-AREA BINGHAM PUMP OUTAGE PIT, BUILDING 643-9G

Potential impacts for this outage pit are discussed in conjunction with the other Bingham pump outage pits in Section F.3.4.

F.3.6 R-AREA BINGHAM PUMP OUTAGE PIT, BUILDING 643-10G

Potential impacts for this outage pit are discussed in conjunction with the other Bingham pump outage pits in Section F.3.4.

F.3.7 R-AREA REACTOR SEEPAGE BASINS*

The R-Area reactor seepage basins consist of six sites (904-103G, 904-104G, 904-57G, 904-58G, 904-59G, and 904-60G). Purge water from the disassembly basins in the reactor building was pumped to the seepage basins from the late

*The reference source of the information in this section is Pekkala, Jewell, Holmes, and Marine, 1987b.

1950s until 1964. The seepage basins have been inactive since 1964 and were backfilled. R-Area basins are contiguous; therefore, they are considered as one site for evaluation and assessment analyses. The surface stream nearest to these R-Area basins is Mill Creek. No hazardous chemical constituents are believed to have been discharged to these basins.

F.3.7.1 Assessment of No Action (No Removal of Waste, and No Remedial or Closure Actions)

Description of Action

The R-Area seepage basins are currently backfilled and receive only minimal upkeep. Radiation surveys are conducted periodically, and herbicide or asphaltic covering is applied infrequently. However, groundwater is extensively monitored for radioactive contamination. Under no action, those activities would be continued, with quarterly groundwater monitoring for 1
TC year and annual monitoring for 29 years. Pylons would be installed to identify the corners of the backfilled basins, and vegetative growth would be controlled and surveyed periodically for radiation.

Comparison of Expected Environmental Releases with Applicable Standards

The regulatory standards and measured or estimated maximum concentrations of constituents which are of concern for regulatory requirements or health risk are presented in Table F-18. Most maximum concentrations are based on PATHRAE modeling, either because no measured values were available or because the calculated concentration was greater than that of the measured concentration.

The maximum estimated concentrations presented in Table F-18 correspond to the calculated peaks. In most cases these peaks occurred prior to the base year. Although the site is not receiving wastes presently, the peak concentrations, in the absence of base year (0 year) concentrations, would conservatively serve as the design basis of the remedial actions. Table F-18 indicates that concentrations of cesium-137, tritium, strontium-90, and yttrium-90 are estimated to exceed the standards at the 1-meter well. Cesium-137 and tritium would exceed standards at the 100-meter well.

Surface-water quality is not significantly affected by the addition of potential contaminants from this site, as the resulting concentrations of constituents in Mill Creek are projected to be below drinking-water standards.

The annual dose and associated risks to an individual resulting from the atmospheric radionuclide releases for the no-action alternative would be
TC negligible when compared to the DOE limit of 25 millirem per year. The dose to the maximum individual would be 4.1×10^{-9} millirem; the risk associated with this dose is 1.2×10^{-25}.

Potential Impacts (Other Than Releases)

The doses resulting from the erosion and biointrusion pathways were all zero. The maximum annual doses for the reclaimed farm pathway and the direct gamma exposure pathway are calculated as 4.5 and 2.3×10^{-6} millirem per year, respectively.

TE Section F.3.13.1 describes impacts to ecological resources from no action. Potential impacts resulting from no action at the R-Area seepage basin (904-57G) are expected to be similar to those described in Section F.3.13.1. PATHRAE analysis and simple dilution modeling based on radionuclide inventories for the R-Area seepage basins indicate that stream concentrations after mixing would remain within water quality guidelines for all closure TE actions for all years.

Based on available data, limited terrestrial impacts are expected at the R-Area seepage basins under no action via the biointrusion pathway. The soil TE concentrations for strontium-90 and cesium-137 exceed DOE's Threshold Guidance Levels criteria by factors of about 1200 and 73,000, respectively. Because these soil criteria are based on human health concerns, they are conservative. Terrestrial effects under no action would be limited to the general area of the waste site (approximately 5.5 acres) and would be mitigated by the depth of the existing backfill (3 to 5 meters).

F.3.7.2 Assessment of No Removal of Waste and Implementation of Cost-Effective Remedial and Closure Actions as Required

Description of Action

TE In the no-removal-and-closure action, no contaminated soil would be removed. However, the surface soil over the 27-acre area shown in Figure F-7 would be removed down to approximately 1 or 2 meters below the original ground surface. The area of removal would include the six basins, the contaminated section of the abandoned sewer, and major areas of groundwater contamination. TC A low-permeability infiltration barrier cap would then be installed over this area (Figure F-2). The capped site would be graded and seeded for erosion control, and culverts or equivalent structures would be installed around the site to receive surface and subsurface drainage. The culverts would discharge into natural drainages to Mill Creek. Site maintenance, groundwater monitoring, placement of identification pylons, and radiation surveys would be carried out as described above.

Source control and groundwater cleanup might be required for no waste removal. It can be seen from the estimated concentrations presented in Table F-18 that the concentrations in groundwater of tritium, cesium-137, strontium-90, and yttrium-90 would exceed the applicable radionuclide concentration standards. One of the possible corrective actions would be to pump the water from groundwater extraction wells and treat it further. The selection of an action plan would be based on site-specific studies and interaction with the regulatory agencies concerned. Treatment technologies are discussed in Appendix C.

Comparison of Expected Environmental Releases with Applicable Standards

The implementation of this closure remedial action would reduce all environmental releases to below MCLs or ACLs. Radionuclides would be removed from the groundwater to below applicable standards (see Table F-18). All other environmental releases are projected to be below regulatory concern.

Surface-water quality would not be significantly affected by the addition of potential contaminants from the groundwater pathway from this site, as the resulting concentrations of constituents in Mill Creek are projected to be below drinking-water standards.

No radionuclides would be released to the atmosphere and individual doses would be zero.

Potential Impacts (Other Than Releases)

The doses due to erosion and biointrusion would all be zero. The calculated TC doses for the reclaimed farm pathway and direct gamma exposure would be 8.1 x 10^{-4} and 2.4 x 10^{-10} millirem per year, respectively.

Closure would be accomplished with a low-permeability cap covering a total of 27.2 acres. While this is a relatively large area, it is adjacent to operations areas and is not habitat for terrestrial species. Also, because erosion and sedimentation measures would be used, no adverse impacts on terrestrial ecological resources are expected as a result of this closure action at the R-Area seepage basins. Terrestrial impacts from biointrusion would be mitigated by the depth of the backfill and the installation of the infiltration barrier, and would be limited to the general area of the waste site. Other ecological impacts would be similar to those discussed in Section F.3.13.2.

F.3.7.3 Assessment of Removal of Waste to the Extent Practicable, and Implementation of Cost-Effective Remedial and Closure Actions as Required

Description of Action

TE In the waste-removal-and-closure action, each of the six backfilled basins in R-Area would be excavated to remove contaminated soil indicated by the zone of elevated dose rates shown in Figure F-8. The thickness of the radioactive zone and the amount of contaminated soil expected to be recovered are shown in Table F-19. During the waste recovery phase, contaminated sections of the abandoned construction sewer would be removed and associated contaminated soil would be recovered. After excavation, each basin would be backfilled with compacted clean soil to approximately 1 or 2 meters below the original ground surface.

The contaminated soil recovered during the excavation phase (7080 cubic TE meters) would be packaged in metal containers and trucked to a waste storage/ disposal facility at the SRP.

Following the recovery of contaminated soil, the remaining surface soil over the 27-acre area shown in Figure F-7 would be removed down to the datum plane identified above. This area includes the six basins, the contaminated section TE of the abandoned sewer, and major areas of groundwater contamination. A low-permeability infiltration barrier would then be installed over the 27-acre area. About 7000 cubic meters of clean backfill would be required in addition to the clean soil excavated. The capped site would be graded and seeded for erosion control, and culverts or equivalent structures would be installed around the site to receive surface and subsurface drainage. The culverts would discharge into natural drainages to Mill Creek.

Table F-19. Volume of Radioactive Soil To Be Excavated at the R-Area Reactor Seepage Basins in the Waste Removal and Closure Action

Site	Building	Thickness of Contamination (m)	Contaminated Soil (m^3)
Basin 1	904-103G	1.8	1630
2	904-104G	1.5	1080
3	904-57G	1.2	710
4	904-58G	1.2	560
5	904-59G	1.2	1090
6	904-60G	1.2	1590
Abandoned sewer		0.6	420
		Total	7080

Groundwater monitoring wells at selected locations that would be removed during installation of the infiltration barrier would be replaced and groundwater monitoring would be continued, quarterly for 1 year and then annually for 29 years. Pylons would be installed to identify the corners of the previous basins, and vegetative growth would be surveyed periodically and controlled to protect the infiltration barrier.

Remedial action may be required since PATHRAE modeling predicts that the concentrations in groundwater of tritium, cesium-137, and strontium-90 would exceed the recommended radionuclide concentration standards (see Table F-18). The potential remedial action would be similar to that discussed in Section F.3.7.2. Final selection of an action would be based on site-specific studies and interactions with regulatory agencies.

Comparison of Expected Environmental Releases with Applicable Standards

The regulatory standards and measured or estimated maximum concentrations of all contaminants of concern from a regulatory and health risk viewpoint are presented in Table F-18 for waste removal and closure without further remedial action. By comparison with waste removal and closure (see Table F-18), the extent and concentration of groundwater contamination by strontium-90 and yttrium-90 would be significantly reduced as a result of the waste removal. For example, the peak concentrations of strontium-90 and yttrium-90 would be reduced by a factor of 100 at the 1-meter well, with yttrium-90 reduced to below its regulatory standard. However, modeling predicts that cesium-137, tritium, and strontium-90 concentrations have exceeded or will exceed the standard; therefore, remedial action might be required.

The implementation of this closure/remedial action would reduce all environmental releases to below MCLs or ACLs. Radionuclides would be removed from the groundwater to below applicable standards (see Table F-18). All other environmental releases are projected to be below regulatory concern.

Surface-water quality would not be significantly affected by the addition of potential contaminants from the site, as the resulting concentrations of constituents in Mill Creek are projected to be below drinking-water standards.

Radionuclides would be released to the atmosphere during the first year only for this action. | TE

The total annual maximum individual dose due to atmospheric releases would be less than 0.022 percent of the DOE limit of 25 millirem per year. The risk associated with this dose would be 1.6×10^{-9} or less. | TC

An analysis of the average individual worker health risks attributable to occupational exposure to radioactive carcinogens was performed using the methodology presented in Appendix I. The total dose to the worker was calculated to be 4200 millirem, which would produce an incremental risk of 1.2×10^{-3}. The total dose to the worker transporting the waste was calculated as 300 millirem, producing an incremental risk of 8.4×10^{-5}. | TC

Potential Impacts (Other Than Releases)

The doses due to erosion and biointrusion would all be zero. The calculated doses for the reclaimed farm pathway and direct gamma exposure doses would be negligible.

For the reasons described in Sections F.3.7.1 and F.3.13.3, no adverse impacts on aquatic or terrestrial resources, endangered species, or wetlands are expected as a result of this closure action at the R-Area seepage basins.

F.3.8 R-AREA REACTOR SEEPAGE BASIN, BUILDING 904-58G (BASIN 4) | TE

This waste site is discussed in conjunction with the other R-Area seepage basins in Section F.3.7.

F.3.9 R-AREA REACTOR SEEPAGE BASIN, BUILDING 904-59G (BASIN 5) | TE

This waste site is discussed in conjunction with the other R-Area seepage basins in Section F.3.7.

F.3.10 R-AREA REACTOR SEEPAGE BASIN, BUILDING 904-60G (BASIN 6) | TE

This waste site is discussed in conjunction with the other R-Area seepage basins in Section F.3.7.

F.3.11 R-AREA REACTOR SEEPAGE BASIN, BUILDING 904-103G (BASIN 1)

This waste site is discussed in conjunction with the other R-Area seepage basins in Section F.3.7.

F.3.12 R-AREA REACTOR SEEPAGE BASIN, BUILDING 904-104G (BASIN 2)

This waste site is discussed in conjunction with the other R-Area seepage basins in Section F.3.7.

F.3.13 POTENTIAL IMPACTS ON BIOLOGICAL RESOURCES IN R-AREA

TE This section addresses generic impacts related to aquatic and terrestrial ecology, endangered species, and wetlands for each closure action. Discussions of site-specific data are presented in the appropriate section above.

There are 12 waste sites located within the R-Area. Ten sites are presently backfilled with soil and abandoned. The six R-Area seepage basins are surfaced with asphalt. The inactive R-Area acid/caustic basin is a wet-weather pond, and one burning/rubble pit (131-1R) received only small quantities of waste and was not backfilled.

F.3.13.1 Assessment of No Action (No Removal of Waste and No Remedial or Closure Action)

Aquatic Ecology

Potential impacts of no action on aquatic resources result from wastes entering groundwater and subsequent outcrop to Par Pond or its tributaries, or, in the case of the R-Area seepage basins, to Mill Creek, a tributary of Upper Three Runs Creek. Table F-20 lists those waste materials identified in groundwater monitoring wells within the R-Area which would exceed EPA water quality criteria for aquatic life. A waste material is listed if the highest average measured value in any well exceeded the criterion. Groundwater data are not available for the Bingham pump outage pits or the R-Area seepage basins. Because groundwater concentrations would be diluted on entering the receiving water body, Table F-19 provides a dilution factor. In all cases, the contaminants listed in the table would be below the EPA aquatic criteria after dilution.

All R-Area waste sites except the R-Area acid/caustic basin and burning/rubble pit 131-1R are backfilled and therefore would cause no adverse impacts to aquatic or semiaquatic organisms as a result of attraction to open-water areas.

Terrestrial Ecology

No action could cause adverse impacts on terrestrial resources at the R-Area waste sites. Data indicate elevated radionuclide levels in soil and vegetation at the R-Area reactor seepage basins and Bingham pump outage pits, respectively. However, the three Bingham pump outage pits and the six seepage basins are backfilled with soil and covered with asphalt, respectively, which could reduce potential transport of radioactive contaminants to the surface by vegetation and, therefore, mitigate adverse impacts.

The R-Area burning/rubble pits and the R-Area acid/caustic basin have received chemical wastes and are either backfilled with soil (burning/rubble pits 131-R) or remain open as a wet-weather pond (burning/rubble pit 131-1R and acid/caustic basin). Therefore, the potential exists for transport of chemical contaminants to the surface by vegetation growing on these sites.

As discussed in Section F.1.6, impacts via the biointrusion pathway are expected to be negligible under all closure actions at the R-Area burning/rubble pits. To assess impacts at the R-Area acid/caustic basins associated with biointrusion under no action, maximum observed concentrations of contaminants in basin soils were compared to phytotoxicological benchmarks, and calculated plant tissue concentrations were compared to dietary levels known to be toxic to birds and mammals. The results indicate that, at the acid/caustic basin, lead and mercury occur in the soils at concentrations known to be toxic to vascular plants. However, in no case do calculated plant tissue concentrations approach those known to be toxic to herbivorous birds and mammals. Therefore, although there could be some effects on the vegetation growing on the sites, the effects should be restricted to the waste sites themselves under no action.

Endangered Species

Table F-20 lists information on endangered species in the vicinity of the R-Area waste sites. Areas apparently used by these species are sufficiently distant from the waste sites that no adverse impacts are expected as a result of closure.

A former colony site for the red-cockaded woodpecker is approximately 800 meters to the southeast of the outage pits in R-Area. This site is beyond the typical foraging distance for this species, as reported on the SRP. Therefore, none of the actions postulated for the site would have any effect on this endangered species or its critical habitats.

Wetlands

Wetlands are found within 500 meters of each of the R-Area waste sites, and within approximately 250 meters of all sites except the Bingham pump outage pits (see Table F-20). The wetlands consist of open water and bottomland hardwood forests. No action would cause no additional impacts on wetlands than may be occurring at the present time. No surface discharges to wetlands are currently occurring, and the no-action alternative would not result in anv such discharges.

F.3.13.2 Assessment of No Removal of Waste and Implementation of Cost-Effective Remedial and Closure Actions as Required

Aquatic Ecology

Closure and possible remedial activities are not expected to adversely impact biological resources. Erosion and sedimentation control measures would eliminate the potential for increased sedimentation. The potential for adverse impacts due to the outcropping of groundwater would be eliminated. TC

Terrestrial Ecology

The potential terrestrial impacts of no waste removal and closure for the waste sites of the R-Area would include temporary disturbance to wildlife due to noise associated with closure activities and uptake of wastes by plant roots. Installation and continued maintenance of the low permeability cap would mitigate impacts from biointrusion from root penetration. TE

Endangered Species and Wetlands

The distance to areas known to be used by endangered species and to wetlands, plus erosion and sedimentation control measures, eliminate the potential for adverse impacts on wetlands and endangered species from the no waste removal and closure.

F.3.13.3 Assessment of Removal of Waste to the Extent Practicable and Implementation of Cost-Effective Remedial and Closure Actions as Required

TE In addition to the measures described in Section F.3.13.2, wastes located in the R-Area waste sites would be removed under this action. Construction activities might take longer than under no waste removal and closure, but they would be similar. Therefore, no adverse impacts to biological resources are expected as a result of waste removal and closure action at the R-Area waste sites.

F.4 ASSESSMENT OF ACTIONS AT C- AND CS-AREA WASTE SITES

This geographic grouping is near the center of the SRP, a short distance south of F- and H-Area. As shown in Figure F-9, it is actually two separate but closely spaced groupings, one formed by waste sites near C-Reactor and the other containing sites in and around the Central Shops (CS) Area.

Sections F.4.1 through F.4.7 contain or reference the section that contains a discussion of sites 4-1 through 4-7. Section F.4.8 discusses biological impacts that are generically applicable to the waste sites in the geographic grouping.

F.4.1 CS BURNING/RUBBLE PIT, BUILDING 631-1G

This burning/rubble pit is discussed in conjunction with the other burning/rubble pits in Section F.1.6. The ecological effects of this site that relate to the C- and CS-Area geographic grouping are discussed in Section F.4.8.

F.4.2 CS BURNING/RUBBLE PIT, BUILDING 631-5G

This burning/rubble pit is discussed in conjunction with the other burning/rubble pits in Section F.1.6. The ecological effects of this site that relate to the C- and CS-Area geographic grouping are discussed in Section F.4.8.

F.4.3 CS BURNING/RUBBLE PIT, BUILDING 631-6G

This burning/rubble pit is discussed in conjunction with the other burning/rubble pits in Section F.1.6. The ecological effects of this site that relate to the C- and CS-Area geographic grouping are discussed in Section F.4.8.

F.4.4 C-AREA BURNING/RUBBLE PIT, BUILDING 131-C

This burning/rubble pit is discussed in conjunction with the other burning/rubble pits in Section F.1.6. The ecological effects of this site that relate to the C- and CS-Area geographic grouping are discussed in Section F.4.8.

F.4.5 HYDROFLUORIC ACID SPILL AREA, BUILDING 631-4G*

F.4.5.1 Assessment of No Action (No Removal of Waste, and No Remedial or Closure Actions)

Description of Action

TE Under no action, the contaminated area would remain in its current status, with groundwater monitoring continuing on a quarterly basis for 1 year and then on an annual basis for 29 years. Site maintenance would continue for the entire 30-year period.

Comparison of Expected Environmental Releases with Applicable Standards

The chemical constituents selected for assessment of the environmental impacts and health risks associated with the hydrofluoric acid spill area were fluoride and lead. Fluoride was selected because it is suspected to be present due to the nature of the material spilled. Lead was chosen because it was found to be present in the groundwater at levels higher than the threshold selection criteria.

The effects of groundwater contaminant transport were modeled by PATHRAE at two hypothetical monitoring wells located 1 and 100 meters downgradient from the site, and the groundwater discharge point at Castor Creek. All modeled constituents in the groundwater have peak concentrations below applicable standards with the exception of lead, which is predicted to have been present in the 1-meter well at a concentration of 7.0×10^{-2} milligram per liter in 1975.

This concentration exceeds the drinking-water standard for lead of 5.0×10^{-2} milligram per liter. Monitoring data indicate that the concentration of lead in the groundwater is currently below the drinking-water standard. Surface-water quality would not be affected significantly by the addition of potential waste constituents from the groundwater pathway from this source, because the concentrations of constituents in Castor Creek from this source are projected to be below drinking-water standards.

No carcinogenic risks from atmospheric chemical releases are expected. The
TC EPA Hazard Index for the maximally exposed individual would be less than 3.5×10^{-7}, and would be insignificant.

Estimates of the lead and fluoride concentrations for the erosion pathway indicate that the concentrations are very small, well below levels of regulatory or health risk concern.

Potential Impacts (Other Than Releases)

Section F.4.8.1 describes general impacts to biological resources for no action. Lead and fluoride were modeled using PATHRAE, which indicates that

*The reference source for the information in this section is Huber and Bledsoe, 1987a.

the hydrofluoric acid spill area would not adversely affect aquatic organisms and habitats in Castor Creek or adjacent wetlands under any closure action. No impacts to terrestrial wildlife that use the creek to drink and feed are expected. Because the waste site remains uncovered under no action, uptake via the biointrusion pathway is possible; however, PATHRAE modeling suggests that the contaminants of concern have already migrated away from the surface soil. This would eliminate uptake by intruding plant roots.

No carcinogenic risks from atmospheric chemical releases are expected. The EPA Hazard Index for the maximally exposed individual would be less than 3.5×10^{-7}, and would be insignificant. TC

Estimates of the lead and fluoride concentrations for the erosion pathway indicate that the concentrations are very small, well below levels of regulatory or health risk concern.

Potential Impacts (Other Than Releases)

Section F.4.8.1 describes general impacts to biological resources for no action. Lead and fluoride were modeled using PATHRAE, which indicates that the hydrofluoric acid spill area would not adversely affect aquatic organisms and habitats in Castor Creek or adjacent wetlands under any closure action. No impacts to terrestrial wildlife that use the creek to drink and feed are expected. Because the waste site remains uncovered under no action, uptake via the biointrusion pathway is possible; however, PATHRAE modeling suggests that the contaminants of concern have already migrated away from the surface soil. This would eliminate uptake by intruding plant roots. TC

The hydrofluoric acid spill area is within 1000 meters of wetlands located in Carolina bays. Continuation of current practices (i.e., no action) should not have any effect on the Carolina bays, because there would be no land disturbance and the waste site does not contain any standing surface water, which would facilitate soil erosion and surface runoff. TC

F.4.5.2 Assessment of No Removal of Waste and Implementation of Cost-Effective Remedial and Closure Actions as Required

Description of Action TE

Under the no-removal-and-closure action, the site would remain in its current status. Groundwater monitoring would continue on a monthly basis for 1 year and then on an annual basis for 29 years. Site maintenance would continue for the entire 30-year period.

Comparison of Expected Environmental Releases with Applicable Standards

The chemical constituents, the consequences of environmental releases, and the pathways would be the same as those for no action. TC

The expected concentration for the erosion pathway is zero.

Potential Impacts (Other Than Releases)

TC The potential ecological impacts of no waste removal and closure for the hydrofluoric acid spill area would be similar to those addressed in Sections F.4.5.1 and F.4.8.2.

F.4.5.3 Assessment of Removal of Waste to the Extent Practicable, and Implementation of Cost-Effective Remedial and Closure Actions as Required

Description of Action

TE The waste-removal-and-closure action would involve the excavation of approximately 230 cubic meters of potentially contaminated soil and its removal to a waste storage/disposal facility. The excavated pit would then be backfilled to grade with clean, compacted soil, with 15 centimeters of topsoil placed over the backfill, and seeded. Groundwater monitoring would continue on a quarterly basis for 1 year and then annually for 29 years. Site maintenance would continue for the entire 30-year period.

Comparison of Expected Environmental Releases with Applicable Standards

TC The chemical constituents, the consequences of environmental releases, and the pathways would be the same as those for no action.

TC Environmental and occupational risks due to atmospheric chemical releases from the hydrofluoric acid spill area are estimated to be about 100 times less than those for no action. No carcinogenic risks are expected, and the noncarcinogenic risks are very low. The highest EPA Hazard Index value for public and occupational exposure for the maximally exposed individual would be less than 3.5×10^{-9} and 1.2×10^{-2}, respectively.

The expected concentration for the erosion pathway is zero.

Potential Impacts (Other Than Releases)

The potential ecological impacts of waste removal and closure for the hydrofluoric acid spill area would be similar to those addressed in Sections F.4.5.1 and F.4.8.3. Waste removal would further eliminate potential ecological impacts through biointrusion.

F.4.6 FORD BUILDING WASTE SITE, BUILDING 643-11G*

The Ford Building waste site (Building 643-11G) is a low-level radioactive waste management facility that received insignificant amounts of waste in past years. No wastes are being discharged to the site at the present time. Background information on the history of waste disposal, waste characteristics, and evidence of contamination are presented in Appendix B, Section B.5.2.

*The reference source for the information in this section is Huber, et al. 1987.

F.4.6.1 Assessment of No Action (No Removal of Waste, and No Remedial or Closure Actions)

Description of Action

Under no action, general area maintenance would be performed, including removal of all trash within the site area. Groundwater monitoring wells would be installed in the vicinity of the site and would be monitored quarterly for 1 year, then annually for 29 years. Site maintenance would continue for the entire 30-year period. TE

Comparison of Expected Environmental Releases with Applicable Standards

It is anticipated that insignificant amounts of radioactivity and chemicals would be released to groundwater, surface water, and air, because the amounts of radioactive and chemical constituents discharged to the site are believed to have been very small and below applicable standards.

Potential Impacts (Other Than Releases)

A general description of the ecological impacts of no action is provided in Section F.4.8.1. In the case of the Ford Building waste site, potential impacts on the aquatic biota cannot be quantified since no PATHRAE analysis or groundwater monitoring has been performed. The Ford Building waste site is located near the wetlands along the upper reaches of Four Mile Creek and Pen Branch. No action is not expected to have any effect on these wetlands because there would be no land disturbance and the waste site does not contain any standing surface water.

F.4.6.2 Assessment of No Removal of Waste and Implementation of Cost-Effective Remedial and Closure Actions as Required

Description of Action

Under the no-removal-and-closure action, general area maintenance would be performed including removal of all trash within the site area. No sediment would be excavated from the waste site. Groundwater monitoring and site maintenance would be conducted as described under no action. TE

Comparison of Expected Environmental Releases with Applicable Standards

It is anticipated that insignificant amounts of radioactivity and chemicals would be released to groundwater, surface water, and air because the amounts of radioactive and chemical constituents discharged to the site are believed to have been very small and below applicable standards.

Potential Impacts (Other Than Releases)

The general ecological impacts of no waste removal and closure for the Ford Building waste site are addressed in Section F.4.8.2.

F.4.6.3 Assessment of Removal of Waste to the Extent Practicable, and Implementation of Cost-Effective Remedial and Closure Actions as Required

Description of Action

TE Under the waste removal and closure action, all trash within the site area would be monitored for contamination and removed to a waste storage/disposal facility. Approximately 345 cubic meters of soil would then be excavated from the site to a depth of 1 meter and removed to a waste storage/disposal facility in metal containers. No waste pretreatment steps are deemed necessary at this time. The site would be backfilled to grade, seeded, and maintained in a manner consistent with the surrounding grounds. Should soil analyses at closure show that elevated concentrations of waste remained in the soil after excavation, groundwater monitoring wells would be installed at the site and monitored quarterly for 1 year and then annually for 29 years. Site maintenance would be continued for the entire 30-year period.

Comparison of Expected Environmental Releases with Applicable Standards

It is anticipated that insignificant amounts of radioactivity and chemicals would be released to groundwater, surface water, and air because the amounts of radioactive and chemical constituents discharged to the site are believed to have been very small and below applicable standards.

Potential Impacts (Other Than Releases)

The general ecological impacts of waste removal and closure for the Ford Building waste site are addressed in Section F.4.8.3. However, removal of wastes and backfilling, proposed as part of the corrective action for this waste site, would minimize any further impacts.

F.4.7 FORD BUILDING SEEPAGE BASIN, BUILDING 904-91G*

The Ford Building seepage basin (904-91G) is in the central shops area of the SRP. Discharges to the basin ceased in 1984. The history of disposal, evidence of contamination, and waste characteristics of the basin are presented in Appendix B, Section B.5.3.

F.4.7.1 Assessment of No Action (No Removal of Waste, and No Remedial or Closure Actions)

Description of Action

TE Under no action, the basin would be monitored for erosion, grass would be cut, and bushes and tree seedlings would be removed. Groundwater monitoring would continue quarterly for 1 year and then annually for 29 years.

Comparison of Expected Environmental Releases with Applicable Standards

PATHRAE modeling predicts that peak concentrations of chromium and tritium either have or will exceed groundwater standards. Table F-21 lists these

*The reference source for the information in this section is Pekkala, Jewell, Holmes, Simmons, and Marine, 1987.

parameters, the corresponding regulatory standards, the maximum mean concentration recorded in monitoring wells, and the maximum concentration found, or predicted to be found, in groundwater near the basins. Peak concentrations of all other constituents are predicted to remain below applicable standards.

Surface-water quality would not be significantly affected by the addition of potential contaminants from the groundwater pathway from the site, as the resulting concentrations of constituents in Pen Branch are projected to be below drinking-water standards.

The nonradioactive contaminants were analyzed to estimate public exposure and risk attributable to atmospheric releases associated with closure (assumed to take place in 1986) and postclosure of the Ford Building seepage basin.

TC Releases are associated with suspension of contaminated dust from wind erosion; the conservative assumption is that dust generation would not be minimized by vegetative cover. Risks due to releases of carcinogens are calculated to be less than 5.0×10^{-10} for year 1986, 2085, and 2985. The EPA Hazard Index for noncarcinogenic releases is calculated to be less than 1.3×10^{-6} for each of the three years.

TC Environmental doses and risks to the maximally exposed individual due to atmospheric radiological releases from the Ford Building seepage basin were calculated using the methodology presented in the introduction to this appendix and in Appendix I. The doses were calculated to be less than 2.2×10^{-4} percent of the DOE limit of 25 millirem per year for each of the 3 years. The risks associated with these doses were calculated to be no greater than 1.5×10^{-11}.

Potential Impacts (Other Than Releases)

TC Section F.4.8.1 describes the ecological impacts of no action. PATHRAE modeling was performed on tritium, cobalt-60, strontium-90, yttrium-90, cesium-137, europium-155, uranium-238, chromium, lead, mercury, and phosphate, which were identified as having a potential impact on the aquatic system. The results indicated that these wastes would not alter the present water quality of Pen Branch. Outcropping concentrations of tritium are elevated above the drinking-water standard; however, they are significantly below the no-effect concentration for developing fish embryos and should, therefore, not affect other aquatic organisms. Wildlife drinking or feeding in Pen Branch should be unaffected by these concentrations after mixing with Pen Branch.

To assess the impacts associated with biointrusion under no action, maximum observed concentrations of contaminants in the soil were compared to phytotoxicological benchmarks. Of the metals, only mercury occurs at concentrations toxic to vascular plants. Both cesium-137 and cobalt-90 occur at concentrations that exceed DOE Threshold Guidance Limits. These results indicate that plant growth could be impaired in the abandoned seepage basin for a long time under no action. Calculations of concentrations of nonradiological contaminants in terrestrial plants growing in the seepage basin do not reveal any burdens that would be toxic to herbivorous birds and mammals.

Because this seepage basin might have standing water during times of heavy rainfall, the water could become contaminated and pose a potential impact to wildlife, including waterfowl, or vegetation that might come into contact with the water. Section F.4.8.1 describes impacts to endangered species and wetlands.

F.4.7.2 Assessment of No Removal of Waste and Implementation of Cost-Effective Remedial and Closure Actions as Required

Description of Action

Implementation of no waste removal and closure would consist of backfilling the basin with clean soil. The berms would be pushed into the basin, the basin would be filled with compacted backfill and topsoil and seeded, and identification pylons would be placed at each corner. A total of 670 cubic meters of backfill would be required. Groundwater monitoring would continue quarterly for 1 year and then annually for 29 years. Site maintenance would be continued for the entire 30-year period. TE TC

Among the potential remedial actions for no waste removal and closure is a groundwater extraction and treatment system for tritium. The final selection of an action would be based on site-specific studies and interactions with regulatory agencies. Some of the possible treatment technologies are discussed in Appendix C.

Comparison of Expected Environmental Releases with Applicable Standards

The no-waste-removal-and-closure action is projected by PATHRAE to have no impact on tritium levels in the groundwater. Levels of chromium would be reduced but would still be above drinking-water standards at the 1-meter well. Levels of tritium and chromium in the groundwater would have to be reduced to less than the MCL of 87,000 picocuries per liter and 0.05 milligram per liter, respectively. Surface water would not be adversely impacted.

The analysis described in the air release portion of Section F.4.7.1 was also performed for this action. There would be no carcinogenic releases because the seepage basin would be capped. Noncarcinogenic releases would be from the volatilization of mercury and phosphate seepage. The EPA Hazard Index is calculated to be 1.3×10^{-16}. TE TC

The analysis for radiological releases described in Section F.4.7.1 was also performed. Releases are assumed to be zero for all constituents except tritium for this action, since the basin would be capped. Tritium has a nonzero source term in the first year due to its volatility. It would decrease to zero in 2085 and 2985 due to radioactive decay. The dose to the maximally exposed individual in 1986 is insignificant, compared to the DOE limit of 25 millirem. The risk associated with the dose is insignificant.

Potential Impacts (Other Than Releases)

A general description of the ecological impacts of no waste removal and closure is provided in Section F.4.8.2. Backfilling the basin would eliminate direct contact exposures and reduce potential impacts from the biointrusion pathway.

F.4.7.3 Assessment of Removal of Waste to the Extent Practicable, and Implementation of Cost-Effective Remedial and Closure Actions as Required

Description of Action

TE Under the waste-removal-and-closure action, the influent pipeline would be blanked off at the retention tank. The retention tank discharge line to the seepage basin and contaminated soil beneath the line would be excavated, packaged in metal containers, and sent to an appropriate onsite waste storage/disposal facility. Vegetation around the basin would be monitored and disposed of as necessary. TE

The estimated depth of contaminated soil to be removed from the floor of the basin is 46 centimeters. This amount of excavation would remove any sediment eroded from the walls to the basin floor since 1984 and most of the contaminated sediment beneath the basin floor. The total volume to be excavated (an estimated 76 cubic meters) includes sediments excavated from the sides and ends of the basin. The proposed excavation would remain well above the water table, which is about 12 meters below the basin floor.

Further closure action at the waste site would involve pushing the berms into the basin, filling the basin with compacted soil to 0.6 meter below the original ground level, adding topsoil or its equivalent, and grading to conform to the original surface contour. A total of 840 cubic meters of backfill would be required. After being graded, the site would be seeded with grass for erosion control and marked with identification pylons at each corner. Groundwater monitoring would continue quarterly for 1 year and then annually for up to 29 years.

Additional corrective action (e.g., pumping and treatment) might be needed to address the constituents already present in the groundwater. The precise actions taken would be selected based on site-specific studies and interactions with regulatory agencies.

Comparison of Expected Environmental Releases with Applicable Standards

Waste removal and closure would have no impact on peak tritium levels in the groundwater, as the peak is predicted to have occurred in the past. Levels of chromium, however, are predicted to be reduced to below the drinking-water standards. Surface water would not be adversely impacted.

The analysis described in the air release portion of Section F.4.7.1 was also performed for this action. Risks due to carcinogenic releases were calculated to be less than 2.5×10^{-14} in 1986 because of excavation activities, and zero in future years since the basin then would be capped. The EPA Hazard Index was calculated for 1986 and would be caused primarily by excavation activities. The EPA Hazard Index for subsequent years (2085 and 2985), was calculated to be due to releases from the volatilization of mercury and phosphate seepage. The Index is calculated to be less than 2.7×10^{-10}. TC

The dose to the maximum individual at the SRP boundary in 1986 would be less than 3.9×10^{-7} percent of the DOE limit of 25 millirem for 1986 and would be due to excavation activities. The risk associated with this dose would be less than 2.8×10^{-14}.

An analysis of the average individual worker's health risks attributable to occupational exposure to carcinogens (both nonradioactive and radioactive) and noncarcinogens was performed using the methodology presented in Appendix I. The risk to a worker from nonradioactive carcinogens was calculated to be less than 8.7×10^{-9}. The EPA Hazard Index for a worker due to noncarcinogens would be 3.6×10^{-2}. The total dose to the worker would be 0.18 millirem, which would produce an incremental risk of 5.0×10^{-8}. The total dose to the worker transporting the waste would be 7.5×10^{-2} millirem, producing an incremental risk of 2.1×10^{-8}.

Potential Impacts (Other Than Releases)

A general description of the ecological impacts of the waste removal and closure plan is provided in Section F.4.8.3.

F.4.8 POTENTIAL IMPACTS ON BIOLOGICAL RESOURCES

This section addresses those generic impacts related to aquatic and terrestrial ecology, endangered species, and wetlands for each closure and remedial action. Where a discussion of site-specific data is required for a given action, it is presented in the appropriate section above.

This appendix discusses seven waste sites located within the C- and CS-Area. The C- and CS area burning/rubble pits are presently backfilled and covered with soil and vegetation. The Ford Building waste site consists of exposed waste. The Ford Building seepage basin at one time contained low-level radioactive waste, but now it is dry, although it occasionally impounds rainwater. All seven waste sites within this geographic grouping are either inactive or abandoned. TE

F.4.8.1 Assessment of No Action (No Removal of Waste and No Remedial or Closure Action)

Aquatic Ecology

A potential aquatic impact of no action for the waste sites of the C- and CS-Areas is the indirect contamination of surface-water bodies via groundwater outcropping from the various waste sites found in this area. Table F-22 lists the waste materials in the groundwater that are known to exceed the freshwater biota criteria for each of the waste sites.

Where data are available, it can be determined that materials not modeled by PATHRAE analysis (see Table F-22) would not be expected to create or enhance existing impacts on the aquatic biota of outcropping streams. This conclusion was based on the estimated dilution factors calculated by dividing the groundwater flux by the flow rate of the receiving stream. The dilution factor indicates that these wastes would be so diluted as not to affect the present water quality of the outcropping stream. Materials modeled by PATHRAE are discussed above for the individual waste sites.

Terrestrial Ecology

The potential terrestrial impacts of no action for the waste sites of the C- and CS-Areas are the exposure of wildlife and vegetation to contaminated standing surface water and the toxicity to vegetation by contaminated soils. Terrestrial impacts of these pathways are addressed above on an individual basis. No impacts are expected at the C- and CS-Areas burning/rubble pit site, given the qualities and types of contaminants buried at the site, the depth of burial of the waste, and the indications from PATHRAE modeling that contaminants have already migrated vertically out of the soil profile.

Endangered Species

No endangered species have been identified in the vicinity of the waste sites of the C- and CS-Area in previous surveys at the SRP (see Table F-22). The habitats in the immediate vicinity of these waste sites are not considered suitable for any Federally endangered species previously reported from the SRP. Therefore, none of the actions proposed for the waste sites of the C- and CS-Area would have any effect on threatened or endangered species.

Wetlands

Wetlands of the C- and CS-Area include two small ponds at Twin Lakes, Carolina bays, and small drainage areas of the upper reaches of Four Mile Creek and Pen Branch. Bottomland hardwood communities exist primarily along small drainages of the upper reaches of Four Mile Creek and Pen Branch and in shallow depressions of the Carolina bays. Table F-22 provides the distances between the waste sites and the wetlands. Potential impacts on these wetlands are addressed on an individual basis where warranted. For most sites, wetlands
TE are considered sufficiently distant so as not to be affected by any closure action.

F.4.8.2 Assessment of No Removal of Waste and Implementation of Cost-Effective Remedial and Closure Actions as Required

Aquatic Ecology

The Ford Building seepage basin could contain standing surface waters that would be left to dry via evaporation before closure operations proceeded. There would be no direct impacts on the aquatic biota of nearby surface streams, unless surface runoff occurred before closure. As described in Section F.4.8.1, indirect contamination of surface waters via groundwater from
TC the various waste sites of C- and CS-Area would not likely cause a change in the present water quality of the outcropping stream.

Terrestrial Ecology

The potential terrestrial impacts of no waste removal and closure for the waste sites of the C- and CS-Area include toxicity to vegetation by contaminated soils and temporary disruption of wildlife due to noise created by closure operations. Closure would reduce the likelihood of impacts from biointrusion; disturbance from noise would be of a temporary nature.

Endangered Species

TC None of the actions proposed for the waste sites of the C- and CS-Area would have any effect on endangered species. See description in Section F.4.8.1.

Wetlands

Section F.4.8.1 describes the wetlands that exist within the vicinity of the C- and CS-Area. Disturbance of the land could initiate soil erosion. Where there is standing water, there is also a potential for surface runoff during heavy rainstorms. Remedial actions would include soil erosion and surface runoff controls for those waste sites that are near wetlands, to prevent sedimentation and contamination of wetlands.

F.4.8.3 Assessment of Removal of Waste to the Extent Practicable and Implementation of Cost-Effective Remedial and Closure Actions as Required

Aquatic Resources

The potential aquatic impacts of waste removal and closure are the same as described in Section F.4.8.2. However, the removal of wastes and contaminated soils from each of the sites of the C- and CS-Area should significantly reduce the amount of wastes leached into groundwater from contaminated soils. TC

Terrestrial Ecology

The potential impact of plant toxicity should be reduced significantly by waste removal and closure. The removal of wastes and contaminated soils should eliminate the potential for the uptake of wastes by vegetation. There would be a temporary disturbance of the wildlife due to noise and habitat loss created by closure activities.

Endangered Species

None of the actions proposed for the waste sites of the C- and CS-Area would have any effect on endangered species. See the description in Section F.4.8.1. TC

Wetlands

Section F.4.8.1 describes the wetlands that exist within the vicinity of the C- and CS-Area. As indicated in Section F.4.8.2, remedial actions should include soil erosion and surface runoff controls to protect those wetlands that are near a waste site.

F.5 TNX-AREA WASTE SITES

The TNX-Area geographic grouping is approximately 7 kilometers southwest of C-Reactor along Road 3; it is in the southwest portion of the SRP, about 15 kilometers south of A-Area. Figure F-10 shows the locations of the waste sites in this grouping, which will be assessed in the following sections.

Sections F.5.1 through F.5.5 contain, or reference the section that contains, a discussion of sites 5-1 through 5-5. Section F.5.6 discusses biological impacts that are generically applicable to the waste sites in this geographic grouping.

F.5.1 D-AREA BURNING/RUBBLE PIT, BUILDING 431-D

This burning/rubble pit is discussed in conjunction with the other burning/rubble pits in Section F.1.6. The ecological effects of this site that relate to the TNX-Area geographic grouping are discussed in Section F.5.6.

F.5.2 D-AREA BURNING/RUBBLE PIT, BUILDING 431-1D

This burning/rubble pit is discussed in conjunction with the other burning/rubble pits in Section F.1.6. The ecological effects of this site that relate to the TNX-Area geographic grouping are discussed in Section F.5.6.

F.5.3 TNX BURYING GROUND, BUILDING 643-5T*

The TNX burying ground (Building 643-5T) is a low-level radioactive waste management facility that received wastes resulting from an experimental evaporator explosion in 1953. Background information on the history of waste disposal, waste characteristics, and evidence of contamination are presented in Appendix B, Section B.6.2.

F.5.3.1 Assessment of No Action (No Removal of Waste, and No Remedial or Closure Actions)

Description of Action

TE Under no action, all sites would be left undisturbed. Sixteen new groundwater monitoring wells would be installed around the project area. These wells
TE would be sampled and analyzed quarterly for the first year, then annually for the next 29 years. Site maintenance would be continued for the entire 30-year period.

Comparison of Expected Environmental Releases with Applicable Standards

All environmental releases are projected to be below applicable standards for no action.

The releases are evaluated in terms of predicted radionuclide concentrations
TC for hypothetical wells 1 meter and 100 meters downgradient of the burying ground. The peak concentrations in the 1-meter well and the 100-meter well are calculated to have occurred in 1958 and 1964, respectively. The predicted peak concentrations of uranium-238 (in picocuries per liter) are 7.5 for the 1-meter well and 0.95 for the 100-meter well, and represent 31 and 4.0 percent, respectively, of the concentrations corresponding to the EPA primary drinking-water standard of 24 picocuries per liter.

No chemical contaminants are predicted to exceed groundwater MCLs in the future; however, peak nitrate concentrations (12 milligrams per liter) were calculated to have exceeded the MCLs at the 1-meter well in 1958. No groundwater monitoring data are available to evaluate current groundwater concentrations.

*The reference source for the information in this section is Dunaway, Johnson, Kingley, Simmons, and Bledsoe, 1987a.

The maximum annual doses resulting from the reclaimed farm and direct gamma exposure pathways would occur 100 years from the present, at which time institutional control of the SRP is assumed lost. The predicted doses are 1.4 x 10^{-4} and less than 1.0 x 10^{-20} millirems per year for the farm and direct gamma pathways, respectively. There would be no dose from the pathway that involves consumption of crops potentially contaminated as a result of biointrusion of subsurface sediments, due to the assumed limited plant-root depth. TC

Surface-water quality would not be significantly affected by the addition of potential contaminants from the groundwater pathway from this site, as the resulting concentrations of constituents from this source in the Savannah River are projected to be below drinking-water standards.

No radionuclides or nonradioactive constituents would be released to the atmosphere, since the waste materials lie buried beneath asphalt, buildings, and transformer pads and no excavation would take place. TC

Potential Impacts (Other Than Releases)

Section F.5.6.1 describes the ecological impacts of no action. Because the TNX burying ground has already been backfilled and covered with buildings and asphalt, the only pathway of ecological concern is the groundwater-to-surface pathway. PATHRAE analysis was conducted on nitrate and uranium-238. Analysis of the PATHRAE-generated groundwater outcrop concentrations indicates that these contaminants would not exceed the EPA water-quality criteria for the protection of aquatic life or equivalent numbers from the technical literature. Therefore, no adverse impacts are expected to occur to the aquatic communities of the Savannah River and adjacent wetlands or to wildlife that use these habitats to drink and feed under any of the closure actions. TE

F.5.3.2 Assessment of No Removal of Waste and Implementation of Cost-Effective Remedial and Closure Actions as Required

Description of Action

Under the no-removal-and-closure action, surface structures (Building 711-T, Trailer Building 676-8T, and a 13.8-kilovolt transformer near Building 673-T) associated with the three known areas of contamination would be relocated. No waste material would be removed. The known burial sites would be covered with a low-permeability cap, graded, and seeded to prevent erosion. The suspected burial area would be treated in one of two ways. If soil samples from this site indicated contamination, overlying surface structures would be relocated and the area would be capped. Otherwise, the site would be left as it is. Sixteen new groundwater monitoring wells would be installed in the vicinity of the sites if the suspected burial site were found to be contaminated. Only 12 groundwater monitoring wells would be required if the suspected burial site were found to be clean. These wells would be sampled and analyzed quarterly for the first year, then annually for the next 29 years. Site maintenance would be continued for the entire 30-year period. TE TC

Comparison of Expected Environmental Releases with Applicable Standards

All environmental releases are projected to be below applicable standards for no waste removal and closure.

Groundwater, surface water, and air releases for no waste removal and closure would be the same as those presented for no action in Section F.5.3.1.

Potential Impacts (Other Than Releases)

TE Impacts on biological resources resulting from this closure action at the TNX burying ground are described in Sections F.5.3.1 and F.5.6.2. The presence of a clay cap and site maintenance would reduce potential for impacts via the biointrusion pathway.

Doses from the reclaimed farm and direct gamma pathways would be essentially eliminated under this action because of the installation of a cap. There would be no impact (dose is zero) for the pathway that involves consumption of crops potentially contaminated as a result of biointrusion of subsurface sediments. Such contamination would be precluded due to the limited plant-root depth.

F.5.3.3 Assessment of Removal of Waste to the Extent Practicable, and Implementation of Cost-Effective Remedial and Closure Actions as Required

Description of Action

Under the waste removal and closure option, surface structures (Building 711-T, Trailer Building 676-8T, and a 13.8-kilovolt transformer near Building 673-T) associated with the three known areas of contamination would be relocated and the three known and one suspected burial sites would be excavated to a depth of 21.41 meters (approximately 896 cubic meters).
TC Excavated materials from the known burial sites would be packaged in metal boxes and sent to a waste storage/disposal facility. Excavated material from the suspected burial site would be treated in one of two ways. If it were determined by the Health Protection Department to be contaminated, it would be containerized in metal boxes and transported to a waste storage disposal facility. If this material were found to be clean, it would be used as fill when the site was backfilled. All four sites would then be backfilled and covered with a low-permeability cap (Figure F-2), dressed with topsoil, and seeded to prevent erosion. Sixteen new groundwater monitoring wells would be installed in the vicinity of the sites if the suspected burial site were found to be contaminated. Only 12 groundwater monitoring wells would be required if the suspected burial site were determined to be clean. These wells would be sampled and analyzed quarterly for the first year, then annually for the next 29 years. Site maintenance would be continued for the entire 30-year period.

Comparison of Expected Environmental Releases with Applicable Standards

All environmental releases are projected to be below applicable standards for waste removal and closure.

Groundwater and surface water releases for waste removal and closure would be the same as those presented for no action in Section F.5.3.1.

The dose to an individual resulting from the release of uranium to the atmosphere has been calculated to be less than 3.4×10^{-4} percent of the DOE limit of 25 millirem per year. The risks associated with this dose would be less than 2.4×10^{-11}. TC

Doses from the reclaimed farm and direct gamma pathways would be essentially eliminated under this action because of the removal of waste and the installation of a cap. There would be no dose for the pathway that involves consumption of crops potentially contaminated as a result of biointrusion of subsurface sediments, due to the limited plant-root depth.

The analysis described in Section F.5.3.1 for nonradioactive air releases was also performed for this action. Releases, attributable to the dust generated from excavation activities, were calculated to have an EPA Hazard Index of less than 1.1×10^{-12} in 1986 and zero after waste removal. TC

An analysis of the average worker's health risks attributable to occupational exposure to carcinogens (both nonradioactive and radioactive) and noncarcinogens was performed using the methodology presented in Appendix I. The risk to a worker due to nonradioactive carcinogens would be zero. The EPA Hazard Index due to noncarcinogens was calculated to be 4.36×10^{-6}. The total dose to the worker was calculated to be 0.30 millirem, which would produce an incremental risk of approximately 8.4×10^{-8}. The total dose to the worker transporting the waste was calculated as 0.13 millirem, producing an incremental risk of less than 3.7×10^{-8}.

Potential Impacts (Other Than Releases)

Impacts to ecological resources resulting from waste removal and closure at the TNX burying ground are described in Sections F.5.3.1 and F.5.6.3. The removal of waste would eliminate the potential for impacts from biointrusion.

F.5.4 OLD TNX SEEPAGE BASIN, BUILDING 904-76G*

The Old TNX seepage basin operated from 1958 to 1980. The basin received a variety of chemicals from the pilot-scale tests conducted at TNX in support of the Defense Waste Processing Facility and the plant separations area. The history of waste disposal, evidence of contamination, and waste characteristics are discussed in detail in Appendix B, Section B.6.3.1.

F.5.4.1 Assessment of No Action (No Removal of Waste, and No Remedial or Closure Actions)

Description of Action

Under no action, the site would be left in its current state and groundwater monitoring would be continued on a quarterly basis for 1 year, then annually for 29 years. Site maintenance would be continued for the entire 30-year period. TE TC

*The reference source for the information in this section is Dunaway, Johnson, Kingley, Simmons, Bledsoe, and Smith, 1987a. TE

Comparison of Expected Environmental Releases with Applicable Standards

A soil and groundwater characterization program (Simmons, Bledsoe, and Bransord, 1985) was established to study the disposition of chemicals and radionuclides sent to the old TNX seepage basin. While the basin was in operation, overflow was diverted to a nearby wetland, creating an outfall delta approximately 30 meters wide within the wetland. The characterization study identified the following contaminants in the swamp sediment and soils: radium-228, thorium-228, tritium, uranium-235, uranium-238, chromium, and mercury. The radionuclide contamination detected in the swamp was concentrated within a meter of the discharge gully leading away from the basin. The mercury was concentrated in spots throughout the swamp, however, and the chromium was also well dispersed. Most of the contamination was localized within the top 0.6 meter of sediment.

In addition to sediment and soil sampling, water samples from the swamp and wells adjacent to the basin were collected. The swamp grab sample showed elevated levels of gross alpha, gross beta, radium, silver, chromium, copper, mercury, and cyanide. The swamp water contained roughly 50 times the MCL for mercury and 700 times the MCL for gross beta.

Groundwater samples collected from the water table aquifer indicated that concentrations of several inorganic and organic chemicals, and radionuclides exceed MCLs or other health-based standards. Table F-23 lists all constituents in the groundwater that currently exceed or are projected to exceed drinking-water standards for no action. No contamination was detected in the Tuscaloosa monitoring well located near the basin.

The PATHRAE computer code was used to estimate contaminant concentrations in the groundwater and surface water near the basin. PATHRAE results indicated that future concentrations (post-1985) of chromium, lead, nitrate, trichloroethylene, and tetrachloromethane will exceed MCLs in groundwater near the basin. PATHRAE results indicated that the outfall delta is the primary source of contaminants entering the wetland. No contaminants were predicted to exceed regulatory standards in the Savannah River.

The nonradioactive constituents were analyzed to estimate public exposure and risk attributable to atmospheric releases from the old TNX seepage basin and the outfall delta. Releases are associated with wind erosion and volatilization of constituents. Risks due to releases of carcinogens were calculated to be less than 1×10^{-8} in the 3 evaluated years. The EPA Hazard Index for noncarcinogen releases is less than 4.5×10^{-4}. TC

Environmental doses and risks to the maximally exposed individual due to radiological releases from the old TNX seepage basin and outfall delta were calculated using the methodology summarized in the introduction to this appendix and presented in Appendix I. The calculated doses were less than 43 percent of the DOE limit of 25 millirem per year for each of the three selected years. The risks associated with the peak dose is less than 3.5×10^{-6}. TC

Potential Impacts (Other Than Releases)

Section F.5.6.1 describes the ecological impacts of no action. Because of previous remedial action, the only pathway relevant to ecological assessment at the old TNX seepage basin is groundwater transport to a surface outcrop. PATHRAE modeling has been performed for chromium, lead, mercury, nickel, nitrate, silver, tetrachloromethane, trichloroethylene, tritium, thorium-232, uranium-235, and uranium-238. Levels of groundwater outcrop contamination predicted by PATHRAE for lead, mercury, silver, and nitrate exceed the EPA water-quality criteria for the protection of aquatic life or equivalent values from the technical literature, indicating a potential for effects on aquatic biota in the relatively unmixed waters of wetlands adjacent to the groundwater TC outcrop. Outcrop concentrations of silver and nitrate would exceed comparison criteria by factors of less than five, indicating little potential for impacts to wetland ecosystems. Dilution of these contaminants would reduce their concentrations to levels less threatening to the wetland biota. Mercury outcrop concentrations exceed the criteria by a factor of more than 10, while lead outcrop concentrations exceed the criteria by almost three orders of magnitude. Biological effects of outcrop concentrations of lead and mercury indicated that mercury was toxic to fathead minnows and lead was toxic to daphnia, but not to bluegill. Therefore, a potential exists for effects on the wetland biota near the outcrop, especially from elevated lead concentrations.

Groundwater outcrop concentrations of lead and nitrate also exceed the EPA drinking-water standards. Thus, wildlife that might drink the contaminated water would receive impacts. However, lead concentrations were only one-fortieth of the no-adverse-effect dietary level of 5.0 parts per million. Calculated tissue concentrations of all metals in wetland biota were below those shown to be toxic to birds and mammals. The nitrate drinking-water standard is one-ninth of the aquatic criteria and does not appear to be particularly appropriate for ecological assessment of such an important and dynamic nutrient. These results indicate that potential impacts would be negligible in view of the limited area of the groundwater outcrop and the conservative assumption of no dilution.

Because of the depth of the backfilled basin, any terrestrial effects would be TE limited to the contaminated delta and swamp area. Based on available data, limited terrestrial impacts are anticipated under all closure actions. The contaminant concentrations in the seepage basin, delta, and swamp soils for tritium, uranium-235 and -238, thorium-228, and nitrate exceed EPA soil criteria. Based on the maximum contaminant concentrations in the seepage TE basin, delta, and swamp soils for chromium, mercury, nickel, and silver, these contaminants could cause vegetation impacts through reduced plant growth and increased plant mortalities. However, food-chain uptake calculations indicate that the predicted vegetation concentrations are below the levels considered toxic to herbivorous terrestrial wildlife.

F.5.4.2 Assessment of No Removal of Waste and Implementation of Cost-Effective Remedial and Closure Actions as Required

Description of Action

Before the site could be closed, an office trailer and an equipment laydown area would have to be relocated, and the asphalt pavement and clay cap over the top of the basin would have to be removed and replaced with one that meets current requirements. Under this action, the top 1.8 meters of basin material would be excavated. The approximately 1218 cubic meters of material would be removed to a waste storage/disposal facility in metal boxes. A low-permeability cap would be placed over the excavated site, and groundwater monitoring would be continued quarterly for 1 year, then annually for 29 years. Site maintenance would be continued for the entire 30-year period. TE

The PATHRAE results indicate that excavating the basin sediments and covering the site with a low-permeability cap would have no significant effect on contaminant releases to the groundwater. Therefore, the contaminant release data given in Table F-23 would also be applicable to this closure action. TE

Additional corrective actions (e.g., treatment of groundwater and excavation of contaminated wetland sediments) might be needed to address constituents already in the groundwater and sediments. The selection of any action would be based on site-specific studies and interactions with regulatory agencies.

Comparison of Expected Environmental Releases with Applicable Standards

The closure and remedial actions described above are expected to reduce groundwater concentrations of cadmium, chromium, lead, mercury, nickel, nitrate, trichloroethylene, tetrachloromethane, gross alpha, gross beta, and radium to within MCLs or ACLs. Excavation of sediments from the outfall delta and backfilling with clean material are expected to reduce contaminant levels in the swamp to levels found in similar undisturbed wetlands. TE

The analysis described in the air release portion of Section F.5.4.1 was also performed for this action. Atmospheric releases of carcinogens are due to the volatilization of the constituents. Risks were calculated to be less than 2.6×10^{-17}. The EPA Hazard Index for releases of noncarcinogens is less than 7.8×10^{-12}. TE TC

The radiological releases and resulting doses are less than those presented in Section F.5.4.1 for no action. The resultant risk to the maximally exposed individual has a peak value of 4.23×10^{-17}. TC

Potential Impacts (Other Than Releases)

Impacts to biological resources resulting from this closure action at the old TNX seepage basin would be similar to those described in Sections F.5.4.1 and F.5.6.2. TE

F.5.4.3 Assessment of Removal of Waste to the Extent Practicable, and Implementation of Cost-Effective Remedial and Closure Actions as Required

Description of Action

Before the site could be excavated, an office trailer and an equipment laydown area would have to be relocated. The asphalt pavement and clay cap over the top of the basin would have to be removed.

TC

The basin covered a surface area of 953 square meters. The 3 meters of clay and sand mix, 15 centimeters of SC-6 clay, and 50 centimeters of topsoil used to backfill and cap the basin in 1981 would have to be removed in addition to the 61 centimeters of contaminated basin bottom sediment. Therefore, approximately 4060 cubic meters of material would have to be excavated. The backfill material excavated from the basin would be reused. Approximately 594 cubic meters of sediment would be excavated and removed to a waste storage/ disposal facility in metal boxes.

TC

Approximately 594 cubic meters of backfill material would be needed to fill the basin. Groundwater monitoring at the site would continue quarterly for the first year and then annually for 29 years. Site maintenance would be continued for the entire 30-year period. Potential remedial action would be implemented as described in Section F.5.4.2.

Comparison of Expected Environmental Releases with Applicable Standards

The PATHRAE results indicated that contaminant releases to the groundwater would not be affected by removing waste from the basin. Therefore, the discussion of expected environmental releases presented in Section F.5.4.2 would also be applicable to waste removal and closure.

TC

The analysis described in the air release portion of Section 5.4.1.1 was also performed for this action. Carcinogenic releases would result solely from the generation of contaminated dust as a result of excavation activities. This would occur only in the first year. Noncarcinogenic releases in the first year would be attributable to the generation of the contaminated dust as a result of excavation activities and to volatilization. In subsequent years the only source would be attributable to volatilization. Risks attributable to carcinogenic releases were calculated to be less than 1.3×10^{-12}. The EPA Hazard Index for releases of noncarcinogens was calculated to be less than 1.2×10^{-8} for each of the 3 years.

TC

The radiological releases and resulting doses are greater than those presented in Section F.5.4.1 for no action. The resultant risk to the maximally exposed individual has a peak value of 1.36×10^{-8}.

TC

An analysis of the health risks to the average individual worker attributable to occupational exposure to carcinogens (both nonradioactive and radioactive) and noncarcinogens was performed using the methodology presented in Appendix I. The risk to a worker due to nonradioactive carcinogens would be less than 5.7×10^{-8}. The EPA Hazard Index due to noncarcinogens would be 8.5×10^{-3}. The total dose to the worker would be 11 millirem, which would produce an incremental risk of 3.1×10^{-6}. The total dose to the worker transporting the waste would be 0.55 millirem, producing an incremental risk of 1.6×10^{-7}.

Potential Impacts (Other Than Releases)

Impacts to ecological resources from this closure action at the old TNX seepage basin would be similar to those described in Sections F.5.4.1 and F.5.6.3.

F.5.5 NEW TNX SEEPAGE BASIN, BUILDING 904-102G*

The new TNX seepage basin (Building 904-102G) is a mixed waste management facility that is presently receiving wastes. Background information on the history of waste disposal, waste characteristics, and evidence of contamination are presented in Appendix B, Section B.6.3.

F.5.5.1 Assessment of No Action (No Removal of Waste, and No Remedial or Closure Actions)

Description of Action

Under no action, groundwater monitoring at the site would be continued quarterly for the first year, then annually for the next 29 years, with periodic site maintenance such as lawn and vegetation cutting. Appropriate signs and fencing would be set up to keep out wild animals and unauthorized persons. TE

Comparison of Expected Environmental Releases with Applicable Standards

PATHRAE predicts that concentrations of barium, chromium, nitrate, and uranium-238 will exceed groundwater standards for no action. Table F-24 lists these parameters, the corresponding regulatory standards, and the maximum concentrations found, or predicted to be found, in the groundwater near the basins. Only contaminants that exceed, or are predicted to exceed, standards are listed. All other constituents are found at levels below applicable standards.

Surface-water quality would not be significantly affected by the addition of potential contaminants from the groundwater pathway from this site, as the resulting concentrations of constituents from this source in the Savannah River are projected to be below drinking-water standards.

The nonradioactive constituents were analyzed to estimate public exposure and risk attributable to atmospheric releases from the new TNX seepage basin.

Releases would be caused by wind erosion and the volatilization of the constituents. Risks were calculated to be less than 1.8×10^{-9} for releases of carcinogens. The EPA Hazard Index for noncarcinogens was calculated to be less than 2.8×10^{-5} for each of the 3 years. TC

*The reference source of the information in this section is Dunaway, Johnson, Kingley, Simmons, and Bledsoe, 1987b.

Environmental doses and risks to the maximally exposed individual due to radiological releases from the new TNX seepage basin were calculated using the methodology presented in the introduction to this appendix and in Appendix I.

The doses were calculated to be less than 1.1×10^{-2} percent of the DOE limit of 25 millirem per year for each of the 3 years. The risk associated with these doses would be less than 7.2×10^{-10}.

Potential Impacts (Other Than Releases)

Section F.5.6.1 describes the ecological impacts of no action. PATHRAE analysis was conducted on barium, chromium, nickel, nitrate, phosphate, sodium, trichloromethane, and uranium-238. The PATHRAE analysis of the groundwater outcrop concentrations of these contaminants indicates that none exceed the EPA criteria for any of the closure actions. Therefore, DOE anticipates no potential impacts on the Savannah River and adjacent wetlands aquatic biota or on the birds and mammals that use these aquatic habitats to feed or drink. TE

Comparisons of maximum concentrations of contaminants measured in basin sediments with phytotoxicological criteria indicate that, although concentrations of several trace metals are elevated, only nickel would be present in toxic concentrations. Because the soil data represent maximum values of all cores collected in the basin, the potential impact of sediment contaminants on the survival and growth of vegetation at the waste site should be minor. Calculations of the uptake of contaminants from these basin soils by vascular plants yield tissue concentrations that are not potentially toxic to birds and mammals that might consume vegetation growing on the site. Thus, impacts associated with contaminated basin sediments would be restricted to the seepage basin.

A comparison of concentrations of constituents in the basin water with drinking-water standards indicates that many waste constituents approach their standards, and that fluoride and sodium exceed their standards. Therefore, these constituents could pose an impact to wildlife that consume basin water. However, given the conservative nature of the drinking-water criteria, these concentrations are not expected to be a problem.

F.5.5.2 Assessment of No Removal of Waste and Implementation of Cost-Effective Remedial and Closure Actions as Required

Description of Action

Under the no-removal-and-closure action, 2170 cubic meters of basin water would be sent to the TNX effluent treatment plant for treatment after the facility starts operations. The basin would be backfilled with approximately 2170 cubic meters of backfill material and capped with a low-permeability cap. Groundwater monitoring at the site would be continued quarterly for 1 year, then annually for the next 29 years. Site maintenance would be continued for the entire 30-year period. TE TC

Remedial actions might be required for this action, since results of PATHRAE modeling predict that the concentrations of barium, chromium, and nitrate in the groundwater would remain above MCLs (see Table F-24).

Any pumpage from groundwater extraction wells would be subject to physical or chemical treatment to reduce contaminants to below standards. Applicable treatment technologies are discussed in Appendix C.

Comparison of Expected Environmental Releases with Applicable Standards

The implementation of this closure/remedial action would reduce all environmental releases to below MCLs or ACLs. Barium, chromium, and nitrate would be removed from the groundwater to below applicable standards (see Table F-24). In addition, all other environmental releases are projected to be below regulatory concern.

TE TC The analysis described in the air release portion of Section F.5.5.1 was also performed for this action. There would be no releases to the atmosphere of noncarcinogenic constituents, since the facility would be capped. Releases of carcinogenic compounds would result in a risk to the maximally exposed individual of 1.04×10^{-20}.

The analysis for radiological releases described in Section F.5.5.1 was also performed, and the releases are assumed to be zero for all 3 years of interest, since closure would effectively bar the atmospheric release of natural uranium.

Potential Impacts (Other Than Releases)

TE Impacts to ecological resources from this closure action at the new TNX seepage basin would be similar to those described in Sections F.5.5.1 and F.5.6.2. Drainage of the basin would eliminate the potential for wildlife being affected by contaminants in the basin water. Backfilling the basin would lessen the potential for impacts from the biointrusion pathway.

F.5.5.3 Assessment of Removal of Waste to the Extent Practicable, and Implementation of Cost-Effective Remedial and Closure Actions as Required

Description of Action

TE Under the waste removal and closure action, the basin water would be sent to the TNX effluent treatment plant for treatment after startup of the facility. Conservative estimates indicate that 2170 cubic meters of basin water would require treatment. If waste in the new TNX seepage basin has seeped to the same depth as in the old basin, then 0.6 meter of sediment would need to be excavated; this corresponds to a volume of approximately 359 cubic meters of material. Nearly all of the remaining waste source materials would be excavated. The excavated material would be transported in metal containers to a waste storage/disposal facility.

TC After excavation, the basin would be backfilled with approximately 2529 cubic meters of backfill material. Groundwater monitoring at the site would be continued quarterly for 1 year and then annually for the next 29 years. Site maintenance would be continued for the entire 30-year period.

TC The concentration and extent of contamination would be significantly reduced by the removal of waste as compared to no action. The nitrate concentration in the 1-meter well would be reduced by a factor of 4.5 and 2.0 in the 100-meter well. Uranium-238 would be reduced to below the applicable standards in both wells. However, remedial actions might be required for this action, since the results of PATHRAE modeling indicate that the concentrations of nitrate in the groundwater would remain above the MCL (see Table F-24). The exact actions would be determined by site-specific studies and interactions with regulatory agencies.

Water from any groundwater extraction wells would be subject to physical or chemical treatment to remove contaminants to within standards. Applicable treatment technologies are discussed in Appendix C.

Comparison of Expected Environmental Releases with Applicable Standards

The implementation of this closure/remedial action would reduce all environmental releases to below MCLs. Nitrate could be removed from the groundwater to below applicable standards (see Table F-24). In addition, all other environmental releases are projected to be below levels of regulatory concern.

The analysis described in the air release portion of Section F.5.5.1 was also performed for this action. Releases would be due to the earth-moving activities in year 1986. The addition of the cap would effectively bar the release of constituents in future years. Risks to the maximally exposed individual would be less than 2.9×10^{-14} for carcinogen releases. The EPA Hazard Index for noncarcinogenic releases would be less than 1.6×10^{-8}.

The analysis for radiological releases described in Section 5.5.1 was also performed. The releases would result from the excavation of the basin during the first year (1986) and would be zero thereafter due to the backfilling of the excavation site. The dose to the maximum individual at the SRP boundary was calculated to be less than 5.3×10^{-5} percent of the DOE limit of 25 millirem; the risk associated with this dose would be less than 3.7×10^{-12}. TC

An analysis of the health risks to the average individual worker that would be attributable to occupational exposure to carcinogens (both nonradioactive and radioactive) and noncarcinogens was performed using the methodology presented in Appendix I. The risk to a worker due to nonradioactive carcinogens was calculated at a value of approximately 1.1×10^{-9}. The EPA Hazard Index due to noncarcinogens was calculated to be approximately 0.11. The total dose to the worker was calculated to be 1.9×10^{-2} millirem, which would produce an incremental risk of 5.3×10^{-9}. The total dose to the worker transporting the waste was calculated as 5.4×10^{-4} millirem, producing an incremental risk of 1.5×10^{-10}.

Potential Impacts (Other than Releases) TE

Resulting impacts to biological resources would be similar to those discussed in Sections F.5.5.1 and F.5.6.3. Drainage of the basin would eliminate the potential for wildlife being affected by contaminants in the basin water. Removal of the waste would eliminate potential impacts from biointrusion.

F.5.6 POTENTIAL IMPACTS TO BIOLOGICAL RESOURCES IN THE TNX-AREA

This section addresses those general impacts related to aquatic and terrestrial ecology, as well as endangered species and wetlands for each closure and remedial action. Where a discussion of site-specific data is required for a given action, it is presented in the appropriate section above.

Four of the five waste sites within the TNX-Area waste sites are inactive. The two D-Area burning/rubble pits are backfilled with soil, the old TNX seepage basin has been backfilled and covered with a clay cap, and the TNX burying ground is located under structures inside the TNX security fence. The fifth site, the new TNX seepage basin, is presently active and is filled to capacity with effluent channeled to Outfall X-13 and eventually to the Savannah River.

F.5.6.1 Assessment of No Action (No Removal of Waste and No Remedial or Closure Action)

Aquatic Ecology

Aquatic impacts for no action for all waste sites located in the TNX-Area are described above for each waste site. In cases where contaminants were not analyzed by PATHRAE, the contaminants in the downgradient wells were compared to EPA water-quality criteria (Table F-25); in these cases, the contaminants did not exceed the criteria after dilution.

Terrestrial Ecology

With the exception of the new TNX seepage basin, the waste sites in the TNX-Area are either backfilled and vegetated or are underneath existing structures on the TNX site. Closure would produce no new impacts on terrestrial ecological resources associated with sites, since no actions would be taken. Potential impacts from biointrusion are described above for each site.

Endangered Species

As indicated in Table F-25, no endangered species or habitat has been identified in the immediate vicinity of TNX-Area waste sites during previous surveys. Thus, this closure action would have no impact on endangered species.

Wetlands

Wetland habitats are found within 1000 meters of each of the TNX-Area waste sites, the nearest being approximately 50 meters from the old TNX seepage basin (Table F-25). Most wetland areas are over 400 meters from the waste sites. Wetland types present include emergent marsh, cypress/tupelo, bottomland hardwood, and open water. Potential impacts to wetlands are described above for each site, as appropriate.

F.5.6.2 Assessment of No Removal of Waste and Implementation of Cost-Effective Remedial and Closure Actions as Required

Aquatic Ecology

In comparison to the impacts from no action, those to aquatic resources resulting from no waste removal and closure are expected to result in decreased surface-water and groundwater contamination. For sites already
TE backfilled, the addition of a cap is expected to reduce water infiltration and

thereby reduce future groundwater contamination. Under this closure action, water from the new TNX seepage basin would be removed for treatment and the basin backfilled and covered with a low-permeability cap and topsoil. Filling the basin would eliminate potential aquatic impacts associated with basin use by organisms. Any discharge of water resulting from corrective actions would meet NPDES requirements and would have no impact on surface streams. | TE

Construction activities might generate some additional sediment. However, the use of engineered sediment control structures would prevent this from having an impact.

Terrestrial Ecology

The potential terrestrial impacts of no waste removal and closure for the waste sites of the TNX-Area include the uptake of wastes by plant roots and temporary disturbance to wildlife due to noise associated with closure activities. Continued maintenance, such as mowing, would prevent impacts from root penetration of the clay cap.

Endangered Species

No impacts to endangered species are expected as a result of this closure action. | TE

Wetlands

Under this closure action, no impacts to nearby wetlands are expected. The potential for increased sedimentation would be eliminated by erosion and sedimentation control measures. | TE

F.5.6.3 Assessment of Removal of Waste to the Extent Practicable and Implementation of Cost-Effective and Closure Actions as Required

No impacts to aquatic ecosystems are expected from this closure action. Waste removal would reduce additional releases of waste materials to groundwater. Because of the similarity of this closure action and the no-waste-removal-and-closure action, the discussion in Section F.5.6.2 is applicable here. | TE | TE

F.6 ASSESSMENT OF ACTIONS AT D-AREA WASTE SITES

This geographic grouping is the area of influence assigned to the D-Area oil seepage basin. It is approximately 1000 meters west of Road A (South Carolina Highway 125) and 1200 meters north of the D-Area steam plant (see Figure F-9).

F.6.1 D-AREA OIL SEEPAGE BASIN, BUILDING 631-G*

F.6.1.1 Assessment of No Action (No Removal of Waste, and No Remedial or Closure Actions)

Description of Action

TE Under no action, the D-Area oil seepage basin would remain in its current state. Groundwater would continue to be monitored on a quarterly basis for TC 1 year and then annually for 29 years. Site maintenance, which includes mowing the grounds, would be continued for the entire 30-year period.

Comparison of Expected Environmental Releases with Applicable Standards

Tetrachloroethylene was the only constituent modeled at the D-Area Oil Basin. Tetrachloroethylene (estimated disposal mass - 0.35 kilogram) was selected because of elevated groundwater samples taken from the D-Area oil basin wells. PATHRAE predicts that the peak concentration of tetrachloroethylene at the 1-meter and 100-meter wells occurred in 1977 and 1978, respectively. These concentrations (0.02 milligram per liter at the 1-meter well, and 0.017 milligram per liter at the 100-meter well) exceed the health-based standard for tetrachloroethylene of 0.0007 milligram per liter. Groundwater monitoring shows elevated total organic carbon (TOC) levels (12.26 milligrams per liter) in downgradient well DOB 1. These elevated concentrations are probably due to the oil that was disposed of in the basin and not tetrachloroethylene. Total organic halogen (TOH) levels in the downgradient wells are not significantly different from the background concentrations.

Surface-water quality would not be affected significantly by the addition of potential contaminants from the groundwater pathway, because the resulting concentration of tetrachloroethylene in the Savannah River (2.0×10^{-10} milligram per liter) is projected to be below its health-based standard.

TC Tetrachloroethylene release to the atmosphere was modeled to estimate carcinogenic risk for each action. For release to the atmosphere, carcinogenic risk to the maximally exposed individual from tetrachloroethylene was calculated to be 2.13×10^{-19} for year 1, the peak year. There is no evidence that noncarcinogens or radioactive contaminants were released to the D-Area Oil Seepage Basin; therefore, these risks were not calculated.

Potential Impacts (Other Than Releases)

Aquatic Resources

A possible pathway for aquatic resources to be affected by no action is through the outcropping of contaminated groundwater to site streams. PATHRAE modeling was performed for tetrachloroethylene. The results indicated that no degradation of Savannah River water quality should occur as a result of

*The reference source for the information in this section is Huber, Johnson, and Bledsoe, 1987.

contaminated groundwater entering the river. In addition, levels of groundwater contamination are not significant ecologically; therefore, impacts to aquatic organisms would not occur for any closure. Table F-26 lists the non-PATHRAE-modeled materials found in the groundwater that are above freshwater aquatic life criteria. These materials should not create or enhance existing impacts on the aquatic biota of the Savannah River. This conclusion was based on the estimated dilution factors calculated by dividing the groundwater flux by the flow rate of the receiving stream. The dilution factor indicates that these wastes would be so diluted they would not affect the present water quality of the outcropping stream. TE

Terrestrial Resources

No adverse impacts to terrestrial resources would be expected from the implementation of any of the closure actions. Soil concentrations of tetrachloroethylene are expected to be low due to the compound's volatility and mobility. In addition, the 2-meter depth of the buried constituent makes biointrusion unlikely. Because the level of tetrachloroethylene at the outcrop is biologically insignificant, no impacts to wildlife from consuming undiluted groundwater at the outcrop would be expected. TE

Endangered Species

Because no endangered species have been sighted within the vicinity of the D-Area oil seepage basin, and because suitable habitat does not exist within 200 meters of the site (Table F-26), these species would not be affected.

Wetlands

As indicated in Table F-26, the nearest wetlands to the site are about 50 meters distant. These are bottomland hardwoods which are located in shallow upland depressions. There are 5.4 acres of wetlands within 200 meters and a total of 16.8 acres within 1000 meters of the site. The latter total includes some open water and emergent marsh. Because no disturbance is planned for this closure action, no adverse effects on wetlands are expected.

F.6.1.2 Assessment of No Removal of Waste and Implementation of Cost-Effective Remedial and Closure Actions as Required

Description of Action

Under the no-waste-removal-and-closure action, the D-Area oil seepage basin would remain in its current state (i.e., backfilled). Groundwater would be monitored quarterly for 1 year and then on an annual basis for 29 years. Site maintenance would continue for the full 30-year period. TE TC

Comparison of Expected Environmental Releases with Applicable Standards

Because PATHRAE modeling for this closure action is the same as no action, the material presented in Section F.6.1.1 is applicable.

Atmospheric releases for this closure action are the same as described in Section F.6.1.1. TC

Potential Impacts (Other Than Releases)

Because PATHRAE modeling for this closure action is the same as no action, the material presented in Section F.6.1.1 is applicable. TE

F.6.1.3 Assessment of Removal of Waste to the Extent Practicable, and Implementation of Cost-Effective Remedial and Closure Actions as Required

Description of Action

Under the waste-removal-and-closure action, all waste would be removed from the D-Area oil seepage basin. Approximately 5742 cubic meters of soil would be excavated to a depth of 1 meter below the bottom of the basin and removed to the SRP sanitary landfill. The basin would then be backfilled and the site graded and seeded. Maintenance of the site, which includes mowing of the grounds, would be continued for the entire 30-year period. Groundwater would be monitored on a quarterly basis for 1 year and then on an annual basis for 29 years. TC

Comparison of Expected Environmental Releases with Applicable Standards

Because PATHRAE modeling for this closure action is the same as that for no action, the material in Section F.6.1.1 is applicable. TE

The analysis described in the air release portion of Section F.6.1.1 was also performed for this action. Releases would be due to earth-moving activities and volatilization of tetrachloroethylene. Carcinogenic risks to the maximally exposed individual would be 2.53×10^{-20} or less.

An analysis of the health risks to the average individual worker that would be attributable to occupational exposure to carcinogens was performed using the methodology presented in Appendix I. The risk to a worker due to nonradioactive carcinogens was calculated as 5.65×10^{-18}. TC

Potential Impacts (Other Than Releases)

Aquatic Resources

Aquatic resources should not be affected by this closure action, because the removal of wastes would eliminate the future influx of wastes to the groundwater. Contaminated groundwater would continue to travel to outcrops on the Savannah River; however, no impacts should occur (see Section F.6.1.1). TE

Terrestrial Resources

The removal of soil and the subsequent backfilling and grading of the waste site could lead to some disruption of terrestrial biota. Wildlife could be temporarily disturbed by noise and human presence. After the remedial actions had been completed and the area revegetated, wildlife use would increase, especially if the site were allowed to succeed beyond the grassland/herbaceous stage. The removal of wastes would further reduce potential effects from biointrusion.

Endangered Species

TE No impacts on endangered species are expected to occur as a result of this closure action (see Section F.6.1.1).

Wetlands

Wetlands located near the site could be affected by erosion, depending on the local drainage pattern. To avoid sedimentation impacts, erosion control measures would be implemented.

F.7 ASSESSMENT OF ACTIONS AT ROAD A AREA WASTE SITE

This geographic area is that influenced by the Road A chemical basin. It is located approximately 400 meters southwest of Road A near its intersection with Road 6 (Figure F-11), and about 3 kilometers east of TNX- and D-Area facilities.

F.7.1 ROAD A CHEMICAL BASIN, BUILDING 904-111G*

The Road A chemical basin (Building 904-111G) is located approximately 400 meters southwest of the intersection of SRP Road A (S.C. Highway 125) and SRP Road 6. The history of waste disposal, evidence of contamination, and waste characteristics at the basin are presented in Appendix B, Section B.8.1.1.

F.7.1.1 Assessment of No Action (No Removal of Waste, and No Remedial or Closure Actions)

Description of Action

TC Under no action, the site would be left in its present condition. Groundwater monitoring with the existing wells would be continued quarterly for the first year, then annually for the next 29 years. Site maintenance would consist of maintaining groundwater monitoring wells and installing and maintaining a site identification sign for the entire 30-year period.

Comparison of Expected Environmental Releases with Applicable Standards

The history of disposal and the nature and quantities of materials disposed of in the Road A chemical basin are not known. Wastes disposed of at the site may have included miscellaneous radioactive and chemical aqueous wastes. Disposal of waste materials ceased in 1973 when the basin was closed and backfilled. Groundwater monitoring at the site began in May 1983 when three monitoring wells were installed; a fourth well was installed in July 1984.

The PATHRAE simulations for the waste constituents at the Road A chemical basin were not based on actual data, because constituent inventories are not available for the site. The inventories were instead estimated from the existing concentrations of lead, and uranium in the groundwater. PATHRAE

*The reference source of the information in this section is Pickett, Muska, and Bledsoe, 1987.

projections indicate that the concentration of lead would remain within regulatory standards. Uranium-238, as simulated by PATHRAE, was predicted to exceed the applicable standard (24 picocuries per liter) at the 1-meter well in 2985. The source terms used in the PATHRAE model assume that uranium-238 is composed of both mobile and less mobile fractions. The less mobile fraction created the maximum 2985 peak reported at 270 picocuries per liter. Monitoring for uranium-238 in the groundwater was not conducted, but its presence would have been detected by the gross alpha screening.

Surface-water quality would not be significantly affected by the addition of potential contaminants from the groundwater pathway from this site; the resulting concentrations of constituents from this source in Four Mile Creek are projected to be below drinking-water standards.

TC

No public exposures or risks attributable to atmospheric releases of lead or uranium are expected, because the site is currently backfilled with soil.

<u>Potential Impacts (Other Than Releases)</u>

Aquatic Resources

TE

Lead and uranium-238 were modeled using PATHRAE. The levels of groundwater outcrop contamination predicted by the model for lead exceed the EPA aquatic life criteria; however, dilution of the groundwater outcrop by Four Mile Creek yields concentrations that are not expected to affect the aquatic biota adversely. In view of the elevated groundwater outcrop concentration for lead, the potential exists under all closure actions for limited effects on the aquatic biota in the relatively unmixed waters of wetlands adjacent to the groundwater outcrop. The groundwater outcrop concentrations for lead and uranium-238 are below drinking-water standards, indicating that there is no potential for adverse effects on wildlife that consume the undiluted groundwater outcrop.

To estimate potential impacts of other wastes, data on water-quality parameters of downgradient wells were reviewed to identify constituents with parameters higher than the water-quality criteria for aquatic life. They included pH, cadmium, and copper (Table F-27). However, considering the dilution factor, concentrations in Four Mile Creek should not change significantly.

Terrestrial Resources

TE

TE

After closure and backfilling in 1973, the Road A chemical basin, as well as a considerably larger area surrounding it (a total area of 3.6 acres), were graded and vegetated with bush-clover. Under this closure action, no further disturbance would occur to the terrestrial ecology of the waste site. Vegetation regrowth has not indicated any adverse impacts. In the absence of soil monitoring data, a definitive assessment of potential terrestrial impacts is not possible. However, in view of the amounts of contaminants disposed of at the site, any terrestrial impacts should be minimal for all closure actions. Because of the depth of the buried waste (3 meters), any effects from the biointrusion pathway should be negligible.

Endangered Species

Since the site would not be disturbed, there would be no impacts on endangered species.

Wetlands

TC As indicated in Table F-27, there are no wetlands within 200 meters of the waste site. Within 1000 meters of the site there are 79.3 acres of wetland, all of which is bottomland hardwood forest. No direct impact to these wetlands would occur because no disturbance would take place.

As discussed above, contaminated groundwater can outcrop in the bottomland hardwood wetlands to the west of the site. While contaminants would be diluted as groundwater flowed from the site to the outcrop, levels could be elevated enough to affect the wetlands ecology.

F.7.1.2 <u>Assessment of No Removal of Waste and Implementation of Cost-Effective Remedial and Closure Actions as Required</u>

<u>Description of Action</u>

TC Under the no-waste-removal and-closure action, a low-permeability cap would be placed on top of the existing landfill. The cap would be placed only on top of the basin site itself. The area of the cap would be approximately 1700 square meters. The low-permeability cap would be graded and seeded. The vegetation would be cut periodically to minimize intrusion of any deep-rooted species through the low permeability cap. Because the materials that were disposed of in the basin would be left in place in this option, groundwater monitoring would be continued quarterly for 1 year, and then annually for the next 29 years. Site maintenance would be continued for the entire 30-year period.

<u>Comparison of Expected Environmental Releases with Applicable Standards</u>

Groundwater

TE The no-waste-removal-and-closure action would result in the same PATHRAE-modeled releases as described in Section F.7.1.1 for no action. All monitored constituents are currently within MCLs, and uranium-238 is the only constituent projected by PATHRAE to exceed its MCL. However, any remedial action would not be considered until additional groundwater monitoring data were obtained and soil characterization studies were completed.

Air

TE No releases to the atmosphere are projected to occur for this action, since
TC the source is currently backfilled with soil and the constituents are not volatile.

Potential Impacts (Other Than Releases)

Aquatic Resources

Aquatic impacts to Four Mile Creek would be expected to be similar to those discussed in Section F.7.1.1. Placement of a low-permeability cap would reduce infiltration through the basin sediments, reducing groundwater contamination. However, groundwater contaminated at current levels would continue to flow to outcrops on Four Mile Creek.

Terrestrial Resources

The site would be revegetated with herbaceous species such as vetch and deep-rooted shrubs and trees eliminated through occasional mowing, which would reduce potential impacts from biointrusion. Noise and human disturbance could disturb wildlife during site operations; however, this disturbance would be temporary.

Endangered Species

As noted in Table F-27, three former colony sites for the endangered red-cockaded woodpecker have been reported within 1000 meters of the Road A chemical basin. No activity has been reported at these colony sites in recent surveys on the SRP. Because of the distance involved, remedial actions should not adversely affect the former woodpecker colony site. In addition, bald eagles have been sighted flying in the area of the site. Any impacts to this species, for example, from construction noise should not be significant; such noise would occur only for a short time. Other habitat in the immediate vicinity of the waste site are not suitable for other Federally endangered species reported on the SRP (Dukes, 1984; Du Pont, 1985). Thus, site actions should not have any effect on these endangered species. TE

Wetlands

Wetlands present in the general area of the Road A chemical basin are discussed in Section F.7.1.1. Because of the distance to the nearest wetland, it is unlikely that any direct impacts resulting from this closure option would occur. Appropriate erosion and sediment control measures would be implemented.

F.7.1.3 Assessment of Removal of Waste to the Extent Practicable, and Implementation of Cost-Effective Remedial and Closure Actions as Required

Description of Action

Under the waste-removal-and-closure action, the existing backfill would be removed from the basin, and contaminated soil from the edges and bottom of the basin would be excavated. It is assumed that removal of 0.6 meter of soil from the bottom and the edge of the basin would be sufficient to remove the contaminants. The estimated volume of backfill to be removed and reemplaced is about 4500 cubic meters. The amount of contaminated soil to be excavated and removed is estimated to be 1000 cubic meters. The contaminated material would be transported in metal containers. Because the history of disposal TC

TC indicates that radioactive materials were disposed of in this basin, it is anticipated that the excavated materials would be removed to a waste storage/disposal facility. The backfill would be reemplaced and a low-permeability cap would be installed. Groundwater monitoring would not be continued.

Comparison of Expected Environmental Releases with Applicable Standards

TE The waste removal and closure action would result in the same PATHRAE-modeled releases as described in Section F.7.1.1 for no action. Groundwater remedial action would not be considered for the reasons discussed in Section F.7.1.2.

Air

TE Releases to the atmosphere are projected to occur for this action, owing to excavation activities in 1986. No releases are expected in future years because the source is backfilled with soil and the constituents are non-

TC volatile. The EPA Hazard Index due to releases of noncarcinogens is less than 1.5×10^{-9}.

Environmental doses and risks to the maximally exposed individual due to radiological releases from the Road A chemical basin were calculated using the methodology summarized in the introduction to this appendix and presented in Appendix I. The calculated doses are less than 1.0×10^{-3} percent of the DOE limit of 25 millirem per year for each of the 3 years. The risks associated with these doses would be less than 7.0×10^{-12}.

TC An analysis of the average individual worker's health risks attributable to occupational exposure to carcinogens (both nonradioactive and radioactive) and noncarcinogens was performed using the methodology presented in Appendix I. The EPA Hazard Index due to noncarcinogens would be approximately 2.3×10^{-3}. The total dose to the worker was calculated to be 0.6 millirem, which would produce an incremental risk of approximately 1.7×10^{-7}. The total dose to the worker transporting the waste was calculated as 0.11 millirem, producing an incremental risk of 3.1×10^{-8}.

Potential Impacts (Other Than Releases)

Aquatic impacts would be expected to be similar to those discussed in Section F.7.1.2. Removal of waste would further lessen groundwater contamination. However, contaminated groundwater would continue to flow to outcrops on Four Mile Creek.

F.8 ASSESSMENT OF ACTIONS AT K-AREA WASTE SITES

The approximate boundaries of the K-Area geographic grouping are Road B on the south and Road 6 on the northwest. This grouping is formed by waste sites associated with K-Reactor. Figure F-12 locates the waste sites in this grouping and shows the proximity to the Road A Area waste site.

Sections F.8.1 through F.8.4 contain or reference the section that contains a discussion of sites 8-1 through 8-4. Section F.8.5 discusses biological impacts that are generically applicable to the waste sites in this geographic grouping.

F.8.1 K-AREA BURNING/RUBBLE PIT, BUILDING 131K

This burning/rubble pit is discussed in conjunction with the other burning/ rubble pits in Section F.1.6. The ecological effects of this site that relate to the K-Area geographic grouping are discussed in Section F.8.5.

F.8.2 K-AREA ACID/CAUSTIC BASIN, BUILDING 904-80G

This acid/caustic basin is discussed in conjunction with the other acid/ caustic basins in Section F.2.1. The ecological effects of this site that relate to the K-Area geographic grouping are discussed in Section F.8.5.

F.8.3 K-AREA BINGHAM PUMP OUTAGE PIT, BUILDING 643-1G

TE Section F.3.4 describes the actions, releases, and other potential impacts for this outage pit in conjunction with the other Bingham pump outage pits. Section F.8.5 describes biological impacts that apply generically to the waste sites in this geographic grouping.

TE

F.8.4 K-AREA REACTOR SEEPAGE BASIN, BUILDING 904-65G*

TE Purge water from K-Reactor was discharged to the K-Area basin. The nearest surface stream to K-Area reactor seepage basin is Indian Grave Branch. This basin has been inactive since 1960.

F.8.4.1 <u>Assessment of No Action (No Removal of Waste, and No Remedial or Closure Actions)</u>

<u>Description of Action</u>

The K-Area reactor seepage basin is no longer in service but is currently
receiving minimal control and upkeep. Vegetative growth is controlled with
TC herbicides, erosion is monitored, fences are maintained, and groundwater is
monitored. Under no action, practices would be continued for this site. The
corners of the basin would be marked with identification pylons. Groundwater
TC monitoring would be conducted quarterly for 1 year and then annually for the
next 29 years. Site maintenance would be continued for the entire 30-year
period.

<u>Comparison of Expected Environmental Releases with Applicable Standards</u>

The monitoring data show that low levels of tritium are in the groundwater
TC around the basin. The distribution of activity indicates that the tritium may
come from an upgradient source. In addition, the groundwater contains other
radionuclides, including strontium-90 and yttrium-90.

*The reference source for the information in this section is Pekkala, et al., 1987b.

The regulatory standards and measured or estimated maximum concentrations of all constituents which are of concern from regulatory or health risk are presented in Table F-28. Most maximum concentration figures are based on modeling, because either no concentration measurements were available or the calculated concentration was greater than the measured concentration.

The maximum estimated concentrations presented in Table F-28 correspond to PATHRAE-calculated peaks. For tritium, these peaks are predicted to have occurred prior to 1985. TC

Table F-28 shows that tritium, strontium-90 and yttrium-90 concentrations exceed the standard for the 1-meter well. Tritium exceeds its standard at the 100-meter well. TE

Surface-water quality is not significantly affected by the addition of potential contaminants from the groundwater pathway from this site, as the resulting concentrations of constituents in Indian Grave Branch are projected to be below drinking-water standards.

The annual dose to an individual resulting from the atmospheric radionuclide releases for the No-action alternative at various times is presented below as a percentage of the DOE limit of 25 millirem per year:

Year	Percentage of DOE limit
1	5.6×10^{-4}
100	1.2×10^{-3}
1000	2.0×10^{-13}

Risks associated with radionuclide releases are no more than 8.5×10^{-11} for each of the three years considered.

Potential Impacts (Other Than Releases)

Section F.8.5.1 describes general impacts from no action to biological resources. Potential ecological concerns at the K-Area reactor seepage basin include contaminated groundwater transport to the surface water of Indian Grave Branch and biointrusion. PATHRAE modeling of wastes at this basin included tritium, cobalt-60, strontium-90, yttrium-90, cesium-137, promethium-147, and plutonium-239. The groundwater outcrops and resulting stream water concentrations of the modeled wastes were compared to EPA aquatic life criteria or equivalent numbers from the technical literature. TC Tritium at year 0 was found to exceed the comparison criterion under all closure actions; no other radiological contaminants exceed the criteria. TE The tritium concentration exceeded the criterion by a factor of 2.5, but did not alter the existing stream water concentration, which itself exceeds the criterion for tritium. Studies of the biological effects of concentrations of tritium in the groundwater outcrop and diluted stream water were well below the no-effect concentration for developing fish embryos. Therefore, no adverse impacts to the aquatic biota of Indian Grave Branch and adjacent wetlands attributable to the transport of radiological contaminants from the K-Area basin are expected under any of the closure actions. TE

Although the tritium concentration in the groundwater outcrop at year 0 slightly exceeds the EPA drinking-water standard, no adverse impacts to wildlife that consume undiluted groundwater are expected, due to the conservative nature of the criterion when applied to wildlife and the low probability of wildlife consistently drinking from the area of the groundwater outcrop.

Based on available data, limited terrestrial impacts are expected at the K-Area basin under no action via the biointrusion pathway. Soil concentration for cobalt-60, strontium-90, and cesium-137 exceeded the soil criteria by factors ranging from 10.4 to 46.4. Any impacts to terrestrial vegetation would be limited to the general area occupied by the basin, which is less than 1000 square meters.

F.8.4.2 Assessment of No Removal of Waste and Implementation of Cost-Effective Remedial and Closure Actions as Required

Description of Action

Under the no-waste-removal-and-closure action, no contaminated soil would be removed, but the basin would be allowed to dry, backfilled, and fitted with an infiltration barrier to reduce the likelihood of the contamination becoming exposed and migrating from the basin. The barrier would consist of an artificial membrane, compacted clay, sand, and gravel and is assumed to be 99-percent effective in preventing passage of infiltrating water. Finally, the basin would be covered with topsoil, graded, and seeded for erosion control. The corners of the basin would be marked with identification pylons. Groundwater monitoring would be conducted quarterly for 1 year and then annually for the next 29 years. Site maintenance would be continued for the entire 30-year period. TE TC

Comparison of Expected Environmental Releases with Applicable Standards

The implementation of this closure action is predicted to reduce all environmental releases except tritium to below MCLs (see Table F-28).

Surface-water quality would not be significantly affected by the addition of potential contaminants from the groundwater pathway from this site, as the resulting concentrations of constituents in Indian Grave Branch are projected to be below drinking-water standards.

No radionuclides would be released to the atmosphere.

Potential Impacts (Other Than Releases)

Sections F.8.4.1 and F.8.5.2 describe impacts on biological resources. Terrestrial impacts would be mitigated substantially, due to backfilling and capping.

F.8.4.3 Assessment of Removal of Waste to the Extent Practicable, and Implementation of Cost-Effective Remedial and Closure Actions as Required

Description of Action

TE Under the waste-removal-and-closure action, the K-Area seepage basin would be allowed to dry by natural seepage and evaporation. Approximately 260 cubic meters of contaminated soil would then be excavated from the floor of the basin. The excavation is projected to reduce the contamination remaining at the basin to the residual concentrations shown in Table F-29.

Table F-29. Proposed Excavation for Cleanup of K-Reactor Seepage Basin in the Waste Removal Action

Basin No.	Maximum concentration picocuries per gram (pCi/g)			Proposed excavation depth (m)	Maximum residual contamination picocuries per gram (pCi/g)		
	Cs-137	Sr-90	Co-60		Cs-137	Sr-90	Co-60
904-65G	510	140	30	0.30	45	95	<1

Except for cobalt-60, the maximum soil contamination level remaining after excavation is expected to be above the soil guidelines used for selecting radioactive contaminants for inclusion in the risk assessment of closure options. Because elevated levels of contamination could remain after excavation, an infiltration barrier would be installed over the basin to reduce the likelihood of the contamination's becoming exposed and/or migrating from the waste site.

TC The excavated contaminated soil would be placed in metal containers or bagged as necessary and trucked to a waste storage/disposal facility at the SRP.

TC After excavation, the basin would be backfilled with about 1,600 cubic meters of clean soil and be fitted with a low-permeability cap. The barrier would consist of an artificial membrane, compacted clay, sand, and gravel and is assumed to be 99-percent effective in preventing passage of infiltrating water. Finally, the basin would be covered with topsoil, graded, and seeded for erosion control.

The corners of the closed basin would be marked with identification pylons. TC Groundwater monitoring would be conducted quarterly for 1 year and then annually for the next 29 years. Site maintenance would be continued for the entire 30-year period.

Comparison of Expected Environmental Releases with Applicable Standards

Expected releases for waste removal are predicted to be the same as those described in Section F.8.4.2 for no waste removal.

The annual dose resulting from atmospheric radionuclide releases for the first year would be 4.0×10^{-6} percent of the DOE limit of 25 millirem per year. The associated risk is 2.9×10^{-13}. There would be no atmospheric radionuclide releases during years 100 and 1000.

An analysis of the health risks to the average individual worker that would be attributable to occupational exposure to radioactive contaminants was performed using the methodology presented in Appendix I. The risk to the average worker is 1.54×10^{-7}, resulting from a total dose of 0.55 millirem. The risk to a worker transporting the waste is 7.84×10^{-8}, resulting from a dose of 0.28 millirem. TC

Potential Impacts (Other Than Releases)

Impacts on biological resources resulting from this closure action are similar to those described in Sections F.8.4.1 and F.8.5.3. Terrestrial impacts from the biointrusion pathway should be negligible under waste removal and closure due to the removal of contaminated soil, backfilling, and the installation of an infiltration barrier. TE

F.8.5 POTENTIAL IMPACTS ON BIOLOGICAL RESOURCES IN K-AREA

This section addresses those general impacts in this geographic grouping that are related to aquatic and terrestrial ecology, endangered species, and wetlands for each closure and remedial action. Discussions of site-specific data are given in the appropriate section above. TE

The K-Area burning/rubble pit and K-Area Bingham pump outage pit are backfilled and covered with soil. The K-Area acid/caustic basin and reactor seepage basin are inactive but act as wet-weather ponds. TE

F.8.5.1 Assessment of No Action (No Removal of Waste and No Remedial or Closure Action)

Aquatic Resources

Potential aquatic impacts could result from wastes entering groundwater and subsequently flowing to outcrops on nearby streams. Table F-30 presents data from groundwater monitoring wells for waste sites in K-Area; no data are available for the K-Area Bingham pump outage pit. The table lists wastes known to exceed EPA water-quality criteria for freshwater aquatic life that were not modeled using PATHRAE. In all cases, these contaminants are predicted to be diluted to concentrations below the EPA criteria.

Terrestrial Resources

The K-Area burning/rubble pit is inactive and has been covered with soil to grade level. Natural brush and grass have begun to grow over the site. The K-Area Bingham pump outage pit is also inactive and in a similar condition. Because no action is planned, no impacts on terrestrial ecosystems have been identified at either site. Potential impacts could occur if vegetation growing at these sites accumulated contaminants through root penetration of the waste, as discussed above.

Endangered Species

Previous surveys indicate little potential for endangered species in the vicinity of K-Area. Therefore, no impacts to these species should occur.

Wetlands

Data on wetlands located near the K-Area waste sites are presented in Table F-30. With the exception of 0.1 acre found within 200 meters of the K-Area seepage basin, no wetland areas are closer than 550 meters from any of the K-Area sites. No action would cause no additional impacts on wetlands over those that may be occurring now.

F.8.5.2 Assessment of No Removal of Waste and Implementation of Cost-Effective Remedial and Closure Actions as Required

Aquatic Resources

The types of impacts on aquatic ecosystems resulting from this closure action would be similar to those described in Section F.8.5.1 for the sites already backfilled. Erosion control measures would be used to prevent potential aquatic impacts from sedimentation due to the remedial actions planned. TE

Terrestrial Resources

Temporary impacts on terrestrial ecosystems might result from site disturbance and noise. Closure and occasional mowing would reduce the potential for waste uptake by vegetation.

Endangered Species

No impacts to endangered species are expected. Endangered species are sufficiently distant from the sites to prevent disturbance as a result of human activities.

Wetlands

Because of their distance from the sites, wetland habitats should not be affected by backfill and remedial activities planned under this closure action. Sedimentation and erosion control procedures would prevent potential wetland disturbance. TE

F.8.5.3 Assessment of Removal of Waste to the Extent Practicable and Implementation of Cost-Effective Remedial and Closure Actions as Required

Aquatic Resources

No impacts on aquatic ecosystems are expected from action. Waste removal would reduce releases to groundwater, although contaminants already leached into the groundwater would continue to flow to outcrops on surface streams. Erosion control and sedimentation measures would be used during waste excavation and closure. TE

Terrestrial Resources, Endangered Species, and Wetlands

TE Due to the similarity of this action and no waste removal and closure, the discussion presented in Section F.8.5.2 is also applicable here. Waste removal would reduce potential impacts from biological accumulation.

F.9 ASSESSMENT OF ACTIONS AT L-AREA WASTE SITES

This geographic grouping is formed by waste sites near L-Reactor. This grouping is approximately 4 kilometers east of K-Reactor, just north of Road B. Figure F-13 shows the locations of the waste sites in the L-Area grouping.

Sections F.9.1 through F.9.12 contain, or reference the section that contains, a discussion of sites 9-1 through 9-12. Section F.9.13 discusses biological impacts that are generically applicable to the waste sites in this geographic grouping.

F.9.1 L-AREA BURNING/RUBBLE PIT, BUILDING 131-L

This burning/rubble pit is discussed in conjunction with the other burning/ rubble pits in Section F.1.6. The ecological effects of this site that relate to the L-Area geographic grouping are discussed in Section F.9.13.

F.9.2 L-AREA ACID/CAUSTIC BASIN, BUILDING 904-79G

This acid/caustic basin is discussed in conjunction with the other acid/ caustic basins in Section F.2.1. The ecological effects of this site that relate to the L-Area geographic grouping are discussed in Section F.9.13.

F.9.3 CMP PITS*

The CMP pits consist of seven adjacent waste sites (Buildings 080-17G, 080-17.1G, 080-18G, 080-18.1G, 080-18.2G, 080-18.3G, and 080-19G). The seven
TE sites were assumed to be a single operating unit for purposes of modeling migration in groundwater and surface water. Also, the actions described in this section would be applicable to each of the CMP pits. For atmospheric transport risks, each of the seven CMP pits was considered separately. However, the effects of these releases will be discussed cumulatively in this section. The history of waste disposal, evidence of contamination, and waste characteristics at these pits are presented in Appendix B, Section B.10.1.

F.9.3.1 Assessment of No Action (No Removal of Waste and No Remedial or Closure Actions)

Description of Action

No action would involve the quarterly monitoring of well clusters 8, 9, 10, 11, 12, and 13 for about 5 years. If at the end of 5 years there were no increase in contaminant levels, the frequency would be reduced to once or

*The reference source of the information in this section is Scott, Kolb, Price, and Bledsoe, 1987.

twice per year for an additional 30-year period. Site maintenance, including upkeep of access roads, monitoring wells, and identification signs, would continue for 30 years.

Comparison of Expected Environmental Releases with Applicable Standards

The chemical constituents selected for consideration of risks associated with the CMP pits are benzene, chloroethylene, 2,4-D, dichloromethane, endrin, Freon, chromium, lead, zinc, silvex, tetrachloroethylene, toxaphene, and trichloroethylene. Each of these compounds was selected because it was found in groundwater at levels higher than the threshold selection criteria, or was expected to be found in the soil as a result of a review of an inventory of materials that were disposed of at this site (Looney et al., 1987). TC

Table F-31 lists the predicted maximum concentrations of the selected constituents and the year of peak occurrence after 1985, based on groundwater modeling for this site. The table also lists health-based standards for comparison purposes and the model estimates concentrations of several constituents in excess of applicable standards at the 1- and 100-meter wells. Table F-31 indicates that the predicted peak concentration of endrin is not anticipated in the groundwater at the 1- and 100-meter wells for more than 700 years. This is the result of endrin's natural resistance to movement through the unsaturated soil zone between the remaining waste and the aquifer.

Surface-water quality would not be significantly affected by the addition of potential contaminants from the groundwater pathway from this site, as the resulting concentrations of constituents from this source in Pen Branch are projected to be below drinking-water standards.

Cumulative environmental risks due to atmospheric chemical releases from the CMP pits are estimated to be low and not significant. Risks to the maximally exposed individual would be below 10^{-9} for carcinogenic risks. The EPA Hazard Index for a maximally exposed individual from noncarcinogens would be less than 10^{-8}. TC

The expected concentrations for erosion and the biointrusion pathways are zero for this option. The erosion rate is such that no waste erodes during the first 1000 years of the simulation, and the 4 meters of soil cover or exceed the root penetration assumed for the biointrusion pathway.

Potential Impacts (Other Than Releases)

Section F.9.13.1 describes the ecological impacts of no action. PATHRAE modeling was performed on benzene, chloroethylene, 2,4-D, dichloromethane, endrin, Freon, chromium, lead, zinc, silvex, tetrachloroethylene, toxaphene, and trichloroethylene, which were identified as having potential impacts on the aquatic system. PATHRAE-generated groundwater outcrop concentrations for no action indicate that only toxaphene occurs at levels of ecological concern. The maximum groundwater outcrop concentration of toxaphene, which might indicate concentrations in wetland habitats bordering Pen Branch in the vicinity of the outcrop, was approximately four orders of magnitude above the EPA water-quality criteria for the protection of aquatic life, indicating the potential for impacts to the biota of these habitats. TC

The estimated (incremental) concentration of toxaphene in Pen Branch attributable to the CMP pits exceeded the EPA aquatic criteria by a factor of approximately seven, indicating a potential, but less serious, problem than in the wetlands. Concentrations of toxaphene in the Savannah River attributable to the CMP pits yielded quotients of less than 0.01 when compared to the EPA aquatic criteria indicating no problem for the biota in the river.

More specific aquatic life criteria, representing levels of toxaphene known to be toxic to aquatic biota representative of the SRP ecosystem in chronic tests, range from 0.09 to 0.20 micrograms per liter. Acute toxicity levels of toxaphene for representative taxa generally range from 1 to 30 micrograms per liter. A comparison of the calculated maximum chronic (undiluted) concentration of toxaphene in Pen Branch backwaters (2.3 micrograms per liter) to these toxicity criteria indicate the potential for significant impacts to biotic communities inhabiting these areas. However, the 10- to 20-fold exceedance indicates that, with any significant amount of dilution, the criteria will not be exceeded and any impacts should be restricted to a relatively small area. Maximum concentrations of toxaphene in Pen Branch attributable to the CMP Pits were two orders of magnitude below the criteria, indicating that there might be no adverse effects due to toxaphene in Pen Branch itself, regardless of the exceedance of the stringent EPA criteria.

No impacts on terrestrial resources, wetlands, or endangered species are expected under this closure action. In addition, there are no significant differences among the closure actions as far as ecological impacts are concerned. TE

F.9.3.2 Assessment of No Removal of Waste and Implementation of Cost-Effective Remedial and Closure Actions as Required

Description of Action

The no-waste-removal-and-closure action would involve monitoring groundwater at the existing wells. Decreased availability of contaminants should result in the decline of observed concentrations, except perhaps at CMP-9. If trends were not downward after 1 year, a decision would be made on whether or not to continue further monitoring, activate the leach field, or install a vacuum recovery system. Site maintenance, including upkeep of access roads, monitoring wells, and identification signs, would continue for 30 years. TE

Additional corrective actions, such as groundwater extraction and treatment, might be used to reduce the levels of all of the contaminants in the groundwater, except endrin and silvex, to below applicable standards. Endrin, in particular, is an extremely slow-moving contaminant that is not anticipated to reach its peak concentration in the aquifer for several hundred years. Thus, efforts to extract it from the groundwater in the near future would be ineffective, because it remains either within the remaining bodies of waste or somewhere along the depth of the unsaturated zone.

Comparison of Expected Environmental Releases with Applicable Standards

The chemical constituents of concern are the same as for no action (see Section F.9.3.1). Table F-31 lists the predicted maximum concentrations of the chemical constituents based on results of groundwater modeling. TE

TE Cumulative estimated environmental risks due to atmospheric chemical releases from the CMP pits for this option are identical to no action (Section F.9.3.1).

TE The predicted concentrations for the erosion, reclaimed farmland, and the bio-intrusion pathways are again zero for no action.

Potential Impacts (Other Than Releases)

Sections F.9.3.1 and F.9.13.2 describe the ecological impacts of no waste removal and closure. Proposed remedial action for the CMP pits, consisting of activated leach fields and/or installation of a vacuum recovery system, should reduce the potential for continuing contamination of the groundwater. However, contaminated groundwater would continue to flow to outcrops on Pen Branch with a potential to produce adverse impacts on adjacent wetlands.

F.9.3.3 Assessment of Removal of Waste to the Extent Practicable, and Implementation of Cost-Effective Remedial and Closure Actions as Required

Description of Action

Currently, 99.5 percent of all hazardous material has been removed from the seven CMP areas. Further action could be taken to lower residual concentrations to background levels. Among the possible actions are:

- Grouting and abandoning four wells totaling approximately 170 meters (CMP-9B, 9C, 16B, 16C).
- Excavating nearly 4000 cubic meters of compacted fill and crushed stone, together with the HDPE liner previously placed in the pit areas.
- Excavating an additional 1500 cubic meters of earth at depths of up to 27 meters below grade. Approximately 370 cubic meters of this material would contain an average concentration of organics of about 15 ppm.

TC

- Incinerating the earth moved.
- Refilling the excavated area to grade with clean soil and seeding for erosion control. The soil excavated and incinerated to remove the organics could be used for fill.
- Continuing groundwater monitoring at surrounding wells quarterly for 1 year, then annually for 29 years.
- Continuing site maintenance for the entire 30-year period.

TE Additional corrective actions, such as groundwater extraction and treatment, could be used in conjunction with this closure action to reduce the present level of contaminants in the groundwater. The selection of actions would be based on site-specific studies and interactions with cognizant regulatory agencies. Removal of the remaining waste, as defined by the original waste boundaries, would not be sufficient to ensure removal of all remaining constituents, particularly endrin. Further investigation would be required to locate the extent of the endrin plume, which is (and will be, for the entire

100-year institutional control period) resident in the unsaturated zone between the waste and the water table. Once the plume location is specified, further strategies could be devised (e.g., a combination of waste removal and remedial actions such as forcing the endrin into the water table, from which it could be pumped and removed) to ameliorate future instances in which endrin exceeds standards.

Comparison of Expected Environmental Releases with Applicable Standards

Table F-31 lists the predicted maximum concentrations of the chemical constituents based on results of groundwater modeling. These data indicate significant contamination of the groundwater in the vicinity of the pits. When the groundwater is discharged to Pen Branch, however, the concentrations are below applicable standards.

Estimated environmental risks due to atmospheric chemical releases from the CMP pits are very low and are considered not significant. Risks due to carcinogens are less than 10^{-11} and EPA Hazard Index values for noncarcinogens are less than 1.1×10^{-9}. TC

The expected concentrations for the erosion, reclaimed farmland, and biointrusion pathways are zero.

An analysis of the health risks to the average individual worker that would be attributable to occupational exposure to carcinogens and noncarcinogens was performed using the methodology presented in Appendix I.

The groundwater remediation system could be designed so that the contaminant levels in the groundwater would fulfill applicable standards. In addition, any release from the treatment system would meet applicable standards.

Potential Impacts (Other Than Releases)

The potential ecological impacts of waste removal and closure for the CMP pits are similar to those described in Sections F.9.3.1 and F.9.13.3.

F.9.4 CMP PIT, BUILDING 080-17.1G

This pit is discussed in conjunction with the other CMP pits in Section F.9.3.

Total risk due to release of carcinogenic contaminants is 7.2×10^{-8}. The total EPA Hazard Index value for noncarcinogens is 0.14. TC

F.9.5 CMP PIT, BUILDING 080-18G

This pit is discussed in conjunction with the other CMP pits in Section F.9.3.

F.9.6 CMP PIT, BUILDING 080-18.1G

This pit is discussed in conjunction with the other CMP pits in Section F.9.3.

F.9.7 CMP PIT, BUILDING 080-18.2G

This pit is discussed in conjunction with the other CMP pits in Section F.9.3.

F.9.8 CMP PIT, BUILDING 080-18.3G

This pit is discussed in conjunction with the other CMP pits in Section F.9.3.

F.9.9 CMP PIT, BUILDING 080-19G

This pit is discussed in conjunction with the other CMP pits in Section F.9.3.

F.9.10 L-AREA BINGHAM PUMP OUTAGE PIT, BUILDING 643-2G

TE The actions, releases, and other potential impacts for this outage pit are discussed in conjunction with the other Bingham pump outage pits in Section F.3.4.

F.9.11 L-AREA BINGHAM PUMP OUTAGE PIT, BUILDING 643-3G

TE The actions, releases, and other potential impacts for this outage pit are discussed in conjunction with the other Bingham pump outage pits in Section F.3.4.

F.9.12 L-AREA OIL AND CHEMICAL BASIN, BUILDING 904-83G*

F.9.12.1 Assessment of No Action (No Removal of Waste and No Remedial or Closure Actions)

Description of Action

Under no action, the site would be left in its present condition. Groundwater monitoring of existing wells would be continued quarterly for 1 year and then annually for 29 years. Site maintenance would be continued for 30 years.

Comparison of Expected Environmental Releases with Applicable Standards

The current groundwater monitoring data indicate that nickel and tetrachloroethylene exceed health-based standards based on the maximum single-well mean for each constituent. PATHRAE simulation indicates that concentrations of cadmium, chromium, lead, nickel, tetrachloroethylene, americium-241, strontium-90, tritium, uranium-238, yttrium-90, cobalt-60, and plutonium-238 either have recently exceeded or are expected to exceed MCLs in groundwater near the basin in the future (Table F-32).

Surface-water quality is not significantly affected by the addition of potential contaminants from the groundwater pathway from this site, as the resulting concentrations of constituents from this source in the Steel Creek/L Lake system are projected to be below drinking-water standards.

Environmental doses and risks to the maximally exposed individual due to radiological releases to the atmosphere from the L-Area oil and chemical basin were calculated using the methodology presented in the introduction to this appendix and in Appendix I. The calculated doses are less than 0.47 percent

*The reference source for the information in this section is Pekkala, Jewell, Price, and Bledsoe, 1987.

of the DOE limit of 25 millirem per year for each of the 3 years. The risks associated with these doses would be less than 3.3×10^{-8}. Environmental risks due to atmospheric chemical releases from the L-Area Oil and Chemical Basin are estimated to be low and not significant. Risks to the maximally exposed individual for no action for carcinogens are 3.7×10^{-8} or less. The EPA Hazard Index value for noncarcinogens is 1.8×10^{-5} or less. TC

Potential Impacts (Other Than Releases)

A general description of the ecological impacts of no action is provided in Section F.9.13.1. PATHRAE modeling was performed on cadmium, chromium, lead, mercury, nickel, tetrachloroethylene, tritium, cobalt-60, strontium-90, cesium-137, uranium-235 and -238, plutonium-238 and 239 and americium-241, which were identified as having potential impacts on the aquatic system. The results indicate that these materials would not alter the present water quality of Steel Creek. Lead and mercury in Steel Creek are presently above the aquatic biota criteria. Since the groundwater flow from the oil and chemical basin becomes part of the undrained uplands and swampy surface depressions of Steel Creek, full dilution of wastes is not likely to occur and some accumulation could occur in these wetland areas.

Because the basin sometimes contains standing water during periods of rainfall, this water could contain wastes from contaminated soils and pose a potential problem to wildlife, including waterfowl, and vegetation that come into contact with it. There is also the potential impact of surface runoff into nearby streams and wetlands during heavy rainstorms, if the runoff is not controlled. Wetlands in the vicinity of the oil and chemical basin consist of the bottomland hardwood communities along Steel Creek and the open-water wetland of L-Lake.

To assess the potential impacts associated with biointrusion under no action, maximum observed concentrations of nonradiological contaminants measured in the sediments were compared to phytotoxicological benchmarks. The metals assessed occur in concentrations toxic to vascular plants. All radionuclides exceed DOE Threshold Guidance Limits. Calculated plant uptake of nonradiological contaminants indicates that plant tissue concentrations would not approach levels considered toxic to herbivorous birds and mammals. Ecological benchmarks to assess similar effects for radiological contaminants are not available. The radiological contaminants are of concern because of their high concentrations in basin sediments. These results indicate the potential for significant effects on plant growth at the waste site itself and possible effects on wildlife using the habitat because of the elevated levels of radionuclides.

F.9.12.2 Assessment of No Removal of Waste and Implementation of Cost-Effective Remedial and Closure Actions as Required

Description of Action

Under the no-waste-removal-and-closure action, the basin water would be removed, and the sediment at the bottom of the basin would be stabilized with concrete to support backfill loads. The concrete decontamination pad and associated piping would be bulldozed into the basin. The basin would then be backfilled with approximately 3000 cubic meters of borrow fill, with an TC

TC additional 900 cubic meters required for a low-permeability cap. Groundwater monitoring would be continued quarterly for 1 year, then annually for the next 29 years. Site maintenance would be continued for the entire 30-year period.

As shown in Table F-32, concentrations of tetrachloroethylene, americium-241, strontium-90, tritium, yttrium-90, and cobalt-60 in groundwater near the basin are predicted by PATHRAE to exceed MCLs. Potential remedial action (e.g., groundwater pumping and treatment) could be required to address these constituents. Any actions taken would be based on site-specific studies and interactions with regulatory agencies. For example, the number, size, location, pumping rate, and pumping duration of groundwater-withdrawal wells would be determined after the contaminant plume was defined and a quantitative flow analysis was performed. Appropriate treatment technologies would be employed to reduce the concentrations of the constituents to below regulatory limits. Before a groundwater remedial action program was initiated, additional monitoring would be needed to define the actual extent and concentration of the contaminant plume.

Comparison of Expected Environmental Releases with Applicable Standards

Regulations promulgated under the Resource Conservation and Recovery Act (RCRA) and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) apply to closure and remedial actions. The regulations require that groundwater affected by the chemical basin be processed to achieve contaminant levels within MCLs established under the Safe Drinking Water Act.

The closure and potential groundwater remedial actions that may be used are expected to reduce the concentrations of tetrachloroethylene, americium-241, strontium-90, tritium, yttrium-90, and cobalt-60 to within MCLs. Surface-water quality would not be significantly affected by the addition of potential contaminants from the groundwater pathway from this site, as the resulting concentrations of constituents in the Steel Creek/L Lake system are projected to be below drinking-water standards. An analysis for radiological releases to the atmosphere described in Section F.9.12.1 was also performed. Risks due to atmospheric release of carcinogenic compounds are 5.85×10^{-26}. EPA Hazard Index values for noncarcinogens are 6.1×10^{-16} or less. No
TE radioactive releases are assumed to occur for this action, since the basin would be capped.

Potential Impacts (Other Than Releases)

Section F.9.13.2 describes the ecological impacts of no waste removal and
TE closure. Closure of the L-Area oil and chemical basin includes drainage of any existing standing water in the basin. However, because the contents of the basin would be released according to the NPDES permit requirements, impacts to the aquatic biota would not be significant. Solidifying the soils and capping the waste site with a low-permeability cap would retard the leaching of wastes into the groundwater; however, contaminations already in the groundwater would continue to flow to outcrops on Steel Creek. The area would be revegetated with shallow-rooted plants and mowed to prevent root penetration into the cap and potential impacts through the biointrusion pathway.

F.9.12.3 Assessment of Removal of Waste to the Extent Practicable and Implementation of Cost-Effective Remedial and Closure Actions as Required

Description of Action

The waste-removal-and-closure action for the L-Area oil and chemical basin includes the removal of any basin water and sediments, backfilling and capping with a low-permeability cover, and continuation of groundwater monitoring.

Any residual rainwater in the basin would be removed to Waste Management Operations for disposal. Basin sediments to a depth of 0.9 meter below the bottom of the basin would be stabilized with concrete and excavated. The 675 cubic meters of friable mixture would be loaded into metal containers for transport to a waste storage/disposal facility. TE

The concrete pad next to the basin and its pipeline to the basin would be removed and sent to a waste storage/disposal facility. The basin would then be backfilled with 3500 cubic meters of borrow fill. The waste site would be covered with a low-permeability cap (900 cubic meters) compacted, and seeded to prevent settling and erosion. Groundwater monitoring would be continued quarterly for the first year, then annually for the next 29 years. Site maintenance would be continued for the entire 30-year period.

As shown in Table F-32, concentrations of tetrachloroethylene, strontium-90, tritium, yttrium-90, and cobalt-60 in groundwater near the basin are predicted by PATHRAE to exceed applicable MCLs. Potential remedial action needed to reduce these constituents to below regulatory standards is discussed in Section F.9.12.2.

Comparison of Expected Environmental Releases with Applicable Standards

Regulations promulgated through RCRA and CERCLA apply to closure and remedial actions. The regulations require that groundwater affected by the chemical basin be processed to achieve contaminant levels within MCLs established under the Safe Drinking Water Act.

The potential groundwater remedial actions described in Section F.9.12.2 are expected to reduce the concentrations of tetrachloroethylene, strontium-90, tritium, yttrium-90, and cobalt-60 to within applicable MCLs. Surface-water quality would not be significantly affected by the addition of potential contaminants from the groundwater pathway from this site, as the resulting concentrations of constituents in the Steel Creek/L Lake system are projected to be below drinking-water standards. TC

The analysis of releases to the atmosphere described in Section F.9.12.1 was also performed for this option. Risks due to atmospheric release of carcinogenic compounds are 1.9×10^{-12} or less. EPA Hazard Index values for noncarcinogens are 9.2×10^{-9} or less. Radioactive releases would be due to excavation activities in 1986 but would be zero thereafter, since the basin would be capped. The dose to the maximally exposed individual was calculated as being less than 3.1×10^{-4} percent of the DOE limit of 25 millirem per year. The risk associated with this dose would be less than 2.2×10^{-11}. TC

TC An analysis of the health risks to the average individual worker attributable to occupational exposure to carcinogens and noncarcinogens for protected workers was performed using the methodology presented in Appendix H. The risks due to carcinogen releases to the average worker were calculated as being less than 2.0×10^{-9}. The EPA Hazard Index value for noncarcinogenic releases to the average worker was 8.7×10^{-4}. The total dose to the worker was calculated to be 24 millirem, which would produce an incremental risk of 6.7×10^{-6}. The total dose to the worker transporting the waste was calculated as 12 millirem, producing an incremental risk of 3.4×10^{-6}.

Potential Impacts (Other Than Releases)

TE Potential ecological impacts from this closure action would be similar to those described in Sections F.9.12.2 and F.9.13.3. Removal of the basin sediments would reduce the potential for further leaching of wastes to the groundwater and would eliminate the biointrusion pathway.

F.9.13 POTENTIAL IMPACTS ON BIOLOGICAL RESOURCES IN L-AREA

TE This section addresses those general impacts related to aquatic and terrestrial ecology, endangered species, and wetlands for each closure and remedial action. Discussion of site-specific data are presented in the appropriate section above.

There are 12 waste sites in L-Area. The L-Area burning/rubble pit is presently covered with soil and vegetation. Other waste sites within this geographic grouping include the seven CMP pits, which have been excavated and capped; the two L-Area Bingham pump outage pits, which contained low-level radioactive waste and are presently backfilled and covered with vegetation; the L-Area acid/caustic basin, which is dry except for an occasional impoundment of rainwater; and the L-Area oil and chemical basin, which is presently dry except for an occasional impoundment of rainwater. All waste sites within this geographic grouping are either abandoned or inactive.

F.9.13.1 Assessment of No Action (No Removal of Waste and No Remedial or Closure Actions)

Aquatic Ecology

TE No action for the waste sites of L-Area could indirectly cause contamination of surface-water bodies via the outcropping of groundwater from the various waste sites of L-Area. Table F-33 lists those groundwater wastes not modeled by PATHRAE that are known to exceed the freshwater EPA aquatic life criteria for each of the waste sites. Available data can determine that materials not modeled using PATHRAE analysis (see Table F-33) would not be expected to create or enhance impacts on the aquatic biota of nearby streams. This conclusion is based on the estimated dilution factor, which was calculated by dividing the groundwater flux by the flow rate of the receiving stream. This factor indicates that levels of waste materials would be so diluted as to not affect the water quality of the receiving stream.

Terrestrial Ecology

Potential terrestrial impacts of no action for the waste sites of L-Area include the exposure of wildlife and/or vegetation to standing contaminated surface waters and contaminated soils. The terrestrial impacts of those waste sites with standing surface waters are addressed individually, as are impacts from biointrusion, as appropriate.

Endangered Species

No endangered species have been identified in the immediate vicinity of the waste sites of L-Area from previous surveys at the SRP (see Table F-33). The habitats in the immediate vicinity of these waste sites are not considered suitable for any Federally endangered species previously reported on the SRP. There have been sightings of the bald eagle in the vicinity of L-Area (Mayer, Hoppe, and Kennamer, 1986), but no nests have been seen in this area. Also, the American alligator has been observed in the former L-Reactor cooling water discharge canal. No action for the waste sites of L-Area is not expected to have any effect on endangered species.

Wetlands

Wetlands of the L-Area include bottomland hardwood and scrub/shrub communities that occur along Steel Creek and the upper reaches of Pen Branch, and the open water wetland of L-Lake. Table F-33 provides the distances between the waste sites and the wetlands of L-Area. Potential impacts on these wetlands are addressed individually where appropriate. Impacts would be unlikely where wetlands are located some distance from a waste site.

F.9.13.2 Assessment of No Removal of Waste and Implementation of Cost-Effective Remedial and Closure Actions as Required

Aquatic Ecology

No waste removal and closure for the waste sites of L-Area could contribute directly and indirectly in the short term to the contamination of surface-water bodies during closure activities. Waste sites that contain standing water are addressed individually. Indirect contamination of surface-water body via groundwater is described in Section F.9.13.1 and for each waste site, as appropriate. According to the possible closure and remedial actions for the various L-Area waste sites, the level of impacts on the aquatic biota should be lower than that of no action.

Terrestrial Ecology

The potential terrestrial impacts of no waste removal and closure for the waste sites of L-Area include toxicity to vegetation via contaminated soils and temporary disturbance of the wildlife due to noise and habitat loss during closure operations.

Endangered Species

TE Potential impacts on endangered species would be similar to those addressed in Section F.9.13.1. Noise generated by this closure action could have a temporary impact on the bald eagle.

Wetlands

Section F.9.13.1 describes the wetlands that exist within the vicinity of L-Area. Because closure operations might induce soil erosion, remedial action should include erosion and surface runoff control to protect the wetlands.

F.9.13.3 Assessment of Removal of Waste to the Extent Practicable and Implementation of Cost-Effective Remedial and Closure Actions as Required

Aquatic Ecology

Aquatic impacts of waste removal and closure for the waste sites of L-Area could include direct and indirect contamination of surface-water bodies. However, closure also involves the removal of wastes and contaminated soils from these waste sites. This closure action would further reduce the potential for wastes entering groundwater.

Terrestrial Ecology

The potential terrestrial impacts of waste removal and closure for the waste sites of L-Area would include temporary disturbance of the wildlife due to noise and habitat loss during closure operations. The removal of wastes and contaminated soils should prevent the uptake of wastes by vegetation.

Threatened or Endangered Species

TE Potential impacts on endangered species would be similar to those addressed in Section F.9.13.1. Noise generated by this closure action may have a temporary impact on the bald eagle.

Wetlands

Section F.9.13.1 describes the wetlands that exist within the vicinity of L-Area. Because closure operations could induce soil erosion, remedial actions should include erosion and surface runoff control to protect the wetlands.

F.10 ASSESSMENT OF ACTIONS AT P-AREA WASTE SITES

This geographic grouping is formed by waste sites associated with P-Reactor, which is approximately 4 kilometers northeast of L-Reactor. Figure F-14 shows the boundaries of this geographic grouping and the locations of the waste sites within it.

Sections F.10.1 through F.10.3 contain or reference the section that contains a discussion of sites 10-1 through 10-3. Section F.10.4 discusses biological impacts that are generically applicable to the waste sites in this geographic grouping.

F.10.1 P-AREA BURNING/RUBBLE PIT, BUILDING 131-P

This burning/rubble pit is discussed in conjunction with the other burning/rubble pits in Section F.1.6. The ecological effects of this site that relate to the P-Area geographic grouping are discussed in Section F.10.4.

F.10.2 P-AREA ACID/CAUSTIC BASIN, BUILDING 904-78G

This acid/caustic basin is discussed in conjunction with the other acid/caustic basins in Section F.2.1. The ecological effects of this site that relate to the P-Area geographic grouping are discussed in Section F.10.4.

F.10.3 P-AREA BINGHAM PUMP OUTAGE PIT, BUILDING 643-4G

TE Section F.3.4 describes the actions, releases, and potential impacts for this outage pit. Section F.10.4 describes the ecological effects of this site that relate to the P-Area geographic grouping.

F.10.4 POTENTIAL IMPACTS TO BIOLOGICAL RESOURCES IN P-AREA

TE This section addresses those general impacts related to aquatic and terrestrial ecology, as well as endangered species and wetlands, for each closure and remedial action. Discussions of site-specific data are presented in the appropriate sections above.

The P-Area burning/rubble pit and the P-Area Bingham pump outage pit have been abandoned and are backfilled and covered with soil. The P-Area acid/caustic basin is inactive and is a wet-weather pond.

F.10.4.1 Assessment of No Action (No Removal of Waste and No Remedial or Closure Action)

Aquatic Resources

Aquatic impacts could result from the contamination of groundwater and its subsequent outcrop into nearby streams. Table F-34 presents data from groundwater monitoring wells for the P-Area waste sites. This table lists waste materials not modeled by PATHRAE analysis that are known to exceed EPA water-quality criteria for freshwater aquatic life. The contaminants listed would be below the EPA criteria after being diluted, based on the estimated dilution factor.

Terrestrial Resources

The P-Area burning/rubble pit is inactive and has been covered with soil to grade level. Natural brush and grass have begun to grow over the site. The P-Area Bingham pump outage pit is also inactive and in similar condition. Because no action is planned under this closure option, no impacts on terrestrial ecosystems have been identified at either site. Impacts could occur at all sites, however, if vegetation growing at the sites accumulated contaminants through root penetration of the waste. Continued maintenance (occasional mowing) might be necessary to prevent the growth of deep-rooted plant species and subsequent bioaccumulation in plants and animals.

Endangered Species

Previous endangered species and habitat surveys indicate little potential for endangered species in the vicinity of P-Area.

Wetlands

An area of wetland vegetation was identified approximately 365 meters from the P-Area burning/rubble pit. Total wetland acreages and the specific wetland vegetation types present are unknown for this site and/or for the P-Area acid/caustic basin. Wetland data for all sites are presented in Table F-34. Because no disturbance is planned under this action, no adverse effects to wetlands are expected.

TE

F.10.4.2 Assessment of No Removal of Waste and Implementation of Cost-Effective Remedial and Closure Actions as Required

Aquatic Resources

The impacts to aquatic ecosystems resulting from this action would be the same as those of No action for the sites already backfilled. Sedimentation and erosion control measures would prevent impacts to aquatic ecosystems from actions proposed.

TE

Terrestrial Resources

Impacts to terrestrial ecosystems could result from site disturbance and noise associated with any corrective action measures undertaken. These impacts would be minimized by proper engineering design and careful operation. For example, the operation of machinery only in defined work areas would prevent disturbance to nearby habitats.

Endangered Species

No impacts to endangered species are expected from this action. Endangered species are sufficiently distant from the sites to prevent their being disturbed by human activities.

TE

Wetlands

Because of the distances from the sites, wetland habitats should not be affected by backfill and the remedial activities planned under this closure action. Sedimentation and erosion control procedures would prevent potential disturbance to wetlands.

TE

F.10.4.3 Assessment of Removal of Waste to the Extent Practicable and Implementation of Cost-Effective Remedial and Closure Actions as Required

Aquatic Resources

No impacts to aquatic ecosystems are expected from this action. Waste removal would reduce additional contaminant releases to the groundwater. Erosion control and sedimentation measures would be required during closure activities. TE

Terrestrial Resources

Because of the similarity of this action and no waste removal and closure, the discussion presented in Section F.10.4.2 is applicable here. Waste removal would reduce any impacts of biological accumulation. TE

Endangered Species

No impacts to endangered species are expected from this action. Endangered species are sufficiently distant from the sites to prevent their being disturbed by human activities. TE

Wetlands

Because of the distances from the sites, wetland habitats should not be affected by closure activities. Sedimentation and erosion control procedures would prevent potential disturbance to wetlands.

F.11 ASSESSMENT OF ACTIONS AT MISCELLANEOUS AREA WASTE SITES

This section assesses two waste sites, the SRL oil test site and the gunsite 720 rubble pit, which are not within the boundaries of the 10 geographic groupings described in the previous sections. The SRL oil test site is south of Road 3, a short distance from CS-Area (see Figure F-8). The gunsite 720 rubble pit is west of Road A, about 10 kilometers south of A-Area and 5 kilometers north of D-Area.

F.11.1 SRL OIL TEST SITE, BUILDING 080-16G*

F.11.1.1 Assessment of No Action (No Removal of Waste and No Remedial or Closure Actions)

Description of Action

Under no action, the site would be left as it is, but four groundwater monitoring wells would be installed (one upgradient and three downgradient). The wells would be monitored quarterly for 1 year and then annually for the next 29 years. Well identification and site identification markers would be TE

*The reference source for the information in this section is Johnson, Pickett, and Bledsoe, 1987.

TE installed and maintained. Otherwise, the site would be allowed to return to its natural state. Site maintenance would be continued for the entire 30-year period.

Comparison of Expected Environmental Releases with Applicable Standards

Estimates of the environmental impact and health risks associated with the SRL oil test site were not determined because chemical constituents at the site did not exceed the selection criteria.

Potential Impacts (Other Than Releases)

Aquatic Resources

Although groundwater monitoring has not been conducted (Table F-35), impacts of no action to the aquatic ecosystem are not likely to occur as a result of groundwater outcropping to a stream, since vertical migration of oil through the soil was found to be minimal. Because vegetative growth on the site is sparse, small quantities of oil could reach a nearby branch of Four Mile Creek due to erosion; however, it is unlikely that any significant impacts to the stream would occur. PATHRAE modeling was not conducted for the SRP oil test site.

Terrestrial Resources

TC Currently, the site is sparsely covered with grasses and weeds. It is likely that vegetative cover would remain sparse under no action. The total uptake of wastes by vegetation is possible.

Endangered Species

TE As noted in Table F-35, no endangered species have been sighted in the vicinity of the oil test site, and habitats in the vicinity are not suitable for such species. Therefore, impacts to endangered species are unlikely for this action.

Wetlands

Depending upon local topography, erosion could carry waste materials to wetlands during storms; however, considering the distances involved (see Table F-35), impacts would not likely be significant.

F.11.1.2 Assessment of No Removal of Waste and Implementation of Cost-Effective Remedial and Closure Actions as Required

Description of Action

TE Under the no-waste-removal-and-closure action, the contaminated soils would not be removed; however, a low-permeability cap would be installed. It is assumed that the area of the cap would cover only the SRL oil test plots, about 6400 square meters. Four groundwater monitoring wells would be installed (one upgradient and three downgradient). The wells would be sampled and analyzed quarterly for 1 year, then annually for the next 29 years. Site and well identification markers would be installed and maintained. Vegetation on top of the cap would be cut periodically to prevent the establishment of any deep-rooted species. Site maintenance would be continued for the entire 30-year period.

Comparison of Expected Environmental Releases with Applicable Standards

As stated before, chemical constituents were not identified for this waste site, and expected environmental releases could not be estimated. However, the installation of a low-permeability cap would reduce the possibility of environmental releases.

Potential Impacts (Other Than Releases)

Aquatic Resources

Impacts on aquatic ecosystems should not occur, because hydrocarbon vertical migration is minimal and a cap and revegetation would prevent transport of wastes to nearby surface waters by erosion. During placement of the cap, appropriate erosion control measures should be used to minimize possible sedimentation of surface waters.

Terrestrial Resources

TC Impacts on terrestrial ecosystems would be beneficial, because the placement of a cap and mowing of vegetation would prevent the uptake of wastes by plants. This action could result in certain short-term adverse impacts such as displacement of wildlife due to noise and other human disturbances.

Endangered Species

Endangered species should not be affected by no waste removal and closure (see Section F.11.1.1).

Wetlands

Wetlands should not be affected. The wastes would be buried under a cap, the revegetation of which would reduce the transport of wastes due to erosion. During placement of the cap, appropriate erosion control measures would have to be implemented to prevent sedimentation.

F.11.1.3 Assessment of Removal of Waste to the Extent Practicable, and Implementation of Cost-Effective Remedial and Closure Actions as Required

Description of Action

TE Under the waste removal and closure action, contaminated soil would be excavated and removed to the SRP sanitary landfill. The soil volume to be excavated would be approximately 140 cubic meters (3.7 meters x 10.7 meters x 0.30 meter deep x 12 plots). The depth of soil excavation was chosen to be 0.3 meter because no hydrocarbon contamination was detected below that depth.

TC The site would be backfilled, graded, seeded to prevent erosion, and then allowed to return to its natural state. A low-permeability cap would not be installed. No signs or upkeep would be required. No groundwater monitoring wells would be installed, because the soil characterization testing indicated no movement of any materials at soil depths below 0.3 meters. TC

Comparison of Expected Environmental Releases with Applicable Standards

As for the other actions, no chemical constituents of concern were identified for this waste site and no environmental releases were estimated. However, removal of the wastes and contaminated soils could reduce the possibility of future environmental releases.

Potential Impacts (Other Than Releases)

Aquatic Resources

Since wastes would be removed, long-term impacts on aquatic ecosystems would not occur. Temporary construction-related impacts and mitigation measures would be similar to those discussed in Section F.11.1.2.

Terrestrial Resources

Since wastes would be removed and a cap would not be installed, vegetation could be allowed to return to its natural state. This would permit a wider variety of wildlife to inhabit the site than under no waste removal and closure and prevent the possible contamination that would occur under no action. Temporary disturbances from waste removal, backfilling, and grading activities would be similar to those discussed in Section F.11.1.2.

Endangered Species and Wetlands

Endangered species and wetlands should not be affected by this action. TE

F.11.2 GUNSITE 720 RUBBLE PIT, BUILDING N80,000, E27.350*

F.11.2.1 Assessment of No Action (No Removal of Waste and No Remedial or Closure Actions)

Description of Action

Under no action, the drums would remain in their present location. Four groundwater monitoring wells would be installed and monitored quarterly for 1 year then annually for the next 29 years. Site maintenance would be continued for the entire 30-year period. TC

Comparison of Expected Environmental Releases with Applicable Standards

Estimates of the environmental releases associated with the gunsite 720 rubble pit were not determined because chemical constituents at the site did not exceed the selection criteria.

*The reference source of the information in this section is Huber and Bledsoe, 1987b.

Potential Impacts (Other Than Releases)

Aquatic Resources

Aquatic impacts, if they were to occur, would involve Upper Three Runs Creek, since this stream receives both groundwater and surface-water flow from the site. However, there is no indication of aquatic impacts, based on data at the site.

Terrestrial Resources

Terrestrial effects associated with no action for the Gun Site 720 rubble pit include a potential for uptake of contaminants in the drums by the vegetation growing at or near the waste site. Also, wildlife could come into contact with wastes.

Endangered Species

As noted in Table F-35, no endangered species or critical habitats have been identified in the vicinity of the waste site. However, American alligators have been reported in Upper Three Runs Creek, approximately 600 meters south of the site, and bald eagles have been sighted flying over the general site area. Because of the distances involved, it is unlikely that alligators would be adversely affected by no action.

Wetlands

Wetland communities found within 200 and 1000 meters of the gunsite 720 rubble pit are given in Table F-35. The only wetland type present within this radius is bottomland hardwood forest. No adverse impacts are expected, based on available information.

F.11.2.2 Assessment of No Removal of Waste and Implementation of Cost-Effective Remedial and Closure Actions as Required

Description of Action

TC
TE

Under the no-waste-removal-and-closure action, remaining liquids in the drums would be stabilized with cement, bentonite, or another appropriate substance, and the drums would be buried. The excavated area would then be backfilled to grade and seeded. Four groundwater monitoring wells would be installed and monitored quarterly for 1 year, then annually for the next 29 years. Site maintenance would be continued for the entire 30-year period.

Comparison of Expected Environmental Releases with Applicable Standards

Chemical constituents have not been identified for this waste site, and environmental releases have not been established. Additional studies are needed to determine whether stabilization of the drummed waste would eliminate possible future environmental releases.

Potential Impacts (Other Than Releases)

Aquatic Resources

As noted in Section F.11.2.1, no aquatic impacts are expected, based on data at the site. Stabilization of the contents of the drums and their subsequent burial would eliminate the surface transport of wastes to Upper Three Runs Creek and lessen groundwater transport.

Terrestrial Resources

This action should eliminate the potential for direct contact of wildlife with the wastes at the site. During burial, refilling, and grading of the stabilized waste drums, noise and construction activities could cause temporary displacement of wildlife. TE

Endangered Species and Wetlands

The discussion in Section F.11.2.1 is generally applicable to this closure action. Closure activities could temporarily discourage eagles from flying over the area. TE

F.11.2.3 Assessment of Removal of Waste to the Extent Practicable, and Implementation of Cost-Effective Remedial and Closure Actions as Required

Description of Action

Under the waste removal and closure action, any drums found during excavation would be removed and transported to a waste storage/disposal facility. Approximately 35 cubic meters of soil located around the buried drums would also be excavated and taken to the same facility. Soil cores would be collected from the bottom of the excavation to determine if any contaminants are present. If no contamination is detected, no groundwater monitoring wells would be installed, and the site would be backfilled to grade and seeded. If contaminants are detected, four groundwater monitoring wells would be installed and monitored quarterly for the first year, then annually for the next 29 years. Site maintenance would be continued for the entire 30-year period. TC

Comparison of Expected Environmental Releases with Applicable Standards

As in the other actions, no chemical constituents of concern were identified for this waste site; therefore, no environmental releases were estimated. However, removal of the waste and backfilling the basin could reduce the possibility of environmental releases.

Potential Impacts (Other Than Releases)

Aquatic Resources

This action would offer the best protection against contamination for Upper Three Runs Creek. TE

Terrestrial Resources

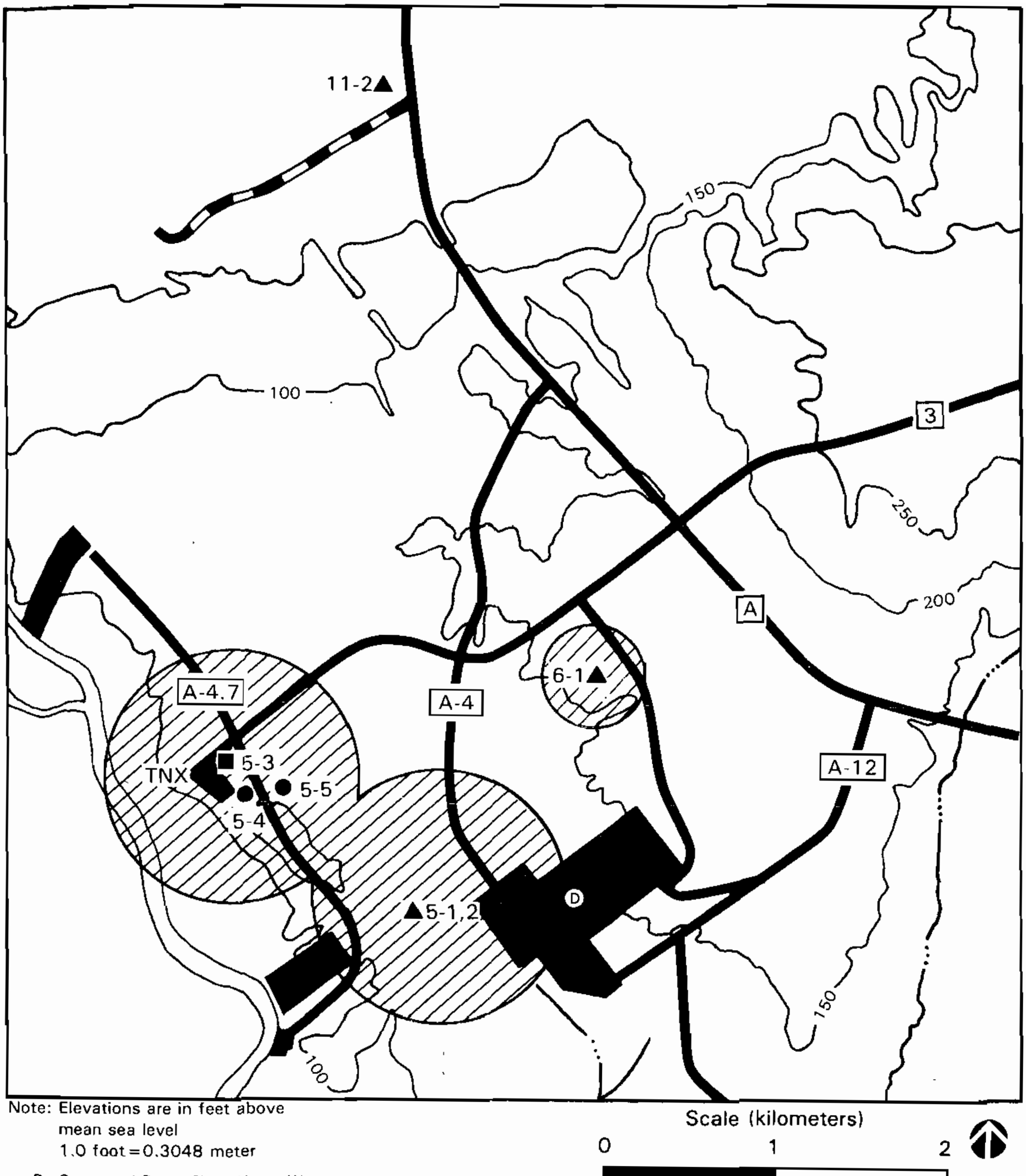
Removal of waste drums and soil followed by regrading and revegetation of the site would reduce the potential for contaminant exposure to terrestrial species. Noise and construction activities would cause temporary disturbance to wildlife.

Endangered Species

The discussion presented in Section F.11.2.1 is applicable to this section as well.

Wetlands

Removal of drums and contaminated soil would prevent any possible contamination to wetlands. Operations associated with cleanup of the site would be conducted to minimize erosion and sedimentation.



Note: Elevations are in feet above mean sea level
1.0 foot = 0.3048 meter

D Steam and Power Plant, Heavy Water Production (on standby)

TNX Pilot Scale Chemical Processing Facility

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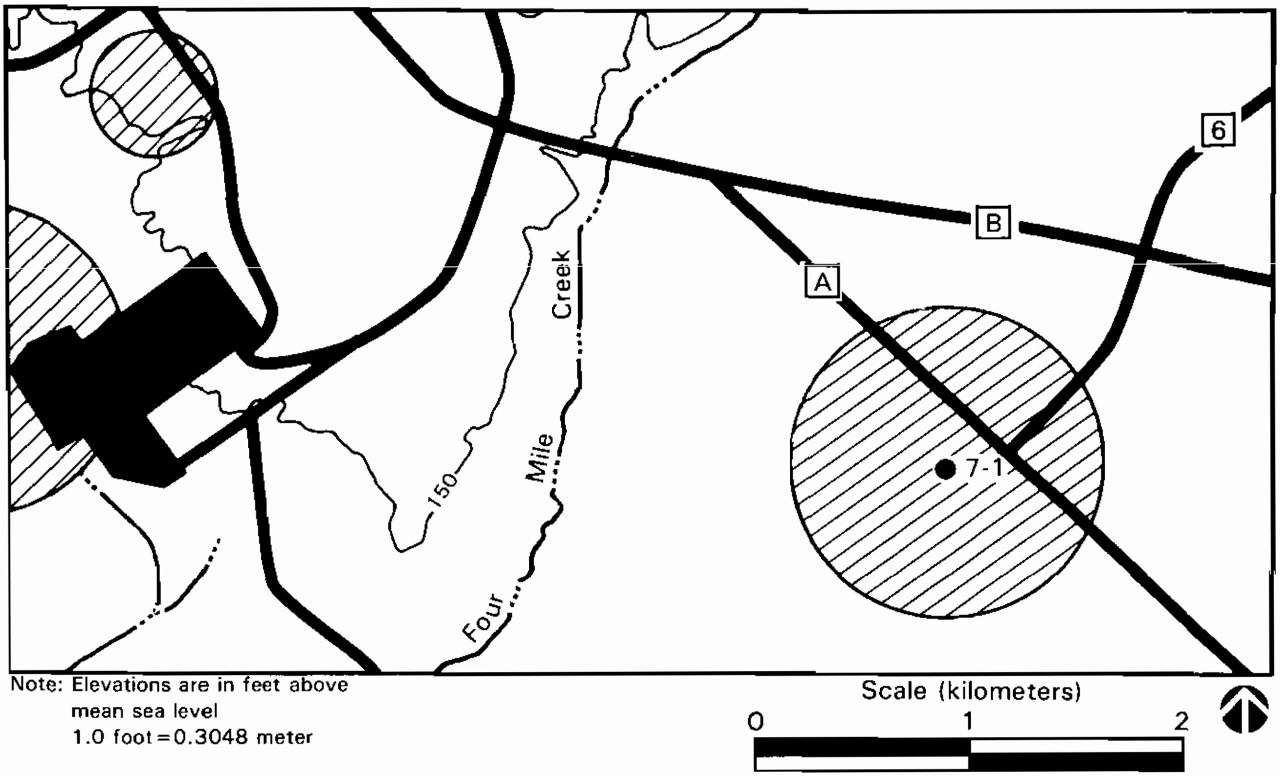
Figure F-10. TNX-Area Waste Sites

Number	Potential Waste Type	Site Name	Building Number
5-1	▲	D-Area Burning/Rubble Pit*	431-D
5-2	▲	D-Area Burning/Rubble Pit*	431-1D
5-3	■	TNX Burying Ground	643-5G
5-4	●	TNX Seepage Basin (old)*	904-76G
5-5	●	TNX Seepage Basin (new)*	904-102G
6-1	▲	D-Area Oil Seepage Basin	631-G
11-2	▲	Gunsite 720 Rubble Pit	N80E27.35

*Indicates that waste type may be contained in the waste site
▲ – Hazardous
■ – Low-level radioactive
● – Mixed

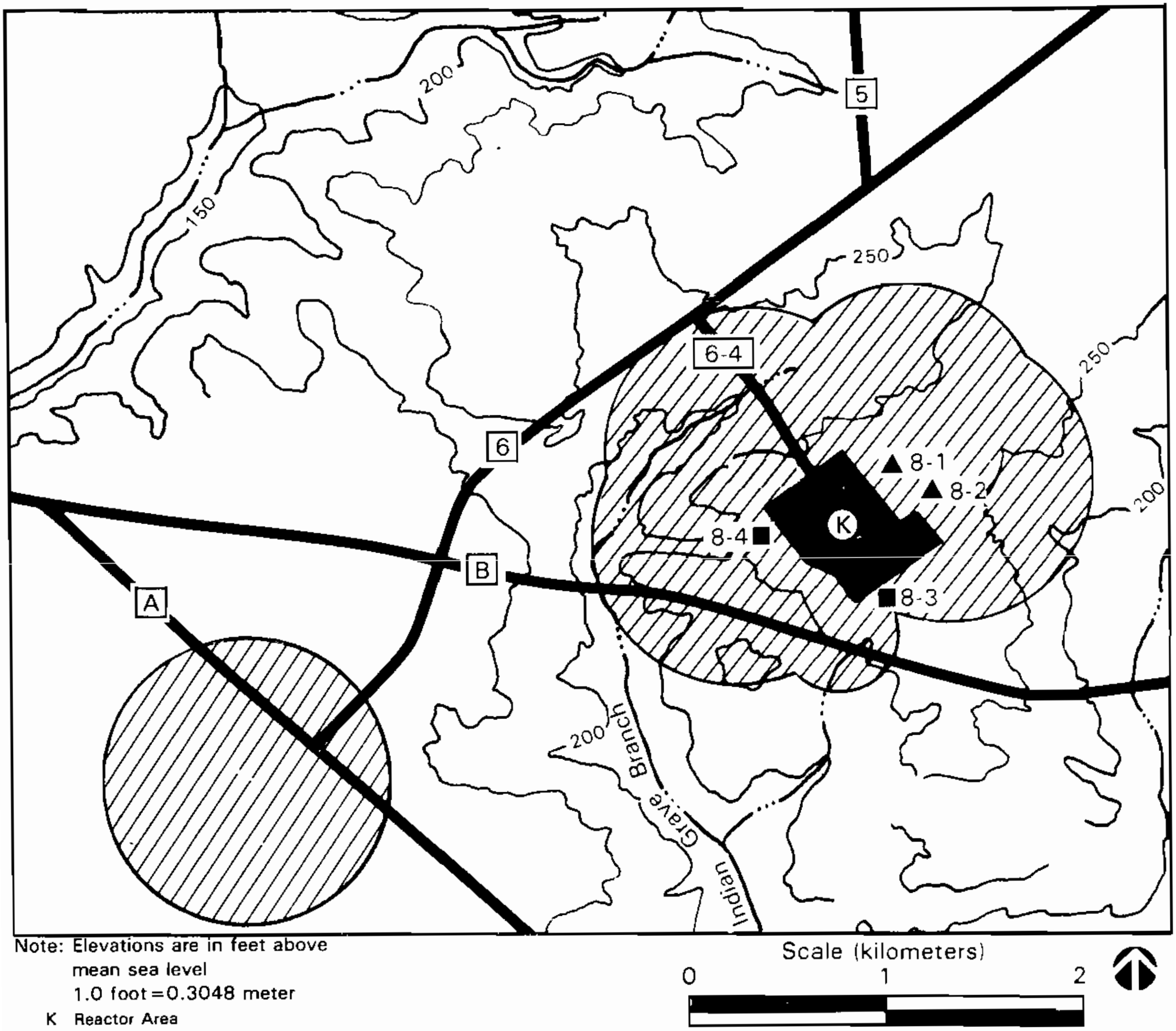
Figure F-10. TNX-Area Waste Sites (continued)



Number	Potential Waste Type	Site Name	Building Number
7-1	●	Road A Chemical Basin*	904-111G

*Indicates that waste type may be contained in the waste site
● – Mixed

Figure F-11. Road A Area Waste Site



Number	Potential Waste Type	Site Name	Building Number
8-1	▲	K-Area Burning/Rubble Pit*	131-K
8-2	▲	K-Area Acid/Caustic Basin*	904-80G
8-3	■	K-Area Bingham Pump Outage Pit*	643-1G
8-4	■	K-Area Reactor Seepage Basin	904-65G

*Indicates that waste type may be contained in the waste site
▲—Hazardous
■—Low-level radioactive

Figure F-12. K-Area Waste Sites

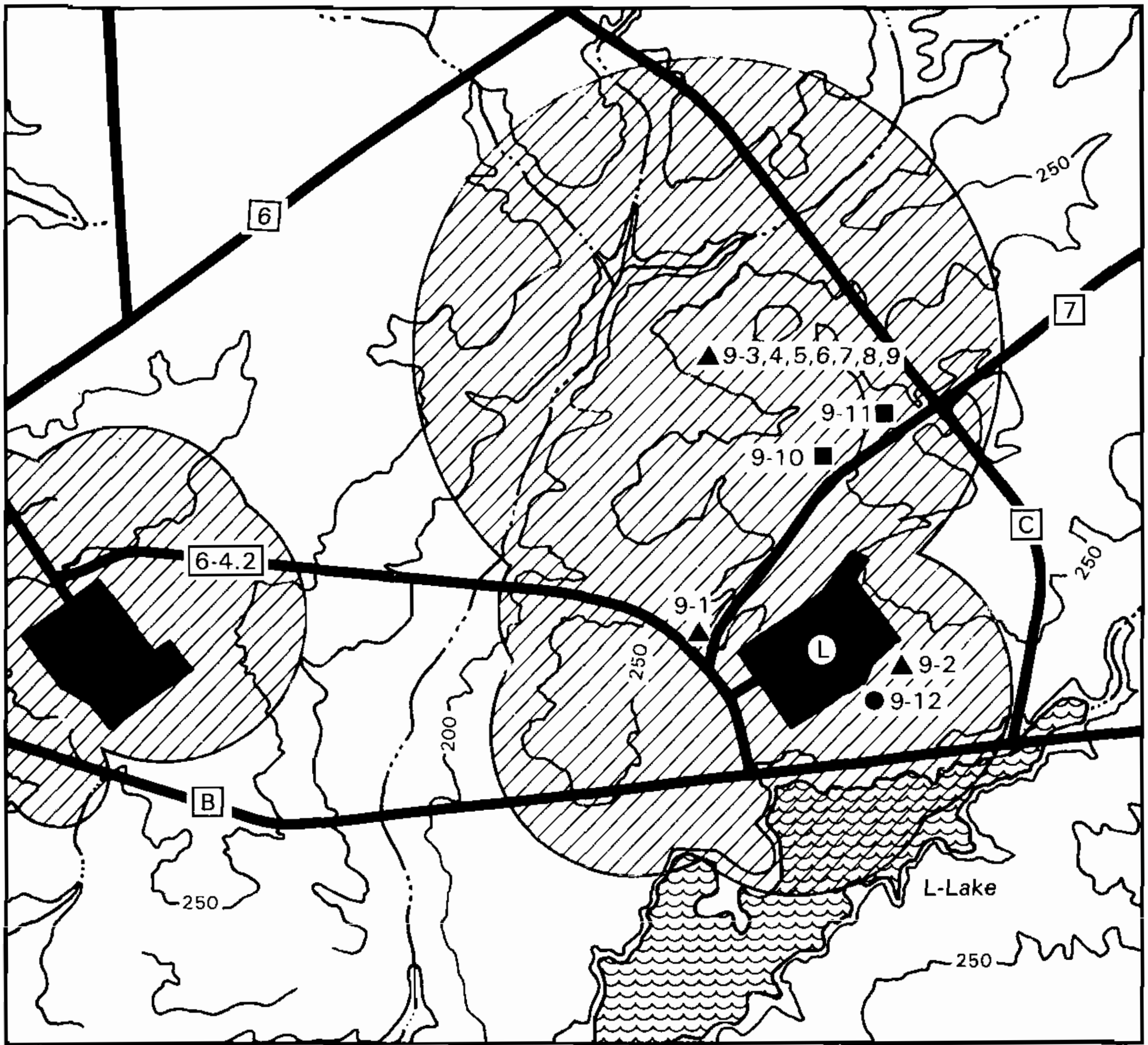


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Figure F-13. L-Area Waste Sites

Number	Potential Waste Type	Site Name	Building Number
9-1	▲	L-Area Burning/Rubble Pit*	131-L
9-2	▲	L-Area Acid/Caustic Basin*	904-79G
9-3	▲	CMP Pit	080-17G
9-4	▲	CMP Pit	080-17.1G
9-5	▲	CMP Pit	080-18G
9-6	▲	CMP Pit	080-18.1G
9-7	▲	CMP Pit	080-18.2G
9-8	▲	CMP Pit	080-18.3G
9-9	▲	CMP Pit	080-19G
9-10	■	L-Area Bingham Pump Outage Pit*	643-2G
9-11	■	L-Area Bingham Pump Outage Pit*	643-3G
9-12	●	L-Area Oil and Chemical Basin*	904-83G

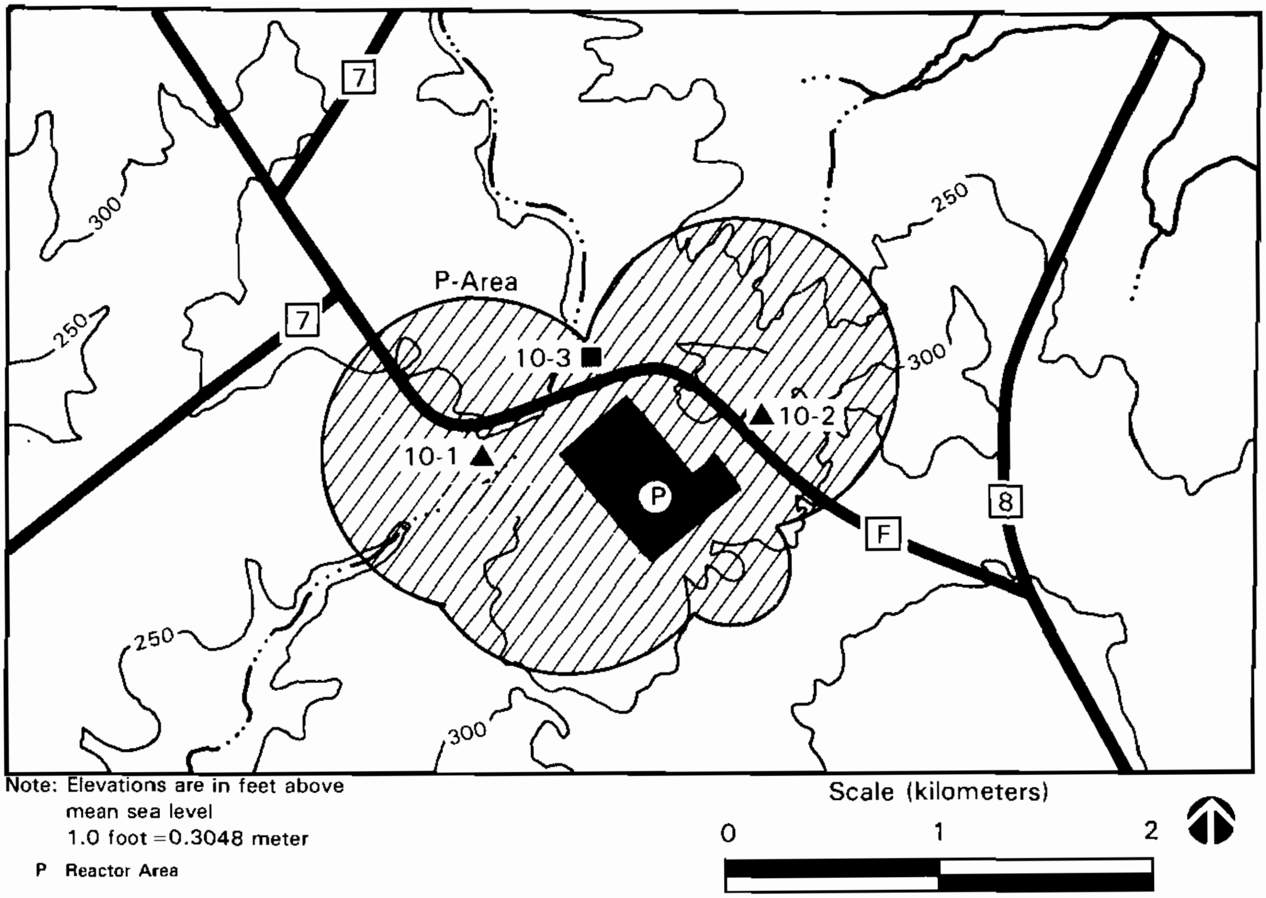
*Indicates that waste type may be contained in the waste site

▲—Hazardous

■—Low-level radioactive

●—Mixed

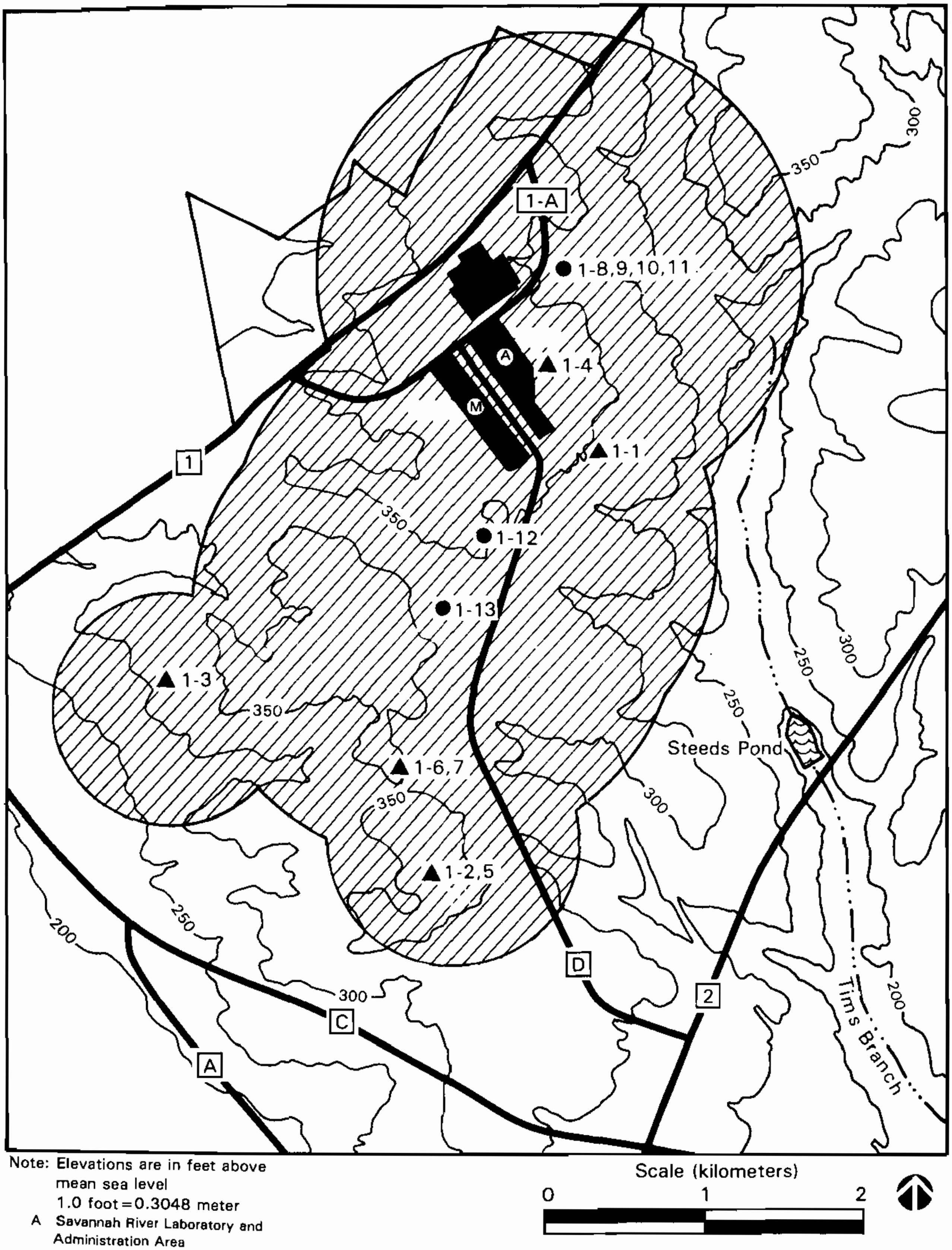
Figure F-13. L-Area Waste Sites (continued)



Number	Potential Waste Type	Site Name	Building Number
10-1	▲	P-Area Burning/Rubble Pit*	131-P
10-2	▲	P-Area Acid/Caustic Basin*	904-78G
10-3	■	P-Area Bingham Pump Outage Pit*	643-4G

*Indicates that waste type may be contained in the waste site
▲ – Hazardous
■ – Low-level radioactive

Figure F-14. P-Area Waste Site



Note: Elevations are in feet above mean sea level
1.0 foot = 0.3048 meter
A Savannah River Laboratory and Administration Area
M Fuel and Target Fabrication

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Figure F-1. A- and M-Area Waste Sites

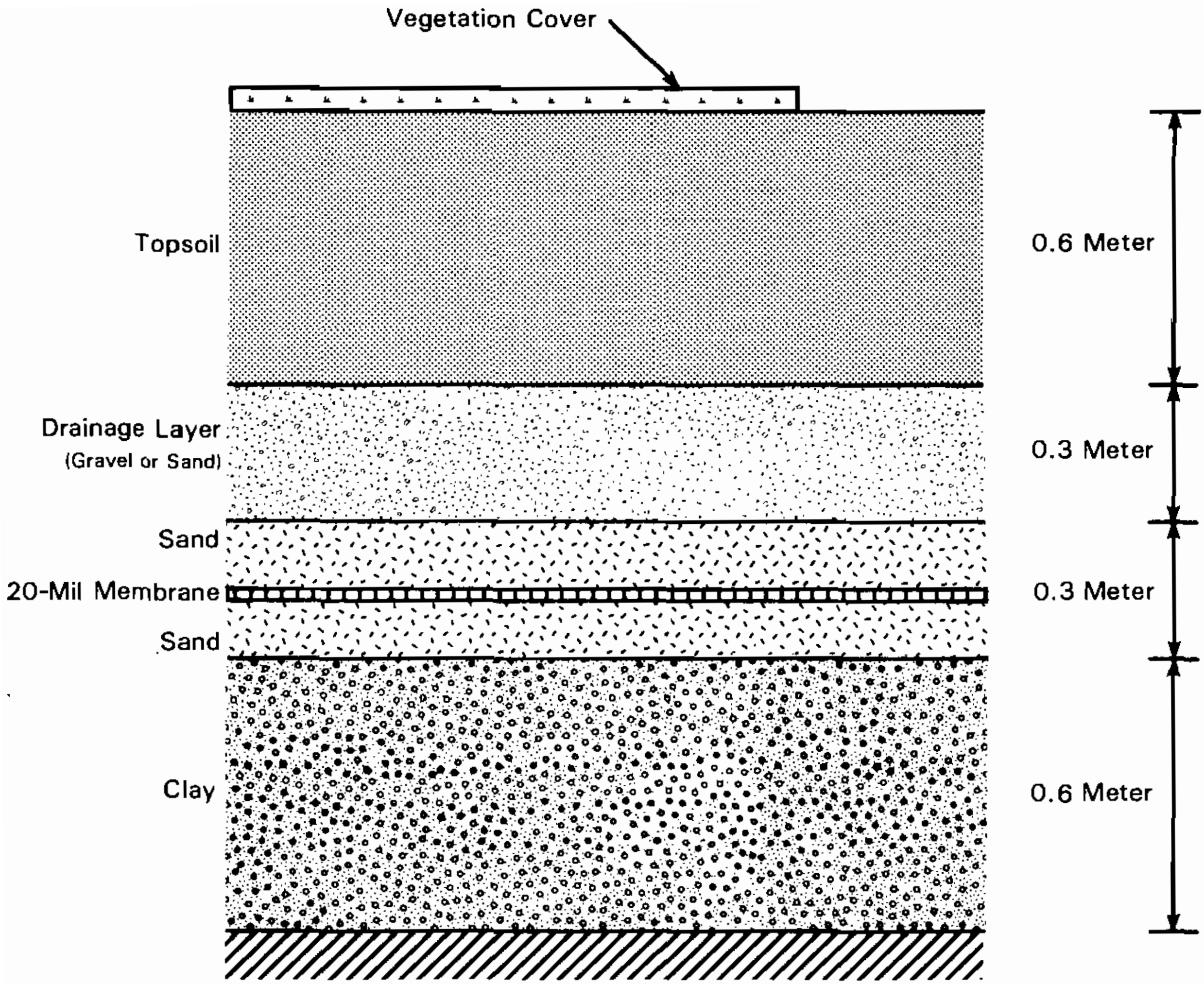
Number	Potential Waste Type	Site Name	Building Number
1-1	▲	716-A Motor Shop Seepage Basin	904-101G
1-2	▲	Metals Burning Pit	731-4A
1-3	▲	Silverton Road Waste Site	731-3A
1-4	▲	Metallurgical Laboratory Basin*	904-110G
1-5	▲	Miscellaneous Chemical Basin*	731-5A
1-6	▲	A-Area Burning/Rubble Pit*	731-A
1-7	▲	A-Area Burning/Rubble Pit*	731-1A
1-8	●	SRL Seepage Basin	904-53G
1-9	●	SRL Seepage Basin	904-53G
1-10	●	SRL Seepage Basin	904-54G
1-11	●	SRL Seepage Basin	904-55G
1-12	●	M-Area Settling Basin	904-51G
1-13	●	Lost Lake	904-112G

*Indicates that waste type may be contained in the waste site

▲—Hazardous

●—Mixed

Figure F-1. A- and M-Area Waste Sites (continued)

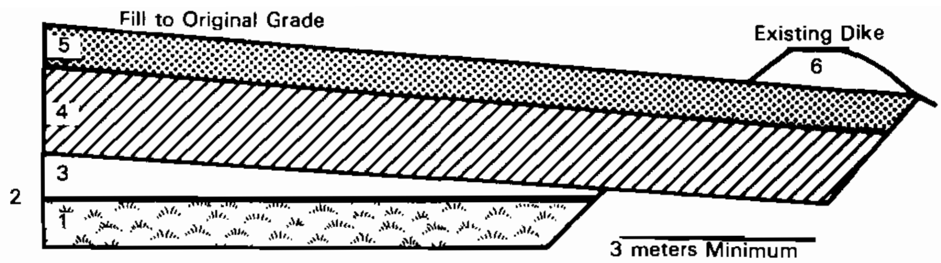


Permeability of Drainage Layer $\geqslant 1 \times 10^{-3}$ cm/sec

Permeability of Clay $\leqslant 1 \times 10^{-7}$ cm/sec

Infiltration Reduction - 99%

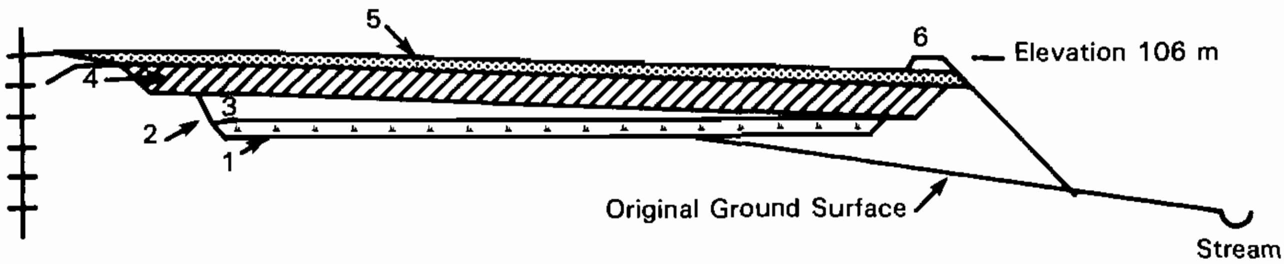
Figure F-2. Low-Permeability Cap



Legend:

1. Crushed stone or washed gravel (8 to 15 cm uniform-size stone). Approximately 0.6 m thick.
2. Geotextile filter fabric.
3. Common borrow fill. Thickness varies from 0 to 1 m.
4. Low-permeability cap. Group approximately 1.3 m thick.
5. Topsoil. Approximately 0.6 m thick.
6. Remove existing dike and use as fill where needed.

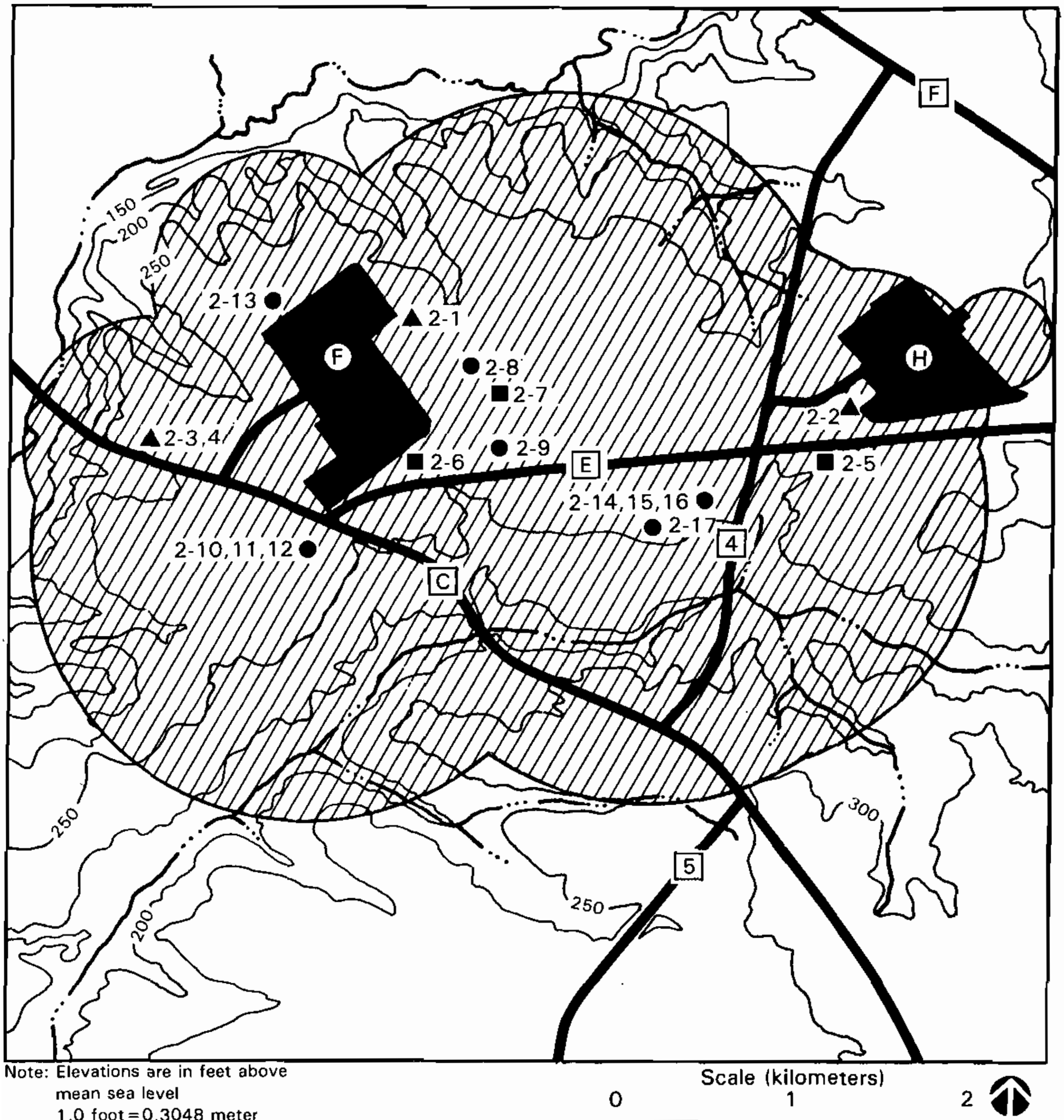
Figure F-3. Typical Basin Backfill Details of SRL Seepage Basins



Legend:

1. Crushed stone or washed gravel (8 to 15 cm uniform-size stone). Approximately 0.6 m thick.
2. Geotextile fiber febric.
3. Common borrow fill. Thickness varies from 0 to 1 m.
4. Low-permeability cap. Group approximately 1.3 m thick.
5. Topsoil. Approximately 0.6 m thick.
6. Remove existing dike and use as fill where needed.

Figure F-4. Backfill Details for SRL Seepage Basin 4



Note: Elevations are in feet above mean sea level
1.0 foot = 0.3048 meter

F, H Separation Areas

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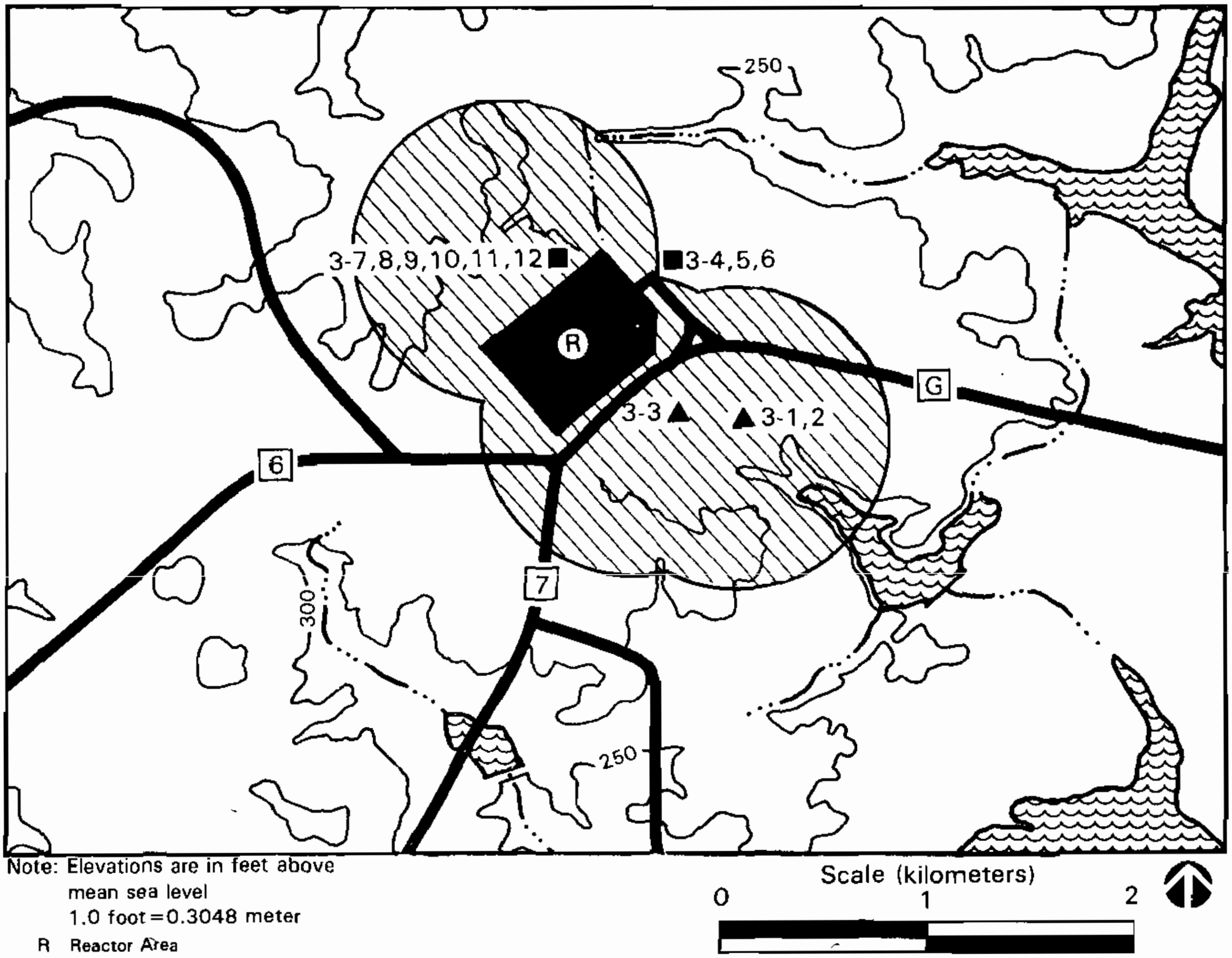
Figure F-5. F- and H-Area Waste Sites

Number	Potential Waste Type	Site Name	Building Number
2-1	▲	F-Area Acid/Caustic Basin*	904-74G
2-2	▲	H-Area Acid/Caustic Basin*	904-75G
2-3	▲	F-Area Burning/Rubble Pit*	231-F
2-4	▲	F-Area Burning/Rubble Pit*	231-1F
2-5	■	H-Area Retention Basin	281-3H
2-6	■	F-Area Retention Basin	281-3F
2-7	■	Radioactive Waste Burial Ground	643-7G
2-8	●	Mixed Waste Management Facility	643-28G
2-9	●	Radioactive Waste Burial Ground	643-G
2-10	●	F-Area Seepage Basin	904-41G
2-11	●	F-Area Seepage Basin	904-42G
2-12	●	F-Area Seepage Basin	904-43G
2-13	●	F-Area Seepage Basin (old)	904-49G
2-14	●	H-Area Seepage Basin	904-44G
2-15	●	H-Area Seepage Basin	904-45G
2-16	●	H-Area Seepage Basin	904-46G
2-17	●	H-Area Seepage Basin	904-56G

*Indicates that waste type may be contained in the waste site
▲—Hazardous
■—Low-level radioactive
●—Mixed

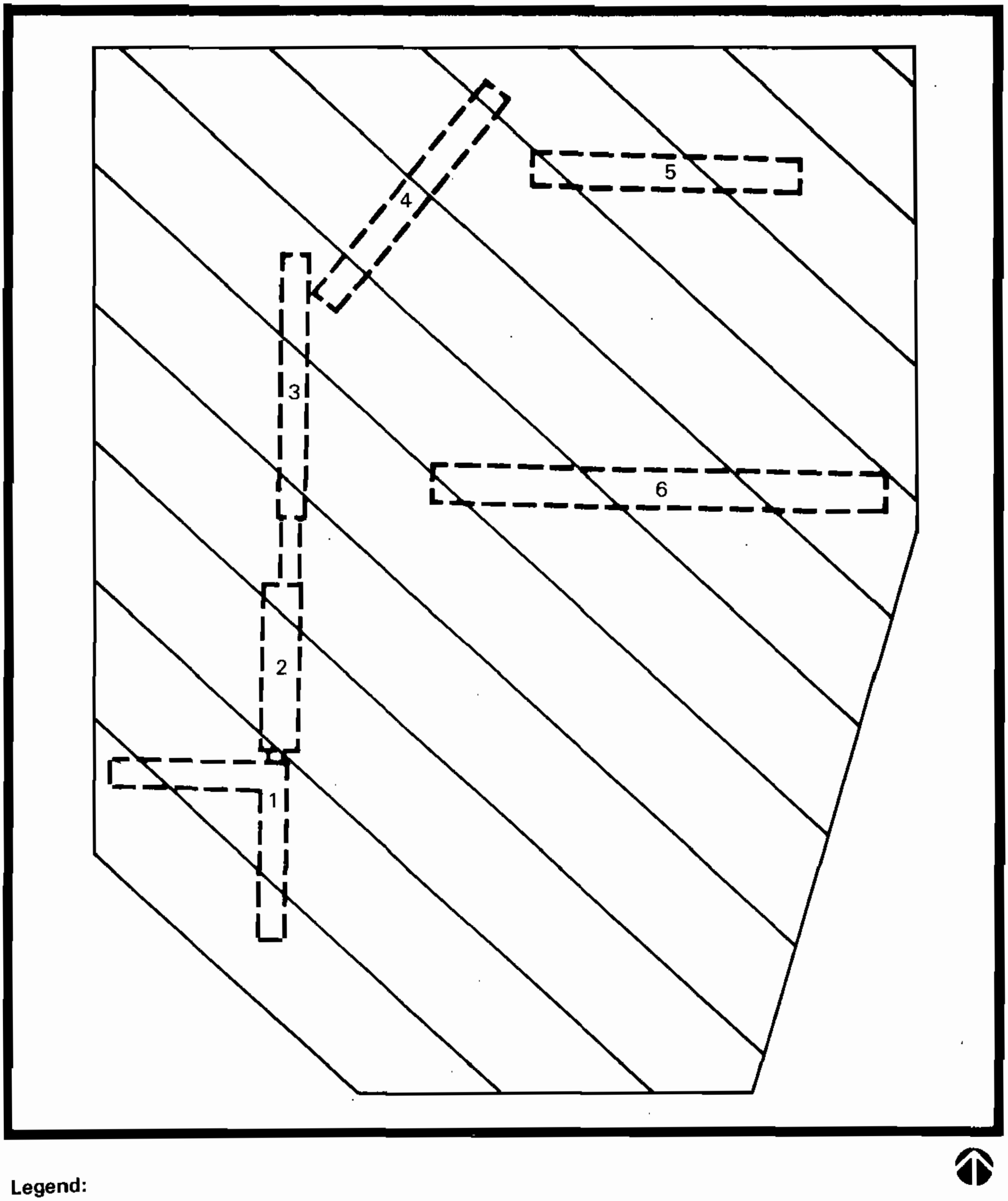
Figure F-5. F- and H-Area Waste Sites (continued)



Number	Potential Waste Type	Site Name	Building Number
3-1	▲	R-Area Burning/Rubble Pit*	131-R
3-2	▲	R-Area Burning/Rubble Pit*	131-1R
3-3	▲	R-Area Acid/Caustic Basin*	904-77G
3-4	■	R-Area Bingham Pump Outage Pit*	643-8G
3-5	■	R-Area Bingham Pump Outage Pit*	643-9G
3-6	■	R-Area Bingham Pump Outage Pit*	643-10G
3-7	■	R-Area Reactor Seepage Basin	904-57G
3-8	■	R-Area Reactor Seepage Basin	904-58G
3-9	■	R-Area Reactor Seepage Basin	904-59G
3-10	■	R-Area Reactor Seepage Basin	904-60G
3-11	■	R-Area Reactor Seepage Basin	904-103G
3-12	■	R-Area Reactor Seepage Basin	904-104G

*Indicates that waste type may be contained in the waste site
▲—Hazardous
■—Low-level radioactive

Figure F-6. R-Area Waste Site



Legend:

▬ ▬ ▬ Covered Basins

Figure F-7. Map of R-Area Reactor Seepage Basins Showing Area To Be Capped (crosshatched)

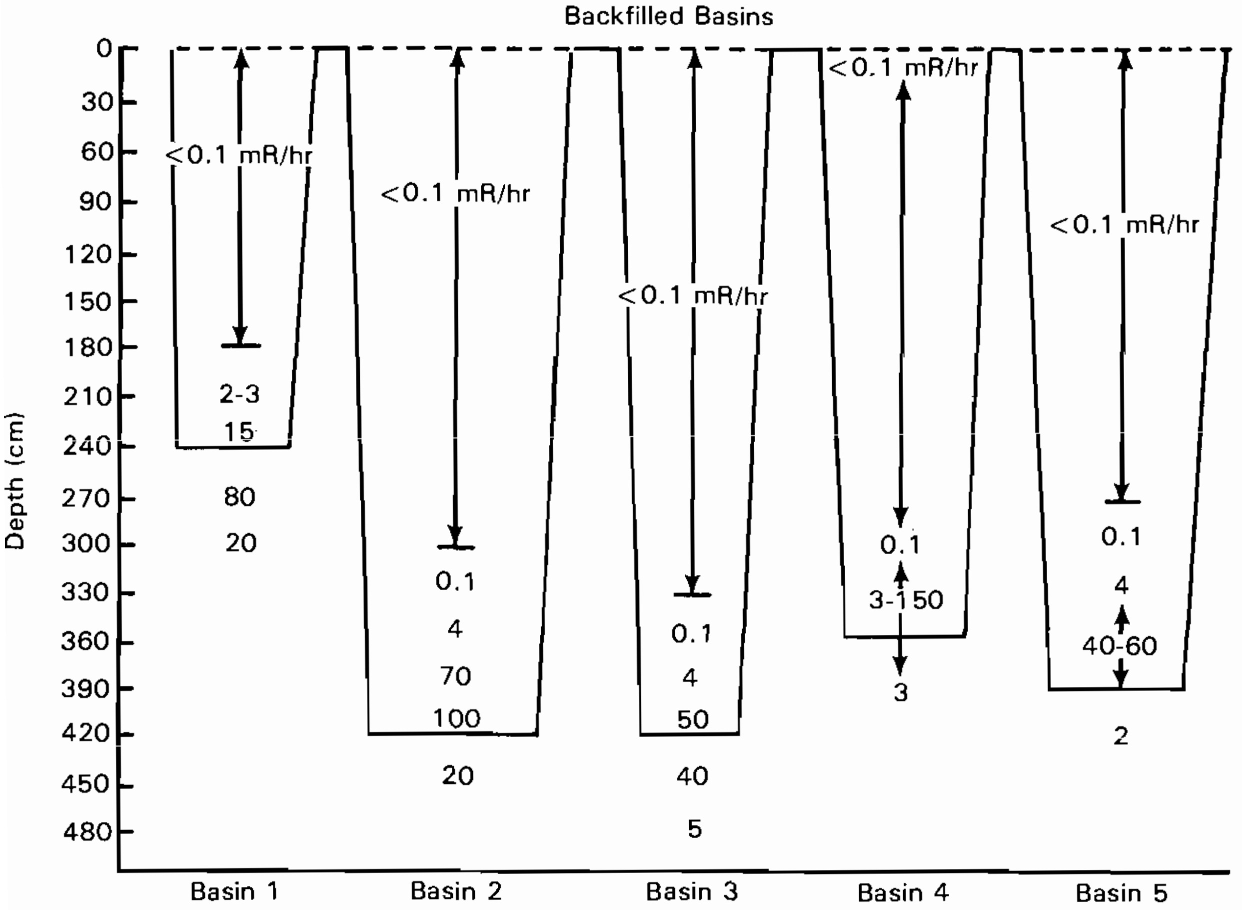
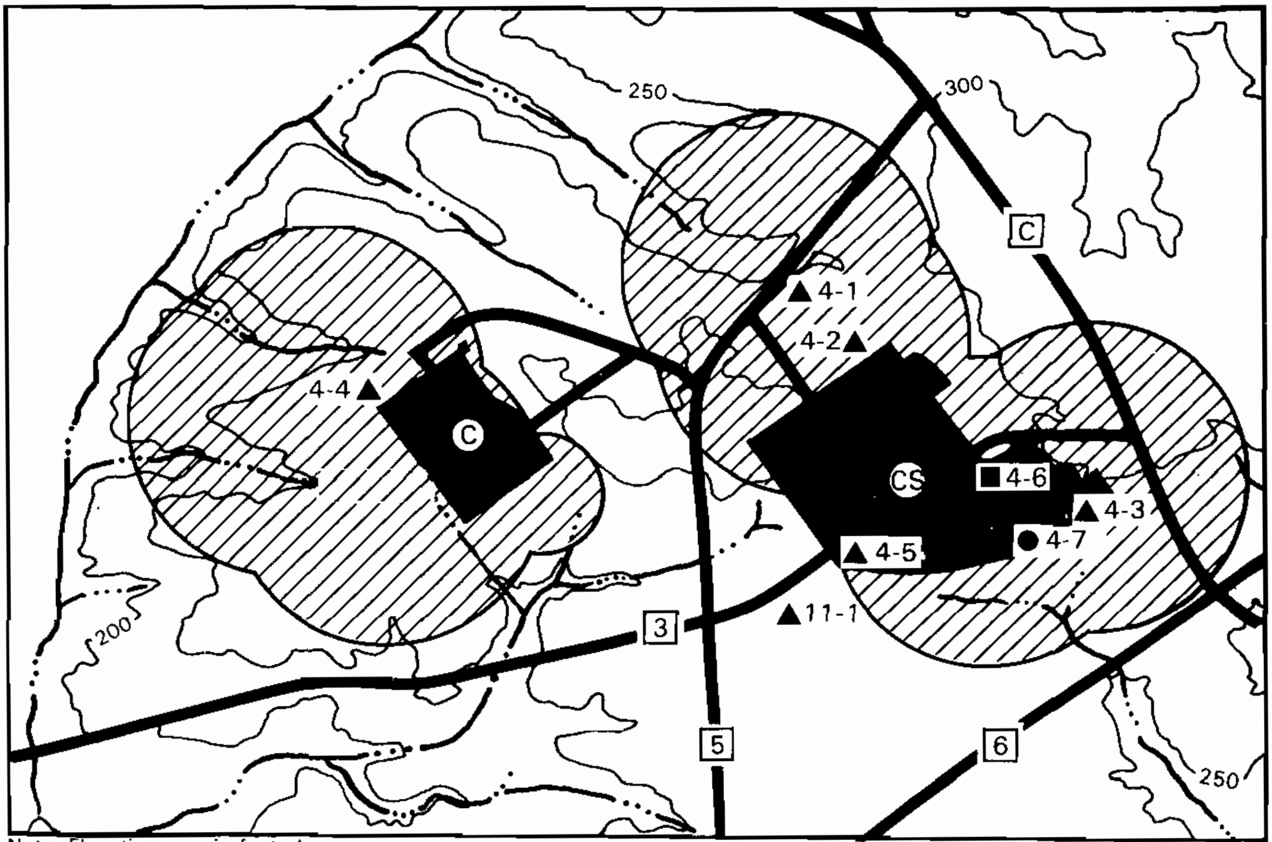


Figure F-8. Dose Rate (mR/hr) in R-Area Seepage Basins Measured in Dry Monitoring Wells



Number	Potential Waste Type	Site Name	Building Number
4-1	▲	CS Burning/Rubble Pit*	631-1G
4-2	▲	CS Burning/Rubble Pit*	631-5G
4-3	▲	CS Burning/Rubble Pit*	631-6G
4-4	▲	C-Area Burning/Rubble Pit*	131-C
4-5	▲	Hydrofluoric Acid Spill Area*	631-4G
4-6	■	Ford Building Waste Site*	643-11G
4-7	●	Ford Building Seepage Basin	904-91G
11-1	▲	SRL Oil Test Site	080-16G

*Indicates that waste type may be contained in the waste site

▲—Hazardous

■—Low-level radioactive

●—Mixed

Figure F-9. C- and CS-Area Waste Sites

Table F-1. Predicted Maximum Concentrations of Various Constituents at Metals Burning Pit[a]

Constituent	Applicable standard[c]	Monitoring data maximum mean concentration	Predicted maximum concentration[b]: No action, 1-m well	Predicted maximum concentration[b]: No action, 100-m well	Predicted maximum concentration[b]: No removal and closure, 1-m well	Predicted maximum concentration[b]: No removal and closure, 100-m well	Predicted maximum concentration[b]: Removal and closure, 1-m well	Predicted maximum concentration[b]: Removal and closure, 100-m well
Cadmium	1.0×10^{-2}	1.4×10^{-2} (well ABP 3)	(d)	(d)	(d)	(d)	(d)	(d)
Tetrachloroethylene	7.0×10^{-4}	1.5×10^{-3} (well ABP 2A)	2.2×10^{-3} (1980)	1.9×10^{-3} (1994)	2.1×10^{-3} (1980)	9.3×10^{-4} (2025)	(e)	(e)
Trichloroethylene	5.0×10^{-3}	4.8×10^{-2} (well ABP 3)	1.0×10^{-1} (1978)	9.1×10^{-2} (1989)	1.0×10^{-1} (1978)	6.8×10^{-2} (2000)	(e)	(e) TC

[a] Source: Adapted from Pickett, Muska, and Marine, 1987. Concentrations are in milligrams per liter.
[b] Number in parentheses represents year in which concentration was reached or is expected to be reached. TC
[c] EPA, 1985a,b, and EPA, 1987.
[d] Constituent did not meet threshold selection criteria for PATHRAE modeling.
[e] Not modeled because the contaminants of concern are assumed to have leached beyond the zone of excavation by the time remedial action would occur.

Table F-2. Predicted Maximum Concentrations of Tetrachloroethylene and Trichloroethylene at Silverton Road Waste Site[a]

Constituent	Applicable standard[c]	Maximum monitored concentration[d]	Predicted maximum concentration: No action[b] 1-m well	No action[b] 100-m well	No removal and closure 1-m well	No removal and closure 100-m well	Removal and closure 1-m well	Removal and closure 100-m well
Tetrachloroethylene	7.0×10^{-4}	3.7×10^{-2} (Well SRW 6)	1.4×10^{-1} (1979)	7.6×10^{-2} (1985)	(e)	(e)	(e)	(e)
Trichloroethylene	5.0×10^{-3}	1.4×10^{-2} (Well SRW 6)	1.3×10^{-1} (1976)	7.1×10^{-2} (1982)	(e)	(e)	(e)	(e)

[a]Source: Adapted from Scott, Killian, Kolb, Corbo, and Bledsoe, 1987. All concentrations are in milligrams per liter. TC
[b]Number in parentheses represents year in which concentration was reached.
[c]EPA 1985a,b, and EPA, 1987.
[d]Concentrations measured on May 4, 1984.
[e]Value identical to that of no action.

Table F-3. Predicted Maximum Concentrations of Various Constituents at Metallurgical Laboratory Basin[a]

Constituent	Applicable standard[c]	Monitoring data maximum mean concentration[d]	Predicted maximum concentration[b]: No action, 1-m well	No action, 100-m well	No removal and closure, 1-m well	No removal and closure, 100-m well	Removal and closure, 1-m well	Removal and closure, 100-m well
Tetrachloromethane	5.0×10^{-3}	(e)	1.6 (1993)	1.6 (1994)	3.8×10^{-1} (2086)	3.8×10^{-1} (2086)	1.3 (2001)	1.3 (2001)
1,1,1-trichloroethane	2.0×10^{-1}	(e)	5.3×10^{-1} (1994)	5.2×10^{-1} (1991)	(e)	(e)	4.4×10^{-1} (1999)	4.3×10^{-1} (1998)
Trichloroethylene	5.0×10^{-3}	4.5×10^{-1} (well AMB 2)	2.7×10^{-2} (1992)	2.6×10^{-2} (1992)	6.7×10^{-3} (2086)	6.7×10^{-3} (2086)	2.2×10^{-2} (2000)	2.1×10^{-2} (1998)
Tetrachloroethylene	7.0×10^{-4}	6.0×10^{-3} (Well AMB 2)	(f)	(f)	(f)	(f)	(f)	(f)
Nickel	1.3×10^{-2}	2.0×10^{-2} (Well AMB 2)	(f)	(f)	(f)	(f)	(f)	(f)
Gross alpha	10-20	7.4×10^{1} (well AMB 1A)	(f)	(f)	(f)	(f)	(f)	(f)
Gross beta	40-60	4.8×10^{7} (well AMB 1A)	(f)	(f)	(f)	(f)	(f)	(f)
Radium	6.0	1.0×10^{1} (well AMB 1A)	(f)	(f)	(f)	(f)	(f)	(f)

[a]Source: Adapted from Michael, Johnson, and Bledsoe, 1987. Concentrations are in milligrams per liter for chemicals and picocuries per liter for radionuclides.
[b]Number in parentheses represents year in which concentration is expected to be reached. TC
[c]EPA, 1985b, 1986, 1987.
[d]Data are for AMB series water table monitoring wells. Trichloroethylene and tetrachloroethylene concentrations are single well maxima.
[e]Below standard.
[f]Not modeled.

Table F-4. Predicted Maximum Concentrations of Tetrachloroethylene at Miscellaneous Chemical Basin[a]

Constituent	Applicable standard	Predicted maximum concentration[b]					
		No action		No removal and closure		Removal and closure	
		1-m well	100-m well	1-m well	100-m well	1-m well	100-m well
Tetrachloroethylene	7.0×10^{-4}(c)	2.2×10^{2} (1990)	2.2×10^{2} (1991)	1.0×10^{2} (2024)	1.0×10^{2} (2025)	(d)	(d)

[a]Source: Adapted from Pickett, Muska, and Marine, 1987. Concentrations are in milligrams per liter.
[b]Number in parentheses represents year in which concentration is expected to be reached. TC
[c]EPA, 1985a.
[d]Value identical to that for no action.

Table F-6. Predicted Maximum Concentrations of Various Constituents at the C-Area Burning/Rubble Pits[a]

			Predicted maximum concentration						
			No action[b]		No removal and closure		Removal and closure		
Constituent	Applicable standard[c]	Monitoring data maximum mean concentration	1-m well	100-m well	1-m well	100-m well	1-m well	100-m well	
Cadmium	1.0×10^{-2}	1.5×10^{-2} (well FBP 3A)	(d)	(d)	(d)	(d)	(d)	(d)	TC
Lead	5.0×10^{-2}	2.2×10^{-1} (well CRP 1)	(e)	(e)	(f)	(f)	(f)	(f)	
Mercury	2.0×10^{-3}	3.4×10^{-3} (well OBP2)	(d)	(d)	(d)	(d)	(d)	(d)	TC
Nitrate	10	55 (well LRP1)	(d)	(d)	(d)	(d)	(d)	(d)	
Trichloroethylene	5.0×10^{-3}	2.6[g] (well CRP 3)	1.9 (1978)	1.8 (1983)	(f)	(f)	(f)	(f)	
Gross alpha	10-20	2.5×10^{1} (well CRP 3)	(d)	(d)	(d)	(d)	(d)	(d)	
Gross beta	40-60	56 (well FBP 1A)	(d)	(d)	(d)	(d)	(d)	(d)	TC
Radium	6.0	7.5 (well CRP 3)	(d)	(d)	(d)	(d)	(d)	(d)	

[a]Source: Adapted from Huber, Johnson, and Marine, 1987. Concentrations are in milligrams per liter for chemicals and picocuries per liter for radionuclides.
[b]Number in parentheses represents year in which concentration was reached.
[c]EPA, 1985b, EPA 1987.
[d]Not modeled.
[e]Below standard.
[f]Value identical to that for no action.
[g]Concentration given for TOH.

Table F-7. Predicted Maximum Concentrations of Various Constituents at the SRL Seepage Basins[a,b]

Constituent	Applicable standard	Monitoring data maximum mean concentration	PATHRAE-modeled maximum concentration without remedial action[c,d]					
			No action		No waste removal and closure		Waste removal and closure	
			1-m well	100-m well	1-m well	100-m well	1-m well	100-m well
Arsenic	0.05	(e)	0.74 (2115)	0.21 (2135)	0.073 (2435)	0.066 (2425)	0.073 (2405)	0.066 (2425)
Nickel	0.013	0.034 (Well ASB 4)	(e)	(e)	(e)	(e)	(e)	(e)
Tritium	87,000	(f)	320,000 (1962)	200,000 (1968)	320,000 (1962)	200,000 (1968)	320,000 (1962)	200,000 (1968)

TC

[a]Source: Fowler, et al., 1987.
[b]Concentrations are in milligrams per liter for chemicals and picocuries per liter for radionuclides.
[c]EPA, 1985b, except where otherwise indicated. Nickel from EPA, 1986. ICRP Publication 30 (ICRP, 1978) methodology was used to calculate radionuclide concentrations that yield annual effective whole-body dose of millirem.
[d]Number in parentheses represents year in which concentration was reached or is expected to be reached.
[e]Below applicable standard.
[f]Not reported.

Table F-8. Predicted Maximum Concentrations of Various Constituents at the M-Area Settling Basin[a,b]

Constituent	Applicable standard[d]	Monitoring data maximum mean concentration[e]	PATHRAE-modeled maximum concentration without remedial action[c]: No action, 1-m well	No action, 100-m well	No waste removal and closure, 1-m well	No waste removal and closure, 100-m well	Waste removal and closure, 1-m well	Waste removal and closure, 100-m well	
Barium	1.0	(f)	16 (2231)	3.7 (2261)	1.8 (2532)	1.5 (2545)	3.0 (2252)	(f)	
Cadmium	0.01	(f)	0.15 (2279)	0.031 (2318)	0.018 (2570)	0.014 (2597)	0.016 (2301)	(f)	
Lead	0.05	(f)	0.076 (1991)	0.074 (1990)	(f)	(f)	0.065 (1995)	0.064 (1994)	TC
Nitrate	10.0	132 (Well MSB 3A)	9300 (1991)	9200 (1990)	2900 (2052)	2900 (2052)	7900 (1995)	7800 (1994)	
Tetrachloroethylene	0.0007[g]	15.6[h]	170 (2021)	170 (2020)	91 (2072)	91 (2072)	170 (2018)	170 (2020)	
Trichloroethylene	0.005	32.2[h]	63 (1991)	62 (1991)	18 (2058)	18 (2059)	53 (1996)	52 (1994)	
1,1,1-trichloroethane	0.20	(f)	4.2 (1991)	4.1 (1990)	1.2 (2058)	1.2 (2057)	3.5 (1995)	3.5 (1996)	TC
Gross alpha	10-20	21.4 (Well MSB 3A)	(i)	(i)	(i)	(i)	(i)	(i)	
Gross beta	40-60	86.2 (Well MSB 3A)	(i)	(i)	(i)	(i)	(i)	(i)	
Radium	6.0	22.3 (Well MSB 4A)	(i)	(i)	(i)	(i)	(i)	(i)	

[a]Source: Adapted from Pickett, Colven, and Bledsoe, 1987.
[b]Concentrations are in milligrams per liter for chemicals and picocuries per liter for radionuclides.
[c]Number in parentheses represents year in which concentration is expected to be reached.
[d]EPA, 1985b. Nickel from EPA, 1986. ICRP Publication 30 (ICRP, 1978) methodology was used to calculate radionuclide concentrations that yield annual effective whole-body dose of 4 millirem.
[e]Monitoring data are for MSB water-table wells (Pickett, Colven, and Bledsoe, 1987). Concentrations shown represent maximum single-well means.
[f]Below applicable standard.
[g]EPA, 1985a, EPA, 1987.
[h]Monitoring data for chlorocarbons reported in construction permit application (DOE, 1984). TC
[i]Constituent is not explicitly included in PATHRAE simulation; gross alpha and beta were included by e ng specific radionuclide inventory.

Table F-9. Environmental Data for A- and M-Area Waste Sites

Waste site	Areal extent of site (m)	Distance to nearest wetland (m)	Area of wetlands within 200 m/1000 m (acres)	Endangered species data	Non-PATHRAE-modeled groundwater contaminants exceeding freshwater biota criteria[a]: Contaminant	Reported level[b]	Criterion[c]	Area of groundwater outcrop; distance (m) to outcrop	Dilution factor[d]
716-A motor shop seepage basin (904-101G)[e]	63.1 x 10.7	800	0/2.2	No endangered species or suitable habitats observed within vicinity	pH Chromium Copper Mercury Lead Zinc	4.6 0.055 0.0093 0.0005 0.012 0.069	6.5-9.0 0.011 0.00017 0.000012 0.000017 0.047	Tims Branch; 914	No information
Metals burning pit (731-4A)[f]	120 x 120	Over 1,000	0/0	No endangered species or suitable habitats observed within vicinity	pH Silver Cadmium Copper Iron Mercury Lead Zinc	4.33 0.0011 0.014 0.026 8.0 0.0003 0.017 0.23	6.5-9.0 0.00014 0.00024 0.0022 1.0 0.000012 0.0026 0.047	Savannah River; 4,000	2.86×10^{-6}
Silverton Road waste site (731-3A)[g]	212 x 62	Over 1,000	0/0	No endangered species or suitable habitats observed within vicinity	pH Chromium Copper Mercury Nickel Zinc	4.4 0.009 0.017 0.073 0.05 6.6	6.5-9.0 0.00024 0.0022 0.000012 0.021 0.047	Savannah River; 3,200	6.04×10^{-6}
Metallurgical laboratory basin (904-110G)[h]	31 x 12	450	0/21.4	No endangered species or suitable habitats observed within vicinity	pH Silver Cadmium Copper Zinc Gross Alpha Gross Beta Radium	4.6 0.0016 0.006 0.026 0.22 74. 48.0 9.7	6.5-9.0 0.00014 0.00024 0.0022 0.047 15.0 42.0 5.0	Savannah River; 13,000	4.84×10^{-7}
Miscellaneous chemical basin (731-5A)[f]	6 x 6	Over 1,000	0/0	No endangered species or suitable habitats observed within vicinity	No data available		N/A	Tims Branch; 610	1.47×10^{-3}

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Table F-9. Environmental Data for A- and M-Area Waste Sites (continued)

Waste site	Areal extent of site (m)	Distance to nearest wetland (m)	Area of wetlands within 200 m/1000 m (acres)	Endangered species data	Non-PATHRAE-modeled groundwater contaminants exceeding freshwater biota criteria[a]: Contaminant	Reported level[b]	Criterion[c]	Area of ground-water outcrop; distance (m) to outcrop	Dilution factor[d]
A-Area burning/ rubble pit 731-A[i]	100 x 54.6	Over 1,000	0/0	No endangered species or suitable habitats observed within vicinity[l]	pH Copper Zinc	4.6 0.039 0.15	6.5–9.0 0.0022 0.047	Savannah River; 11,280[m]	1.52×10^{-6}(m)
A-Area burning/ rubble pit 731-1A[i]	173.4 x 9.4	Over 1,000	0/0	No endangered species or suitable habitats observed within vicinity[l]	pH Copper Zinc	4.6 0.039 0.15	6.5–9.0 1.0022 0.047	Savannah River; 11,280[m]	1.52×10^{-6}(m)
SRL seepage basin 904-53G[j]	40.0 x 19.0	0	7.1/35.2	No endangered species or suitable habitats observed within vicinity	pH Iron Zinc Radium	4.2 11.8 0.16 5.4	6.5–9.0 1.0 0.047 5.0	Savannah River; 13,000	2.42×10^{-5}
SRL seepage basin 904-53G[j]	40.0 x 40.0	0	7.1/35.2	No endangered species or suitable habitats observed within vicinity	pH Iron Zinc Radium	4.2 11.8 0.16 5.4	6.5–9.0 1.0 0.047 5.0	Savannah River; 13,000	2.42×10^{-5}
SRL seepage basin 904-54G[j]	53.0 x 38	0	7.1/35.2	No endangered species or suitable habitats observed within 200 m of vicinity	pH Iron Zinc Radium	4.2 11.8 0.16 5.4	6.5–9.0 1.0 0.047 5.0	Savannah River; 13,000	2.42×10^{-5}
SRL seepage basin 904-55G[j]	94.0 x 46.0	0	7.1/35.2	No endangered species or suitable habitats observed within vicinity	pH Iron Zinc Radium	4.2 11.8 0.16 5.4	6.5–9.0 1.0 0.047 5.0	Savannah River; 13,000	2.42×10^{-5}

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Table F-9. Environmental Data for A- and M-Area Waste Sites (continued)

Waste site	Areal extent of site (m)	Distance to nearest wetland (m)	Area of wetlands within 200 m/1000 m (acres)	Endangered species data	Non-PATHRAE-modeled groundwater contaminants exceeding freshwater biota criteria[a]			Area of ground-water outcrop; distance (m) to outcrop	Dilution factor[d]
					Contaminant	Reported level[b]	Criterion[c]		
M-Area settling basin (904-51G)[k]	100 x 85	200	0.2/2.0	No endangered species or critical habitats observed within vicinity, except 1 alligator which has lived in the basin since 1985.	pH Gross alpha Gross beta Radium	4.1 21. 86. 22.	6.5-9.0 15.0 42.0 5.0	Upper Three Runs Creek 4000	3.65×10^{-4}
Lost Lake (904-112G)[k]	10-25 acres	100	2.0/No data	No endangered species or critical habitats observed within vicinity, except as noted for 904-51G	pH Gross alpha Gross beta Radium	4.1 21. 86. 22.	6.5-9.0 15.0 42.0 5.0	Upper Three Runs Creek 4000	3.65×10^{-4}

[a]Concentrations reported as milligrams per liter for chemicals and picocuries per liter for radionuclides.
[b]Average value for groundwater well containing highest concentration.
[c]Based on ICRP, 1979; EPA, 1985b,c, 1986; DOI, 1968.
[d]*Equivalent to groundwater flux divided by flow rate of receiving stream.*
[e]Data from Huber, Johnson, and Bledsoe, 1987, except as otherwise indicated.
[f]Data from Pickett, Muska, and Marine, 1987, except as otherwise indicated.
[g]Data from Scott, Killian, Kolb, Corbo, and Bledsoe, 1987, except as otherwise indicated.
[h]Data from Michael, Johnson, and Bledsoe, 1987, except as otherwise indicated.
[i]Data from Huber, Johnson, and Marine, 1987, except as otherwise indicated.
[j]Data from Fowler et al., 1987, except as otherwise indicated.
[k]Data from Pickett, Colven, and Bledsoe, 1987, except as otherwise indicated.
[l]Data on the area not given in site specific reference; however, based on other nearby waste sites, endangered species or suitable habitat are not *expected*.
[m]Calculation based on groundwater flux for C-Area burning/rubble pit.

Table F-11. Predicted Maximum Concentrations (mg/L) of Chromium at Acid/Caustic Basins[a]

Constituent	Applicable standard[c]	Monitoring data maximum mean concentration[f]	Predicted maximum concentration: No action[b], 1-m well	No action[b], 100-m well	No removal and closure, 1-m well	No removal and closure, 100-m well	Removal and closure, 1-m well	Removal and closure, 100-m well
Lead	5.0×10^{-2}	(d)	5.4×10^{-2} (1971)	5.4×10^{-2} (1971)	(e)	(e)	(e)	(e)
Tetrachloro-ethylene[f]	7.0×10^{-4}	5.1×10^{-2} (Well LAC 2)	9.4×10^{-2} (1971)	9.4×10^{-2} (1972)	(e)	(e)	(e)	(e)

[a]Source: Adapted from Ward, Johnson, and Marine, 1987.
[b]Number in parentheses represents year in which concentration is expected to be reached.
[c]EPA, 1985b. Tetrachloroethylene from EPA, 1985a.
[d]Below applicable standard.
[e]Value identical to that for no action.
[f]TOH concentration assumed to be all tetrachloroethylene.

Table F-12. Predicted Maximum Concentrations of Various Constituents at the H-Area Retention Basin[a,b]

Constituent	Applicable standard[d]	Monitoring data maximum mean concentration	PATHRAE-modeled maximum concentration[c]					
			No action		No waste removal and closure		Waste removal and closure	
			1-m well	100-m well	1-m well	100-m well	1-m well	100-m well
Strontium-90	42	(e)	14000 (2007)	(f)	3800 (2021)	(f)	2200 (2021)	(f)
Yttrium-90	550	(e)	14000 (2007)	(f)	3800 (2021)	(f)	2200 (2021)	(f)

[a]Source: Adapted from Scott, Killian, Kolb, Corbo, and Marine, 1987.
[b]Concentrations are in picocuries per liter.
[c]Year of occurrence in parentheses.
[d]ICRP Publication 30 (ICRP, 1979) methodology was used to determine concentrations that yield annual effective whole-body dose of 4 millirem.
[e]Not reported.
[f]Below applicable standard.

Table F-13. Predicted Maximum Concentrations of Various Constituents at the Radioactive Waste Burial Grounds[a,b]

Constituent	Applicable standard[d]	PATHRAE-modeled maximum groundwater concentration without remedial action[c]: No action, 1-m well	No action, 100-m well	No waste removal and closure, 1-m well	No waste removal and closure, 100-m well	Waste removal and closure, 1-m well	Waste removal and closure, 100-m well
Cesium-134	7.4×10^1	2.3×10^2 (1957)	(e)	2.3×10^2 (1957)	(e)	2.3×10^2 (1957)	(e)
Cesium-137	1.1×10^2	9.4×10^2 (1957)	2.9×10^2 (1962)	9.4×10^2 (1957)	2.9×10^2 (1962)	9.4×10^2 (1957)	2.9×10^2 (1962)
Cobalt-60	2.1×10^2	2.5×10^3 (1957)	4.7×10^2 (1961)	2.5×10^3 (1957)	4.7×10^2 (1961)	2.5×10^3 (1957)	4.7×10^2 (1961)
Neptunium-237	1.4×10^{-1}	1.5×10^0 (2420)	4.0×10^{-1} (2778)	(f)	(f)	(f)	(f)
Nickel-63	1.0×10^4	4.4×10^5 (1957)	1.5×10^5 (1963)	4.4×10^5 (1957)	1.5×10^5 (1963)	4.4×10^5 (1957)	1.5×10^5 (1963)
Plutonium-238	1.4×10^1	6.7×10^2 (1957)	2.2×10^2 (1963)	6.7×10^2 (1957)	2.2×10^2 (1963)	6.7×10^2 (1957)	2.2×10^2 (1963)
Plutonium-239	1.3×10^1	8.3×10^1 (1957)	2.9×10^1 (1963)	8.3×10^1 (1957)	2.9×10^1 (1963)	8.3×10^1 (1957)	2.9×10^1 (1963)
Strontium-90[g]	4.2×10^1	1.0×10^3 (1957)	3.1×10^2 (1962)	1.0×10^3 (1957)	3.1×10^2 (1962)	1.0×10^3 (1957)	3.1×10^2 (1962) TC
Technetium-99	4.2×10^3	1.3×10^4 (1957)	4.6×10^3 (1963)	1.3×10^4 (1957)	4.6×10^3 (1963)	1.3×10^4 (1957)	4.6×10^3 (1963)
Tritium	8.7×10^4	2.1×10^9 (1957)	5.6×10^8 (1962)	2.1×10^9 (1957)	5.6×10^8 (1962)	2.1×10^9 (1957)	5.6×10^8 (1962)
Uranium-238	2.4×10^1	4.1×10^1 (1957)	(e)	4.1×10^1 (1957)	(e)	4.1×10^1 (1957)	(e)
Yttrium-90	5.5×10^2	1.0×10^3 (1957)	(e)	1.0×10^3 (1957)	(e)	1.0×10^3 (1957)	(e)

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Table F-13. Predicted Maximum Concentrations of Various Constituents at the Radioactive Waste Burial Grounds[a,b] (continued)

Constituent	Applicable standard[d]	PATHRAE-modeled maximum groundwater concentration without remedial action[c]					
		No action		No waste removal and closure		Waste removal and closure	
		1-m well	100-m well	1-m well	100-m well	1-m well	100-m well
Cadmium	1.0×10^{-2}	3.7×10^{-2} (2235)	(e)	(e)	(e)	(e)	(e)
Lead	5.0×10^{-2}	1.9×10^{0} (1957)	6.8×10^{-1} (1963)	1.9×10^{0} (1957)	6.8×10^{-1} (1963)	1.9×10^{0} (1957)	6.8×10^{-1} (1963)
Mercury	2.0×10^{-3}	6.5×10^{-3} (1957)	2.3×10^{-3} (1963)	6.5×10^{-3} (1957)	2.3×10^{-3} (1963)	6.5×10^{-3} (1957)	2.3×10^{-3} (1963)
Xylene	6.2×10^{-1}	7.0×10^{-1} (2056)	7.0×10^{-1} (2057)	(e)	(e)	(e)	(e)

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[a]Source: Jaegge et al., 1987.
[b]Concentrations are in milligrams per liter for chemicals and picocuries per liter for radionuclides.
[c]Number in parentheses represents year in which concentration was reached or is expected to be reached.
[d]EPA 1985b, except where noted; ICRP Publication 30 (ICRP, 1979) methodology was used to calculate radionuclide concentrations that yield an annual effective whole-body dose of 4 millirem; xylene standard from EPA, 1981b.
[e]Below applicable standard.
[f]Not reported.
[g]An additional above standard peak for the mobile fraction of strontium-90 exists at the 1-meter well for no action. The predicted concentration of this peak is 3.5×10^{2} picocuries per liter at year 2185.

Table F-14. Predicted Maximum Concentrations of Various Constituents at the F-Area Seepage Basins[a,b]

Constituent	Applicable standard[c]	Monitoring data *maximum mean* concentration[d]	PATHRAE-modeled maximum concentrations without remedial action[c]								
			No action			No waste removal and closure			Waste removal and closure		
			1-m well	100-m well	*Four Mile* Creek	1-m well	100-m well	*Four Mile* Creek	1-m well	100-m well	*Four Mile* Creek
Cadmium	0.01	0.023 (well FSB77)	(e)	(e)	(e)	(e)	(e)	(e)	(e)	(e)	(e)
Lead	0.05	0.198 (well FSB 78)	0.051 (2545)	(e)	(e)	(e)	(e)	(e)	(e)	(e)	(e)
Nickel	0.013	0.086 (well FSB 78)	(f)	(f)	(f)	(f)	(f)	(f)	(f)	(f)	
Nitrate	10	309.1 (well FSB 78)	1000 (1987)	1000 (1987)	(e)	1000 (1987)	1000 (1987)	(e)	1000 (1987)	1000 (1987)	(e)
Tritium	8.7×10^4	3.8×10^7 (well FSB 78)	4.5×10^7 (1957)	2.7×10^7 (1964)	(e)	4.5×10^7 (1957)	2.7×10^7 (1964)	(e)	4.5×10^7 (1957)	2.7×10^7 (1964)	(e)
Americium-241	2.5	(h)	11 (2545)	(f)	(f)	(e)	(f)	(f)	(e)	(f)	(f)
Iodine-129	20	(h)	230 (1988)	220 (1990)	(e)	88 (2036)	88 (2037)	(e)	88 (2036)	88 (2037)	(e)
Strontium-90	42	340000	1400 (2009)	(e)	(e)	(e)	(e)	(e)	(e)	(e)	(e)
Yttrium-90	550	(h)	1400 (2009)	(e)	(e)	(e)	(e)	(e)	(e)	(e)	(e)

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Table F-14. Predicted Maximum Concentrations of Various Constituents at the F-Area Seepage Basins[a,b] (continued)

Constituent	Applicable standard[c]	Monitoring data maximum mean concentration[d]	PATHRAE-modeled maximum concentrations without remedial action[c] — No action: 1-m well	No action: 100-m well	No action: Four Mile Creek	No waste removal and closure: 1-m well	No waste removal and closure: 100-m well	No waste removal and closure: Four Mile Creek	Waste removal and closure: 1-m well	Waste removal and closure: 100-m well	Waste removal and closure: Four Mile Creek
Uranium-238	24	(h)	2000 (2215)	52 (2985)	(e)	48 (2985)	(e)	(e)	(e)	(e)	(e)
Radium	6	63.00 (well FSB 78)	(g)	(g)	(g)	(g)	(g)	(g)	(g)	(g)	(g)
Gross alpha	10-20	3129 (well FSB 78)	(g)	(g)	(g)	(g)	(g)	(g)	(g)	(g)	(g)
Gross beta	40-60	4035 (well FSB 78)	(g)	(g)	(g)	(g)	(g)	(g)	(g)	(g)	(g)

[a]Source: Adapted from Killian et al., 1987a.
[b]Concentrations in milligrams per liter for chemicals and picocuries per liter for radionuclides.
[c]EPA, 1985b. ICRP Publication 30 (ICRP, 1979) methodology was used to determine radionuclide concentrations that yield annual effective whole-body dose of 4 millirem.
[d]Data are for FSB water-table monitoring wells. The concentration level provided for each constituent is the maximum single-well mean from FSB wells. Time series data are not reported for tritium or strontium-90 in Killian et al., 1987a. Tritium concentration that is provided was detected in well FSB 78 on April 9, 1985. Strontium-90 data are maximum concentration data for the groundwater.
[e]Below applicable standards.
[f]Not reported or not modeled.
[g]Constituent was not explicitly modeled with PATHRAE; gross alpha and beta were modeled by estimating specific radionuclide inventory.

Table F-15. Predicted Maximum Concentrations of Various Constituents at the Old F-Area Seepage Basin[a,b]

			PATHRAE-modeled maximum concentration[c]					
			No action		No waste removal and closure		Waste removal and closure	
Constituent	Applicable standard[d]	Monitoring data maximum mean concentration[e]	1-m well	100-m well	1-m well	100-m well	1-m well	100-m well
Lead	0.05	0.117 (well FNB 2)	(f)	(f)	(f)	(f)	(f)	(f)
Nickel	0.013	0.045 (well FNB 3)	(g)	(g)	(g)	(g)	(g)	(g)
Nitrate	10	77.6 (well FNB 2)	1600 (1956)	69 (1964)	1600 (1956)	69 (1964)	1600 (1956)	69 (1964)
Trichloroethylene	0.005	0.021 (well FNB 3)	0.58 (1956)	0.023 (1965)	0.58 (1956)	0.023 (1965)	0.58 (1956)	0.023 (1965)
Uranium-238	24	(h)	3600 (2312)	(f)	310 (2370)	(f)	(f)	(f)
Strontium-90	42	(h)	900 (2027)	(f)	(f)	(f)	(f)	(f)
Yttrium-90	550	(h)	900 (2027)	(f)	(f)	(f)	(f)	(f)
Radium	6	31.7 (well FNB 2)	(i)	(i)	(i)	(i)	(i)	(i)
Gross alpha	10-20	203 (well FNB 2)	(i)	(i)	(i)	(i)	(i)	(i)
Gross beta	40-60	1234 (well FNB 2)	(i)	(i)	(i)	(i)	(i)	(i)

[a]Source: Adapted from Odum et al., 1987.
[b]Concentrations are in milligrams per liter for chemicals and picocuries per liter for radionuclides.
[c]Year of occurrence in parentheses.
[d]MCLs for chemicals given in EPA, 1985b, 1987; health-based standard for nickel from EPA, 1986; for radionuclides, ICRP Publication 30 (ICRP, 1979) methodology was used to determine concentrations that yield annual effective whole-body dose of 4 millirem. TC
[e]Value listed for trichloroethylene is for TOH.
[f]Below applicable standard.
[g]Not modeled.
[h]Not reported.
[i]Not explicitly included in PATHRAE model; gross alpha and beta were modeled by estimating specific radionuclide inventory.

Table F-16. Predicted Maximum Concentrations of Various Constituents at the H-Area Seepage Basins[a]

Constituent	Applicable standard[d]	Monitoring data maximum mean concentration[b]	PATHRAE-modeled maximum concentration without remedial action[b,c]: No action, 1-m well	No action, 100-m well	No action, Four Mile Creek	No waste removal and closure, 1-m well	No waste removal and closure, 100-m well	No waste removal and closure, Four Mile Creek	Waste removal and closure, 1-m well	Waste removal and closure, 100-m well	Waste removal and closure, Four Mile Creek
Chromium	0.05	0.136 (well HSB 68)	(e)	(e)	(e)	(e)	(e)	(e)	(e)	(e)	(e)
Lead	0.05	0.055 (well HSB 67)	0.065 (2105)	(e)	(e)	(e)	(e)	(e)	(e)	(e)	(e)
Mercury	0.002	0.0033 (well HSB 67)	(e)	(e)	(e)	(e)	(e)	(e)	(e)	(e)	(e)
Nickel	0.013	0.037 (well HSB 69)	(f)	(f)	(f)	(f)	(f)	(f)	(f)	(f)	(f)
Nitrate	10	65 (well HSB 69)	480 (1985)	480 (1986)	18 (1992)	480 (1985)	370 (1995)	14 (2000)	480 (1985)	370 (1995)	14 (2000)
Gross alpha	10-20	497 (well HSB 68)	(f)	(f)	(f)	(f)	(f)	(f)	(f)	(f)	(f)
Gross beta	40-60	10598 (well HSB 68)	(f)	(f)	(f)	(f)	(f)	(f)	(f)	(f)	(f)
Radium	6	34 (well HSB 68)	(f)	(f)	(f)	(f)	(f)	(f)	(f)	(f)	(f)
Tritium	87,000	3.7×10^7 (well H6)	1.9×10^7 (1956)	1.0×10^7 (1965)	1.7×10^5 (1979)	1.9×10^7 (1956)	1.0×10^7 (1965)	1.7×10^5 (1979)	1.9×10^7 (1956)	1.0×10^7 (1965)	1.7×10^5 (1979)
Plutonium-238	14	(g)	31 (2105)	(e)	(e)	(e)	(e)	(e)	(e)	(e)	(e)
Iodine-129	20	(g)	220 (1986)	210 (1990)	(e)	130 (2008)	130 (2008)	(e)	130 (2008)	130 (2008)	(e)

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Table F-16. Predicted Maximum Concentrations of Various Constituents at the H-Area Seepage Basins (continued)[a]

Constituent	Applicable standard[d]	Monitoring data maximum mean concentration[b]	PATHRAE-modeled maximum concentration without remedial action[b,c]								
			No action			No waste removal and closure			Waste removal and closure		
			1-m well	100-m well	Four Mile Creek	1-m well	100-m well	Four Mile Creek	1-m well	100-m well	Four Mile Creek
Americium-241	2.5	(g)	21 (2105)	(g)	(g)	(e)	(g)	(g)	(e)	(g)	(g)
Uranium-234	21	(g)	46 (2033)	(e)	(e)	(e)	(e)	(e)	(e)	(e)	(e)
Uranium-238	24	(g)	40 (2033)	(e)	(e)	(e)	(e)	(e)	(e)	(e)	(e)
Neptunium-237	0.14	(g)	19 (1997)	1.3 (2375)	(g)	0.90 (2735)	0.82 (2925)	(g)	0.86 (2735)	0.78 (2925)	(g)
Strontium-90	42	1,800	1,800 (1975)	(e)	(e)	1,800 (1975)	(e)	(e)	1,800 (1975)	(e)	(e)
Yttrium-90	550	(g)	1,800 (1975)	(e)	(e)	1,800 (1975)	(e)	(e)	1,800 (1975)	(e)	(e)

[a]Concentrations are in milligrams per liter for chemicals and picocuries per liter for radionuclides.
[b]From Killian et al., 1987b. Tritium value is four-year mean (1982 through 1985). Strontium-90 value is maximum for groundwater.
[c]Year of occurrence in parentheses.
[d]EPA, 1985b, except where noted. Health-based standard for nickel from EPA, 1986. ICRP Publication 30 (ICRP, 1979) methodology was used to calculate radionuclide concentrations that yield annual effective whole-body dose of 4 millirem.
[e]Below applicable standard.
[f]Not modeled; gross alpha and beta were modeled by estimating specific radionuclide inventory.
[g]Not reported.

Table F-17. Environmental Data for F- and H-Area Waste Sites

Waste site	Areal extent of site (m)	Distance to nearest wetland (m)	Area of wetlands within 200 m/1000 m (acres)	Endangered species data	Non-PATHRAE-modeled contaminants exceeding freshwater biota criteria[a]: Contaminant	Reported level[b]	Criterion[c]	Area of ground-water outcrop; distance (m) to outcrop	Dilution factor[d]
F-Area acid/ caustic basin (904-74G)[e]	15.2 x 15.2	600	No data available	No endangered species or suitable habitat observed within vicinity[m]	pH Silver Cadmium Iron Zinc Gross alpha Gross beta Radium	4.9,9.6 0.003 0.003 2.1 0.54 84. 222. 10.	6.5-9.0 0.000012 0.00008 1.0 0.047 15.0 42.0 5.0	Upper Three Runs Creek; 1525	2.72×10^{-5}[o]
H-Area acid/ caustic basin (904-75G)[e]	15.2 x 15.2	1200	0/0	No endangered species or suitable habitat observed within vicinity[m]; however, a bald eagle has been observed about 500 meters from the site[n]	No data available			Tributary to Four Mile Creek; 425	5.98×10^{-4}[o]
F-Area burning/ rubble pit 231-F[f]	18.9 x 83.8	1070	0/0	No endangered species or suitable habitat observed within vicinity[m]	pH Cadmium Copper Mercury Zinc Gross beta	4.3 0.015 0.009 0.0002 0.057 56.	6.5-9.0 0.00008 0.00066 0.000012 0.047 42.0	Upper Three Runs Creek; 1525	8.04×10^{-5}[p]
F-Area burning/ rubble pit 231-1F[f]	26.8 x 99.1	1070	0/0	No endangered species or suitable habitat observed within vicinity[m]	pH Cadmium Copper Mercury Zinc Gross beta	4.3 0.015 0.009 0.0002 0.057 56.	6.5-9.0 0.00008 0.00066 0.000012 0.047 42.0	Upper Three Runs Creek; 1525	8.04×10^{-5}[p]

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Table F-17. Environmental Data for F- and H-Area Waste Sites (continued)

Waste site	Areal extent of site (m)	Distance to nearest wetland (m)	Area of wetlands within 200 m/1000 m (acres)	Endangered species data	Non-PATHRAE-modeled contaminants exceeding freshwater biota criteria[a]			Area of ground-water outcrop; distance (m) to outcrop	Dilution factor[d]
					Contaminant	Reported level[b]	Criterion[c]		
H-Area retention basin (281-3H)[g]	36.6 x 61	200	0/78	No endangered species or habitat observed within vicinity; however, a bald eagle has been observed about 250 meters from the site[n].	No data available			Tributary of Four Mile Creek; 120	4.63×10^{-5}
F-Area retention basin (281-3F)[g]	36.6 x 61	200	0/44	No endangered species or suitable habitat observed within vicinity	No data available			Four Mile Creek; 1200	4.63×10^{-4}
Radioactive waste burial ground (643-7G)[h]	440 x 1100	0	4/194[m]	No endangered species or suitable habitat observed within vicinity	No data available			Four Mile Creek; 1000	2.73×10^{-2}
Mixed waste management facility (643-28G)[h]	Site located within boundaries of site 643-7G; information the same as for that site								
Radioactive waste burial ground (old) (643-G)[h]	280 x 1100	150	4/194[m]	No endangered species or suitable habitat observed within vicinity	No data available			Four Mile Creek; 1000	2.73×10^{-2}

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Table F-17. Environmental Data for F- and H-Area Waste Sites (continued)

Waste site	Areal extent of site (m)	Distance to nearest wetland (m)	Area of wetlands within 200 m/1000 m (acres)	Endangered species data	Non-PATHRAE-modeled contaminants exceeding freshwater biota criteria[a]			Area of ground-water outcrop; distance (m) to outcrop	Dilution factor[d]
					Contaminant	Reported level[b]	Criterion[c]		
F-Area seepage basin 904-41G[i]	27 x 84	400	0/102	No endangered species or suitable habitat observed within vicinity[k]; however, a bald eagle has been observed about 400 meters from the site	pH	3.20	6.5-9.0	Four Mile Creek; 490	7.50×10^{-3}
					Copper	0.17	0.002		
					Iron	4.8	1.0		
					Nickel	0.086	0.019		
					Zinc	5.1	0.047		
					Gross alpha	3100.	15.0		
					Gross beta	4040.	42.0		
					Radium	63.0	5.0		
F-Area seepage basin 904-42G[i]	27 x 161	400	0/102	No endangered species or suitable habitat observed within vicinity[k]; however, a bald eagle has been observed about 400 meters from the site	pH	3.20	6.5-9.0	Four Mile Creek; 490	7.50×10^{-3}
					Copper	0.17	0.002		
					Iron	4.8	1.0		
					Nickel	0.086	0.019		
					Zinc	5.1	0.047		
					Gross alpha	3100.	15.0		
					Gross beta	4040.	42.0		
					Radium	63.0	5.0		
F-Area seepage basin 904-43G[i]	94 x 219	400	0/102	No endangered species or suitable habitat observed within vicinity[b]; however, a bald eagle has been observed about 400 meters from the site	pH	3.20	6.5-9.0	Four Mile Creek; 490	7.50×10^{-3}
					Copper	0.17	0.002		
					Iron	4.8	1.0		
					Nickel	0.086	0.019		
					Zinc	5.1	0.047		
					Gross alpha	3100.	15.0		
					Gross beta	4040.	42.0		
					Radium	63.0	5.0		

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Table F-17. Environmental Data for F- and H-Area Waste Sites (continued)

Waste site	Areal extent of site (m)	Distance to nearest wetland (m)	Area of wetlands within 200 m/1000 m (acres)	Endangered species data	Non-PATHRAE-modeled contaminants exceeding freshwater biota criteria[a]			Area of ground-water outcrop; distance (m) to outcrop	Dilution factor[d]
					Contaminant	Reported level[b]	Criterion[c]		
Old F-Area seepage basin 904-49G[j]	59 x 91	200	0.1/166	No endangered species or suitable habitat observed within vicinity[j]; however, a candidate species, the sand-borrowing may fly, is present nearby[j] and a bald eagle has been observed about 400 meters from the site	pH	3.5	6.5-9.0	Upper Three Runs Creek; 900	4.53×10^{-4}
					Beryllium	0.007	0.0053		
					Copper	0.22	0.00066		
					Nickel	0.045	0.0073		
					Zinc	0.91	0.047		
					Gross alpha	202.	15.0		
					Gross beta	1200.	42.0		
					Radium	32.	5.0		
H-Area seepage basin 904-44G[k]	27 x 73	200	3.8/184	No endangered species or suitable habitat observed within vicinity[k]; however, a bald eagle has been observed about 400 meters from the site	pH	3.8	6.5-9.0	Four Mile Creek; 240	3.67×10^{-2}
					Copper	0.030	0.002		
					Nickel	0.037	0.019		
					Zinc	3.1	0.047		
					Gross alpha	497.0	15.0		
					Gross beta	10,600	42.0		
					Radium	34.	5.0		
H-Area seepage basin 904-45G[k]	36 x 140	200	3.8/184	No endangered species or suitable habitat observed within vicinity[k]; however, a bald eagle has been observed about 400 meters from the site	pH	3.8	6.5-9.0	Four Mile Creek; 240	3.67×10^{-2}
					Copper	0.030	0.002		
					Nickel	0.037	0.019		
					Zinc	3.1	0.047		
					Gross alpha	497.0	15.0		
					Gross beta	10,600	42.0		
					Radium	34.	5.0		

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Table F-17. Environmental Data for F- and H-Area Waste Sites (continued)

Waste site	Areal extent of site (m)	Distance to nearest wetland (m)	Area of wetlands within 200 m/1000 m (acres)	Endangered species data	Non-PATHRAE-modeled contaminants exceeding freshwater biota criteria[a]			Area of ground-water outcrop; distance (m) to outcrop	Dilution factor[d]
					Contaminant	Reported level[b]	Criterion[c]		
H-Area seepage basin 904-46G[k]	107 x 146	200	3.8/184	No endangered species or suitable habitat observed within vicinity[k]; however, a bald eagle has been observed about 400 meters from the site	pH Copper Nickel Zinc Gross alpha Gross beta Radium	3.8 0.030 0.037 3.1 497.0 10,600. 34.	6.5-9.0 0.002 0.019 0.047 15.0 42.0 5.0	Four Mile Creek; 240	3.67×10^{-2}
H-Area seepage basin 904-56G[k]	9.7 acres	200	3.8/184	No endangered species or suitable habitat observed within vicinity[k]; however, a bald eagle has been observed about 400 meters from the site	pH Copper Nickel Zinc Gross alpha Gross beta Radium	3.8 0.030 0.037 3.1 497.0 10,600. 34.	6.5-9.0 0.002 0.019 0.047 15.0 42.0 5.0	Four Mile Creek; 240	3.67×10^{-2}

[a]Concentrations are in milligrams per liter for chemicals and picocuries per liter for radionuclides.
[b]Average value for groundwater well containing highest concentration; levels rounded.
[c]Based on ICRP, 1978; EPA, 1985b,c; National Technical Advisory Committee, 1968.
[d]Equivalent to groundwater flux divided by flow rate of receiving water body.
[e]Data from Ward, Johnson, and Marine, 1987, except as otherwise indicated.
[f]Data from Huber, Johnson, and Marine, 1987, except as otherwise indicated.
[g]Data from Scott, Killian, Kolb, Corbo, and Marine, 1987, except as otherwise indicated.
[h]Data from Jaegge, Kolb, Looney, Marine, Towler, and Cook, 1987, except as otherwise indicated.
[i]Data from Killian et al., 1987a, except as otherwise indicated.
[j]Data from Odum et al., 1987, except as otherwise indicated.
[k]Data from Killian et al., 1987b, except as otherwise indicated.
[l]Separate data not provided for sites 643-7G/643-28G and 643-G.
[m]Data on the area not given in site specific reference; however, based on other nearby waste sites, endangered species or suitable habitat are not expected.
[n]Mayer, Hoppe, and Kennamer, 1986.
[o]Calculation based on groundwater flux for L-Area acid/caustic basin.
[p]Calculation based on groundwater flux for C-Area burning/rubble pit.

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Table F-18. Predicted Maximum Concentrations of Various Constituents at R-Reactor Seepage Basins

Constituent	Applicable standard[b]	Measured concentration	*PATHRAE-modeled maximum concentration without remedial action*[a]					
			No action		No waste removal and closure		Waste removal and closure	
			1-m well	100-m well	1-m well	100-m well	1-m well	100-m well
Gross beta	40-60	1.5×10^4 (c) (well RSE 6)	(d)	(d)	(d)	(d)	(d)	(d)
Cesium-137	1.1×10^2	(e)	3.3×10^3 (1965)	1.7×10^3 (1970)	3.3×10^3 (1965)	1.7×10^3 (1970)	3.3×10^3 (1965)	1.7×10^3 (1970)
Tritium	8.7×10^4	(e)	1.5×10^8 (1963)	6.5×10^7 (1969)	1.5×10^8 (1963)	6.5×10^7 (1969)	1.5×10^8 (1963)	6.5×10^7 (1969)
Strontium-90[f]	4.2×10^1	(e)	4.3×10^4 (2094)	(g)	9.3×10^3 (2111)	(g)	9.3×10^1 (2111)	(g)
Yttrium-90[f]	5.5×10^2	(e)	4.3×10^4 (2094)	(g)	9.3×10^3 (2111)	(g)	(g)	(g)

[a]Source: Pekkala, Jewell, Holmes, and Marine, 1987b. Number in parentheses represents year in which concentration was reached or is expected to be reached.
[b]EPA, 1985b. ICRP Publication 30 (ICRP, 1979) methodology was used to calculate radionuclide concentrations that yield annual effective whole-body dose of 4 millirem.
[c]Gross beta value is a 3-year mean (1982 through 1984).
[d]Not modeled.
[e]Not reported.
[f]Absolute peaks for facilitated transport fraction occurred at the 1-m well in 1965 and at the 100-m well in 1970. The peak concentrations were 7.2×10^2 and 3.7×10^2 pCi/L, respectively. These peaks are not affected by the closure option.
[g]Below applicable standard.

Table F-20. Environmental Data for R-Area Waste Sites

Waste site	Areal extent of site (m)	Distance to nearest wetland (m)	Area of wetlands within 200 m/1000 m (acres)	Endangered species data	Non-PATHRAE-modeled groundwater contaminants exceeding freshwater biota criteria[a]			Area of ground-water outcrop; distance (m) to outcrop	Dilution factor[d]
					Contaminant	Reported level[b]	Criterion[c]		
R-Area burning/ rubble pit 131-R[e]	6.4 x 72.5	250 to Pond 4; 335 to next nearest wetland	0/No data available	No endangered species observed within vicinity; however, a former red-cockaded woodpecker colony is located within 500m[i]	pH Silver Cadmium Copper Iron Mercury	4.4 0.002 0.0023 0.008 2.3 0.0003	6.5-9.0 0.00032 0.00036 0.0034 1.0 0.000012	Par Pond; 1980	4.86×10^{-4}[j] based on Lower Three Runs Creek flow
R-Area burning/ rubble pit 131-1R[e]	10 x 71.9	250 to Pond 4; 335 to next nearest wetland	0/No data available	No endangered species observed within vicinity; however, a former red-cockaded woodpecker colony is located within 500m[i]	pH Silver Cadmium Copper Iron Mercury	4.4 0.002 0.0023 0.008 2.3 0.0003	6.5-9.0 0.00032 0.00036 0.0034 1.0 0.000012	Par Pond; 1980	4.86×10^{-4}[j] based on Lower Three Runs Creek flow
R-Area acid/ caustic basin (904-77G)[f]	15.2 x 15.2	150	No data available	No endangered species observed within vicinity; however, a former red-cockaded woodpecker colony is located within 500 m[i]	pH Silver Cadmium Zinc	4.3 0.003 0.018 0.068	6.5-9.0 0.00032 0.00036 0.47	Par Pond; 1525	1.65×10^{-4}[k] based on Lower Three Runs Creek flow
R-Area Bingham pump outage pit 643-8G[g]	6 x 76	500	0/26.1 ac	No endangered species observed within vicinity; however, a former red-cockaded woodpecker colony is located about 800m SE	No data available			Joyce Branch, (drains to Par Pond); 570	6.31×10^{-4}[l] based on Lower Three Runs Creek flow

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Table F-20. Environmental Data for R-Area Waste Sites (continued)

Waste site	Areal extent of site (m)	Distance to nearest wetland (m)	Area of wetlands within 200 m/1000 m (acres)	Endangered species data	Non-PATHRAE-modeled groundwater contaminants exceeding freshwater biota criteria[a]			Area of groundwater outcrop; distance (m) to outcrop	Dilution factor[d]	
					Contaminant	Reported level[b]	Criterion[c]			TE
R-Area Bingham pump outage pit 643-9G[g]	5 x 76	500	0/26.1 ac	No endangered species observed within vicinity; however, a former red-cockaded woodpecker colony is located about 800m SE	No data available			Joyce Branch, (drains to Par Pond); 570	6.31×10^{-41} based on Lower Three Runs Creek flow	
R-Area Bingham pump outage pit 643-10G[g]	8 x 159	500	0/26.1 ac	No endangered species observed within vicinity; however, a former red-cockaded woodpecker colony is located about 800m SE	No data available			Joyce Branch, (drains to Par Pond); 570	6.31×10^{-41} based on Lower Three Runs Creek flow	
R-Area seepage basin 904-57G[h]	9 x 90	450	0/78.6	No endangered species observed within vicinity; however, a former red-cockaded woodpecker colony is located within 1000 m	No data available			Mill Creek (tributary to Upper Three Runs Creek); 440	3.55×10^{-4}	TC
R-Area seepage basin 904-58G[h]	11 x 93	450	0/78.6	No endangered species observed within vicinity; however, a former red-cockaded woodpecker colony is located within 1000 m	No data available			Mill Creek (tributary to Upper Three Runs Creek); 440	3.55×10^{-4}	

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Table F-20. Environmental Data for R-Area Waste Sites (continued)

Waste site	Areal extent of site (m)	Distance to nearest wetland (m)	Area of wetlands within 200 m/1000 m (acres)	Endangered species data	Non-PATHRAE-modeled groundwater contaminants exceeding freshwater biota criteria[a]			Area of ground-water outcrop; distance (m) to outcrop	Dilution factor[d]
					Contaminant	Reported level[b]	Criterion[c]		
R-Area seepage basin 904-59G[h]	12 x 90	450	0/78.6	No endangered species observed within vicinity; however, a former red-cockaded woodpecker colony is located within 1000 m	No data available			Mill Creek (tributary to Upper Three Runs Creek); 440	3.55×10^{-4}
R-Area seepage basin 904-60G[h]	14 x 150	450	0/78.6	No endangered species observed within vicinity; however, a former red-cockaded woodpecker colony is located within 1000 m	No data available			Mill Creek (tributary to Upper Three Runs Creek); 440	3.55×10^{-4}
R-Area seepage basin 904-103G[h]	9 m x 120 m	450	0/78.6	No endangered species observed within vicinity; however, a former red-cockaded woodpecker colony is located within 1000 m	No data available			Mill Creek (tributary to Upper Three Runs Creek); 440	3.55×10^{-4}

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Table F-20. Environmental Data for R-Area Waste Sites (continued)

Waste site	Areal extent of site (m)	Distance to nearest wetland (m)	Area of wetlands within 200 m/1000 m (acres)	Endangered species data	Non-PATHRAE-modeled groundwater contaminants exceeding freshwater biota criteria[a]			Area of groundwater outcrop; distance (m) to outcrop	Dilution factor[d]
					Contaminant	Reported level[b]	Criterion[c]		
R-Area seepage basin 904-104G[h]	14 x 40 m	450	0/78.6	No endangered species observed within vicinity; however, a former red-cockaded woodpecker colony is located within 1000 m[i]	No data available			Mill Creek (tributary to Upper Three Runs Creek); 440	3.55×10^{-4}

[a]Concentrations are in milligrams per liter for chemicals and picocuries per liter for radionuclides.
[b]Average value for groundwater well containing highest concentration.
[c]Based on ICRP 30, 1978; EPA, 1985b,c; National Technical Advisory Committee, 1968.
[d]Equivalent to groundwater flux divided by flow rate of receiving stream.
[e]Data from Huber, Johnson, and Marine, 1987, except as otherwise indicated.
[f]Data from Ward, Johnson, and Marine, 1987, except as otherwise indicated.
[g]Data from Pekkala, Jewell, Holmes, and Marine, 1987a, except as otherwise indicated.
[h]Data from Pekkala, Jewell, Holmes, and Marine, 1987b, except as otherwise indicated.
[i]Data on the area not given in site specific reference; however, statement is based on information given for the R-Area Bingham Pump Outage Pit which is located nearby.
[j]Calculated based on groundwater flux for C-Area burning/rubble pit.
[k]Calculated based on groundwater flux for L-Area acid/caustic basin.
[l]Calculated based on groundwater flux for L-Area Bingham pump outage pit.

Table F-21. *Predicted Maximum Concentrations of Various Constituents at the Ford Building Seepage Basin*[a,b] TE

Constituent	Applicable standard[d]	Monitoring data maximum mean concentration	PATHRAE-modeled maximum concentration without remedial action[c]: No action, 1-m well	No action, 100-m well	No waste removal and closure, 1-m well	No waste removal and closure, 100-m well	Waste removal and closure, 1-m well	Waste removal and closure, 100-m well
Chromium	0.05	(e)	0.18 (2334)	(e)	0.073 (2393)	(e)	(e)	(e)
Nickel	0.013	0.023 (well HXB 1)	(f)	(f)	(f)	(f)	(f)	(f)
Tritium	87,000	(g)	11,000,000 (1966)	7,000,000 (1973)	11,000,000 (1966)	7,000,000 (1973)	11,000,000 (1966)	7,000,000 (1973)

[a] Concentrations are in milligrams per liter for the chemicals and picocuries per liter for tritium.
[b] Source: Pekkala, Jewell, Holmes, Simmons, and Marine, 1987. TC
[c] Year of occurrence in parentheses.
[d] EPA, 1985b, except where noted; Health-based standard for Nickel from EPA, 1986; ICRP Publication 30 (ICRP, 1979) methodology was used to calculate radionuclide concentrations that yield annual effective whole-body dose of 4 millirem.
[e] Below standard.
[f] Not modeled.
[g] Not reported.

Table F-22. Environmental Data for C- and CS-Area Waste Sites

Waste site	Areal extent of site[m]	Distance to nearest wetland	Area of wetlands within 200 m/1000 m	Endangered species data	Non-PATHRAE-modeled groundwater contaminants exceeding freshwater biota criteria[a]: Contaminant	Reported level[b]	Criterion[c]	Area of ground-water outcrop; distance (m) to outcrop	Dilution factor[d]
CS-Area burning/rubble pit 631-1G[e]	9.1 x 61.0	150	No information	No endangered species or suitable habitats observed within vicinity[i]	pH Cadmium Copper Zinc	4.40 0.002 0.009 0.061	6.5-9.0 0.00022 0.002 0.047	Four Mile Creek; 3355	1.75×10^{-3}[j]
CS-Area burning/rubble pit 631-5G[e]	10.7 x 117.3	150	No information	No endangered species or suitable habitats observed within vicinity[i]	pH Cadmium Copper Zinc	4.40 0.002 0.009 0.061	6.5-9.0 0.00022 0.002 0.047	Four Mile Creek; 3355	1.75×10^{-3}[j]
CS-Area burning/rubble pit 631-6G[e]	9.1 x 88.4	600	o/No information	No endangered species or suitable habitats observed within vicinity[i]	No data available			Pen Branch 2135	2.2×10^{-3}[j]
C-Area burning/rubble pit 131-C[e]	7.6 x 106.7	400	0/55.6	No endangered species or suitable habitats observed within vicinity	pH Silver Cadmium Copper Iron Gross alpha Radium	5.06, 11.77 0.003 0.003 0.006 5.249 25.25 7.5	6.5-9.0 0.00011 0.00022 0.002 1.0 15.0 5.0	Four Mile Creek; 1250	8.75×10^{-4}
Hydrofluoric acid spill area 631-4G[f]	9.1 x 9.1	200	0/35	No endangered species or suitable habitats observed within vicinity	pH Silver Chromium Mercury	4.40 0.001 0.008 0.00023	6.5-9.0 0.00011 0.002 0.000012	Castor Creek; 500	1.26×10^{-5}

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Table F-22. Environmental Data for C- and CS-Area Waste Sites (continued)

Waste site	Areal extent of site	Distance to nearest wetland	Area of wetlands within 200 m/1000 m	Endangered species data[a]	Non-PATHRAE-modeled groundwater contaminants exceeding freshwater biota criteria			Area of groundwater outcrop; distance (m) to outcrop	Dilution factor[d]
					Contaminant	Reported level[b]	Criterion[c]		
Ford Bldg. waste site 643-11G[g]	6.7 x 51.5	600	0/22	No endangered species or suitable habitats observed within vicinity	No data available			No data available	
Ford Bldg. seepage basin 904-91G[h]	12 x 24	700	0/21	No endangered species or suitable habitats observed within vicinity	pH Cadmium Nickel	4.38 0.0016 0.023	6.5-9.0 0.00025 0.022	Tributary of Pen Branch; 300	1.36×10^{-3}

[a]Concentrations are in milligrams per liter for chemicals and picocuries per liter for radionuclides.
[b]Average value for groundwater well containing highest concentration.
[c]Based on ICRP 30, 1978; EPA, 1985b,c; National Technical Advisory Committee, 1968.
[d]Equivalent to groundwater flux divided by flow rate of receiving stream.
[e]Data from Huber, Johnson, and Marine, 1987, except as otherwise indicated.
[f]Data from Huber and Bledsoe, 1987a, except as otherwise indicated.
[g]Data from Huber, Simmons, Holmes, and Marine, 1987, except as otherwise indicated.
[h]Data from Pekkala, Jewell, Holmes, Simmons, and Marine, 1987, except as otherwise indicated.
[i]Data on area not given in site specific reference; however, based on other nearby waste sites, endangered species or suitable habitat are not expected.
[j]Calculation based on groundwater flux for C-Area burning/rubble pit.

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Table F-23. Predicted Maximum Concentration of Various Constituents at the Old TNX Seepage Basin[a,b]

Constituent	Applicable standard[d]	Monitoring data maximum mean concentration[e]	PATHRAE-predicted maximum concentrations for all closure options[c]		
			1-m well	100-m well	Outcrop
Cadmium	0.01	0.015 (well XSB 4)	(f)	(f)	(f)
Chromium	0.05	(g)	0.079 (1983)	0.077 (1986)	(g)
Lead	0.05	0.085 (well XSB 2)	0.056 (1983)	0.054 (1986)	0.28 (1985)
Mercury	0.002	0.346 (well XSB 2)	(g)	(g)	(g)
Nickel	0.013	0.274 (well XSB 2)	(g)	(g)	(g)
Nitrate	10.0	225 (well XSB 2)	2100 (1983)	2000 (1986)	260 (1985)
Trichloroethylene	0.005	(h)	0.51 (1983)	0.49 (1986)	0.038 (1985)
Tetrachloromethane	0.005	(h)	0.029 (1983)	0.028 (1987)	(g)
Gross alpha	10-20	202 (well XSB 4)	(f)	(f)	(f)
Gross beta	40-60	114 (well XSB 4)	(f)	(f)	(f)
Radium	6	92 (well XSB 2)	(f)	(f)	(f)

[a]Source: Adapted from Dunaway, Johnson, Kingley, Simmons, Bledsoe, and Smith, 1987a.
[b]Concentrations are in milligrams per liter for chemicals and picocuries per liter for radionuclides. TC
[c]Year of occurrence in parentheses.
[d]MCLs for chemicals given in EPA, 1985b, 1985d, 1987; Health-based standard for nickel from EPA, 1986; for radionuclides, ICRP Publication 30 (ICRP, 1979) methodology was used to determine concentrations that yield annual effective whole-body dose of 4 millirem.
[e]Concentrations represent maximum single-well means reported for XSB wells (Dunaway, Johnson, Kingley, Simmons, Bledsoe, and Smith, 1987a; Zeigler, Lawrimore, and Heath, 1986). TC
[f]Not modeled.
[g]Below applicable standard.
[h]Maximum mean concentration data not available.

Table F-24. Predicted Maximum Concentrations of Various Constituents at the New TNX Seepage Basin[a,b] TE

Constituent	Applicable standard[d]	Monitoring data maximum mean concentration	PATHRAE-modeled maximum concentration without remedial action[c]					
			No action		No waste removal and closure		Waste removal and closure	
			1-m well	100-m well	1-m well	100-m well	1-m well	100-m well
Barium	1.0	(e)	5.7 (2059)	(e)	1.3 (2110)	(e)	(e)	(e)
Chromium	0.05	(e)	0.15 (2563)	(e)	0.062 (2614)	(e)	(e)	(e)
Nitrate	10	(e)	4500 (1987)	1900 (1990)	1000 (2005)	940 (2007)	1000 (2005)	940 (2007)
Uranium-238	24	(f)	29 (2563)	(e)	(e)	(e)	(e)	(e)

[a]Concentrations are in milligrams per liter for chemicals and picocuries per liter for radionuclides. TE
[b]Source: Dunaway, Johnson, Kingley, Simmons, and Bledsoe, 1987b; Dunaway, 1987b.
[c]Year of occurrence in parentheses.
[d]EPA, 1985b, except where noted; ICRP Publication 30 (ICRP, 1979) methodology was used to calculate radionuclide concentrations that yield annual effective whole-body dose of 4 millirem.
[e]Below standard.
[f]Not reported; gross alpha below standard.

Table F-25. Environmental Data for TNX-Area Waste Sites

Waste site	Areal extent of site (m)	Distance to nearest wetland (m)	Area of wetlands within 200 m/1000 m (acres)	Endangered species data	Non-PATHRAE-modeled contaminants exceeding freshwater biota criteria[a]: Contaminant	Reported level[b]	Criterion[c]	Area of groundwater outcrop; distance (m) to outcrop	Dilution factor[d]
0-Area burning/ rubble pit 431-0[e]	15.2 x 82.9	240	0/No data available	No endangered species or suitable habitat seen within vicinity.[i]	pH	4.0	6.5-9.0	Savannah River; 1065	1.54×10^{-6j}
					Silver	0.001	0.00014		
					Cadmium	0.0018	0.00024		
					Copper	0.011	0.0022		
					Iron	4.0	1.0		
					Mercury	0.0034	0.000012		
					Zinc	0.26	0.047		
					Gross beta	47.0	42.0		
					Radium	5.8	5.0		
D-Area burning/ rubble pit 431-1D[e]	11.6 x 73.8	240	0/No data available	No endangered species or suitable habitat seen within vicinity of site.[i]	pH	4.0	6.5-9.0	Savannah River; 1065	1.54×10^{-6j}
					Silver	0.001	0.00014		
					Cadmium	0.0018	0.00024		
					Copper	0.011	0.0022		
					Iron	4.0	1.0		
					Mercury	0.0034	0.000012		
					Zinc	0.26	0.047		
					Gross beta	47.0	42.0		
					Radium	5.8	5.0		
TNX burying ground (643-5G)[f]	20 x 20	250	0/192	No endangered species or suitable habitat seen within vicinity.	No data available			Savannah River; 400	1.87×10^{-7}
Old TNX seepage basin (904-76G)[g]	23 x 42	100	9.8/229	No endangered species or suitable habitat seen within vicinity.	ph	3.6	6.5-9.0	Savannah River; 300	2.20×10^{-7}
					Beryllium	0.037	0.0053		
					Cadmium	0.015	0.00024		
					Iron	62.0	1.0		
					Zinc	2.8	0.047		
					Copper	0.076	0.0022		
					Gross alpha	202.3	15.0		
					Gross beta	114.0	42.0		
					Radium	92.0	5.0		

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Table F-25. Environmental Data for TNX-Area Waste Sites (continued)

Waste site	Areal extent of site	Distance to nearest wetland (m)	Area of wetlands within 200 m/1000 m (acres)	Endangered species data	Non-PATHRAE-modeled contaminants exceeding freshwater biota criteria[a]			Area of groundwater outcrop; distance (m) to outcrop	Dilution factor[d]
					Contaminant	Reported level[b]	Criterion[c]		
New TNX seepage basin (904-102G)[h]	Large basin, 30 x 205 Small basin, 3 x 6	200	0/196	No endangered species or suitable habitat seen within vicinity	Basin water:				
					pH	9.6	6.5-9.0	Savannah River; 610	1.21×10^{-6}
					Silver	0.02	0.00014		
					Cadmium	0.002	0.00024		
					Copper	0.056	0.0022		
					Iron	2.2	1.0		
					Mercury	0.0013	0.000012		
					Lead	0.006	0.00026		
					Zinc	0.16	0.047		
					Groundwater:				
					pH	4.7	6.5-9.0		
					Cadmium	0.0016	0.00024		
					Copper	0.01	0.0022		
					Iron	8.3	1.0		
					Mercury	0.0006	0.000012		
					Lead	0.009	0.00026		
					Zinc	0.29	0.047		

[a]Concentrations are in milligrams per liter for chemicals and picocuries per liter for radionuclides.
[b]Average value for groundwater well containing highest concentration.
[c]Based on ICRP 30, 1978; EPA 1985b,c; National Technical Advisory Committee, 1968.
[d]Equivalent to groundwater flux divided by flow of receiving stream.
[e]Data from Huber, Johnson, and Marine, 1987, except where otherwise indicated.
[f]Data from Dunaway, Johnson, Kingley, Simmons, and Bledsoe, 1987a, except as otherwise indicated.
[g]Data from Dunaway, Johnson, Kingley, Simmons, Bledsoe, and Smith, 1987a, except as otherwise indicated.
[h]Data from Dunaway, Johnson, Kingley, Simmons, and Bledsoe, 1987b, except as otherwise indicated.
[i]Data on the area not given in site specific reference; however, based on other nearby waste sites, endangered species or suitable habitat are not expected.
[j]Calculations based on groundwater flux for C-Area burning/rubble pit.

TC

Table F-26. Environmental Data for D-Area Oil Seepage Basin

Waste site	Areal extent of site (m)	Distance to nearest wetland (m)	Area of wetlands within *200 m/1000 m* (acres)	Endangered species data	Non-PATHRAE-modeled groundwater contaminants *exceeding freshwater biota criteria*[a]			Area of groundwater outcrop; distance to outcrop	Dilution factor[d]
					Contaminant	Reported level[b]	Criterion[c]		
D-Area oil seepage basin[e]	16.4 x 116.7	50	5.5/49.5	No endangered species seen in vicinity of site and no suitable habitat within vicinity	pH Copper Mercury Lead	4.50 0.008 0.0002 0.012	6.5 - 9.0 0.0022 0.000012 0.00026	Savannah River; 2100	2.31×10^{-6}

TC

[a]Concentrations are in milligrams per liter for chemicals and picocuries per liter for radionuclides.
[b]Average value for groundwater well containing highest concentration.
[c]Based on ICRP 30, 1978; EPA, 1985b,c; National Technical Advisory Committee, 1968.
[d]Equivalent to groundwater flux divided by flow rate of receiving stream.
[e]Data *from Huber, Johnson*, and Bledsoe, 1987, except as otherwise indicated.

Table F-27. Environmental Data for Road A Chemical Basin

Waste site	Areal extent of site	Distance to nearest wetland (m)	Area of wetlands within 200 m/1000 m (acres)	Endangered species data	Non-PATHRAE modeled contaminants exceeding freshwater biota criteria[a]: Contaminant	Reported level[b]	Criterion[c]	Area of groundwater outcrop; distance (m) to outcrop	Dilution factor[d]
Road A chemical basin (904-111G)[e]	30 x 53; however, larger area (3.7 acres) was graded when site was closed in 1973	200	0/79.3	Bald eagles have been sighted in basin area.[f] Three former red-cockaded woodpecker colonies are within 1 kilometer	pH Cadmium Copper	4.53 0.002 0.01	6.5-9.0 0.00022 0.002	Four Mile Creek and/or swamp system; 200	3.02×10^{-6} (assumes outcrop to Four Mile Creek)

[a]Concentrations are in milligrams per liter for chemicals and picocuries per liter for radionuclides.
[b]Average value for groundwater well containing highest concentration.
[c]Based on ICRP, 1978; EPA, 1985b,c; National Technical Advisory Committee, 1968.
[d]Equivalent to groundwater flux divided by flow rate of receiving stream.
[e]Data from Pickett, Muska, and Bledsoe, 1987, except as otherwise indicated.
[f]From Mayer, Hoppe, and Kennamer, 1986.

TC

Table F-28. Predicted Maximum Concentrations of Groundwater Constituents at K-Reactor Seepage Basin[a]

Constituent	Applicable standard[c]	Measured concentration	PATHRAE-modeled maximum concentration without remedial action[b]			
			No action		No waste removal and closure, and waste removal and closure	
			1-m well	100-m well	1-m well	100-m well
Tritium	8.7×10^4	2.8×10^5[d] (well KSB 1)	7.2×10^6 (1960)	4.4×10^6 (1967)	7.2×10^6 (1960)	4.4×10^6 (1967)
Strontium-90	4.2×10^1	(e)	1.2×10^3 (1997)	(f)	(f)	(f)
Yttrium-90	5.5×10^2	(e)	1.2×10^3 (1997)	(f)	(f)	(f)

[a]Source: Pekkala, Jewell, Holmes, and Marine, 1987b. Concentrations are in picocuries per liter. TE
[b]Number in parentheses represents the year in which concentration was reached or is expected to be reached.
[c]EPA, 1985b. ICRP Publication 30 (ICRP, 1979) methodology was used to calculate radionuclide concentrations that yield an annual effective whole body dose of 4 millirem.
[d]Tritium value is mean for 1986.
[e]Not reported.
[f]Below applicable standard.

Table F-30. Environmental Data for K-Area Waste Sites

Waste site	Areal extent of site (m)	Distance to nearest wetland (m)	Area of wetlands within 200 m/1000 m (acres)	Endangered species data	Non-PATHRAE-modeled contaminants exceeding freshwater biota criteria[a]			Area of groundwater outcrop; distance (m) to outcrop	Dilution factor[d]
					Contaminant	Reported level[b]	Criterion[c]		
K-Area burning/ rubble pit (131-K)[e]	9.1 x 70.1	550	0/No data available	No endangered species or suitable habitat observed within vicinity[i]	pH Cadmium Copper Iron	4.4 0.004 0.037 2.101	6.5–9.0 0.00025 0.0022 1.0	Indian Grave or Pen Branch; 1220 or 1675	4.07×10^{-5}[j]; based on Pen Branch flow
K-Area acid/caustic basin (904-80G)[f]	15.2 x 15.2	650	0/No data available	No endangered species or suitable habitat observed within vicinity[i]	pH Silver Cadmium Iron	4.8 0.022 0.003 4.1	6.5–9.0 0.00015 0.00025 1.0	Indian Grave Branch; 1525	1.38×10^{-5}[k]; based on Pen Branch flow
K-Area Bingham pump outage pit (643-1G)[g]	18 x 122	600	0/1.4	No endangered species or suitable habitat observed within vicinity	No data available			Pen Branch; 1675	4.86×10^{-3}[l]
K-Area seepage basin (904-65G)[h]	21 x 41	200	0.1/100	No endangered species or suitable habitat observed within vicinity	pH Silver Lead	4.2 0.02 0.005	6.5–9.0 0.00027 0.00015	Indian Grave Branch; 710	5.66×10^{-5}

[a]Concentrations are in milligrams per liter for chemicals and picocuries per liter for radionuclides.
[b]Average value for groundwater well containing highest concentration.
[c]Based on ICRP, 1978; EPA, 1985b,c; National Technical Advisory Committee, 1968.
[d]Equivalent to groundwater flux divided by flow rate of receiving stream.
[e]Data from Huber, Johnson, and Marine, 1987, except as otherwise indicated.
[f]Data from Ward, Johnson, and Marine, 1987, except as otherwise indicated.
[g]Data from Pekkala, Jewell, Holmes, and Marine, 1987a.
[h]Data from Pekkala, Jewell, Holmes, and Marine, 1987b.
[i]Data on the area not given in the site specific reference; however, based on other nearby waste sites, endangered species or suitable habitat are not expected.
[j]Calculation based on groundwater flux for C-Area burning/rubble pit.
[k]Calculation based on groundwater flux for L-Area acid/caustic basin.
[l]Calculation based on groundwater flux for L-Area Bingham pump outage pit.

Table F-31. Predicted Maximum Concentrations of Various Chemical Constituents at CMP Pits[a]

Constituent	Applicable standard	Monitoring data maximum mean concentration	Predicted maximum concentration: No action[b], 1-m well	No action[b], 100-m well	No removal and closure, 1-m well	No removal and closure, 100-m well	Removal and closure, 1-m well	Removal and closure, 100-m well
Benzene	5.0×10^{-3}[c]	(d)	3.6×10^{-1} (1993)	2.1×10^{-1} (1995)	(e)	(e)	(e)	(e)
Chloroethylene	2.0×10^{-3}[c]	(d)	3.8×10^{-1} (1992)	2.2×10^{-1} (1994)	(e)	(e)	(e)	(e)
2,4-0	1.0×10^{-1}[c]	(f)	7.2×10^{-1} (1993)	4.1×10^{-1} (1995)	(e)	(e)	(e)	(e)
Dichloromethane	6.0×10^{-2}[g]	(d)	3.8×10^{-1} (1992)	2.2×10^{-1} (1994)	(e)	(e)	(e)	(e)
Endrin	2.0×10^{-4}[c]	(f)	9.3×10^{-4} (2708)	5.4×10^{-4} (2786)	(e)	(e)	(e)	(e)
Lead	5.0×10^{-2}[c]	5.3×10^{-2} (well CMP 12)	1.1×10^{-1} (1992)	6.5×10^{-2} (1994)	(e)	(e)	(e)	(e)
Silvex	1.0×10^{-2}[c]	(f)	2.3 (2012)	1.3 (2016)	(e)	(e)	(e)	(e)
Tetrachloroethylene	7.0×10^{-4}[g]	(d)	8.2×10^{1} (1997)	4.7×10^{1} (2000)	(e)	(e)	(e)	(e)
Toxaphene	5.0×10^{-3}[c]	(f)	2.3×10^{-1} (2003)	1.3×10^{-1} (2006)	(e)	(e)	(e)	(e)
Trichloroethylene	5.0×10^{-3}[c]	(d)	2.1 (1994)	1.2 (1996)	(e)	(e)	(e)	(e)
Gross alpha	10-20	95 (well CMP 13)	(h)	(h)	(h)	(h)	(h)	(h)
Radium	6.0	12 (well CMP 11)	(h)	(h)	(h)	(h)	(h)	(h)

[a]Source: Scott, Kolb, Price, and Bledsoe, 1987. Concentrations are in milligrams per liter for chemicals and picocuries per liter for radionuclides.
[b]Number in parentheses represents year in which concentration is expected to be reached.
[c]Source: EPA, 1985b, 1987.
[d]Statistical comparison between up and down gradient wells not performed for this parameter.
[e]Value identical to that of no action.
[f]Concentration is below standard.
[g]Source: EPA, 1985a, 1987.
[h]Constituent not modeled.

Table F-32. Predicted Maximum Concentrations of Various Constituents at the L-Area Oil and Chemical Basin[a,b]

Constituent	Applicable standard[d]	Monitoring data maximum mean concentration[h]	PATHRAE-modeled maximum concentration without remedial action[c]: No action, 1-m well	No action, 100-m well	No waste removal and closure, 1-m well	No waste removal and closure, 100-m well	Waste removal and closure, 1-m well	Waste removal and closure, 100-m well
Cadmium	0.01	(e)	0.03 (1986)	(e)	(e)	(e)	(e)	(e)
Chromium	0.05	(e)	3.3 (2027)	0.098 (2495)	(e)	(e)	(e)	(e)
Nickel	0.013	0.017 (well LCO 1)	0.12 (2098)	(e)	(e)	(e)	(e)	(e)
Lead	0.05	(e)	0.22 (2098)	(e)	(e)	(e)	(e)	(e)
Tetrachloro-ethylene	.0007[f]	0.056 (well LCO 1)	0.016 (1979)	0.016 (1979)	0.016 (1979)	0.016 (1979)	0.016 (1979)	0.016 (1979)
Americium-241	2.5	(g)	180 (2098)	(e)	5.3 (2211)	(g)	(e)	(g)
Cobalt-60	210	(g)	7300 (1976)	(e)	7300 (1976)	(e)	7300 (1976)	(e)
Plutonium-238	14	(g)	18 (2098)	(e)	(e)	(e)	(e)	(e)
Strontium-90	42	(g)	2100 (1980)	(e)	2100 (1980)	(e)	2100 (1980)	(e)
Tritium	8.7×10^4	(g)	4.6×10^8 (1962)	3.2×10^8 (1967)	4.6×10^8 (1962)	3.2×10^8 (1967)	4.6×10^8 (1962)	3.2×10^8 (1967)

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Table F-32. Predicted Maximum Concentrations of Various Constituents at the L-Area Oil and Chemical Basin for the Three Closure Options[a,b] (continued)

Constituent	Applicable standard[d]	Monitoring data maximum mean concentration[h]	PATHRAE-modeled maximum concentration without remedial action[c]					
			No action		No waste removal and closure		Waste removal and closure	
			1-m well	100-m well	1-m well	100-m well	1-m well	100-m well
Uranium-238	24	(g)	130 (2027)	(e)	(e)	(e)	(e)	(e)
Yttrium-90	550	(g)	2100 (1980)	(e)	2100 (1980)	(e)	2100 (1980)	(e)

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[a]Source: Adapted from Pekkala, Jewell, Price, and Bledsoe, 1987.
[b]Concentrations are in milligrams per liter for chemicals and picocuries per liter for radionuclides.
[c]Year of maximum concentration is in parentheses.
[d]MCLs for chemicals are given in EPA, 1985b; Health based standard for nickel found in EPA, 1986; for radionuclides, ICRP Publication 30 (ICRP, 1979) methodology was used to determine concentrations that yield annual effective whole-body dose of 4 millirem.
[e]Below applicable standard.
[f]EPA, 1985a.
[g]Not reported.
[h]Data are for LCO series water-table monitoring wells. The concentration level provided for nickel is a maximum single well mean. Value listed for tetrachloroethylene was reported as TOH.

Table F-33. Environmental Data for L-Area Waste Sites

Waste site	Areal extent of site (m)	Distance to nearest wetland (m)	Area of wetlands within 200 m/1000 m (acres)	Endangered species data	Non-PATHRAE-modeled groundwater contaminants exceeding freshwater biota criteria[a]: Contaminant	Reported level[b]	Criterion[c]	Area of ground-water outcrop; distance (m) to outcrop	Dilution factor[d]
L-Area burning/ rubble pit 131-L[e]	8.8 x 70.1	1035	0/0	No endangered species or suitable habitat observed in vicinity[k]; however, the bald eagle has been sighted in the general L-Area[j]	pH Silver Cadmium Copper Iron Zinc Gross alpha	4.3 0.002 0.004 0.012 5.1 0.052 24.	6.5–9.0 0.00015 0.00025 0.0029 1.0 0.047 15.0	Pen Branch; 1220	2.2×10^{-31}
L-Area acid/ caustic basin 904-79G[f]	15.2 x 15.2	400	0/234	No endangered species or suitable habitat observed in vicinity[g]; however, the bald eagle *has been sighted* in the general L-Area[j]	pH Beryllium Cadmium Iron Zinc	4.4 0.006 0.002 7.5 0.4	6.5–9.0 0.0053 0.00031 1.0 0.047	Steel Creek/ Headwaters of L-Lake; 270	1.42×10^{-5}; based on Steel Creek flow
CMP pit 080-17G[g]	3 to 5 x 15 to 23	200	0.6/86	No endangered species or suitable habitat observed in vicinity[g]; however, the bald eagle has been sighted in the general L-Area[j]	pH Silver Cadmium Copper Zinc Gross alpha Radium	4.8 0.002 0.002 0.01 5.9 95.0 12.0	6.5–9.0 0.00015 0.00025 0.0022 0.047 15.0 5.0	Pen Branch; 800	1.76×10^{-3}
CMP pit 080-18.2G[g]	3 to 5 x 15 to 23	200	0.6/86	No endangered species or suitable habitat observed in vicinity[g]; however, the bald eagle	pH Silver Cadmium Copper Zinc Gross alpha Radium	4.8 0.002 0.002 0.01 5.9 95.0 11.0	6.5–9.0 0.00015 0.00025 0.0022 0.047 15.0 5.0	Pen Branch; 800	1.76×10^{-3}

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Table F-33. Environmental Data for L-Area Waste Sites (continued)

Waste site	Areal extent of site (m)	Distance to nearest wetland (m)	Area of wetlands within 200 m/1000 m (acres)	Endangered species data	Non-PATHRAE-modeled groundwater contaminants exceeding freshwater biota criteria[a]			Area of groundwater outcrop; distance (m) to outcrop	Dilution factor[d]
					Contaminant	Reported level[b]	Criterion[c]		
				has been sighted in the general L-Area[j]					
CMP pit 080-18.3G[g]	3 to 5 x 15 to 23	200	0.6/86	No endangered species or suitable habitat cbserved in vicinity[g]; however, the bald eagle has been sighted in the general L-Area[j]	pH	4.8	6.5-9.0	Pen Branch; 800	1.76×10^{-3}
					Silver	0.002	0.00015		
					Cadmium	0.002	0.00025		
					Copper	0.01	0.0022		
					Zinc	5.9	0.047		
					Gross alpha	95.0	15.0		
					Radium	12.0	5.0		
CMP pit 080-19G[g]	3 to 5 x 15 to 23	200	0.6/86	No endangered species or suitable habitat observed in vicinity[g]; however, the bald eagle has been sighted in the general L-Area[j]	pH	4.8	6.5-9.0	Pen Branch; 800	1.76×10^{-3}
					Silver	0.002	0.00015		
					Cadmium	0.002	0.00025		
					Copper	0.01	0.0022		
					Zinc	5.9	0.047		
					Gross alpha	95.0	15.0		
					Radium	12.0	5.0		
CMP pit 080-17.1G[g]	3 to 5 x 15 to 23	200	0.6/86	No endangered species or suitable habitat observed in vicinity[g]; however, the bald eagle has been sighted in the general L-Area[j]	pH	4.8	6.5-9.0	Pen Branch; 800	1.76×10^{-3}
					Silver	0.002	0.00015		
					Cadmium	0.002	0.00025		
					Copper	0.01	0.0022		
					Zinc	5.9	0.047		
					Gross Alpha	95.0	15.0		
					Radium	12.0	5.0		

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Table F-33. Environmental Data for L-Area Waste Sites (continued)

Waste site	Areal extent of site (m)	Distance to nearest wetland (m)	Area of wetlands within 200 m/1000 m (acres)	Endangered species data	Non-PATHRAE-modeled groundwater contaminants exceeding freshwater biota criteria[a]			Area of ground-water outcrop; distance (m) to outcrop	Dilution factor[d]
					Contaminant	Reported level[b]	Criterion[c]		
CMP pit 080-18G[g]	3 to 5 x 15 to 23	200	0.6/86	No endangered species or suitable habitat observed in vicinity[g]; however, the bald eagle has been sighted in the general L-Area[j]	pH Silver Cadmium Copper Zinc Gross alpha Radium	4.8 0.002 0.002 0.01 5.9 95.0 12.0	6.5-9.0 0.00015 0.00025 0.0022 0.047 15.0 5.0	Pen Branch; 800	1.76×10^{-3}
CMP pit 080-18.1G[g]	3-5 x 15-23	200	0.6/86	No endangered species or suitable habitat observed in vicinity[g]; however, the bald eagle has been sighted in the general L-Area[j]	pH Silver Cadmium Copper Zinc Gross alpha Radium	4.8 0.002 0.002 0.01 5.9 95.0 12.0	6.5-9.0 0.00015 0.00025 0.0022 0.047 15.0 5.0	Pen Branch; 800	1.76×10^{-3}
L-Area Bingham pump outage pit 643-2G[h]	9 x 130	400	0/14	No endangered species or suitable habitat observed within vicinity[h]; however, the bald eagle has been sighted in the general L-Area[j]	No data available			Pen Branch; 350	4.86×10^{-3}

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Table F-33. Environmental Data for L-Area Waste Sites (continued)

Waste site	Areal extent of site (m)	Distance to nearest wetland (m)	Area of wetlands within 200 m/1000 m (acres)	Endangered species data	Non-PATHRAE-modeled groundwater contaminants exceeding freshwater biota criteria[a]			Area of ground-water outcrop; distance (m) to outcrop	Dilution factor[d]
					Contaminant	Reported level[b]	Criterion[c]		
L-Area Bingham pump outage pit 643-3G[h]	8 x 144	400	0/14	No endangered species or suitable habitat observed within vicinity[h]; however, the bald eagle has been sighted in the general L-Area[j]	No data available			Pen Branch; 350	4.86×10^{-3}
L-Area oil and chemical basin 904-83G[i]	24 x 36	400 (L-Lake)	0/248	The alligator has been observed in the L-Reactor dis-charge canal 420 m from the basin. Habitats within 200 m are not suitable for endangered species.	pH Copper Iron Zinc	4.4 0.014 14. 0.087	6.5-9.0 0.0029 1.0 0.047	Headwaters of L-Lake: 600	8.78×10^{-5}, based on Steel Creek flow

[a]Concentrations are in milligrams per liter for chemicals and picocuries per liter for radionuclides.
[b]Average value for groundwater well containing the highest concentration.
[c]Based on ICRP 30, 1979; EPA, 1985b,c; National Technical Advisory Committee, 1968.
[d]Equivalent to groundwater flux divided by flow rate of receiving stream.
[e]Data from Huber, Johnson, and Marine, 1987, except as otherwise indicated.
[f]Data from Ward, Johnson, and Marine, 1987, except as otherwise indicated.
[g]Data from Scott, Kolb, Price, and Bledsoe, 1987, except as otherwise indicated.
[h]Data from Pekkala, Jewell, Holmes, and Marine, 1987a, except as otherwise indicated.
[i]Data from Pekkala, Jewell, Price, and Bledsoe, 1987, except as otherwise indicated.
[j]Data from Mayer, Hoppe, and Kennamer, 1986.
[k]Data on area not given in site specific reference; however, based on other nearby waste sites, endangered species or suitable habitat are not expected.
[l]Calculation based on groundwater flux for C-Area burning/rubble pit.

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Table F-34. Environmental Data for P-Area Waste Sites

Waste site	Areal extent of site (m)	Distance to nearest wetland (m)	Area of wetlands within 200 m/1000 m (acres)	Endangered species data	Non-PATHRAE-modeled groundwater contaminants exceeding freshwater biota criteria[a]: Contaminant	Reported level[b]	Criterion[c]	Area of groundwater outcrop; distance (m) to outcrop	Dilution factor[d]
P-Area burning/ rubble pit 131-P[e]	18.3 x 64	365	0/No data available	No endangered species or suitable habitat observed within vicinity[h]	pH Cadmium Copper Iron Mercury	4.4 0.003 0.015 1.0 0.00025	6.5-9.0 0.00031 0.0029 1.0 0.000012	Steel Creek; 150	6.47×10^{-4}[i]
P-Area acid/caustic basin 904-78G[f]	15.2 x 15.2	400	0/No data available	No endangered species or suitable habitat observed within vicinity[h]	pH Silver Beryllium Iron Zinc	4.40 0.002 0.006 2.2 0.11	6.5-9.0 0.00032 0.0053 1.0 0.047	Par Pond; 1525	1.65×10^{-4}[j]; based on Lower Three Runs Creek flow
P-Area Bingham pump outage pit 643-4G[g]	8 x 144	750	0/8.5	No endangered species or suitable habitat observed within vicinity	No data available			Tributary to Par Pond; 550	6.31×10^{-4}[k]; based on Lower Three Runs Creek flow

[a]Concentrations are in milligrams per liter for chemicals and picocuries per liter for radionuclides.
[b]Average value for groundwater well containing highest concentration.
[c]Based on ICRP 30, 1978; EPA, 1985b,c; National Technical Advisory Committee, 1968.
[d]Equivalent to groundwater flux divided by flow rate of receiving stream.
[e]Data from Huber, Johnson, and Marine, 1987, except as otherwise indicated.
[f]Data from Ward, Johnson, and Marine, 1987, except as otherwise indicated.
[g]Data from Pekkala, Jewell, Holmes, and Marine, 1987a, except as otherwise indicated.
[h]Data on the area not given in site specific reference; however, based on other nearby sites endangered species or suitable habitat are not expected.
[i]Calculation based on groundwater flux for C-Area burning/rubble pit.
[j]Calculation based on groundwater flux for L-Area acid/caustic basin.
[k]Calculation based on groundwater flux for L-Area Bingham pump outage pit.

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Table F-35. Environmental Data for Miscellaneous Area Waste Sites

Waste site	Areal extent extent of site (m)	Distance to nearest wetland (m)	Area of wetlands within 200 m/1000 m (acres)	Endangered species data	Non-PATHRAE-modeled groundwater contaminants exceeding freshwater biota criteria: Contaminant	Reported level	Criterion	Area of ground-water outcrop; distance (m) to outcrop	Dilution factor[a]
SRP oil test site 080-16G[b]	70 x 100	225	0/40	No endangered species or suitable habitat identified within vicinity	No data available			No data available	
Gunsite 720 rubble pit N80K, E27, 35K[c]	35 m^2	200	2.7/369	No endangered species or suitable habitat identified within vicinity; however, an American alligator nest has been located within 600 m south of the site[c]. Also, the bald eagle has been seen in the general area of the site[d].	No data available			No data available	

[a]Equivalent to groundwater flux divided by flow of receiving stream.
[b]Data from Johnson, Pickett, and Bledsoe, 1987, except as otherwise indicated.
[c]Data from Huber and Bledsoe, 1987b, except as otherwise indicated.
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