3.0 ALTERNATIVES

3.1 SRP WASTE MANAGEMENT OPERATIONS (Base Case from ERDA-1537)

Current waste management operations at the Savannah River Plant are carried out in accordance with the following U.S. Department of Energy (DOE) policies:

> "...manage radioactive waste in such a manner as to minimize the radiation exposure and associated risk to man and his environment over the lifetime of the radionuclides: (ERDAM 0511),[1] and
>
> "control potential sources of pollution as far below established standards as practical, considering both technology and economics" (ERDAM 0510).[2]

They follow all established standards including those adopted by South Carolina and approved by the Environmental Protection Agency for nonradioactive releases and those specified by DOE for radioactive releases (ERDAM 0524).[3]

The DOE policies quoted above are implemented by a system of administrative controls. These controls include:

- Guides for the annual exposure to individuals in the offplant population caused specifically by release of radioactivity from the Savannah River Plant.
- Operating guides for the release of individual radionuclides from plant facilities.

The waste produced at the Savannah River Plant is presently stored onsite, and the environmental impacts of the waste management operations were analyzed in the base environmental impact statement, ERDA-1537. Releases of radionuclides are prevented if practical, even if the level of activity is below existing guidelines.

Current plans for the management of radioactive waste at the Savannah River Plant are presented in "Integrated Radioactive Waste Management Plan - Savannah River Plant"[4] issued by DOE. These plans are updated annually to reflect new technical developments and changes in policies and criteria. The plan presented is consistent with the base case in ERDA-1537, i.e., Alternative 4, "continue existing operations and improve waste management practices in accordance with DOE policies and standards."

High-level liquid radioactive wastes are produced at SRP primarily from chemical separations operations in the F and H Areas. These wastes are stored in large underground tanks in each area. Because the waste can be removed from the tanks as desired, this storage method does not foreclose any of the possible options for long-range management of the wastes. The high-level waste storage areas for radioactive liquids, sludges, and crystallized salts are adjacent to the separations areas and consist of two tank farms linked to the separations areas and to each other by pipelines with secondary containment.

Chemical separations processes in the high radiation (heavily shielded) and low radiation (moderately shielded) processing areas, so-called "hot" or "warm" canyons, generate aqueous waste streams that contain most of the fission products. Those waste streams that come from the hot canyon are high-heat waste (HHW) and those from the warm canyon are referred to as low-heat waste (LHW). This terminology is used to identify the source of the waste and to indicate that LHW will not require auxiliary heat removal, as does HHW. In other respects, LHW is similar to HHW.

The term "high-level liquid waste" includes both HHW and LHW. The wastes are generated in chemical separations operations generally as nitric acid solutions. They are made alkaline with sodium hydroxide and are then transferred by gravity flow from the processing buildings to the waste storage tank farm through underground pipes that are enclosed in a secondary concrete conduit for double containment.

The high-heat waste from the canyon is placed in double-walled tanks equipped with the necessary cooling coils and is aged for one to two years to permit settling and the decay of short-lived fission products. During this period, insoluble materials form a layer of sludge at the bottom of the tank. The sludge is a mixture of oxides and hydroxides of manganese, iron, and some aluminum. Small amounts of uranium, plutonium, and mercury are also present. This sludge contains essentially all of the fission products originally in the irradiated fuel except cesium. After aging, the supernate, containing dissolved salts and the radioactive cesium, is transferred to a continuous evaporator. The condensate from the evaporator is passed through an ion exchange column to remove a small amount of entrained cesium and is then discharged to a seepage basin. The concentrate from the evaporator is transferred to a cooled waste tank where the suspended salts settle. During cooling, additional salt crystallizes. The supernate remaining after crystallization is again returned to the evaporator for further evaporation. This process continues until essentially all the liquid has been converted to a crystallized salt cake.

The low-heat waste is handled similarly to high-heat waste. Typical compositions of the two forms of high-level waste supernates are given in Tables 3-1 through 3-4.

TABLE 3-1

Concentration Range of Major Constituents of LHW Supernates

Constituent	*Concentration, M*
Na^+	0.2 - 11.0
OH^-	0.06 - 7.9
NO_3^-	0.2 - 2.8
$Al(OH)_4^-$	0.01 - 1.1

TABLE 3-2

Concentration Range of Major Radioactive Constituents of LHW Supernates

Constituent	*Concentration Range, Ci/gal*
^{134}Cs	$<6 \times 10^{-6}$ - 10^{-2}
^{137}Cs	5×10^{-5} - 0.1
^{144}Ce	$<8 \times 10^{-5}$ - 10^{-2}
^{103}Ru	$<3 \times 10^{-3}$ - 10^{-2}
^{106}Ru	$<5 \times 10^{-5}$ - 4×10^{-2}
^{90}Sr	8×10^{-7} - 10^{-5}
^{238}Pu	7×10^{-6} - 10^{-4}

TABLE 3-3

Concentration Range of Major Constituents in Aged HHW Supernates

Constituent	*Concentration, M*
Na^+	4.0 - 12.5
NO_3^-	1.6 - 6.4
NO_2^-	0.2 - 3.2
$Al(OH)_4^-$	0.4 - 1.6
OH^-	0.8 - 6.3

TABLE 3-4

Concentration Range of Major Radioactive Constituents of Aged HHW Supernates

Constituent	*Concentration Range, Ci/gal*
^{134}Cs	0.2 - 4.6
^{137}Cs	1.7 - 15
^{103}Ru	ND - 0.2
^{89}Sr	$<10^{-6}$ - 3×10^{-5}
^{90}Sr	2×10^{-4} - 4×10^{-3}

3.2 PREFERRED ALTERNATIVE — CONSTRUCTION AND UTILIZATION OF TYPE III TANKS AS CURRENTLY DESIGNED

In October 1979, 32 tanks were in service for high-level waste storage at SRP. The 32 tanks include three essentially empty tanks designated as emergency spares, but exclude Tank 16. Tank 16 has been retired from service, cleaned of residual sludge, and is now being chemically cleaned. Nine of these tanks were built since 1967 and are of the most recent basic design, designated Type III; the others were constructed in the 1950s and 1960s and are of three different generic designs, designated Types I, II, and IV. In addition, four more tanks of the basic Type III design, but with some improvements in detail, are essentially complete but are not yet in service. (Note that the designation "Type III" refers to the third design series of double-walled tanks; the Type IV" designation was applied to the single-walled, uncooled tanks several years after their design, construction, and initial utilization, which preceded the earliest Type III design.)

The fourteen Type III tanks covered by this EIS are in various stages of construction (see Table D-1). These tanks were funded by three separate projects authorized in Fiscal Years 1976, 1977, and 1978. The proposed action considered by this environmental statement includes completing the construction of the fourteen tanks and then using the tanks to store waste. This action will facilitate the continued safe interim storage of waste from the SRP production of nuclear materials and make possible the retirement from service of tanks of older designs beginning with known leaking tanks.

The design of the Type III tanks evolves from the more than 25 years in waste tank operational experience at the SRP. Major improvements that were adopted in successive series of tanks are listed in Table 3-5. The proposed action is consistent with the base case in ERDA-1537, i.e., Alternative 4, "Improve Waste Management Practices in Accordance with ERDA Policies and Standards."

The locations of the various tanks within the F and H Areas are shown in Figures 3-1 and 3-2. Also shown are the fiscal years in which various groups of tanks were authorized.

3.2.1 Design Features

The design of the Type III tanks is illustrated in Figure 3-3. Basically, the tanks consist of a steel primary container in the shape of a free standing toroid built around a central concrete column which supports the 48-in.-thick concrete roof slab. The primary container has an 85 ft outside diameter, 6 ft 9 in. inside

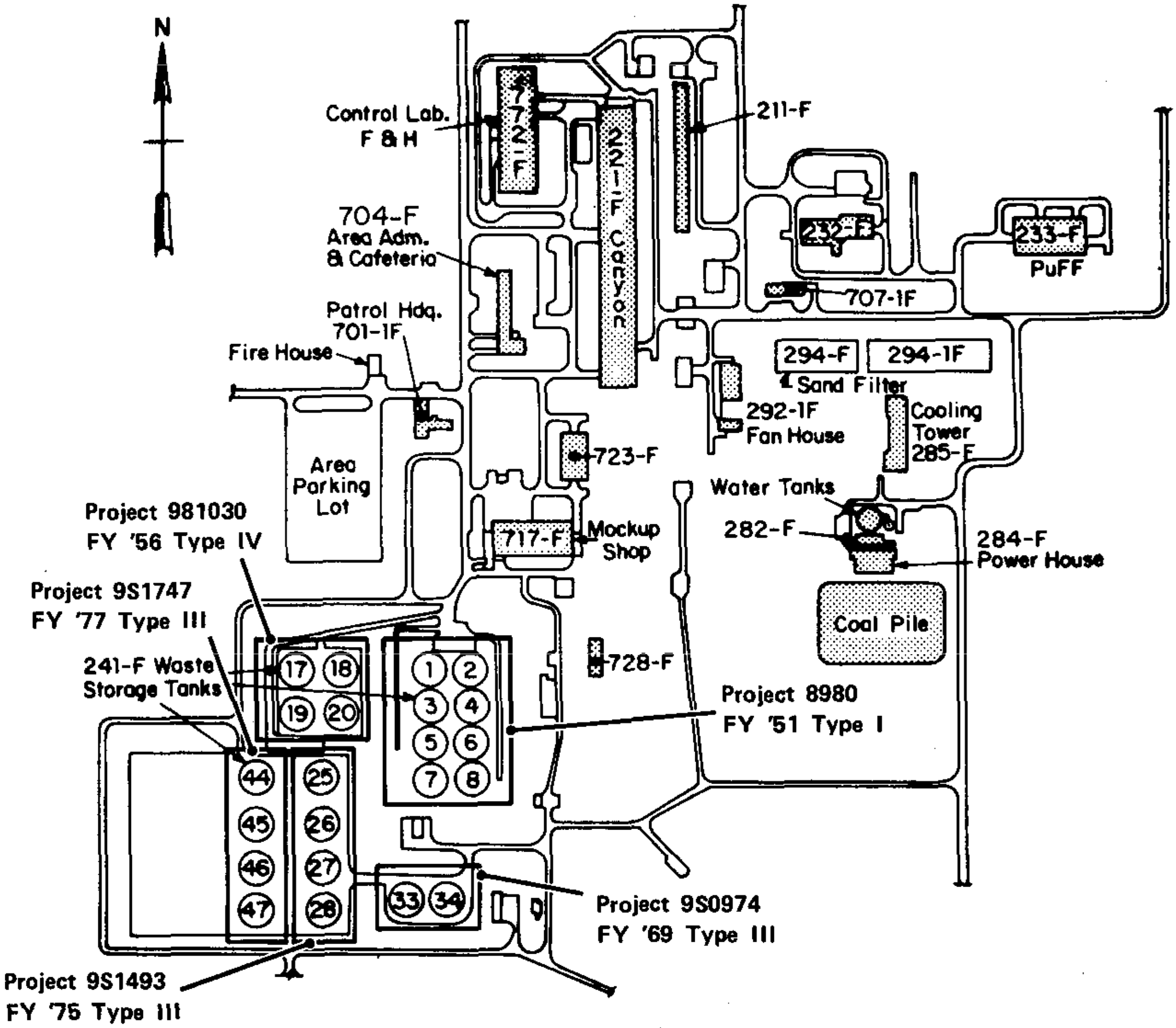

FIGURE 3-1. 200-F Area Waste Tank Locations

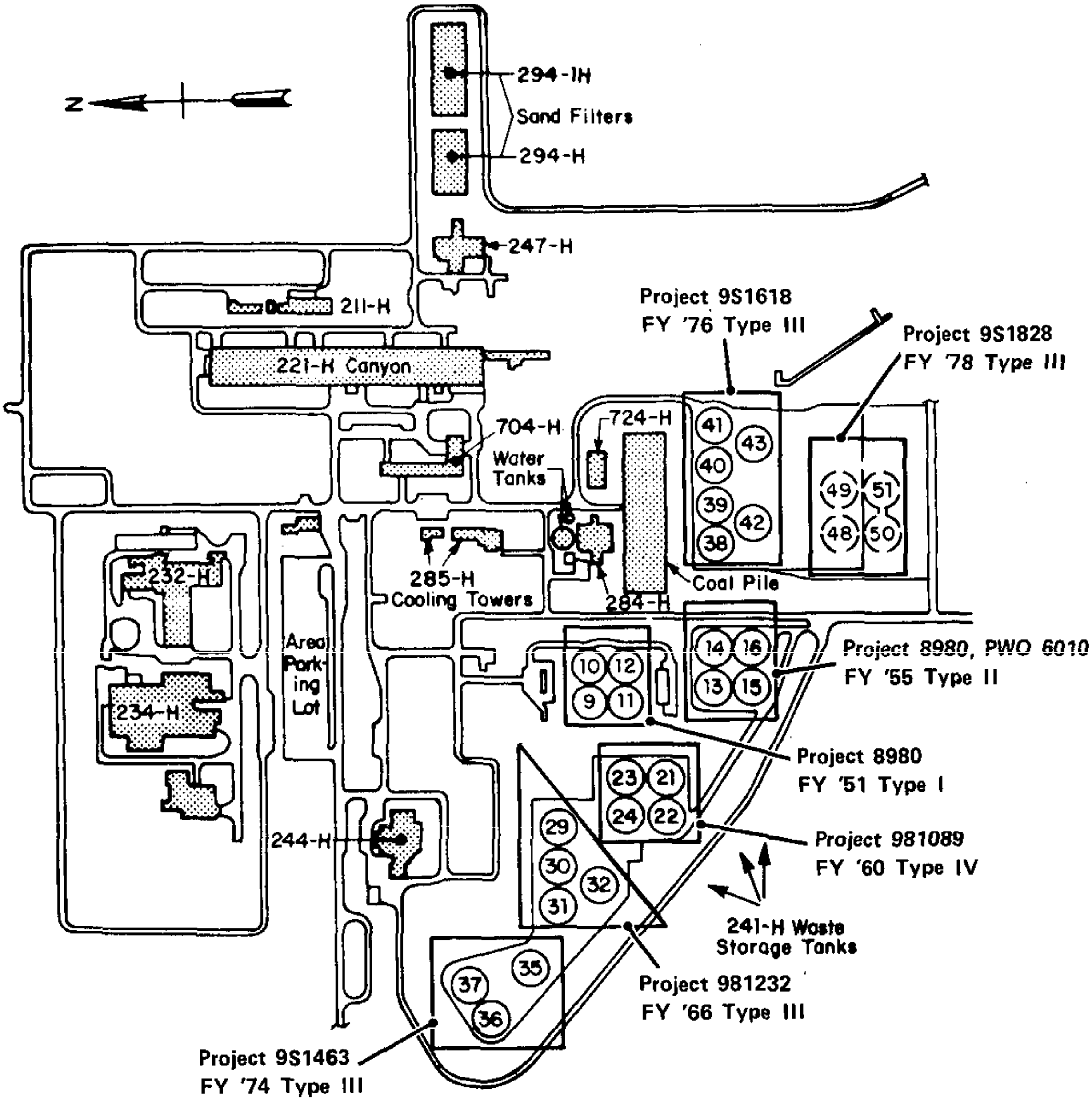

FIGURE 3-2. 200-H Area Waste Tank Locations

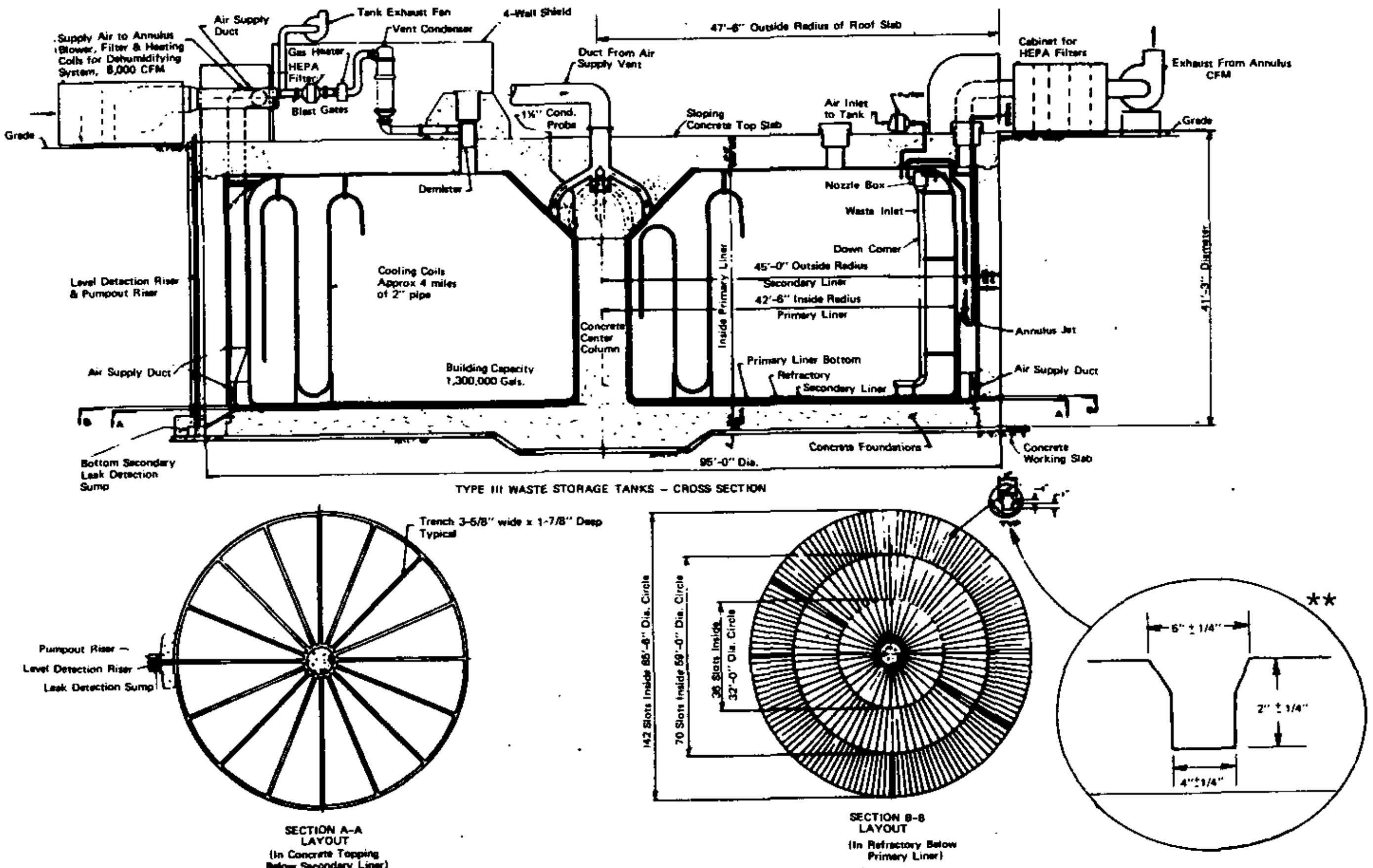

FIGURE 3-3. Type III Waste Storage Tanks
(Building 241-F, Tanks 25 through 28 and 44 through 47)*
(Building 241-H, Tanks 38 through 43 and 48 through 51)*

* Under construction

C| ** Added figure and clarified some dimensions on diagram.

diameter around the central concrete column, and is 33 ft tall; it has a volume of 1,300,000 gallons. The primary container rests on a bed of insulating concrete (8 inches thick). It is contained within a full-height steel secondary container also toroidal in shape, but without a separate steel top. There is a 2-ft 6 in. annulus between the outside of the primary container and the secondary container. The secondary container is encased in a concrete vault ranging from 2.5 to 4 ft thick. Penetrations through the roof provide openings for instrumentation, ventilation, and waste transfers as well as access to the tank space and annulus for inspections and entry of cooling coils. The design is described in greater detail in Appendices A and B and also in Section II-4 of ERDA-1537, *Waste Management Operations*, SRP.

The Type III tank design drew on the years of operating experience accumulated with the earlier types of waste tanks (I, II, and IV). One of the most important changes was the incorporation of a postfabrication heat treatment to the primary tank to eliminate the high residual stresses induced by seam welding in the field of the many individual steel plates which go to make up a single tank. High residual stress is an essential factor in promoting the stress corrosion cracking which has been experienced in nine of the sixteen Type I and II waste tanks (see Appendix B). The efficiency of the stress-relieving heat treatment applied to all Type III tanks is evidenced by the fact that no leaks have been observed in any of the nine Type III tanks put in service to date (initial service began in 1971).

Other major design improvements incorporated in the successive Type III tanks include full-height steel secondary vessels (vs. the 5-ft high "pans" under the Type I and II primary tanks), air cooling of the center column and bottom of the primary tanks, roof support column mounted on the tank foundation, and bottom-supported, distributed cooling coils. In addition, numerous improvements have been incorporated in instrumentation, surveillance and leak detection facilities, off-gas and spill monitoring, materials of construction, and quality control specifications and surveillance. The initial and subsequent improvements incorporated in the Type III tanks are summarized in Table 3-5 and discussed in the following sections. Additional details concerning design features, quality control practices, and other measures to provide increased assurance against escape of radioactive waste from storage facilities are presented in Appendix A.

3.2.2 Tank Design Improvements and Engineered Safety Features

Specially designed features are provided to mitigate the consequences of abnormal events or postulated accidents. In addition to these engineered safety features, administrative controls provide detailed procedures for performing normal operations and methods for recognizing and correcting abnormal conditions.

TABLE 3-5

Improvements in SRP High-Level Waste Tank Design

Tank Type	*I*	*II*	*III*	*III*	*III*	*III*	*III*	*III*	*III*	*III*
Tank Numbers	*1-12*	*13-16*	*29-32*	*33, 34*	*35*	*36, 37*	*25-28*	*38-43*	*44-47*	*48-51*
Project No.					*74-1-a*	*74-1-a*	*75-1-a*	*76-8-a*	*77-13-d*	*78-18-b*
(DuPont Project No.)	*(8980)*	*(PWO)*	*(1232)*	*(974)*	*(1463)*	*(1463)*	*(1493)*	*(1618)*	*(1747)*	*(1828)*
• Primary Liner Stress Relief			✓	✓	✓	✓	✓	✓	✓	✓
• Single Roof Support Column		✓	✓	✓	✓	✓	✓	✓	✓	✓
• Full-Height Secondary Liner			✓	✓	✓	✓	✓	✓	✓	✓
• Secondary Liner Leak Detection										
a) Radiation Probe Conduits						✓				
b) Collection Channel Grids and Sump							✓	✓	✓	✓
• Primary Liner Steel Specifications	A-285 Grade B →		←		A-516 Grade 70		→	←	A-537 Class I	→
a) As rolled	✓	✓	✓	✓						
b) Normalized					✓	✓	✓	✓	✓	✓
c) Sand- or Grit-Blasted								✓	✓	✓
• Secondary Liner Steel Specifications	A-285 Grade B →		←			A-516 Grade 70				→

TABLE 3-5, Contd

Tank Numbers	*1-12*	*13-16*	*29-32*	*33,34*	*35*	*36,37*	*25-28*	*38-43*	*44-47*	*48-51*
• Fixed Distributed Cooling Coils	✓	✓				✓	✓	✓	✓	✓
• Bottom Support of Cooling Coils Except 32 and 35			✓	✓		✓	✓	✓	✓	✓
• Air-Cooling Under Primary Tank			✓	✓	✓	✓	✓	✓	✓	✓
• Permanently Installed Annulus Jets	*	*	*	*	✓	✓	✓	✓	✓	✓
• Hydrogen Monitors	**		*	*	✓	✓	✓	✓	✓	✓
• Wire Mesh Separators	***	***	✓	✓	✓	✓	✓	✓	✓	✓
• Entry Line Jackets Continuous to Primary Tank					✓	✓	✓	✓	✓	✓
• Fully Shielded Vent Condenser and Filter					✓	✓	✓	✓	✓	✓
• Tank Top Sloped to Drain Rainwater							✓	✓	✓	✓
• Multiple Inspection Ports into Annulus		*			✓	✓	✓	✓	✓	✓

* Added later.

** Added to Tank 4 only (fresh HHW receiver).

*** Being added to evaporator feed tanks (7 and 13) and tanks scheduled for salt removal (1,2,3,9,10,19,20,22,24).

3.2.2.1 Single Roof Support Column

Improved stress distribution in the primary tank is achieved by mounting the roof supporting column on the foundation pad rather than on the bottom of the primary tank (as in Type I tanks with 12 columns and Type II tanks with one central column) and by providing an annular clearance around the roof supporting column.

3.2.2.2 Full-Height Secondary Liner

Tank design without an annular space was rejected because of the reduction in leak detection capability and the loss of containment capability should the primary containment be breached. A secondary containment other than full-height (vs. 5-ft pan for Type I and II tanks) steel liner was rejected because of the loss of containment capability for high leak rates. Secondary containment permits annulus jets to transfer the leaking material back into the tank before it reaches the environment. Then the tank contents can be transferred to another tank, if required. Spare tank volume is maintained in sound double-walled tanks in each of the two waste tank areas (F and H). This volume is equivalent to the largest volume of waste stored in any one tank.

3.2.2.3 Secondary Containment

All primary transfer systems and storage containers have secondary containment. Transfer lines are jacketed in secondary containers which drain to collection and leak detection boxes. All connections in transfer lines such as diversion boxes, waste tank inlet risers, or evaporator enclosures have secondary containment. The Type III tanks (25-51) have full-height secondary tanks about the primary tank.

In the FY-1974 and subsequent Type III tanks, the packed telescoping joint in the line jackets is eliminated, and the jacket is continuous to the tank interior with a seal weld to the primary tank upper knuckle. This provides greater jacket integrity and permits hydrostatic testing of the jacket. To accommodate expansion, the jacket passes through a slightly larger pipe sleeve welded to the secondary liner and embedded in the concrete vault wall. The annulus between the jacket and the sleeve is packed with asbestos to seal off the tank annulus space from the tank exterior.

3.2.2.4 Leak Detection Systems

Conductivity probes and pneumatic level measuring devices are installed in the secondary container around each Type III waste tank to detect any accumulation of waste due to failure of the primary tank. These devices have visual and audio alarms located in the operating control rooms.

More recently installed transfer lines also have leak collection boxes installed in the transfer line jacket at the low point of the line. In the unlikely event that a leak develops in the transfer line, the waste would drain to the collection box and be detected by a conductivity probe.

3.2.2.5 Secondary Liner Leak Detection

a) Collection Channels and Sump

Beginning with waste tanks constructed under the FY-1975 project, the capability to monitor for leaks in the secondary container was added. This feature will permit verification of the integrity of the secondary container. A grid of interconnected radial channels is formed on the inside of the concrete base slab on which the secondary tank rests. The channels are sloped to drain through a collection pipe to a sump inside the concrete enclosure around the tanks. An access pipe rises to grade from the sump to allow for liquid measurement, sampling, and pumpout of any liquid collected.

b) Radiation Probe Conduits

A gamma monitoring tube network was installed beneath the tank foundation slab of Tanks 36 and 37 (FY-1974, Project 74-1-a) because no leak detection grid (as planned for future Type III tanks) was included in this project. (The gamma monitoring network was not installed under Tank 35, also a FY-1974 tank, because the tank was urgently needed for fresh waste service, and the installation of monitoring tubes would have significantly delayed completion of this tank.)

Twice yearly a gamma radiation detector is passed into the tube liners. Because there is earth and concrete shielding between the tubes and the stored waste, radiation levels in the liner are low, and indications of high radiation would indicate waste in the ground outside the tank. The count rate is observed for any change from background.

Gamma radiation monitoring was replaced by the grid system of channels (Section 3.2.3.5.a) because drainage to the sump can be continuously monitored if desired, as opposed to checks twice per year with the radiation monitor. The grid system was also less expensive and provided perhaps better leak detection capability.

3.2.2.6 Improved Primary Liner Steel Specifications

a) Specially Heat Treated Steel

FY-1976 tanks were constructed with normalized A 516-70 steel. Normalizing is a heat treatment (analogous to annealing) that refines grain size and improves the toughness of the steel plate. A 537-Class 1 steel was used for FY-1977 and -1978 tanks. This steel is supplied only in normalized condition, and the chemical composition is similar to A 516-70 except that minor alloying additions are specified to ensure higher and more uniform strength among various heats of the steel. See Appendix B for additional discussion of the selection of materials.

b) Sandblasting

Tank surfaces are sand- or gritblasted prior to tank fabrication to facilitate inspection requirements. Plate surfaces are inspected for inclusions and laminations. These defects are easier to detect with mill scale removed by the sandblasting. Plate edges are ground clean and smooth to inspect for end laps.

3.2.2.7 Fixed Distributed Cooling Coils

The first seven Type III tanks built were designed to be cooled by up to ten removable cooling bundles containing many vertical pipes spaced a few inches apart. The primary objective of the design change from the distributed coils (on four-foot centers) used in the Type I and II tanks was to make the coils replaceable in the event of failure. For the same reason, the horizontal coils of the earlier tanks were omitted from the Type III models because they could not be made replaceable, and experience had shown that most of the fission product heat from the sludge layer was first transmitted into the supernatant liquid and thence into the vertical coils. Air cooling under the primary tank bottom was provided to ensure that the tank steel does not become overheated.

Close-packed coil bundles are adequate for cooling unevaporated (as received) waste, including a sludge layer several feet thick, because thermal convection circulates the supernatant liquid and carries the heat to the coils. However, in tanks receiving evaporator concentrate, cooling surfaces soon became encrusted with crystallized waste salts and all heat must flow through the deposited salt by conduction, which is relatively inefficient. Hence cooling coils must be distributed as widely and uniformly throughout the tank as possible, so that a maximum volume of solid salt can be accumulated before the salt thickness on any one coil becomes too great to pass its share of the heat to be dissipated.

For this reason, tanks authorized in FY-1974 and subsequently (except Tank 35) have been or are being provided with distributed coils on three-foot triangular centers, sacrificing replaceability for improved efficiency in concentrate service.

Unlike the distributed vertical coils in the Type I and II tanks, which are supported from the tank roof, the distributed coils in Type III tanks are supported from the tank bottom. This change eliminates any possibility of overloading the roof if the accumulated salt mass settles several inches, carrying down the coils embedded in it.

The distributed cooling coil system is designed to cool waste concentrate adequately despite salt encrustations, as discussed above. At maximum salt accumulation the system can remove 1/2 million or more Btu/hr per tank, sufficient to remove both sensible and radiolytic heat from evaporator concentrate. In non-saturated waste solutions, the system has a nominal design rating of six million Btu/hr, and can handle at least ten million Btu/hr for liquid waste in which convection cooling is effective. However, based on experience, an operating limit of 3.5 million Btu/hr is applied to tanks receiving fresh high-heat waste to assure adequate heat removal from the sludge into the supernate.

3.2.2.8 Air Cooling Under Primary Tank

Type III tank ventilation and dehumidification systems not only supply low relative humidity air to the outer annulus space directly but also route part of the air to the inner annulus, and from there it passes beneath the primary tank through radial channels in the concrete base slab and exhausts into the outer annulus. The annulus ventilation system has a capacity of about 8000 cfm, up to half of which can be passed through the inner annulus and beneath the primary tank in tanks for FY-1976, -1977, and -1978, compared to 1000 cfm in earlier Type III tanks. The increased airflow is to aid in cooling the tank bottom. This cooling eliminates the need for horizontal coils near the bottom of the tanks.

3.2.2.9 Permanently Installed Annulus Jets

These are steam-jet eductors used to transfer liquids. All the waste tanks have jets installed in the annulus to provide a ready means to transfer any leakage into the annulus back into the tank before any release to the environment. Then the tank may be emptied if required. The jet steam service is connected when service is required.

3.2.2.10 Ventilation Systems

The ventilation systems that provide an air sweep through waste tanks are designed to maintain the vapor space negative with respect to atmospheric pressure. This negative pressure prevents the release of contaminated air to the atmosphere during normal operation through inadequately sealed risers or tank openings. In the event of loss of forced ventilation or of a loss of cooling which could result in the liquid contents reaching the boiling point, particulate filters on both the exhaust and inlet piping will minimize the release of airborne radioactivity to the atmosphere.

3.2.2.11 Hydrogen and Radioactivity Monitors

Instrumentation to monitor continuously the concentration of hydrogen in the gas mixture within each waste tank and the radioactivity in filtered air leaving the tank was installed in FY-1974 and all later tanks.

a) Hydrogen Monitors

Waste water decomposes into H_2 and O_2 in high radiation fields. In a full, fresh high-heat waste tank (3.5×10^6 Btu/hr), the decomposition is rapid enough to reach the flammable limit in less than half a day unless purge ventilation is maintained.

Hydrogen monitors are included for the new tanks to provide continuous monitoring of the vapor exhausting from the tank to detect any increase in hydrogen content in the tank. The system includes a combustible gas detector, a control unit, a gas sampling system, and an alarm.

The gas in the sample is subject to flameless burning on the face of a catalyst-coated sensing element where a change in electrical resistance, highly specific to the proportion of combustible gas in the sample, takes place. Changes in electrical balance are sensed at the control unit to produce appropriate meter and indicator displays. System alarms produce immediate followup by operating and Health Protection personnel to determine the cause of the alarm.

b) Radioactivity Monitor

A fraction of the tank exhaust air, after filtration, is passed at 3 to 5 cfm through a 3-in.-diameter filter paper. The filter paper is monitored by a photomultiplier tube whose signal is amplified and sent to the tank farm control room. The detector alarms at an increase in radioactivity above background, currently about 1500 c/m beta-gamma, and alerts operating and Health Protection personnel to check for an abnormal condition. The filter paper is routinely changed weekly, if no abnormal conditions occur, and processed through the Health Protection Department counting room to measure and maintain records of low-level radioactive release from the tank.

3.2.2.12 Radiation Monitors

Gamma monitors are strategically located above the waste tanks throughout the tank farm to detect any increase in the atmospheric radioactivity. In addition, a gamma monitor is mounted at each concentrate inlet riser to alert personnel quickly to any surface spill. Each monitor has an alarm in the operating control room.

3.2.2.13 Wire Mesh Separator

Wire mesh separators are installed on Type III tanks. The tank air purge leaving the tanks pass through the separator to remove entrained liquids. The effluent from a separator passes through a water-cooled condenser to remove excess humidity and entrained radioactivity. The condensate is recycled to the tank. The saturated air from the condenser is then heated to a temperature above its dew point to prevent moisture from condensing on and blinding the exhaust filters with subsequent loss of filter efficiency.

3.2.2.14 Automatic Air Blow of Gang Valves

If steam pressure is lost during operation of a transfer jet (steam-jet eductor), the potential for suckback of waste into the gang valve exists. To prevent this, a bypass is installed from
C| the air header to the process side of the gang valve. In case of loss of steam supply, the pressure switch located in the steam supply will signal the automatic valve in the plant air line to air blow the gang valve.

3.2.2.15 Emergency Power

Each waste tank farm is provided with emergency diesels that will provide power to critical systems (such as cooling water pumps, liquid level instrumentation, ventilation, etc.) in the event of loss of normal power.

3.2.2.16 Earthquake Protection

All new waste tanks (FY-1974 project and beyond) and new evaporator facilities are constructed to maintain functional
C| integrity in a design basis earthquake (DBE) producing ground accelerations at the site of 20% of the acceleration of gravity (0.2 g) at zero period. Studies* of the effects of such an earthquake on existing waste storage tanks concluded[5] that (1) the primary containers would not be damaged if fill limits are not exceeded, (2) the secondary metal containers would not be damaged, and (3) moderate cracking of the concrete structures could occur.

3.2.2.17 Tornado and Hurricane Protection

All new waste tanks (FY-1974 project and beyond) were designed to maintain functional integrity in the following design basis** tornado or wind storm:

- 290-mph tangential velocity (230)
- 70-mph transverse velocity (50)
- Average 3-psi ambient pressure drop in 3 seconds (1.5)
- Wind-generated missiles

The numbers in parentheses are the present values for the design basis tornado at SRP based on the referenced Texas Tech** report, but were derived after the waste tank design was adopted. The design basis tornado has an estimated recurrence frequency of less than 10^{-5} per year.

C| * Effects of a DBE on underground waste storage tanks were evaluated by John A. Blume & Associates, Seismic Analysis of Waste Storage Tanks, Report DPE-3409, E. I. du Pont de Nemours & Co. (Inc.), Design Division, Engineering Department, Wilmington, DE (1975).

** The design basis tornado for SRP was derived from a study by Texas Tech University, "Development of Windspeed Risk Models for the Savannah River Plant Site," Institute for Disaster Research and Department of Civil Engineering, Lubbock, TX (October 1975).

Detailed evaluation of tornado resistance of the present waste tanks leads to the following conclusions:

- Small high-velocity missiles and massive low-velocity missiles could damage above-ground structures (e.g., ventilation equipment) and disrupt electrical services. Activity release from the waste tank would be minor.

- The primary liner of any double-walled tank may deform below the top knuckle if the annulus pressure exceeds the internal pressure by some specific amount, which ranges from 1.3 to 2.7 psi. Pressure differentials in that range are unlikely, because the area of the annulus vent is about nine times that of the tank vent, and damage would probably increase the areas of the vents.

- Small lightweight plugs could possibly be lifted from the tank and tank annuli and transferred as missiles. It was concluded that waste would not be entrained or aspirated from the tanks because the area of the openings exposed to the liquid is relatively small, and the distance from the ground surface to the liquid surface is large. The riser plugs do not have to be restrained against tornado forces.

Above-ground structures (with the exception of the evaporator) can be assumed to lose their function in the event of a design basis tornado.

The likelihood of release of radioactivity from waste handling and storage equipment as a result of hurricane-generated winds is much lower than for a tornado. The maximum recorded wind speed of 75 mph for the plantsite occurred during passage of hurricane Gracie in 1959, and no significant damage occurred on the plant. This wind speed is about the maximum expected because of the inland location of the plant.

3.2.2.18 Closed Loop Waste Tank Cooling System

The cooling water system is operated at a pressure greater than the hydrostatic head of the waste at maximum fill level. If a leak develops in a cooling coil, the waste will not enter the cooling water system, but rather cooling water will flow into the tank. The proper cooling water pressure is maintained by an elevated surge tank in the closed cooling loop. Heat is removed by a cooling tower.

3.2.2.19 Storm Water Diversion System

Each waste tank farm has a storm water sewer system to route surface water runoff through a monitor before discharge to Four Mile Creek. Because this sewer drainage may become contaminated from surface spills of waste, the system is segregated and continuously monitored with swirl-cell gamma detectors.

The F- and H-Area waste farms are divided into zones, based on the terrain. Each zone is monitored individually, and if any monitor detects radioactivity, the contents of that sewer system are automatically (or manually) diverted to a lined retention basin for further handling. Once it is in the retention basin, the water may be:

- Pumped to natural effluent streams if within guidelines.
- Pumped to seepage basins if this would not exceed the current operating guide limits for such discharges.
- Pumped through a filter-deionizer system for removal of radioactivity with effluent from this system recycled to the retention basin, sent to seepage basins, or released to a plant stream. The filter-deionizer would be regenerated, and the radioactivity collected would be sent to waste tank storage.

A radiation detector is installed in the storm sewer for each zone and is located sufficiently upstream from the diversion gates to allow the necessary response time for operating the sluice gates. The radiation detector will automatically initiate diversion of storm water when gamma activity greater than normal is detected. Although some radionuclides included in liquid waste are not gamma emitters, they are always accompanied by other gamma-emitting fission products. An alarm is sounded and a sample of water is collected automatically when water is diverted.

On signal from a storm sewer monitor, the appropriate storm water sluice gates will operate to divert flow (which otherwise would go to Four Mile Creek) to the retention basin. Sluice gates are driven by electric motors. Manually operated handwheels are provided for emergency use. Storm water sluice gates and water monitors are furnished with emergency power.

The storm water systems are automatically (or manually) diverted to controlled holding areas if they become contaminated to levels that exceed established operating guides. These guides are well within the release limits cited in ERDA Manual Chapter 0524.

3.2.2.20 Monitoring Wells

A system of monitoring wells is provided within and about the radioactive waste storage sites to monitor for leaks from waste tanks, transfer lines, and other tank farm equipment and to monitor possible migration of radionuclides from their storage locations.

Two types of wells are installed: dry wells in which a gamma radiation monitor is inserted to measure increases in radiation dose rates and water wells from which water samples are drawn for laboratory analysis.

Currently there are 73 dry monitor wells and 49 water monitor wells in the F- and H-Area waste tank farms. Thirteen of the water wells are being used to monitor for any leakage from Tank 16 sludge removal and chemical cleaning.

The Health Protection Department personnel routinely collect and analyze samples from the water wells and routinely monitor radiation levels in the dry wells.

3.2.3 Reasonably Foreseeable Environmental Effects

The only significant adverse effects caused by the construction and operation of the new waste tanks will be (1) the small offsite population dose commitment (less than 1.3 man-rem for population living within 150 km of SRP) from release of radionuclides, primarily tritium as water vapor from the waste tanks, and (2) the commitment of about one acre of land for each waste tank for an indefinite period.

Use of the new tanks will provide safer containment for future waste produced as a result of operation of SRP for defense purposes. In addition, these new tanks will allow early retirement of older design tanks, which have a greater potential for adverse environmental effects because they do not have all of the design improvements incorporated in the new tanks.

3.2.4 Effect on Tank Durability

Design of the new waste tanks has incorporated features which help maximize the durability of the tanks for the service*

* Service includes receiving fresh high-level liquid radioactive waste, storing waste while it cools and while a layer of insoluble sludge forms on the bottom of the tank, receiving evaporator concentrate, and storing crystallized salt formed from evaporator concentrate.

for which they will be used. These features include improved steel, stress relief of the steel, full secondary containment, improved ventilation of the tank bottom and annulus, excess cooling capacity, leak detection instrumentation, and continuous gas and radioactivity monitoring.

Continuing operational control of the waste composition sent to the tanks will also contribute to maximum tank durability.

3.2.5 Effect on Ease of Waste Retrieval from the Tanks

Waste retrieval has already been successfully demonstrated from similar tanks, and therefore there is no adverse effect foreseen in the design of the new waste tanks.

3.2.6 Relationship to Long-Term Waste Management Program

The Waste Management Program has required in the past and will require in the future the transfer of liquid, sludge, and salt between tanks to fulfill the requirements of the program. Such transfer, of course, is essential to the long range plans to remove the waste from the tanks for final disposal. Experience gained with the sludge removal and chemical cleaning of Tanks 10 and 16 indicates that the present tank design permits efficient waste transfer and tank cleanout.

Installation of the new tanks is highly desirable for completion of a long range waste disposal program in an efficient manner. In particular, segregation of older waste (both sludge and salt) from more current waste is made possible by use of the new tanks. Another advantage is that the waste is maintained in an easily retrievable condition.

The Department of Energy has published the Final Environmental Impact Statement, Long-Term Management of Defense High-Level Waste (R&D Program for Immobilization), Savannah River Plant (DOE/EIS-
C| 0023), November 1979, to analyze the environmental implications of the proposed continuation of a large Federal research and development program directed toward the immobilization of SRP high-level waste. The new waste tanks will provide reliable storage of the waste and allow adequate time to implement the strategy of the long-term management plan.

3.2.7 Waste Tank Utilization Plans

Current plans for utilization of existing and new waste tanks at SRP are shown graphically in Appendix F. This is the January 1980 forecast of tank usage. These forecasts are routinely updated.

Most of the new tanks will be placed in service almost immediately after their completion, with several serving temporarily as receivers for supernate currently stored in older-design tanks. Liquid supernate will be transferred directly from older tanks to the new ones; this transfer will be completed by the end of CY-1981. Direct transfer of supernate, rather than processing it through the evaporators, will make it possible to remove the more mobile liquid from the older tanks earlier than could otherwise be done. Salt dissolution and transfer will begin also in CY-1980 and be essentially complete by the end of CY-1982. Except for the Tank 16 demonstrations, sludge removal operations will not begin until CY-1982; these operations will continue through CY-1987.

Sludge and salt removal, chemical cleaning, decommissioning, and dismantling of waste tanks are discussed in more detail in Appendix C.

3.3 OTHER ALTERNATIVES

As described in Section 3.2, the design of the SRP Type III waste tanks has evolved continuously over a twenty-five year period and has involved the review of a large number of alternative designs with the steady incorporation of advantageous new features and the rejection of others. Construction of the waste tanks in the 1976, 1977, and 1978 SRP projects according to the latest developments in the Type III tank design is now substantially complete. However, the Court requested a rereview of the specific design and safety features of the Type III tanks. The Court-ordered alternatives for SRP are thicker and more chemically resistant steel plates, an impressed current cathodic protection system to guard against stress corrosion cracking, better waste retrieval equipment, and enlarged tank openings to facilitate retrieval.

3.3.1 Thicker and More Chemically Resistant Tank Steel

The alternative of using thicker and more chemically resistant steel plates for the tanks to enhance resistance to corrosion and increase tank life is examined in this section. The use of thicker and more corrosion-resistant steel plates has no effect upon either the ease of waste retrieval or on the choices of technology for long-term waste storage or final disposal. It does have some perceived effect upon tank durability, and therefore on reducing the potential for adverse environmental effects in the event of containment failures.

The tank life predictions are based on the following considerations:

- A survey[6] of the life of large, field-erected, carbon-steel vessels from several hundred cases in industrial and utility service indicated a service life ranging from 40 to 60 years for above-ground steel storage tanks (accessible for inspection and maintenance painting). Buried steel tanks or pipelines in corrosive soil conditions can have extremely short lives of 3 to 10 years. However, in the underground SRP storage tanks, ground contact with the primary and secondary tanks is prevented by the concrete support structure. The dry air in the annulus reduces external corrosion to an even greater extent than for painted field-erected tanks, and the life expectancy of the waste tanks should be at least comparable to these tanks.

- Wall thickness measurements on all Type I, II, and III SRP tanks, some with up to 25 years of service, and measurements of the bottom plate thickness on two SRP tanks have shown no wall thinning due to general corrosion. The ultrasonic method of measurement of tank wall thickness can detect a loss of about 0.03 inch or more, or a general corrosion rate of less than 0.001 in./yr. Test coupons exposed in synthetic and actual waste solutions showed both general and pitting-type corrosion to be insignificant (rates of less than 0.001 in./yr). Examination of one of the cracked tanks (Tank 16H) showed that the stress-corrosion cracks originated on the internal surfaces and that corrosion on the external surface of the steel was minor. Thus, general corrosion appears to be a negligible factor as a life-limiting feature for the SRP waste tanks. It is therefore not obvious that increases in wall thickness or in general corrosion resistance would contribute to an increased life of the SRP tanks beyond the 40-60 year estimate, even if that were required.

The alternative of more chemically resistant plates has, in essence, been adopted via the change to a normalized (heat-treated) steel and postfabrication stress relief of the primary tanks. As described in Appendix B, the corrosion resistance of the steel used in waste tanks has been studied extensively at Savannah River, and the key factor has been found to be stress corrosion. The steel used in the early tanks (ASTM A285-B, not stress-relieved), was susceptible to nitrate stress corrosion. Studies have shown that the Type III tanks (constructed since 1967), which are made of ASTM A516-70 or ASTM A-537 Class I steel and which are stress-relieved after erection, have greatly improved resistance to stress corrosion. No leaks have been observed in Type III tanks in the eight years that they have been in service, whereas leaks were observed in Types I and II tanks in less than one year. Furthermore, improvements in the control of waste composition, which were adopted in 1977, have also reduced the probability of stress corrosion cracking.

The wall thickness specification of the new tanks was based upon consideration of working stress instead of thinning due to corrosion. Based on the measurements mentioned earlier, the thickness of the steel in the tank walls is considered adequate. Adequate resistance to applied mechanical forces basically involve general engineering principles and is primarily a function of design, yield strength of the steel, and section thickness. This aspect of waste tank construction is straightforward, and thicker walls are not required to meet the structural requirements.

3.3.1.1 Reasonably Foreseeable Environmental Effects

The environmental effects of using tanks with thicker walls would be the same as for the waste tanks currently under construction. However, requiring thicker steel walls would entail abandoning the tanks currently under construction and building new tanks. Thus, there would be an incremental impact on construction and demand on land. This would delay the program to empty, chemically clean, and remove from service the Type I and II tanks (nine of which have leaked), and pose a higher potential risk to the environment.

A major impact of requiring thicker steel plates is cost. Stopping construction and not utilizing the tanks under construction would result in the loss of about $80,000,000 already spent or committed. Construction of tanks with thicker walls would cost more than the $126,000,000 authorized for the 14 tanks under construction.

3.3.1.2 Effect on Tank Durability

There is a perceived safety factor in thicker walls; however, fabrication, welding, and stress relief of thicker plates is more difficult and potentially less efficient. Since the experience with SRP tanks in service for periods up to 25 years has shown that there is no problem with general corrosion, thicker steel plates might actually result in lower durability due to the more difficult fabrication problems.

3.3.1.3 Effect on Ease of Waste Retrieval from the Tanks

Tank wall thickness would not have any effect on waste retrieval because waste retrieval equipment is supported by the concrete structure on top of the tank.

E | #### 3.3.1.4 Effect on Choice of Technology and Timing for Long-Term Radioactive Waste Storage and Final Disposal

There are no foreseeable effects.

3.3.1.5 Advantages and Disadvantages

The advantages and disadvantages of thicker and more corrosion-resistant steel are summarized as follows.

Advantages

- Perceived safety factor due to thicker steel to compensate general corrosion.

Disadvantages

- Delay in implementing interim waste management program
- Difficulty in fabricating, welding, and stress-relieving the steel
- Additional cost for new tanks
- Loss of money already spent on tanks under construction
- Incremental impact due to construction and demand on land

3.3.2 Cathodic Protection

Corrosion of a metal can be defined as loss of metal by a chemical reaction in which the metal is converted to an oxidized state. This reaction is accompanied by loss of electrons from the metal to the surroundings in the form of an electric current. Suppression of this current, by impressing an external electric potential (such as from a battery or rectifier), prevents the corrosion. This process of suppression is called cathodic protection. One method to implement cathodic protection involves the use of an active metal anode (such as magnesium or aluminum) to supply electrons by corroding preferentially to suppress the corrosion of the desirable structure. In essence the active anode forms a battery with the structure to be protected. A combination of chemically inert anodes and power rectifiers to supply an external potential can also be used. In the case of the tanks, the latter method would be employed and the inert anodes would be immersed in the waste solution in the tank and the current impressed between them and the tank.

Cathodic protection is used to protect metal surfaces that are exposed to moist or wet corrosive conditions. Two factors control the effectiveness of cathodic protection: the surface potential of the metal (the amount of force needed to drive electrons from the metal as it is being oxidized or corroded, measured as V[olts] and the current density (the amount of electrical current in milliamperes per unit area resulting from the surface potential on the metal surface). The relationship between these two factors is primarily influenced by the composition of the metal, but it is also influenced by the oxidized corrosion surface layer (rust) on the metal, crevices and pits in the metal surface, stress on the metal, and the temperature of the metal and the surrounding solution. The current flow required for successful cathodic protection alters the chemical compounds where the metal and solution meet, but at the low current densities usually required for satisfactory corrosion control, this effect is insignificant, unless the metal is very sensitive to the altered environment.

Under proper conditions cathodic protection can prevent general and pitting corrosion and the initiation of stress cracks. It cannot, however, prevent propagation of existing cracks. Cathodic protection was considered for SRP waste tanks in 1972.[7] This 1972 study concluded that cathodic protection could be feasible for waste tanks but only after solution of several technical, engineering, and maintenance considerations centering around proper current distribution. After an analysis of the requirement of maintaining uniform electrical potential and current flow, it was concluded that (1) sludge would need to be suspended in the supernate at all times, (2) formation of a salt cake would introduce large uncertainty on the effectiveness of cathodic protection, (3) a system of monitoring for uniform distribution of current potential and flow over a long period of surveillance would be required, (4) a high integrity system to electrically insulate the anode from the tank would be required to prevent electrochemical attack of the tank, and (5) the possibility of accelerated corrosion due to stray currents would need to be evaluated. Many of these requirements, such as those to keep the sludge suspended at all times and not to evaporate the supernate to salt, are in direct conflict with the current SRP interim management program for high-level waste of maintaining waste in solid form to the extent practical and could appreciably increase the hazards in the interim program.

As a result of the improved tank construction including improved materials of construction, stress relief of finished tanks, and better understanding and definition of SRP waste that caused corrosion problems in waste tanks, development of the information necessary to implement cathodic protection was not undertaken. In fact, implementation of cathodic protection in waste tank service was judged to be counterproductive.

3.3.2.1 Reasonably Foreseeable Environmental Effects

The primary environmental effect is the potential problem due to the production of reactive gases with the requirement for sufficient ventilation of the vapor space above the waste in the tanks. Keeping the waste in liquid form would also increase the potential environmental risk.

The consumption of electricity would be negligible.

3.3.2.2 Effect on Tank Durability

A properly designed and adjusted cathodic protection system might eliminate general and pitting corrosion, and enhance tank durability. However, there must be a uniform distribution of current to prevent increased localized corrosion. Therefore, the cathodic protection system may be detrimental because of design, installation, operating, and monitoring problems.

The cooling coils in the waste tanks would be especially susceptible to corrosion problems if the cathodic protection system were not properly adjusted.

3.3.2.3 Effect on Ease of Waste Retrieval from the Tanks

The effect of cathodic protection on waste retrieval is to alter the composition of the waste by electrolytically converting water in the waste to H_2 and O_2, nitrate to nitrite, nitrite to nitrogen or ammonia and converting more sodium hydroxide to sodium carbonate because the increased ventilation will bring more carbon dioxide to the waste surface. Easily platable cations such as ruthenium, copper, and nickel will be reduced to metal on the tank wall and may adhere, thus making their removal difficult.

3.3.2.4 Effect on Choices and Timing on Technology for Long-Term Radioactive Waste Storage and Its Final Disposal

There are no foreseeable effects.

3.3.2.5 Advantages and Disadvantages

The advantages and disadvantages of a cathodic protection system are summarized as follows.

Advantages

- Eliminate general and pitting corrosion

Disadvantages

- Difficult to design and to maintain proper adjustment.
- May not provide uniform distribution of current
- Produces reactive gases
- Possible adverse effect on retrieval of waste

- May produce a steel surface potential conducive to stress cracking
- Use of electrical energy
- Additional studies relating to the engineering and maintenance considerations of ensuring proper electrical potential and current distribution are required
- May require keeping sludge in solution and stopping the salt crystallization program, both of which would increase environmental risk. Additional tanks would be required to store the more dilute waste.

3.3.3 Better Waste Retrieval Equipment and Enlarged Tank Openings

Although adequate waste removal methods have already been demonstrated for routine waste management operations as described in Appendix C, the sludge removal and chemical cleaning program for Tank 16 now in progress and salt removal techniques planned for 1980 are expected to develop more efficient methods to remove the wastes for the waste solidification program. This work includes testing and evaluation of existing equipment as well as development of improved equipment, as appropriate.

The long-shafted pumps that are being used to remove liquid waste, redissolve salt, or slurry sludge from the tanks are designed to fit into any tank riser two feet or larger in diameter. The SRP Type III waste tanks (No. 38-51) contain 9 access risers three feet or more in diameter which can be made available for use in retrieving waste. These risers are distributed over the tank top to provide adequate coverage for waste removal.

Pumping of all three waste products has been demonstrated in existing waste tanks by dissolution and hydraulic slurrying techniques. Therefore, larger riser openings are unnecessary.

There are good reasons to maintain riser openings as small as practical to provide maximum roof strength and to minimize release to the environment from any severe reaction within the tank or releases caused by tornadic winds removing the riser covers.

3.3.3.1 Reasonably Foreseeable Environmental Effects

No significant environmental effects, either positive or negative, are foreseen if the present openings were enlarged by 50%. However, the holes should be as small as practicable to minimize releases of radioactive material to the environment due to a reaction in the tank or as a result of a tornadic wind removing riser covers.

3.3.3.2 Effect on Tank Durability

Enlargement of tank top opening may reduce the stability of the tank top and therefore influence tank durability or the ability to retrieve the waste.

3.3.3.3 Effect on Ease of Waste Retrieval from the Tanks

Present waste retrieval systems involve slurrying and pumping. These systems can be accommodated in the present tank openings. Improved retrieval equipment can be designed to fit the present openings.

3.3.3.4 Effect on Choices and Timing of Technology for Long-Term Radioactive Waste Storage and Its Final Disposal

No effects are foreseen because the openings could be enlarged in the future if required to accommodate improved waste retrieval methods or equipment with essentially no environmental effects.

3.3.3.5 Advantages and Disadvantages

The possible advantages and disadvantages of enlarged tank openings and better waste retrieval equipment are:

Advantages

- Greater flexibility for equipment design
- Higher capacity units (need has not been demonstrated)
- Less time required for waste removal and cleaning (not demonstrated)

Disadvantages

- Possibly decreased tank roof strength
- Larger openings for radioactive material release
- Difficulty of sealing larger openings

3.4 NO ACTION ALTERNATIVES

The "No Action" alternatives were discussed in ERDA-1537 as follows:

Alternative 1 — store no additional radioactive waste onsite as a result of:

- shutdown of production operations, or
- processing of irradiated fuel at another site, or
- shipping all newly generated wastes to an offsite facility for processing and storage (except low-level waste)

Alternative 2 — store no radioactive waste onsite and restore waste management areas to their preplant condition

Alternative 3 — indefinitely continue present waste management practices without additional improvements

Implementation of any of these "No Action" alternatives would either preclude SRP from meeting its mission of producing special nuclear material for national defense or result in violation of DOE Waste Management policies. These "No Action" alternatives are therefore not considered to be consistent with the operation of the SRP and with the objectives of lowest practical radioactive releases and the best use of available technology.

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