E.4 HEALTH EFFECTS STUDIES: EPIDEMIOLOGY

Various epidemiologic studies have been conducted at some of the sites evaluated in this PEIS because of the concern for potential adverse health effects associated with the manufacture and testing of nuclear weapons. These studies focus on the DOE workforce and residents of communities surrounding DOE sites.

E.4.1 Background

The health effects associated with ionizing radiation exposure were first published about 60 years ago. Studies published in the 1930s first documented cancer among painters who used radium to paint watch dials back in 1910 to 1920. Radiation therapy for disease has been used since the 1930s and studies have shown that the risk of cancer was related to the amounts of radiation received. Nuclear weapons research and manufacture, and consequent exposure to radiation occurred beginning in the late 1930s. Exposure to radionuclides has changed over time with higher levels occurring in the early days of research and production. Numerous epidemiologic studies have been conducted among workers who manufactured and tested nuclear weapons due to the concern with potential adverse health effects. More recently, concerns about radiologic contaminants offsite have resulted in health studies among communities that surround DOE facilities. The following section briefly gives an overview of epidemiology followed by a review of epidemiologic studies of sites evaluated in this PEIS.

Epidemiology is the study of the distribution and determinants of disease in human populations. The distribution of disease is considered in relation to time, place, and person. Relevant population characteristics should include the age, race, and sex distribution of a population, as well as other characteristics related to health, such as social characteristics (e.g., income and education), occupation, susceptibility to disease, and exposure to specific agents. Determinants of disease include the causes of disease, as well as factors that influence the risk of disease.

E.4.1.1 Study Designs

Ecologic Studies. Ecologic studies compare the frequency of a disease in groups of people in conjunction with simple descriptive studies of geographical information in an attempt to determine how health events among populations vary with levels of exposure. These groups may be identified as the residents of a neighborhood, a city, or a county where demographic information and disease or mortality data are available. Exposure to specific agents may be defined in terms of residential location or proximity to a particular area, such as distance from a waste disposal site. An example of an ecologic study is a comparison of the rate of heart disease among community residents by drinking water quality.

The major disadvantage of ecologic studies is that the measure of exposure is based on the average level of exposure in the community, when what is really of interest is each individual's exposure. Ecologic studies do not take into account other factors such as age and race that may also be related to disease. These types of studies may lead to incorrect conclusions, an "ecologic fallacy." For the above example, it would be incorrect to assume that the level of water hardness influences the risk of getting heart disease. Despite the obvious problems with ecologic studies, they can be a useful first step in identifying possible associations between the risk of disease and environmental exposures. However, because of their potential for bias they should never be considered more than an initial step

in investigation of disease causation.

Cohort Studies. The cohort study design is a type of epidemiologic study frequently used to examine occupational exposures within a defined workforce. A cohort study requires a defined population that can be classified as being exposed or not exposed to an agent of interest, such as radiation or chemicals that influence the probability of occurrence of a given disease. Characterization of the exposure may be qualitative (e.g., high, low, or no exposure) or very quantitative (e.g., radiation measured in Sieverts (Sv), chemicals in parts per million [ppm]). Surrogates for exposure, such as job titles, are frequently used in the absence of quantitative exposure data.

Individuals enumerated in the study population are tracked for a period of time and fatalities recorded. In general, overall rates of death and cause-specific rates of death have been assessed for workers at the PEIS sites. Death rates for the exposed worker population are compared with death rates of workers who did not have the exposure (internal comparison), or compared with expected death rates based on the U.S. population or state death rates (external comparison). If the rates of death differ from what is expected, an association is said to exist between the disease and exposure. In cohorts where the exposure has not been characterized, excess mortality can be identified, but these deaths cannot be attributed to a specific exposure, and additional studies may be warranted. More recent studies have looked at other disease endpoints, such as overall and cause-specific cancer incidence (newly diagnosed) rates.

Most cohort studies at PEIS sites have been historical cohort studies, that is, the exposure occurred some time in the distant past. These studies rely on past records to document exposure. This type of study can be problematic if exposure records are incomplete or were destroyed. Cohort studies require extremely large populations that have been followed for many (20 to 30) years. They are generally difficult to conduct and are very expensive. These studies are not well suited to studying diseases that are rare. Cohort studies do, however, provide a direct estimate of the risk of death from a specific disease, and allow an investigator to look at many disease end points.

Case-Control Studies. The case-control study design starts with the identification of persons with the disease of interest (case) and a suitable comparison (control) population of persons without the disease. Controls must be persons who are at risk for the disease and are representative of the population that generated the cases. The selection of an appropriate control group is often quite problematic. Cases and controls are then compared with respect to the proportion of individuals exposed to the agent of interest. Case-control studies require fewer persons than cohort studies, and therefore, are usually less costly and less time consuming, but are limited to the study of one disease (or cause of death). These types of studies are well suited for the study of rare diseases and are generally used to examine the relationship between a specific disease and exposure.

E.4.1.2 Definitions

Unfamiliar terms frequently used in epidemiologic studies, including those used in this document, are defined below.

Age, gender, and cigarette smoking are the principal determinants of mortality. Standardization is a statistical method used as a control for the effects of age, gender, or other characteristics so that death rates may be compared among different population groups. There are two ways to standardize rates, the indirect or direct methods. In general, the indirect method of standardization is most frequently used.

Indirect Standardization: The disease rates in the reference (comparison) population are multiplied by the number of individuals in the same age and gender groups in the study population to obtain the expected rate of disease for the study population.

Direct Standardization: The disease rates in the study population are multiplied by the number of individuals in the same age and gender group in the reference (comparison) population. This gives the expected rates of disease for the reference population if these rates had prevailed in that group.

Standardized Mortality Ratio: The standardized mortality rate (SMR) is the ratio of the number of deaths observed in the study population to the number of expected deaths. The expected number of deaths is based on a reference (or comparison population). Death rates for the U.S. (or state) population are most frequently used as the comparison to obtain expected rates. An SMR of 1 indicates a similar risk of disease in the study population compared with the reference population. An SMR greater than 1 indicates excess risk of disease in the study population compared with the reference group, and an SMR less than 1 indicates a deficit of disease.

Relative Risk: The ratio of the risk of disease among the exposed population to the risk of disease in the nonexposed population. Relative risks are estimated from cohort studies.

Odds Ratio: The ratio of the odds of disease if exposed, to the odds of disease if not exposed. Under certain conditions the odds ratio approximates the relative risk. Odds ratios are estimated from case-control studies.

E.4.2 Oak Ridge Reservation

Surrounding Communities. The population-based National Cancer Institute's mortality survey for selected nuclear facilities Cancer in Populations Living Near Nuclear Facilities (NIH Publication No. 90-874, July 1990) examined the cancer mortality within an 80 km (50 mi) radius around several nuclear facilities, including Anderson and Roane counties (JAMA 1991a:1403-1408). No excess cancer mortality was observed in the population living in the exposed counties when compared to the U.S. white male population, nor when compared to the population of the control counties (Blount, Bradley, Coffee, Jefferson, and Hamblen, TN, and Henderson, NC), nor when time trends were assessed.

Tennessee Medical Management, Inc. used data from the Tennessee Cancer Reporting System to compare mortality and incidence data for counties near Oak Ridge, Tennessee, for the 3-year period, 1988 to 1990, to the U.S. population (TMM 1993a). For Oak Ridge, total deaths from all causes was significantly lower than expected. For Anderson County, the observed number of deaths from uterine cancer and from cancer of respiratory and intrathoracic organs was statistically greater than expected and the number of deaths from brain cancer, breast cancer, and the "all other sites" category were lower than expected for Anderson County. For Roane County, the number of deaths from cancer of the respiratory and intrathoracic organs was statistically greater than expected. The number of deaths from cancer of the digestive organs and the peritoneum; from uterine cancer; and from lip, oral cavity, and pharynx cancer was lower than expected.

Tennessee Medical Management, Inc. examined new (incident) cancer cases and identified the following as statistically significant: For Anderson County, the observed numbers of cases of cancer of the prostate and of cancer of the lung and bronchus were greater than expected. Leukemia, stomach

and small intestine cancers, and cancers of the colon and intestinal tract were lower than expected. For Roane County, the number of cases of cancer of the lung and bronchus was greater than expected. Non-Hodgkin's lymphoma, female breast cancer, esophageal cancer, cancer of the pancreas, and cancer in all sites were lower than expected. The only consistent excess reported for both cancer mortality and cancer incidence was for cancer of respiratory and intrathoracic organs.

Because of a concern for possible contamination of the population by mercury, the Tennessee Department of Health and Environment conducted a pilot study in 1984 (TN DHE 1984a). The study showed no difference in urine or hair mercury exposures (residence or activity in contaminated areas based on soil measurements or consumption of fish caught in the contaminated areas), compared to those with little potential exposure. Mercury levels in some soils measured as high as 2,000 ppm. Analysis of a few soil samples showed that most of the mercury in the soil, however, was inorganic, thereby lowering the probability of bioaccumulation and health effects. Examination of the long-term effects of exposure to mercury and other chemicals continues.

State Health Agreement Program. Under the State Health Agreement Program managed by DOE's Office of Epidemiologic Studies, a grant was awarded to the Tennessee Department of Health and Environment. The purpose of the grant was to determine the extent of exposure to contaminants among workers and residents of the surrounding community as a result of ORR operations, and to assess the current status of health outcomes and determine their potential association with these exposures.

A dose reconstruction feasibility study began in 1992, with the contract awarded by the State of Tennessee to ChemRisk. The contractor performed extensive review of Oak Ridge documents and issued a report, which concluded that sufficient information exists to reconstruct past releases and offsite doses caused by radioactive and hazardous materials. The report also concluded that doses from mercury, polychlorinated biphenyl, radioactive iodine, and radioactive cesium may have been great enough to cause harmful health effects in the offsite population. Based on this information, a full dose reconstruction study was initiated in August 1994.

Other activities supported under the grant include: development of a birth defects registry, a quality improvement program for the Tennessee cancer registry, a review and evaluation of the DOE occupational medical program, and the implementation of a community participation/public information program.

Technical support to the State health department is provided by a 12-member Oak Ridge Health Agreement Steering Panel. The Health Advisory Panel provides direction and oversight to those working on health studies, ensures public input, and informs the public of activities related to the health studies. A representative of the Centers for Disease Control and Prevention's National Center for Environmental Health is a member of the advisory panel. A representative from DOE serves as an ex-officio member.

Workers. Between 1943 and 1985, there were 118,588 male and female individuals of all races who were employed in any of the Oak Ridge facilities. These included Oak Ridge National Laboratory (ORNL) for nuclear research (also called the X-10 Facility); the Y-12 Plant (Y-12) under management of the Tennessee-Eastman Corporation (1943 to 1947), which produced enriched uranium by the electromagnetic separation process; Y-12 under management of Union Carbide (1948 to 1984), which fabricated and certified nuclear weapons parts; and the K-25 Site (K-25) (Oak Ridge Gaseous Diffusion Plant), which produced enriched uranium through the gaseous process. Analyses

at the Oak Ridge facilities have been carried out mostly for white males, and for specific cohorts taking into consideration time-related exposure risks.

Oak Ridge National Laboratory. The mortality experience of 8,375 white males employed at least a month between 1943 and 1972 at ORNL was compared with the U.S. white male population using SMR analyses in a 1985 paper by Checkoway et al. (BJIM 1985a:525-533). Increases in deaths from leukemia (SMR - 1.49, 16 observed), cancer of the prostate (SMR - 1.16, 14 observed), and Hodgkin's disease (SMR - 1.10, 5 observed) were observed, although none were statistically significant. Dose response analyses were performed for all causes of death combined, all cancers combined, leukemia, and prostate cancer comparing exposed worker death rates with nonexposed worker death rates. Dosimetry data were available for the entire period of the study with the total population external radiation dose measuring 13,500 mrem. No dose response gradients were observed. Death rates were calculated for 11 different job categories by length of time in each job in an attempt to determine whether specific work environments were related to cancer and leukemia. Leukemia mortality was observed to be related to length of employment in engineering and maintenance jobs.

Followup to this cohort study was expanded through 1984 in an updated study by Wing et al. (JAMA 1991a:1397-1402). Again, death rates in the worker population were compared with those in the U.S. population. Nonstatistically significant increases were noted for cancers of the pancreas (SMR - 1.09, 25 observed), prostate (SMR - 1.05, 26 observed), brain (SMR - 1.04, 15 observed), and lymphosarcoma and/or reticulasarcoma (SMR - 1.05, 9 observed). There was a significant increase in deaths from leukemia (SMR - 1.63, 28 observed, 95 percent confidence interval [CI] 1.08-2.35). The total population external radiation dose was 144 Sv. Dose response analyses performed for all causes except cancer, lung cancer, and leukemia did not demonstrate a relationship between level of external radiation and increased risk of death from these outcomes. There was a significant dose response relationship (4.94 percent per 1,000 mrem) between cancer deaths and level of external radiation dose using models with a 20-year lag. A subgroup of workers who were monitored for internal contamination had nonstatistically elevated SMRs for cancer of the prostate (SMR - 1.12, 10 observed) and lymphosarcoma and/or reticulasarcoma (SMR - 1.65, 6 observed). The workers monitored for internal contamination had a statistically significant elevated SMR for leukemia (SMR - 2.23 16 observed, 95 percent CI 1.27-3.62).

A second publication on the above data set examined the effect of controlling for a number of possible selection and confounding factors on the risk coefficient for all cancer dose responses (AJIM 1993a:265-279). Models were adjusted for the following variables with little change in the previously reported risk coefficient: employment during the World War II era, short-term employment, job category, and exposure to beryllium, lead, and mercury. The authors concluded that the previously calculated dose response estimate was fairly stable when adjustments were made for a wide range of potential confounders that were not explored in the earlier study.

Y-12 Plant. Y-12 is a nuclear weapons materials fabrication plant where the radiologic exposure of greatest concern is internal exposure from the inhalation of uranium compounds. The Tennessee Eastman Corporation managed the plant from 1943 to 1947. Polednak and Frome reported a followup through 1974 of all 18,869 white male workers employed at Y-12 from 1943 to 1947 (JOM 1981a:169-178). The workers included those exposed to internal (alpha) and external (beta) radiation through the inhalation of uranium dusts, electrical workers who performed maintenance in the exposed areas, and other nonexposed workers. Individual measures of exposure were not available for any members of this cohort, so exposure levels were inferred from plant areas of work and jobs.

High average air levels of uranium dust were documented in departments employing chemical workers. Elevated SMRs were observed for mental, psychoneurotic, personality disorders (SMR - 1.36, 36 observed), emphysema (SMR - 1.16, 100 observed), diseases of the bones and organs of movement (SMR - 1.22, 11 observed), lung cancer (SMR - 1.09, 324 observed), and external causes of death (SMR - 1.09, 623 observed). The lung cancer SMR was greater among workers employed for 1 year or more compared with workers employed less than 1 year and was more pronounced in workers hired at the age of 45 or older (SMR - 1.51; 95 percent CI 1.01-2.31). Of the workers employed after the age of 44, the SMR for lung cancer was greatest for electrical workers (SMR - 1.55, 7 observed), alpha chemistry workers (SMR - 3.02, 7 observed), and beta process workers (SMR - 1.51, 11 observed).

During the early operation of Y-12 from 1942 to 1947, a group of male workers was exposed to phosgene gas on a chronic basis (N - 694) and a smaller group of males received acute exposures (N - 106) along with a small group of females (N - 91) (ER 1980a:357-367; TIH 1985a:137-147). A control group of 9,280 workers who also worked at Y-12 during the same era, but who did not have phosgene exposure, was also described. All groups were followed through the end of 1978. The SMRs for the chronically exposed group and the control group were similar for all causes examined. There was no evidence for increased mortality from respiratory diseases in this group and the SMR for lung cancer, while elevated, was similar to the lung cancer SMR for workers in the rest of the plant. Among those with acute exposures, the SMR for respiratory diseases was elevated (SMR - 2.66, 5 observed) and this elevation may be related to residual lung damage from the acute phosgene exposure. It was difficult to trace the vital status of the 91 women; therefore, description of these highly exposed workers was limited to listing the frequency of their initial symptoms after exposure. As expected, nausea, vomiting, and coughing were the most frequently reported symptoms. Unexpectedly, the women experienced a lower frequency of pneumonitis than their male counterparts.

The portion of the Y-12 cohort employed between 1947 and 1974 was described in a study by Checkoway et al. (AJE 1988a:255-266). This study included 6,781 white male workers first employed at Y-12 between 1947 and 1974 who were employed for at least 30 days. Mortality data were collected for the cohort through the end of 1979 and were used to perform SMR and cause specific dose-response analyses. Nonstatistically significant increases were observed for all cancers (SMR - 1.01, 196 observed), diseases of the blood-forming organs (SMR - 1.48, 3 observed), kidney cancer (SMR - 1.22, 6 observed), brain cancer (SMR - 1.80, 14 observed), and other lymphatic cancers (SMR - 1.86, 9 observed). A statistically significant increase in deaths from lung cancer (SMR - 1.36, 89 observed; 95 percent CI - 1.09-1.67) was observed compared with the U.S. lung cancer rates, but not with Tennessee lung cancer rates (SMR - 1.18, 95 percent CI - 0.95-1.45). Dose-response analyses for lung cancer and internal alpha radiation dose and external gamma radiation dose did not reveal a positive relationship for a 0- or 10-year lag. Examination of lung cancer rates distributed across both internal and external dose categories suggested a dose-response with external radiation dose among individuals who had 5 or more rems of internal dose. Brain cancer was not related to the level of internal or external radiation dose.

The Y-12 cohort studied by Checkoway was updated through the end of 1990 by Loomis and Wolf and included African-American and white female workers (AJIM 1996a:131-141). The dose-response analyses were not included in the update; therefore, only SMR analyses are reported. For all workers examined as a group, nonstatistically significant elevations were observed for cancer of the pancreas (SMR - 1.36, 34 observed), skin cancer (SMR - 1.07, 11 observed), breast cancer (females only, SMR - 1.21, 11 observed), prostate cancer (SMR - 1.31, 36 observed), kidney cancer (SMR - 1.30, 16

observed), brain cancer (SMR - 1.29, 20 observed), cancers of other lymphatic tissues (SMR - 1.32, 22 observed), and diseases of the blood-forming organs (SMR - 1.23, 6 observed). The SMR for lung cancer was statistically significant (SMR - 1.17, 202 observed; 95 percent CI 1.01-1.34), particularly in the white male segment of the population (SMR - 1.20, 194 observed; 95 percent CI - 1.04-1.38). Examination of the lung cancer mortality by year of hire, latency, duration of employment, and calendar year at risk indicated the excess was confined to those who were first hired before 1954 (SMR - 1.27, 161 observed), and was greatest in persons employed 5 to 20 years with 10 to 30 years of followup. Elevated lung cancer deaths was first evident between 1955 and 1964 and continued to increase from 1975 to 1979, followed by a decrease in lung cancer death rates.

Between 1953 and 1963 Y-12 used mercury in a process to produce large quantities of enriched lithium. Cragle et al. studied all workers employed at Y-12 at least 5 months between January 1, 1953 and April 30, 1958 (N - 5,663) (JOM 1984a:817-821). This group was categorized into workers exposed to mercury and workers not exposed to mercury based on results of urinalysis data supplied by the plant. Vital status followup was complete through the end of 1978 and SMRs were calculated. Compared with nonexposed workers, there were no differences in the mortality patterns for: 1) mercury-exposed workers as a whole, 2) workers with the highest mercury exposures, and 3) workers employed more than a year in a mercury process. The authors acknowledge that mortality is not the optimal end point to assess health effects related to mercury exposure.

The mercury workers were involved in a clinical study by Albers et al. who examined 502 Y-12 workers, 247 of whom worked in the mercury process 20 to 35 years prior to the examination (AN 1988a:651-659). Correlations between declining neurological function and increasing exposure were identified. An exposure assessment was determined for each mercury worker during the time of employment in the mercury process. Study subjects who had at least one urinalysis equal to or greater than 0.6 mg/liters of mercury showed decreased strength, coordination, and sensation along with increased tremor, and prevalence of Babinski and snout reflexes when compared with the 255 nonexposed workers. Clinical polyneuropathy was associated with the level of the highest exposure, but not with the duration of exposure.

K-25 Site. K-25 enriched uranium beginning in 1945 using a gaseous diffusion process. There was potential exposure to uranium dust, oxidized uranium compounds, uranium hexafluoride, and a number of chemical compounds used in the process. In later years of operation, the gas centrifuge process was used to enrich uranium. No analyses of death rates for this population have been published; however, health effects have been studied.

Powdered nickel was used at K-25 in the production of the barrier material used to separate and enrich uranium. Workers who fabricated the barrier material were exposed to nickel powder through inhalation. Cragle et al. (IARC 1984a:57-63) updated an earlier study by Godbold et al. (JOM 1979a:799-806) of 814 workers who were employed in the manufacture of barrier material between 1948 and 1953. A comparison group of white males employed at K-25 sometime between 1948 and 1953 (N - 7,552) was also selected. The SMRs in the barrier group were similar to those in the nonbarrier worker group for most noncancer outcomes. The nickel workers were noted to have a higher rate of death from cancers of the buccal cavity and pharynx (SMR - 2.92, 3 observed) than the nonnickel workers (SMR - 0.23, 3 observed). When the directly standardized rates were compared, the rate of buccal cavity and pharynx cancer in the nickel workers was approximately 19 times higher than the rate in the nonnickel workers. The authors acknowledge that the number of cases is quite small and recommended additional followup to determine if this trend continued. There were no nasal sinus cancers observed in the worker population exposed to metallic nickel, in contrast to the results

of studies of workers in nickel refineries where the rates of sinus cancer related to nickel compounds are quite high.

K-25 workers employed in the gas centrifuge process were the focus of an interview study by Cragle et al. (AOEH 1992a:826-834). The study was conducted in order to determine the incidence rate for cancer and illness symptoms among workers exposed to epoxy resin and solvents prevalent in the process. A total of 263 workers determined to have worked closest and longest to the process were compared with 271 employees employed at the plant during the same time, but did not work in the centrifuge process. The centrifuge workers and the noncentrifuge workers had similar overall cancer incidence rates. However, the centrifuge workers reported five incident bladder cancers versus none reported by the noncentrifuge group. The centrifuge workers also reported significantly more rashes, dizziness, and numb or tingling limbs during employment, which are symptoms associated with high solvent exposure. One of the epoxy resins used in the early years of the process was a potential bladder carcinogen, but none of the workers with bladder cancer had jobs that required routine, hands-on work with that material. A specific causative agent for the increase in bladder cancer was not identified.

Combined Oak Ridge Reservation Facilities. Frome et al. reported on the mortality experience of World War II workers employed at three ORR facilities between 1943 and 1947 (RR 1990a:138-152). Poisson regression analyses were used as a control for potential confounders such as facility of employment, socioeconomic status, period of follow-up, and birth year. The cohort included white males employed at any ORR facility at least 30 days between the start of the operation and 1947 and were never employed at an ORR facility after 1947 (N - 28,008). Elevated mortality was statistically significant for all causes (SMR - 1.11, 11,671 observed); tuberculosis (SMR - 1.37, 108 observed); mental, psychoneurotic, and personality disorders (SMR - 1.60, 81 observed); cerebrovascular disease (SMR - 1.11, 833 observed); diseases of the respiratory system (SMR - 1.25, 792 observed); emphysema (SMR - 1.24, 209 observed); all accidents (SMR - 1.28, 694 observed); and motor vehicle accidents (SMR - 1.44, 339 observed). The only elevated site-specific cancer that was statistically significant was lung cancer (SMR - 1.27, 850 observed). A surrogate for radiation exposure based on a worker's job and department was used to indicate the probability of exposure. This surrogate for actual radiation exposure was not associated with increased rates of cancer.

Carpenter investigated earlier reports of an association between brain cancer and employment at Y-12 by conducting a case-control study of workers employed between 1943 and 1977 at ORNL or Y-12 (JOM 1987a:601-604). Cases consisted of 72 white males and 17 white females with brain cancer. Four controls were selected for each case matched on age, sex, cohort, year of birth, and year of hire. Analyses with respect to internal and external radiation exposures indicated no association with brain cancer. Two companion papers were also published from this case-control study, one examined relationships between brain cancer and chemical exposures (AJIM 1988a:351-362) and the other examined nonoccupational risk factors (AJPH 1987a:1180-1182). No statistically significant association between the use of 26 chemicals evaluated and the risk of brain cancer was observed. The chemicals evaluated included those encountered in welding fumes, beryllium, mercury, 4,4-methylene bis 2-chloroaniline or MOCA, cutting oils, thorium, methylene chloride, and other solvents. Excess brain cancer was observed, however, among individuals employed for more than 20 years (odds ratio - 7.0, 9 cases; 95 percent CI 1.2-41.1). Analysis of 82 cases with complete medical records revealed an association with a previous diagnosis of epilepsy (odds ratio - 5.7, 4 cases; 95 percent CI 1.0-32.1) recorded for pre-employment and health status followup.

Causes of death among white male welders (N - 1,059) employed between 1943 and 1973 at Y-12, K-

25, and ORNL were studied by Polednak (AEH 1981a:235-242). Based on deaths reported through 1974, mortality from all causes for welders was slightly lower than that expected based on death rates for U.S. white males (SMR - 0.87, 173 observed). Nonstatistically significant decreases in mortality were also observed for all cancers (SMR - 0.88, 32 observed), especially digestive cancer (SMR - 0.49, 5 observed); diseases of the circulatory system (SMR - 0.74, 72 observed); diseases of the digestive system (SMR - 0.76, 9 observed); and accidents (SMR - 0.89, 16 observed). Nonstatistically significant increases were noted for lung cancer (SMR - 1.50, 17 observed); diseases of the respiratory system (SMR - 1.33, 13 observed), especially emphysema (SMR - 2.21, 6 observed); and suicide (SMR - 1.64, 10 observed). A sub-group of welders (N - 536) exposed to nickel oxides (possible respiratory carcinogens) at K-25 were compared with welders at the other two facilities (N - 523). The risk of lung cancer and other respiratory diseases did not differ between the two groups.

Combined Nuclear Sites. ORR workers have been included in several studies that have examined occupational risks across the nuclear complex, both in the United States and internationally. These combined studies have been undertaken in an attempt to increase the statistical power of the studies to detect the effects of low-level chronic radiation exposure.

Y-12 workers were included in a lung cancer case-control study of workers from the Fernald Feed Materials and Production Center cohort and the Mallinckrodt Chemical Works cohort. Dupree et al. conducted a nested case-control study of lung cancer (N - 787) to investigate the relationship between lung cancer and uranium dust exposure (Epidemiology 1995a:370-375). Eligible cases included workers who were employed at least 183 days in any of the facilities and died before January 1, 1983, with lung cancer listed anywhere on the death certificate. Inclusion of deaths through 1982 allowed over 30 years of observation at each facility. One control was matched to each case on facility, race, gender, and birth and hire dates within 3 years. Data collected on all study members included smoking history, first pay code (a surrogate for socioeconomic status), complete work histories, and occupational radiation monitoring records. Annual radiation lung dose from deposited uranium was estimated for each study member. Annual external whole body doses from gamma radiation were determined for workers who had personal monitoring data available. Potential confounders considered in the analysis were smoking (ever/never used tobacco) and pay code (monthly/nonmonthly). With a 10-year lag, cumulative lung doses ranged from 1 to 137 rads for cases and from 0 to 80 rads for controls. The odds ratios for lung cancer mortality for seven cumulative internal dose groups did not demonstrate increasing risk with increasing dose. An odds ratio of 2.0 was estimated for those exposed to 25 rads or more, but the 95 percent confidence interval of -.20 to 20 showed great uncertainty in the estimate. There was a suggestion of an exposure effect for workers hired at age 45 years or older.

A combined site mortality study included workers from ORNL, the Hanford Site, and the Rocky Flats Plant (RR 1993a:408-421). Earlier analyses of these cohorts indicated that risk estimates calculated through extrapolation from high-dose data to low-dose data did not seriously underestimate risks of exposure to low-dose radiation (AJE 1990a:917-927; RR 1989a:19-35). The updated analyses were performed in order to determine whether the extrapolated risks represented an over-estimation of the true risk at low doses. The study population consisted of white males employed at one of the three facilities for at least 6 months and monitored for external radiation. The Hanford population also included females and nonwhite workers. The total population dose was 123,700 rem. Analyses included trend tests for site-specific cancer deaths and several broad noncancer categories. Statistically significant trends were noted for cancer of the esophagus, cancer of the larynx, and Hodgkin's disease. These cancers were not related to radiation exposure levels in previously published studies. Excess relative risk models were calculated for the combined DOE populations

and for each DOE site separately. Without exception, all risk estimates included the possibility of zero risk (i.e., the confidence interval for the risk coefficient went from below zero to above zero). There was evidence of an increase in the excess relative risk for cancer with increasing age in the Hanford and ORNL populations; both populations showed significant correlations of all cancer with radiation dose among those 75 years and older.

An international effort to pool data from populations exposed to external radiation included the ORNL population in addition to other radiation worker populations in the United States, Canada, and Britain (RR 1995a:117-132). The cohort comprised 95,673 workers (85.4 percent men) employed 6 months or longer and the population dose was 384,320 rem. There was no evidence of an association between radiation dose and mortality from all causes or from all cancers. There was a significant dose-response relationship with leukemia, excluding chronic lymphocytic leukemia (excess relative risk - 2.18 per 100 rem; 90 percent CI 0.1-5.7) and multiple myeloma (excess relative risk not computed; 44 observed). The study results do not suggest that current radiation risk estimates for cancer at low levels of exposure are appreciably in error.

Memorandum of Understanding. DOE entered into a Memorandum of Understanding with the Department of Health and Human Services to conduct health studies at DOE sites. The National Institute for Occupational Safety and Health is responsible for the conduct or management of worker studies.

The following studies are managed by the National Institute for Occupational Safety and Health with funding from DOE: a study of multiple myeloma among workers at K-25 at ORR (expected completion date 1996), a multisite study to assess the potential association between paternal exposure to ionizing radiation and the risk of leukemia in offspring of exposed male workers, a study of neurologic health outcomes in workers exposed to high levels of mercury between 1953 and 1963, studies of mortality among ORR workers, a multisite study of mortality among female nuclear workers, a multisite exposure assessment of hazardous waste/cleanup workers, a chronic beryllium disease study, and a multisite study of heat stress and performance among carpenters.

E.4.3 Savannah River Site

SRS, established in 1953 in Aiken, SC, produces plutonium, tritium, and other nuclear materials. There are reports that millions of curies of tritium have been released over the years both in plant exhaust plumes and in surface and groundwater streams (ED 1982a:135-152).

Surrounding Communities. In 1984, Sauer and Associates examined mortality rates in Georgia and South Carolina by distance from the Savannah River Plant (now known as SRS) (SR duPont 1984b). Rates for areas near the plant were compared with U.S. rates and with rates for counties located more than 80-km (50-mi) away. Breast cancer, respiratory cancer, leukemia, thyroid cancer, bone cancer, malignant melanoma of the skin, nonrespiratory cancer, congenital anomalies or birth defects, early infancy death rates, stroke, or cardiovascular disease in the populations living within 80 km (50 mi) of the plant did not show any excess risk compared with the reference populations.

State Health Agreement Program. Under the State Health Agreement Program managed by DOE's Office of Epidemiologic Studies, a grant was awarded to the Medical University of South Carolina in 1991 to develop the Savannah River Region Health Information System. The purpose of the Savannah River Region Health Information System database was to assess the health of populations surrounding SRS by tracking cancer rates and birth defects rates in the area. Information from the

registry is available to public and private health care providers for use in evaluating cancer control efforts. A steering committee provides advice to the Savannah River Region Health Information System and communicates public concerns to the System. It consists of 12 community members and persons with technical expertise representing South Carolina and Georgia. The meetings are open to the public.

Workers. A descriptive mortality study was conducted that included 9,860 white male workers who had been employed at lease 90 days at the Savannah River Plant between 1952 and the end of 1974 (AJIM 1988b:379-401). Vital status was followed through the end of 1980 and mortality was compared with the U.S. population. SMRs were computed separately for hourly and salaried employees. For hourly employees, nonstatistically significant increases were seen for cancer of the rectum (SMR - 1.09, 5 observed), cancer of the pancreas (SMR - 1.08, 10 observed), leukemia and aleukemia (SMR - 1.63, 13 observed), other lymphatic tissue (SMR - 1.06, 5 observed), benign neoplasms (SMR - 1.33, 4 observed), and motor vehicle accidents (SMR - 1.10, 63 observed). Salaried employees exhibited nonstatistically significant increases in cancer of the liver (SMR - 1.84, 3 observed), cancer of the prostate (SMR - 1.35, 5 observed), cancer of the bladder (SMR - 1.87, 4 observed), brain cancer (SMR - 1.06, 4 observed), leukemia and aleukemia (SMR - 1.05, 4 observed), and other lymphatic tissue (SMR - 1.23, 3 observed). No trends between increasing duration of employment and SMRs were observed. A statistically significant excess of leukemia deaths was observed for hourly workers employed at least 5, but less than 15 years (SMR - 2.75, 6 observed). Review of the plant records and job duties of the workers who died from leukemia indicated that two of the cases had potential routine exposure to solvents, four had potential occasional exposure to solvents, and one had potential for minimal exposure. Benzene, a known carcinogen, was reportedly not used at the plant.

Epidemiologic Studies. DOE's Office of Epidemiologic Studies has implemented an Epidemiologic Surveillance Program at SRS to monitor the health of current workers. This program will evaluate the occurrence of illness and injury in the workforce on a continuing basis, and the results will be issued in annual reports. The implementation of this program will facilitate an ongoing assessment of the health and safety of the SRS workforce and will help identify emerging health issues.

Epidemiologic surveillance, which is currently operational at a number of DOE sites, including production sites and research and development (R&D) facilities, uses routinely collected health data, including descriptions of illness resulting in absences lasting 5 or more consecutive workdays, disabilities, and OSHA-recordable injuries and illnesses abstracted from the OSHA 200 log. These health event data, coupled with demographic data about the active workforce at the participating sites, are analyzed to evaluate whether particular occupational groups are at increased risk of disease or injury when compared with other workers at a site. As the program continues and data for an extended period of time become available, time trend analysis will become an increasingly important part of the evaluation of worker health. Monitoring the health of the workforce provides a baseline determination of the illness and injury experience of workers and a tool for monitoring the effects of changes made to improve the safety and health of workers. Noteworthy changes in the health of the workforce may indicate the need for more detailed study or increased health and safety measures to ensure adequate protection for workers.

Memorandum of Understanding. DOE entered into a Memorandum of Understanding with the Department of Health and Human Services to conduct health studies at DOE sites. The Centers for Disease Control and Prevention's National Center for Environmental Health is responsible for dose reconstruction studies and the National Institute for Occupational Safety and Health is responsible for

worker studies. These activities are funded by DOE.

A study of mortality among SRS workers employed from 1952 to 1974 to examine whether risks of death due to selected causes may be related to occupational exposures at SRS is being conducted by the National Institute for Occupational Safety and Health. SRS is also included in several multisite studies managed by the institute. The first study is to assess the potential association between paternal work-related exposure to ionizing radiation and the risk of leukemia in offspring of exposed male workers. The second study is to examine causes of death among female workers at nuclear weapons facilities to develop risk estimates based on exposures to external and internal ionizing radiation and to hazardous chemicals. A third multisite project is a case-control study of multiple myeloma, a type of blood cell cancer.

A dose reconstruction project around SRS is being conducted by the National Center for Environmental Health to determine the type and amount of contaminants to which people living around the site may have been exposed, to identify exposure pathways of concern, and to quantify the doses people may have received as a result of SRS operations. The estimated completion date is 1999 or 2000.

E.4.4 Kansas City Plant

Surrounding Communities. No known epidemiologic studies have been conducted in the surrounding communities to date.

Epidemiologic Surveillance. DOE's Office of Epidemiologic Studies has implemented an Epidemiologic Surveillance Program at the Kansas City Plant to monitor the health of current workers. This program will evaluate the occurrence of illness and injury in the workforce on a continuing basis and annual reports will be issued reporting the results of the ongoing surveillance. The implementation of this program currently supports the automation of occupational medical data management at the site to facilitate electronic access to key information used in surveillance. The program will facilitate an ongoing assessment of the health and safety of the site's workforce and help to identify any emerging health issues in a timely manner.

Currently operational at a number of DOE sites, including production sites and R&D laboratories, epidemiologic surveillance makes use of routinely collected health data, including reasons for illness, absence lasting 5 or more consecutive workdays, disabilities, and OSHA-recordable injuries and illnesses abstracted from the OSHA 200 log. These health event data, coupled with demographic data about the active workforce at the participating sites, are analyzed to evaluate whether particular occupational groups are at increased risk of disease or injury when compared with other workers at a site. As the program continues and data become available for an extended period of time, trend analysis will become an increasingly important part of the evaluation of worker health. Monitoring for changes in the health of the workforce provides both a baseline determination of the illness and injury experience of workers and a tool for monitoring the effects of changes made to improve the safety and health of workers. Epidemiologic surveillance also provides an early warning of noteworthy changes in health and safety that may indicate areas in need of additional, more-detailed study or increased health and safety measures to ensure adequate protection for workers.

E.4.5 Pantex Plant

Surrounding Communities. A June 1994 study by the Texas Cancer Registry, Texas Department of

Health, showed significant increases in prostate cancer mortality among Potter County and Randall County males, and leukemia mortality among Carson County males during the period between 1981 and 1992 (TX DOH 1994a). There were no statistically significant increases observed in site-specific cancer mortality among females during this period. For cancer incidence during the period between 1986 and 1992, no statistically significant excesses in males were seen; however, cancer of the prostate was slightly elevated in Potter/Randall County males. Analysis of the four major cell-specific types of leukemia, showed a significant excess in the incidence of chronic lymphocytic leukemia among Potter/Randall County females. This study was conducted in Carson, Potter, and Randall Counties, which are located near Pantex. This study focused only on cancers of the breast, prostate, brain, thyroid, and leukemia, which were of specific concern to citizens in the area. Other radiation-associated cancers, such as bone and lung, were not included in this study. Although prostate cancer and chronic lymphocytic leukemia have not been linked to radiation exposure, further followup to this study was recommended.

Workers. An epidemiologic study of Pantex workers was published by Acquavella (HP 1985b:735-746). This study compared total and cause-specific mortality for Pantex workers employed between 1951 and December 31, 1978, with expected cause-specific mortalities based on U.S. death rates. Significantly fewer deaths were observed in the workforce than would be expected based on U.S. death rates for the following causes of death: all cancers, arteriosclerotic heart disease, and digestive diseases. No specific causes of death occurred significantly more frequently than expected. Slightly elevated mortality ratios were observed for brain cancer and leukemia; neither excess was statistically significant. The four deaths from brain cancer all occurred among those who had worked at the plant less than 5 years. The four deaths from leukemia occurred with equal frequency among those who had worked at the plant a short time and those who had worked more than 15 years.

Memorandum of Understanding. A followup of the 1985 mortality study of the Pantex workforce is planned. The update will be conducted by the National Institute for Occupational Safety and Health as part of a research program funded by DOE under a Memorandum of Understanding with the Department of Health and Human Services. The followup study is scheduled to commence either in late 1996 or early 1997. In addition, female workers at Pantex will be included in a National Institute for Occupational Safety and Health funded multisite study of mortality among female nuclear weapons workers.

Epidemiologic Surveillance. DOE's Office of Epidemiologic Studies Epidemiologic Surveillance Program was implemented at Pantex in 1993 in order to monitor the health of current workers. This program evaluates the occurrence of illness and injury in the workforce on a continuing basis and issues the results of the ongoing surveillance in annual reports. The program facilitates an ongoing assessment of the health and safety of the site's workforce and helps to identify any emerging health issues in a timely manner. Monthly data collection began on January 1, 1994, and the results of the first complete year of epidemiologic surveillance will be presented to workers and other site stakeholder groups in spring 1996.

Currently operational at a number of DOE sites, including production sites and R&D laboratories, epidemiologic surveillance makes use of routinely collected health data including descriptions of illness resulting in absences lasting 5 or more consecutive workdays, disabilities, and OSHA-recordable injuries and illnesses abstracted from the OSHA 200 log. These health event data, coupled with demographic data about the active workforce at the participating sites, are analyzed to evaluate whether particular occupational groups are at increased risk of disease or injury when compared with other workers at a site. As the program continues and data become available for an extended period of

time, trend analysis will become an increasingly important part of the evaluation of worker health. Monitoring for changes in the health of the workforce provides both a baseline determination of the illness and injury experience of workers and a tool for monitoring the effects of changes made to improve the safety and health of workers. Noteworthy changes in the health of the workforce may indicate areas in need of more detailed study or increased health and safety measures to ensure adequate protection for workers.

E.4.6 Los Alamos National Laboratory

Los Alamos and adjacent counties comprise a unique setting and history. LANL, for much of its existence, was a closed community where most of the residents had direct economic ties to the laboratory. Nearly all male residents and some of the female residents are employed at LANL. Medical care in Los Alamos County had been centralized at the laboratory and a single community hospital. This is a unique, highly educated community situated adjacent to lands populated by Native Americans.

Surrounding Communities. Selected cancer mortality and incidence (newly diagnosed cancer) rates between 1950 and 1969, for 11 selected cancers among white males in Los Alamos County were compared with rates for the State of New Mexico, U.S. rates, and with rates of five socioeconomic and occupational control counties and five high-education western counties, based on U.S. Bureau of the Census information (ER 1981a:86-105). The comparisons were made to identify cancer types that were greater than expected while taking into account important factors, such as income and education, associated with cancer patterns. Six cancer types were identified that had rates greater than cancer rates for one or more of the four comparison groups; they are: cancer of the bile ducts and liver, bladder, prostate, brain and nervous system, lympho- and reticulo-sarcoma, and leukemia. Cancer rates of the prostate, bladder, and leukemia were also greater than expected.

Compared with New Mexico white males, Los Alamos County Anglo-white males show nonstatistically significant excesses in cancer incidence from 1969 to 1974 for the stomach, colon, rectum, pancreas, lung, and bladder (ER 1981a:86-105). All cancers combined show a 35-percent statistically significant excess. Los Alamos County white females show nonstatistically significant excesses for cancer of the stomach, large intestine, lymphosarcoma and reticulasarcoma, and leukemia. All cancers combined show a statistically significant 40-percent excess.

In 1991, the New Mexico Department of Health initiated epidemiologic studies in response to citizen concerns about an apparent excess of brain tumors among residents of the western area neighborhood of Los Alamos County as a result of historical LANL nuclear operations. The New Mexico Department of Health conducted a descriptive study of brain cancer incidence in Los Alamos County and for 22 other sites (NM DOH 1993a). The study showed that during the mid- to late-1980s an excess of approximately 80 percent of brain cancer had occurred in Los Alamos County compared with a New Mexico reference population and national statistics. The excess incidence had disproportionately occurred among persons who were residents of the western area at the time of diagnosis or death; however, there were only three cases, and they were confined to the 2-year time period, 1986 to 1987. Additional descriptive studies showed that the brain cancer rates for Los Alamos County were within the range of rates observed across New Mexico counties from 1983 to 1987 and 1988 to 1991. A review of mortality statistics for benign or unspecified neoplasms of the brain and nervous system showed no deaths from these causes in Western Area residents during 1984 to 1990.

Los Alamos County breast cancer incidence rates remained level, but higher than New Mexico rates from 1970 to 1990. Reproductive and demographic factors associated with the risk of breast cancer were thought to account for the higher rates. A special study was conducted to examine the recent increase in breast cancer since 1988 (NM DOH 1994a). The New Mexico Tumor Registry concluded that the increase seen between 1988 and 1992 was primarily due to increased detection of early stage disease.

The incidence of ovarian cancer in Los Alamos County women was elevated from the mid-1970s to 1990. From 1986 through 1990, ovarian cancer incidence in Los Alamos County was roughly two-fold higher compared with New Mexico reference population rates. The excess ovarian cancer rate was confined to a census tract corresponding to two neighborhoods and was four- to six-fold higher than that observed in the remaining Los Alamos County census tracts.

The incidence rates for melanoma (cancer of the skin) in Los Alamos County were elevated from 1970 through 1990, with peak elevations occurring from the mid- to late-1980s. There was approximately a twofold excess risk compared with a New Mexico State reference population. The excess melanoma incidence observed in Los Alamos County was thought to be related to the high ambient solar ultraviolet radiation intensity due to its high altitude.

A fourfold increase in thyroid cancer incidence during the late 1980s was noted in a study by Athas (NM DOH 1996a). A case-series records review was initiated to examine data relating to the detection, diagnosis, and known risk factors for thyroid cancer. All cases of thyroid cancer diagnosed among Los Alamos County residents between 1970 and 1995 were identified through the New Mexico Tumor Registry. The incidence rate for thyroid cancer in Los Alamos County was slightly higher than New Mexico rates between 1970 and the mid-1980s. There was a statistically significant fourfold increase during the late 1980s and early 1990s compared with the State, but the rate began to decline in 1994 and 1995.

The higher than expected number of thyroid cancer cases could not be explained by changes in diagnosis of thyroid cancer among Los Alamos County residents. Additional analyses suggested that increased medical surveillance and greater access to medical care were responsible for the recent excess in Los Alamos County.

Potential risk factors for thyroid cancer including therapeutic irradiation, genetic susceptibility, occupational radiation exposure, and weight were also examined. However, the investigation did not identify a specific cause for the elevated rate of thyroid cancer in Los Alamos County.

Male Workers. A mortality study of 224 white males with the highest internal depositions of plutonium 239 (10 nanocuries or more) at LANL were examined by Voelz et al. (LANL 1985a). Followup was through April 1980. SMRs were low for all cause of death (SMR - 0.56, 95 percent CI - 0.40-0.75), all malignant neoplasms (SMR - 0.54, 95 percent CI - 0.23-1.06), compared with U.S. white males and lung cancer (SMR - 20, 95 percent CI - 0-110).

A cohort mortality study by Wiggs et al. examined the causes of death among 15,727 white males hired at LANL between 1943 and 1977 (HP 1994a:577-588). The purpose of the study was to determine if plutonium deposition and external ionizing radiation were related to worker mortality. After nearly 30 years of followup, the LANL workforce experienced 37 percent fewer deaths from all causes, and 36 percent fewer deaths due to cancer than expected when compared with death rates for

the U.S. population.

The researchers identified a subset of 3,775 workers who had been monitored for plutonium exposure; of these, 303 workers were categorized as "exposed" based on a urine bioassay for plutonium; the remainder were nonexposed. One case of rare bone cancer, osteogenic sarcoma, a type of cancer related to plutonium exposure in animal studies, was noted among the plutonium exposed group. The overall mortality and site-specific rates of cancer did not differ significantly between the two groups of workers. A nonstatistically significant increase in lung cancer among the exposed group was noted, but there was no information on cigarette use among the workers.

When researchers examined data for the 10,182 workers who were monitored for exposure to external ionizing radiation (including 245 workers exposed to plutonium) they observed a dose-response relationship for cancers of the brain/central nervous system, cancer of the esophagus, and Hodgkin's disease. When the 225 plutonium-exposed workers were excluded from the analysis, there was a statistically significant dose response between external ionizing radiation and kidney cancer and lymphocytic leukemia.

A special lifetime medical study was conducted on 26 of the workers who have the largest internal depositions of plutonium at LANL. Voelz and Lawrence reported on the 42-year followup of the 26 white males who designed and built the first atomic bomb and were determined to have had a significant deposition of plutonium-239 sometime in 1944 or 1945 based on job assignment, working conditions, and urine levels of plutonium (HP 1991a:181-190). Their mortality experience was compared to U.S. white males adjusted for age and calendar time. The mortality rates were also compared with rates for a cohort of LANL workers hired at the same time and born between the same years; no significant differences were for all cause mortality and all cancer mortality. One of the seven reported deaths was due to bone sarcoma, the most frequent radiation-induced cancer observed in persons with radium depositions.

Wiggs reported on 6,970 women employed at LANL for at least 6 months from 1943 through 1979, with deaths determined through 1981 (LA Wiggs 1987a). The mortality rates for all causes of death combined and all cancers combined were 24 and 22 percent below the rate for the U.S. population, respectively. Although the overall rates are low, women occupationally exposed to ionizing radiation have elevated rates for cancer of the ovary and of the pancreas relative to those not exposed. An unusual finding was that female radiation workers experienced a statistically significant excess of death from suicide. In a special in-depth study, the suicides were compared to two control groups, deaths from other injuries and deaths from noninjuries. History of employment as a radiation worker was significantly associated with death from suicide for both comparison groups. No significant associations for duration of employment, plutonium exposure, or martial status were seen (APHA 1988a).

As result of a reported threefold excess of malignant melanoma among laboratory workers at LLNL in California and similarities between occupational exposures and prevailing sunshine conditions at LANL and LLNL, an investigation was undertaken to assess the risk of melanoma at LANL (Lancet 1981a:712-716). Incidence data were obtained from the New Mexico Tumor Registry. No excess risk for melanoma was detected at LANL among 11,308 laboratory workers between 1969 and 1978. Six cases were identified where about 5.7 were expected (Lancet 1982a:883-884). The rate for the total cohort, Hispanic males and females, non-Hispanic males and females were not significantly different from the corresponding New Mexico rates.

A special in-depth study of 15 cases diagnosed through 1982 did not detect an association between melanoma and exposure to any type of external radiation as measured by film badges, neutron exposures, plutonium body burden based on urine samples, or employment as a chemist or physicist (HP 1983c:587-592). However, the workers with melanoma were more educated than the comparison group using the college and graduate degree as a measure of education, a finding consistent with other reports of malignant melanoma according to the authors. The numbers in this study are too small to detect any but large excesses.

Memorandum of Understanding. DOE entered into a Memorandum of Understanding with the Department of Health and Human Services to conduct health studies at DOE sites. The National Institute for Occupational Safety and Health is responsible for managing or conducting the worker studies. The following multisite studies that include LANL are currently underway: a study of mortality among female nuclear weapons workers, a case-control study of multiple myeloma, a leukemia study, and an exposure assessment of hazardous waste/cleanup workers.

E.4.7 Lawrence Livermore National Laboratory

Surrounding Communities. The California Department of Health Services released a study of cancer occurrence among children and young adults living or born in Livermore, California (CA DHS 1995a). The study specifically aimed to determine the risk of leukemia and non-Hodgkin's lymphoma among young people living near LLNL. An increased risk of these two cancers among children living near the Sellafield nuclear facility in England had been suggested by a British study (JRSS 1989a:307-325).

Investigators studied two groups of children and young adults under the age of 25: those who were born in Livermore between 1960 and 1990 and those who actually lived in Livermore between 1960 and 1991. No increased risk of leukemia or non-Hodgkins lymphoma was detected among Livermore children living near a nuclear facility, as suggested by the British study. However, a 2.4-fold increase in the risk of malignant melanoma, a form of skin cancer which can be fatal, was found for children and young adults who lived in Livermore between 1960 and 1991 compared with youngsters who lived other places within Alameda County. An even more significant 6.4-fold increased risk of malignant melanoma was found in children born in Livermore between 1960 and 1991. The rate of melanoma was highest in those under 20 years of age. No increased risk of any other type of cancer was found. The report states that "it is not possible, within the scope of the current study, to assess whether or not melanoma cases had any affiliation with LLNL."

Workers. In 1981, a joint study undertaken by the California Department of Health Services and LLNL reported that 19 cases of malignant melanoma were observed between 1972 and 1977 among approximately 5,100 LLNL employees (Lancet 1981a:712-716). This incidence rate was significantly higher than that expected in the comparable population of the San Francisco Bay Area. Preliminary findings, however, suggested that this apparent increase in the malignant melanoma was not associated with length of employment at LLNL, nor with type of monitored radiation exposure. No other cancers were increased among LLNL employees from 1969 to 1980 (WJM 1985a:214-218).

The reasons for the malignant melanoma increase were not clear, and a series of studies was prompted to investigate the problem. A case-control study reported five occupational factors having causal relationships with the observed excess in malignant melanoma: exposure to radioactive materials, exposure to volatile photographic chemicals, Site 300 at LLNL, chemist duties based on

job titles, and Pacific Test Site (LLNL 1984b). The association between melanoma and occupational factors reported in the study was criticized by Shy et al. (LLNL 1985a). A question concerning surveillance bias was also raised, because the number of cases was too small and because of the excessive number of exposure factors analyzed. The authors noted that evidence for a dose-response gradient was not provided and the biological plausibility of causal hypothesis was not established.

Various studies investigated the role of surveillance bias in relation to the elevated incidence of melanoma. Hiatt and Fireman reported that the increase among melanoma incidence is associated with increased biopsy rates for pigmented nevi in LLNL employees compared with matched controls who belonged to the same prepaid health plan but who did not work at LLNL (PM 1986a:652-660). The occupational physicians caring for LLNL employees may be more aware of the potential malignancy of pigmented lesions than those caring for non-LLNL employees. Subsequently, the increasing percentage of thin cutaneous malignant melanoma over time (1969 to 1976, 1977 to 1984, and 1984 to 1986) reported at LLNL suggests increased efforts to diagnosis cutaneous malignant melanoma early on (Lancet 1987a: 1435). The mean thickness of cutaneous malignant melanoma among LLNL employees has decreased more rapidly between 1976 and 1984 than those from the comparison laboratory (AD 1990a:967-969). On the other hand, others reported that the thinner lesions were only confirmed prior to 1976, and after 1976 there was no difference in lesion thickness (Epidemiology 1993a:43-47).

The most recent case-control study of malignant melanoma concluded that there was no association between occupational factors and the increased melanoma diagnosis among LLNL employees (LLNL 1994e). No clear explanation for the increased melanoma among LLNL workers has been provided. Increased awareness and enhanced surveillance are currently suspected, and monitoring of mortality from melanoma continues at LLNL.

Memorandum of Understanding. DOE entered into a Memorandum of Understanding with the Department of Health and Human Services to conduct health studies at DOE sites. The National Institute for Occupational Safety and Health is responsible for managing or conducting the worker studies. The Institute funded a grant to examine the industrial hygiene system at LLNL that will allow the study of complex exposure scenarios.

E.4.8 Sandia National Laboratories

Community Studies. There are no known epidemiologic studies that have been conducted which examine the impact of SNL on the health of the surrounding communities.

Epidemiologic Surveillance. The Office of Epidemiologic Studies Epidemiologic Surveillance Program has been implemented at SNL to monitor the health of current workers at the Albuquerque site. This program monitors and evaluates the occurrence of illness and injury in the workforce on a continuing basis and annual reports are issued reporting the results of the ongoing surveillance. The program facilitates a continuing assessment of the health and safety of the site's workforce and helps to identify any emerging health issues. Refinements to epidemiologic surveillance at SNL include the anticipated addition of selected dosimetry data, enhancing the program's ability to monitor potential health effects associated with radiation exposure.

Epidemiologic surveillance makes use of routinely collected health data including reasons for illness absence lasting five or more consecutive workdays, disabilities, and OSHA-recordable injuries and illnesses abstracted from the OSHA 200 log. These health event data, coupled with demographic data

about the active workforce are analyzed to evaluate whether particular occupational groups are at increased risk of disease or injury when compared with other workers at SNL. As the program continues and data become available for an extended period of time, trend analysis will become an increasingly important part of the evaluation of worker health. Monitoring for changes in the health of the workforce provides a baseline rate of illness and injury among the workers and a tool to evaluate changes in industrial hygiene and health physics practices. Epidemiologic surveillance also provides an early warning of changes in health and safety that may indicate areas in need of more detailed study or increased safety measures to ensure adequate protection for workers.

Workers. Broadwell et al. report that 25 workers, 5 currently, and 20 formerly involved in the manufacture of hybrid microcircuits, underwent clinical evaluations at the request of a management union committee concerned about chronic solvent exposures in an R&D laboratory (AJIM 1995a:677-698). A battery of neurobehavioral tests was administered to compare the solvent-exposed group with age-, ethnicity-, and education-matched controls. The tests included MMPI-I, handgrip strength, tactile sensitivity, dexterity, color discrimination, visual acuity and contrast sensitivity, and tests selected from the computerized Neurobehavioral Evaluation System. Clinical narratives and retrospective exposure assessments in the study group suggested chronic low-level exposure to solvents, with intermittent acute excursions. The most frequently reported symptoms from the clinical questionnaires were upper respiratory irritation (68 percent), poor concentration and memory loss (48 percent), depressed mood (40 percent), lower respiratory irritation (28 percent), eye irritation (28 percent), distal upper extremity paresthesia (24 percent), and skin rash (12 percent). Work-related diagnosis included upper respiratory mucosal irritation and sinusitis (44 percent), lower respiratory reactive disease (12 percent), and dermatitis (5 percent). Ten of the 25 exposed workers (40 percent) had a history of a clinical syndrome with headache, dizziness, disequilibrium, fatiguability, memory impairment, difficulty in concentration, and loss of initiative following acute solvent exposures. Solvent exposures linked to this syndrome were intermittent, and symptoms were reversible after cessation of what were reported as high-level exposures. Several exposed workers showed clinical evidence of an acquired toxic encephalopathy supporting an association between long-term solvent exposure and depressed mood, with increased somatic symptoms. Significant differences (after Bonferroni correction) were found between the two groups on the following Neurobehavioral Evaluation System subtests: finger tapping, simple reaction time, symbol digit substitution, mood scale, and symptom questionnaire. Differences also reached significance for contrast sensitivity, vibrotactile threshold, and handgrip strength. Attention to engineering controls, chemical fume hood ventilation, work practices, safety training, and personal protective gear was markedly improved when the lab was moved in the fall of 1990.

E.4.9 Nevada Test Site

Surrounding Communities. Above ground testing of nuclear weapons at NTS Test Range Complex in southern Nevada between 1951 and 1958 resulted in the dissemination of radioactive fallout over southeastern Nevada and southwestern Utah through wind dispersion. Several epidemiologic studies have been conducted to investigate possible adverse health effects of low-level radiative fallout on residents of these states. These studies focused on leukemia and thyroid disease in children downwind of NTS.

A series of ecologic studies showed equivocal results in potentially exposed children. A cross sectional review of thyroid nodularity among teenage children reported by Weiss et al. found no significant difference in the frequency of nodules among potentially exposed and nonexposed children (AJPH 1971a:241-249). Exposure was defined in terms county of residence. Rallison et al.

reported no significant difference in any type of thyroid disease between Utah children exposed to fallout radiation in the 1950s and control groups drawn from Utah and Arizona (AJM 1974a:457-463; JAMA 1975a:1069-1072).

To investigate the possible relationship between childhood leukemia and radioactive fallout, Lyon et al. conducted a mortality study of Utah children under 15 years old who died in Utah between 1944 and 1975 (NEJM 1979a:397-402). Lyon et al. selected this age group because of the reported increased susceptibility of children to the neoplastic effects of radiation and the lack of a comparison group over 14 years of age with suitable low exposures. Lyon et al. obtained death certificates from the Utah vital statistics registrar and based on year of death, categorized decedents into either high (fallout years of 1951 to 1958) or low exposure periods (combined pre-fallout years of 1944 to 1950 and post-fallout years of 1959 to 1975). From estimated fallout patterns contained in maps of 26 tests, Lyon et al. categorized 17 southern rural counties as high fallout area and the remaining northern urban counties as low fallout area. Age-specific mortality rates derived for deaths which occurred in the combined low exposure periods were compared with those in the high exposure period. For reasons unknown, leukemia mortality during the low exposure periods in high fallout counties was half that of the United States and Utah. A significant excess of leukemia occurred among children statewide who died during the high fallout period compared to those who died during the low fallout periods (SMR - 1.40, 95 percent CI - 1.08-1.82, $p<0.01$). This excess was more pronounced among those who resided in the high fallout area (SMR - 2.44, 95 percent CI - 1.18-5.03). No pattern was found for other childhood cancers in relation to fallout exposure. Actual radiation dosage was not available, and the effects of migration were not determined for this study.

Beck and Krey (Science 1983a:18-24) reconstructed exposure of Utah residents studied by Lyon et al. (NEJM 1979a:397-402) to external gamma-radiation from NTS fallout through measurements of residual cesium-137 and plutonium in soil. Beck and Krey found that residents in southwest Utah closest to NTS received the highest exposures, but noted that residents of urban northern areas received a higher mean dose and a significantly greater population dose than did residents of most counties closer to the test site. Northern Utah residents received higher average bone doses than southern Utah residents; therefore, distance from NTS should not be the sole criteria for dividing the state into geographic subgroups for the purpose of conducting epidemiologic studies. Beck and Krey concluded that bone doses to southern Utah residents were too low to account for the excess leukemia deaths identified by Lyon et al. They also determined that bone and whole body doses from NTS fallout were small relative to lifetime doses most Utah residents receive from background radiation, and that it was unlikely that these exposures would have resulted in any observed health effects.

Land et al. (Science 1984a:139-144) attempted to confirm the association between leukemia and fallout reported by Lyon et al. (NEJM 1979a:397-402) using cancer mortality data from the National Center for Health Statistics for the period 1950 through 1978. No statistically significant differences in mortality from leukemia or other childhood malignancies between northern and southern Utah were observed. The small observed difference in leukemia mortality between the border and interior counties was opposite in direction to that reported by Lyon et al. Results indicated a downward trend in childhood leukemia mortality over time. Eastern Oregon and the State of Iowa also were selected for comparison with Utah. The leukemia mortality rate for eastern Oregon was higher, and Iowa lower than the rate for Utah. Although both were not statistically significant, Land et al. concluded that these results suggest that the association reported by Lyon et al. merely reflects an unexplained low leukemia rate in southern Utah for the period 1944 to 1949.

Another study that assessed the development of cancer among individuals potentially exposed to

radioactive fallout has been reported by Rallison et al. (HP 1990c:739-746). This study examined the thyroid neoplasia risk in a cohort of children born between 1947 to 1954 in two counties near nuclear test sites, one in Utah and one in Nevada. A comparison group of Arizona children presumed to have no fallout exposures was also evaluated. The children (11 to 18 years of age) were examined between 1965 to 1968 for thyroid abnormalities and were reexamined in 1985 and 1986. Children living in the nuclear testing (Utah/Nevada) area had a higher rate of thyroid neoplasia than the comparison children (in Arizona), but the differences were not statistically significant. The authors concluded that living near NTS in the 1950s has not resulted in a statistically significant increase in thyroid neoplasms.

A study by Johnson examined cancer incidence in a cohort of Mormon families in southwest Utah near the NTS (JAMA 1984b:230-236). The study compared cancer incidence among all Utah Mormons during the period 1967 to 1975 with cancer incidence among two exposed populations: persons residing in a high fallout area and an exposure effects group residing in a broader area that received less intense exposure from radioactive fallout. Limitations of the study include: the inability to locate 40 percent of the defined population, the lack of verifying the reported diagnosis of cancer, and the inability to interview a comparable control group.

Cancer incidence for both exposed groups was compared with that of all Utah Mormons for two time periods, 1958 to 1966 and 1972 to 1980. Johnson found an apparent increased incidence of leukemia and cancers of the thyroid and bone for residents of the high fallout area for both time periods (p - 0.01). Additional analyses suggested that a higher proportion of the cancers among exposed groups were in radiosensitive tissues and the proportional excess increased with time compared with all Utah Mormons. The ratio of radiosensitive cancers to all other cancers from 1958 to 1966 was 24 percent higher among the high fallout area group and 29.6 percent higher among those in the fallout effects group. For 1972-80, the ratio was 53.3 percent higher in the high fallout area group and 300 percent higher in the fallout effects group.

Machado examined cancer mortality rates of a three-county region in southwestern Utah in comparison to the remainder of Utah (AJE 1987c:44-61). There was no excess risk of cancer mortality in southwest Utah, with the exception of leukemia, which showed a statistically significant excess for all ages combined, and for children age 0 to 14. In fact, mortality from all cancer sites combined was lower in southwest Utah than the remainder of the state. The authors noted that their findings, including those for leukemia, were inconsistent with the cancer incidence study conducted by Johnson (JAMA 1984b:230-236).

Archer measured soil, milk, and bone strontium-90 levels to identify states with high-, intermediate-, and low-fallout contamination (AEH 1987a:263-271). He then correlated the deaths from radiogenic and nonradiogenic leukemias with the time periods of aboveground nuclear testing both in the United States and Asia. The results show that leukemia deaths in children were higher in states with high exposure and lower in states with less exposure. He showed that leukemia deaths in children peaked approximately 5.5 years following nuclear testing peaks. The last leukemia peak in the United Sates occurred from 1968 to 1969, 5.5 years after the last year of a 3-year period of intensive testing in Asia. The increases were seen in the radiogenic leukemias (myeloid and acute leukemias), and not with all other leukemias.

Kerber et al. updated a previously identified cohort of children living in portions of Utah, Nevada, and Arizona, to estimate individual radiation doses and determine thyroid disease status through 1985 to 1986 (JAMA 1993a:2076-2082). Of the 4,818 children originally examined between 1965-70,

2,473 were included in the followup exam. Outcomes of interest included thyroid cancers, neoplasms, and nodules based on physical examinations of the thyroid. Exposure of the thyroid to radioiodines was based on radionuclide deposition rates provided by DOE and surveys of milk producers. Children with questionable findings were referred to a panel of endocrinologists for further examination. The authors reported an excess number of thyroid neoplasms (combined benign and malignant) and a positive dose-response trend for neoplasms, both of which were statistically significant. The authors also reported a positive dose-response trend for thyroid nodules, not statistically significant, and a positive dose-response trend for thyroid carcinomas with marginal statistical significance. The authors estimated that an excess of between 1 and 12 neoplasms (between 0 to 6 excess malignancies) was probably caused by exposure to radioiodines from the nuclear weapons testing. A letter to the editor criticized Kerber et al. for relying on food histories obtained 22 years after the fact to depict radioiodine intake, and for the untested modeling approach for determining dose to the thyroid (JAMA 1994a:825-826). These concerns were addressed by Kerber et al., which acknowledged the uncertainties in the dose estimates, but concluded that their estimates were conservative (JAMA 1994b:826).

Till et al. estimated doses to the thyroid of 3,545 subjects who were exposed to radioiodine fallout from NTS (HP 1995a:472-483). The U.S. Public Health Service first examined this cohort for thyroid disease between 1965 to 1970 and later in 1985 to 1986. Till et al. assigned individual doses based on age, residence histories, dietary histories, and lifestyle. Individualized dose and uncertainty was combined with the results of clinical examinations to determine the relationship between dose from NTS fallout and thyroid disease incidence.

Workers. Military personnel and civilian employees of the Department of Defense observed and participated in maneuvers at the NTS Test Range Complex during above ground tests. An excess number of leukemia cases was reported (9 cases, 3.5 expected) among the 3,224 men who participated in military maneuvers in August 1957 at the time of the nuclear test explosion "Smoky" (JAMA 1980a:1575-1578). The participants were located and queried on their health status, diseases, or hospitalizations as of December 1981. Various Federal records systems were linked, including clinical files, and next of kin were queried about cause of death for those participants who were deceased. Exposure information was available from film badges records, and the mean gamma dose for the entire cohort was 466.2 mrem. In a later report of the same cohort, the number of incident cases of leukemia had increased to 10 with 4 expected (JAMA 1983a:620-624). No excess in "total cancers" was observed, however. In addition, four cases of polycythemia vera were reported where 0.2 was expected (JAMA 1984a:662-664). The excess in leukemia cancer incidence and mortality appear to be limited to the soldiers who participated in "Smoky."

The leukemia excess was not observed in a National Research Council mortality study of soldiers exposed to five series of tests at two sites: Nevada Test Site (PLUMBBOB) and the Pacific Proving Ground (DOE 1985b; NAS 1985a). The National Research Council reported that the number of leukemia cases in "Smoky" was greater, but the increase was considered nonsignificant when analyzed with the data from the other four tests. In 1989, however, it was discovered that the roster of the atomic veterans cohort on which the National Research Council based its 1985 study contained misclassification errors. As a result, this study is being reanalyzed, and the National Research Council anticipates publishing the new results by 1997.

APPENDIX F: FACILITY ACCIDENTS

F.1 Evaluation Methodologies and Assumptions

F.1.1 Introduction

The potential for facility accidents and the magnitudes of their consequences are important factors in evaluating the stockpile stewardship and management alternatives addressed in this programmatic environmental impact statement (PEIS). The health risk issues are twofold:

- Whether accidents at any of the individual stockpile stewardship and management facilities (or reasonable combinations thereof) pose unacceptable health risks to workers or the general public.
- Whether alternative locations for stockpile stewardship and management facilities (or reasonable combinations thereof) can provide lesser public or worker health risks. These lesser risks may arise either from a greater isolation of the site from the public or from a reduced frequency of such external accident initiators as seismic events, and aircraft crashes.

Guidance for implementing Council on Environmental Quality regulation, 40 Code of Federal Regulations 1502.22, as amended (51 FR 15618), requires the evaluation of impacts which have low probability of occurrence but high consequences if they do occur; thus, facility accidents must be addressed to the extent feasible in this PEIS. Further, public comments received during the scoping process clearly indicated the public's concern with facility safety and consequent health risks and the need to address these concerns in the decision-making process.

For the No Action case, potential accidents are defined in existing facility documentation, such as safety analysis reports, hazards assessment documents, National Environmental Policy Act (NEPA) of 1969 documents, and probabilistic risk assessments. The accidents include radiological and chemical accidents that produce high consequences but have a low likelihood of occurrence, and a spectrum of other accidents that have a higher likelihood of occurrence and lesser consequences than the high consequence accidents. The data in these documents includes accident scenarios, probabilities, materials at risk, source terms (quantities of hazardous materials released to the environment), and consequences.

For new, modified, or upgraded stockpile stewardship and management facilities, the identification of accident scenarios and associated data would normally be a product of safety analysis reports performed on completed facility designs. However, facility designs have not been completed for the alternatives analyzed in the programmatic portion of this PEIS. Accordingly, the accident information developed for this PEIS has been developed based upon existing information for similar facilities. The likelihood and consequences of accidents (which are site dependent) are recomputed for each of the stockpile stewardship and management proposed sites where a facility may be located. This calculation reflects the effects of such site parameters as population size and distribution, meteorology, and distance to the site boundary.

This analysis also acknowledges, semi-quantitatively, the differences in likelihood of accident initiators at specific sites (e.g., aircraft impacts, beyond design basis seismic events, and so forth), as well as qualitatively discussing the opportunities for risk reduction afforded by the potential

incorporation of new technologies, processes, or protective features in the stockpile stewardship and management facilities that will enhance public health and safety over the existing facilities.

Subsequent to this PEIS, evaluation of the specific benefits achieved by such measures would be presented in the tiered project-specific NEPA document for each facility. Also, for each new facility, a Hazards Analysis Document that identifies and estimates the effects of all major hazards that have the potential to impact the environment, workers, and the public would be issued in conjunction with the Conceptual Design Package. Additional accident analyses for identified major hazards would be provided in a Preliminary Safety Analysis Report (SAR) to be issued during the period of Definitive Design (Title II) Review. A Final SAR would be prepared during the construction period and issued before testing begins as final documented evidence that the new facility can be operated in a manner that does not present any undue risk to the health and safety of workers and the public.

The accident scenarios chosen to represent the impacts for each alternative were arrived at through a screening process based on a larger set of accidents presented in existing safety documentation for similar facilities. Documents such as those shown in table F.1.1-1 were reviewed for applicable accident scenarios and data. The process sought to identify a bounding accident in each of several classes of events (e.g., fire, explosion, spill, mechanical, criticality, natural phenomena initiators, and external initiators) applicable to the alternative. The process also sought to identify bounding accidents over the spectrum of high to low probability of occurrence in order to include high-consequence/low-probability and low-consequence/high-probability accidents. These accidents are generally referred to as beyond evaluation basis accidents and evaluation basis accidents, respectively. In accordance with Department of Energy (DOE) NEPA Guidelines, beyond evaluation basis accidents are generally in the probability of occurrence range of 10 *-7* to 10 *-6* per year (yr), and evaluation basis accidents generally have a probability of occurrence greater than 10 *-6* /yr. These two designations are used only if formal SARs have not been prepared. In cases where SARs have been prepared, they are the source documents for two equivalent designations "beyond design basis accidents" and "design basis accidents." Based on discussions and meetings with experts, including a workshop, the accident scenarios were modified to reflect expected stockpile management facility conditions. For example, the material at risk identified in a safety report for a similar facility was adjusted to reflect the material at risk applicable to the Stockpile Stewardship and Management Program. A complete description of the development of accident scenarios for the alternatives is provided in a topical report (HNUS 1996a).

For each alternative, a number of evaluation and beyond evaluation basis accidents have been identified and are generally referred to as the "composite set of accidents." Two subsets of the composite set are also referred to as the "composite set of evaluation basis accidents" and the "composite set of beyond evaluation basis accidents." Impacts are presented for the composite set of accidents to reflect the combined impacts of evaluation basis and beyond evaluation basis accidents. The impacts for the composite set of evaluation basis accidents are also provided to reflect the impacts of high-frequency/low-consequence accidents and impacts for the composite set of beyond evaluation basis accidents are provided to show the impacts of low-frequency/high-consequence accidents. Evaluation basis accidents are generally in a frequency range greater than 10-6/yr, while beyond evaluation basis accidents are generally in a frequency range of 10-7 to 10-6/yr. In some cases, accidents less than 10-7 are included in the composite set of beyond evaluation basis accidents to provide information that is relevant to decisionmaking and that otherwise would not be considered.

For each alternative, each accident is analyzed to estimate its risk (i.e., mathematical product of an accident's probability of occurrence and the accident's consequences) and consequences (e.g., cancer

fatalities) to a noninvolved worker, a member of the public at the site boundary and the population out to 80 kilometers (km) (50 miles [mi]) from the accident. The estimated risks for the composite set of accidents analyzed for the alternative are mathematically combined to obtain an average risk (cancer fatalities per year) and consequences (cancer fatalities), given that the accidents occurred. The data on individual accidents used to calculate the composite values are provided in section F.2.

Table F.1.1-1.-- Source Documents Reviewed for Applicable Accident Scenarios

Item Number	Title	Site	Report Number	Date Published
01	"The Continued Operation of the Pantex Plant & Associated Storage of Nuclear Weapon Components EIS" Safety Information Document	Pantex	Draft Rev. 2	January 1995
02	Stockpile Stewardship and Management/PEIS Expanded Data Call Addendum to the Alternative Report for "Pit Manufacturing at Los Alamos National Laboratory"	LANL	none	June 1995
03	Stockpile Stewardship and Management/PEIS Expanded Data Call Addendum to Alternative Report for "Pit Manufacturing at Los Alamos National Laboratory"	LANL	LA-UR-95-2670	Sept. 1995
04	Appendix D "Accident Analysis"	LLNL	Volume II	Feb. 1992
05	Stockpile Stewardship and Management PEIS "Canned Secondary Assembly and Case Manufacturing Facility" Data Report Chapter 8 - Design Process for Accident Mitigation	LLNL	SST 95-07-006 Revision 1	July 17, 1995
06	Draft EIS and EIR for "The Continued Operation of Lawrence Livermore National Laboratory & Sandia National Laboratories, Livermore" **Unclassified Controlled Nuclear Information**	Sandia/LLNL	Volume 1 DOE/EIS - 0157 SCH90030847	Feb. 1992
07	Preliminary Draft EIS "The Continued Operation of the Pantex Plant & Associated Storage of Weapons Components" **Unclassified Controlled Nuclear Information**	Pantex	DOE/EIS 0225 DEIS Vol.1 & 2	Sept. 1995
08	EA for the "Proposed Interim Storage of Enriched Uranium Above the Maximum Historical Storage Level at the Y-12 Plant, Oak Ridge, Tennessee"	Y-12	DOE/EA-0929	Sept. 1994
09	"Basis for Interim Operation for the Pantex Plant, Amarillo, Texas"	Pantex	none	June 1995

10	"Revision 2 of the Basis for Interim Operation for TA-55-4"	LANL	ESH-3:94-105	June 1994
11	"Submittal of Revised JCO for CMR Facility" **Unclassified Controlled Nuclear Information**	LANL	none	Feb. 1995
12	"Accident/Event Analysis" (Safety Information Document)	Pantex	Draft-Rev. 2	Jan. 1995
13	"CMR Facility (SM-29) Final Safety Analysis Report" **Unclassified Controlled Nuclear Information**	LANL	CMR-FAC-94-001	Feb. 1994
14	Executive Summary - "Hazards Analysis of the Los Alamos National Laboratory Plutonium Facility (TA-55)" **Unclassified Controlled Nuclear Information**	LANL	TA-55 FSAR	July 13, 1995
15	Stockpile Stewardship and Management/PEIS "Alternative Report for Pit Manufacturing at SRS" **Unclassified Controlled Nuclear Information**	SRS	NMP-PLS-950176	Sept. 1, 1995
16	Draft Safety Analysis Report for "The Device Assembly Facility at the Nevada Test Site" **Unclassified Controlled Nuclear Information**	NTS	DAF SAR-001-193-5394C	March 1995
17	"U.S. Department of Energy Defense Programs Safety Survey Report" Volume III: Appendix B - Uranium Facilities **Unclassified Controlled Nuclear Information**	DOE	DOE/DP/70056-HI	Nov. 1993
18	"U.S. Department of Energy Defense Programs Safety Survey Report" Volume I: Main Report **Unclassified Controlled Nuclear Information**	DOE	DOE/DP/70056-HI	Nov. 1993
19	"U.S. Department of Energy Defense Programs Safety Survey Report" Volume II: Appendix A - Plutonium Facilities **Unclassified Controlled Nuclear Information**	DOE	DOE/DP/70056-HI	Nov. 1993
20	"U.S. Department Of Energy Defense Programs Safety Survey Report" Volume VI: Appendix E - Spent-fuel Handling Facilities **Unclassified Controlled Nuclear Information**	DOE	DOE/DP/70056-HI	Nov. 1993
21	"TA-55 Final Safety Analysis Report" Volume I **Unclassified Controlled Nuclear Information**	LANL	TA-55-PRD-108-01.0	July 13, 1995

22	"TA-55 Final Safety Analysis Report" Volume II **Unclassified Controlled Nuclear Information**	LANL	LA-CP-95-169	July 13, 1995
23	"TA-55 Hazard Analysis" **Unclassified Controlled Nuclear Information**	LANL	LA-CP-94-0076	July 13, 1995
24	"Nuclear Explosive Facilities Final Safety Analysis Report Nuclear Explosive Cells Module" (Buildings 12-44 Cells 1-6, 12-85, 12-96, and 12-98) **Unclassified Controlled Nuclear Information**	Pantex	Volume 1 - Draft B	July 1995
25	"Nuclear Explosive Facilities Final Safety Analysis Report Nuclear Explosive Cells Module" (Buildings 12-44 Cells 1-6, 12-85, 12-96, and 12-98) **Unclassified Controlled Nuclear Information**	Pantex	Volume 2 - Draft B	July 1995
26	"Chemical High Explosives Hazards Assessment for the Pantex Plant, Amarillo, Texas"	Pantex	none	Oct. 1993
27	(Data Call) Tab D: "Facility Operations" **Unclassified Controlled Nuclear Information**	Y-12	OR-9183	no date
28	"Nuclear Explosive Facilities Final Safety Analysis Report Nuclear Explosive Bays Module" (Buildings 12-64, 12-84, 12-99, and 12-104) **Unclassified Controlled Nuclear Information**	Pantex	Rev. 1 Draft 2 Volume 1	Dec. 1994
29	"Nuclear Explosive Facilities Final Safety Analysis Report Nuclear Explosive Bays Module" (Buildings 12-64, 12-84, 12-99, and 12-104) **Unclassified Controlled Nuclear Information**		Rev. 1 Draft 2 Volume 2	Dec. 1994
30	"Preliminary Safety Analysis Report Special Nuclear Materials Component Staging Facility" **Unclassified Controlled Nuclear Information**	Pantex	none	April 1989
31	"Safety Analysis Report - On-Site Transportation" **Unclassified Controlled Nuclear Information**	Pantex	Draft B	Sept. 1995
32	Stockpile Stewardship and Management/PEIS "Assembly/disassembly Nevada Test Site Alternative"	NTS	Volume 1	Aug. 4, 1995

33	Appendix 11-K - Release Fraction Data, Appendix 11-J - Consequence Equations Used in the Accident Analysis, Appendix 11-F - Seismic Accident Analysis, Appendix 11-E - Derivation of Data Values Used in the Accident Analysis **Unclassified Controlled Nuclear Information**	LANL	CMR-FAC-94-001	Feb., 1994
34	Draft "Design Process for Accident Mitigation" **Pit Disassembly and Conversion Facility Unclassified Controlled Nuclear Information**	LANL	Section 8	Aug. 21, 1995
35	**"U.S. Department of Energy Defense Programs Safety Survey Report" Volume V: Appendix D - Laboratory Facilities Unclassified Controlled Nuclear Information**	DOE	DOE/DP/70056-HI	Nov. 1993

F.1.2 Safety Design Process

One of the major design goals for stockpile stewardship and management facilities is to achieve a reduced risk to workers and the public relative to that associated with similar facilities in the existing Nuclear Weapons Complex. Significant changes exist between stockpile stewardship and management facilities and the current facilities design criteria and safety standards, which will reduce total risk to the public. These changes include design to current DOE structural and safety criteria; smaller throughput, batch size and inventories of certain hazardous materials; and elimination of some hazardous materials. This will reduce potential offsite health effects if an accidental release were to occur.

Stockpile stewardship and management facilities will be designed to comply with current Federal, state, and local laws; DOE orders; and industrial codes and standards. As a result, a facility will be provided that is highly resistant to the effects of natural phenomena, including earthquake, flood, tornado, high wind, as well as credible events appropriate to the site, such as fire and explosions, and manmade threats to its continuing structural integrity for containing hazardous materials. The facilities will be designed to maintain their continuing structural integrity in the event of any credible accident or event, including an aircraft crash, if credible at these sites.

The design process for new and modified stockpile stewardship and management facilities will comply with the requirements for safety analysis and evaluation in DOE O 430.1, Life-Cycle Asset Management and DOE Order 5480.23, Nuclear Safety Analysis Reports. Safety assessment is required to be an integral part of the design process to ensure compliance with all DOE safety criteria by the time that the facilities are constructed and in operation.

For new facilities, the safety analysis process begins early in conceptual design by identifying hazards with the potential to produce unacceptable safety consequences to workers or the public. As the design develops, failure mode and effects analyses are performed to identify events that have the potential to release hazardous material. The kinds of events considered include equipment failure, spills, human error, fire and explosions, criticality, earthquake, electrical storms, tornado, flood, and

aircraft crash. These postulated events become focal points for design changes or improvements to prevent unacceptable accidents. These analyses continue as the design progresses to assess the need for safety equipment and to assess the performance of this equipment in accident mitigation. Eventually, the safety analyses are formally documented in an SAR and/or in a probabilistic risk assessment. The probabilistic risk assessment documents the estimated frequency and consequence for an entire spectrum of accidents and helps to identify design improvements that could make meaningful safety improvements.

The first SAR is completed at the conclusion of conceptual design and includes identification of hazards and some limited assessment of a few enveloping design basis accidents. This analysis includes deterministic safety analysis and failure modes and effects analysis of major systems. A detailed, comprehensive Preliminary SAR is completed by the completion of preliminary design and provides a broad assessment of the range of design basis accident scenarios and the performance of equipment provided in the facility specifically for accident consequence mitigation. A limited probability risk assessment may be included in that analysis.

The SAR continues to be developed during detailed design. The safety review of this report and any supporting probabilistic risk assessment is completed and safety issues resolved before the facility construction is initiated. There is also a Final SAR produced that documents safety-related design changes during construction and the impact of those changes on the safety assessment. It also includes the results of any safety-related research and development that has been performed to support the safety assessment of the facility. Final approval of the Final SAR is required before the facility is allowed to commence operation.

F.1.3 Analysis Methodology

F.1.3.1 Introduction

The MELCOR Accident Consequence Code System (MACCS) was used to estimate the radiological consequences of all stockpile stewardship and management facilities for all accidents. The CHEMS-PLUS (CHEMS-PLUS, Enhanced Chemical Hazard Evaluation Methodologies, Arthur D. Little, Inc., July 1988) computer code was used to estimate the consequences of nonradiological accidents. A discussion of the MACCS code is provided in section F.1.3.2. A detailed description of the MACCS model is available in a three volume report: *MELCOR Accident Consequence Code System* (MACCS), NUREG/CR-4691, SAND 86-1562, February 1990.

F.1.3.2 MELCOR Accident Consequence Code System

MACCS models the offsite consequences of an accident that releases a plume of radioactive materials to the atmosphere. Should such an accidental release occur, the radioactive gases and aerosols in the plume would be transported by the prevailing wind while dispersing in the atmosphere. The environment would be contaminated by radioactive materials deposited from the plume, and the population would be exposed to radiation. The objectives of a MACCS calculation are to estimate the range and probability of the health effects induced by the radiation exposures not avoided by protective actions.

In order to understand MACCS, one must understand its two essential elements: the time scale after an accident is divided into various "phases" and the region surrounding the facility is divided into a polar-coordinate grid.

The time scale after the accident is divided into three phases: emergency phase, intermediate phase, and long-term phase. The emergency phase begins immediately after the accident and could last up to seven days following the accident. In this period, the exposure of population to both radioactive clouds and contaminated ground is modeled. Various protective measures can be specified for this phase, including evacuation, sheltering, and dose-dependent relocation.

The intermediate phase can be used to represent a period in which evaluations are performed and decisions are made regarding the type of protective measure actions that need to be taken. In this period, the radioactive clouds are assumed to be gone, and the only exposure pathways are those from the contaminated ground. The only protective measure that can be taken during this period is temporary relocation.

The long-term phase represents all time subsequent to the intermediate phase. The only exposure pathways considered here are those resulting from the contaminated ground. A variety of protective measures can be taken in the long-term phase in order to reduce doses to acceptable levels: decontamination, interdiction, and condemnation of property.

The spatial grid used to represent the region is centered on the facility itself. The user specifies the number of radial divisions as well as their endpoint distances. Up to 35 of these divisions may be defined, extending out to a maximum distance of 9,999 km (6,213 mi). The angular divisions used to define the spatial grid correspond to the sixteen directions of the compass.

Since the emergency phase calculations use highly nonlinear dose-response models for early fatality and early injury, it is necessary for those calculations to be performed on a finer grid than the calculations of the intermediate and long-term phases. For this reason, the 16 compass sectors are divided into 3, 5, or 7 user-specified subdivisions in the calculations of the emergency phase.

The increased likelihood (probability) of cancer fatality to a member of the public is taken as 5.0x10 -*4* times the dose in person-rem for values of dose less than 20 rem. For larger doses, when the rate of exposure is greater than 10 rads per hour, the increased likelihood of cancer fatality is doubled. The MACCS code was applied in a probabilistic manner using a weather bin sampling technique. Centerline doses as a function of distance were calculated for each of 150 meteorological sequence samples; the mean value of these doses and increased likelihoods of cancer fatality for the distance corresponding to the location of the maximum offsite individual at each site were reported for that individual. Doses to noninvolved workers were calculated similarly, except that these workers will experience an increased likelihood of cancer fatality of 4.0x10 -*4* times the dose in person-rem for doses less than 20 rem or exposure rates less than 10 rads per hour. For larger doses, when the rate of exposure is greater than 10 rads per hour, the increased likelihood of cancer fatality is doubled.

The hypothetical worker was placed at 1,000 meters (m) (3,281 feet [ft]) or at the site boundary, whichever is less. It should be noted that since the doses and cancer fatalities for the maximum offsite individual and the workers reported in the high-consequence/low-probability accident tables are mean values based on approximately 100 meteorological sequence samples, there is no direct correlation between the mean value of dose and the mean value of cancer fatalities.

Offsite population doses and latent cancer fatalities are calculated by MACCS using a methodology similar to that described for the maximum offsite individual. In the case of the population, each of the sampled meteorological sequences was applied to each of the 16 sectors (accounting for the

frequency of occurrence of the wind blowing in that direction). Population doses are the sum of the individual doses in each sector. Once again, the mean value of the calculated population doses and latent cancer fatalities for each of the trials are reported.

F.2 Stockpile Management

F.2.1 Weapons Assembly/Disassembly

Studies of evaluation basis accidents (EBA) and beyond evaluation basis accidents (BEBA) have been performed for the downsized weapons assembly/disassembly (A/D) operations. The studies postulated a set of accident scenarios that were representative of the risks and consequences for workers and the public from operations. Although not all potential accidents were addressed, those that were postulated have consequences and risks that are expected to envelop the consequences and risks of an operating facility.

The accident analyses in this PEIS have been closely coordinated with the Pantex Site-Wide EIS to ensure consistency. The Pantex Site-Wide EIS is a more detailed evaluation of the Pantex Plant (Pantex) operations than this PEIS. Consequently, if there are any differences between the two documents, this PEIS defers to the Pantex Site-Wide EIS as the more accurate analysis of potential impacts from accidents.

F.2.1.1 Accident Scenarios and Source Terms

A range of hazardous conditions and potential accidents were reviewed as candidates for estimating the risks to workers and the public from operating this facility. Through a screening process, several evaluation basis and beyond evaluation basis accidents were selected for further definition and analysis. A brief description of each of the six accident scenarios and source terms is presented below. Table F.2.1.1-1 presents a summary of each accident scenario and source term. Further detail can be found in a topical report (HNUS 1996a).

Scenario 1: Aircraft impact and release

Pantex Plant. Pantex is located approximately 13.6 km (8.5 mi) from the northeast-southwest runway at Amarillo International Airport. The scenario involving aircraft impact considers an impact into a cell or bay, possibly causing a fire and subsequent detonation of high explosive (HE) with burning plutonium, or pit damage from debris. An assessment of the probability of aircraft impact into Pantex structures has been prepared for the Draft Environmental Impact Statement for the Continued Operation of the Pantex Plant and Associated Storage of Nuclear Weapons Components (DOE/EIS-0225D, March 1996). Based on existing information, aircraft impact into an assembly cell or bay buildings and the release of hazardous material is considered a credible but extremely unlikely event with an estimated probability in the range of $1x10^{-7}$ to $5x10^{-6}$/yr. For calculation purposes a value of $8x10^{-7}$/yr is assumed. A high-speed military aircraft or a large commercial aircraft crashing into a single facility could cause sufficient damage to release plutonium. The degree of damage incurred and any subsequent release of radioactive materials depends on the size and speed of the aircraft involved, among other factors. The impacts of an aircraft crash into a stockpile stewardship and management weapons A/D Facility are based on an analysis performed for the Pantex Site-Wide EIS of an aircraft crash into Zone 4 and Zone 12 facilities. Since stockpile stewardship and management facilities are only in Zone 12, the Pantex Site-Wide EIS impacts were scaled to 28 percent of the public risk, and 61 percent of the maximum offsite individual risk. For the noninvolved worker, the Pantex Site-Wide EIS estimates that a worker at 100 m (328 ft) will not survive the aircraft crash effects. For the *Stockpile Stewardship and Management PEIS* , the noninvolved worker is assumed to be at 1,000 m (3,281 ft) and survives the crash. The accident consequences and risks to the

noninvolved worker and the maximally exposed individual are discussed in section F.2.1.2.

Table F.2.1.1-1.-- Accident Scenarios for Downsized Weapons Assembly/Disassembly Operations

Accident Scenario	Site	Accident Frequency (Per Year)	Total Material Released to Environment
1. Aircraft impact and release	Pantex	8x10-7	1
	NTS	$<1x10^{-7}$	Not applicable
2. Explosive dispersal of plutonium from high explosives detonation in cell or bay	Pantex	$5.7x10^{-6}$	62 g to 5,000 g plutonium2 metal
	NTS	$5.7x10^{-6}$	96 g to 5,000 g plutonium2metal
3. Mechanical release due to pit drop or impact of forklift breaching pit cladding	Pantex	$7.8x10^{-3}$	$6x10^{-5}$ g plutonium metal
	NTS	$7.8x10^{-3}$	$6x10^{-5}$ g plutonium metal
4. Inadvertent activation of explosive squib on tritium reservoir	Pantex	0.02	1.8 g of tritium oxide and 18.2 g of elemental tritium
	NTS	0.02	1.8 g of tritium oxide and 18.2 g of elemental tritium
5. Operational fire-induced plutonium release	Pantex	$1x10^{-5}$	20 g plutonium oxide
	NTS	$1x10^{-5}$	20 g plutonium oxide
6. Fire-induced release from tritium reservoirs in staging vault	Pantex	$4x10^{-7}$	600 g tritium oxide2
	NTS	$4x10^{-7}$	600 g tritium oxide2

Nevada Test Site. The probability of an aircraft impact into the downsized weapons A/D facilities is estimated at less than 10^{-7} /yr and, in accordance with NEPA guidelines, does not have to be considered further.

Scenario 2: Explosive dispersal of plutonium from HE detonation in cell or bay. The combined probability of an explosive dispersal of plutonium in a bay ($7x10^{-7}$/yr) or cell ($5x10^{-6}$/yr) is $5.7x10^{-6}$ /yr. This value is conservatively based on 2,000 weapons operations per year. The anticipated number of weapons operations per year is 300 for the downsize A/D mission at Pantex.

Scenario 2.1: Explosive dispersal of plutonium from high explosives detonation in an assembly bay. Explosive dispersal of a plutonium pit would be the greatest when HE is in direct contact with the pit during an explosion or fire. The explosion would blow off the roof and doors of the bay; thus, no material would be retained inside the structure. As a result, it is assumed that all of the respirable plutonium would be released into the environment.

Pantex Plant. For the purposes of this analysis, the release of respirable plutonium from a Pantex assembly bay is assumed to be 5,000 grams (g) (176 ounces [oz]). The probability of this accident is $7x10^{-7}$/yr.

Nevada Test Site. For the purposes of this analysis, the release of respirable plutonium from a Nevada Test Site (NTS) assembly bay is assumed to be 5,000 g (176 oz). The probability of this accident is $7x10^{-7}$ /yr.

Scenario 2.2: Explosive dispersal of plutonium from high explosives detonation in an assembly cell assuming no roof collapse. A detonation of less than 45 kilograms (kg) (100 pounds [lb]) (130 lb trinitrotoluene [TNT] equivalent) of HE is estimated to be the amount of HE that would not cause the roof of a gravel gertie cell at Pantex or NTS to at least partially collapse. The explosion, which would cause greater than atmospheric pressures, would exist in the cell for approximately 1 minute. Since the roof does not collapse, a large fraction of the plutonium would be retained by the intact structures. In the case of large detonations causing the cell roof to collapse, the estimated release and consequences are bounded by the case in which the roof does not collapse.

Pantex Plant. The calculated respirable release from a Pantex assembly cell for this scenario is estimated to be 62 g (2.2 oz) of plutonium. The probability of this accident is $5x10^{-6}$/yr.

Nevada Test Site. The total respirable release from the NTS assembly cell for this scenario is estimated to be 96 g (3.4 oz) of plutonium. The probability of this accident is $5x10^{-6}$/yr.

Scenario 3: Mechanical release due to dropping a pit and breaching the cladding. For the purposes of this analysis, a pit is generically defined as a 6.5-kg (14-lb) spherical shell clad in thin metal alloy. Operational scenarios that have the potential to release small quantities of plutonium include dropping a pit onto the floor, cracking the external cladding because of disassembly stress, hitting a pit with other equipment, pulling out a pit tube during A/D, and breaching a container and pit with a forklift. A pit drop accident is used to characterize the category of events leading to violation of pit integrity.

An event of this nature has occurred at Pantex, where a weapon cladding was cracked, resulting in localized contamination around the pit. In this instance, the airborne contamination was insufficient to actuate the radiation alarm, and the worker dose was less than 0.1 rem.

Pantex Plant. The probability of a pit drop or forklift impact accident with a small plutonium release to a cell or bay at Pantex is $7.8x10^{-3}$ /yr. The total release to the environment is estimated to be $6x10^{-5}$ g of plutonium. *Nevada Test Site.* The probability of a pit drop or forklift impact accident with a small plutonium release to a cell or bay at NTS is $7.8x10^{-3}$ /yr. The total release to the environment is estimated to be $6x10^{-5}$ g of plutonium.

Scenario 4: Inadvertent activation of explosive squib on tritium reservoir. During assembly or disassembly of a nuclear explosive, conditions could be encountered in which an electro-explosive device is accidentally fired and releases tritium from a reservoir. There have been two events (one at a weapons complex and one at a military installation) in which a squib was inadvertently actuated, releasing tritium from a reservoir. Since the events occurred, added precautions have been implemented. For this scenario, the squib valve must fire, releasing tritium from the reservoir, and the stem tube must be breached or disconnected from the pit (the latter is a normal step of disassembly).

For the purposes of this analysis, a reservoir is assumed to contain 20 g (0.7 oz) of elemental tritium. The entire amount of this tritium is assumed to be released in gaseous form. (Only hydrogen tritide is

considered in assessing of worker dose, because only about 1 percent of hydrogen tritide is converted to tritium oxide after 1 hour.) All elemental tritium is 100 percent respirable. The amount of tritium which becomes airborne in the cell or bay is thus 20 g (0.7 oz). Upon detecting tritium, the exhaust fans will continue to operate and exhaust tritium to the atmosphere. The potential offsite doses from the tritium release would depend on the extent of tritium oxidation, which is estimated to be 9 percent as a bounding limit.

Pantex Plant. The probability of inadvertent squib activation during operations in an assembly cell or bay is 0.02/yr. The total release is estimated to be 1.8 g (0.06 oz) of tritium oxide and 18.2 g (0.6 oz) of elemental tritium.

Nevada Test Site. The probability of inadvertent squib activation during operations in an assembly cell or bay is estimated to be the same as at Pantex with the same total release of 1.8 g (0.06 oz) of tritium oxide and 18.2 g (0.6 oz) of elemental tritium.

Scenario 5: Operational fire-induced plutonium dispersal. The metal-clad plutonium pits are designed to maintain their integrity for certain temperature levels but are not intended to function as barriers against release. The facilities (assembly cells or bays) that can have plutonium pits outside of their containers would likely remain intact in a fire not associated with an explosion. A bounding scenario for fire-induced plutonium dispersal assumes the radioactive material limit in a cell or bay is dispersed by fire with no containment.

Pantex Site. The probability of an operational fire-induced plutonium dispersal is $1x10^{-5}$ /yr. The total material released is 20 g (0.7 oz) of plutonium oxide.

Nevada Test Site. The operational fire at Pantex is assumed to occur at NTS with the same frequency and release as at Pantex.

Scenario 6: Fire-induced release from tritium reservoirs in staging vault. In this scenario, an earthquake is assumed to cause a fire in the vault where in-process tritium reservoirs are stored. The fire causes 100 percent of the tritium reservoirs in the vault to fail, releasing its entire contents. In addition, it is assumed that the elemental tritium is completely oxidized by the fire.

Pantex Plant. The probability of a release of tritium from the Pantex A/D staging area is $4x10^{-7}$ /yr. For the purposes of this analysis, the release is assumed to be 600 g (21 oz) of tritium oxide.

Nevada Test Site. It is assumed that this scenario at Pantex would be applicable at NTS. Therefore, the accident probability is $4x10^{-7}$ /yr. For the purposes of this analysis, the release is assumed to be 600 g (21 oz) of tritium oxide.

F.2.1.2 Accident Consequences and Risk

Tables F.2.1.2-1 and F.2.1.2-2 list the set of accidents selected to represent consequences and risks to workers and the public from accidental releases of radioactive materials during operations at Pantex and NTS, respectively. For each accident, the table identifies the frequency of occurrence and the consequences to a hypothetical worker located 1,000 m (3,281 ft) from the accident, a hypothetical individual located at the nearest site boundary, and the public out to a distance of 80 km (50 mi). The risks of cancer fatality for the worker, the individual at the site boundary, and the public for the

composite set of accidents are also shown.

Table F.2.1.2-1.-- Downsized Weapons Assembly/Disassembly Operations at Pantex Plant, Impacts of Accidents

	Noninvolved Worker at 1,000 Meters		Maximum Offsite Individual		Population to 80 Kilometers		
Accident Scenario	**Dose (rem)**	**Probability of Cancer Fatality[3]**	**Dose (rem)**	**Probability of Cancer Fatalitya**	**Dose (person-rem)**	**Cancer Fatalities**	**Accident Frequency (per year)**
1. Aircraft impact and release[4]	23	9.2x10-3	23	0.012	2.8×10^{3}	1.4	8.0×10^{-7}
2. Explosive dispersal of plutonium in cell or bay	16.9	6.8×10^{-3}	12.9	6.5×10^{-3}	3.8×10^{3}	1.9	5.7×10^{-6}
3. Mechanical release from impact breach of pit cladding	3.2×10^{-6}	1.3×10^{-9}	2.4×10^{-6}	1.2×10^{-9}	6.5×10^{-4}	3.2×10^{-7}	7.8×10^{-3}
4. Inadvertent activation of explosive squib on tritium reservoir	9.7×10^{-4}	3.9×10^{-7}	7.4×10^{-4}	3.7×10^{-7}	0.20	9.9×10^{-5}	0.02
5. Operational fire-induced plutonium release	0.52	2.1×10^{-4}	0.40	2.0×10^{-4}	107	0.054	1.0×10^{-5}
6. Fire-induced release from tritium reservoirs in staging vault[4]	0.31	1.2×10^{-4}	0.24	1.2×10^{-4}	66	0.033	4.0×10^{-7}
Impacts for Composite Set of EBAs and BEBAs[5]							
Expected consequences[6]		2.0x10-6		2.0×10^{-6}		5.2×10^{-4}	
Expected risk (per year)		5.6×10^{-8}		5.6×10^{-8}		1.5×10^{-5}	
Impacts for Composite Set of EBAs							
Expected consequences[6]		1.7×10^{-6}		1.7×10^{-6}		4.8×10^{-4}	

Expected risk (per year)		4.8×10^{-8}		4.6×10^{-8}		1.3×10^{-5}	
Impacts for Composite Set of BEBAs							
Expected consequences[6]		6.2x10-3		8.0x10-3		0.94	
Expected risk (per year)		7.4×10^{-9}		9.7×10^{-9}		1.1×10^{-6}	

Table F.2.1.2-2.-- Downsized Weapons Assembly/Disassembly Operations at Nevada Test Site, Impacts of Accidents

	Noninvolved Worker at 1,000 Meters		Maximum Offsite Individual		Population to 80 Kilometers		
Accident Scenario	**Dose (rem)**	**Probability of Cancer Fatality[7]**	**Dose (rem)**	**Probability of Cancer Fatality**	**Dose (person-rem)**	**Cancer Fatalities**	**Accident Frequency (per year)**
1. Aircraft impact and release	[8]	[8]	[8]	[8]	[8]	[8]	[8]
2. Explosive dispersal of plutonium in cell or bay	26.1	0.01	2.3	1.1×10^{-3}	361	0.18	5.7×10^{-6}
3. Mechanical release from impact breach of pit cladding	4.7×10^{-6}	1.9×10^{-9}	4.0×10^{-7}	2.0×10^{-10}	5.4×10^{-5}	2.7×10^{-8}	7.8×10^{-3}
4. Inadvertent activation of explosive squib on tritium reservoir	1.4×10^{-3}	5.7×10^{-7}	1.2×10^{-4}	6.2×10^{-8}	0.016	8.1×10^{-6}	0.02
5. Operational fire-induced plutonium release	0.77	3.1×10^{-4}	0.066	3.3×10^{-5}	8.9	4.4×10^{-3}	1.0×10^{-5}
6. Fire-induced release from tritium reservoirs in staging vault[9]	0.42	1.7×10^{-4}	0.038	1.9×10^{-5}	5.6	2.8×10^{-3}	4.0×10^{-7}
Impacts of Composite Set of EBAs and BEBAs[10]							
Expected consequences[11]		2.7×10^{-6}		2.9×10^{-7}		4.4×10^{-5}	

Expected risk (per year)		7.4×10^{-8}		8.1×10^{-9}		1.2×10^{-6}	
Impacts for Composite Set of EBAs							
Expected consequences[11]		2.7x10-6		2.9×10^{-7}		4.4×10^{-5}	
Expected risk (per year)		7.4×10^{-8}		8.1×10^{-9}		1.2×10^{-6}	
Impacts for Composite Set of BEBAs							
Expected consequences[11]		1.7×10^{-4}		1.9×10^{-5}		2.8×10^{-3}	
Expected risk (per year)		6.7×10^{-11}		7.7×10^{-12}		1.1×10^{-9}	

1 For the aircraft crash accident, the Stockpile Stewardship and Management PEIS impacts are based on a percentage of the risks described in the Pantex Site-Wide Draft EIS. See the discussion under Scenario 1 in this section for additional details.

2 The maximum amount of material is a hypothetical amount chosen for the purposes of this analysis. HNUS 1996a.

3 Probability (increased likelihood) of cancer fatality to a hypothetical member of the public located at the site boundary or a worker located at 1,000 m (3,281 ft) from the accident as a result of exposure to the indicated dose if the accident occurred.

4 A beyond evaluation basis accident (BEBA). All other listed accidents are evaluation basis accidents (EBA).

5 For the offsite population of 285,409, the average probability of cancer fatality/risk of cancer fatality (per year) for the composite set of accidents is $1.8 \times 10^{-9}/5.3 \times 10^{-11}$.

6 Result of exposure to the indicated dose if the accident occurs. All values are mean values. Model results.

7 Probability (increased likelihood) of cancer fatality to a hypothetical member of the public located at the site boundary or to a worker located 1,000 m (3,281 ft) from the accident as a result of exposure to the indicated dose if the accident occurred.

8 Not applicable. The probability of an aircraft crash is estimated to be lower than 10^{-7} /yr.

9 A beyond evaluation basis accident (BEBA). All other listed accidents are evaluation basis accidents (EBA).

10 For the offsite population of 18,517, the average probability of cancer fatality/risk of cancer fatality (per year) for the composite set of accidents is $2.4 \times 10^{-9}/6.5 \times 10^{-11}$.

11 Result of exposure to the indicated dose if the accident occurs. All values are mean values. Model results.

APPENDIX F: FACILITY ACCIDENTS

F.2.2 Secondary and Case Fabrication

Evaluation basis accidents and beyond evaluation basis accidents have been studied for the secondary and case fabrication operations. The studies postulated a set of accident scenarios that were representative of the risks and consequences for workers and the public that can be expected from operations. Although not all potential accidents were addressed, those that were postulated have consequences and risks that are expected to envelop the consequences and risks of the relocated operations.

F.2.2.1 Accident Scenarios and Source Terms

A range of hazardous conditions and potential accidents were reviewed as candidates to represent the risks of the facility's operation to workers and the public. Through a screening process, several evaluation basis accidents and beyond evaluation basis accidents were selected for further definition and analysis. A brief description of each of the 12 accident scenarios and source terms is presented below. Table F.2.2.1-1 presents a summary of each accident scenario and source term. Further detail can be found in a topical report (HNUS 1996a).

Scenario 1: Nuclear criticality. Criticality accidents are postulated at nearly all locations where highly enriched uranium (HEU) is handled. Potential causes include operator error and loss of safe geometry resulting from fire damage to aluminum birdcage containers or structural damage from an earthquake. Both ground-level and elevated fission product releases to the atmosphere are postulated. The postulated criticality is based on the characteristics of a solution as specified by the U.S. Nuclear Regulatory Commission.

For the accidental criticality evaluated, it is assumed that 1x1019 fissions occur before reaching a stable, subcritical condition. This total is comprised of an initial burst of 1x1018 fissions followed by repeated bursts of 1x1017 fissions over an 8-hour period as liquid is assumed to be boiled from a solution system. 100 percent of the xenon and krypton formed is released; 25 percent of the iodine is released.

Oak Ridge Reservation. The criticality accident frequency is assumed to be extremely unlikely (1x10-6 to 1x10-4/yr).

Los Alamos National Laboratory. The criticality accident frequency is assumed to be extremely unlikely (1x10-6 to 1x10-4/yr).

Lawrence Livermore National Laboratory. The criticality accident frequency is assumed to be extremely unlikely (1x10-6 to 1x10-4/yr).

Scenario 2: Fire-induced dispersion of highly enriched uranium from a building collapse and resultant fire. The postulated accident assumes that a beyond evaluation basis earthquake causes the uranium process, component fabrication, and storage facilities to collapse. Ruptured gas lines and/or hydraulic lines cause fires in the process and component fabrication facilities.

Oak Ridge Reservation. The frequency of this accident is beyond evaluation basis (1x10-7 to 1x10-6).

The total HEU source term released in oxide form is estimated to be 17 kg (37 lb) and 1.5 kg (3.3 lb) of depleted uranium.

Los Alamos National Laboratory. The accident defined for Oak Ridge Reservation (ORR) is assumed to be valid at Los Alamos National Laboratory (LANL). The frequency is assumed to be in the range of 1x10-7 to 1x10-6/yr. The total release is 17 kg (37 lb) of HEU and 1.5 kg (3.3 lb) of depleted uranium. The location of the release is the Chemistry and Metallurgy Research Building.

Table F.2.2.1-1.-- Accident Scenarios for Secondary and Case Fabrication

Accident Scenario	Site	Accident Frequency (per year)	Total Material Released to Environment
1. Nuclear criticality	ORR	1x10-6 to 1x10-4	1x1019 fissions
	LANL	1x10-6 to 1x10-4	1x1019 fissions
	LLNL	1x10-6 to 1x10-4	1x1019 fissions
2. Fire-induced dispersion of highly enriched uranium from a building collapse and resultant fire	ORR	1x10-7 to 1x10-6	17 kg of HEU and 1.5 kg of depleted uranium
	LANL	1x10-7 to 1x10-6	17 kg of HEU and 1.5 kg of depleted uranium
	LLNL	1x10-7 to 1x10-6	17 kg of HEU and 1.5 kg of depleted uranium
3. Dry criticality resulting from vehicle accident	ORR	1x10-6 to 1x10-4	1x1018 fissions
	LANL	1x10-6 to 1x10-4	1x1018 fissions
	LLNL	1x10-6 to 1x10-4	1x1018 fissions
4. Fire-induced release of highly enriched uranium from solvent fire	ORR	1x10-6 to 1x10-4	4 kg of HEU
	LANL	1x10-6 to 1x10-4	4 kg of HEU
	LLNL	1x10-6 to 1x10-4	4 kg of HEU
5. Fire-induced release of highly enriched uranium from metallurgical operations	ORR	1x10-6 to 1x10-4	3.75 kg of HEU
	LANL	1x10-6 to 1x10-4	3.75 kg of HEU
	LLNL	1x10-6 to 1x10-4	3.75 kg of HEU
6. Fire-induced release of lithium	ORR	1x10-6 to 1x10-4	2,800 kg Li2O
	LANL	1x10-6 to 1x10-4	2,800 kg Li2O
	LLNL	1x10-6 to 1x10-4	2,800 kg Li2O
7. Fire-induced release of highly enriched uranium on loading dock	ORR	1x10-6 to 1x10-4	0.8 kg of HEU
	LANL	1x10-6 to 1x10-4	0.8 kg of HEU
	LLNL	1x10-6 to 1x10-4	0.8 kg of HEU
8. Filter failure-induced release of highly enriched uranium	ORR	1x10-6 to 1x10-4	1.6 kg of HEU
	LANL	1x10-6 to 1x10-4	1.6 kg of HEU
	LLNL	1x10-6 to 1x10-4	1.6 kg of HEU

9. Mechanical release of hydrogen fluoride	ORR	1x10-6 to 1x10-4	386 kg of hydrogen fluoride
	LANL	1x10-6 to 1x10-4	386 kg of hydrogen fluoride
	LLNL	1x10-6 to 1x10-4	386 kg of hydrogen fluoride
10. Fire-induced release of hydrogen cyanide	ORR	1x10-6 to 1x10-4	300 kg of acetonitrile solvent
	LANL	1x10-6 to 1x10-4	300 kg of acetonitrile solvent
	LLNL	1x10-6 to 1x10-4	300 kg of acetonitrile solvent
HNUS 1996a.			

Lawrence Livermore National Laboratory. The accident defined for ORR is assumed to be valid at Lawrence Livermore National Laboratory (LLNL). The frequency is assumed to be in the range of 1x10-7 to 1x10-6/yr. The total release is 17 kg (37 lb) of HEU and 1.5 kg (3.3 lb) of depleted uranium.

Scenario 3: Dry criticality resulting from vehicle accident. A vehicle accident is postulated in which the contents are dislodged and possibly mixed with moderating materials, creating a criticality. HEU oxide powder is spilled and collected in the vehicle's low point. The accidental criticality could be initiated by an error in strapping or by wheels falling off a bottle dolly. The postulated criticality results in 1x10 *18* fissions for the dry criticality.

Oak Ridge Reservation. The accident frequency is assumed to be in the range of extremely unlikely (1x10-6 to 1x10-4/yr).

Los Alamos National Laboratory. The accident is assumed to occur at LANL with a frequency of 1x10-6 to 1x10-4/yr.

Lawrence Livermore National Laboratory. The accident is assumed to occur at LLNL with a frequency of 1x10-6 to 1x10-4/yr.

Scenario 4: Fire-induced release of highly enriched uranium from a solvent fire. A fire releasing uranium aerosols is postulated to occur. The types of fires include contaminated trash, solvents containing uranium solutions, uranium chips, and larger uranium metal shapes. A solvent fire releasing uranium-laden combustion gases at ground level is assumed. In this scenario, the entire contents of an extraction column would be released via a pipe break or other failure and are ignited by an electrical fault. Complete combustion would occur.

Oak Ridge Reservation. The release at ORR is estimated to be 4 kg (8.8 lb) of HEU with a frequency in the range of 1x10-6 to 1x10-4/yr.

Los Alamos National Laboratory. The accident is assumed to occur at LANL with a frequency in the range of 1x10-6 to 1x10-4/yr and a release of 4 kg (8.8 lb) of HEU.

Lawrence Livermore National Laboratory. The accident is assumed to occur at LLNL with a frequency in the range of 1x10-6 to 1x10-4/yr and a release of 4 kg (8.8 lb) of HEU.

Scenario 5: Fire-induced release of highly enriched uranium. A uranium fire accident is postulated to occur during metallurgical operations when a 4-liter (L) (1-gallon [gal]) container of briquettes ignites while check weighing before being loaded into a crucible. The total material at risk is estimated to be 15 kg (33 lb) of HEU.

Oak Ridge Reservation. The accident is assumed to occur with a frequency in the range of 1x10-6 to 1x10-4 /yr and a release of 3.75 kg (8.31 lb) of HEU.

Los Alamos National Laboratory. The accident is assumed to occur with a frequency in the range of 1x10-6 to 1x10-4 /yr and a release of 3.75 kg (8.3 lb) of HEU.

Lawrence Livermore National Laboratory. The accident is assumed to occur with a frequency in the range of 1x10-6 to 1x10-4/yr and a release of 3.75 kg (8.31 lb) of HEU.

Scenario 6: Fire-induced release of lithium. A lithium fire is postulated to occur when burning lithium produces hazardous lithium oxide.

Oak Ridge Reservation. The probability of the accident is assumed to be in the range of 1x10-6 to 1x10-4/yr and to release 2,800 kg (6,170 lb) of lithium oxide.

Los Alamos National Laboratory. The probability of the accident is assumed to be in the range of 1x10-6 to 1x10-4/yr and to release 2,800 kg (6,170 lb) of lithium oxide.

Lawrence Livermore National Laboratory. The probability of the accident is assumed to be in the range of 1x10-6 to 1x10-4/yr and to the release 2,800 kg (6,170 lb) of lithium oxide.

Scenario 7: Fire-induced release of highly enriched uranium on loading dock. A uranium metal fire at the loading dock is postulated to occur and results in a release of heated uranium aerosols at ground level. The fire is assumed to burn for 30 minutes and, during that time, completely oxidate the uranium metal in the transport vehicle. The effective release height is estimated to be 30 m (98 ft) because of thermal buoyancy.

Oak Ridge Reservation. The amount of HEU released to the atmosphere is 0.8 kg (1.8 lb) with an assumed frequency in the range of 1x10-6 to 1x10-4/yr.

Los Alamos National Laboratory. The accident is assumed to occur at LANL with a frequency in the range of 1x10-6 to 1x10-4/yr. The release is estimated to be 0.8 kg (1.8 lb) of HEU with a release height of 30 m (98 ft).

Lawrence Livermore National Laboratory. The accident is assumed to occur at LLNL with a frequency in the range of 1x10-6 to 1x10-4/yr. The release is estimated to be 0.8 kg (1.8 lb) of HEU with a release height of 30 m (98 ft).

Scenario 8: Filter failure release of highly enriched uranium. Mechanical upsets are events such as spills, forklift punctures, loss of filtration, and piping failures. The mechanical upset would result

in small releases to the atmosphere, unless the off-gas filters in the fluid bed system fail. The bounding accident scenario postulates that both the primary and secondary filters rupture internally, allowing the contained charge of uranium oxide and uranium fluoride particles to be released to the atmosphere via the exhaust stack.

Oak Ridge Reservation. The release to the atmosphere is 1.6 kg (3.5 lb) of HEU from the filter. The assumed accident frequency is in the range of 1x10-6 to 1x10-4/yr.

Los Alamos National Laboratory. The release to the atmosphere is 1.6 kg (3.5 lb) of HEU from the filter. The assumed accident frequency is in the range of 1x10-6 to 1x10-4/yr.

Lawrence Livermore National Laboratory. The release to the atmosphere is 1.6 kg (3.5 lb) of HEU from the filter. The assumed accident frequency is in the range of 1x10-6 to 1x10-4/yr.

Scenario 9: Mechanical release of hydrogen fluoride. This accident is postulated as a large spill of hydrogen fluoride that would generate a dense cloud of hydrogen fluoride that can exceed Level of Concern limits. It is assumed that the entire contents of a tank containing 386 kg (850 lb) of hydrogen fluoride would leak from a 2.54-centimeter (cm) (1-inch [in]) hole, emptying the tank in 12 minutes.

Oak Ridge Reservation. The accident frequency is assumed to range from 1x10-6 to 1x10-4/yr. The release is the tank's entire contents of 386 kg (850 lb) of hydrogen fluoride.

Los Alamos National Laboratory. The accident frequency is assumed to range from 1x10-6 to 1x10-4/yr. The release is the tank's entire contents of 386 kg (850 lb) of hydrogen fluoride.

Lawrence Livermore National Laboratory. The accident frequency is assumed to range from 1x10-6 to 1x10-4/yr. The release is the tank's entire contents of 386 kg (850 lb) of hydrogen fluoride.

Scenario 10: Fire-induced release of hydrogen cyanide during a vehicle impact. A vehicular traffic accident is postulated to occur and cause a rupture in one or more drums containing acetonitrile solvent waste. The spill is ignited by a spark, and the resulting fire spreads to other drums in the area. The fire produces hydrogen cyanide.

Oak Ridge Reservation. The accident frequency is assumed to be in the range of 1x10-6 to 1x10-4/yr. The release involves 300 kg (660 lb) of solvent waste.

Los Alamos National Laboratory. The accident frequency is assumed to be in the range of 1x10-6 to 1x10-4/yr. The release involves 300 kg (660 lb) of solvent waste.

Lawrence Livermore National Laboratory. The accident frequency is assumed to be in the range of 1x10-6 to 1x10-4/yr. The release involves 300 kg (660 lb) of solvent waste.

F.2.2.2 Accident Consequences and Risk

Tables F.2.2.2-1, F.2.2.2-2 , and F.2.2.2-3 list the set of accidents selected to represent consequences and risks to workers and the public from accidental releases of radioactive materials during operations at ORR, LANL, and LLNL, respectively. For each accident, the table identifies the frequency of occurrence and the consequences to a hypothetical worker at a specified distance from the accident, a hypothetical individual located at the nearest site boundary, and the public out to a

distance of 80 km (50 mi). The risks of cancer fatality for the worker, the individual at the site boundary, and the public for the composite set of accidents are also shown.

Table F.2.2.2-1.-- Secondary and Case Fabrication at Oak Ridge Reservation, Impacts of Accidents

	Noninvolved Worker at 619 Meters		Maximum Offsite Individual		Population to 80 Kilometers		
Accident Scenario	**Dose (rem)**	**Probability of Cancer Fatality 12**	**Dose (rem)**	**Probability of Cancer Fatalitya**	**Dose (person-rem)**	**Cancer Fatalities**	**Accident Frequency (per year)**
1. Nuclear criticality	0.051	2.0x10 *-5*	0.051	2.5x10 *-5*	3.1	1.5x10 *-3*	1.0x10 *-5*
2. Fire-induced dispersion of highly enriched uranium from a building collapse and resultant fires 13	2.4	9.6x10 *-4*	2.4	1.2x10 *-3*	363	0.18	5.0x10 *-7*
3. Dry criticality resulting from vehicle accident	5.1x10 *-3*	2.0x10 *-6*	5.1x10 *-3*	2.5x10 *-6*	0.31	1.5x10 *-4*	1.0x10 *-5*
4. Fire-induced release of highly enriched uranium from solvent fire	0.57	2.3x10 *-4*	0.57	2.9x10 *-4*	86	0.04	1.0x10 *-5*
5. Fire-induced release of highly enriched uranium from metallurgical operations	0.54	2.2x10 *-4*	0.54	2.7x10 *-4*	80.6	0.04	1.0x10 *-5*
7. Fire-induced release of highly enriched uranium on loading dock	0.083	3.3x10 *-5*	0.083	4.2x10 *-5*	17.6	8.8x10 *-3*	1.0x10 *-5*
8. Filter failure-induced release of highly enriched uranium	0.23	9.2x10 *-5*	0.23	1.1x10 *-4*	34.3	0.017	1.0x10 *-5*
Impacts for Composite Set of EBAs and BEBAs 14							
Expected consequences 15		*1.1x10-4*		1.3x10 *-4*		0.02	
Expected risk (per year)		6.4x10 *-9*		8.0x10 *-9*		1.2x10 *-6*	

Impacts for Composite Set of EBAs							
Expected consequences *15*		*1.0x10-4*		1.2x10-4		0.018	
Expected risk (per year)		5.9x10 *-9*		7.4x10-9		1.1x10 *-6*	
Impacts for Composite Set of BEBAs							
Expected consequences*15*		*9.7x10-4*		1.2x10^{-3}		0.18	
Expected risk (per year)		4.9x10-10		6.0x10-10		9.1x10-8	

Table F.2.2.2-2.-- Secondary and Case Fabrication at Los Alamos National Laboratory, Impacts of Accidents

	Noninvolved Worker at 862 Meters		Maximum Offsite Individual		Population to 80 Kilometers		
Accident Scenario	**Dose (rem)**	**Probability of Cancer Fatality 16**	**Dose (rem)**	**Probability of Cancer Fatalitya**	**Dose (person-rem)**	**Cancer Fatalities**	**Accident Frequency (per year)**
1. Nuclear criticality	0.034	1.4x10 *-5*	0.034	1.7x10 *-5*	4.9	2.4x10 *-3*	1.0x10 *-5*
2. Fire-induced dispersion of highly enriched uranium from a building collapse and resultant fire *17*	1.6	6.2x10 *-4*	1.6	7.7x10 *-4*	360	0.18	5.0x10 *-7*
3. Dry criticality resulting from vehicle accident	3.4x10 *-3*	1.4x10 *-6*	3.4x10 *-3*	1.7x10 *-6*	0.49	2.4x10 *-4*	1.0x10 *-5*
4. Fire-induced release of highly enriched uranium from solvent fire	0.36	1.5x10 *-4*	0.36	1.8x10 *-4*	84.5	0.042	1.0x10 *-5*
5. Fire-induced release of highly enriched uranium from metallurgical operations	0.34	1.4x10 *-4*	0.34	1.7x10 *-4*	79.4	0.04	1.0x10 *-5*
7. Fire-induced release of highly enriched uranium on loading dock	0.053	2.1x10 *-5*	0.053	2.6x10 *-5*	15.0	7.5x10 *-3*	1.0x10 *-5*

8. Filter failure-induced release of highly enriched uranium	0.15	5.8x10 -5	0.15	7.3x10 -5	33.8	0.017	1.0x10 -5
Impacts for Composite Set of EBAs and BEBAs18							
Expected consequences 19		6.8x10 -5		8.4x10 -5		0.02	
Expected risk (per year)		4.1x10 -9		5.1x10 -9		1.2x10 -6	
Impacts for Composite Set of EBAs							
Expected consequences19		6.3x10-5		7.9x10-5		0.018	
Expected risk (per year)		3.8x10 -9		4.7x10 -9		1.1x10 -6	
Impacts for Composite Set of BEBAs							
Expected consequences19		6.2x10-4		7.7x10-4		0.18	
Expected risk (per year)		3.1x10-10		3.9x10-10		8.9x10-8	

Table F.2.2.2-3.-- Secondary and Case Fabrication at Lawrence Livermore National Laboratory, Impacts of Accidents

	Noninvolved Worker at 247 Meters		Maximum Offsite Individual		Population to 80 Kilometers		
Accident Scenario	**Dose (rem)**	**Probability of Cancer Fatality20**	**Dose (rem)**	**Probability of Cancer Fatality**	**Dose (person-rem)**	**Cancer Fatalities**	**Accident Frequency (per year)**
1. Nuclear criticality	0.07	2.8x10 -5	0.07	3.5x10 -5	9.9	5.0x10 -3	1.0x10 -5
2. Fire-induced dispersion of highly enriched uranium from a building collapse and resultant fire21	3.4	1.4x10 -3	3.4	1.7x10 -3	1.2x10 3	0.58	5.0x10 -7
3. Dry criticality resulting from vehicle accident	7.0x10 -3	2.8x10 -6	7.0x10 -3	3.5x10 -6	0.99	5.0x10 -4	1.0x10 -5

4. Fire-induced release of highly enriched uranium from solvent fire	0.8	3.2x10 -4	0.80	4.0x10 -4	273	0.14	1.0x10 -5
5. Fire-induced release of highly enriched uranium from metallurgical operations	0.75	3.0x10 -4	0.75	3.8x10 -4	257	0.13	1.0x10 -5
7. Fire-induced release of highly enriched uranium on loading dock	0.11	4.2x10 -5	0.11	5.3x10 -5	53.2	0.027	1.0x10 -5
8. Filter failure-induced release of highly enriched uranium	0.32	1.3x10 -4	0.32	1.6x10 -4	109	0.055	1.0x10 -5
Impacts for Composite Set of EBAs and BEBAs22							
Expected consequences 23		1.5x10 -4		1.8x10 -4		0.063	
Expected risk (per year)		8.9x10 -9		1.1x10 -8		3.8x10 -6	
Impacts for Composite Set of EBAs							
Expected consequences23		1.4x10-4		1.7x10-4		0.06	
Expected risk (per year)		8.2x10 -9		1.0x10 -8		3.5x10-6	
Impacts for Composite Set of BEBAs							
Expected consequences23		1.4x10-3		1.7x10-3		0.6	
Expected risk (per year)		6.8x10-10		8.5x10-10		2.9x10-7	

12 Probability (increased likelihood) of cancer fatality to a hypothetical member of the public located at the site boundary or a worker located at the indicated distance from the accident as a result of exposure to the indicated dose if the accident were to occur.

13 A beyond evaluation basis accident (BEBA). All other listed accidents are evaluation basis

accidents (EBA).

14 For the offsite population of 1,096,144, the average probability of cancer fatality/risk of cancer fatality (per year) for the composite set of accidents is 1.8x10-8/1.1x10-12.

15 Result of exposure to the indicated dose if the accident occurs. All values are mean values. Model results.

16 Probability (increased likelihood) of cancer fatality to a hypothetical member of the public located at the site boundary or a worker located at the indicated distance from the accident as a result of exposure to the indicated dose if the accident occurred.

17 A beyond evaluation basis accident (BEBA). All other listed accidents are evaluation basis accidents (EBA).

18 For the offsite population of 281,812, the average probability of cancer fatality/risk of cancer fatality (per year) for the composite set of accidents is 7.1x10-8/4.3x10-12.

19 Result of exposure to the indicated dose if the accident occurs. All values are mean values. Model results.

20 Probability (increased likelihood) of cancer fatality to a hypothetical member of the public located at the site boundary or a worker located 247 m (810 ft) from the accident as a result of exposure to the indicated dose if the accident occurred.

21 A beyond evaluation basis accident (BEBA). All other listed accidents are evaluation basis accidents (EBA).

22 For the offsite population of 7,843,061, the average probability of cancer fatality/risk of cancer fatality (per year) for the composite set of accidents is 8.0x10-9/4.8x10-13.

23 Result of exposure to the indicated dose if the accident occurs. All values are mean values.

APPENDIX F: FACILITY ACCIDENTS

F.2.3 Pit Fabrication and Intrusive Modification Pit Reuse

Studies of evaluation basis accidents and beyond evaluation basis accidents have been performed for the pit fabrication and intrusive modification pit reuse operations. The studies postulated a set of accident scenarios that were representative of the risks and consequences for workers and the public that can be expected from operations. Although not all potential accidents were addressed, those that were postulated have consequences and risks that are expected to envelop the consequences and risks of the relocated operations.

F.2.3.1 Accident Scenarios and Source Terms

A range of hazardous conditions and potential accidents were reviewed as candidates to represent the risks to workers and the public of the replacement pit fabrication and intrusive modification operations at Savannah River Site (SRS) and LANL, respectively. Through a screening process, several evaluation basis accidents and beyond evaluation basis accidents were selected for further definition and analysis. Descriptive information on these accidents is provided in table F.2.3.1-1.

Table F.2.3.1-1.-- Accident Scenarios for Pit Fabrication and Intrusive Modification Pit Reuse

Accident Scenario	Site	Accident Frequency (per year)	Total Material Released to Environment
1. Fire-induced release of plutonium from a glove box	LANL	1x10-4 to 0.01	0.24 g plutonium oxide
	SRS	1x10-4 to 0.01	0.24 g plutonium oxide
2. Operational release of tritium	LANL	1x10-6 to 1x10-4	21,000 Ci of tritium oxide [24]
	SRS	1x10-6 to 1x10-4	21,000 Ci of tritium oxide [24]
3. Mechanical release of nitric acid into confined area	LANL	1x10-6 to 1x10-4	6,100 gal of 80-percent nitric acid in bermed area
	SRS	1x10-6 to 1x10-4	6,100 gal of 80-percent nitric acid in bermed area
4. Earthquake-induced mechanical release of nitric acid	LANL	1x10-7 to 1x10-6	6,100 gal of 80-percent nitric acid in bermed area
	SRS	1x10-7 to 1x10-6	6,100 gal of 80-percent nitric acid in bermed area
5. Earthquake-induced release of plutonium	LANL	1x10-6 to 1x10-4	0.61 g of plutonium metal
	SRS	1x10-6 to 1x10-4	0.61 g of plutonium metal
6. Earthquake-induced release of plutonium	LANL	1x10-7 to 1x10-6	0.63 g of plutonium metal
	SRS	1x10-7 to 1x10-6	0.63 g of plutonium metal
7. Wet criticality	LANL	1x10-7 to 1x10-6	5x1017 fissions
	SRS	1x10-7 to 1x10-6	5x1017 fissions
8. Mechanical-induced release of plutonium	LANL	0.01 to 1x10-1	7.2x10-12 g of plutonium oxide
	SRS	0.01 to 1x10-1	7.2x10-12 g of plutonium oxide

9. Explosive-induced release of plutonium	LANL	1x10-4 to 0.01	0.05 g of plutonium metal
	SRS	$1x10^{-4}$ to 0.01	0.05 g of plutonium metal
10. Fire-induced release of plutonium on loading dock	LANL	$1x10^{-6}$ to $1x10^{-4}$	0.8 g plutonium oxide
	SRS	$1x10^{-6}$ to $1x10^{-4}$	0.8 g plutonium oxide

Scenario 1: Fire-induced release of plutonium from a glove box. A fire is postulated within a laboratory which involves cleaning liquid such as acetone or isopropyl alcohol and burns the gloves in a glove box. The fire releases the plutonium contamination from the outer surface of the gloves that are in the glove box. Fire suppression and ventilation systems are assumed to be inoperable.

Los Alamos National Laboratory. The accident frequency is estimated to be in the range of $1x10^{-4}$ to 0.01/yr. The estimated release is 0.24 g ($8.47x10^{-3}$ oz) of plutonium oxide.

Savannah River Site. The accident frequency is estimated to be in the range of $1x10^{-4}$ to 0.01/yr. The estimated release is 0.24 g ($8.47x10^{-3}$ oz) of plutonium oxide.

Scenario 2: Operational release of tritium from special recovery line. This postulated accident is initiated by the loss of the inert atmosphere in the disassembly glove box in the special recovery line. As a result of the loss of inert atmosphere, a fire is assumed to start. As the tritium storage container is heated, tritium is released. It is assumed that released tritium bypasses the tritium collection system.

Los Alamos National Laboratory. The accident frequency is estimated to be in the range of $1x10^{-6}$ to $1x10^{-4}$/yr. For the purposes of this analysis, the release is assumed to be 21,000 curies (Ci) of tritium oxide.

Savannah River Site. The accident is assumed to be applicable at SRS with an estimated frequency in the range of $1x10^{-6}$ to $1x10^{-4}$/yr. For the purposes of this analysis, the release is assumed to be 21,000 Ci of tritium oxide.

Scenario 3. Mechanical release of nitric acid into confined bermed area. A mechanical failure in a tank, valve, or piping is postulated that releases the entire contents of an 80-percent nitric acid storage tank. The tank is located outdoors within a bermed area. The inventory is confined to the berm surrounding the tank.

Los Alamos National Laboratory. The nitric acid tank contains 23,090 L (6,100 gal) of 80-percent nitric acid. The bermed area is 27 square meters ($m^{2)}$ (288 square feet [$ft^{2]}$). The accident frequency is estimated to be in the range of $1x10^{-6}$ to $1x10^{-4}$/yr.

Savannah River Site. The same nitric acid tank and bermed area are assumed to located at SRS. The tank contains 23,090 L (6,100 gal) of 80-percent nitric acid. The bermed area is 27 m^2 (288 ft^2). The accident frequency is estimated to be in the range of $1x10^{-6}$ to $1x10^{-4}$/yr.

Scenario 4: Beyond evaluation basis earthquake-induced release of nitric acid. A mechanical failure in a tank, valve, or piping is postulated that releases the entire contents of an 80-percent nitric

acid storage tank. The tank is located outdoors within a bermed area; however, a beyond evaluation basis earthquake ruptures the berm. The inventory is not confined to the berm surrounding the tank.

Los Alamos National Laboratory. The nitric acid tank contains 23,090 L (6,100 gal) of 80-percent nitric acid. The accident frequency is estimated to be in the range of 1x10-7 to 1x10-6/yr.

Savannah River Site. The same nitric acid tank and bermed area are assumed to be located at SRS. The tank contains 23,090 L (6,100 gal) of 80-percent nitric acid. The accident frequency is estimated to be in the range of 1x10-7 to 1x10-6/yr.

Scenario 5: Evaluation basis earthquake-induced release of plutonium. The forces from the seismic event are applied to the facility and confinement systems within the facility. For the source term analysis, both anchorage failures and support stand failures are assumed to cause enclosures to fall over. On impact with the floor, glove box windows may break or fall out, connecting rings and connections to exhaust ductwork may separate, and solution transfer lines may break. The enclosures may also fail structurally. For the source term analysis, if the seismic margins assessment shows that an enclosure will fail, it is assumed that the enclosure will be breached, and material that becomes airborne will be released to the laboratory. The building structure, high-efficiency particulate air (HEPA) filter plenums, and ductwork from the plenums to the structure will remain a functional confinement barrier following an earthquake.

Los Alamos National Laboratory. The accident frequency is estimated to be in the range of 1x10-6 to 1x10-4/yr. The release is calculated to be 0.61 g (0.02 oz) of plutonium metal.

Savannah River Site. This accident is also assumed to occur at SRS. The accident frequency is estimated to be in the range of 1x10-6 to 1x10-4/yr. The release is calculated to be 0.61 g (0.02 oz) of plutonium metal.

Scenario 6. Beyond evaluation basis earthquake-induced release of plutonium. The forces from the seismic event are applied to the facility and confinement systems within the facility. For the source term analysis, both anchorage failures and support stand failures are assumed to cause enclosures to fall over. On impact with the floor, glove box windows may break or fall out, connecting rings and connections to exhaust ductwork may separate, and solution transfer lines may break. The enclosures may also fail structurally. For the source term analysis, if the seismic margins assessment shows that an enclosure will fail, it is assumed that the enclosure will be breached, and material that becomes airborne will be released to the laboratory. For the beyond evaluation basis earthquake, the building structure, HEPA filter plenums, and ductwork from the plenums to the structure are assumed not to be functional confinement barriers.

Los Alamos National Laboratory. The accident frequency is estimated to be in the range of $1x10^{-7}$ to $1x10^{-6}$/yr. The release is calculated to be 0.63 g (0.02 oz) of plutonium metal.

Savannah River Site. This accident is also assumed to occur at SRS. The accident frequency is estimated to be in the range of $1x10^{-7}$ to $1x10^{-6}$/yr. The release is calculated to be 0.63 g (0.02 oz) of plutonium metal.

Scenario 7: Wet criticality. The wet criticality accident occurs in a glove box where the plutonium in solution exceeds the critical mass.

Los Alamos National Laboratory. The wet criticality accident that is postulated results in 5x1017 fissions. The frequency of occurrence of a criticality is estimated to be in the range of $1x10^{-7}$ to $1x10^{-6}$/yr.

Savannah River Site. The wet criticality is also assumed to occur at SRS. The accident results in 5x1017 fissions. The frequency of occurrence of a criticality is estimated to be in the range of 1x10-7 to 1x10-6/yr.

Scenario 8: Mechanical-induced release of plutonium from a degraded storage container. This postulated scenario assumes a package is dropped and the oxide contents spill onto the room floor. The material at risk is assumed to be 4.5 kg (9.9 lb) of plutonium oxide. No credit is taken for the inner metal container (assumed to have been ruptured by the plutonium oxidation reaction), the inner plastic bag (assumed to have deteriorated), or the outer package (assumed to be a slip-lid can with a degraded seal).

Los Alamos National Laboratory. The accident frequency is in the range of 0.01 to 0.1/yr. The release is estimated to be $7.2x10^{-12}$ g ($2.5x10^{-13}$ oz) of plutonium oxide.

Savannah River Site. The accident frequency is in the range of 0.01 to 0.1/yr. The release is estimated to be $7.2x10^{-12}$ g ($2.5x10^{-13}$ oz) of plutonium oxide.

Scenario 9: Explosion-induced release of plutonium. This postulated accident is the result of a chemical explosion in an ion-exchange column. The explosion causes a breach of the glove box containing the ion exchange column. It is assumed that the normal ventilation system is inoperable.

Los Alamos National Laboratory. The accident frequency is in the range of $1x10^{-4}$ to 0.01/yr. The release of plutonium metal is estimated to be 0.05 g ($1.76x10^{-3}$ oz).

Savannah River Site. The accident frequency is in the range of $1x10^{-4}$ to 0.01/yr. The release of plutonium metal is estimated to be 0.05 g ($1.76x10^{-3}$ oz).

Scenario 10: Fire-induced release of plutonium on loading dock. This postulated scenario involves a fire on the loading dock involving a combustible plutonium contaminated waste drum. This scenario also assumes that the loading dock is open to the atmosphere at the time of the fire.

Los Alamos National Laboratory. The accident frequency is estimated to be in the range of $1x10^{-6}$ to $1x10^{-4}$/yr. The release is calculated to be 0.8 g (0.03 oz) of plutonium oxide.

Savannah River Site. The accident frequency is estimated to be in the range of $1x10^{-6}$ to $1x10^{-4}$ /yr. The release is calculated to be 0.8 g (0.03 oz) of plutonium oxide.

F.2.3.2 Accident Consequences and Risk

Tables F.2.3.2-1 and F.2.3.2-2 list the set of accidents selected to represent consequences and risks to workers and the public from accidental releases of radioactive materials during operations. For each

accident, the table identifies the frequency of occurrence and the consequences to a hypothetical worker located at 1,000 m (3,281 ft) from the accident, a hypothetical individual located at the nearest site boundary, and the public out to a distance of 80 km (50 mi). The risks of cancer fatality for the worker, the individual at the site boundary, and the public for the composite set of accidents are also shown.

Table F.2.3.2-1.-- Pit Fabrication and Intrusive Modification Pit Reuse at Savannah River Site, Impacts of Accidents

	Noninvolved Worker at 1,000 Meters		Maximum Offsite Individual		Population to 80 Kilometers		
Accident Scenario	**Dose (rem)**	**Probability of Cancer Fatality[25]**	**Dose (rem)**	**Probability of Cancer Fatality[25]**	**Dose (person-rem)**	**Cancer Fatalities**	**Accident Frequency (per year)**
1. Fire-induced plutonium release from a glove box	0.035	1.4×10^{-5}	5.8×10^{-4}	2.9×10^{-7}	4.3	2.2×10^{-3}	1.0×10^{-3}
2. Operational release of tritium	6.5×10^{-3}	2.6×10^{-6}	1.1×10^{-4}	5.5×10^{-8}	0.79	4.0×10^{-4}	1.0×10^{-5}
5. Earthquake-induced release of plutonium - evaluation basis earthquake	0.099	4.0×10^{-5}	1.7×10^{-3}	8.4×10^{-7}	12.3	6.2×10^{-3}	1.0×10^{-5}
6. Earthquake-induced release of plutonium - beyond evaluation basis earthquake[26]	0.10	4.1×10^{-5}	1.7×10^{-3}	8.6×10^{-7}	12.8	6.4×10^{-3}	5.0×10^{-7}
7. Wet criticality[26]	8.5×10^{-4}	3.4×10^{-7}	1.4×10^{-5}	7.0×10^{-9}	0.019	9.5×10^{-6}	5.0×10^{-7}
8. Mechanical-induced release of plutonium	1.2×10^{-12}	4.7×10^{-16}	2.0×10^{-14}	9.9×10^{-18}	1.5×10^{-10}	7.3×10^{-14}	0.05
9. Explosion-induced release of plutonium	8.1×10^{-3}	3.3×10^{-6}	1.4×10^{-4}	6.9×10^{-8}	1.0	5.1×10^{-4}	1.0×10^{-3}
10. Fire-induced release of plutonium on loading dock	0.11	4.6×10^{-5}	1.9×10^{-3}	9.7×10^{-7}	14.3	7.2×10^{-3}	1.0×10^{-5}
Impacts for Composite Set of EBAs and BEBAs[27]							

Expected consequences[28]		3.5×10^{-7}		7.3×10^{-9}		5.4×10^{-5}	
Expected risk (per year)		1.8×10^{-8}		3.8×10^{-10}		2.8×10^{-6}	
Impacts for Composite Set of EBAs							
Expected consequences[28]		3.4×10^{-7}		7.3×10^{-9}		5.3×10^{-5}	
Expected risk (per year)		1.8×10^{-8}		3.8×10^{-10}		2.8×10^{-6}	
Impacts for Composite Set of BEBAs							
Expected consequences[28]		3.3×10^{-5}		4.4×10^{-7}		3.2×10^{-3}	
Expected risk (per year)		3.3×10^{-11}		4.4×10^{-13}		3.2×10^{-9}	

Table F.2.3.2-2.-- Pit Fabrication and Intrusive Modification Pit Reuse at Los Alamos National Laboratory, Impacts of Accidents

	Noninvolved Worker at 1,000 Meters		Maximum Offsite Individual		Population to 80 Kilometers		
Accident Scenario	**Dose (rem)**	**Probability of Cancer Fatality[29]**	**Dose (rem)**	**Probability of Cancer Fatality[29]**	**Dose (person-rem)**	**Cancer Fatalities**	**Accident Frequency (per year)**
1. Fire-induced plutonium release from a glove box	0.064	2.6×10^{-5}	0.035	1.7×10^{-5}	9.5	4.7×10^{-3}	1.0×10^{-3}
2. Operational release of tritium	0.012	4.8×10^{-6}	6.6×10^{-3}	3.3×10^{-6}	1.8	8.8×10^{-4}	1.0×10^{-5}
5. Earthquake-induced release of plutonium - evaluation basis earthquake	0.18	7.4×10^{-5}	0.099	5.0×10^{-5}	27.2	0.014	1.0×10^{-5}
6. Earthquake-induced release of plutonium - beyond evaluation basis earthquake[30]	0.19	7.6×10^{-5}	0.10	5.1×10^{-5}	28.1	0.014	5.0×10^{-7}
7. Wet criticality[30]	1.5×10^{-3}	6.1×10^{-7}	8.7×10^{-4}	4.4×10^{-7}	0.12	6.2×10^{-5}	5.0×10^{-7}

8. Mechanical-induced release of plutonium	2.2×10^{-12}	8.7×10^{-16}	1.2×10^{-14}	5.9×10^{-16}	3.2×10^{-10}	1.6×10^{-13}	0.05
9. Explosion-induced release of plutonium	0.015	6.1×10^{-6}	8.2×10^{-3}	4.1×10^{-6}	2.2	1.1×10^{-3}	1.0×10^{-3}
10. Fire-induced release of plutonium on loading dock	0.21	8.5×10^{-5}	0.12	5.7×10^{-5}	31.5	0.016	1.0×10^{-5}
Impacts for Composite Set of EBAs and BEBAs[31]							
Expected consequences[32]		6.4×10^{-7}		4.3×10^{-7}		1.2×10^{-4}	
Expected risk (per year)		3.3×10^{-8}		2.2×10^{-8}		6.2×10^{-6}	
Impacts for Composite Set of EBAs							
Expected consequences[32]		6.4×10^{-7}		4.3×10^{-7}		1.2×10^{-4}	
Expected risk (per year)		3.3×10^{-8}		2.2×10^{-8}		6.2×10^{-6}	
Impacts for Composite Set of BEBAs							
Expected consequences[32]		3.8×10^{-5}		2.6×10^{-5}		7.1×10^{-3}	
Expected risk (per year)		3.8×10^{-11}		2.6×10^{-11}		7.1×10^{-9}	

24 The maximum amount of material is a hypothetical amount chosen for the purpose of this analysis. **HNUS 1996a.**

25 Probability (increased likelihood) of cancer fatality to a hypothetical member of the public located at the site boundary or a worker located 1,000 m (3,281 ft) from the accident as a result of exposure to the indicated dose if the accident occurred.

26 A beyond evaluation basis accident (BEBA). All other listed accidents are evaluation basis accidents (EBA).

27 For the offsite population of 747,836, the average probability of cancer fatality/risk of cancer fatality (per year) for the composite set of accidents is 7.2x10-11/3.7x10-12.

28 Result of exposure to the indicated dose if the accident occurs. **All values are mean values. Model results.**

29 Probability (increased likelihood) of cancer fatality to a hypothetical member of the public located at the site boundary or a worker located 1,000 m (3,281 ft) from the accident as a result of exposure

to the indicated dose if the accident occurred.

30 A beyond evaluation basis accident (BEBA). All other listed accidents are evaluation basis accidents (EBA).

31 For the offsite population of 287,977, the average probability of cancer fatality/risk of cancer fatality (per year) for the composite set of accidents is 4.2x10-10/2.2x10-11.

32 Result of exposure to the indicated dose if the accident occurs. All values are mean values. Model results.

APPENDIX F: FACILITY ACCIDENTS

F.2.4 Nonintrusive Modification Pit Reuse

A set of potential accidents can be postulated for the nonintrusive modification pit reuse for which there may be releases of hazardous materials that may impact onsite workers and the public. Any such impacts, however, are expected to be bounded by the impacts associated with weapons A/D or pit fabrication.

F.2.5 High Explosives Fabrication

Evaluation basis accidents and beyond evaluation basis accidents have been studied for the HE fabrication operations. The studies postulated a set of accident scenarios that were representative of the risks and consequences for workers and the public from operations. Although not all potential accidents were addressed, those that were postulated have consequences and risks that are expected to envelop the consequences and risks of the relocated operations.

F.2.5.1 Accident Scenarios and Consequences

A range of hazardous conditions and potential accidents were reviewed as candidates to represent the risks to workers and the public of the HE fabrication operations. The physical releases (of chemicals and energy) from postulated accidents at the existing HE fabrication facilities at Pantex were used as an analog for potential releases at LANL and LLNL. A range of accidents was considered, from the release of particulates and dust through processing techniques, to the release of explosives from a fire or explosion, to the effects of blast pressure and fragment and debris scatter from an explosion.

The release of particulates and dust through processing operations would be contained where those operations occur. There is a probability in the range of 0.01 to 0.1/yr that the filtration systems fail during these operations. If there is filter failure, the operations would be halted. The releases from such accidents would have marginal effects (may cause minor occupational illnesses).

A release of chemical HE to the environment during a fire is estimated to occur with a probability in the range of $1x10^{-4}$ to 0.01/yr. Such a release would range up to 79 kg (175 lb) of explosives (released over a 10 minute period). The resulting environmental concentrations from a release, either triaminotrinitrobenzene (TATB) or TNT, of this magnitude were simulated. The TATB (which is representative of other explosives such as cyclotrimethylenetrinitramine [RDX] and cyclotetramethylenetetranitramine [HMX]) concentrations in the path of the plume would exceed the threshold limit value-time weighted average (TLV-TWA) of 1.5 mg/m^3 for distances up to 1,500, 2,200; and 2,400 m (5,000; 7,100; and 8,000 ft) from the release for Pantex, LLNL, and LANL, respectively. If the explosive were TNT, the plume concentrations would exceed the TLV-TWA limit of 0.5 milligrams (mg)/cubic meter (m^3) for distances up to 3,100; 4,500; and 5,000 m (10,200; 14,700; and 16,600 ft) from the release for Pantex, LLNL, and LANL, respectively. Concentrations of HE at each of the site boundaries would be 0.9, 54, and 50 mg/m^3, respectively. Concentrations of HE at 1,000 m (3,281 ft) from the fire (typical for a noninvolved worker) at each of the sites would be 3.0, 5.2, and 6.2 mg/m^3, respectively.

A release of chemical HE from the various processing facilities caused by an accidental explosion has a probability in the range of $1x10^{-4}$ to $1x10^{-6}$ /yr. Such a release would range up to 79 kg (175 lb) of TATB (or HMX or RDX) or up to 29 kg (64 lb) of TNT. The explosive force from such an accident would result in elevating the HE to a height of 68 m (223 ft) before its downwind transport. The maximum concentration to those who could be exposed would be 6.7 mg/m^3 for TATB or 2.5 mg/m^3 for TNT, at a distance of 800 m (2,600 ft) from the release; this distance is offsite for LANL and LLNL but onsite for Pantex. The maximum offsite concentration at Pantex would be 3.2 mg/m^3 or 1.2 mg/m^3 for TATB or TNT, respectively. The TLV-TWA limits for TATB would be exceeded between 180 and 3,500 m (580 and 11,600 ft) from the release; these limits for TNT would be exceeded in the interval from 170 to 3,700 m (550 to 12,300 ft) from the release. The noninvolved worker (1,000 m [3,281 ft] from the explosion) could be exposed to TATB or TNT concentrations of 6.4 or 2.4 mg/m^3, respectively, essentially the maximum concentration found near the ground.

It should be noted that the TLV-TWA represents a TWA limit to a worker for a 40-hour workweek. The toxic exposures considered here are of a much shorter duration, on the order of minutes.

F.2.6 Storage of Plutonium Strategic Reserves

Evaluation basis accidents and beyond evaluation basis accidents have been studied for the storage of plutonium strategic reserves. The studies postulated a set of accident scenarios that were representative of the risks and consequences for workers and the public that can be expected from operations. Although not all potential accidents were addressed, those that were postulated have consequences and risks that are expected to envelop the consequences and risks of the relocated operations.

F.2.6.1 Accident Scenarios and Source Terms

A range of hazardous conditions and potential accidents were reviewed as candidates to represent the risks to workers and the public from operating this facility. Through a screening process, several evaluation basis and beyond evaluation basis accidents were selected for further definition and analysis. A brief description of each of the accident scenarios and source terms is presented below. Table F.2.6.1-1 presents a summary of each accident scenario and source term. Further detail can be found in a topical report *(HNUS 1996a).*

Scenario 1: Fire-induced release of plutonium from storage vault.

The combustible material within the vault mostly consists of tags and paperwork. Further, the design and configuration of the vault preclude the introduction of combustible materials in sufficient quantities to significantly alter the thermal environment. Therefore, the only proposed method to initiate a fire in the vault is by the introducing and initiating large amounts of gasoline, jet fuel, or other high-energy-density fuel. Additionally, because of vault, storage container, and pit designs, not all of the pits stored in the vault would be affected by the fire.

For an internal fire to cause some storage containers to fail through would take a sustained (more than 30-minute) exposure to a fire. Even if the storage container containing the pit fails, it is assumed that the material encapsulating the pit retains enough of its integrity so that no plutonium is released, or so that the contribution from pits is insignificant.

Table F.2.6.1-1.-- Accident Scenarios for Storage of Plutonium Strategic Reserves

Accident Scenario	Site	Accident Frequency (per year)	Total Material Release to Environment
1. Fire-induced release of plutonium from storage vaults	Pantex	$5x10^{-8}$	11.4 g plutonium oxide
	NTS	Not applicable	Not applicable
2. Mechanical release of plutonium on loading dock	Pantex	$6x10^{-4}$	0.04 g plutonium oxide
	NTS	$6x10^{-4}$	0.04 g plutonium oxide
HNUS 1996a.			

Pantex Plant. The accident frequency is estimated at $5x10^{-8}$ /yr. The release is estimated to be 11.4 g (0.4 oz) of plutonium oxide.

Nevada Test Site. The vault fire accident is not considered to be a credible scenario because there is no conceivable way to get enough flammable material inside the underground vaults to make this accident possible.

Scenario 2: Mechanical release of plutonium on loading dock

. In this postulated event, a forklift driver attempting to pick up a pallet containing pit storage containers in the shipping and receiving area punctures two of the storage containers. It is assumed that both storage containers contain pits, that the storage containers fall on the floor, and that any loose material in the form of powder is shaken out of the storage container onto the floor.

Pantex Plant. The accident frequency is $6x10^{-4}$ /yr. The release is estimated to be 0.04 g ($1.41x10^{-3}$ oz) of plutonium oxide.

Nevada Test Site. This accident is assumed to occur at NTS at a frequency of $6x10^{-4}$ /yr and release 0.04 g ($1.41x10^{-3}$ oz) of plutonium oxide.

F.2.6.2 Accident Consequences and Risk

Tables F.2.6.2-1 and F.2.6.2-2 list the set of accidents selected to represent consequences and risks to workers and the public from accidental releases of radioactive materials during operations at Pantex and NTS, respectively. For each accident, the table identifies the frequency of occurrence and the consequences to a hypothetical worker located at 1,000 m (3,281 ft) from the accident, a hypothetical individual located at the nearest site boundary, and the public out to a distance of 80 km (50 mi). The risks of cancer fatality for the worker, the individual at the site boundary, and the public for the composite set of accidents are also shown.

Table F.2.6.2-1.-- Storage of Plutonium Strategic Reserves at Pantex Plant, Impacts of Accidents

	Maximum Worker at 1,000 Meters		Maximum Offsite Individual		Population to 80 Kilometers		
Accident Scenario	**Dose (rem)**	**Probability of Cancer Fatality33**	**Dose (rem)**	**Probability of Cancer Fatality33**	**Dose (person-rem)**	**Cancer Fatalities**	**Accident Frequency (per year)**
1. Fire-induced release of plutonium from storage vaults34	1.6	6.4×10^{-4}	0.51	2.6×10^{-4}	59	0.03	5.0×10^{-8}
2. Mechanical release of plutonium from loading dock	5.6×10^{-3}	2.3×10^{-6}	1.8×10^{-3}	9.0×10^{-7}	0.21	1.0×10^{-4}	6.0×10^{-4}
Impacts for Composite Set of EBAs and BEBAs35							
Expected consequences36		2.3×10^{-6}		9.2×10^{-7}		1.1×10^{-4}	
Expected risk (per year)		1.4×10^{-9}		5.5×10^{-10}		6.4×10^{-8}	
Impacts for Composite Set of EBAs							
Expected consequences36		2.3x10-6		9.0x10-7		1.0×10^{-4}	
Expected risk (per year)		1.4×10^{-9}		5.4×10^{-10}		6.2×10^{-8}	
Impacts for Composite Set of BEBAs							
Expected consequences36		$< 6.4 \times 10^{-4}$		2.6×10^{-4}		0.03	
Expected risk (per year)		3.2×10^{-11}		1.3×10^{-11}		1.5×10^{-9}	

Table F.2.6.2-2.-- Storage of Plutonium Strategic Reserves at Nevada Test Site, Impacts of Accidents

	Noninvolved Worker at 1,000 Meters		Maximum Offsite Individual		Population to 80 Kilometers		
Accident Scenario	**Dose (rem)**	**Probability of Cancer Fatality37**	**Dose (rem)**	**Probability of Cancer Fatality37**	**Dose (person-rem)**	**Cancer Fatalities**	**Accident Frequency (per year)**

1. Fire-induced release of plutonium from storage vaults [38]	39	39	39	39	39	39	39
2. Mechanical release of plutonium from loading dock	9.6×10^{-3}	3.8×10^{-6}	1.8×10^{-4}	8.9×10^{-8}	0.013	6.5×10^{-6}	6.0×10^{-4}
Impacts for Composite Set of EBAs and BEBAs							
Expected consequences[40]		41		41		41	
Expected risk (per year)		41		41		41	
Impacts for Composite Set of EBAs[38]							
Expected consequences[40]		3.8×10^{-6}		8.9×10^{-8}		6.5×10^{-6}	
Expected risk (per year)		2.3×10^{-9}		5.3×10^{-11}		3.9×10^{-9}	
Impacts for Composite Set of BEBAs							
Expected consequences[40]		41		41		41	
Expected risk (per year)		41		41		41	

F.2.7 Storage of Uranium Strategic Reserves

Studies of evaluation basis accidents and beyond evaluation basis accidents have been performed for the storage of uranium strategic reserves. The studies postulated a set of accident scenarios that were representative of the risks and consequences for workers and the public that can be expected from operations. Although not all potential accidents were addressed, those that were postulated have consequences and risks that are expected to envelop the consequences and risks of the relocated operations. In this manner, no other credible accidents with an expected frequency of occurrence larger than 10-7/yr are anticipated that will have consequences and risks larger than those described in this section.

F.2.7.1 Accident Scenarios and Source Terms

A range of hazardous conditions and potential accidents were reviewed as candidates to represent the risks to workers and the public from facility operation. Through a screening process, several evaluation basis accidents and beyond evaluation basis accidents were selected for further definition and analysis. A brief description of each of the five accident scenarios and source terms is presented below. Table F.2.7.1-1 presents a summary of each accident scenario and source term. Further detail can be found in a topical report (HNUS 1996a).

Scenario 1: Criticality

. Criticality accidents were considered for routine handling in storage areas. Hypothetical scenarios were analyzed in the tube vault involving loading and unloading activities that might result in criticality. A facility worker could accidentally overdraw and drop a loaded tube tray, allowing the cans to fall and tumble into a critical pile. A criticality accident could also result from overloading the tube vault (spacing between slots on tube trays physically prevents overloading). A forklift could accidentally crush or jam a sufficient number of cans together to cause a criticality accident (spacing between the slots also makes it physically impossible for a forklift to accidentally crush or jam a sufficient number of cans together to cause a criticality accident).

Oak Ridge Reservation. The probability of a criticality in the vault area is assumed to be in the range of $1x10^{-6}$ to $1x10^{-4/yr}$. A single pulse of $1x10^{17}$ fissions is produced before the solid matrix disassembles.

Pantex Plant. The probability of a criticality in the vault area is assumed to be in the range of $1x10^{-6}$ to $1x10^{-4/yr}$. A single pulse of $1x10^{17}$ fissions is produced before the solid matrix disassembles.

Nevada Test Site. The probability of a criticality in the vault area is assumed to be in the range of $1x10^{-6}$ to $1x10^{-4}$ /yr. A single pulse of $1x10^{17}$ fissions is produced before the solid matrix disassembles.

Scenario 2: Fire-induced release of highly enriched uranium from aircraft crash.

An aircraft crash into the vault area, followed by a large fire, bounds the potential consequences associated with the facility. The concern then rises that the multiple barriers of some of the stored HEU could be breached solely because of the crash itself. It is estimated that an engine block penetrating the facility might impact 15 percent of the available containers. Therefore, it is assumed that the impacted 15 percent would be subject to release in the first ten minutes of the fire. Because of the insulated shipping containers, after one hour it is assumed that 1 percent of the total inventory would be available for release. To assume that any impact results in a complete release of the encased materials is a conservative assumption and is used for the purposes of this bounding study.

Table F.2.7.1-1.-- Accident Scenarios for Storage of Uranium Strategic Reserves

Accident Scenario	Site	Accident Frequency (per year)	Total Material Release to Environment
1. Criticality	ORR	$1x10^{-6}$ to $1x10^{-4}$	$1x10^{17}$ fissions
	Pantex	$1x10^{-6}$ to $1x10^{-4}$	$1x10^{17}$ fissions
	NTS	$1x10^{-6}$ to $1x10^{-4}$	$1x10^{17}$ fissions
2. Fire-induced release of HEU from aircraft crash	ORR	not applicable	
	Pantex	$1x10^{-7}$	270 grams of HEU
	NTS	not applicable	

3. Fire-induced release of lithium hydride from aircraft crash	ORR	not applicable	
	Pantex	$1x10^{-7}$	2.5 g/s to 2.8 g/s
	NTS	not applicable	
4. Fire-induced release of HEU from vault	ORR	$1x10^{-6}$ to $1x10^{-4}$	37.64 kg HEU
	Pantex	$1x10^{-6}$ to $1x10^{-4}$	37.64 kg HEU
	NTS	$1x10^{-6}$ to $1x10^{-4}$	37.64 kg HEU
5. Explosive release of HEU from vault	ORR	$1x10^{-6}$ to $1x10^{-4}$	540 grams of HEU
	Pantex	$1x10^{-6}$ to $1x10^{-4}$	540 grams of HEU
	NTS	$1x10^{-6}$ to $1x10^{-4}$	540 grams of HEU
HNUS 1996a.			

Oak Ridge Reservation. This accident is not applicable to ORR because the probability of an aircraft crash into a facility is much less than 10^{-7}/yr.

Pantex Plant. This accident is considered a beyond evaluation basis accident ($1x10^{-7}$ /yr). The release for radiological impacts is 270 g (9.5 oz) of HEU. For chemical toxicity impacts, the release is 1.5 g/seconds (s) for 10 minutes then 1.7 g/s for the second hour of the accident.

Nevada Test Site. This accident is not applicable to NTS because the probability of an aircraft crash into a facility is much less than 10^{-7}/yr.

Scenario 3: Fire-induced release of lithium from an aircraft crash.

Of the chemical accident scenarios, no mechanisms were identified that could potentially release a significant amount of lithium hydride or uranium to the environment, other than the potential jet fuel-fed fires following an aircraft crash. A large aircraft crash with significant secondary fuel fire is therefore assumed to be the bounding hazardous chemical accident. The release scenario is similar to scenario 2.

Oak Ridge Reservation. This accident is not applicable to ORR because the probability of an aircraft crash into a facility is much less than 10^{-7}/yr.

Pantex Plant. This accident is considered a beyond evaluation basis accident ($1x10^{-7}$ /yr). For chemical toxicity impacts, the release is 2.5 g/s for 10 minutes then 2.8 g/s for the second hour of the accident.

Nevada Test Site. This accident is not applicable to NTS because the probability of an aircraft crash into a facility is much less than 10^{-7}/yr.

Scenario 4: Fire-induced release of highly enriched uranium.

It is assumed that 3,785 L (1,000 gal) of fuel are inserted into the vault area and that a pool 0.64-cm (1/4-in) deep develops. The area covered by that pool will be approximately 595 m^2 (6,400 ft^2). It is

assumed that only in the innermost 20 percent of the fire will temperatures be sufficient to ignite uranium, and that only the topmost of the three drums will reach those temperatures, the lower ones being cooled through conduction to the vault base and the fuel. Of the drums reaching those temperatures, half are assumed to fail and, of those, half fail at the bottom, releasing some or all of their contents. The drum density in the new vault areas is approximately one set of three per 0.9 to 1.0 m^2 (10 to 11 ft^2). Thus, 1,920 drums will be within the fire, and 128 of them will reach high enough temperatures to ignite the uranium, of which 32 will fail at the bottom and expel their contents.

Oak Ridge Reservation. The frequency of this accident is assumed to be in the range of $1x10^{-6}$ to $1x10^{-4/yr}$. The amount estimated to be released will be 37,640 g (1,328 oz).

Pantex Plant. The frequency of this accident is assumed to be in the range of $1x10^{-6}$ to $1x10^{-4}$ /yr. The amount estimated to be released will be 37,640 g (1,328 oz).

Nevada Test Site. The frequency of this accident is assumed to be in the range of $1x10^{-6}$ to $1x10^{-4}$ /yr. The amount estimated to be released will be 37,640 g (1,328 oz).

Scenario 5: Explosion-induced release of highly enriched uranium from vault.

In an explosion, it is assumed that the drums and cans will provide sufficient protection to prevent the uranium from igniting. Consequently, even though there may be significant damage to the drums and/or cans, since the metal contents have not oxidized or vaporized, there is assumed to be no release. For those cans containing powders, the situation is different, in that the powder may spill from the drum and then be released. It is assumed that the storage arrangement will protect all but the "front row" of cans.

Considering a 5x4 arrangement in the pallet, and using the side with five cans, about 25 percent of the cans will feel the blast. Thus, about 250 cans may be damaged. However, it is assumed that only 100 cans, representing the faces of the four closest stacks of pallets, are sufficiently damaged to spill their contents.

Oak Ridge Reservation. Assuming that half the contents of each of the 100 cans spill, 540 g (19 oz) will be released. The estimated probability is in the range of $1x10^{-6}$ to $1x10^{-4}$ /yr.

Pantex Plant. Assuming that half the contents of each of the 100 cans spill, 540 g (19 oz) will be released. The estimated probability is in the range of $1x10^{-6}$ to $1x10^{-4}$/yr.

Nevada Test Site. Assuming that half the contents of each of the 100 cans spill, 540 g (19 oz) will be released. The estimated probability is in the range of $1x10^{-6}$ to $1x10^{-4}$/yr.

F.2.7.2 Accident Consequences and Risk

Table F.2.7.2-1 lists the set of accidents selected to represent consequences and risks to workers and the public from accident releases of radioactive materials and other hazardous effects during operations at ORR. For each accident, the table identifies the frequency of occurrence, and the consequences to a hypothetical worker at a specified distance from the accident, a hypothetical individual located at the nearest site boundary, and the public out to a distance of 80 km (50 mi). The

risks of cancer fatality for the worker, the individual at the site boundary, and the public for the composite set of accidents are also shown.

Table F.2.7.2-1.-- Storage of Uranium Strategic Reserves at Oak Ridge Reservation, Impacts of Accidents

	Noninvolved Worker at 619 Meters		Maximum Offsite Individual		Population to 80 Kilometers		
Accident Scenario	**Dose (rem)**	**Probability of Cancer Fatality[42]**	**Dose (rem)**	**Probability of Cancer Fatality[42]**	**Dose (person-rem)**	**Cancer Fatalities**	**Accident Frequency (per year)**
1. Criticality	5.1×10^{-4}	2.0×10^{-7}	5.1×10^{-4}	2.5×10^{-7}	0.031	1.5×10^{-5}	1.0×10^{-5}
4. Fire-induced release of highly enriched uranium from vault	5.4	2.2×10^{-3}	5.4	2.7×10^{-3}	806	0.40	1.0×10^{-5}
5. Explosive release of highly enriched uranium from vault	0.077	3.1×10^{-5}	0.077	3.9×10^{-5}	11.6	5.8×10^{-3}	1.0×10^{-5}
Impacts for Composite Set of EBAs and BEBAs[43]							
Expected consequences[44]		7.3×10^{-4}		9.1×10^{-4}		0.14	
Expected risk (per year)		2.2×10^{-8}		2.7×10^{-8}		4.1×10^{-6}	
Impacts for Composite Set of EBAs							
Expected consequences[44]		[45]		[45]		[45]	
Expected risk (per year)		[45]		[45]		[45]	
Impacts for Composite Set of BEBAs							
Expected consequences[44]		[46]		[46]		[46]	
Expected risk (per year)		[46]		[46]		[46]	

F.3 Comparison of the No Action Alternative to Proposed Alternatives at Pantex Plant and Oak Ridge Reservation

F.3.1 Pantex Plant

Existing operations at Pantex that have the potential for risks to workers and the public are weapons A/D and storage of plutonium. Under the No Action alternative storage would continue in Zone 4 and weapons A/D would continue in Zones 4 and 12. The risks of accidents to workers and the public are addressed in applicable SARs and would not be expected to change if they were continued. Under the proposed actions, weapons A/D operations would be entirely relocated to Zone 12.

Through relocation, the A/D operations would be performed in existing, modern facilities resulting in a decrease in the facility footprint in Zone 12 compared to the footprint in Zone 4. Although the risks of accidents due to internal initiators like fires and explosions are not expected to decrease significantly, risks would be reduced through the engineered safety features of a modern facility. More importantly, all Zone 4 operations have a higher probability of an externally initiated accident caused by an aircraft crash because Zone 4 is closer to the nearby commercial airport and traffic patterns than Zone 12. The probability of an aircraft crash into a Zone 12 facility is also decreased as a result of a reduction in the size of the facility compared to the existing facilities in Zone 4.

F.3.2 Oak Ridge Reservation

Existing operations at ORR that have the potential for risks to workers and the public are secondary and case fabrication and storage of HEU. Under the No Action alternative, these operations would continue to be performed in the facilities where they presently exist. The risks of accidents to workers and the public are addressed in applicable SARs and would not be expected to change if they were to be continued.

Under the proposed actions, secondary and case fabrication and HEU storage would be downsized into fewer existing buildings in the same vicinity as buildings associated with the No Action alternative. The risks of accidents to workers and the public from internal causes such as fires and criticality are not expected to change. However, all of the buildings that would perform the downsized operations would be upgraded to meet natural phenomena requirements. These upgrades are expected to reduce risks, which would not happen under the No Action alternative.

F.4 Secondary Impacts of Accidents

The primary impacts of accidents are measured in terms of public and worker exposures to radiation and toxic chemicals. The secondary impacts of accidents include all elements of the environment. For example, if an accident occurred, a radiological release may contaminate farmland, surface and underground water, recreational areas, industrial parks, historical sites, or the habitat of an endangered species. As a result, farm products may have to be destroyed; the supply of drinking water may be lowered; recreational areas may be closed; industrial parks may suffer economic losses during shutdown for decontamination; historical sites may have to be closed to visitors; and the endangered species may move closer to extinction.

This section addresses the secondary impacts of a high consequence EBA and BEBA in the region of a radiological release. The accidents were selected to illustrate the effects of accidents evaluated for each of the technologies. The levels of radioactivity that have a potential for secondary effects are based on analysis using the MACCS computer code with 50 percent meteorology conditions for each site.

The region of secondary effects extends out from the point of release in a pattern formed by

dispersion parameters such as meteorology. The level of exposure is generally decreasing with increasing distance from the release point. Figures F.4.1.-1 through F.4.6-2 show the shapes of patterns for each site at a distance at which the level of radioactivity from the accidental release would be higher than the level of radioactivity from natural background at each site.

These results are useful for comparing the environmental sensitivity of sites with respect to the secondary impacts for an accidental radiological release. In reviewing the results, it is useful to note whether the impacted area extends beyond the site boundary where the economic impacts would be larger than if the area were contained within the site boundary. It is also useful to note the size of the contaminated area in which the level of radioactivity exceeds exposures from natural background.

F.4.1 Oak Ridge Reservation

In the region of ORR, the natural background level of radiation (excluding radon) is 95 millirems (mrem)/yr, plus an additional 200 mrem from radon. The results shown in figures F.4.1-1 and F.4.1-2 indicate the radiation levels at various distances from the accident. Section 4.2 describes the land, water, biotic, cultural, paleontological, and socioeconomic resources in the ORR environment that may receive secondary impacts from accidents.

F.4.2 Savannah River Site

In the region of SRS, the natural background level of radiation (excluding radon) is 98 mrem/yr, plus an additional 200 mrem from radon. The results shown in figure F.4.2-1 indicate the radiation levels at various distances from the accident. Section 4.3 describes the land, water, biotic, cultural, paleontological, and socioeconomic resources in the SRS environment that may receive secondary impacts from accidents.

F.4.3 Pantex Plant

In the region of Pantex, the natural background level of radiation (excluding radon) is 134 mrem /yr, plus an additional 200 mrem from radon. The results shown in figures F.4.3-1 and F.4.3-2 indicate the radiation levels at various distances from the accident. Section 4.5 describes the land, water, biotic, cultural, paleontological, and socioeconomic resources in the Pantex environment that may receive secondary impacts from accidents.

F.4.4 Los Alamos National Laboratory

In the region of LANL, the natural background level of radiation (excluding radon) is 140 mrem/yr, plus an additional 200 mrem from radon. The results shown in figures F.4.4-1 and F.4.4-2 indicate the radiation levels at various distances from the accident. Section 4.6 describes the land, water, biotic, cultural, paleontological, and socioeconomic resources in the LANL environment that may receive secondary impacts from accidents.

F.4.5 Lawrence Livermore National Laboratory

In the region of LLNL, the natural background level of radiation (excluding radon) is 100 mrem per/yr, plus an additional 200 mrem from radon. The results shown in figure F.4.5-1 indicate the radiation levels at various distances from the accident. Section 4.7 describes the land, water, biotic,

cultural, paleontological, and socioeconomic resources in the LLNL environment that may receive secondary impacts from accidents.

F.4.6 Nevada Test Site

In the region of NTS, the natural background level of radiation (excluding radon) is 113 mrem per/yr, plus an additional 200 mrem from radon. The results shown in figures F.4.6-1 and F.4.6-2 indicate the radiation levels at various distances from the accident. Section 4.9 describes the land, water, biotic, cultural, paleontological, and socioeconomic resources in the NTS environment that may receive secondary impacts from accidents.

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33 Probability (increased likelihood) of cancer fatality to a hypothetical member of the public located at the site boundary or a worker located 1,000 m (3,281 ft) from the accident as a result of exposure to the indicated dose if the accident occurred.

34 A beyond evaluation basis accident (BEBA). All other listed accidents are evaluation basis accidents (EBA).

35 For the offsite population of 285,409, the average probability of cancer fatality/risk of cancer fatality (per year) for the composite set of accidents is $3.0 \times 10^{-10}/2.2 \times 10^{-13}$.

36 Result of exposure to the indicated dose if the accident occurs. All values are mean values. Model results.

37 Probability (increased likelihood) of cancer fatality to a hypothetical member of the public located at the site boundary or a worker located 1,000 m (3,281 ft) from the accident as a result of exposure to the indicated dose if the accident occurred.

38 For the offsite population of 18,517, the average probability of cancer fatality/risk of cancer fatality (per year) for the composite set of accidents is $3.5 \times 10^{-10}/2.1 \times 10^{-13}$.

39 The accident is not possible at NTS.

40 Result of exposure to the indicated dose if the accident occurs.

41 No beyond evaluation basis accidents were identified for NTS. The impacts for the composite set of EBAs and BEBAs is the same as the impacts for the composite set of EBAs. All values are mean values. Model results.

42 Probability (increased likelihood) of cancer fatality to a hypothetical member of the public located at the site boundary or to a worker located 619 m from the accident as a result of exposure to the indicated dose if the accident occurred.

43 For the offsite population of 1,096,144, the average probability of cancer fatality/risk of cancer fatality (per year) for the composite set of accidents is $1.3 \times 10^{-7}/3.7 \times 10^{-12}$.

44 Result of exposure to the indicated dose if the accident occurs.

45 The impacts of evaluation basis accidents (EBA) are identical to the data shown in this table.

46 All accidents are in the frequency range of 10^{-6} to 10^{-4} per year and are grouped together as EBAs. As a result, there are no impacts shown for beyond evaluation basis accidents (BEBA). All values are mean values. Model results.

APPENDIX G: INTERSITE TRANSPORTATION

G.1 Transportation Risk Analysis Methodology

The transportation risk assessment estimates the health effects, in terms of annual fatalities, from the transportation of plutonium and highly enriched uranium (HEU) for each programmatic environmental impact statement (PEIS) alternative. For this assessment, the PEIS alternatives can be described as combinations of pit fabrication, secondary and case fabrication, and assembly/disassembly (A/D) sites. The potential sites for these functions are:

- A/D--Nevada Test Site (NTS) or Pantex Plant (Pantex)
- Pit Fabrication--Los Alamos National Laboratory (LANL) or Savannah River Site (SRS)
- Secondary and Case Fabrication--LANL, Lawrence Livermore National Laboratory (LLNL), or Oak Ridge Reservation (ORR)

In addition, the sites considered for the storage of the strategic reserve of plutonium and HEU and the tritium recycling site were considered in the analysis for estimating risk. The strategic reserve of plutonium and HEU could be located at six potential sites: Hanford, Idaho National Engineering Laboratory (INEL), NTS, ORR, Pantex, or SRS. Two of these sites, NTS and Pantex, are considered by the Stockpile Stewardship and Management PEIS due to the assumption that storage of the strategic reserve in the form of pits and secondaries would be collocated at the weapons A/D sites. The other four sites are being considered by the *Storage and Disposition of Weapons-Usable Fissile Materials Draft Programmatic Environmental Impact Statement* (DOE/EIS-0229-D, February 1996) for consolidated storage of all plutonium and uranium. Tritium recycling would remain at SRS. All of the alternatives are shown in table G.1-1.

For each of the special nuclear materials and radioactive materials involved, the radiological risk calculations were performed using the RADTRAN Version 4 computer code, developed and maintained by Sandia National Laboratories (SNL) at Albuquerque, NM (RADTRAN 4: *Volume 3 User Guide [SAND89-2370, January 1992]).*

The RADTRAN code combines user-determined demographic, transportation, packaging, and material factors with health physics data to calculate the expected radiological consequences of accident-free and accident risk from transporting radioactive material.

For performing the calculations, plutonium and HEU would be transported via Department of Energy's (DOE) safe secure trailers. Tritium would be transported by DOE's contract air carrier. The packaging types and the number of packages per shipment would be in accordance with regulatory requirements.

For this analysis, the isotopic composition was assumed to be 93 percent uranium-235 for HEU shipments and 100 percent tritium for tritium shipments. Plutonium was assumed to be weapons-grade material.

The transport index is a regulatory characteristic of a package and is equal to the radiation dose rate in millirem per hour at a distance of 1 meter (m) (3.3 feet [ft]) from the outside of the package. The transport index values were estimated to be the maximum allowed by regulatory checks incorporated in RADTRAN. These regulatory checks limit the product of the number of packages and the transport

index of each package to a value of about 16. The quantity of material per package, number of packages per truckload, and number of truckloads per year were estimated.

Table G.1-1.-- Annual Health Impact from Transportation of Materials for Each Alternat

						Health Effe	
Alternative	**Pit Fabrication Site**	**Secondary and Case Fabrication Site**	**Plutonium Storage Site**	**HEU Storage Site**	**Tritium Recycling Site**	**Accident**	**Acciden Free**
No Action	LANL (limited)	ORR	Pantex	ORR	SRS	2.57x10 -3	7.64x10 4
Assembly/Disassembly at NTS	LANL	ORR	NTS	ORR	SRS	4.78x10 -3	1.34x10 3
	LANL	ORR	Pantex	Pantex	SRS	6.47x10 -3	1.87x10 3
	LANL	ORR	ORR	ORR	SRS	5.30x10 -3	1.51x10 3
	LANL	ORR	NTS	NTS	SRS	8.44x10 -3	2.39x10 3
	LANL	ORR	SRS	SRS	SRS	6.00x10 -3	1.76x10 3
	LANL	ORR	INEL	INEL	SRS	8.76x10 -3	2.52x10 3
	LANL	ORR	Hanford	Hanford	SRS	9.88x10 -3	2.84x10 3
	SRS	ORR	NTS	ORR	SRS	7.03x10 -3	2.03x10 3
	SRS	ORR	Pantex	Pantex	SRS	8.26x10 -3	2.44x10 3
	SRS	ORR	ORR	ORR	SRS	5.55x10 -3	1.61x10 3
	SRS	ORR	NTS	NTS	SRS	1.07x10 -2	3.07x10 3
	SRS	ORR	SRS	SRS	SRS	5.87x10 -3	1.70x10 3
	SRS	ORR	INEL	INEL	SRS	1.08x10 -2	3.15x10 3

	SRS	ORR	Hanford	Hanford	SRS	1.19×10^{-2}	3.49×10^{3}
	LANL	LANL	NTS	NTS	SRS	3.87×10^{-3}	1.02×10^{3}
	LANL	LANL	Pantex	Pantex	SRS	3.06×10^{-3}	8.06×10^{4}
	LANL	LANL	ORR	ORR	SRS	5.67×10^{-3}	1.61×10^{3}
	LANL	LANL	SRS	SRS	SRS	6.39×10^{-3}	1.85×10^{3}
	LANL	LANL	INEL	INEL	SRS	4.80×10^{-3}	1.25×10^{3}
	LANL	LANL	Hanford	Hanford	SRS	5.91×10^{-3}	1.59×10^{3}
	SRS	LANL	NTS	NTS	SRS	6.13×10^{-3}	1.70×10^{3}
	SRS	LANL	Pantex	Pantex	SRS	4.84×10^{-3}	1.37×10^{3}
	SRS	LANL	ORR	ORR	SRS	5.93×10^{-3}	1.71×10^{3}
	SRS	LANL	SRS	SRS	SRS	6.23×10^{-3}	1.81×10^{3}
	SRS	LANL	INEL	INEL	SRS	6.80×10^{-3}	1.90×10^{3}
	SRS	LANL	Hanford	Hanford	SRS	7.92×10^{-3}	2.23×10^{3}
	LANL	LLNL	NTS	NTS	SRS	3.58×10^{-3}	1.08×10^{3}
Assembly/Disassembly at NTS (Continued)	LANL	LLNL	Pantex	Pantex	SRS	4.76×10^{-3}	1.39×10^{3}
	LANL	LLNL	ORR	ORR	SRS	7.43×10^{-3}	2.21×10^{3}
	LANL	LLNL	SRS	SRS	SRS	8.16×10^{-3}	2.44×10^{3}
	LANL	LLNL	INEL	INEL	SRS	4.40×10^{-3}	1.25×10^{3}

	LANL	LLNL	Hanford	Hanford	SRS	4.52×10^{-3}	1.38×10^{-3}
	SRS	LLNL	NTS	NTS	SRS	5.83×10^{-3}	1.77×10^{-3}
	SRS	LLNL	Pantex	Pantex	SRS	6.54×10^{-3}	1.96×10^{-3}
	SRS	LLNL	ORR	ORR	SRS	7.68×10^{-3}	2.32×10^{-3}
	SRS	LLNL	SRS	SRS	SRS	8.00×10^{-3}	2.39×10^{-3}
	SRS	LLNL	INEL	INEL	SRS	6.40×10^{-3}	1.89×10^{-3}
	SRS	LLNL	Hanford	Hanford	SRS	6.53×10^{-3}	2.02×10^{-3}
Assembly/Disassembly at Pantex	LANL	ORR	Pantex	ORR	SRS	2.57×10^{-3}	7.64×10^{-4}
	LANL	ORR	Pantex	Pantex	SRS	4.49×10^{-3}	1.36×10^{-3}
	LANL	ORR	ORR	ORR	SRS	3.32×10^{-3}	9.94×10^{-4}
	LANL	ORR	NTS	NTS	SRS	6.47×10^{-3}	1.88×10^{-3}
	LANL	ORR	SRS	SRS	SRS	4.03×10^{-3}	1.23×10^{-3}
	LANL	ORR	INEL	INEL	SRS	6.78×10^{-3}	2.00×10^{-3}
	LANL	ORR	Hanford	Hanford	SRS	7.90×10^{-3}	2.28×10^{-3}
	SRS	ORR	Pantex	ORR	SRS	3.89×10^{-3}	1.20×10^{-3}
	SRS	ORR	Pantex	Pantex	SRS	5.80×10^{-3}	1.80×10^{-3}
	SRS	ORR	ORR	ORR	SRS	3.10×10^{-3}	9.67×10^{-4}
	SRS	ORR	NTS	NTS	SRS	8.26×10^{-3}	2.44×10^{-3}

	SRS	ORR	SRS	SRS	SRS	3.41×10^{-3}	1.07×10^{-3}
	SRS	ORR	INEL	INEL	SRS	8.32×10^{-3}	2.52×10^{-3}
	SRS	ORR	Hanford	Hanford	SRS	9.44×10^{-3}	2.85×10^{-3}
	LANL	LANL	Pantex	Pantex	SRS	2.25×10^{-3}	5.96×10^{-4}
Assembly/Disassembly at Pantex (Continued)	LANL	LANL	ORR	ORR	SRS	4.86×10^{-3}	1.40×10^{-3}
	LANL	LANL	NTS	NTS	SRS	3.06×10^{-3}	8.06×10^{-4}
	LANL	LANL	SRS	SRS	SRS	5.58×10^{-3}	1.64×10^{-3}
	LANL	LANL	INEL	INEL	SRS	3.98×10^{-3}	1.05×10^{-3}
	LANL	LANL	Hanford	Hanford	SRS	5.10×10^{-3}	1.38×10^{-3}
	SRS	LANL	Pantex	Pantex	SRS	3.57×10^{-3}	1.03×10^{-3}
	SRS	LANL	ORR	ORR	SRS	4.65×10^{-3}	1.38×10^{-3}
	SRS	LANL	NTS	NTS	SRS	4.84×10^{-3}	1.37×10^{-3}
	SRS	LANL	SRS	SRS	SRS	4.95×10^{-3}	1.48×10^{-3}
	SRS	LANL	INEL	INEL	SRS	5.52×10^{-3}	1.57×10^{-3}
	SRS	LANL	Hanford	Hanford	SRS	6.64×10^{-3}	1.90×10^{-3}
	LANL	LLNL	Pantex	Pantex	SRS	5.92×10^{-3}	1.71×10^{-3}
	LANL	LLNL	ORR	ORR	SRS	8.59×10^{-3}	2.54×10^{-3}
	LANL	LLNL	NTS	NTS	SRS	4.76×10^{-3}	1.39×10^{-3}

	LANL	LLNL	SRS	SRS	SRS	9.33×10^{-3}	2.74×10^{-3}
	LANL	LLNL	INEL	INEL	SRS	5.57×10^{-3}	1.56×10^{-3}
	LANL	LLNL	Hanford	Hanford	SRS	5.69×10^{-3}	1.70×10^{-3}
	SRS	LLNL	Pantex	Pantex	SRS	7.24×10^{-3}	2.15×10^{-3}
	SRS	LLNL	ORR	ORR	SRS	8.39×10^{-3}	2.51×10^{-3}
	SRS	LLNL	NTS	NTS	SRS	6.54×10^{-3}	1.96×10^{-3}
	SRS	LLNL	SRS	SRS	SRS	8.71×10^{-3}	2.59×10^{-3}
	SRS	LLNL	INEL	INEL	SRS	7.10×10^{-3}	2.09×10^{-3}
	SRS	LLNL	Hanford	Hanford	SRS	7.23×10^{-3}	2.22×10^{-3}

The transportation accident model in RADTRAN assigns accident probabilities to a set of accident categories. For the truck and air analysis, the eight accident-severity categories defined in the Nuclear Regulatory Commission's (NRC) Final Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes (NUREG 0170, December 1977) were used. The least severe accident category (Category I) represents low magnitudes of crush force, accident-impact velocity, fire duration, or puncture-impact speed. The most severe category (Category VIII) represents a large crush force, high-impact velocity, high puncture-impact speed, an 88-kilometer [km] per hour (54.6-mile [mi] per hour) collision into the side of the vehicle and a 982-degree Celsius (°C) (1,800-degree Fahrenheit [°F]) fire lasting 1.5 hours to produce a release of the material (plutonium, HEU, or tritium). The release fractions for Category VIII accidents were conservatively estimated to be 0.1 for all types of materials analyzed.

To perform the risk calculations, distance and distance fractions for rural, suburban, and urban populations for each intersite route were estimated using the INTERSTAT routing code. INTERSTAT is part of the RADTRAN model. Although the distance fractions in the rural, suburban, and urban populations are slightly different for each route, among the routes considered, the average distance fractions for population distribution for rural, suburban, and urban were 78, 20, and 2 percent, respectively. Also included are nonradiological impacts due to air pollution and highway accidents. Fatalities from potential air pollution were estimated using 1.0×10^{-7} cancer fatalities per urban kilometer. Highway accident fatalities were estimated from national statistics using 1.5×10^{-8} rural, 3.7×10^{-9} suburban, and 2.1×10^{-9} urban for occupational risks per kilometer, and 5.3×10^{-8} rural, 1.3×10^{-8} suburban, and 7.5×10^{-9} for nonoccupational risks per kilometer (SNL 1986a:167).

To estimate accident and accident-free impacts, the radiation dose from each shipment was converted to a risk factor by multiplying the occupational accident-free and accident dose by $4.0x10^{-4}$ cancers per person-rem and the public accident-free and accident dose by $5.0x10^{-4}$ cancers per person-rem (ICRP 1991a:22). The resultant annual health risks are presented as potential fatalities. The combined resultant health risks are presented as potential fatalities.

The estimated annual impacts for each alternative were derived by summing the health effects from individual routes. The potential sites for each alternative and the corresponding annual impacts are presented in table G.1-1.

1 Estimated fatalities per year. Source: RADTRAN model results.

APPENDIX G: INTERSITE TRANSPORTATION

G.2 Packaging

Packaging refers to a container and all accompanying components or materials necessary to perform its containment function. Packagings used by DOE for hazardous materials shipments are either certified to meet specific performance requirements or built to specifications described in Department of Transportation (DOT) hazardous materials regulations (49 Code of Federal Regulations [CFR] Subchapter C). For relatively low-level radioactive materials, DOT Specification Type A packagings are used. These packagings are designed to retain their contents under normal transportation conditions. More sensitive radioactive materials shipments require use of highly sophisticated Type B packaging, designed and tested to prevent the release of contents under all credible transportation accident conditions.

Plutonium, HEU, and components containing tritium are DOE-unique hazardous materials that require special protection. In addition to meeting the stringent Type B containment and confinement requirements of NRC's 10 CFR 71 and DOT's 49 CFR, packaging for nuclear weapons and components must be certified separately by DOE. DOE employs a closed, Government-owned and -operated Transportation Safeguards System for the intersite transport of nuclear weapons and components, including plutonium and HEU. Specially designed safe secure trailers are utilized to ensure high levels of safety and physical protection. Limited-life components are transported almost exclusively by DOE's contract air carrier.

As a representation of a typical Type B packaging used to transport weapons components, the testing sequence for the 6M, Type B packaging used for the shipment of HEU is described below. Plutonium and tritium packaging requires a similar, high level of protection. Most other radioactive and hazardous materials, such as low-level waste, would be transported by commercial truck. Historical summaries of the hazardous and nonhazardous materials shipped to and from each of the candidate sites are presented in tables G.3-1, G.3-2, and G.3-3.

In addition to meeting standards demonstrating it can withstand normal conditions of transport without loss or dispersal of its radioactive contents, the model 6M, Type B packaging used for DOE shipments must survive certain severe hypothetical accident conditions that demonstrate resistance to impact, puncture, fire, and water submersion. Test conditions do not duplicate accident environments but, rather, produce damage equivalent to extreme and unlikely accidents. The 6M, Type B packaging is judged as surviving extreme sequential testing if it retains all of its contents except for minuscule allowable releases, and if the dose rate outside the packaging does not exceed 1 rem/hour at a distance of 1 m from the package surface. Drum sizes (outer package) can vary from 38 to 420 liters (10 to 110 gallons).

The complete sequence of tests is listed below:

- **Drop Test.** A 9-m (30-ft) drop onto a flat, essentially unyielding, horizontal surface, striking the surface in a position at which maximum damage is expected
- **Puncture Test:** A 1-m (40-inch [in]) drop onto the upper end of a 15-centimeter (cm) (6-in) diameter solid, vertical, cylindrical, mild steel bar mounted on an essentially unyielding, horizontal surface
- **Thermal Test:** An exposure for not less than 30 minutes to a heat flux not less than that of a

radiation environment of 800 °C (1,475 °F) with an emissivity coefficient of at least 0.9

- **Water-Immersion Test:** A subjection to water pressure equivalent to immersion under a head of water of at least 15 m (50 ft) for not less than 8 hours

The regulatory test conditions for the 6M, Type B packaging and other similar packagings are much more demanding than they might appear. For example, an impact on a very hard surface (desert caliche) at over 32 km (200 mi) per hour is not as likely to deform the packaging as would a drop of 9 m (30 ft) onto an unyielding target.

The 6M, Type B packaging is made up of several component parts each playing an integral engineered role in containment and confinement of the radioactive material being shipped. The applicable DOE Safety Analysis Report for Packaging provides additional detail that shows that the package provides a high level of public safety regardless of the accidental conditions it might encounter during transportation. A typical 6M, Type B packaging approved for use by DOE is covered by a Certificate of Compliance. Although 6M, Type B packagings have been involved in severe accidents, the integrity of the packaging has never been compromised. A representative 6M packaging is shown in figure G.2-1.

Source: RADTRAN model results.

APPENDIX G: INTERSITE TRANSPORTATION

G.3 Intersite Shipment Data

Table G.3-1 presents a 5-year (1990 through 1994) summary of the nonhazardous and hazardous cargo shipped by commercial carriers to and from each of the candidate sites.

Table G.3-2 presents a summary, by chemical name, of hazardous materials shipped to and from Kansas City Plant (KCP), LANL, LLNL, and NTS for 1994. Table G.3-3 presents a summary, by chemical name, of hazardous materials shipped to and from ORR, Pantex, SNL, and SRS in 1994. All references to SNL refer to the Albuquerque location.

Table G.3-1.-- Five-Year Summary of Cargo Shipments by Commercial Carrier to a

	1990		1991		1992		1
Site	**Shipments (number)**	**Weight (kg)**	**Shipments (number)**	**Weight (kg)**	**Shipments (number)**	**Weight (kg)**	**Shipment (number)**
Kansas City Plant							
Hazardous	800	363,943	350	142,510	455	142,155	668
Nonhazardous	18,774	1,933,747	13,680	1,704,409	14,530	1,169,727	13,354
All cargo	19,574	2,297,690	14,030	1,846,919	14,985	1,311,882	14,022
Los Alamos National Laboratory							
Hazardous	851	544,668	680	316,974	1,089	363,818	1,133
Nonhazardous	28,266	4,129,802	28,757	3,943,075	36,805	1,855,129	46,663
All cargo	29,117	4,674,470	29,437	4,260,049	37,894	2,218,947	47,796
Lawrence Livermore National Laboratory							
Hazardous	987	931,582	453	277,618	2,264	3,329,414	4,510
Nonhazardous	5,080	729,180	78	455,632	39,818	3,161,580	50,902
All cargo	6,067	1,660,762	531	733,250	42,082	6,490,994	55,412
Nevada Test Site							
Hazardous	1,742	20,627,008	1,325	15,777,433	1,432	17,834,469	1,143
Nonhazardous	23,107	38,455,253	21,898	36,197,342	19,938	31,944,034	16,568
All cargo	24,849	59,082,261	23,223	51,974,775	21,370	49,778,503	17,711
Oak Ridge Reservation							
Hazardous	2,141	3,592,513	1,433	2,254,290	3,896	8,546,187	3,130
Nonhazardous	55,921	8,176,837	57,217	6,905,370	69,771	7,448,941	74,479
All cargo	58,062	11,769,350	58,650	9,159,660	73,667	15,995,128	77,609
Pantex Plant							
Hazardous	1,869	407,622	1,339	462,842	1,124	601,087	1,080
Nonhazardous	8,494	1,262,617	10,085	1,314,989	10,191	1,317,023	11,135

All cargo	10,363	1,670,239	11,424	1,777,831	11,315	1,918,110	12,215
Sandia National Laboratories							
Hazardous	454	114,870	482	120,977	554	124,924	456
Nonhazardous	20,653	2,944,455	20,018	2,254,413	26,986	2,850,913	34,136
All cargo	21,107	3,059,325	20,500	2,375,390	27,540	2,975,837	34,592
Savannah River Site							
Hazardous	1,151	4,049,534	643	3,192,682	1,462	2,625,821	1,386
Nonhazardous	36,012	227,513,797	33,870	151,211,460	34,348	136,905,940	34,816
All cargo	37,163	231,563,331	34,513	154,404,142	35,810	139,531,761	36,202
Gross weights, which include the weight of the package.							
SAIC 1995a:1.							

Source: RADTRAN model results.

APPENDIX G: INTERSITE TRANSPORTATION

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Table G.3-3.-- Summary of Hazardous Materials Shipped to and from Oak Ridge Reservation Pantex Plant, Sandia National Laboratories, and Savannah River Site, 1994

	ORR		Pantex		SNL		SRS	
Commodity	Shipments (number)	Weight (kg)	Shipments (number)	Weight (kg)	Shipments (number)	Weight (kg)	Shipments (number)	Weig (kg)
Acetylene gas	13	8,101					17	3,372
Aluminum nitrate	1	5					2	53
Aluminum sulfate, solid	1	378					2	6,277
Ammonia, anhydrous	3	686			1	7	4	587
Ammonium fluoride	1	1						
Ammonium hydroxide			1	34				
Ammonium sulfate								
Argon	199	430,223	8	1,250	1	6	33	82,713
Asbestos articles	33	37,544						
Asphalt			1	540				
Beryllium metal								
Beryllium metal or powder	1	6,638						
Cadmium nitrate	1	489						
Cadmium sulfate								
Calcium nitrate	1	1	1	2				
Chlorine	35	63,200	4	1,780				
Class A poison	2	10			7	1,919		
Class B poison	2	3,680	2	1,343	2	60		
Combustible liquid, n.o.s.	28	2,237	7	1,142	1	4	3	119
Corrosive material, n.o.s.	183	213,634	60	15,996	94	26,185	120	290,50
Dry ice	153	45,406			2	511		

Empty haz containers (non-radiological)	210	576,434			1	752		
Enriched boric acid								
Environmentally hazardous substance (marine pollutant)	3	80					1	20
Environmentally hazardous substance	10	4,934						
Etiologic agent, n.o.s.	1	144						
Explosives, n.o.s. (Class 1.1)			27	25,058	26	41,891		
Explosives, n.o.s. (Class 1.2)			1	40	5	29,821		
Explosives, n.o.s. (Class 1.3)			2	2,650	27	259,008		
Explosives, n.o.s. (Class 1.4)	7	3,870	93	14,008	28	2,064	8	4,859
Ferrous sulfamate	1	2,749	1	21				
Ferrous sulfate	2	2,041						
Flammable gas, n.o.s.	42	24,301	13	1,734	9	372	25	57,028
Flammable liquid, n.o.s.	140	54,056	54	6,947	48	3,352	33	28,406
Flammable solid, n.o.s.	35	360	58	6,068	9	1,222	1	7
Fluoboric acid	1	1						
Fuel oil (diesel, 1-6)	109	366,209					3	2,188
Gasoline	166	624,837					10	4,790
Hazardous waste (nonradiological)	3	12	1	19			8	1,438
Helium	33	42,913	11	640	157	33,864	21	27,444
Hydrocarbon gas, compressed or liquefied								

Hydrochloric acid	16	95	6	20			25	43,606
Hydrofluoric acid	2	59					7	6,885
Hydrofluoric acid solution, spent	1	4					1	27
Hydrogen gas	11	39,032	3	217			13	2,620
Hydrogen peroxide	8	1,911	1	2			9	3,870
Irritant, n.o.s.								
Isobutane, compressed or liquefied	2	1						
Lithium metal	24	3,290	9	845	2	10		
Lubricating oil	13	1,589	14	3,766			22	8,391
Magnesium, powder, metal strip	10	6					1	39
Mercuric nitrate								
Methanol, liquid	1	1					1	123
Methyl isobutylketone								
Misc. hazardous material	19	653	1	13	1	114	1	75
N-dodecane								
Natural gas, compressed or liquefied							1	373
Nitric acid fuming	14	20,827	3	59			22	6,270
Nitric acid (over 40 percent)	1	18					4	306
Nitric acid, fuming	1	2					3	1,143
Nitrogen	58	269,550	2	384	1	8	32	69,318
Nonflammable gas, n.o.s.	141	103,053	29	6,310	18	2,649	205	1,477,
Organic peroxide, n.o.s.	2	2					2	11
Orm A, n.o.s.	2	7,874						
Orm B, n.o.s.								

Orm D, consumer commodity							10	4,619
Orm E, n.o.s.	5	11,544						
Other regulated material, liquid	3	79					1	626
Other regulated material, solid	1	159						
Oxidizer, n.o.s.	47	1,486	2	35	2	49	4	15,321
Oxygen	24	4,811	2	258			20	26,036
Poison, liquid, n.o.s.	47	5,880	4	124	10	231	1	1
Poison, solid, n.o.s.	50	258			19	47	1	1
Propane, compressed or liquefied	5	227					1	68
RAM, empty packages	68	313,080	88	159,735			17	24,540
RAM, fissile, <20 percent uranium-235	3	6,275						
RAM, fissile, >20 percent uranium-235	15	2,318						
RAM, fissile, HRCQ								
RAM, fissile, HRCQ, IR, PINS							17	212,30
RAM fissile, HRCQ, UNIR, PINS								
RAM, fissile, n.o.s.	10	36,770	1	1,659	1	195	2	220
RAM, fissile, UNIR, PINS								
RAM, fissile, waste			1	7,254				
RAM, HRCQ, special	2	4,364						
RAM, instr. and articles	9	5,875	5	91				

RAM, LSA, n.o.s.	454	1,120,758	9	465				
66	1,270,833							
RAM, LSA, waste	6	111,223						
RAM, ltd. quant., n.o.s.	209	197,911	48	57,469	107	8,176	239	64,891
RAM, medical isotopes	107	390						
RAM, n.o.s.	135	124,546	23	3,903	107	302	32	69,099
RAM, n.o.s., HRCQ	1	13,744						
RAM, n.o.s., special	58	38,376	6	89			6	216
RAM, n.o.s., waste	1	109						
RAM, U-metal, pyrop	3	529			1	11		
RAM, UOx, n.o.s.	1	2						
Small arms ammunition	1	1,013	4	4,913	2	1,237		
Sodium hydroxide (caustic soda)	27	70,840			1	134	52	39.585
Sodium metal, (non-RAM)	3	65			1	136		
Sodium nitrate	3	233	1	2			3	169
Spontaneously combustible material	1	3			1	6		
Sulfuric acid	13	103,875			3	211	13	81,353
Toxic gas, inhalation hazard	16	340	1	653			7	1,675
Trichloroethane 1.1.1	8	247	2	108				
Wet cell batteries	21	27,448	2	684			81	83,084
Total	3,169	6,438,748	612	328,329	695	414,553	1,147	2,754,

Gross weights, which include the weight of the package. n.o.s. - not otherwise specified; RAM - radioactive material. SAIC 1995a:2.

G.4 Highway Distance

Table G.4-1 presents highway distances between sites being evaluated.

Table G.4-1.-- Highway Distances Between Selected Sites in Kilometers (Miles)

Site	SRS	SNL	Pantex	ORR	NTS	LANL	LLNL
KCP	1,599 (993)	1,259 (782)	869 (540)	1,153 (716)	2,330 (1,447)	1,293 (803)	2,919 (1,832)
LLNL	4,249 (2,639)	1,713 (1,064)	2,178 (1,353)	3,911 (2,429)	958 (595)	1,860 (1,155)	
LANL	2,605 (1,618)	166 (103)	535 (332)	2,267 (1,408)	1,220 (758)		
NTS	3,610 (2,242)	1,074 (667)	1,539 (956)	3,272 (2,032)			
ORR	531 (330)	2,145 (1,369)	1,732 (1,076)				
Pantex	2,070 (1,286)	472 (293)					
SNL	2,542 (1,579)						
DOE 1991j; DOE 1992o:3; McNally 1990a.							

Source: RADTRAN model results.

APPENDIX H: ENVIRONMENTAL MANAGEMENT

H.1 Overview

This appendix provides a general overview of the Department of Energy (DOE) Environmental Restoration and Waste Management Program, including the categories of waste streams managed by DOE; the applicable Federal statutes and DOE orders; waste minimization and pollution prevention; waste treatment, storage, and disposal; transportation of wastes; and facility transition management. Site-specific discussions of current waste management activities will follow in section H.2. Stockpile management project-specific waste management activities are addressed in appendix section A.3. Stockpile stewardship project-specific waste management activities are addressed in appendix I (National Ignition Facility [NIF]), appendix J (Contained Firing Facility [CFF]), and appendix K (Atlas Facility).

H.1.1 Waste Categories

Wastes are generated in gaseous, liquid, and solid forms and are categorized by their health hazard and handling requirements. The categories are listed in table H.1.1-1.

Table H.1.1-1.-- Waste Categories

Category	Characterization
Spent nuclear fuel	Nuclear reactor fuel that has been irradiated to the extent that it has undergone significant isotopic change to the point that fission-product poisons have reached an uneconomic threshold. DOE is no longer reprocessing spent nuclear fuel solely to recover fissile and fertile material. Although spent nuclear fuel is not categorized as a nuclear waste, the definition is provided here since it is radioactive material that must be stored, managed, and handled.
High-level	Highly radioactive material that results from the reprocessing of spent nuclear fuel including liquid waste produced directly in reprocessing, and any solid waste derived from the liquid that contains fission products in sufficient concentrations and other highly radioactive material that the NRC, consistent with existing law, determines to require permanent isolation.
Transuranic	Radioactive waste contaminated with alpha-emitting elements with an atomic number greater than uranium, half-life greater than 20 years, and in concentrations greater than 100 nanocuries per gram (nCi/g). Such wastes result primarily from fuel reprocessing, and from the fabrication of plutonium weapons components and plutonium-bearing reactor fuel. Generally, little or no shielding is required ("contact-handled" transuranic waste), but energetic gamma and neutron emissions from certain transuranic nuclides and fission-product contaminants may require shielding or remote handling ("remote-handled" transuranic waste).

Low-level	Radioactive waste that is not spent nuclear fuel, high-level waste (HLW), transuranic (TRU) waste, or byproduct material as defined by DOE Order 5820.2A, *Radioactive Waste Management.* Includes research and development (R&D) fissionable test specimens with TRU less than 100 nCi/g. The radiation level from this waste may sometimes be high enough to require shielding for handling and transport. In 10 CFR 61, NRC defines four disposal categories of low-level waste (LLW) that require differing degrees of confinement and/or monitoring: classes A, B, C, and Greater-Than-Class C.
Hazardous	Nonradioactive waste that has characteristics identified by either or both of the following Federal statutes: *The Resource Conservation and Recovery Act* (RCRA) (40 CFR 261) as amended or the *Toxic Substances Control Act* (TSCA). These toxic, corrosive, reactive, or ignitable substances and RCRA-listed wastes have been identified as posing health or environmental risks. Hazardous waste includes chemicals (such as chlorinated and nonchlorinated hydrocarbons), explosives, leaded oil, paint solvents, sludges, acids, organic solvents, heavy metals, and pesticides.
Mixed	Waste containing both hazardous and radioactive constituents.
Nonhazardous (Sanitary)	Solid sanitary waste that includes garbage, is routinely generated by normal housekeeping activities and does not have a defined health risk (neither radioactive nor hazardous). Solid sanitary waste is regulated under RCRA, Subtitle D. Liquid sanitary waste includes sewage and industrial waste, and is treated in a wastewater process before discharge to a publicly owned treatment works or surface waters. The management of liquid sanitary waste is regulated by the *Clean Water Act* (CWA) and the National Pollutant Discharge Elimination System (NPDES).
Nonhazardous (Other)	Other wastes that do not have a defined health risk, such as process wastewater.

H.1.2 Applicable Federal Statutes and Department of Energy Orders

Most of the regulations that impact the storage, treatment, and disposal of wastes were promulgated since the original Nuclear Weapons Complex (Complex) was established. In many cases, the technology available at the time the Complex was constructed does not meet current requirements for full compliance and, as a result, interim agreements have been made with the regulatory agencies. Through continuous upgrade programs, processes have been improved or added to meet the requirements of any new regulations. Operations continue on the basis of using "best available technology" for facilities that were in operation before the regulation came into effect. In the siting and construction of any new facilities, the intent is to meet current regulations and to reach the goal of maximum recycling, minimal waste generation, no liquid discharges to the surface, and treatment and stabilization of unavoidable wastes sufficient for long-term storage or permanent disposal either on or offsite.

In order to operate at most of its facilities, DOE has entered into numerous agreements with states and the Environmental Protection Agency (EPA) to address compliance issues concerning certain aspects of environmental regulatory requirements that have arisen due either to the age of DOE facilities or the uniqueness of DOE operations. For the most part, DOE facilities are in compliance with the major portion of all environmental regulatory requirements, and these compliance agreements address specific situations. At the same time, most of these compliance agreements

include a commitment from DOE to achieve compliance with each specific requirement by a specified date, including a schedule and milestones for achieving that compliance. These schedules and milestones are renegotiated on an ongoing basis as a result of changing budgets, additional environmental findings, and other factors. These agreements guide DOE activities at the sites under applicable environmental laws, regulations, and other standards. Compliance with the terms of these negotiated agreements is one of the highest DOE priorities. Site operations would be conducted in accordance with commitments DOE has made and would make in these agreements. DOE would work with the regulators to amend existing agreements and to develop new agreements to ensure continued compliance. Under no circumstances would DOE's performance pursuant to any existing compliance agreement be compromised or diminished as a result of the proposed action.

The following section summarizes the applicable Federal statutes and DOE orders:

Atomic Energy Act. The *Atomic Energy Act* gives DOE the authority to manage and regulate nuclear materials handled and generated at its facilities; however, DOE seeks to make its internal guidelines consistent with standards applied to commercial nuclear facilities regulated by the U.S. Nuclear Regulatory Commission (NRC). Pursuant to the *Atomic Energy Act* , DOE is committed to the practice of as low as reasonably achievable exposure to radiation from its operations, whereby exposures and resultant doses are maintained as low as social, economic, technical, and practical considerations permit.

Resource Conservation and Recovery Act. The *Resource Conservation and Recovery Act* (RCRA) was passed in 1976 as an amendment to the *Solid Waste Disposal Act* of 1965. RCRA regulates the "cradle to grave" management (generation, accumulation, storage, treatment, recycling, transport, and disposal) of hazardous waste, nonhazardous waste, underground storage tanks containing petroleum products and hazardous substances, and medical waste. Subtitle C of RCRA mandates that hazardous wastes be treated, stored, and disposed of in a manner that will minimize the threat to human health and the environment. To carry out this mandate, RCRA requires that owners and operators of hazardous waste treatment, storage, and disposal facilities obtain operating or post-closure care permits for certain waste management activities. RCRA defines the requirements for treatment, storage, and disposal facilities. Subtitle D of the law addresses the management of nonhazardous solid waste. Title 40 of the *Code of Federal Regulations* (CFR) implements the statutory provisions of RCRA. RCRA is a program which may be delegated to the states and for most states where DOE facilities are located, such delegation has occurred.

Land Disposal Restrictions. The *Hazardous and Solid Waste Amendments* to RCRA enacted in 1984 required the EPA to evaluate all listed and characteristic hazardous wastes according to a strict schedule and to develop requirements by which disposal of these wastes would be protective of human health and the environment. The implementing regulations for accomplishing this statutory reatment that substantially reduce the waste's toxicity or the likelihood that the waste's hazardous constituents will migrate. After the land disposal restriction's effective date, restricted wastes that do not meet treatment standards are prohibited from land disposal unless they qualify for certain variances or exemptions. EPA has promulgated standards for each of the five statutorily designated categories (40 CFR 268.31-40 CFR 268.35).

In addition to prohibiting disposal before appropriate treatment, land disposal restrictions prohibit any storage of land-disposal-restricted hazardous wastes (including mixed waste) except "for the purpose of the accumulation of such quantities of hazardous waste as are necessary to facilitate proper recovery, treatment, or disposal" (40 CFR 268.50). EPA has determined that storage of a hazardous

waste pending development of treatment capacity does not constitute storage to accumulate sufficient quantities to "facilitate proper recovery, treatment, or disposal."

Underground Storage Tank Provisions. The requirements for the facilities that use tank systems for storing or treating hazardous waste are outlined in 40 CFR 264, Subpart J. These requirements include assessment of the existing tank system's integrity, design, and installation of new tank systems or components, and secondary containment. Hazardous wastes or treatment reagents are not placed in a tank system if they could cause the tank, its ancillary equipment, or the containment system to rupture, leak, corrode, or otherwise fail. Controls and practices to prevent spills and overflows from tank or containment systems are also required. Inspection requirements, procedures for response to leaks or spills, the disposition of leaking or unfit-for-use tanks, and closure and post-closure care requirements are also outlined in 40 CFR 264, Subpart J. Ignitable or reactive and incompatible hazardous wastes have special requirements.

Resource Conservation and Recovery Act Corrective Action Program. Hazardous waste permits require sites to institute corrective action programs for investigating and remediating Solid Waste Management Units. This program applies to all operating, closed, or closing RCRA facilities.

Federal Facility Compliance Act. The *Federal Facility Compliance Act* was passed in 1992. It waived sovereign immunity for Federal facilities and included provisions concerning DOE compliance with RCRA hazardous waste treatment for mixed waste. The *Federal Facility Compliance Act* required DOE to have approved site-specific mixed waste treatment plans and related orders in place 3 years (October 1995) from the date of enactment in order to avoid the imposition of fines and penalties (except for sites already subject to a permit, agreement, or order addressing compliance with the RCRA land disposal restrictions storage prohibition).

In an April 6, 1993, *Federal Register* notice (58 FR 17875), DOE published its schedule for submitting plans for treating mixed wastes for each facility at which DOE generates or stores mixed waste. Two interim versions of the plans were used to facilitate discussions among states and other interested parties. A subsequent consent order signed by the regulatory agency requires implementation of the final site treatment plan. For mixed waste for which identified treatment technologies exist, the plans provide a schedule for submitting permit applications, entering into contracts, initiating construction, conducting systems testing, starting operation, and processing mixed wastes. For mixed waste without an identified treatment technology, the plans include a schedule for identifying and developing technologies, identifying the funding requirements for research and development (R&D), submitting treatability study exemptions, and submitting R&D permit applications. In cases where DOE proposes radionuclide separation, the plans also provide an estimate of the volume of waste that would exist without such separation as well as cost estimates and underlying assumptions. DOE also prepared summary documents of the final plans to provide a national picture of DOE's technology needs and possible options for treatment of its mixed waste. The summaries were provided to all states and made available to other interested parties.

Comprehensive Environmental Response, Compensation, and Liability Act. The *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA), as amended by the *Superfund Amendments and Reauthorization Act* (SARA) of 1986, provides liability, compensation, cleanup, and emergency response for hazardous substances (including radionuclides) released to the environment. The cleanup of inactive waste disposal sites is one of the major requirements of CERCLA. It provides for prioritization of cleanup actions (National Priorities List [NPL] or Superfund List) and directs that a Federal Facility Compliance Agreement be negotiated with EPA

and the state to coordinate CERCLA and RCRA compliance activities in one comprehensive strategy for each Federal facility. CERCLA also requires public participation in the selection of remediation alternatives, and this involvement or participation usually addresses the requirements of CERCLA, RCRA, and the *National Environmental Policy Act* (NEPA). Title III of CERCLA further requires that the National Response Center (operated by the U.S. Coast Guard) be notified in the event that a nonpermitted release of a reportable quantity of hazardous substance or radionuclides occurs. In the case of such a release, the National Response Center alerts the appropriate Federal emergency personnel who assess the event, formulate a response, and notify cognizant local emergency agencies. SARA requires industries to report the hazardous substances used at their facilities to include reporting inventories of these substances.

National Contingency Plan. The National Contingency Plan is an implementation regulation that sets forth requirements necessary to comply with CERCLA and SARA. For every site that is targeted for remedial response action under Section 104 of CERCLA, the National Contingency Plan requires that a detailed remedial investigation/feasibility study be conducted. The remedial investigation emphasizes data collection and site characterization. Its purpose is to define the nature, extent, and significance of contamination at a site in order to evaluate, select, and design a cost-effective remedial action. The feasibility study emphasizes analysis of data and decision making; it uses results from the remedial investigation to develop response objectives and alternative remedial responses. These alternatives are then evaluated in terms of their engineering feasibility, public health protection, environmental impacts, and costs. The remedial investigation/feasibility study leads to a decision that sets forth the method selected for remedial action to clean up the NPL site. Under the provisions of CERCLA, Federal facilities have the lead for CERCLA actions.

Toxic Substances Control Act. *The Toxic Substances Control Act* (TSCA) was enacted in 1976 to ensure that the manufacture, sale, storage, and disposal of toxic chemical substances do not present an unreasonable risk of injury to human health or the environment. Its applicability to DOE sites deals principally with the management and disposal of polychlorinated biphenyls (PCBs), asbestos, and dioxin. The problem created by dioxin is that currently there is a limited capability to treat these materials. Radioactively contaminated PCBs and PCB-contaminated materials generated by DOE are destroyed annually by the K-1435 TSCA Incinerator at K-25 at Oak Ridge Reservation (ORR).

Clean Air Act. The original *Clean Air Act* (CAA) was passed in 1955. It was wholly replaced by the *Air Quality Act* of 1967, but the name *Clean Air Act, which was reauthorized in 1990* , is still used. The CAA establishes air quality requirements and pollutant emission limits. The National Emissions Standards of Hazardous Air Pollutants (NESHAP) is a section of CAA that sets air quality standards for air emissions such as radionuclides, benzene, beryllium, and asbestos. NESHAP regulations require the use of EPA-approved monitoring instrumentation, sampling methodology, calculations, and modeling for each Federal facility.

Clean Water Act. The *Federal Water Pollution Control Act* , as amended by the *Clean Water Act* (CWA) of 1977, establishes a Federal/state scheme for controlling the introduction of pollutants into the Nation's water. The CWA created the National Pollutant Discharge Elimination System (NPDES) program. This program regulates nonradiological effluent discharges to ensure that surface water bodies meet applicable water quality standards. Each discharge point (outfall) is permitted through the NPDES program. New NPDES permit regulations for stormwater discharges require DOE to also characterize surface runoff during rain events.

Safe Drinking Water Act. The *Safe Drinking Water Act* (SDWA) was enacted in 1975 and is

designed to protect drinking water resources. Primary drinking water standards set by SDWA apply to drinking water "at the tap" as delivered by public water systems. Of equal significance is that drinking water standards are used to determine groundwater protection regulations under a number of other statutes. The SDWA requires DOE to obtain permits and to complete sample analyses and site inspections of public/industrial water supplies and sources of drinking water. It also imposes requirements on the installation and maintenance of drinking water wells.

Department of Energy Orders. The primary DOE orders governing waste management are as follows:

- DOE Order 5400.1, General Environmental Protection Program. Establishes environmental protection program requirements, authorities, and responsibilities for DOE operations for assuring compliance with applicable Federal, state, and local environmental protection laws and regulations, Executive orders, and internal department policies. Requires the preparation of waste minimization plans that describe how waste minimization activities will be promoted and implemented.
- DOE Order 460.1, (Packaging and Transportation Safety). Establishes the requirements for the packaging and transportation of hazardous materials, hazardous substances, and hazardous wastes.
- DOE Order 5820.2A, Radioactive Waste Management. Establishes policies and guidelines by which DOE manages its radioactive waste, waste byproducts, and radioactively contaminated surplus facilities.

H.1.3 Waste Minimization and Pollution Prevention

Waste minimization is the reduction, to the extent feasible, of radioactive and hazardous waste before treatment, storage, or disposal of the waste. Pollution prevention fully utilizes source reduction techniques in order to reduce risks to public health, safety, welfare, and the environment, as well as utilizing environmentally sound recycling to achieve these same goals. Each DOE site is required to have a Waste Minimization and Pollution Prevention Awareness Plan. To report their progress towards their goals in the plan, each site prepares an Annual Report on Waste Generation and Waste Minimization Progress. When planning for facilities to be constructed by 2005, it will be necessary to consider currently available technology while providing modular, flexible designs that can incorporate process improvements as they become available. In accordance with Executive Orders 12856, 12873, and DOE policy, the facilities that would support the Stockpile Stewardship and Management Program would be designed for waste minimization with an overall operating philosophy of pollution prevention. This waste minimization program would contribute to decreases in waste treatment, storage, and disposal costs and lower health risks to workers and the public. Technical approaches are being sought to optimize the number of production operations required, to increase the use of nonhazardous chemicals and environmentally benign waste-producing chemicals, to increase the use of recyclable chemicals and materials, and implement the new design or redesign of existing processes and products. Some criteria useful in determining successful technologies include improved processing yield, reduced quantities of scrap, reduced waste and processing of byproducts, reduced use of hazardous chemicals, positive return on investment, and continued product quality.

H.1.4 Waste Treatment, Storage, and Disposal

Waste management activities that would support the Stockpile Stewardship and Management

Program are assumed to be current per site and are contingent upon decisions to be made through the Waste Management PEIS. Any future waste management facilities that may be required to support the Stockpile Stewardship and Management Program would be coordinated with any decisions resulting from the Waste Management PEIS and any respective site-specific NEPA documentation.

Treated waste is waste that, following generation, has been altered chemically or physically to reduce its toxicity or prepare it for storage or disposal. Waste treatment can include volume reduction activities, such as incineration or compaction, that may be performed on waste prior to either storage or disposal or both. Stored waste is waste that, following generation (and usually some treatment), is being temporarily retained in a retrievable manner and monitored pending disposal. Disposed waste is waste that has been put in final emplacement to ensure its isolation from the environment, with no intention of retrieval. Deliberate action is required to regain access to the waste. Disposed wastes include materials placed in geologic repositories or buried in landfills.

Waste that is staged for processing would be stored according to its characterization and form. The disposal of waste is managed by the DOE Office of the Assistant Secretary for Environmental Management (EM). A facility near Carlsbad, NM, for disposal of retrievable and newly generated transuranic (TRU) waste, is planned. All surface facilities at the Waste Isolation Pilot Plant (WIPP) have been completed. To date, only underground excavations for the test phase have been done, and the remaining excavation would be completed once the facility is operational. The original planned test phase has been abandoned, and in its place an experimental program at Idaho National Engineering Laboratory is being conducted to develop the technical data to support the permit application under 40 CFR 191 and 40 CFR 268. Once operational, WIPP would become a permanent disposal site. The total projected capacity of WIPP is 175,543 cubic meters ($m^{3)}$ (229,602 cubic yards [yd^3]), of which 7,080 m^3 (9,260 yd^3) could be remote-handled.

A supplemental environmental impact statement (EIS) is being prepared for the proposed phased development of WIPP for disposal of TRU waste. This supplemental EIS will analyze the impacts of waste storage, characterization, certification, processing or treatment, and loading at the generator sites. It will also discuss the impacts of transportation of TRU waste between generator sites and WIPP. The impacts of waste disposal operations at WIPP will also be analyzed, including the impacts of waste receipt, waste package inspection, monitoring, emplacement, and subsequent activities associated with eventual closure, decommissioning, and institutional control of WIPP once disposal operations have been completed. Options for the interim storage of TRU waste are evaluated in the Draft Waste Management Programmatic Environmental Impact Statement (DOE/EIS-0200-D). Yucca Mountain, NV, is a site being studied to determine its suitability for the disposal of commercial spent nuclear fuel and Department of Defense high-level waste (HLW). To date, no decisions to utilize either the Yucca Mountain repository or WIPP have been made. The remainder of this section discusses some of the treatment, storage, and disposal options that may be utilized with the various waste streams from stockpile stewardship and management facilities.

Gaseous Waste. Gaseous wastes can be nonhazardous (e.g., inert gases and air), hazardous (e.g., chlorinated hydrocarbon vapor and polyaromatic hydrocarbon vapor), or radioactive (e.g., tritium and xenon). Most hazardous gaseous wastes that are combustible may be incinerated to destroy the hazardous constituents by converting the combustibles into carbon dioxide and water vapor, while capturing any particulates that may result. When a particulate (ash) is contaminated with heavy metals, the end product must be stabilized into an approved solid form suitable for disposal.

Gaseous radioactive wastes are held for interim storage in tanks; adsorbed on surfaces in filters,

molecular sieves, or active beds; refrigerated and liquefied or solidified; or reacted to form an aqueous solution. Gaseous waste may be oxidized, mixed with other liquid wastes, or solidified in a stable form for long-term disposal. Reactive gases such as tritium are captured on reactive beds, in molecular sieves, or in cryogenic traps for recycling back to the process. Inert radioactive gases such as xenon and argon can be separated by cryogenic capture and held in storage tanks until they decay sufficiently to permit release. Gases that decay to metals can be captured on activated charcoal beds and held until they can be stabilized, packaged, and disposed of as solid waste. When sufficiently decayed, gases may be released to the atmosphere.

Liquid Waste. Liquid waste includes both wastewaters and nonwastewaters. Wastewaters are a mixture of water and organic, inorganic, or radioactive contaminants. Liquid radioactive wastes are processed according to their chemical nature and radiological sources and activities. Liquid wastes that meet release criteria in applicable regulations can be released at permitted discharge points. Where conditions permit, liquids can be processed and recycled to replace virgin feedstocks. Waste processing removes the hazardous or radioactive contaminants from the releasable or recyclable liquids. The largest volume of liquid radioactive waste is low-level waste (LLW), typically in aqueous solution from process operations. Some of this waste is contaminated with hazardous compounds such as solvents or resins, and the result is a liquid mixed waste. Liquid HLW would not be generated in stockpile stewardship and management facilities, but is part of the reference conditions at candidate sites where spent fuel or target processing was conducted. The desired final waste form for liquid wastes is a stable solid that is resistant to stresses from heat generation and from internal and external physical loads. The form must remain stable while stored and the radioactive constituents must not be allowed to migrate to the surroundings.

Mixed waste often has combustible constituents. These are most readily decomposed in thermal treatment (incineration) or chemical reaction resulting in the creation of an ash. The resulting material would be granular and suitable for stabilization in a cemented form in which the hazardous constituents (radionuclides and heavy metals) are bound in compounds that have an affinity for heavy metals and radionuclides. These processes have been utilized in various forms, and their retention properties have been credibly demonstrated.

Liquid LLW is normally processed to reclaim or remove the excess water, leaving a saturated salt solution. This can be accomplished by clarification processes normal to water treatment or by evaporation. This usually results in the greatest volume reduction for liquid waste. The subsequent stabilization and solidification of the concentrated solution results in a waste form that does not leach its active constituents for a time sufficient to allow the radioactive constituents to decay.

Liquid radioactive and hazardous wastes are usually stored in tanks, where they are staged for further processing. Processes are employed to concentrate the hazardous constituents. These processes result in significant volume reductions, with the reclaimed water processed to a purity sufficient for permitted discharge or recycle.

Liquid hazardous waste concentrates may contain combustive hydrocarbons and heavy metal contaminants. These can be treated by incineration to produce a dry waste. If this waste is still hazardous after treatment, it can then be processed into a stabilized solid that would not leach its hazardous constituents while in storage or in a disposal facility. Liquid low-level and noncombustible hazardous waste can also be processed into a stabilized solid form for storage and disposal.

Solid Waste. Solid radioactive waste typically consists of contaminated materials (e.g., filters,

clothing, storage vessels, cleaning materials, and tools) that have been used in, or contaminated by, nuclear materials processing. The term is also applied to those stabilized forms resulting from gaseous or liquid waste processing. In solid waste handling, forms and materials would be segregated, combustibles could be incinerated, and the resultant materials would be reduced in volume, stabilized if necessary, and packaged in specified containers for storage or disposal.

The only HLW stored at sites considered for the Stockpile Stewardship and Management Program is liquid HLW in tanks at Savannah River Site (SRS). It would be processed to a borosilicate glass, stored in an engineered facility onsite, and eventually shipped to a Federal repository.

Dry LLW that consists of protective clothing, containers, process materials, and equipment is stored in specified containers designed to retain the waste constituents for a time sufficient to permit decay of the radioactive constituents.

Solid hazardous waste may contain combustible hydrocarbon compounds or mixtures with heavy metal contamination. These wastes are usually shipped offsite to RCRA-permitted commercial facilities where they are treated, if required, and disposed of. Wastes that retain their hazardous constituents after processing must be packaged into forms that would retain the hazardous constituents safely within the waste form. For LLW or hazardous waste that results from liquid waste processing or incineration, the accepted form is solidification with a cement-like bonding agent.

Some mixed waste can be processed to remove its hazardous constituents and can be disposed of as LLW. Otherwise, it can be processed into stabilized forms and packaged for storage in an engineered facility until a licensed facility is available for permanent disposal. Solid nonhazardous wastes from process wastewater evaporation ponds or from sanitary waste treatment plants are usually deposited as sludge in a landfill.

Sites under consideration for stockpile stewardship and management facilities that do not have or have planned an onsite LLW disposal facility would ship their LLW offsite to one of DOE's LLW disposal facilities. As shown in table H.1.4-1, data from the DOE Integrated Database were used to calculate LLW disposal land usage factors from 1990 to 1993 for Los Alamos National Laboratory (LANL), Nevada Test Site (NTS), and SRS. ORR (Oak Ridge National Laboratory [ORNL]) is not listed because it only accepts ORNL-generated LLW. To determine a usage factor for the waste management impact analysis, an average value was calculated and then rounded down to the nearest hundred cubic meters. For the proposed Class II LLW disposal facility at ORR, a 3,300-m3/hectares (ha) (1,700-yd $^{3/acre)}$ usage factor was assumed (OR DOE 1995e:1).

Table H.1.4-1.-- Low-Level Waste Disposal Land Usage Factors for Department of Energy Sites

Site	Total Cumulative Volume (m^3)	Estimated Area Utilized (ha)	Land Usage Factor (m^3/ha)
1993			
LANL	220,700	17.4	12,684
NTS	458,435	174.2	2,632
SRS	665,239	67.9	9,797

1992			
LANL	218,000	17.2	12,674
NTS	439,700	55.0	7,995
SRS	649,700	78.2	8,308
1991			
LANL	215,700	17.2	12,541
NTS	419,600	55.0	7,629
SRS	636,700	78.2	8,142
1990			
LANL	209,900	17.0	12,347
NTS	408,400	No Data	No Data
SRS	612,800	72.1	8,499
Average			
LANL	NA	NA	12,562
NTS	NA	NA	6,085
SRS	NA	NA	8,687
NA - not applicable. DOE 1991h; DOE 1992f; DOE 1994c; DOE 1994d.			

H.1.5 Transportation

DOE complies with applicable Department of Transportation (DOT) regulations (10 CFR 71 and 49 CFR) when shipping hazardous materials over public roads. Transportation, especially for radioactive material, is highly regulated by Federal, state, and local laws. The stringent packaging requirements, combined with strict regulations and procedures governing the shipment of hazardous and radioactive materials, ensure that transport is a safe activity. Federal DOT regulations require the use of appropriate warning placards on vehicles and labels on packages to alert workers, officials, and the public to the hazardous nature of the shipped material. The use of placards on vehicles and warning labels on packages is a joint responsibility of the carrier and the shipper. The labels and placards are familiar to emergency response personnel and are valuable in determining content and hazard information.

Shipments of hazardous materials, including radioactive materials, must be accompanied by properly completed shipping papers such as bills of lading and cargo manifests that contain detailed information on the material being transported. These papers must be kept in the vehicle transporting the material and must be available for inspection by responsible officials at any time. The shipper must certify on the shipping papers that the hazardous material offered for transport is properly classified, packaged, marked, labeled, and made ready for transport according to all DOT regulations.

Radioactive material is shipped in secure packages. Type A packages contain small amounts of radioactive material and are designed to withstand normal conditions of transport. Type A packages are subjected to rigorous water spray, free-fall compression, and penetration tests carried out in sequence to ensure that radioactive materials are contained. Type B packaging is designed to contain more hazardous, and larger amounts of, radioactive waste. It can withstand severe accident conditions and contain radioactive materials under any credible circumstance.

If WIPP is determined to be a suitable disposal facility for TRU and mixed TRU wastes pursuant to the requirements of 40 CFR 191 and 40 CFR 268, TRU wastes would be shipped in TRUPACT-II (contact-handled) and RH-72B (remote-handled) containers. No remote-handled waste is expected to be generated in any of the stockpile stewardship and management facilities. To determine the number of TRU waste shipments required, 8.7 m3 (11.5 yd^3) of waste per truck shipment, 17.5 m^3 (23 yd^3) of waste per regular train shipment, and 52.4 m3 (69 yd^3) of waste per dedicated train shipment was assumed (*DOE 1994v:* B-4).

The additional shipments of LLW from stockpile stewardship and management sites without onsite LLW disposal were estimated. All LLW would be transported in a solid form. A typical shipment would consist of 80 208-liter (L) (55-gallon [gal]) drums loaded into an enclosed semi-trailer type truck. Each drum is assumed to be fully loaded, resulting in a total shipment volume of 17 m^3 (21.7 yd^3). The truck is assumed to operate as an "exclusive-use" vehicle.

H.1.6 Facility Transition Management

Any transition activities of facilities from a production mode to a cleanup mode that are part of the baseline for this PEIS are discussed as appropriate in the impacts sections of chapter 4 and in section H.2 of this appendix. Decontamination and decommissioning (D&D) considerations of stockpile stewardship and management facilities would be planned for in the design.

The DOE Office of the Assistant Secretary for Defense Programs (DP) is responsible for the safe operation, shutdown, and ultimate disposition of facilities used to support the nuclear weapons program. EM is responsible for final facility disposition, which may include D&D of inactive facilities or refurbishment of them for further economic development. Transition activities would require appropriate NEPA evaluation and would proceed consistent with programs within EM, DP, and Materials Disposition. Depending on the site, facility transition activities are in different stages of planning. The dominant time-intensive activities are building characterizations of the environmental hazards related to the building and the deactivation of the facility.

At the end of their useful lives, all potential facilities would require decommissioning. The transition process begins when DOE management decides to stop operating the production facility and ends when responsibility for the facility is formally turned over to EM. Transition plans would be required for all facility transfers to EM. These plans define the actions necessary to bring the identified facilities into a condition acceptable for transfer to EM. Some facility transition issues that would be considered in the facilities design process are:

- Land-use criteria defined for the period after cleanup
- Interim storage of mixed waste
- Disposal facilities for hazardous and LLW

The cleanup of proposed stockpile stewardship and management facilities would be significantly less difficult because consideration for waste minimization and ease of decontamination would be included in the facility design. The surfaces that come in contact with potential contaminants would be easier to decontaminate. In-process decontamination (to reduce operational exposures) would significantly reduce the cleanup required at the end of the facilities' life.

In spite of the best design and process practices, many of the proposed stockpile stewardship and management facilities would require decontamination efforts at the end of their life. Because of the necessity of working inside contaminated areas during the cleanup phase, the potential for exposure for cleanup workers is higher than during the operation phase. All D&D workers would wear protective clothing and would be supplied breathing air, as appropriate, to minimize their exposure.

Technologies for cleanup are established and are improving as experience in working with nuclear facilities increases. The use of robotics, improved task planning, and new materials to prevent the spread of contamination have already improved current cleanup activities. By the time the proposed stockpile stewardship and management facilities are decommissioned, DOE will have gained considerable cleanup experience; thus, further improvements should be expected.

DOE 1993h; DOE 1994k; DOE 1994n; DOE 1995gg; OR DOE 1995g; OR MMES 1993f; OR MMES 1995c.

H.2 Waste Management Activities

H.2.1 Oak Ridge Reservation

ORR consists of three operating industrial complexes in and around the city of Oak Ridge. The Energy Systems Waste Management Organization provides the waste management oversight for ORR. It also provides guidance to each of the operating facility waste management divisions that are responsible for operating and managing their respective waste management facilities and activities. Because there is no spent nuclear fuel, HLW, or TRU waste associated with the fabrication of secondaries and cases, there will be no further discussion of these wastes at ORR in this appendix.

Y-12 Plant. Laboratory, maintenance, construction, demolition, and cleanup activities; machining operations; and waste produced in the purification of uranium for recycle are the primary waste generation activities at the Y-12 Plant (Y-12). In addition, metal-plating operations generate plating waste solutions while various laboratory activities generate reactive wastes and waste laboratory chemicals. Liquid process waste and the sludge resulting from the treatment of these process wastes are generated throughout the plant. Waste oils and solvents are generated from machining and cleaning operations. Daily operations such as janitorial services and floor sweepings generate both noncontaminated and uranium-contaminated industrial trash.

Pollution Prevention. The Y-12 Pollution Prevention Awareness Program Plan describes the overall program in detail. The program is designed to maintain the flow of information pertaining to waste minimization and pollution prevention and to facilitate activities to implement real reductions in waste generation. A summary description of the four key elements of the Waste Minimization and Pollution Prevention Program includes a promotional campaign, information exchange, a waste tracking system, and waste assessment performance.

One goal of the program is to sustain an effective pollution prevention effort by improving the awareness of the employees of waste minimization opportunities and activities. Improved awareness is accomplished in many ways including training, posters, publications, seminars, promotional campaigns, and recognition of individuals and teams for activities that reduce waste generation. Waste minimization activities at other ORR sites and other weapons sites provide useful input to the program. Using ideas developed by others is an important aspect that can save time and resources.

Tracking waste generation in a manner that lends itself to waste minimization reporting is a prerequisite to documenting successes or failures in waste minimization efforts. Y-12 is improving its ability to record and track waste shipments. Process waste assessments are being conducted as part of the ongoing program to identify, screen, and analyze options to reduce the generation of waste. This determines the amount of material in a workplace that is disposed of as waste during work operations. The assessment provides a summary of hazardous materials usage and waste production and identifies those processes and operations that need to be improved or replaced to promote waste minimization.

Low-Level Waste. Machining operations that use stock materials including steel, stainless steel, aluminum, depleted uranium, and other materials produce machine turnings and fines as waste products. Waste treatment provides controlled conversion of waste streams generated from operations to an environmentally acceptable, or to a more efficiently handled or stored, form. This activity includes continuing operation and maintenance of facilities that treat wastewaters and solid waste

generated from production and production support activities. Waste minimization and planned treatment facilities are expected to reduce the magnitude of these wastes. In 1993, Y-12 treated approximately 1,030,000 L (272,000 gal) of liquid LLW and 4,730 m3 (6,200 yd ^{3}) of solid LLW (ORiting approval from the state.

The Waste Coolant Processing Facility is a biodegradation and storage facility for waste coolants that may be LLW and utilizes the following equipment for coolant treatment:

- Three storage tanks
- Feed tank
- Waste processing reactor/clarifier
- Sludge holding tank
- Two sludge blenders/dryers
- Effluent holding tank
- Transfer pumps

Microorganisms biodegrade approximately 114,000 L (30,000 gal) of waste coolant per month into harmless products. Each batch of coolant takes approximately 30 days to treat. After treatment, the clarifier separates the wastes into three process streams: floating oily solids, liquid effluent, and settled biological solids. Floating solids are dewatered in the dryer/ribbon blender and are transferred to drums. Liquid effluent is sent to the Central Pollution Control Facility or West End Treatment Facility/West Tank Farm for final treatment prior to NPDES discharge. Biological solids are further treated in the aeration tank and are then recycled or sent through the blender for dewatering. Nonrecycled solids are currently pumped into tankers for storage. This practice will continue until adequate treatment and disposal methods are established.

Long-term storage options include storage in warehouses, tanks, and vaults, as well as storage of Y-12 wastes in buildings at K-25. The major Y-12 LLW storage facilities, described below, are summarized in table H.2.1-2. As of June 1994, approximately 7,930 m3 (10,400 yd ^{3}) of LLW and 4,740 m3 (6,210 yd ^{3}) of uranium-contaminated scrap metal were stored at Y-12 (OR MMES 1995c5-25). The Classified Waste Storage Facility (located in Building 9720-25) will provide for the permitted storage of solid LLW and mixed LLW, which is classified for national securtiy purposes under provisions of the Atomic Energy Act. These wastes are currently being stored by the waste generators. The facility will meet plant security requirements for classified waste management and guildlines for the management of LLW and mixed LLW.

Containerized waste storage units in Buildings 9206 and 9212 provide for the storage of cans of ash resulting in the combustion of uranium-contaminated solid wastes. Combustile solid waste contaminated with enriched uranium are turned into ash by oxidation during the uranium recovery process. The resulting cans of ash are stroed in contanerized storage units in Buildings 9206 and 9212 until uranium accountability results have been obtained and the material can be returned to the uranium recovery process for further processing to recover the enriched uranium.

The Depleted Uranium Oxide Storage Vaults I and II are located on the Chestnut Ridge northeast of Building 9213. The vaults are constructed of reinforced concrete and provide a retreivable storage repository for uranium oxide, uranium metal, and a blended mixture of uranium sawfines and oxide. The vaults contain a negative pressure exhaust system that operates during material entry. The exhaust is filtered and monitored prior to its release to the atmoaphere. The facility utilizes forklift trucks, electric hoists, and a motorized drum dumper during operation. Depleted uranium oxide and blended sawfines are delivered in sealed 208-L (30- and 55-gal) drums. The containers have a weight

limit of 386 kilograms (kg) (850 pounds [lb]).

The Old Salvage Yard contains both low-level uranium-contaminated and nonradioactive scrap metal. Most scrap currently sent to this facility is contaminated. The Contaminated Scrap Metal Storage is an area within the Old Salvage Yard that is used to store uranium-contaminated scrap metal. Contaminated scrap is being placed in approved containers and eventually will be transferred to the aboveground storage pads. Noncontaminated scrap is sold when offsite shipments are allowed. This facility is located at the west end of Y-12.

Y-12 has no current onsite LLW disposal capability. All disposal activities at the Bear Creek Burial Ground were terminated on June 30, 1991. This landfill was used to dispose of radiologically contaminated solid waste. These wastes are currently containerized and stored at Y-12 in aboveground storage pads or are shipped offsite for incineration. In 1993, approximately 187 m3 (245 yd^3) of solid nonmetallic LLW were sent offsite to be compacted or incinerated with the ash returned to Y-12 for storage (OR MMM 1995c:5-15). Also, 745m (976yd) of contaminated scrap were sent to be smelted offsite. The proposed LLW disposal facilities project would provide new disposal facilities at a new centralized location of ORR. The proposed LLW disposal facilities would utilize state-of-the-art disposal technologies, invcluding lined trenches with leahate collection treatment capabilities and tumulus confinement disposal units. The Class-II Facility, for wastes contaminated with very low concentrations of short (less than 30 years) half-lite radionuclides, is expected to be operational in 2002. DOE has indefinately postponed consturction of the Class-I Facility, for wastes contaminated with very low cncentrations of predonminately long (greater than 30 years) half-lite radionuclides.

Mixed Low-Level Waste. Mixed LLW is generated from the development, metal preparation, fabrication, and assembly/industrial engineering functions at Y-12. Mixed LLW is hazardous waste such as solvents, degreasers, biodegradable coolants, organic and inorganic acids, biodenitrification sludge, and wastewater that is contaminated with enriched and/or depleted uranium. There is no disposal of mixed waste at Y-12; however, future plans include disposal of mixed wastes at a permitted offsite commercial facility. Mixed wastes are put in storage awaiting treatment or disposal, treated at Y-12, or sent to another ORR facility for treatment and disposal. Table H.2.1-3 presents the inventory of mixed LLW at Y-12 as of December 31, 1994, along with a 5-year projection. In 1993, approximately 2,410,000 L (636,000 gal) of liquid mixed LLW was treated at Y-12 (OR MMES 1995c-7-9). The Y-12 Waste Management Division operates several mixed LLW treatment facilities which are described below and summarized in the table H.2.1-1.

The Groundwater Treatment Facility treats wastewatere from the Liquid Storage Facility at Y-12 and seepwater collected at K-25 to remove volatile and nonvolatile organic compounds and iron. It is part of the Disposal Area Remedial Action program to collect and treat contaminated groundwater from the Beer Creek Burial Grounds. The Groundwater Treatment Facility is located at the far west end of Y-12, adjacent to the West End Treatment Facility. This facility utilizes an air stripping operation to remove volatie organics. In addition, carbon adsorption eliminates nonvolatile organics and PCBs. Iron removal equipement is also operational After treatment, wastewater is sampled and recycled if additionla processing is required. Wastewater that meets discharge specifications is pumped into East Fork Poplar Creek through an NPDES monitoring station. The GroundWater Treatment Facility treated and discharged approximately 2,780,000L (735,000gal) during 1992 (DOE 1994n).

The West End Treatment Facility/West Tank Farm treats the following nitrate-bearing wastes generated by Y-12 production operations: nitric acid wastes, nitrate-bearing rinsewaters, mixed acid

wastes, waste coolants, mop water, caustic wastes, and biodenitrification sludges. Treatment operations consist of biological denitrification, biological oxidation, metals precipitation, coagulation, flocculation, clarification, filtration, hydrogen-ion concentration adjustment, degassification, and carbon adsorption. Wastes are received at the West End Treatment Facility/West Tank Farm in 18,900-L (5,000-gal) tankers, 2,270-L (600-gal) polytanks, and in smaller, approved waste transportation containers such as drums, bottles, and carboys. Detailed waste analysis documentation is used to determine the treatment scheme and temporary storage location of each shipment. The West End Treatment Facility effluent polishing system facilitates the removal of uranium, trace metals, and suspended solids. The treated wastewater is then discharged to East Fork Poplar Creek through an NPDES monitoring station. Sludges, spent carbon, and spent filter material generated during the treatment processes are currently stored in 1,890,000-L (500,000-gal) tanks. A major modification to the West End Treatment Facility/West Tank Farm is currently in the design phase. This modification will remove all heavy metals up front, thus separating the hazardous sludge from the nonhazardous sludge. Approximately two-thirds of the current sludge volume generated can then be disposed of as nonhazardous wastes.

The Y-12 Cyanide Treatment Unit provides storage and treatment of waste solutions containing metallic cyanide compounds from spent plating baths and precious metal recovery operations or other areas. The cyanide reduction process performed within the unit is currently performed in 208-L (55-gal) containers. After waste is treated at the Cyanide Treatment Unit, it is transferred to the West End Treatment Facility for further treatment then discharged to the East Fork Poplar Creek.

As of June 1994, approximately 16,600 m3 (21,700 yd^3) of mixed LLW were stored at Y-12 (OR MMES 1995c7-32). Table H.2.1-2 summarizes the mixed LLW storage facilities at Y-12 that are described below.

The Containerized Waste Storage Area consists of three concrete pads covering apporoximately 2,320 square meters (m) (24,800 square feet [ft]). These pads provide storage for LLW, RCRA hazardous, and mixed LLW. An impermeable dike surrounds each pad to porovide spill containment. Fire protection at this facility will be upgraded, contingent on funds.

The Building 9811-1 RCRA Storage Facility (OD7 and OD8) contains a diked storage area for tanks (OD7) and an enclosed storage area for containers (OD8) with a capacity of 1,000drums. The OD7 contains four 114,000-L (30,000-gal) tanks, two 37,9000-L (10,000-gal) tanks, and associated piping and pumps. RCRA waste oil/solvent mixtures containing various concentrations of chlorinated and nonchlorinated hydrocarbon solvents, uranium, trace PCBs, and water for specific chemical constituents are stored at OD8 in 208-L(55-gal) drums and 1,140-L (300-gal) Tuff-tanks to await sampling and analytical results. Wastes deemed compatible with OD7 materials are pumped into those tanks. Noncompatible wastes are transported to different facilities.

The Waste Oil/Solvent Storage Facility (OD9) is a permitted RCRA TSCA hazardous waste storage facility. It consists of a diked area supporting five 151,000-L (40,000 Gal) tanks, a tanker transfer station with five centrifugal transfer pumps, and a drum storage area. Three tanks hous PCB wastes contaminated with uranium, one tank contains nonradioactive PCB wastes, and one tank holds RCRA hazardous wastes. Likewise, a diked and covered pad furnishes space for $33m^3$ (43 yd^3 of containerized waste. Wastes assigned to this facility are first stored at OD8 (Building 9811-1 RCRA storage facility) to await laboratory results. The diked area contains additional space for a sixth 151,000-L (40,000-gal) tank. This facility is projected to be used until 2010, due to the anticipated lack of disposal outlets for uranium-contaminated organic liquids.

The Liquid Organic Waste Solvent Storage Facility (OD10) contains four 24,600-L (6,500-gal) and two 11,400-L (3,000-gal) stainless steel tanks for storage of ignitable nonreactive liquids, including those contaminated with PCBs and uranium. In addition, a diked and covered storage area provides space for 40,000-L (10,600 gal) of containerized waste. The facility is capable of segregating various spent solvents for collection and storage. Major solvent waste streams are transferred to tanks until final disposition.

Building 9720-9 storage area supplies a drum storage area for mixed and PCB wastes, including an area designed to contain flammable wastes. The western half, which contains space for approximately 1,500 drums, stores both PCB and RCRA hazardous waste. The facility's eastern half is not currently in use. Upgrades are underway to the ventilation, diking, and fire-suppression systems to comply with RCRA, TSCA, and DOE standards and to allow for mixed and PCB waste storage.

The RCRA Staging and Storage Facility (Building 9720-31) prepares solid, liquid, and sludge wastes for offsite shipment. The facility consists of seven storage rooms and seven staging rooms, each with a separate ventilation system. The staging rooms house small containers that are packed with compatible materials and shipped. The storage rooms hold larger containers, such as 208-L (55-gal) drums. Each room, which can hold up to 90 drums, accommodates a different class of hazardous waste.

The RCRA and PCB Container Storage Area (Building 9720-58) is a warehouse facility utilized for staging prior to treatment or disposal of PCB-contaminated equipment (transformers, capacitors, and electrical switchgear) and nonreactive, nonignitable RCRA waste contaminated with uranium. Waste containers received at Building 9720-58 include 114- and 208-L (30- and 55-gal) drums, 1,250- and 2,500-L (330- and 660-gal) portable tanks, B-25 boxes, and self-contained PCB equipment.

The Solid Storage Facility provides 1,630 m2 (17,500 ft^2) of storage space for PCB- and uranium-contaminated soil. The facility also contains a synthetic liner for leachate collection and a leak detection system. Collected leachate is transferred to the Liquid Storage Facility for pretreatment. The Solid Storage Facility is currently undergoing the RCRA Part B permitting process. No additional wastes are being added to the facility.

Hazardous Waste. Plating rinsewaters, waste oil, and solvents from machining and cleaning operations; contaminated soil, soil solutions, and soil materials from RCRA closure activities; and waste contaminated with hazardous constituents from construction/demolition activities are the major sources of hazardous waste. In 1993, approximately 8,840,000 L (2,340,000 gal) of hazardous liquid were treated (OR MMES 1995c:6-6). The remaining hazardous waste consists of 1,080 m^3 (1,420 yd^3) of solid waste which is stored at the RCRA Storage and Staging Facility. In 1994, approximately 190 m3 (250 yd^3) of PCB hazardous material was shipped offsite for treatment (DOE 1995h). The Y-12 Waste Management Division operates several hazardous treatment facilities that are described below and are summarized in table H.2.1-4.

The Plating Rinsewater Treatment Facility treats dilute plating rinsewaters contaminated primarily with chromium, copper, nickel, and zinc. In addition, the facility can treat cyanide-bearing wastes and remove chlorinated hydrocarbons. The design capacity for this facility is 30.3 million l/yr (MLY) (8 million gal/yr [MGY]). Under normal conditions, the Plating Rinsewater Treatment Facility treats 852,000 L (225,000 million gal) of plating rinsewater per year (DOE 1995gg). The facility is located

across the street from the Building 9401-2 plating shop, which produces most of Y-12's rinsewaters. The facility neutralization, equalization, and cyanide destruction equipment is located outdoors in a diked basin. The remainder of the facility process is located in Building 9623. Rinsewaters are received via a direct pipeline from the plating shop. In addition, rinsewaters may be received in tankers, polytanks, or in any acceptable waste shipping container. The Plating Rinsewater Treatment Facility performs the following treatment operations: pH adjustment, flow equalization, heavy metal removal by electrochemical precipitation, flocculation, clarification, carbon adsorption, and filtration. After the clarification operation, the rinsewater is transferred to the Central Pollution Control Facility. The Central Pollution Control Facility provides the carbon adsorption operation, final filtration, and discharge to East Fork Poplar Creek through an NPDES monitoring station. Treated rinsewater is sometimes recycled for use as make-up water for Central Pollution Control Facility processes. Sludge from the clarification process is transferred to the Central Pollution Control Facility and then taken to the West Tank Farm for interim storage.

The Steam Plant Wastewater Treatment Facility treats approximately 144 MLY (38 MGY) of wastewater from steam plant operations, demineralizers, and coal pile runoff (OR MMES 1995c:8-7). Treatment processes include wastewater collection/sedimentation, neutralization, clarification, pH adjustment, and dewatering. The treatment facility utilizes automated processes for continuous operation. All solids generated during treatment are nonhazardous and are disposed of in the sanitary landfill. The treated effluent is monitored prior to NPDES discharge to the East Fork Poplar Creek. The Y-12 utilities department manages this facility.

Hazardous waste is being stored until the management and operations contractor and DOE approve shipment for offsite disposal under the DOE "No Rad Added" performance objective. As of June 1994, approximately 60 m3 (79 yd^3) of hazardous waste and 20 m3 (26 yd^3) of PCB wastes was in storage at Y-12 (OR MMES 1995c:6-11). Table H.2.1-5 summarizes the major existing Y-12 hazardous wast storage facilities described below.

The Oil Landfarm Soil Storage Facility contains approximately 420 m^3 (550 yd^3 of soil contaminated with PCBs and volatile organics (OR DOE 1993a:9-21). The soil was excavated from the Oil Landfarm and Tributary 7 in 1989. The soil is contained in a covered, double-lined concrete dike with a leak-detection system. The leak-detection system will soon be modified to enhance detection capabilities.

The Liquid Storage Facility of the Disposal Area Remedial Actions Liquid Storage Treatment Unit is a hazardous waste storage facility built during the Bear Creek Burial Ground closure activities. It is located in Bear Creek Valley approximately 3.2 kilometers (km) (2 miles [mi]) west of Y-12. It collects and stores groundwater and otehr wastewaters received fromt he seep collection lift station, the Solid STorage Facility, tankers, polytanks, and the diked area rainfall accumulation. Feed streams may contain oil contaminated with PCB's, volatile and nonvolatile organic compounds, and heavy metals. Processing and storage equipment include:

- Two 284,000-L (75,000-gal) bulk storage tanks
- 22,700-L (6,000-gal) oil storage tank
- Gravity separator
- Filtering unit
- Composite sampling station
- Tanker transfer station

The wastewater travels through the gravity separator, cartridge filters, and composite sampling station prior to storage in the bulk tanks. A reinforced concrete dike surrounds all equipment to provide spill containment. After sufficient wastewater accumulates in the bulk storage tanks, it is processed at the Groundwater Treatment Facility. A new leachate collection system collects and pumps hazardous waste seepage from the burial ground to the Liquid Storage Facility.

The Y-12 Waste Management Division operates Industrial Landfill V, which provides for the disposal of industrial and institutional solid waste and special wastes such as asbestos materials, empty aerosol cans, materials contaminated with beryllium oxide, glass, fly ash, coal pile runoff sludge, empty pesticide containers, and Steam Plant Wastewater Treatment Facility sludge. The landfill area is located on Chestnut Ridge near the eastern end of the plant and serves Y-12, ORNL, K-25, and other DOE prime contractors at Oak Ridge. The landfill utilizes shallow land burial by the area fill method and is permitted by the State of Tennessee. Requests are filed with the state to provide disposal for additional materials as needed.

The Chestnut Ridge Borrow Area Waste Pile (Industrial Waste Landfill III) consists of mercury-contaminated soil removed from the Oak Ridge Civic Center area and deposited at Y-12 Chestnut Ridge. No further disposal at this site has been made.

Nonhazardous Waste. Major waste-generating activities include construction and demolition activities that produce large volumes of noncontaminated wastes, including lumber, concrete, metal objects, and soil and roofing materials. Industrial trash is generated by daily operations throughout the plant. These operations include janitorial services, floor sweepings in production areas, and production activities. In 1993, Y-12 generated 145 million L (38.3 million gal) of industrial and sanitary liquid waste (OR MMES 1995c:8-5) that included oils and solvents, operational wastewater, Central Pollution Control Facility/Plating Rinsewater Treatment Facility wastewater, steam plant wastewater, environmental restoration waste, and liquid waste received from ORNL and K-25. The Waste Storage Facility in Building 9720-25 has a solid waste baler with an 8:1 compaction ratio (DOE 1994n). Approximately 43,900 m3 (57,600 yd^3) of solid nonhazardous waste were compacted and/or stored during 1993 (OR MMES 1995c:8-5).

The Sludge Handling Facility (T-118) was designed and constructed to provide water filtration and sludge dewatering in support of a storm sewer cleaning and relining project. Filtered water was reused by the sewer-cleaning contractor, and the dewatered slude was stored in specially constructed containers for future disposal. The facility is currently being used to store containers of LLW.

The Steam Plant Ash Disposal Facility is used to collect, dewater, and dispose of sluiced bottom ash generated during operation of the coal-fired steam plant. An additional trench was constructed for the disposal of sanitary and industrial wastes generated by ORNL, K-25, and Y-12. In order to comply with environmental regulations for landfill operations, the Steam Plant Ash Disposal Facility includes a leachate collection system, a transfer system to discharge the collected leachate into the Oak Ridge public sewage system, groundwater monitoring wells, and a gas migration/ventilation system.

In 1992, approximately 677 m^3 (887 yd^3 of clean scrap metal was stored at Y-12 (OR DOE 1993b:9-6). The new salvage yard is used for the staging and public sale of nonradioactive, nonhazardous scrap metal. Sales have been suspended, however, until procedures to meet the DOE "No Rad Added" performance objective have been approved. The New Salvage Yard provides accumulation and sorting activities for nonradiologically contaminated scrap metal. Plans are in place to provide an

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automotive lead cell battery repository for used batteries until recycling options are initiated. This facility is located near the Bear Creek Burial Ground.

The new Industrial Landfill V and Construction Demolition Landfill VI permits disposal of approximately 93,500 m^3/yr (122,000 $yd^{3/yr}$) of industrial and sanitary waste (OR MMES 1995c:8-18). The facilities were designed and operated in accordance with Tennessee solid waste disposal regulations. A baler, located in Building 9720-25, is used for compaction of sanitary/industrial solid waste destined for the Industrial Landfill V.

Oak Ridge National Laboratory Because ORNL is a research facility, it has many diverse waste-generating activities, each of which may produce only a small quantity of waste. Isotope production, utilities, and support functions such as photography are additional sources of waste. The radioactive wastes produced by each activity at ORNL reflect the nature of its operation. A large number of radioisotopes are handled, in isotope production and packaging, in reactor and accelerator operations, in reprocessing studies on nuclear fuel, and in investigations into the interactions of radioactivity with living systems. The radioactive wastes generated by these activities can be classified as follows:

- Concentrates generated by the treatment of intermediate-level wastes, which are disposed of by hydrofracture.
- LLW contaminated with beta/gamma emitting radioactivity. These wastes, which have a low surface dose rate, are compacted, if possible, and disposed of in earthen trenches; those wastes that exhibit a high surface dose rate are disposed of in augered holes.
- Low-level alpha-emitting wastes, which are evaluated for criticality hazards before disposal in augered holes.

Pollution Prevention. Waste segregation is used to minimize the generation of solid LLW. By providing collection barrels for both radioactive and nonradioactive wastes, the volume of wastes that requires handling as radioactive waste has been reduced. Before these procedures were implemented, radioactive and nonradioactive wastes were discarded in the same barrel. This contaminated the nonradioactive portion and required special disposal of an inflated amount of waste.

Low-Level Waste. Isotope production and research activities generate a variety of low-level radioactive wastes to include low-level wastewater. Sources of solid LLW include contaminated equipment, filters, paper, rags, plastic, and glass and sludge from the Process Waste Treatment Plant. Table H.2.1-6. shows the LLW treatment facilities that are operating at ORNL. In 1993, 434 m3 (569 yd^3) of solid LLW were compacted and 180,000 L (47,700 gal) of liquid LLW were solidified at ORNL. Approximately 25 m3 (33 yd^3) were sent offsite to be compacted and/or incinerated (OR MMES 1995c:5-14, 5-15).

Solid LLW to include radioactive scrap metal is placed in storage prior to disposal. Table H.2.1-7 lists the LLW and mixed LLW storage facilities currently operating at ORNL. As of June 1994, approximately 1,050 m3 (1,370 yd^3) of solid LLW and 2,960 m3 (3,870 yd^3) of radioactive scrap metal were in storage awaiting disposal at ORNL (OR unit on ORR. It receives solid LLW, including radioactively contaminated asbestos. Table H.2.1-8 lists the LLW disposal units at SWSA-6. As of the end of 1993, approximately 606 m3 (794 yd^3) of solid LLW were buried at SWSA-6 (OR MMES 1995c:5-27).

The area designated as SWSA-6 at ORNL is the only active onsite disposal unit on ORR. It receives

solid LLW, including radioactively contaminated asbestos. Table H.2.1-8 lists the LLW disposal units at SWSA-6. As of the end of 1993, approximately 606 m^3 (794 yd^3 of solid LLW were buried at SWSA-6 (OR MMES 1995c:5-29).

Mixed Low-Level Waste. Mixed wastes are generated by research projects and some facility operations. Isotope production and research activities generate a variety of mixed low-level and mixed TRU wastes. Table H.2.1-9 presents the inventory of mixed LLW at ORNL as of December 31, 1994, along with a 5-year projection.

As shown in table H.2.1-6, three facilities are currently treating or are capable of treating mixed waste at ORNL: the Process Waste Treatment Plant, the Liquid Low-Level Waste Evaporation Facility, and the Melton Valley Low-Level Waste Immobilization Facility (DOE 1995gg). One other treatment facility at ORNL, the Nonradiological Wastewater Treatment Plant, is operating and could be used to treat mixed waste.

The Process Waste Treatment Plant is designed to treat process wastewaters, groundwater, and evaporator condensate wastewaters that contain low levels of radioactivity. Small concentrations of radioactive materials have occasionally been processed. Process wastewaters may contain small quantities of radionuclides, metals, anions, and organic chemicals. Under normal operating conditions, the Process Waste Treatment Plant can process wastewater at a rate of 492 L/minute (min) (130 gal/min). The design capacity is 757 L/min (200 gal/min) (DOE 1994n). Wastewaters can contain organic materials and low levels of radioactivity. The facility can treat waste streams with some heavy metals but not streams containing PCBs.

The Liquid Low-Level Waste Evaporation Facility treats liquid LLW using evaporation. It operates in a semicontinuous mode; waste is accumulated in collection tanks and transferred through underground piping to an evaporator system. The design capacity is 106,000 L/day (28,000 gal/day). The facility processes an average of 1,140 L (300 gal) of liquid wastes per day under normal operating conditions (OR DOE 1993a:9-22). The facility can treat waste streams containing organic contaminants.

A summary of the mixed LLW storage facilities at ORNL is shown in table H.2.1-7. An estimate of the capacity of these facilities is also given. As of June 30, 1994, approximately 3,190 m3 (4,180 yd^3) of mixed waste were in storage at ORNL (OR MMES 1995c:7-32).

The only disposal of mixed waste done at ORNL is the burial of radioactive asbestos at SWSA-6. Asbestos contaminated with low levels of radioactivity is placed in silos. In 1992, approximately 23 m3 (30 yd^3) of contaminated asbestos was buried (OR DOE 1993b:9-4). Low-level contaminated biological waste has also been buried at SWSA-6.

Hazardous Waste. Hazardous wastes are generated in laboratory research, electroplating operations, painting and maintenance operations, descaling, demineralizer regeneration, and photographic processes. Few hazardous wastes are treated in onsite facilities. Onsite treatment at ORNL includes elementary neutralization and detonation facilities. A summary of the hazardous waste treatment facilities at ORNL is shown in table H.2.1-10.

The Chemical Detonation Facility treats small amounts of wastes that would be dangerous to transport offsite. Explosives such as aged picric acid are detonated in the detonation facility. Certain

other wastes (e.g., spent photographic processing solutions) are processed onsite into a nonhazardous state. Those wastes that are safe to transport are shipped to offsite RCRA-permitted commercial treatment/disposal facilities.

The Nonradiological Wastewater Treatment Plant is designed to reduce pollutant concentrations in nonradiological wastewaters including hazardous wastes to levels acceptable for effluent discharge. The plant operates in a continuous mode and involves physical and chemical processing steps. The facility contains a heavy-metal removal system, where the pH of the wastewater is raised to 10.5 in a clarifier. Polymers are added to induce flocculation and settling of the metal precipitates. The wastewater is passed through a filtration system to remove particulates. An air stripper then removes volatile organics and activated carbon columns remove mercury. In 1993, approximately 23,800,000 L (6,300,000 gal) of liquid hazardous wastes were treated at the Nonradiological Wastewater Treatment Plant (OR MMES 1995c:6-6).

As of June 1994, approximately 60 m3 (79 yd^3) of hazardous waste and 20 m3 (26 yd^3) of PCB waste were stored at ORNL (OR MMES 1995c:6-11). PCB wastes are managed in storage facilities until they can be shipped offsite for treatment and/or disposal. PCB-contaminated and hazardous wastes are temporarily stored at Building 7507, and PCB-contaminated wastes are stored on the 7507W storage pad. Due to the "No Rad Added" policy, hazardous wastes are being stored as mixed waste. A listing of the hazardous waste storage facilities at ORNL is shown in table H.2.1-11. Approximately 10 m3 (13 yd^3) of asbestos wastes were sent offsite in 1992 to Y-12 Sanitary and Industrial Landfill II. About 12 m3 (16 yd^3) of hazardous and PCB wastes were sent to K-25 for storage and incineration in the TSCA incinerator (OR DOE 1993b:9-5).

Nonhazardous Waste. Nonhazardous wastes result from ORNL maintenance and utilities. The s team plant and the sanitary waste treatment plant produce a sludge which is sampled to demonstrate that it is nonhazardous and meets the Y-12 Industrial and Sanitary Landfill II waste acceptance criteria. The sewage treatment facility treats sanitary and laundry wastewater. It is an extended aeration-activated sludge unit followed by mixed media tertiary filtration of secondary effluent dewatering. The sludge is dried onsite in open-air drying beds. In 1993, approximately 331 million L (88 million gal) of industrial and sanitary liquid waste were treated at the sewage treatment plant (OR MMES 1995c:8-7).

The Melton Valley Low-Level Waste Immobilization Facility is currently treating nonhazardous liquid waste (OR DOE 1994a:A-20). The facility can be used to solidify liquid mixed LLW that has a pH greater than 12.5 and that contains some heavy metals. This liquid mixed LLW is transferred from tanks by interconnecting pipelines. Batches of waste are pumped from a liquid decantation system to a solidification system as required to provide adequate storage-tank capacity. The facility operates only on a campaign basis to provide adequate storage capacity. Solidification is currently performed using cementation. Design capacity is 62,500 L (16,500 gal) of liquid waste per month. Under normal operating conditions, the facility can process 7,570 L/month (mo) (2,000 gal/mo) as required to provide adequate storage-tank capacity. The facility cannot treat HLW, alpha-contaminated waste with TRU activity levels greater than 100 nanocuries per gram (nCi/g), organic wastes, or PCBs.

Scrap metals are discarded from maintenance and renovation activities and are recycled when appropriate. Construction and demolition projects also produce nonhazardous industrial wastes. All solid nonhazardous and medical wastes (after they are autoclaved to render them noninfectious) except scrap metal are sent to the Y-12 Industrial and Sanitary Landfill II. Approximately 16 m3 (21

yd ^{3}) of scrap metal were placed in storage at ORNL in 1992. This waste will remain at ORNL until it is characterized as nonradioactive per the "No Rad Added" policy (OR DOE 1993b:9-7).

Rainfall runoff from the ORNL steam plant coal yard storage area plus additional wastewater from the sulfuric acid tank diked area runoff, steam plant boiler blowdown, and water softener regenerate are collected in a basin. This waste is treated at the Coal Yard Runoff Treatment Facility.

K-25 Site. Enrichment, maintenance, decontamination, and R&D activities have generated a wide variety of waste at K-25. Because of its past uranium enrichment mission, uranium is the predominant radionuclide found in K-25 waste streams. Waste management activities are increasing. Low-level radioactive wastes from other DOE sites are placed in building vaults until a final disposition strategy is identified. Also, PCB wastes and RCRA wastes contaminated with uranium began arriving from other DOE sites in 1987 for incineration in the K-1435 TSCA incinerator. Tables H.2.1-12 and H.2.1-13 summarize the treatment and storage facilities, respectively, at K-25 that are capable of treating and storing multiple categories of waste.

Pollution Prevention. K-25 policy mandates minimization of waste generated while achieving compliance with applicable environmental regulations. Five waste reduction options are used at K-25: segregation, material substitution, process innovation, mechanical volume reduction, and recycling/reuse. In recent years, some aluminum cans, worker clothing, and office furniture have been recycled for use at K-25. Such recycling has saved approximately 1,150,000 kg (2,520,00 lb) of materials as of 1991. K-25 management supports the waste reduction program. An example of this program is the conversion to gas-fired boilers to reduce capacity excursions and, in effect, reduce or eliminate fly ash production.

Low-Level Waste. Solid LLW is generated by discarding radioactively contaminated construction debris, wood, paper, asbestos and trapping media. Solid LLW is also generated by process equipment and by removing radionuclides from liquid and airborne discharges. Currently, solid LLW is being stored for future disposal. Table H.2.1-14 shows the storage facilities that deal only with LLW. Specifics on some of the storage facilities are described below. Treatment of the current inventory of contaminated scrap metal at K-25 (as well as at Portsmouth, Paducah, and Fernald facilities) is expected to occur over the next 3 to 5 years as part of a comprehensive DOE Scrap Metal Program to be managed through K-25. All contaminated scrap metal is stored aboveground at the K-770 scrap metal facility until further disposal methods are evaluated.

The Uranium Hexafluoride Cylinder Program is directed toward improving the safety and reliability of long-term storage for 7,000 cylinders currently at K-25. These cylinders remain from the now-terminated gaseous diffusion mission. In storage at the site are approximately 5,000 9-metric tons (t) (10-tons) and 13-t (14 tons) cylinders of depleted uranium hexafluoride; 1,000 cylinders of normal-assay feed uranium hexafluoride; 400 cylinders containing more than 23 kg (50 lbs) of "enriched" material; and 600 miscellaneous empty cylinders. The Uranium Hexafluoride Cylinder Program is being designed to develop a clear understanding of the current conditions of the cylinders and define any near-term and long-term actions for safe storage of the cylinders, pending decisions on ultimate disposition of the uranium hexafluoride material. Some of the initial actions in the program are a baseline inspection, a corrosion coupon program, and an ultrasonic thickness measurement program. The baseline inspection identified a variety of cylinder defects that will require special attention and also identified four breached cylinders. Immediate corrective actions have been taken to handle the breached cylinders and a schedule of activities has been developed for moving and repairing the cylinders.

The cylinders containing normal-assay feed uranium hexafluoride are currently being shipped to the Paducah Gaseous Diffusion Plant. The current DOE direction for the 5,000 cylinders with depleted uranium hexafluoride is to store them until at least 2020, at which time conversion to oxide will be performed if no other uses have been determined. A plan for cleaning the cylinders containing more than 110 kg (50 lb) of enriched material and empties has not yet been approved (this may be performed at K-25 or at one of the operating gaseous diffusion plants).

Currently, there are no onsite disposal facilities being operated at K-25. An ORR Centralized Waste Management Organization has been established and assigned the responsibility to design, construct, and operate all new LLW disposal facilities for ORR. This organization is physically located at K-25.

Mixed Low-Level Waste . Mixed LLW primarily consists of contaminated waste oils, solvents, sludges, soils, and acid wastes. Table H.2.1-15 presents the inventory of mixed LLW as of December 31, 1992, along with a 5-year projection. Sludges contaminated with low-level radioactivity were generated by settling and scrubbing operations and were stored in K-1407B and K-1407C ponds. Sludges have been removed from these ponds, and a portion have been fixed in concrete at the K-1419 Sludge Treatment Facility and stored at Building K-33. These materials are considered mixed LLW and will be shipped offsite for disposal at a permitted commercial facility.

Most of the treatment of mixed waste is at the TSCA Incinerator and the Central Neutralization Facility. The majority of waste treated at the TSCA Incinerator cannot be treated by commercial incinerators because of radioactive contamination. All waste sent to this facility must be fully characterized and identified. DOE has an approved chain-of-custody system for all waste received from offsite. The K-1435 TSCA Incinerator is capable of incinerating waste that is mixed or contains PCBs. In 1990, a limited amount of waste was incinerated as a part of the startup testing. The incinerator began full operations in early 1991 and met all regulatory requirements in processing 1,000 m3 (1,310 yd^3) of mixed waste. Mixed TSCA waste is being generated in the ash residue at the TSCA Incinerator. Compliance issues regarding the management of the mixed PCB and radioactive waste generated in the ash are being pursued with EPA by DOE.

Most of the radioactively contaminated wastewater treated at the Central Neutralization Facility is generated at the TSCA Incinerator from the wet scrubber blowdown. Treated effluents are discharged through a designated release point. The contaminated sludges that precipitate in the sludge-thickener tank are stored in an approved aboveground storage area at K-25.

RCRA-mixed, radioactive land-disposal-restricted waste (including some nonradiological classified land-disposal-restricted waste) has been stored in some areas for longer than 1 year. These wastes are currently subject to the land disposal restriction that permits storage only for accumulation of sufficient quantities to facilitate proper treatment, recycling, or disposal. This waste is being stored because of the nationwide shortage of treatment and disposal facilities for this type of waste. Private-sector technology demonstrations are being conducted that involve uranium extractions from sludge.

Uranium-contaminated PCB wastes (i.e., mixed wastes) are being stored in excess of the 1-year limit imposed by TSCA because of the lack of treatment and disposal capacities. DOE and EPA have signed a Federal Facility Compliance Agreement, effective February 20, 1992, to bring the facility into compliance with TSCA regulations for use, storage, and disposal of PCBs. It also addresses the approximately 10,000 pieces of nonradioactive PCB-containing dielectric equipment associated with the shutdown of diffusion plant operations.

In 1989, during routine inspections of the drums of stabilized K-1407 pond sludge at the K-1417 storage facility, it was discovered that many of the drums had begun to corrode. Free liquid (waste with a pH of 12) on top of the concrete in the drums was found to be causing the corrosion (OR DOE 1993a:9-16). An action plan has been implemented to decant and/or dewater the mixed waste contained in the drums. A total of 45,000 drums of stabilized material and 32,000 drums of raw sludge must be processed and moved to storage facilities that meet regulations governing mixed wastes. All containers will be transferred to and stored in new and existing facilities at the K-1065 site, and the K-31 and K-33 buildings.

Hazardous Waste. Hazardous wastes generated at K-25 include PCB articles and items, waste oils and items, and uncontaminated asbestos waste. All hazardous wastes are managed according to applicable state and Federal regulations and DOE orders. Several waste management facilities are already in place. Changing laws and regulations have made it necessary to upgrade several facilities and to design and construct new facilities that reflect the most recent environmental technology. The Central Neutralization Facility and the TSCA Incinerator are the two major facilities that treat hazardous waste.

The Central Neutralization Facility provides pH adjustment and chemical precipitation for several aqueous streams throughout K-25. The main purpose of the Central Neutralization Facility is to treat wastewater to ensure compliance with the requirements of NPDES discharge limits on pH, heavy metal concentrations, and suspended solids. The treatment system consists of two 94,600-L (25,000-gal) reaction tanks and a 227,000-L (60,000-gal) sludge-thickener tank. Acidic wastes are neutralized with a hydrated-lime slurry, and basic wastes are neutralized with sulfuric or hydrochloric acid. The hydrated lime bin and acid tanks are located at the facility. The treatment facility is physically divided into two distinct sections for treating both hazardous and nonhazardous waste streams.

The TSCA Incinerator consists of storage tanks, dikes, and the incinerator. The incinerator system consists of a liquid, solid, and sludge feed system; a rotary kiln incinerator; and a secondary combustion chamber. The wastes treated at this facility include oils, solvents, chemicals, sludges, and aqueous waste.

In general, most of the waste stored at K-25 is designated as hazardous waste that has been contaminated with PCBs. Recyclable materials such as mercury and silver-bearing photographic wastes are stored before recycling, while other hazardous wastes are stored until sufficient quantity is accumulated for an offsite shipment. All offsite disposals of hazardous wastes were halted in 1991 until procedures addressing a DOE performance objective of "No Rad Added" were developed by the sites and approved by DOE Headquarters. Incineration is the preferred method for offsite treatment or disposal of wastes, particularly PCB wastes; however, landfills and other types of disposal are used as needed. On the K-25 Site all hazardous waste is treated as mixed LLW.

Nonhazardous Waste. Computer paper is being recycled from the K-25 Computer Technology Center. The program for recycling paper is being reviewed for expansion into nonradiological areas. Product substitutions at the paint shop and photography lab have resulted in a decrease of waste generation. No percentage of reduction has been calculated due to the lack of baseline data.

Waste assay monitors have been purchased and are being used to screen solid, potentially radioactive waste to determine the potential to manage it as a nonhazardous waste. The K-770 clean scrap yard provides storage for nonradioactive scrap metal. The scrap metal is stockpiled before being sold to

the public. The solid nonhazardous waste from K-25 is sent to Y-12 Industrial Landfill V. Some materials such as furniture, file cabinets, and paper are sold through property sales. The only nonhazardous treatment facility at K-25 is the Sanitary Waste Treatment Plant (Building K-1203). The system consists of an extended aeration treatment plant with a rate capacity of approximately 2,270,000 L/day (600,000 gal/day). The current demand is about 1,140,000 L/day (301,000 gal/day) (OR MMES 1995c:8-9). The sanitary sludge is disposed of in the Y-12 landfill. The Central Neutralization Facility does treat some nonhazardous liquid waste streams along with hazardous and/or mixed waste streams.

H.2.2 Savannah River Site

The process of manufacturing useful nuclear materials has produced radioactive, mixed, and hazardous wastes that are treated, stored, or disposed of at SRS. The *Savannah River Site Waste Management Final Environmental Impact Statement* (DOE/EIS-0217, July 1995) addressed the tasks to be completed in the next 10 years to clean up existing waste units and bring current operations into compliance with applicable regulations. The EIS discusses the current conditions and provides DOE's preferred alternatives for processing current and future waste streams. It also addresses the development and funding of processes to minimize waste generation and to safely process and dispose of future waste generation. Because there is no spent nuclear fuel associated with the fabrication of primaries, there will be no further discussion of spent nuclear fuel at SRS.

Pollution Prevention. Pollution prevention, previously driven by best management practices and economics, is now mandated by statutes, regulations, and agency directives. The SRS Waste Minimization and Pollution Prevention Program is designed to achieve a continuous reduction of wastes and pollutant releases to the maximum extent feasible in accordance with regulatory requirements while fulfilling national security missions. The SRS Waste Minimization and Pollution Prevention Awareness Plan addresses wastes and potential pollutants of all types and establishes priorities for accomplishing waste minimization and pollution prevention through source reduction, recycling, treatment, and environmentally safe disposal.

High-Level Waste. Liquid HLW containing actinides and hazardous chemicals was generated from recovery and purification of TRU products and from spent fuel processing, and is retrievably stored in 51 underground tanks. One of these tanks is out of service. The tanks are managed in compliance with Federal laws, State of South Carolina regulations, and DOE orders. The waste is segregated by heat generation rate, neutralized to excess alkalinity, and stored to permit the decay of short-lived radionuclides before its volume is reduced by evaporation. Of the 51 tanks, 29 are located in the H-Area Tank Farm, and 22 are located in the F-Area Tank Farm. The tanks are of four different designs, but all are of carbon steel. Newer tanks which have full height secondary containment and forced water cooling are used for waste processing. Some older tanks contain salt and sludge awaiting waste removal. Old tanks that have had waste removed except for residue are used to store low-activity waste. The older tanks will be taken out of service when space in other tanks becomes available due to transfer to the Defense Waste Processing Facility.

High-heat liquid waste is stored for 1 to 2 years to allow decay of radionuclides before being processed through evaporators. Low-heat waste is sent directly to the evaporator feed tanks. Each tank farm has one evaporator that is used to reduce the volume of the water and concentrate the solids. A replacement higher capacity evaporator is planned that may be used in conjunction with the current evaporators. Liquids can be reduced to 25 to 33 percent of their original volume and stored as salts or sludges. Cesium removal columns can operate in conjunction with the evaporators. The evaporators obtain decontamination factors of 10,000 to 100,000 and the cesium removal columns can obtain another 10 to 200 decontamination factors. Decontaminated liquids (overheads) are sent to the Effluent Treatment Facility for processing before being released to Upper Three Runs Creek. The concentrated salt solution is processed to remove radionuclides, and the decontaminated solution is sent to the Defense Waste Processing Facility Saltstone Facility for solidification and onsite storage in the Saltstone Vaults.

The remaining sludges and salts contain the majority of the radionuclides and are stored separately

awaiting vitrification. Prior to vitrification, salt would be precipitated in the in-tank precipitation process. The precipitate and sludge would be fed into the vitrification process in the Defense Waste Processing Facility. The waste would be mixed with borosilicate glass and immobilized by melting and then pouring the mixture into stainless steel cylinders. These cylinders would be stored in a shielded facility at the Defense Waste Processing Facility until a repository is available. Figure H.2.2-1 illustrates HLW management at SRS. Tables H.2.2-1, H.2.2-2, and H.2.2-3 list HLW inventories and treatment and storage facilities at SRS.

Table H.2.2-1.-- High-Level Wastes at Savannah River Site

Waste Matrix	Number of Waste Streams	Inventory as of September 30, 1994 (m^3)	Number ofWaste Streams Five-Year Projection	Total Generation Five-Year Projection (m^3)
Remote-Handled				
Aqueous liquids, slurries	2	127,040	2	15,430
SR DOE 1995c; WSRC 1995a.				

Table H.2.2-2.-- High-Level Waste Treatment Capability at Savannah River Site

Treatment Unit	Treatment Method	Input Capability	Output Capability	Total Capacity 1 (m^3 per year)	Comment
F- and H-Tank Farms	Neutralization dissolution and chemical reaction	HLW aqueous liquid solutions and slurries	HLW aqueous liquid, sludge, and solutions	2	Operational
Savannah River Technology Center high activity treatment probe	Ion exchange	HLW aqueous liquid	Mixed LLW liquid and HLW sludge	1,725	Operational
F- and H-evaporators	Evaporation and ion exchange (cesium removal)	HLW aqueous liquid	HLW sludge, salt, slurry, and organic solid	26,900 3	Operational
Replacement evaporator	Evaporation and ion exchange (cesium removal)	HLW aqueous liquid	HLW sludge, salt, slurry, and organic solid	13,800	Design and construction phase planned for 1999

Defense Waste Processing Facility	Vitrification	HLW and precipitate slurry	HLW borosilicate	18,800	Operational
Extended sludge processing	Soil washing to remove soluble salts, precipitation	HLW sludge	HLW sludge	834	Operational
In-tank precipitation	Soil washing to remove soluble salts, precipitation	HLW salt solution	LLW salt solution and HLW precipitate slurry	Would produce 22,700 m^3 salt solution and 1,900 m^3 precipitate	Operational
Late wash	Washing to remove sodium nitrate	HLW precipitate slurry	HLW precipitate	24,600	Undergoing design and construction

Table H.2.2-3.-- High-Level Waste Storage at Savannah River Site

Storage Unit	Input Capability	Total Capacity[4]	Comment
F- and H-Area Tank Farms[5]	HLW, corrosive, toxic aqueous liquids, salt, and sludge	145,000 m^3	Operational
Defense Waste Processing Facility vitrification plant, glass waste storage buildings	HLW solid borosilicate glass in stainless steel cylinders	2,286 canisters (3.8 t glass)	First unit available December 31, 1995, one building constructed, one more planned
Defense Waste Processing Facility vitrification plant, failed equipment storage	Failed melters	3,720 m^3	

Transuranic Waste. All TRU waste currently being generated is stored in containers on aboveground storage pads in compliance with state regulations and DOE orders. Older TRU wastes (prior to 1965) were buried in plastic bags and cardboard boxes in earthen trenches. Wastes containing more than 0.1 curies (Ci) per package were placed in concrete containers and buried. Wastes containing less than 0.1 Ci per package were buried unencapsulated in earthen trenches. Since 1974, TRU wastes containing more than 10 nCi/g have been stored in retrievable containers free of external contamination. Polyethylene- lined galvanized drums containing more than 0.5 Ci are additionally protected by closure in concrete culverts.

Currently, approximately 85 percent of the TRU waste in storage is suspected of being contaminated with hazardous constituents. Presently, waste is characterized by onsite generators and is being stored prior to final disposal. TRU waste containing less than 100 nCi/g may be disposed of as LLW at SRS. Waste containing greater than 100 nCi/g and meeting the final WIPP Waste Acceptance Criteria will be sent to WIPP, if it is determined to be a suitable repository pursuant to the requirements of 40 CFR 191 and 40 CFR 268. Waste not meeting the acceptance criteria as currently packaged will be

repackaged as necessary to meet the WIPP Waste Acceptance Criteria. If additional treatment is necessary for disposal at WIPP, SRS would develop the appropriate treatment technology, or ship this waste to another facility for treatment. Studies are underway to solve the problem of high-heat TRU waste, which is unique to SRS. Wastes with high plutonium-238 fractions generate too much heat to be shipped in the Transuranic Package Transporter (TRUPACT)-II container. TRU waste is currently stored on 17 pads at the Solid Waste Disposal Facility in E-Area. The TRU waste management plan is illustrated in figure H.2.2-2. Table H.2.2-4 lists the mixed TRU waste inventories. Tables H.2.2-5 and H.2.2-6 present the TRU and mixed TRU waste treatment and storage facilities.

Table H.2.2-4.-- Transuranic and Mixed Transuranic Waste at Savannah River Site

Waste Matrix	Number of Waste Streams	Inventory as ofSeptember 30, 1994 (m^3)	Number of Waste StreamsFive-Year Projection	Total GenerationFive-Year Projection(m^3)
Contact-Handled				
Organic liquids	1	<1	0	0
Combustible debris	3	7,693	1	240
Debris	2	199	2	2,613
Ash	1	<1	0	0
Total	**5**	8,162	1	2,853
DOE 1995gg; WSRC 1995a.				

Table H.2.2-5.-- Transuranic and Mixed Transuranic Waste Treatment Capability at Savannah River Site

Treatment Unit	Treatment Method	Input Capability	Output Capability	Total Capacity[6]	Comment
TRU Waste Characterization/ Certification Facility	Assaying, sorting, decontamination, size reduction, welding, venting, and encapsulation	Mixed and nonmixed TRU wastes	Certified forms for disposal	1,720 m3/yr	Begin operations in 2007
Alpha vitrification	Vitrification	TRU and mixed TRU waste	Certified and stabilized forms for disposal	559 m^3/yr liquid or 2,280 m^3/yr solid	Planned

Table H.2.2-6.-- Transuranic and Mixed Transuranic Waste Storage at Savannah River Site

Storage Unit	Input Capability	Total Capacity (m^3)	Comment
TRU storage pads	Miscellaneous solid TRU waste, extraction procedure toxic, listed	34,400	Operational RCRA Part A. No offsite waste planned. Buried waste to be exhumed, processed at TRU Waste Facility, and shipped to WIPP. Nineteen pads in use, 10 additional pads planned.
SR DOE 1995c; WSRC 1995a; WSRC 1995b.			

Low-Level Waste. Both liquid and solid LLW are treated at SRS. Liquids are managed and processed to remove and solidify the radioactive constituents and to release the balance of the liquids to permitted discharge points in compliance with state regulations. The bulk of liquid waste is aqueous process waste including effluent cooling water, purge water from storage basins for irradiated reactor fuel or target elements, distillate from the evaporation of process waste streams, and surface water runoff from areas where there is a potential for radioactive contamination. Aqueous LLW streams are sent to the Effluent Treatment Facility where they are treated by filtration, reverse osmosis, and ion exchange to remove the radionuclide contaminants. After treatment, the effluent is discharged to Upper Three Runs Creek. The resultant wastes are concentrated by evaporation and stored in the H-Area Tank Farm prior to treatment in the Defense Waste Processing Facility Saltstone Facility. In that facility, they are processed with grout for onsite disposal. Figure H.2.2-3 illustrates the LLW processing at SRS. Treatment and storage facilities for LLW are listed in tables H.2.2-7 and H.2.2-8.

Disposal of solid LLW at SRS traditionally has been accomplished using engineered trenches in accordance with the guidelines and technology existing at the time of disposal. Currently, packaged LLW is deposited in the E-Area vaults, which are concrete structures that meet the requirements of DOE orders, incorporate technological advances, and address more stringent Federal regulations and heightened environmental awareness. Four basic types of vaults/buildings are utilized for the different waste categories: low-activity waste vault, intermediate-level nontritium vault, intermediate-level tritium vault, and long-lived waste storage building. The vaults are below-grade concrete structures, and the storage building is a metal building on a concrete pad. Long-lived waste is being stored until a final disposition can be determined. Additional information on these facilities is given in table H.2.2-9.

Table H.2.2-7.-- Low-Level and Mixed Low-Level Waste Treatment Capability at Savannah River Site

Treatment Unit	Treatment Method	Input Capability	Output Capability	Total Capacity[7] (m^3 per year)	Comment

Consolidated Incineration Facility and Ashcrete Stabilization Facility	Incineration/stabilization	LLW, mixed LLW, liquid, solid, ash, and slurry	Stabilized LLW, mixed LLW, and solid waste	4,630 (liquid) 17,830 (solid)	Planned, approved, RCRA final, available 1996
F- and H-Areas Effluent Treatment Facility	Neutralization, chemical precipitation, filtration, carbon adsorption, reverse osmosis, ion exchange, evaporation, and mercury adsorption	Mixed LLW, aqueous liquids (F- and H- area wastewater, evaporator overheads and condensate, and cesium removal column effluent)	Corrosive LLW liquid concentrate, treated water effluent used activated carbon, and used ion exchange resins (solid LLW)	1,930,000	Operational, NPDES operating
M-, L-, and H-Area compactors	Compaction	Solid LLW job waste	Compacted LLW	3,983	Operational
Hazardous/Mixed Waste Containment Building	Physical and chemical decontamination, wet chemical oxidation, encapsulation, and amalgamation	Liquids and solids, mixed LLW, toxic, corrosive, reactive, metal, sludge, and debris	Containment facility	703	Planned, approved, begin operation in 2006
Low-level waste smelter	Offsite decontamination	LLW and equipment	Recovered metal	600	Offsite facility
Non-alpha vitrificationfacility	Sorting and vitrification	LLW, mixed LLW, and hazardous wastes	Mixed LLW	3,090	Proposed facility
Offsite mixed wastetreatments	Amalgamation, PCB destruction, acid bath, and smelting	Mixed LLW	Solid LLW	124	Offsite facilities
M-area Liquid Effluent Treatment Facility	Filtration, flocculation neutralization, and precipitation	Liquid mixed LLW	Wastewater, solid mixed LLW, and sludge	999,000	Operational, NPDES: operating

M-Area Vendor Treatment Facility	Vitrification	Aqueous liquids and slurries, mixed LLW, and sludges	Wastewater, solid mixed LLW, and borosilicate glass	2,470	Planned, approved, contract awarded for construction NPDES
Savannah River Technology Center ion exchange treatment probe low activity	Ion exchange	Mixed LLW and aqueous liquids	Aqueous liquid, solid, and mixed LLW	11,200	Operational, RCRA: interim
Soil Sort Facility	Sorting and separating contaminated soils	LLW soil	Low-level contaminated and uncontaminated soil	2,540	Proposed facility
Offsite supercompactor	Compaction	Solid LLW	Compacted solid LLW	42,400	Commercial facilities
Onsite supercompactor	Compaction	Solid LLW	Compacted solid LLW	5,700	Proposed facility
Z-Area Saltstone Facility	Stabilization (solidification with radionuclide binders)	Liquids, mixed LLW, sludges, toxic, corrosive	Solid LLW, nonhazardous	28,400	Operational, permitted disposal, CWA, RCRA: final

Table H.2.2-8.-- Low-Level and Mixed Low-Level Waste Storage at Savannah River Site

Storage Unit	Input Capability	Total Capacity[8] (m^3)	Comment
Burial ground solvent tanks (S23-30)	Liquid mixed LLW	727	To be closed, RCRA Part A
Defense Waste Processing Facility organic waste storage tank (430-S)	Liquid mixed LLW, ignitable, toxic	568	Operational, RCRA Part A
Liquid waste solvent tanks (S33-36)	Liquid mixed LLW	454	Planned facility
M-Area Process Waste Interim Treatment/Storage Facility	Liquid mixed LLW, listed, (electroplate sludge)	8,300	Operational, RCRA Part A
Mixed waste storage buildings (643-29E and 643-43E)	Liquid mixed LLW solid, toxic, listed, ignitable, metal, sludge, soil	1,300	Operational, RCRA Part A

Mixed waste storage shed (316-M)	Liquid and solid mixed LLW	120	Operational, RCRA Part A
Savannah River Laboratory high activity storage tanks (772-2A)	Liquid mixed LLW, toxic, toxicity characteristic teaching procedure	198	Operational, RCRA Part A
Hazardous Waste Storage Facility (645-2N)	Mixed LLW	580	Operational, RCRA Part B
Process waste interim treatment	Liquid mixed LLW	8,300	Operational, RCRA Part A
Long-lived waste storage buildings	Process water deionizers containing carbon 14	3,330	Planned facility

Table H.2.2-9.-- Waste Disposal at Savannah River Site

Disposal Unit	Input Capability	Capacity [9,10] (m^3)	Comment
Hazardous/mixed waste disposal vaults	Solid mixed LLW and listed (CIF, Ashcrete, blowdown, and vitrified)	45,600	10 vaults are planned and funded, RCRA submitted 1990, available 2002.
Intermediate-level waste vaults	Solid LLW	27,000	2 vaults operational, additional 5 planned
Low activity waste vaults	Solid LLW, compacted waste, contaminated equipment, filters, sediment, job control waste, process beds, soils, resins, and lithium-aluminum melted forms	61,500	1 vault constructed additional 12 planned.
LLW disposal facility, slit trenches	Solid LLW	407,000	58 trenches planned
Z-area saltstone vaults	Solid LLW	1,110,000	2 vaults operational, additional 12 vaults planned

Solid LLW is segregated into several categories to facilitate proper treatment, storage, and disposal. Solid LLW that radiates less than 200 mrem per hour at 5 centimeters (cm) (1.97 inch [in]) from the unshielded container is considered low-activity waste. If it radiates greater than 200 mrem per hour at 5 cm (1.97 in), it is considered intermediate-activity waste. This waste is typically contaminated equipment from separations, reactors, or waste management facilities. Intermediate-activity tritium waste is intermediate-activity waste with greater than 10 Ci of tritium per container. Spent lithium-aluminum targets from tritium operations equipment is included in this waste. Long-lived waste is contaminated with long-lived isotopes that exceed the waste acceptance criteria for disposal. Resin contaminated with carbon 14 from reactor operations is an example. Excavated soil from radiological materials areas that is potentially contaminated and cannot be economically demonstrated to be uncontaminated is managed as suspect soil. Solid LLW typically consists of protective clothing, contaminated equipment, irradiated hardware, spent lithium-aluminum targets (from tritium

extraction), and spent deionizer resins. All LLW is disposed of in the Solid Waste Disposal Facility in E-Area between F- and H-Areas. Wastes are compacted and packaged for burial. Monitoring wells are located near each disposed waste area to verify performance and to monitor groundwater in the vicinity of the vaults. As of December 1994, the total inventory of LLW disposed of at SRS was 676,400 m3(884,700 yd ^{3}) (DOE 1995gg).

Mixed Low-Level Waste . *Management of mixed wastes includes safe storage until treatment is available.* Mixed LLW is stored in A-, E-, M-, N-, and S-Areas in various tanks and buildings. These facilities include burial ground solvent tanks, the M-Area process waste interim treatment/storage facility, Savannah River Technology Center mixed waste storage tanks, and the organic waste storage tanks. These South Carolina Department of Health and Environmental Control-permitted facilities will remain in use until appropriate treatment and disposal is performed on the waste.

The Hazardous/Mixed Waste Treatment and Disposal Facility and the Consolidated Incineration Facility will process both mixed and hazardous wastes. The mixed waste management plan for SRS, illustrated in figure H.2.2-4, has been reevaluated through the development of a Site Treatment Plan in accordance with the *Federal Facility Compliance Act* of 1992. Mixed waste inventories are listed in table H.2.2-10. Treatment facilities and processes are listed in table H.2.2-7. The capacities and status of the different storage facilities are listed in table H.2.2-8.

Table H.2.2-10.-- Mixed Low-Level Waste at Savannah River Site

Waste Matrix	Number of Waste Streams	Inventory as of September 30, 1994 (m^3)	Number of Waste Streams Five-Year Projection	Total Generation Five-Year Projection (m^3)
Aqueous liquids/slurries	6	158	8	4,692
Debris	12	4,069	13	3,840
Special waste	4	83	4	32
Homogeneous solids	12	2,726	5	155
Lab packs	1	8	1	5
Organic liquids	3	139	4	587
Soil/gravel	2	17	0	0
Total	40	7,200	35	9,311
DOE 1995gg; WSRC 1995a; WSRC 1995b.				

Hazardous Waste. Typical hazardous wastes at SRS include lead, mercury, cadmium, 1,1,1-trichloro-ethane, leaded oil, trichlorotrifluoroethane, benzene, and paint solvents. Figure H.2.2-5 illustrates the processing of hazardous wastes at SRS. Table H.2.2-11 lists hazardous waste storage facilities at SRS. This waste is stored in RCRA-permitted buildings in B-, M-, and N-Areas, and open storage areas located on the asphalt pads within the fenced area of N-Area. DOE started to send hazardous waste offsite for treatment and disposal, but in 1990 imposed a moratorium on shipments of hazardous materials from radiological areas. Waste that is not subject to the moratorium is shipped to an offsite vendor for processing and disposal. SRS annually publishes the SRS Tier Two

Emergency and Hazardous Chemical Inventory Report, which lists hazardous chemicals that are present above their minimum threshold level or that are categorized as extremely hazardous substances by the emergency planning Community *Right-to-Know Act* of 1986. The annual reports filed under the *Superfund Amendments and Reauthorization Act* for the SRS facilities include year-to-year inventories of these chemicals.

Table H.2.2-11.-- Hazardous Waste Storage at Savannah River Site

Storage Unit	Input Capability	Capacity (m^3)	Comment
Solid Waste Storage Pads	Containerized solid hazardous wastes only	1,758	
Building 316-M	Containerized hazardous wastes	117	RCRA-permitted interim status
Building 710-B	Containerized hazardous wastes	146	RCRA-permitted interim status
Building 645-N	Containerized hazardous wastes	171	RCRA-permitted interim status
Building 645-4N	Containerized hazardous wastes	426	RCRA-permitted interim status
SR DOE 1995c.			

Nonhazardous Waste. Municipal solid waste generated at SRS is currently being sent to a permitted offsite disposal facility. DOE is evaluating a proposal to participate in an interagency effort to establish a regional solid waste management center at SRS (DOE/EA-0989, DOE/EA-1079).

SRS disposes of other nonhazardous wastes in addition to the nonhazardous wastes disposed of in the sanitary landfill. These wastes consist of scrap metal, powerhouse ash, domestic sewage, scrap wood, construction debris, and used railroad ties.

Scrap metal is sold to salvage vendors for reclamation. Powerhouse ash and domestic sewage sludge are used for land reclamation. Scrap wood is burned onsite or chipped for mulch. Construction debris is used for erosion control. Railroad ties are shipped offsite for disposal. Nonhazardous waste management is illustrated in figure H.2.2-6.

1 For those facilities already in use, this is a normal operating capacity; whereas, for facilities under design or construction, this is a design capacity. Schedules and capacities for facilities under design or construction are subject to changes such as availability of funds, results of treatability studies, and permit issuance.

2 Batch process; depends on available tanks and process used.

3 Based on net tank space gained. Input volume. SR DOE 1994b; SR DOE 1995b; SR DOE 1995c; WSRC 1995a; WSRC 1995b.

4 Schedules and capacities for facilities under design or construction are subject to changes such as availability of funds and permit issuance.

5 Tanks that do not meet secondary containment criteria as described in the Federal Facility Compliance Agreement are not included. SR DOE 1994b; SR DOE 1995c.

6 For facilities under design or construction this is a design capacity. Schedules and capacities for facilities under design or construction are subject to changes such as availability of funds, results of treatability studies, and permit issuance. SR DOE 1995c; WSRC 1995a; WSRC 1995b.

7 For those facilities already in use, this is a normal operating capacity; whereas, for facilities under design or construction, this is a design capacity. Schedules and capacities for facilities under design or construction are subject to changes such as availability of funds, results of treatability studies, and permit issuance. SR DOE 1995c; WSRC 1995a.

8 Schedules and capacities for facilities under design or construction are subject to changes such as availability of funds and permit issuance. WSRC 1995a.

9 Schedules and capacities for the facilities under design or construction are subject to changes such as availability of funds and permit issuance.

10 Includes current capacity and projections through 2024. SR DOE 1994b; SR DOE 1995c; WSRC 1995a; WSRC 1995b.

H.2.3 Kansas City Plant

At Kansas City Plant (KCP), stockpile activities for national security result in the generation and management of hazardous, solid industrial, and sanitary wastes. No LLW or mixed LLW are routinely generated. However, operations resulting in the generation of LLW or mixed LLW may occasionally occur. There is no spent nuclear fuel, high-level, and TRU waste associated with the fabrication of nonnuclear components. The manufacturing operations include machining, plastic fabrication, plating, and electrical and mechanical assembly. Past activities associated with the manufacturing of nonnuclear components for nuclear weapons has resulted in some environmental contamination. The principal sources of contamination at KCP resulted from accidental spills and leaks during manufacturing operations. These spills and leaks have contaminated soils with Volatile Organic Carbons (VOCs), PCBs, and petroleum hydrocarbons. KCP is not on the NPL for sites requiring environmental restoration in accordance with CERCLA and SARA. However, there are some remedial actions required per a consent order between DOE and EPA. Pending future funding levels, these remedial actions are scheduled to be completed by 2001.

KCP does not presently dispose of waste onsite, although onsite disposal and leaks/discharges have occurred in the past. On March 6, 1989, EPA requested DOE to enter into a RCRA Section 3008(h) Administrative Order on Consent. On June 23, 1989, DOE and EPA Region VII signed the order. The provisions of the order require DOE to conduct all assessment and remediation activities regulated under the order in accordance with approved environmental restoration remediation schedules.

Pollution Prevention . A formal Waste Minimization and Pollution Prevention Awareness Program has been initiated and is ongoing at KCP to comply with EPA regulations and DOE orders. This program includes coordinating the development, promotion, implementation, and reporting of site-wide waste reduction activities. Activities include establishing site-wide recycling and source reduction programs for all waste streams. Near-term objectives are to reduce the disposal volume of sanitary, hazardous, and LLW streams. KCP will pursue and adopt appropriate processes and programs to minimize and recycle KCP wastes.

Low-Level Waste . KCP typically generates very small quantities of LLW (<1 m^3 /yr). Activities that generate LLW are the disassembly and testing of irradiated components, scheduled replacement of tritium exit signs, removal of used radioactive sources, and general debris (i.e., small amounts of contaminated cleanup towels, disposable gloves, and packing materials) from laboratory and assembly operations. Liquid LLW is solidified and mixed into concrete or plaster of paris for final handling and disposal in accordance with NTS waste acceptance criteria.

LLW is accumulated and stored in two controlled access areas used to store both LLW and mixed waste. LLW is stored onsite until sufficient quantities accumulate to warrant shipment to approved LLW disposal facilities at NTS. The last shipment of solid LLW took place in September 1995. The current inventory of LLW in storage is <1 m^3 .

Mixed Low-Level Waste . KCP currently has no mixed waste in storage. Process changes have been made to control the generation of mixed waste. The potential exists for mixed waste to be generated by changes in conditions in current operations or by new processes being brought into KCP through nonnuclear consolidation or new business. KCP mixed waste would be stored with LLW in a controlled access, RCRA-permitted storage area.

Hazardous Waste. Hazardous waste is generated by a number of activities at KCP and consists of wastes such as acidic and alkaline liquids, solvent, and oils and coolants. Processes such as plating, etching, electronic assembly, metals and plastics machining and forming, and wastewater treatment are the principal generating processes. Waste stream residue generated at KCP that is not reclaimed, treated onsite at the Industrial Wastewater Pretreatment Facility, or recycled, is manifested and shipped under contract with waste transporters to permitted offsite facilities. KCP utilizes processes that do not require a permit under RCRA in order to treat hazardous wastes.

Hazardous wastes are managed in compliance with RCRA requirements as delineated in the Operating Permit issued by the Missouri Department of Natural Resources under the provisions of 40 CFR 270-272. KCP currently operates RCRA interim status waste storage areas for containerized nonradioactive hazardous wastes and bulk storage tanks for nonradioactive hazardous wastes.

The KCP Environmental Restoration Program serves to identify the nature and extent of environmental contamination at inactive waste sites. The site investigations conducted to date have indicated that hazardous waste constituents found in soil and groundwater at KCP are associated with past operations and are found at or near units now considered regulated hazardous waste management and solid waste management units. Site reevaluation visits are conducted by KCP personnel for all treatment, storage, or disposal facilities utilized by KCP.

Waste that requires disposal under TSCA continues to decrease. The primary generation source of PCB wastes over the past 15 years has been equipment upgrades and electrical substation replacement (i.e., replacement of transformers). These projects are now complete, and this category of waste is primarily generated from restoration and remediation projects.

Hazardous waste quantities generated at and subsequently shipped offsite from KCP in 1994 are shown in table H.2.3-1. A summary of the hazardous waste storage facilities is shown in table H.2.3-2.

Table H.2.3-1.-- Hazardous Waste Quantities Shipped Offsite in 1994, Kansas City Plant

Description	Number of Shipments Containing Description	Quantity (kg)	Estimated Volume (m^3)[11]
Aerosols	1	2,480	2.5
Combustible liquid, n.o.s.	5	32,660	32.7
Corrosive liquid, n.o.s.	1	1,720	1.7
Cyanides, inorganic, n.o.s.	1	51	< 0.1
Environmentally hazardous substances, solid, n.o.s.	21	110,297	73.5
Flammable liquids, n.o.s.	4	20,930	20.9
Flammable liquids, poisonous, n.o.s.	1	1,180	1.2
Hazardous waste, liquid, n.o.s.	3	25,100	25.1
Hazardous waste, solid, n.o.s.	33	261,250	174.2
Isocyanate solutions, n.o.s.	1	3,830	3.8

Mercury	1	154	0.1
Polychlorinated biphenyls	3	10,555	7.0
Polychlorinated biphenyls (less than one pound reportable quantity)	5	41,485	27.7

Table H.2.3-2.-- Hazardous Waste Storage Capability at Kansas City Plant

Storage Unit	Input Capability	Design Capacity[12] (m^3)	Comment
2x40 yd^3 waste dumpsters	Solid hazardous waste (construction/D&D asbestos debris)	61.2	Operational; interim status
Acid pad	Liquid and solid hazardous waste (also sludge)	180.0	Operational; interim status
Acid plating waste tank	Liquid hazardous waste (also sludge)	22.7	Operational; interim status
Alkaline plating waste tank	Liquid hazardous waste (also sludge)	22.7	Operational; interim status
Bulk solvent waste tanks	Liquid hazardous waste	60.6	Operational; interim status
Demolition lot	Liquid and solid hazardous waste (also sludge, gas)	668.0	Operational; interim status
L-lot	Liquid hazardous waste	758.0	Operational; interim status
Oil/coolant storage tank	Liquid hazardous waste (also sludge)	30.3	Operational; interim status
PCB waste tank	Liquid hazardous waste (also sludge)	30.3	Operational; interim status
Reclamation area	Liquid and solid hazardous waste (also sludge)	16.0	Operational; interim status
Red-X lot	Liquid and solid hazardous waste (also sludge, gas)	250.0	Operational; interim status
Test cell #1	Solid hazardous waste (cyanide wastes)	82.5	Operational; interim status
Test cell #2	Liquid and solid hazardous waste (also gas)	82.5	Operational; interim status
Test cell #3	Solid hazardous waste (classified wastes)	82.5	Operational; interim status
Test cell #4	Liquid hazardous waste (PCB liquids)	82.5	Operational; interim status
Test cell #11	Liquid and solid hazardous waste (also sludge)	22.5	Operational; interim status

Nonhazardous Waste. Nonhazardous wastes are generated routinely and include general plant refuse such as paper, cardboard, glass, wood, plastics, scrap, metal containers, etc. Nonhazardous wastes are segregated and recycled, whenever possible. The wastes are transported to a sanitary landfill. Sanitary wastewaters are discharged to the sanitary sewer in compliance with Kansas City, MO, sewer-use ordinance provisions and permit discharge limits. Biomedical waste is incinerated offsite at an incinerator permitted and approved by the Kansas Department of Health and Environment.

KCP also generates wastes that do not meet the definition of hazardous wastes and are not allowed to be incorporated with normal refuse sent to municipal solid waste landfills. These wastes are managed on a case-by-case basis in accordance with applicable regulations or best management practices.

11 For those shipments in which only a mass quantity was provided, a volume estimate was made based on density factors of 1,000 kg/m^3 for liquids and 1,500 kg/m^3 for solid.
n.o.s. - not otherwise specified.
DOE 1995h.

12 Schedules and capacities for facilities under design or construction are subject to changes based on the availability of funds, permit issuance, etc.
DOE 1994n; KCP 1995a:4. DOE 1994k.

H.2.4 Pantex Plant

This section describes the baseline conditions and specific waste management operations at Pantex. As part of its normal operation, Pantex generates low-level, mixed low-level, hazardous, and nonhazardous wastes. Tables H.2.4-1 and H.2.4-2 present a detailed description of treatment and storage facilities and their estimated capacities.

Table H.2.4-1.-- Waste Treatment Capability at Pantex Plant

Treatment Unit	Treatment Method (s)	Input Capability	Output Capability	Total Capacity[13] (m^3/yr)	Comment
Batch Master Hazardous Waste Tank System (Bldg. 12-68)	Filtration, neutralization, and precipitation	Bldg. 12-5C metal cleaning bath, plating process waste, sodium hydroxide radiator cleaner, and spent electrolyte solutions	Metal precipitates to Hazardous Waste Storage Pad and effluent to wastewater treatment plant	Process as needed	Nonoperational due to pending closure
Building 11-15A	Immobilization	Mixed LLW	To be determined	185	Planned
Building 11-9	Immobilization	Mixed LLW	To be determined	185	Planned
Building 11-9S	Stabilization and macroencapsulation	Mixed LLW and hazardous waste	Sent to hazardous waste treatment and processing facility when completed	2 m^3/treatment	Also used as 90-day accumulation area for hazardous and mixed LLW
Building 11-50 (Wastewater Treatment Facility)	Filtration of organics and undissolved HE particles	HE machining operations	Playa 2	684	
Building 12-43 (HE Filtration Facility)	Filtration of HE and carbon	Explosive machining operations in Building 12-24	Playa 1	180	Sock filter and carbon filter

Building 12-73	Settlement and filtration	HE-contaminated water	Sanitary sewage system	Variable	Settling tank and fabric filter system
Burning Ground: one cage, one tray, and one pan	Open burning or detonation	Solid mixed LLW and hazardous waste	Ash to 11-71X storage pad	909	Design capacity. Interim permit until April 2001.
Closed-loop decon system	Reduction	Contaminated lead (solid mixed LLW)	Acid bath (liquid mixed LLW) to offsite commercial vendor	Campaign	One process per year. Standby mode.
Compactor (Bldg. 12-42)	Hydraulic ram compactor-in-drum compaction	Solid LLW (gloves, kim wipes, paper)	Compacted LLW in 17H 55-gallon drums to storage igloo 4-56	Process as needed	No TRU waste, waste greater than Class C, mixed waste, free liquids, or gases
Hazardous Waste Treatment & Processing Facility	Immobilization repackaging, neutralization compaction, shredding, sorting, and solidification	Liquid and solid LLW, mixed LLW and hazardous waste	To be determined. May be stabilized solids	500	Available for treating mixed waste by 1998
Sanitary Sewage Treatment System	Aeration and anaerobic microbial action	Sanitary sewage and industrial waste	Lagoon (chlorine pretreatment)	2,460,000 L/day	Permitted flow. Operational flow about 1,310,000 L/day.

Table H.2.4-2.-- Waste Storage Capability at Pantex Plant

Storage Unit	Input Capability	Total Capacity (m^3)[14]	Comment
Buildings 4-46, 4-72 and 4-74	Liquid and solid mixed LLW	187	Permitted capacity pending permit modification. Operating capacity is 120 m^3.
Buildings 11-7A and 11-7B	Liquid and solid mixed LLW	402	Permitted and operating storage capacity.
Building 11-7N Pad	Various liquid/solid hazardous waste, mixed LLW, and LLW	125	Interim permit dated April 19, 1990. Permitted and operating capacity.

Building 11-9N Pad	Various liquid and solid hazardous wastes	379	Permit dated March 1994. Permitted capacity. Operating capacity is 252 m^3.
Conex containers WM-1 to WM-8	Containerized solid mixed low-level and silver photo wastes	575	Permit dated April 1, 1991. Permitted capacity. Operating capacity is 120 m^3.
Conex containers WM-1A, WM-1B,WM-3A, WM-5A, WM-5B	Containerized liquid and solid LLW	377	No plans to receive offsite waste. Permitted capacity pending permit modification. Operating capacity is 75 m^3.
Conex containers (25)	Solid/liquid LLW	1,800	Each Conex can store 72 55-gal drums (15 m^3) for an operating capacity of 375 m^3.
Magazine 4-50	Liquid/solid mixed LLW, hazardous waste, and LLW	421	Final permit dated April 24, 1992. Permitted capacity. Operating capacity is 40 m^3.
Magazine 4-56	Liquid and solid LLW	421	Temporary storage before shipment to NTS. Operating capacity is 40 m^3.
RCRA Hazardous Staging Facility (Bldg. 16-16)	Containerized liquid/solid LLW and mixed LLW	1,050	Permitted capacity. Operating capacity is 333 m^3. Currently under construction.

Pantex's goals regarding the management of LLW, mixed LLW, and hazardous wastes are as follows:

- Minimize the volumes of low-level radioactive and hazardous wastes generated to the extent technologically and economically practicable
- Recycle those wastes using the best available technology
- Minimize contamination of existing or proposed real property and facilities
- Ensure safe and efficient long-term management of all wastes

Pollution Prevention. The Pantex Waste Minimization Program was formed to define an effective waste minimization system for the site. A committee provides awareness of the program, identifies tasks, and provides a liaison between the site and outside entities. Some of this program's accomplishments are listed below:

- Compact 1,200 drums to approximately 250 drums using a compactor
- Separate radioactive and hazardous waste materials when shearing weapons components
- Reclaim oil, antifreeze, and refrigerant
- Substitute a scintillation solution that is nonhazardous
- Reuse explosives and solvents
- Repackage paint into smaller containers
- Substitute naphtha with nonhazardous biodegradable cleaning solutions

Transuranic Waste. No TRU waste or mixed TRU waste is currently generated at Pantex during normal operation. However, there is potential for an off-normal event to generate small amounts of

contact-handled TRU waste or mixed TRU waste during a weapon dismantlement activity. Three drums of TRU waste were generated several years ago from an incident during weapon dismantlement. Ultimately, Pantex plans to ship its TRU waste to a DOE-approved storage site when one is available. In the interim, approximately 1 m^3 of TRU waste is temporarily stored in Building 12-42 (DOE 1995gg).

Low-Level Waste. The waste streams for LLW have the following options available for management consideration:

- Continue to ship to an approved DOE disposal site such as NTS
- Compact solid waste, if possible
- Improve computerized tracking of radioactive waste
- Implement an improved segregation program

Solid LLW consists of contaminated parts from weapons A/D functions and waste materials associated with these functions, such as protective clothing, cleaning materials, filters, and other similar materials. The compactible portions of this waste are processed at the Pantex Solid Waste Compaction Facility and staged along with the noncompactible portions for shipment to a DOE-approved disposal site. Table H.2.4-3 lists Pantex's primary LLW streams, how they are generated, primary radioactive constituents, and method of storage or disposal. Table H.2.4-4 presents the inventory of LLW at Pantex as of December 2, 1994. A 5-year projection is also given.

Mixed Low-Level Waste. The waste streams for mixed LLW have the following options available for management consideration:

- Treat to satisfy Land Disposal Restriction requirements and store onsite. This is the option now being used at Pantex (PX DOE 1996b:4-193).
- Treat to satisfy Land Disposal Restriction requirements and ship to an approved commercial facility for storage or disposal.
- Ship offsite for treatment and disposal.

Pantex generates solid mixed LLW during weapons component testing. These wastes consist primarily of depleted uranium and beryllium residue and fragments from explosives components tests, contaminated gravel, cleaning materials, and protective clothing associated with these operations. Other mixed LLW streams include cleaning materials from weapons A/D operations. Table H.2.4-5 lists Pantex's primary mixed waste streams, composition, method of process, and treatment alternatives. Pantex will manage mixed waste in accordance with the Pantex Plant Federal Facility Compliance Act Compliance Plan. Pantex currently has a contract with a commercial facility for mixed waste treatment and/or disposal. Table H.2.4-6 lists organic liquid mixed LLW waste streams that are being evaluated for commercial treatment and/or disposal. Table H.2.4-7 lists the mixed waste storage inventory as of September 1995. Projections for the following 5 years are also included.

Mixed LLW (HE contaminates only) is currently treated at the Burning Ground which has a permitted capacity of 180 m^3/yr (236 yd^3/yr) (DOE 1995gg). The Hazardous Waste Treatment and Processing Facility is being planned to house mixed waste mobile treatment units.

Hazardous Waste. The waste streams for hazardous waste have the following options available for management consideration:

- Continue to ship to approved hazardous waste disposal facilities
- Encapsulate solid waste and ship to an approved DOE disposal site
- Treat onsite to neutralize corrosive wastes

Table H.2.4-8 presents the inventory and 5-year projection for hazardous waste at Pantex as of December 2, 1994. Two facilities treat hazardous waste: the Burning Ground Facility and the Hazardous Waste Treatment Processing Facility. The Burning Ground is an open-burning area where explosives, explosives-contaminated waste, and explosives-contaminated spent solvents are burned, resulting in a large reduction in volume. The Hazardous Waste Treatment and Processing Facility will house liquid-phase and solid-phase hazardous, low-level, and mixed waste processing facilities. The facility has been planned and approved and should be available in 1998 (DOE 1995gg).

Not all of the hazardous waste is treated at Pantex. Table H.2.4-9 shows the amount of hazardous waste shipped offsite in 1994. There are several separate storage facilities for hazardous wastes. At the Hazardous Waste Drum Storage Area, all drums containing liquid are placed in spill-containment pans. The facility is inspected weekly for leaking drums. Small lab samples of hazardous waste are stored in two chemical storage containers in this area. The materials stored there include asbestos, mercury-contaminated wastes, Burning Ground ash, and electroplating sludge. At Building 16-1, used crank case oil is stored underground until sufficient quantities are generated for offsite processing.

Table H.2.4-3.-- Low-Level Waste Streams at Pantex Plant

Sources	Waste Description	Radioactive Constituents	Primary Materials	Dispo
Assembly/dismantlement operations	Debris from demilitarization and sanitization operations	Thorium, U-238, tritium	Generally noncompactible crushed/granulated plastic and metal debris	Dispo of at I appro offsite facilit
Assembly/dismantlement/ stockpile surveillance	Compactible material from normal assembly/dismantlement/stockpile surveillance	U-238, tritium, thorium, and plutonium	Lab wipes and other support materials	Dispo of at I appro offsite facilit
Assembly/dismantlement and stockpile surveillance operations	Radiological materials from normal operations associated with weapons assembly, dismantlement, facility surveillance, container monitoring and routine sample counting operations	U-238, tritium, thorium, and plutonium	Protective clothing, wipes, swipes, tape, plastic and other material in the radiation protection program	Dispo of at I appro offsite facilit

Weapon component testing and evaluation	Debris generated during past testing of mock devices associated with any known waste stream	Depleted U-238 residue	Contaminated soil and gravel, additional miscellaneous materials	Storec onsite pendir eventu shipm DOE-appro dispos site
Decontamination products	Materials generated during the decontamination of a concrete assembly work cell (one time generation)	Tritium	Protective clothing, concrete rubble, solidified liquids, tools, equipment, plastic and paper products containing tritium	Storec onsite pendir eventu shipm DOE-appro dispos site
PX DOE 1995i.				

Table H.2.4-4.-- Low-Level Waste Inventory at Pantex Plant

Waste Stream Name	Inventory as of December 2, 1994(m^3)	Total GenerationFive-Year Projection (m^3)
Beryllium waste, radioactive	114	0[15]
Tritium contaminated waste (solid/liquid)	55	179
Lab packs, nonregulated radioactive (solid)	1	1
Contaminated soil	8	0
Waste water	7	9
Contaminated metal, radioactive	2	0.02
Desiccant, radioactive	0.2	22
Plant refuse (paper, foam, rags, cardboard)	105	711
Miscellaneous ash, radioactive	9	0
Total	**301**	**922**

Table H.2.4-5.-- Mixed Low-Level Waste Streams at Pantex Plant

Treatability Group	Waste Stream Name	Composition[16]	Process Description	Treatment Alternatives
Organic liquids	Paint waste - organic liquids	Paint and solvent	Stripping, surface preparation, and repainting	Planning packed bed reactor (Mobile Treatment Unit)
	Spent solvents	Freon, methyl ethyl ketone, High Explosive (HE), and dimethyl sulfoxide	Cleaning dissolution of HE	Planning hydrothermal oxidation (Mobile Treatment Unit or offsite commercial vendor)
	Contaminated liquid	Mercury-contaminated oil	Vacuum pump oil change	Planning packed bed reactor (Mobile Treatment Unit)
Aqueous liquids	Wastewater	Water, HE, chromium, lead	Water-let and thermal shock activities	Planning evaporation oxidation and stabilization (Mobile Treatment Unit)
	Alodine solution	Chromic acid, fluoride salt and iron cyanide	Surface preparation before paint removal	Planning plating waste treatment (Mobile Treatment Unit)
	Metal cleaning waste	Water, alodine, nitric acid, U, Th, cadmium, Cr, Lead, and Hg	Etching and cleaning of metals	Planning plating waste treatment (Mobile Treatment Unit)
Homogeneous solids	Wastewater sludge from explosives	Explosive-contaminated solids, dimethyl sulfoxide	Filtering of wastewater with HE	Open-air burning
	Burning Ground ash	Inorganic ash residue, metals, and some unburned organic material	Burning of HE and HE-contaminated materials	Planning stabilization/barium sulfate (Mobile Treatment Unit)
	Process residues	Residues resulting from treatment of mixed waste	Waste not generated until onsite mixed waste treatment commences in 2000.	Planning stabilization (Mobile Treatment Unit)

Soils/gravels	ER potential mixed waste (soils)	Contaminated soils from solid waste management units, spill cleanup, drill cuttings, sample wastes, etc.	ER program site contaminated soils	Planning thermal desorption and stabilization
Debris waste	Solvent-contaminated solid material	Alcohol, kimwipes, filters, rags, leads, solvents	Weapon dismantlement and maintenance	Planning macroencapsulation
	Contaminated scrap metal	Contaminated scrap metal from demilitarized and sanitized weapons parts	Demilitarized and sanitation activities	Planning macroencapsulation
	Lead-contaminated waste, solid	Seals and tape intermixed with gloves and paper	Demilitarization and sanitization activities	Planning macroencapsulation
	Mercury-contaminated solids	Glass bulbs, mercury-contaminated solids	Maintenance of lighting	Planning macroencapsulation
	Heterogeneous debris- metal contaminated waste	Metals, alodine, light ballasts, beryllium	Maintenance and special activities	Planning macroencapsulation
	Heterogeneous debris	Solid wipes, gloves, and anti-C suits	Painting, paint removal, maintenance testing, and disarmament activities	Planning macroencapsulation
	Plutonium-contaminated solids	Personnel protective equipment, epoxy, floor sweepings, paint, and paint thinner	Dismantlement operations in Building 12-98	Planning macroencapsulation
	Contaminated explosives and contaminated support materials	Support materials with explosive residue, mercury, and solvents	Assembly/disassembly process	Planning macroencapsulation

Lab packs	Lab packs	Epoxy, uranium, acid, lead, thorium nitrate crystals	Disposal of chemicals from testing labs	Proposed radiation surveying followed by separation and onsite treatment if unable to reclassify as hazardous
	Miscellaneous organic liquids	Halogenated and nonhalogenated solvents	Paints, solvents, and special product materials storage	Planning hydrothermal oxidation (Mobile Treatment Unit)
	Scintillation fluids	Scintillation fluids packaged with vermiculite	Radioactivity testing	Commercial treatment. Fluids need to be bulked first.
Special wastes	Used batteries	Nickel, cadmium, lead, silver, mercury, and asbestos	Dismantlement activities	Decontaminate and recategorize as hazardous waste
	Lead waste	Portion of lead drum liners	Removal of lead liners	Planning treatment utilizing decontamination. If not successful, then macroencapsulation (Mobile Treatment Unit)
	Aerosol containers	Discarded spray paint cans	General maintenance	Decontamination

Table H.2.4-6.-- Organic Liquid Waste Stream Candidates for Commercial Treatment and/or Disposal

Waste Stream	Quantities of Waste (L)	Treatable Volume(L)	Composition[17]	Process Description
Lab packs[18]	4,030	988	Scintillation vials packed in cardboard boxes in vermiculite	Laboratory waste packages
Organic debris; solvent-contaminated	163	163	Joint test assembly cleanup water, oil, water	Support material
Spent solvent	3,920	1,740	Scintillation vials packed in cardboard boxes in vermiculite; joint test assembly cleanup water; freon with HE	Spent solvents

Mercury-contaminated liquids	492	492	Oil contaminated with mercury	Discarded oil from vacuum pumps in laboratory equipment; source of mercury contamination from samples analyzed in lab equipment
Total	**8,605**	**3,383**		

Table H.2.4-7.-- Mixed Low-Level Waste Inventory at Pantex Plant

Treatability Group	Number of Waste Streams	Inventory as ofMarch 1995 (m^3)	Total Generation Five-Year Projection (m^3)
Aqueous liquids/slurries	3	2	22
Organic liquids	3	3	2
Homogeneous solids	3	19	29
Soils	1	None	190
Debris waste	8	97	714
Lab packs	3	7	4
Special wastes	3	<1	1
Total	**24**	**128**	**963**
DOE 1995gg.			

Table H.2.4-8.-- Hazardous Waste Inventory at Pantex Plant

Waste Stream Name	Inventory as ofDecember 2, 1994 (m^3)	Total Generation Five-Year Projection (m^3)
Explosive-contaminated solid waste	4	23
Burning Ground waste from thermal treatment	1	7
Lab packs (solid)	0.4	6
Photographic film	0	0.7
Lead waste	0.7	0.08
Spent halogenated and nonhalogenated solvents and mixtures	2	34
Heavy metal contaminated parts	0	0.8
Contaminated soil[19]	0	14,800
Sodium hydroxide waste (solid)	0	8
Paint sludge	2	3

Wastewater from operations and monitoring Contaminated soil19	0.4	34
Metal cleaner and photographic waste	0.05	13
Recyclable and nonrecyclable used batteries	0.4	197
Solvent-contaminated solids	3	29
Mercury (solid/liquid)	0	0.01
Sandblasting waste	0.6	1
Lead-contaminated waste	0	0.7
Miscellaneous organics(solid/liquid)	0.4	15
Contaminated engine oil	0.1	2
Oil filter waste	0.02	0.5
Miscellaneous discards contaminated with heavy metals	23	356
Empty organic compressed gas cylinders	0.3	24
Recyclable scrap metal with precious metals	0.2	1
Total	**39**	**15,556 20**

Table H.2.4-9.-- Hazardous Waste Quantities Shipped Offsite in 1994, Pantex Plant

Description	Number of Shipments Containing Description	Quantity (kg)	Estimated Volume 21 (m^3)
Hazardous waste, solid, n.o.s.	9	14,200	9
Corrosive liquids, n.o.s.	2	538	0.5
Flammable liquids, n.o.s.	1	202	0.2
Hazardous waste, liquid, n.o.s.	2	149	0.2
Oxidizing substances, solid, corrosive, n.o.s.	1	166	0.1
Oxidizing substances, solid, poisonous, n.o.s.	1	6	<0.1
Poisonous liquids, n.o.s.	1	28	<0.1

Class 1 non-RCRA hazardous waste includes waters that contain asbestos, PCBs with a concentration greater than 50 parts per million (ppm), and oils with a total petroleum hydrocarbon concentration greater than 1,500 ppm. Table H.2.4-10 presents the Class 1 non-RCRA hazardous waste streams, current inventories as of December 2, 1994, and projected generation volumes. Medical waste is defined as any solid waste that is generated in the diagnosing, treating, or immunizing of human beings or animals, in research, or in producing or testing biologicals. This waste includes cultures and stocks, pathological wastes, human blood and blood products, sharps, animal waste, and isolation

wastes. Pantex currently generates approximately two boxes of medical waste per week, each with a capacity of 0.142 m^3 (0.186 yd^3). The annual generation rate of medical waste at Pantex is approximately 15 m^3 (19 yd^3) (PX DOE 1995i: 14-15).

Table H.2.4-10 Class 1 Non-Resource Conservation and Recovery Act Hazardous Waste Inventory at Pantex Plant

Waste Stream	Inventory as of December, 1994 (m^3)	Total Generation Five-Year Projection (m^3)
Beryllium waste	0	740
Empty Containers	142	985
PCB-contaminated solids	0.05	0.05
Crank case oil	1	260
Asbestos solids	13	24
PCB-contaminated oil	0	0.06
Paint residue	3	53
Contaminated soil[22]	5	2,350
Metal cleaning waste (solid)	0	0.3
Wastewater *Contaminated soil*[22]	24	1,600
Recyclable and nonrecyclable photographic waste	0.02	0.3
Contaminated metal	0.1	0.7
Antifreeze and engine coolants	0.3	337
Desiccant	0	4
Plant refuse, such as paper, foam, rags, and cardboard	51	543
Used oil filters generated during maintenance	3	23
Miscellaneous ash	4	5
Resins, tar, or tarry sludge (excess material from laboratories)	3	36
Total	**249**	**6,961**

Nonhazardous Waste. The Sewage Treatment Quality Upgrade is a project for 1996 at Pantex. This project would upgrade Pantex's sanitary system to ensure that wastewater standards are met through secondary/tertiary treatment. This project includes upgrading the existing treatment lagoon to treat sewage, repairing and replacing existing deteriorated sewer lines, constructing a closed system to eliminate the use of open ditches for conveyance of industrial wastewater discharges, and implementing a plant stormwater management system.

Table H.2.4-11. Class 2 Nonhazardous Waste Disposal in Amarillo Landfill from Pantex Plant

Year	Total Disposal (kg)	Total Volume of Disposal (m^3)
1989	79,600	53
1990	335,000	223
1991	307,000	205
1992	371,000	247
1993[24]	428,000	285
1994	589,000	393
1995-1999 (estimate)[25]	2,610,000	1,740

Class 2 nonhazardous waste (general refuse) is collected at each building from trash cans and placed in dumpsters. This includes cardboard, computer paper, white paper, colored paper, mixed steel, steel and aluminum cans, mixed metal, mixed plastic, foam rubber, and glass. Currently, telephone directories, paper, certain plastics, and some steel and aluminum cans are being recycled. The weights of Class 2 nonhazardous waste disposed of from 1989 to 1994 and the estimated volumes for 1995 through 1999 are given in table H.2.4-11.

DOE 1994n; KCP 1995a:4.

13 For those facilities already in use this is a normal operating capacity; whereas, for facilities under design or construction this is a design capacity. Schedules and capacities for facilities under design or construction are subject to changes such as availability funds and permit issuance. DOE 1993h; DOE 1994n; DOE 1995gg; PX DOE 1995i; PX DOE 1996b.

14 Schedules and capacities for facilities under design or construction are subject to changes such as availability of funds and permit issuance. DOE 1994n; PX DOE 1995i; PX DOE 1996b.

15 One-time event, no further generation is expected. PX DOE 1995i.

16 Typical radionuclides that may be present in the mixed waste include uranium, thorium, and tritium. ER - environmental restoration. DOE 1994k; DOE 1995gg.

17 Mixed LLW stream may include uranium, thorium, tritium, and plutonium.

18 Cardboard boxes and vermiculite used to pack scintillation vials will be recontainerized and treated as separate sampling lots. PX DOE 1995i.

19 These waste streams are primarily associated with environmental restoration activities.

20 Of this total, about 550 m3 is directly from weapons activities. PX DOE 1995i.

21 For those shipments in which only a mass quantity was provided, a volume estimate was made based on density factors of 1,000 kg/m 3 for liquids and 1,500 kg/m 3 for solids. n.o.s. - not otherwise specified. DOE 1995h.

22 These waste streams are primarily associated with environmental restoration activities. PX DOE 1995i.

23 Contract for disposal began in 1989 and included approximately 3 months.

24 In midyear, recycling was stopped because of low cost effectiveness.

25 Waste minimization efforts are expected to provide an average reduction of 4 percent each year. PX DOE 1995i. DOE 1994k.

H.2.5 Los Alamos National Laboratory

Laboratory research activities at LANL result in the generation of TRU, mixed TRU, mixed low-level, low-level, hazardous, and nonhazardous wastes. Wastes are treated, stored, and disposed of both on and offsite. LANL is not listed on the NPL. As a function of obtaining a RCRA permit, however, the Hazardous and Solid Waste Amendments of 1984 mandate that permits for treatment, storage, and disposal facilities include provisions for corrective action to mitigate releases from facilities in operation and to clean up contamination in areas designated as solid waste management units at LANL. LANL does not generate or manage HLW. The site does manage a small amount of spent nuclear fuel originating from the Omega West Reactor. This spent nuclear fuel is in temporary storage at the Chemistry and Metallurgy Research Complex awaiting shipment to SRS for long-term storage.

Pollution Prevention. Radioactive, hazardous, and mixed wastes are treated, stored, or disposed of at LANL. The total amount of waste generated and disposed of at LANL has been, and is being, reduced through the efforts of the pollution prevention and waste minimization programs at the site. The LANL Waste Minimization and Pollution Prevention Program is an ambitious program aimed at source reduction, product substitution, recycling, surplus chemical exchange, and waste treatment. The program is tailored to meet Executive Order 12780, DOE orders, and RCRA and EPA guidelines. All wastes at LANL, including radioactive, mixed, hazardous, and nonhazardous regulated waste, are included in the LANL Pollution Prevention Program. Reductions in the volumes of radioactive wastes generated have been achieved through methods such as intensive surveying, waste segregation, recycling, and use of administrative and engineering controls.

Transuranic Waste. The primary source of LANL liquid TRU waste is the processing of caustic and acidic wastes by the Plutonium Facility (Technical Area [TA]-55). Treatment of liquid TRU wastes yields a solid TRU waste and a liquid LLW that is further treated at TA-50. The pretreatment facility consists of storage and neutralization tanks, a clariflocculator and filter tanks, two precipitate storage tanks, and an in-drum cement mixing area. Lime and/or iron sulfate are added to the liquid TRU stream, resulting in a precipitate containing over 99.9 percent of the plutonium and americium. The precipitate is mixed with cement in drums to form the solid TRU waste. Variations in waste volumes and radioactive content result primarily from program changes, facility D&D activities, and general cleanup programs for laboratory areas.

The TRU waste size reduction facility at LANL is designed to repackage and reduce the volume of various types of metallic waste items such as glove boxes, process equipment, and ductwork. The items are processed in the disassembly/cutting area where attached combustible items are removed and where a plasma torch cuts it into smaller pieces for packaging. The pieces are placed into accepted WIPP containers, then sealed for storage at TA-54, Area G.

LANL has managed solid TRU waste at TA-54, Area G, since approximately 1957. Solid TRU and mixed TRU wastes are stored above ground on asphalt pads at TA-54, Area G. Membrane-covered fabric dome enclosures provide weather protection and prevention of run-on. Drums stored on pallets and fiberglass-reinforced, polyester-coated crates are fitted with skids to maintain them above the floor. Additional TRU container storage units are located within permanent structures at TA-3 and TA-55. These units support R&D activities and are not intended for long-term storage of mixed TRU waste. High-activity or remote-handled TRU wastes are placed in shafts at TA-54, Area G.

In January 1993, the New Mexico Environment Department issued Compliance Order 93-03, which required LANL to retrieve TRU wastes from aboveground earth-covered Pads 1, 2, and 4 and manage them in accordance with requirements of 40 CFR 264, Subpart I. Pursuant to the December 1993 Consent Agreement, LANL has initiated the TRU Waste Inspectable Storage Project to provide for retrieval and inspection of the wastes and replacement in new aboveground storage domes at TA-54, Area G.

In addition, LANL completed the Preconceptual Study for EPA in September 1994 to identify short- and long-term storage needs for mixed TRU waste. This study recommended constructing eight new storage domes for TRU waste at Area G by the year 2000. The domes will have the same structural design and operational capabilities as existing structures. However, based on estimates of anticipated TRU and mixed TRU waste generation, this design may not provide sufficient capacity for all wastes by the year 2000. New requirements for fire protection are being evaluated to determine whether they will further reduce available storage capacity by reducing aisle space.

Most of LANL's TRU waste is currently stored on four asphalt pads, all designated as RCRA interim status storage units. TRU wastes are currently being stored, pending the outcome of WIPP to serve as a repository for these wastes. Assuming WIPP is determined to be a suitable repository for these wastes, pursuant to the requirements of 40 CFR 191 and 40 CFR 268, these wastes will be treated to meet WIPP Waste Acceptance Criteria and packaged in accordance with DOE, NRC, and DOT requirements for transport to WIPP for disposal. The TRU Retrieval Tension Support Dome project will retrieve approximately 16,900 containers of TRU waste from three storage pads. Drums will be cleaned and inspected for corrosion and leakage. Extensively damaged drums and drums containing liquids will be overpacked. Drums which are not overpacked may have HEPA filters installed to prevent the potential for accumulation of hydrogen gas in the drum headspace during storage. All of the drums and crates will be reconfigured in six temporary storage domes erected exclusively for the storage of this waste.

Mixed TRU waste represents the majority of the mixed waste stored at LANL, accounting for approximately 80 percent of the total volume of TRU waste. All mixed TRU waste has been characterized by process knowledge. Some of the waste requires remote-handling during waste management. The regulatory status of stored mixed TRU waste can be broken down into three categories: (1) facilities that meet RCRA storage requirements; (2) facilities designed prior to and subject to RCRA but not in compliance with current storage requirements; and (3) facilities designed and operated prior to RCRA and subject to RCRA.

LANL has identified approximately 7,690 m3 (10,000 yd3) of mixed TRU waste in storage (DOE 1995gg). Mixed TRU waste has been stored since 1971. The hazardous components of TRU waste are not well defined. Activities to improve characterization of mixed TRU waste are the subject of a revised waste analysis plan that was submitted to the New Mexico Environment Department in March 1995. Activities to improve storage of these wastes are the subject of a separate compliance order. The preferred option to meet Federal Facility Compliance Act requirements follows the DOE national policy on mixed TRU waste, which is shipment to WIPP. Table H.2.5-1 provides information about the mixed TRU waste streams at LANL that are expected to go to WIPP.

The LANL TRU Waste Certification Plan specifies all required information for certification. This information on certifiable/certified TRU waste that is required for transportation, for completion of the WIPP data package, and for certification is supplied by the waste generator. Uncertified waste

packages, primarily stored in drums and crates, will be repackaged and treated when possible to meet the WIPP Waste Acceptance Criteria. Table H.2.5-2 describes the current and planned TRU and mixed TRU waste treatment capability at LANL. Table H.2.5-3 shows TRU and mixed TRU waste storage at LANL.

Special modes have been created for storing high beta-gamma active hot-cell wastes (remote-handled TRU wastes), for wastes containing more than 1 gram of plutonium-238, and for the TRU cement paste previously generated at the TA-21 Liquid Waste Treatment Plant. The hot-cell waste is handled remotely and stored in modified shafts. Because the waste is actually below ground during storage, little additional shielding is needed. The storage array currently employed is compatible with the remote-handled canister now approved for WIPP disposal.

The following LANL facilities treat TRU wastes:

- *Radioactive Liquid Waste Treatment Technical Area 50 (TA-50, Room WM-66).* This facility consists of holding/accumulation, neutralization, precipitation, settling, immobilization, and certification for aqueous wastes. The sludge produced is dewatered to 30- to 40-percent solids, placed in lined 208-L (55-gal) drums, and forwarded to TA-54, Area G for storage.
- *Plutonium Facility Solidification (TA-55).* This facility immobilizes liquid and particulate process residues in cement. The solidified product from the process is WIPP-certifiable TRU waste. It is sent to TA-54, Area G for storage.
- *Size Reduction Facility (WM-69).* This facility is designed to repackage and reduce the volume of various types of metallic waste items such as glove boxes, process equipment, and duct work.
- *Drum Preparation Facility.* This facility would be used to clean retrieved drums of TRU waste. Modifications are currently in final design. Drums coated with a "grease" to enhance long-term storage capability would be steam-cleaned and integrity checked before transfer to the waste preparation or transportation facilities. A RCRA Part B Permit application has been submitted to operate the facility. At the present time, there are no drums being cleaned in the drum preparation facility.
- *Transuranic Waste Treatment Facility.* This is a planned but not funded facility. The multiprocess facility would be used for processing LANL legacy TRU waste to meet WIPP certification requirements. Hot-cell capability would exist to process remote-handled waste. The facility would handle currently generated wastes from present and future environmental restoration/corrective actions; and legacy waste from storage and previously treated wastes.

The following LANL facilities store TRU wastes:

- *TA-54-153, TA-54-48 Transuranic Storage Pad (Building 153).* This unit is a steel frame tension support structure on a curbed asphalt pad. It would be used for damaged fiberglass reinforced plastic coated boxes once retrieved from the current storage configurations. Initial repairs would be made to the containers prior to shipment to onsite processing facilities. This unit is 95 percent full.
- *Corrugated Metal Pipe Storage (Pit 29).* This waste stream is no longer generated at LANL. During 1986, the 158 TRU corrugated metal pipes stored at TA-21, Area T, were retrieved, decontaminated, and moved to TA-54, Area G, for storage. They were placed horizontally in the upper layer of Pit 29. Accepted waste streams are corrugated metal pipes and cemented sludge.
- *Storage Holding Shed (MD-8).* This unit is used for TRU waste. This unit is RCRA-permitted,

but currently does not have any waste stored in it.

- *TRU Shafts (Various).* High beta-gamma active TRU hot-cell wastes are handled remotely and stored in modified shafts. Because the waste is below ground during storage, little additional shielding is needed.
- *TRU Storage Pads (Pads 1, 2, 4, Pit 9).* Drums are stacked with other TRU wastes on asphalt pads and covered with 1 to 2 m (3 to 7 ft) of earth backfill.
- *TRU Storage Trenches (Trenches A, B, C).* Through 1985, the high activity plutonium-238 wastes were routinely packaged in 114-L (30-gal) drums and placed in concrete casks for storage. Drums of combustible and noncombustible waste were placed in separate casks. The casks were sealed with asphalt and then covered with earth.
- *New Domes, TA-54-224, 283.* Operational soon.

Low-Level Waste. Both liquid and solid LLW are generated and managed at LANL. In 1993, approximately 2,694 m3 (3,524 yd^3) of solid LLW were generated (as packaged for treatment, storage, and disposal, not including process wastewater). LLW process wastewater generation in 1993 was 21,400 m3. Liquid LLW is generated from many areas throughout LANL. Major generators are the Chemistry-Metallurgy Building (TA-3), TA-21 Site, Radiochemistry (TA-48), and Plutonium Processing (TA-55). LANL has two onsite liquid LLW treatment facilities. The liquid LLW treatment facilities include a chemical treatment and ion-exchange plant and a 132,659 m3/yr chemical treatment plant. Significant waste-generating processes for solid LLW are concentrated in nine TAs: TA-2, Omega Site; TA-3, South Mesa (mainly the Chemistry and Metallurgy Research Building and the Sigma Complex); TA-21, DP-Site; TA-35, Ten-Site; TA-46, WA-Site; TA-48, Radiochemistry Laboratory; TA-50, Waste Management Site; TA-53, Meson Physics Facility; and TA-55, Plutonium Facility.

Solid LLW, such as paper, plastic, glassware, and rags, are separated into compactible and noncompactible materials by the waste generators. Compactible waste is solid waste that consists of trash-type materials such as paper, plastic, rubber, and small items of glassware and small items such as short lengths of pipe conduit and small pieces of wood or sheet metal. Excluded are larger noncompactible items, waste chemicals, free or absorbed liquids, biological waste, pressurized containers, powders, and other particularly hazardous materials.

LLW noncompactible items such as large equipment and much of the D&D wastes generally are not packaged but delivered to the burial site in covered or enclosed vehicles. Short-term storage may occur at treatment or disposal facilities to accumulate a required quantity of waste for an operation to be conducted effectively. Area G, situated in Mesita del Buey in TA-54, is the active burial and storage site for solid LLW at LANL. The area has been used since 1957. Burial facilities within the area include pits and shafts of varying dimensions. Most solid LLW waste generated at LANL is buried in large pits ranging in size from 122 to 183 m (400 to 600 ft) long, 8 to 30 m (26 to 98 ft) wide, and 8 to 20 m (26 to 66 ft) deep. The current disposal facility has a remaining capacity of 22,000 m^3 (28,770 yd^3). At current operational generation rates and implementation of waste minimization, Area G has an operational life of 10 years. However, if environmental restoration activity cleanups are accelerated as presently planned, Area G will reach its useful design life by the end of 1997. Continued construction at Area G is dependent on decisions made in conjunction with the LANL Site-Wide EIS and DOE Waste Management PEIS. As an alternative to the continued construction at Area G, LANL is exploring other options for the disposal of LLW in the future (e.g., NTS) (DOE 1995q:NM 23).

Mixed Low-Level Waste. Under the Federal Facility Compliance Act, DOE is required to develop a

site treatment plan for mixed wastes at LANL. The site treatment plan is intended to bring LANL into compliance with land disposal restrictions storage prohibitions under the New Mexico Hazardous Waste Act and RCRA. On March 31, 1995, DOE submitted its proposed site treatment plan to the New Mexico Environment Department for review, public comment, and approval. On October 4, 1995, a Compliance Order was issued by the State of New Mexico requiring LANL to comply with the site treatment plan for the treatment of mixed wastes at LANL. The Compliance Plan Volume of the site treatment plan provides overall schedules for achieving compliance with the RCRA storage and treatment requirements, a schedule for the submittal of applications for permits, construction of treatment facilities, technology development, offsite transportation for treatment, and the treatment of mixed wastes in full compliance with the New Mexico Hazardous Waste Act and RCRA. An annual update to the site treatment plan is required.

LANL has approximately 600 m3 (785 yd3) of mixed LLW in storage. The waste is made up of just over 5,000 separate items that have been combined into 30 treatability groups, each with a preferred treatment option as shown in table H.2.5-4. LANL just completed recharacterizing the mixed LLW as required by the Federal Facility Compliance Agreement; the recharacterization resulted in a significant decrease in the volume reported in past documentation. Over 1,200 mixed LLW items (approximately 14 m3 [18.3 yd3]) are suspect for radioactive contamination. A field sort, survey, and decontamination operation will determine whether or not these wastes are contaminated with radioactivity. If not, they will be treated at commercial offsite facilities. If contaminated, they will be handled with the preferred option identified for that treatability group.

Five-year projections estimate that approximately 108 m3 (141 yd^3) of mixed LLW would be generated at LANL. Almost all of this waste would result from small-scale R&D projects. Each project would be reviewed for waste minimization and waste treatment, storage, and disposal requirements.

The large variety and relatively small volumes of waste require a substantial array of treatment options. Table H.2.5-5 summarizes LLW and mixed LLW treatment capability at LANL. The treatment of mixed LLW is built around two major components: using offsite commercial treatment or treatment available at other DOE sites, and mixed waste treatment skids that are being designed to treat onsite hazardous and mixed waste streams that are not amenable to offsite treatment. LANL has one existing facility designed to treat mixed waste, the lead decontamination trailer.

A commercial lead decontamination unit has been purchased and located at TA-50. The treatment process is applicable to lead shapes with surface contamination. The unit would be used to decontaminate lead bricks to allow recycling by using an abrasive slurry of water, blasting media, and air. A lead sulfide sludge would be produced which would be solidified for disposal.

The scintillation vial crusher is a standard crusher with a vibrating screen to separate the broken vial glass from the liquid waste. This unit crushes the vials allowing separation of the vial from the liquid. The glass is disposed of as LLW, and the liquid is collected for further treatment. The unit does not rinse vial solid residues.

The following LANL facility would treat mixed LLW:

- *Reactive Waste Treatment.* A wet chemical process would be used to handle reactive mixed wastes, including pyrophoric uranium, sodium metal, and lithium hydride. The process would create a nonhazardous metal salt that would be solidified. Feed materials are limited to chips

and powders. Pieces must be smaller than 0.3 m (1 ft) in diameter.

Table H.2.5-6 describes mixed LLW storage at LANL. Table H.2.5-7 summarizes waste disposal at LANL. LANL currently has 1,700 drum equivalents of mixed LLW in storage at TA-54, Areas G and L. Additional container storage facilities exist to support research activities at other areas at the laboratory including TAs -3, -16, -21, -50, and -55. Wastes are stored in compliance with 40 CFR 265 (and, in some cases, Part 264) requirements. To comply with the Federal Facility Compliance Agreement, schedules to complete facility upgrades that address 40 CFR 264 permitted standards and/or identified best management practices were submitted to EPA in September 1994. Several upgrades have been completed. For TA-55, a Part B Permit application addressing storage requirements under 40 CFR 264 is currently in development.

The storage of mixed wastes at Areas L and G complies with requirements of 40 CFR 265, Subpart I, the interim management standards that currently apply to these units. LANL believes that the Area G storage facility also generally complies with the requirements of 40 CFR 264. Both facilities are being upgraded, as necessary, to comply with 40 CFR Part 264 requirements before the permit is issued for these units, which is not anticipated to occur before 1998.

The following LANL facilities are used for storage of mixed LLW:

- *Low-Level Waste Shaft (Shaft 145).* Tritiated waste (>20 mCi/m3 [740 MBq/m3]) has been placed in asphalt lined or encapsulated drums and then placed in shafts lined with corrugated metal pipe at Area G. This shaft has been removed from the RCRA Permit and is no longer considered a mixed waste shaft. Shaft 145 is now an LLW shaft.
- *Lead Stringer Shafts (Shaft 35).* The shafts are 9.14 m (30 ft) deep by 1.83 m (6 ft) in diameter and lined with corrugated pipe located at Area L. The stringers are approximately 7.62 m (25 ft) by 0.15 m (0.5 ft) by 0.2 m (0.7 ft) hollow steel columns filled with a concrete/lead mixture. The wastes were generated at Los Alamos Meson Physics Facility.
- *TA-21-61.* Used during the 1980s for storage of PCB wastes, this building has a large diked area for waste storage. The floor is sealed with an epoxy paint. In 1990, two drums of liquid mixed LLW were stored in this facility. In 1991, the RCRA Part A application was modified identifying this facility as an interim status storage facility for mixed LLW. No mixed LLW are presently stored in this facility. LANL anticipates closing this unit in 1996.
- *Mixed Waste Dome.* Solid mixed LLW is stored primarily at Area G in Building 49. This facility contains a bermed (curbed) asphalt pad with a tension support dome structure (18.29 m by 134.11 m) (60 ft by 440 ft).
- *Area L Gas Cylinder Storage.* The RCRA Part B application for this facility was approved November 9, 1989. Accepted waste streams are legacy waste compressed gas cylinders.
- *Mixed Waste Berm.* Liquid mixed LLW is stored at TA-54, Area L. This storage area has an approximate 378,540-L (100,000-gal) capacity.

Hazardous Waste. LANL produces a wide variety of hazardous wastes. Small volumes of all chemicals listed under 40 CFR 261.33 could be generated as a result of ongoing research. Primary laboratory sites for basic and applied chemistry R&D generate typical chemical wastes consisting primarily of laboratory reagent chemicals, pump oil, solvents, test samples, and miscellaneous laboratory wastes. Significant volumes of beryllium, lithium hydride, and magnesium turnings are generated from the main shop department. Plating solutions containing chromates and cyanides, acid or base wastes heavily contaminated with copper, and nitric and sulfuric acid wastes are also generated. All developer, ferric chloride, and sodium hydroxide hazardous wastes are sent out of state

for incineration. Fixer photo-wastes undergo metals recycling for silver and other precious metals. Nearly all of LANL's chemical waste is treated at commercial offsite facilities, but LANL does perform volume reduction for some waste (e.g., crushing scintillation vials) and treatment of barium sands. In the future, these hazardous wastes, which cannot be handled by commercial facilities, will be treated at yet to be determined offsite locations. Table H.2.5-8 shows hazardous waste quantities shipped offsite from LANL in 1994. Table H.2.5-9 lists LANL hazardous waste treatment capability. Table H.2.5-10 describes LANL hazardous waste storage capability.

HE waste is generated during processing and testing of various HE materials. Processing, which includes pressing, machining, and casting HE, produces pieces of HE, chips, machine cuttings, and powder. The chips, cuttings, and powder usually are in the form of waterborne suspensions, collected in specially designed accumulating and settling sump tanks. Wastes also consist of materials contaminated with HE: paper, oils, solvents, wood, machine tools, fixtures, and so forth. Chemically the wastes consist of cyclotetramethylenetetranitramine, cyclotrimethylenetrinitramine, trinitrotoluene, pentaerythritoltetranitrate, triaminotrinitrobenzene, ammonium nitrate, barium nitrate, boric acid, nitrocellulose, tetryl, nitroguanidine, and various plastic binders.

All HE hazardous wastes and potentially contaminated HE waste are picked up and delivered to the TA-16 (S-Site) incinerator or flash pad where it is burned. Treated ash residue that is nonhazardous is disposed of in the industrial non-RCRA landfill, TA-54, Area J. Any residue with hazardous constituents remaining is shipped offsite to a commercial RCRA-permitted disposal facility.

HE wastewater is treated by gravity settlement in a sump and then discharged from NPDES-permitted outfalls. Initially, there were 21 such outfall discharges from widespread TAs that process HE. Waste minimization efforts have reduced the number of outfalls from 21 to 2. Dissolved constituents are not removed by this treatment. As a result, there are often compliance issues associated with the NPDES permit. LANL is under Administrative Order from EPA to treat all HE wastewater by 1997, and LANL has agreed to this requirement. To meet this obligation, LANL is developing a HE wastewater treatment facility that will collect and treat these wastewaters with stepped filtration. The ultimate goal for this facility is zero discharge with complete recycling of the system water. Construction is scheduled for completion in 1997 (DOE 1995q:NM 22).

All hazardous waste treatment, storage, and disposal facilities at LANL are either fully permitted, have interim status, or are operating pursuant to enforceable agreements with the regulators while other waste management facilities are being developed. LANL does not landfill RCRA hazardous waste onsite, but contracts with certified transporters to deliver hazardous waste to commercial RCRA-permitted disposal facilities. Before waste is sent offsite, the potential disposal facility is inspected by LANL personnel. Operating records and permits are also reviewed. LANL has an EPA Letter of Authorization allowing disposal of PCB-contaminated articles at the TA-54, Area G Landfill.

TA-54, Area L, is the waste transfer, packaging, and storage unit for accumulating, packaging, and greater-than-90-day storage of RCRA hazardous waste. Concrete containment structures and modular storage buildings are located at Area L. These facilities are used for accumulating, packaging, and storing waste containers generated throughout LANL. Hazardous waste containers generated at the various laboratories are routinely delivered to the waste transfer, packaging, and storage facilities.

Thermal Treatment Facilities at Technical Area-16. Four types of open burn units are at the TA-16 burning ground: a flash pad, where any HE contamination is removed from excess equipment or

scrap generated within the TA; two burn pads for destruction of solid HE material; a pad with trays in which HE-contaminated waste oil is burned; and two pressure vessels for reacting HE-contaminated sludge.

The flash pad area is covered with sand. Material to be flashed is placed on the pad with any necessary additional fuel to maintain the burn until all HE has been reacted. The scrap material is then handled as solid nonhazardous waste. Because the burn pad sand may contain toxic characteristic barium, it is put in drums, stored, and managed as a hazardous waste until sampling and analysis are complete. Burn pad sand that is toxic characteristic for barium is treated at TA-54, Area L, to render it nonhazardous.

The two burn pads are used to destroy solid chunks of excess or off-specification HE and machine turnings. The material is placed on a sand-filled steel table lined with refractory brick and then ignited. Used oil and/or solvent that may be contaminated with HE is poured into metal trays lined with fire brick. The trays are in a sand-filled metal tray. The oil is ignited using a remotely operated "electric match." Approximately 374 L (99 gal) of oil are burned each month.

HE-contaminated washwater is collected in sumps at HE fabrication facilities in several TAs. HE settles out of the washwater, is collected in a vacuum truck, and is taken to TA-16 for treatment. Up to 1,650 kg (3,638 lbs) of sludge can be burned in the pressure vessels at one time. Processing liquid effluent is sent to a nearby carbon-filter wastewater treatment unit (TA-16). Treated effluent is regulated by an NPDES permit.

Thermal Treatment Facilities at Technical Areas -14, -15, -36, and -39 . Open detonation sites for destruction of excess or waste HE are at TAs -14, -15, -36, and -39. These sites are used routinely to detonate scrap HE, failed experimental detonations, unneeded classified explosives shapes, and small quantities of reactive chemicals. These sites consist of detonation points on the open ground, often in a small canyon. Material to be detonated is placed on sand or on a wooden table at the firing point and detonated with a remote firing mechanism.

Industrial Incinerator at Technical Area 16. A baffled single-chamber industrial incinerator, equipped for combustion of potentially HE-contaminated trash and machine oil, is located outdoors in the northeastern part of TA-16. The incinerator burns potentially HE-contaminated paper, cardboard, wooden boxes, and occasionally a limited volume of potentially HE-contaminated machine oil. The industrial incinerator does not burn wastes other than those permitted by 40 CFR 264.340(b)(i), (ii), (iii), or (iv) [NMHWMR 206.D.8a(2)(a)(i), (ii), (iii), or (iv)]. Emissions from the incinerator conform to Federal and state standards.

Nonhazardous Waste. Nonhazardous wastes are generated routinely and include general facility refuse such as paper, cardboard, glass, wood, plastics, scrap, metal containers, and dirt and rubble. In 1993, 5,453 m3 (7,132 yd3) of solid nonhazardous wastes were generated by LANL (LANL 1994b:6). Nonhazardous wastes are segregated and recycled whenever possible. Trash is accumulated onsite in dumpsters, which are emptied on a regular basis by a commercial waste disposal firm and taken to the county sanitary landfill.

Solid sanitary waste generated by LANL is currently disposed of at the Sandia Canyon Site (TA-61) on East Jemez Road. Owned by DOE, this site serves the landfill needs of both LANL and Los Alamos County. Approximately one-third of the domestic solid waste disposed of at the county landfill originates from LANL. The county has operated this landfill under a Special Use Permit from

DOE since 1971. The existing sanitary landfill is expected to reach the end of its useful life by 2008. At that time, either a new landfill will have to be constructed or provisions made for offsite disposal.

Administratively controlled waste is not regulated by RCRA and TSCA but is deemed by LANL to be inappropriate for disposal at the Los Alamos County sanitary landfill. Examples are classified computer equipment, magnetic tapes, or any wastes controlled for national security purposes. These wastes are disposed of in the Area J solid waste landfill at TA-54, which is regulated by the New Mexico Solid Waste Bureau, as is the sanitary landfill. Future plans for disposal will depend on the future strategy for sanitary waste disposal. If not, an alternative site will be identified when Area J reaches capacity (DOE 1995q:NM 24).

A new LANL Sanitary Wastewater Treatment Plant and Collection System have been completed to replace 7 existing wastewater treatment facilities and 30 existing septic tanks. The new treatment plant enables reuse of the treated wastewater for nondrinking water uses such as cooling and irrigation. The plant and collection system is designed to meet the requirements of LANL's existing Federal Facility Compliance Agreement.

Waste Category
Mixed scrap metal
Cemented process sludge
Solidified aqueous waste
Combustible debris
Noncombustible debris
Solidified inorganic and organic process solids
Glove box and ducting metallic waste
Mixed scrap metal
Noncombustible debris
Metallic waste
Total
DOE 1995gg.

Table H.2.5-1.-- Mixed Transuranic Wastes for Disposal at the Waste Isolation Pilot Plant at Los Alamos National Laboratory

Storage Locations	Storage Method	RCRA Code	Inventory as of December 31, 1994 (m^3)	Projected Generation (1995-1999) (m^3)
TA-54 Area G Pit 9, TA-54 Area G 54-153, TA-54 Area G 54-48, TA-54 Area G Pad 1,2, and 4	Container (covered), Container (retrievably buried)	D008	2,206.38	25

TA-54 Area G Pit 9, TA-54 Area G 54-153, TA-54 Area G 54-48, TA-54 Area G Pad 1,2, and 4	Container (covered), Container (pad), Container (retrievably buried)	D007 D008, D009, F001, F002, F005	3,052.97	100
TA-54 Area G Pit 9, TA-54 Area G 54-153, TA-54 Area G 54-48, TA-54 Area G Pad 1,2, and 4	Container (covered), Container (pad), Container (retrievably buried)	F001	1,277.42	100
TA-54 Area G Pit 9, TA-54 Area G 54-153, TA-54 Area G 54-48, TA-54 Area G Pad 1,2, and 4	Container (covered), Container (retrievably buried)	D007,D008, D019, D040, F001, F002, U080	252.43	125
TA-54 Area G Pit 9, TA-54 Area G 54-153, TA-54 Area G 54-48, TA-54 Area G Pad 1,2, and 4	Container (covered), Container (pad), Container (retrievably buried)	D008, D019, D040	213.06	125
TA-54 Area G Pit 9, TA-54 Area G 54-153, TA-54 Area G 54-48, TA-54 Area G Pad 1,2, and 4	Container (covered), Container (pad), Container (retrievably buried)	D006, D007, D008, D019, D021, D039, F001, F002, F003	527.65	150
TA-54 Area G Pit 9, TA-54 Area G 54-153, TA-54 Area G 54-48, TA-54 Area G Pad 1,2, and 4	Container (covered), Container (pad), Container (retrievably buried)	D007, D008	142.46	100
TA-54 Area G Remote shafts	Remote shafts	D008	2.12	8
TA-54 Area G Remote shafts	Remote shafts	D008	15.84	8
TA-54 Area G Pad 1,2, and 4	Container (covered)	D008	0.567	No future generation
			7,690.897	**741**

Treatment Unit
Plutonium Facility solidification (TA-55)
Pretreatment Plant (Rm. WM-66, TA-50-1)
Size Reduction Facility(WM-69)
TRU Waste Treatment Facility
Radioactive liquid waste treatment (TA-50-1)
Radioactive Liquid Waste Treatment Plant

Drum Preparation Facility

TCLP - Toxicity Characteristic Leaching Procedure. DOE 1994k.

Table H.2.5-2.-- Transuranic and Mixed Transuranic Treatment Capability at Los Alamos National Laboratory

Treatment Method	Input Capability	Output Capability	Design Feedrate	Comment
Encapsulation	Liquid, solid and sludge mixed TRU waste, TRU waste, hazardous waste. Solid type: filters, glass, metal, paper, plastic, rags, rubber, corrosive, listed, reactive, TCLP	Solid mixed TRU and TRU cement; corrosive, listed, reactive, TCLP. Contact-handled shielded containers to TA-54, Area G storage	0.08 m^3/hr	Operational; the solidified product from the process is WIPP certifiable TRU
Liquid/solid separation, sedimentation, neutralization, precipitation	Liquid mixed TRU waste. Specific waste: listed, corrosive, TCLP. Contact-handled	Liquid TRU to Radioactive Liquid Waste Treatment (TA-50-1), TRU sludge-solidified (cement) to Certified Waste Pad storage. Specific Waste: listed, corrosive, TCLP. Contact-handled	5.70 m^3/hr	Operational
Size reduction	Solid mixed TRU waste, TRU waste, LLW. Solid type: equipment, filters, glass, metal, other, paper, plastic, rags, rubber	Size reduced TRU metal to storage LANL TA-54, Area G; TRU certified mixed waste and certified TRU waste to storage Certified Waste Pad	1.36 m^3/hr	Operational
Decontamination, solidification, repackaging, shredding, size reduction	Solid and sludge mixed TRU waste, TRU waste. Solid type: filters, glass, labpack, metal, paper, plastic, rags, rubber. Specific waste: corrosive, reactive, TCLP. Contact-handled and remote-handled	Solid and sludge mixed TRU waste, TRU waste. Solid type: filters, glass, labpack, metal, paper, plastic, rags, rubber. Specific waste: TCLP. Contact-handled and remote-handled TRU certified mixed waste and TRU certified	Planned	Planned but not funded Date available: January 1, 2000

		waste disposal to WIPP		
Adsorption, liquid/solid separation, coagulation, filtration, neutralization, precipitation	Liquid mixed TRU waste, LLW, corrosive	Liquid sludge, mixed LLW, LLW. Specific waste: listed liquid effluent to storage; vacuum filter sludge to storage	30 m^3/hr	Operational; NPDES Permit
Neutralization, precipitation	Liquid mixed TRU waste, mixed LLW, LLW, hazardous waste, corrosive	Gas, liquid, sludge, solid mixed TRU waste, TRU waste, mixed LLW, LLW, hazardous waste, sanitary waste Solid LLW to disposal TA-54; Solid TRU to storage TA-54; Solid TRU to disposal WIPP	600 m^3/hr	Planned but not funded. Date available: January 1, 2004. Will replace the existing treatment plant, TA-50-1, including the pretreatment plant which cannot realistically be modified or upgraded to meet expected ES&H requirements
Decontamination	Solid mixed TRU waste, TRU waste, hazardous waste. Solid type: Construction/D&D debris, equipment, filters, glass, metal, paper, plastic, rags, rubber, soil. Specific waste: reactive, listed, ignitable, TCLP, corrosive	Liquid, solid and sludge mixed TRU waste, TRU waste, LLW	0.50 m^3/hr	Operational

Storage Unit
Certified waste pad
TRU storage pad 1
TRU storage pad 2
TRU storage pad 4
Storage holding shed, MD-8
TRU storage trench A
TRU storage trench B
TRU storage trench C
TRU shafts
TRU storage pad, pit 9
Short-term enhanced storage
Corrugated metal pipes storage, pit 29

New TRU storage pad, Bldg. 153

Table H.2.5-3.-- Transuranic and Mixed Transuranic Waste Storage at Los Alamos National Laboratory

Input Capability	Design Capacity[26] (m^3)	Comment
Solid mixed TRU waste, TRU waste, hazardous waste. Solid type: glass, metal, paper, plastic, rags, rubber, soil. Specific waste: corrosive, ignitable, listed, reactive, TCLP. Contact-handled	570	Operational
Solid and sludge mixed TRU waste, TRU waste; metal, other; listed, TCLP.	Under evaluation per LANLsite treatment plan	Operational
Solid and sludge mixed TRU waste, TRU waste; hazardous waste; other; ignitable, listed, TCLP	Under evaluation per LANLsite treatment plan	Operational
Solid and sludge mixed TRU waste, TRU waste; hazardous waste; other; listed, TCLP	3,000	Operational
Solid mixed TRU waste, TRU waste, hazardous waste. Specific waste: corrosive, ignitable, listed, reactive, TCLP. Contact-handled	6.25	Operational
Solid mixed TRU waste, TRU waste, hazardous waste. Specific waste: corrosive, ignitable, listed, reactive, TCLP	Under evaluation per LANL site treatment plan	Operational
Solid mixed TRU waste, TRU waste, hazardous waste. Specific waste: corrosive, ignitable, listed, reactive, TCLP	Under evaluation per LANL site treatment plan	Operational
Solid mixed TRU waste, TRU waste, hazardous waste. Specific waste: corrosive, ignitable, listed, reactive, TCLP	Under evaluation per LANL site treatment plan	Operational
Solid mixed TRU waste, TRU waste. Solid type: equipment, glass, metal, paper, plastic, rags, rubber, soil. Specific waste: listed. Contact-handled, remote-handled	357	Operational
Solid and sludge mixed TRU waste, TRU waste, hazardous waste. Specific waste: listed, TCLP	Under evaluation per LANL site treatment plan	Operational
Solid mixed TRU waste, TRU waste. Specific waste: listed, TCLP. Remote-handled	Under evaluation per LANL site treatment plan	Planned and funded
Solid and sludge mixed TRU waste, TRU waste, hazardous waste. Specific waste: listed. Contact-handled	418.81	Operational
Solid mixed TRU waste, TRU waste, hazardous waste. Solid type: equipment, filters, glass, metal, paper, plastic, rags, rubber, soil. Specific waste: listed. Contact-handled	570	Operational

Treatability Group
IPA wastes
Scintillation fluids
Lead blankets
Soil with heavy metals
Environmental restoration soils
Aqueous organic liquids
Halogenated organic liquids
Nonhalogenated organic liquids
Bulk oils
Polychlorinated biphenyls wastes with *Resource Conservation and Recovery Act* components
Organic-contaminated combustible solids
Combustible debris
Aqueous wastes with heavy metals
Corrosive solutions
Aqueous cyanides, nitrates, chromates, and arsenates
Water-reactive wastes
Compressed gases requiring scrubbing
Compressed gases requiring oxidation
Organic-contaminated noncombustible solids
Elemental mercury
Activated or inseparable lead
Noncombustible debris
Inorganic solid oxidizers
Lead wastes
Mercury wastes
Compressed gases
Biochemical laboratory wastes
Dewatered treatment sludge
Nonradioactive or suspect waste items
Surface-contaminated lead
Lead requiring sorting
Total
LANL 1995a.

Table H.2.5-4.-- Mixed Low-Level Waste Streams at Los Alamos National Laboratory

Number of Items	Net Volume (m^3)	Projected Net Volume (1995-2000) (m^3)	Preferred Option	Alternate Option	Treatment Site
104	15.89	0.01	Commercial thermal treatment	Hydrothermal	offsite

18	2.47	4.0	Commercial thermal treatment	Hydrothermal	offsite
4	0.74	0.2	Commercial treatment	Macroencapsulation	offsite
59	10.53	2.0	Commercial treatment	Chelator extraction	offsite
36	39.32	unknown	Commercial treatment	Macroencapsulation	offsite
45	1.65	0.5	Evaporative oxidation	Hydrothermal	onsite
385	16.58	5.5	Hydrothermal	DETOX process	onsite
275	14.34	10.0	Hydrothermal	DETOX process	onsite
28	3.75	3.0	Hydrothermal	DETOX process	onsite
4	0.74	0.2	Hydrothermal	DETOX process	onsite
307	28.32	7.0	Thermal desorption	Under evaluation per LANL site treatment plan	onsite
83	13.82	1.5	Macroencapsulation	Under evaluation per LANL site treatment plan	onsite
203	1.85	1.0	Chemical plating waste skid	Evaporative oxidation	onsite
162	1.36	0.5	Chemical plating waste skid	Evaporative oxidation	onsite
15	0.13	0.01	Chemical plating waste skid	Evaporative oxidation	onsite
78	6.03	0.2	Water-reactive metals skid	Under evaluation per LANL site treatment plan	onsite
13	0.35	0.1	Gas scrubbing skid	Under evaluation per LANL site treatment plan	onsite
6	0.08	0.1	Gas oxidation skid	Under evaluation per LANL site treatment plan	onsite
80	7.82	8.0	Thermal desorption	Under evaluation per LANL site treatment plan	onsite
45	0.5	0.05	Amalgamation	Under evaluation per LANL site treatment plan	onsite
74	15.6	1.0	Macroencapsulation	Under evaluation per LANL site treatment plan	onsite
41	5.62	3.0	Macroencapsulation	Under evaluation per LANL site treatment plan	onsite

55	0.2	0.05	Hydrothermal	Under evaluation per LANL site treatment plan	onsite
186	51.44	10.0	Under evaluation per LANL site treatment plan	Under evaluation per LANL site treatment plan	Under evaluation per LANL site treatment plan
63	18.3	25.5	Under evaluation per LANL site treatment plan	Under evaluation per LANL site treatment plan	Under evaluation per LANL site treatment plan
10	1.25	2.0	Under evaluation per LANL site treatment plan	Under evaluation per LANL site treatment plan	Under evaluation per LANL site treatment plan
9	1.34	unknown	Under evaluation per LANL site treatment plan	Under evaluation per LANL site treatment plan	Under evaluation per LANL site treatment plan
1,288	268.17	unknown	Under evaluation per LANL site treatment plan	Under evaluation per LANL site treatment plan	Under evaluation per LANL site treatment plan
1,250	14.24	9.5	Sort, survey, and decontaminate	Appropriate treatment	onsite
125	56.2	12.5	Lead decontamination trailer	Under evaluation per LANL site treatment plan	onsite
48	9.97	0.0	Sort based on treatment	Under evaluation per LANL site treatment plan	onsite
5,099	608.61	107.9			

26 Schedules and capacities for facilities under design or construction are subject to changes based on the availability of funds, permit issuance, and so forth. New shafts and domes can be built as needed. Only one half of the 64-acre site is used for aboveground storage.
DOE 1994k.
DOE 1994k.

H.2.6 Lawrence Livermore National Laboratory

The DOE Oakland Operations Office is the field organization responsible for the implementation of waste management plans at Lawrence Livermore National Laboratory (LLNL). The LLNL Hazardous Waste Management Division is responsible for preparing those plans. The Division is also responsible for processing all hazardous wastes, radioactive wastes, and mixed wastes generated at both the Livermore Site and Site 300. The Livermore Site and Site 300 do not generate or manage spent nuclear fuel or HLW. Both the Livermore Site and Site 300 are on the NPL for sites requiring environmental restoration in accordance with CERCLA and SARA. Because there is no spent nuclear fuel, HLW, or TRU waste associated with any of the proposed activities at the Livermore Site and Site 300 (secondary and case fabrication, HE fabrication, nonnuclear fabrication, NIF, and CFF), there will be no further discussion in this appendix of spent nuclear fuel, HLW, or TRU waste generation and management at the Livermore Site and Site 300.

Pollution Prevention. The *Waste Minimization and Pollution Prevention Awareness Plan* published on April 25, 1994, documents LLNL projections for present and future waste minimization and pollution prevention. The plan specifies those activities and methods used to reduce the quantity and toxicity of wastes generated at the site.

Low-Level Waste. LLNL has a relatively large inventory of noncertified LLW that must be characterized, certified, and disposed of. Most of this waste was generated between 1988 and 1993 and consists of roughly 7,000 drum equivalents. An ongoing multiphase project will ultimately conclude with the disposal of the entire LLNL legacy LLW inventory. This project includes the preparation of a waste disposal addendum to the LLNL waste disposal application that will cover legacy waste and any waste certification procedures.

Aqueous LLW is treated at Building 514, the Liquid Waste Treatment Facility. At the facility, containerized and bulk radioactive liquid wastes are transferred into one of the six 7,000-L (1,850-gal) tanks to be treated chemically. The tanks are used to treat both radioactive and mixed waste liquids. Following treatment, if the tank's contents are below established sewer discharge limits, the liquid is released to the sanitary sewer. The precipitate wastes from the chemical treatments are filtered to create a filter cake. The filter cake is then stabilized. Captured filtrate is either discharged to the sanitary sewer or retreated.

No liquid LLW is generated at Site 300. Most Site 300 solid LLW is generated from the detonation of test assemblies on firing tables. The debris consists of gravel and fragments of wood, metal, and glass; larger debris consists of tent poles and pieces of wood, steel, aluminum, concrete, plastic, glass, burlap bags, cables, and other inert testing materials. These parts are contaminated with depleted uranium and sometimes, thorium. Firing table operations have also periodically generated wastes containing tritium. LLW, including the gravel from firing table operations, is packaged in approved waste containers and transported to Building 804 for staging, pending shipment to the Livermore Site or shipment directly to NTS for disposal.

Mixed Low-Level Waste. Current inventories of mixed LLW at LLNL total approximately 457 m^3 (598 yd^3). Schedules for waste treatment vary by waste stream. Mixed waste (other than wastewater, which is treated at Building 514) is appropriately packaged and stored at the Area 514 complex or the Area 612 complex, pending establishment of a suitable onsite or offsite facility that can dispose of such waste according to applicable regulations. Descriptions of mixed waste treatment options,

inventory, treatment, disposal and storage facilities for LLW, and mixed LLW are listed in tables H.2.6-1, H.2.6-2, and H.2.6-3.

Some mixed waste can be chemically or physically treated at LLNL. Existing treatment for mixed wastes includes neutralization, flocculation, chemical reduction and oxidation, precipitation, separation, filtration, solidification, size reduction, shredding, adsorption, and blending. Mixed wastes are currently treated in the Building 513 Solidification Unit, the Area 514 Wastewater Filtration Unit, and the Area 514 Wastewater Treatment Tank Farm Unit.

LLNL has requested regulatory agency approval to add centrifugation and evaporation treatment units, as well as to increase current treatment operations for mixed wastes. Also, mixed wastes are stored in appropriate units at the Livermore Site for extended periods until they can be shipped to an approved offsite treatment and/or disposal facility. Although LLNL does not have current existing treatment units to treat its organic liquid mixed waste, it is planning to develop treatment technology for these waste streams.

The matrices of the mixed LLW to be generated in the future include aqueous liquid, homogeneous solids, organic and inorganic debris, organic liquids, reactive metals, elemental lead, high efficiency particulate air (HEPA) filters, and elemental mercury. The aqueous liquid and homogeneous solids waste streams are projected to each generate 92 percent of the mixed LLW. Organic liquids will account for almost 3 percent of the future volume and the organic/inorganic debris is projected to account for approximately 4 percent of the mixed LLW. Reactive metals, elemental lead, HEPA filters, and elemental mercury account for the remaining 1 percent.

Soils from environmental restoration activities may contain low-level radioactivity (primarily tritium and some depleted uranium at Site 300) mixed with low concentrations of VOCs and possibly some metals (i.e., cadmium, lead, chromium, copper, nickel, zinc, beryllium, and mercury) in the soil matrix. The waste would primarily be generated during drilling operations and minor excavations. Environmental restoration drilling activities at LLNL are likely to occur through 1998. The generation rate of wastes from LLNL drilling is estimated to be 20 to 50 drums per year, or approximately 17 to 42 m^3 (22 to 55 yd^3) through 1998 (LLNL 1995h:6-2).

At Site 300, liquids (groundwater) from developing, testing, and purging wells that contain tritium and VOCs as the primary contaminants could potentially be generated. The total estimated volume of potential liquid mixed waste is less than 18,927 L/yr (5,000 gal/yr). This would correspond to 76 m^3 (100 yd^3) through 1998 (LLNL 1995h:6-2). Future generation of mixed waste at Site 300 is not anticipated.

Hazardous Waste. As a research facility, LLNL generates a variety of hazardous wastes, many in relatively small quantities. Almost all buildings generate hazardous wastes, ranging from common household items such as fluorescent light tubes, batteries, and lead-based paint to solvents, metals, cyanides, toxic organics, pesticides, asbestos, and PCBs. Table H.2.6-4 lists hazardous waste quantities shipped offsite from LLNL in 1994.

LLNL presently operates five hazardous waste management facilities. These are the Area 514 Facility, Area 612 Facility, Building 233 Facility, Building 693 Facility, and Building 419 Facility. The Area 514 and 612 facilities include treatment and storage units for hazardous and mixed wastes; the Building 233 facility is a container storage unit for hazardous and mixed wastes; the Building 693 Facility is a container storage unit for hazardous wastes, but will eventually be used for the storage of

both hazardous and mixed wastes; and the Building 419 Facility includes inactive treatment units that are awaiting regulatory closure.

LLNL is currently operating its hazardous waste management activities under the interim status standards of the California Code of Regulations, Title 22, Part 66265. A RCRA Part B Permit application has been submitted to the State of California for continued operation, and a final permit is expected in 1996. Under interim status, LLNL receives hazardous and/or mixed wastes from Site 300.

Site 300 operates two hazardous waste management units. These units are only used for the treatment and long-term storage (i.e., greater than 90-day storage) of hazardous wastes. The Building 883 container storage area is a covered storage area on the southwest side of Building 883. The facility is designed primarily to hold hazardous waste before it is transferred to the Area 612 Facility at LLNL for treatment, storage, and disposal or sent directly offsite for disposal. It is currently permitted under the RCRA Part B Permit for Site 300. Table H.2.6-5 lists hazardous waste quantities shipped offsite from Site 300 in 1994.

Table H.2.6-1. Mixed Low-Level Waste Streams at Lawrence Livermore National Laboratory

Waste Description	Source Description	Inventory as of January 1995(m^3)	Total Generation 1995-1999 Projection (m^3)	Treatment Option
Organic fluids and glass	Changing R&D activities which provide liquid organic fluids in glass vials	5.5	5	Treating or plan to treat onsite
Filter cake	Rotary drum vacuum filtration of LLNL wastewaters (Building 514)	105.9	110	Treating or plan to treat onsite
Inorganic trash	Changing R&D activities which generate cleanup trash and used safety equipment such as coveralls	8.7	7	Treating or plan to treat offsite
Wash waters	Laboratory-wide R&D	68.1	1,350	Treating or plan to treat onsite
Inorganic sludges and particulates	Onsite retention tank cleaning and surface spill cleanup	2.8	5	Treating or plan to treat onsite
Scrap metal	Onsite research and maintenance including lab	15.2	5	Treating or plan to treat offsite
Lead bricks	Used and discarded lead bricks which may have been used for shielding purposes	3.9	5	Treating or plan to treat offsite

Halogenated solvent	From/by phase separation from onsite waste water treatment processes	7.1	10	Treating or plan to treat onsite
Oils	Waste oils skimmed by phase separation from onsite waste water treatment processes	3.6	8.5	Treating or plan to treat onsite
Soil-1	Soil excavated from onsite trenching activities	10.1	10	Treating or plan to treat onsite
Lithium metal	Used and discarded laboratory waste from changing R&D activities	1.0	1.0	Treating or plan to treat onsite
Oils	Draining of vacuum pumps. Onsite R&D activities which use halogenated solvents	13.7	20	Treating or plan to treat onsite
HEPA filters	Generated by onsite research activities and facility maintenance	3	15	Treating or plan to treat offsite
Organic liquids	Changing biomedical and nuclear chemistry R&D activities	0.3	1	Treating or plan to treat onsite
Inorganic trash-3	Changing research and laboratory cleanup activities	50.7	50	Treating or plan to treat offsite
Lab packs with metals	Onsite R&D activities	0.8	1.5	Treating or plan to treat offsite
Metal chips and coolant	Depleted uranium turnings and chips from machining operations	3.2	unknown	Treatment options still being assessed
Contaminated soils	Waste generated from equipment maintenance	6.6	30	Treating or plan to treat onsite
Liquid mercury waste	Equipment maintenance	0.09	0.05	Treating or plan to treat offsite
Stabilized sludges and particulates	Sludges from tank bottoms and equipment cleanout that have been solidified/stabilized with cement	141.3	125	Treating or plan to treat onsite
Organic sludges and particulates	Sump waste, lab sink waste, dip tanks, etc.	1.2	5	Treating or plan to treat onsite

Other reactives	Contaminated equipment and containerized waste generated from onsite R&D activities	4.4	1	Treatment options still being assessed
Total		**457.19**	**1,765**	
DOE 1995gg.				

Table H.2.6-2. Low-Level Waste and Mixed Low-Level Waste Treatment Capability at Lawrence Livermore National Laboratory

Treatment Unit	Treatment Method	Input Capability	Output Capability	Total Capacity[1] (m^3/yr)	Comment
Building 513 shredding unit	Shredding, size reduction	Solid mixed LLW	Solid mixed LLW to Area 612 container storage units	5.5×10^6 kg/yr	RCRA Part A interim status; Closure date: 2009
Building 612 drum/container crushing unit	Size reduction	Solid mixed LLW	Solid mixed LLW (crushed empty drums) to Area 612 container storage unit	1.248×10^6 kg/yr	Permits: District Air; RCRA Part A interim status; Closure date: 2004
Area 514-1 cold vapor evaporation unit	Evaporation neutralization	Liquid mixed LLW	Liquid mixed LLW to Area 514 wastewater filtration	7,495	Permits: District Air; RCRA Part A interim status; Closure date: 2011
Area 514-1 centrifugation unit	Centrifugation separation	Liquid mixed LLW	Liquid mixed LLW to Area 514 wastewater filtration	7,495	Permits: District Air; RCRA Part A interim status; Closure date: 2011
Area 514 wastewater filtration unit	Filtration	Liquid mixed LLW	Solid mixed LLW to Area 612 container storage unit	3,731	Permits: RCRA Part A interim status; Closure date: 2004

Area 514 Wastewater Treatment Tank Farm	Liquid/solid separation, ion exchange, neutralization; leaching, oxidation, carbon adsorption, precipitation; deactivation, reduction, flocculation	Liquid mixed LLW	Liquid mixed LLW to Area 514 wastewater filtration	7,495	Permits: RCRA Part A interim status; Closure date: 2004
Area 514-1 carbon adsorption unit	Carbon adsorption, solvent extraction	Liquid mixed LLW	Liquid mixed LLW to Area 514 wastewater filtration	7,495	Permits: District Air; Closure date: 2011
Area 514-1/portable blending unit	Neutralization blending, flocculation	Liquid mixed LLW	Mixed LLW to Area 514 wastewater filtration	7,495	Permits: District Air; Closure date: 2011
Area 514-1/tank blending unit	Neutralization blending, flocculation	Liquid mixed LLW	Mixed LLW to Area 514 wastewater filtration	7,495	
Building 513 solidification unit	Solidification neutralization stabilization, immobilization	Liquid mixed LLW, solid mixed LLW	Solid mixed LLW to Area 612 container storage units	1,347	RCRA Part A interim status; Closure date: 2004
Building 612 size reduction unit	Size reduction, decontamination	Solid mixed LLW	Solid mixed LLW (size reduced) to Area 612 container storage units	1 x 10^6kg/yr	RCRA Part A interim status; this unit replaces the size reduction unit in building 419. Closure date: 2011
Decontamination and Waste Treatment Facility	Will replace areas 514 and 612 using same type treatment methods	Liquid mixed LLW, solid mixed LLW; liquid LLW; solid LLW	**Not determined**	Not determined	The RCRA Part B permit application has not been submitted yet. This is a planned facility.

Table H.2.6-3. Low-Level Waste and Mixed Low-Level Waste Storage at Lawrence Livermore National Laboratory

Storage Unit	Input Capability	Design Capacity[2] (m^3)	Comment
Receiving, segregation, and container storage (Area 612-4)	Liquid mixed LLW; solid mixed LLW	180.1	Container storage-RCRA Part A interim status; Closure date: 2009
Building 513 container storage unit	Solid mixed LLW	60	Container storage-RCRA Part A interim status; Closure date: 2004
Building 625 container storage unit	Liquid mixed LLW; solid mixed LLW	80.28	Container storage-RCRA Part A interim status; Closure date: 2009
Building 612 container storage unit	Liquid mixed LLW; solid mixed LLW	145.9	Container storage-RCRA Part A interim status; Closure date: 2009
Building 614 west cells container storage	Liquid mixed LLW; solid mixed LLW	2.55	Container storage-RCRA Part A interim status; Closure date: 2004
Area 514-2 container storage unit	Liquid mixed LLW; solid mixed LLW	39.4	Container storage-RCRA Part A interim status; Closure date: 2009
Area 514-1 container storage unit	Liquid mixed LLW; solid mixed LLW	53.4	Container storage-RCRA Part A interim status; Closure date: 2009
Area 514 storage tank (514-R501 unit)	Liquid mixed LLW; liquid hazardous waste	84.5	Tank storage-RCRA Part A interim status; Closure date: 2004
Area 514-3 container storage unit	Liquid mixed LLW; solid mixed LLW	83.47	Container storage-RCRA Part A interim status; Closure date: 2009
Area 612 tank trailer storage unit	Liquid mixed LLW	19	Tank storage-RCRA Part A interim status; Closure date: 2009
Area 612-1 container storage unit	Solid mixed LLW	1,086.4	Container storage-RCRA Part A interim status; Closure date: 2004
Area 612-5 container storage unit	Solid mixed LLW	760.78	Container storage-RCRA Part A interim status; Closure date: 2004

Area 612-2 container storage unit	Liquid mixed LLW; solid mixed LLW	40	Container storage-RCRA Part A interim status; Closure date: 2009
Building 612 container storage unit	Liquid mixed LLW; solid mixed LLW; PCB TSCA mixed only	281.9	Container storage-RCRA Part A interim status; Closure date: 2014
Building 233 container storage unit	Liquid mixed LLW; solid mixed LLW	56.63	Container storage-RCRA Part A interim status; Closure date: 2023

Table H.2.6-4. Hazardous Waste Quantities Shipped Offsite in 1994, Lawrence Livermore National Laboratory

Description	Number of Shipments Containing Description	Quantity (kg)	Estimated Volume[3] (m^3)
Articles, explosives, n.o.s.	6	12	<0.1
Barium nitrate	1	68	<0.1
Blue asbestos	8	321,113	214.1
Caustic alkali liquids, n.o.s.	17	3,828	3.8
Combustible liquid, n.o.s.	23	31,472	31.5
Compounds, cleaning liquid	3	91	<0.1
Corrosive solids, poisonous, n.o.s.	1	5	<0.1
Corrosive liquids, n.o.s.	41	11,755	11.8
Corrosive solids, n.o.s.	8	585	0.4
Corrosive liquids, oxidizing, n.o.s.	5	612	0.6
Corrosive liquids, poisonous, n.o.s.	3	151	0.2
Corrosive liquids, flammable, n.o.s.	3	37	<0.1
Environmentally hazardous substances, solid, n.o.s.	2	23,827	15.6
Environmentally hazardous substances, liquid, n.o.s.	1	438	0.4
Flammable solids, n.o.s.	10	977	0.7
Flammable liquids, corrosive, n.o.s.	12	302	0.3
Flammable liquids, n.o.s.	37	17,292	17.3
Flammable solids, poisonous, n.o.s.	1	12	<0.1
Flammable solids, corrosive, n.o.s.	1	32	<0.1
Flammable liquids, poisonous, n.o.s.	16	988	1.0
Hazardous waste, liquid	1	1,429	1.4
Hazardous waste, solid, n.o.s.	2	36,505	24.3
Hazardous waste, solid	3	37,025	24.7

Metal powders, flammable, n.o.s.	4	872	0.6
Nitrates, inorganic, n.o.s.	1	40	<0.1
Non-RCRA hazardous waste solid	53	287,054	191.4
Non-RCRA hazardous waste, liquid	60	62,121	62.1
Organochlorine pesticides, solid toxic, n.o.s.	1	8	<0.1
Oxidizing substances, liquid, corrosive, n.o.s.	2	211	0.2
Oxidizing substances, solid, corrosive, n.o.s.	2	16	<0.1
Oxidizing substances, solid, n.o.s.	7	149	0.1
Oxidizing substances, solid, poisonous, n.o.s.	5	65	<0.1
Oxidizing substances, liquid, n.o.s.	1	6	<0.1
Poisonous solids, corrosive, n.o.s.	1	6	<0.1
Poisonous liquids, corrosive, n.o.s.	4	288	0.3
Poisonous solids, n.o.s.	12	177	0.1
Poisonous liquids, n.o.s.	11	329	0.3
Polychlorinated biphenyls	20	21,779	14.5
Pyrophoric, liquids, n.o.s.	2	19	<0.1
Pyrophoric metals, n.o.s.	3	150	0.1
Pyrophoric solids, n.o.s.	1	15	<0.1
Substances, explosive, n.o.s.	1	8	<0.1
Substances which in contact with water emit flammable gases, liquid	5	39	<0.1
Substances which in contact with water emit flammable gases, solid	12	158	0.1

LLNL generates several types of medical wastes consisting of biohazardous waste and sharps (i.e., needles, blades, and glass slides) waste from biomedical research, Center for Chemical Forensics, and health services facilities. In July 1991, LLNL registered with the Alameda County Environmental Health Services as a large-quantity generator of medical waste, and submitted an application for a medical waste treatment permit. The treatment permit was issued in August 1991 and is valid through July 1996.

Table H.2.6-5. Hazardous Waste Quantities Shipped Offsite in 1994, Lawrence Livermore National Laboratory Site 300

Description	Number of Shipments Containing Description	Quantity (kg)	Estimated Volume[4] (m^3)
Combustible liquids, n.o.s.	5	30,030	30.0

Compounds, cleaning liquid	4	174	0.2
Corrosive liquids, n.o.s.	1	309	0.3
Non-RCRA hazardous waste liquid	10	34,036	34.0
Non-RCRA hazardous waste solid	8	28,316	18.9

Medical wastes from the Biomedical Sciences Division are autoclaved in Building 365 for sterilization before disposal as sanitary waste, except those biological wastes containing carcinogens. These wastes are inactivated chemically, or when this is not possible, disposed of in an appropriately labeled carcinogen/radioactive waste container. Sharps waste is sent to a commercial incinerator following sterilization.

Medical waste from Site 300 is generated at the Medical Facility, Building 877. These wastes are transported to LLNL where they are autoclaved at Building 365. The sterilized materials are then disposed of as sanitary waste.

Nonhazardous Waste. The Livermore Site discharges approximately 1.1 million liters per day (0.209 million gallons per day) of wastewater to the city of Livermore sewer system; this amount is less than 7 percent of the total flow to the city system (LLNL 1995d:6-1). This volume includes wastewater generated by Sandia National Laboratories (SNL) (Livermore). The wastewater contains sanitary sewage and industrial effluent from both LLNL and SNL and is discharged according to permit requirements and the city of Livermore Public Services Ordinance. The effluent is processed at the Livermore Water Reclamation Plant. As part of the Livermore-Amador Valley Wastewater Management Program, the treated sanitary wastewater is transported out of the valley through a pipeline and discharged into the San Francisco Bay. A small portion of the treated effluent from the Livermore Water Reclamation Plant is used for summer irrigation of the municipal golf course, which is next to the Livermore Water Reclamation Plant. Sludge from the treatment process is disposed of in sanitary landfills.

Administrative and engineering controls at the Livermore Site prevent potentially contaminated wastewater from being discharged directly to the sanitary sewer. Wastewater is collected and monitored at several different points from its generation to its release to the municipal collection system. LLNL completed construction of a diversion system to hold wastewater that is unacceptable for release to the Livermore Water Reclamation Plant. When an unacceptable discharge is detected by the monitoring system, the diversion system is automatically activated. Up to 775,000 L (205,000 gal) of potentially contaminated sewage can be held pending analysis to find the appropriate handling methods. The diverted effluent may be returned to the sanitary sewer, shipped for offsite disposal, or treated at LLNL's Hazardous Waste Management Facility.

Sanitary wastewater generated within the General Services Area at Site 300 is discharged to an onsite sewer lagoon. Other more remotely located buildings on Site 300 are serviced by septic systems and leach fields. Industrial wastewaters are contained in retention tanks and analyzed, and their proper disposition decided. These wastewaters may be shipped to LLNL for treatment and discharged to the sanitary sewer system or shipped directly to an offsite treatment and disposal facility. The nonhazardous rinsewaters from the HE machining, pressing, and formulation processes are disposed of by surface evaporation from two ponds.

LLNL does not have any onsite solid waste disposal facilities. After waste reduction and recycling, solid wastes are collected in dumpsters and other similar containers and transported to the Vasco Road Landfill for disposal. Solid waste generated at Site 300 is transported to the Corral Hollow Sanitary Landfill, approximately 6.44 km (4 mi) east of Site 300 on Corral Hollow Road. The San Joaquin County Public Works Department is currently evaluating alternatives for solid waste disposal, including expansion of the Corral Hollow Sanitary Landfill, siting of new landfills, and construction of a transfer station for disposal at another landfill.

The California Integrated Waste Management Act of 1989 mandates reductions in sanitary waste by counties. Sanitary waste must be reduced by at least 25 percent by 1995; the base year for this reduction is 1990. By 2000, the reduction must be 50 percent compared to the 1990 base. LLNL has already reduced this waste stream by over 40 percent from the 1990 base (LLNL 1995b:68).

1 For those facilities in use this is a normal operating capacity; whereas, for facilities under design or construction this is a design capacity. Schedules and capacities for facilities under design or construction are subject to changes based on the availability of funds, results of treatability studies, permit issuance, etc. DOE 1994n; LLNL 1996i:2.

2 Schedules and capacities for facilities under design or construction are subject to changes based on the availability of funds, permit issuance, etc. > DOE 1994k.

3 For those shipments in which only a mass quantity was provided, a volume estimate was made based on density factors of 1,000 kg/m^3 for liquids and 1,500 kg/m^3 for solids. n.o.s. - not otherwise specified. DOE 1995h.

4 For those shipments in which only a mass quantity was provided, a volume estimate was made based on density factors of 1,000 kg/m^3 for liquids and 1,500 kg/m^3 for solids. n.o.s. - not otherwise specified. DOE 1995h.

H.2.7 Sandia National Laboratories

At the Albuquerque location of SNL, activities for R&D on national security and energy projects result in the generation and required management of TRU, low-level, mixed, hazardous, solid industrial, and sanitary wastes. SNL also has five spent nuclear fuel storage facilities: the Manzano Storage Structures, the Annular Core Research Reactor Facility, the Sandia Pulse Reactor Facility, the Hot Cell Facility, and the Special Nuclear Materials Storage Facility. Past activities associated with nuclear weapon development, engineering, and testing at the site has resulted in environmental contamination. The principal sources included tests on weapons and weapon components, discharges of radioactive liquids and hazardous chemicals into the environment, oil spills, disposal of radioactive waste and hazardous chemicals in landfills, rocket launches, and burning of waste, including HE. The contaminated facilities range from reactors to scrap yards. SNL is not on the NPL for sites requiring environmental restoration in accordance with CERCLA and SARA. Because there is no spent nuclear fuel, HLW, or TRU waste associated with any of the proposed activities at SNL (nonnuclear fabrication and NIF), there will be no further discussion of these wastes at SNL in this appendix.

Pollution Prevention. A formal Waste Minimization and Pollution Prevention Awareness Program was initiated at SNL in 1989 to comply with EPA regulations and DOE orders. A Waste Minimization and Pollution Prevention Awareness Plan was completed in December 1991 and updated in December 1992 and May 1994. The plan specifies those activities and methods required to reduce the quantity and toxicity of wastes generated at the site.

Low-Level Waste. Onsite disposal of LLW at SNL was terminated in December 1988 as a result of a DOE order. Currently, all newly generated LLW is stored temporarily above ground at generator sites or in transportation containers at the inactive Technical Area III disposal site. In 1994, approximately 53 m3 (69 yd3) of LLW was accepted at the Technical Area III storage site (SNL 1995g:3-5). This waste consisted primarily of fission product and uranium-contaminated waste on a volumetric basis, and tritium-contaminated waste on an activity basis. The total liquid LLW and solid LLW generated in 1994 as packaged for treatment or storage was 0.912 m3 (1.19 yd^3) and 53.3 m^3 (69.7 yd^3), respectively (SNL 1995f:7). All LLW packages were stored at the Technical Area III storage site and shipped for disposal at NTS.

Mixed Low-Level Waste. Unique tests and experimental programs at SNL have generated small volumes of a broad variety of mixed wastes. The total SNL liquid mixed LLW and solid mixed LLW generated in 1994 as packaged for treatment or storage was 0.007 m^3 (2 gal) and 1.94 m^3 (2.54yd^3), respectively (SNL 1995f:7).

SNL has submitted a Part B Permit application for a permit under RCRA, as amended, to allow for the storage and treatment of mixed radioactive and hazardous wastes. In August 1990, SNL submitted a RCRA Part A Permit application (interim status) to the State of New Mexico for the storage and limited treatment of mixed waste. In October 1992, a permitting strategy in the form of a Letter Agreement was submitted to the State of New Mexico for the SNL mixed waste Part B Permit application. In November 1992, SNL submitted a RCRA Part B Permit application for mixed waste. This application and the Part A application were amended in August 1993 and December 1994 submittals to the state. In January 1995, SNL submitted a revised mixed waste Part A and Part B Permit application to the New Mexico Environment Department. Treatments in the combined permit application now include compaction, stabilization/solidification, shredding/baling,

decontamination/waste segregation, pH neutralization, encapsulation, chemical stripping/dissolution, destruction/extraction, chemical precipitation, amalgamation, ion exchange, reverse osmosis, demineralization, and hazard separation.

The Environmental Restoration Program at SNL is being performed under a RCRA Hazardous and Solid Waste Amendments Permit. The permit outlines the corrective action or cleanup processes at specific sites at SNL. The Environmental Restoration Program currently has no existing mixed waste in inventory. It is likely that some mixed waste will be generated during corrective action activities such as RCRA closures, RCRA facility investigations, corrective measures studies, and the implementation of selective corrective measures. The possible waste forms include soil and soil cuttings from drilling and excavation, excavated material such as discarded equipment, contaminated groundwater, decontamination liquid from the cleaning of drilling and sampling equipment, and personal protective equipment (SNL 1995c:6-2).

Although there are currently no operational onsite mixed LLW treatment facilities at SNL, plans are underway to develop some limited capabilities to ensure that mixed LLW can be treated to meet the land disposal restrictions treatment standards using existing technologies. The mixed waste site treatment plan at SNL is heavily integrated with the work at other DOE sites that are tasked with developing mobile treatment units for use at multiple sites. This development involves proving-in new applications of technologies that are currently available but will require testing through treatability studies (SNL 1995c:iii).

Other waste streams, such as explosives, are being studied for onsite treatment by SNL because of its unique nature or handling requirements, or for development of treatment procedures that will facilitate eventual disposal, such as those required by the Nevada Operations Office for disposal at NTS. Offsite commercial treatment and disposal is an option for a small volume of scintillation waste and for waste that may not be treatable to meet the NTS Waste Acceptance Criteria (SNL 1995c:iii).

The Radioactive and Mixed Waste Management Facility at SNL Technical Area III was completed in 1990. Due to changes in regulations during construction, some facility upgrades are required before operations can begin. Once operational, mixed LLW will be treated in accordance with the strategies identified in the mixed waste Site Treatment Plan. This 557-m2 (6,000-ft2) facility will provide the means to open, treat, and repackage LLW and mixed LLW. The Radioactive and Mixed Waste Management Facility is expected to be operational in 1996 (SNL 1995g:3-5).

Currently, the Waste Operations Department operates the Technical Area III interim storage site. There are nine units described in the current RCRA Mixed Waste Part B Permit application, as amended in December 1994. The seven Manzano bunkers, the Radioactive and Mixed Waste Management Facility, and Building 6596 will be the main areas for mixed waste storage in the future. No additional storage capacity will be needed based on future generation rates. Most of these units are within the SNL technical areas although explosives are stored in the Manzano bunkers.

The mixed waste streams at SNL have been combined into 16 treatability groups, each with a preferred treatment option. Descriptions of the mixed waste treatability groups, volumes, preferred treatment option, and treatment site and facility are listed in table H.2.7-1. Treatment and storage facilities for LLW and mixed LLW are listed in tables H.2.7-2 and H.2.7-3.

Table H.2.7-1. Mixed Low-Level Waste Streams at Sandia National Laboratories

Treatability Group	Number of Waste Streams	Inventory as of May 1995 (m3)	Projected Generation 1995 to 1999 5 (m^3)	Preferred Treatment Option	Treatment Site and Facility
Inorganic debris (with an explosive component): neutron generators, thermal batteries, and four small waste streams contaminated wit h energetic materials	6	2.7	<1	Deactivation	Onsite treatability study
Inorganic debris (with a water reactive constituent): lithium batteries and activated metallic sodium	2	0.04	<1	Deactivation	Onsite treatability study
Reactive metals: pyrophoric metal powders and finely divided metal powders	7	0.02	<1	Deactivation/ stabilization	Onsite treatability study
Elemental lead: lead shielding, bricks, pigs, boxes, and gasket	3	0.04	<1 6	Macroencapsulate	Onsite using Pantex MTU
Aqueous liquids (corrosive): liquid acids or bases (pH < 2.1 or >12.4)	2	0.02	<1	Neutralization and stabilization	Onsite treatability study
Elemental mercury: tritium-contaminated mercury from temperature and altitude chambers; and tritium and uranium-238 contaminated mercury	1	0.0001	<1 7	Amalgamate	Onsite using Pinellas MTU
Organic liquids I: hazardous scintillation waste and methanol	1	0.2	0 8	Incineration	Offsite commercial facility
Organic debris (with organic contaminants): swipes, wipes, and personal protective equipment contaminated with solvents	32	28	1 9	Thermal desorption	Onsite using GJPO MTU

Inorganic debris (with TCLP metals): cadmium sheets or rods, circuit boards with lead or silver solder, batteries, cables, electronic devices, weapons components	42	7	15 [10]	Macroencapsulate	Onsite using Pantex MTU
Heterogeneous debris: contains both organic (combustible) and inorganic (noncombustible) debris	10	29	155 [11]	No data provided	Onsite
Organic liquids II: vacuum pump oils, mixed nonhalogenated solvents, and a grinding sludge with trichloroethylene	1	2.7	<1	Hydrothermal processing	Onsite using LANL MTU (Treatability study at LANL)
Organic debris (with TCLP metals): swipes, wipes, personnel protection equipment, and trash contaminated with metals	3	0.6	<1	Macroencapsulate	Onsite using Pantex MTU
Oxidizers: uranyl perchlorates, uranyl nitrates, thorium nitrates, and uranium oxynitrate	3	0.01	<1	Deactivation	Onsite treatability study
Aqueous liquids (organic contaminants): corrosive liquid with methanol	1	0.01	159 [11]	Evaporation, oxidation	Treatability study at GJPO
Soils <50 percent debris	None	0	89 [11]	No current inventory at SNL	No current inventory at SNL
Cyanide waste: potassium cyanide with uranium-238	None	0.001	0	Oxidation	Treatability study at LANL
Total	114	70.3411	<428	-	-

Table H.2.7-2. Low-Level Waste and Mixed Low-Level Waste Treatment Capability at Sandia National Laboratories

Treatment Unit	Treatment Method	Input Capability	Output Capability	Total Capacity[12] (m3/yr)	Comment

Radioactive and Mixed Waste Management Facility	Compaction, solidification, neutralization, precipitation, shredding, and stripping	Liquid and solid mixed LLW, solid LLW	Compacted various waste forms, gamma assay of waste packages, mixing and solidification of liquid wastes, performed bench scale treatment of waste, and segregated and repackaged various waste types	Bench scale	Status: under construction Date available: December 31, 1996 Termination date: January 1, 2020

Table H.2.7-3. Low-Level Waste and Mixed Low-Level Waste Storage at Sandia National Laboratories

Storage Unit	Input Capability	Design Capacity 13 (m3)	Comment
Annular Core Research Reactor	Liquid and solid mixed LLW and liquid and solid LLW	29	Currently not storing waste. Part B submitted November 8, 1992; amended August 30, 1993. Date available: unknown. Termination date: January 1, 2020.
Area III Interim Storage Site	Liquid and solid mixed LLW and liquid and solid LLW	2,520	Operational; RCRA interim status: August 31, 1993. Termination date: April 1, 2020.
Building 819	Liquid and solid mixed TRU, TRU, mixed LLW, and LLW	259	Operational; RCRA Part B permit application submitted; amended August 30, 1993. Termination date: April 1, 2020.
Building 6502 High Bay	Liquid and solid mixed LLW	424	Nonoperational due to upgrades/major repairs Date available: January 1, 1995. RCRA interim status. Termination date: January 1, 2020.
Building 6596 High Bay Waste Storage Facility	Liquid and solid mixed TRU, TRU, mixed LLW, and LLW	916	Nonoperational due to upgrades/major repairs. Termination date: July 16, 2020.
Explosives Storage Igloo	Solid mixed LLW	57	Operational; RCRA interim status: August 31, 1993. Termination date: April 1, 2020.
Manzano Facility (7057)	Liquid and solid mixed TRU, TRU, mixed LLW, and LLW	183	Operational; RCRA Part B submitted November 8, 1992, and amended August 30, 1993. Termination date: unknown.

Manzano Facility (7045)	Liquid and solid mixed TRU, TRU, mixed LLW, and LLW	183	Operational; RCRA Part B submitted November 8, 1992, and amended August 30, 1993. Termination date: unknown.
Manzano Facility (7063)	Liquid and solid mixed TRU, TRU, mixed LLW, and LLW	235	Operational; RCRA Part B submitted November 8, 1992, and amended August 30, 1993. Termination date: unknown.
Manzano Facility (7078)	Liquid and solid mixed TRU, TRU, mixed LLW, and LLW	235	Operational; RCRA Part B submitted November 8, 1992, and amended August 30, 1993. Termination date: unknown.
Manzano Facility (7055)	Liquid and solid mixed TRU, TRU, mixed LLW, and LLW	235	Operational; RCRA Part B submitted November 8, 1992, and amended August 30, 1993. Termination date: unknown.
Manzano Facility (7118)	Liquid and solid mixed TRU, TRU, mixed LLW, and LLW	235	Operational; RCRA Part B permit application submitted November 8, 1992, and amended August 30, 1993. Termination date: unknown.
Sandia Pulse Reactor Dense Pac	Solid mixed LLW and solid LLW	31	Operational; RCRA interim status. Termination date: April 1, 2000.
Sandia Pulse Reactor Nova Vault	Solid and liquid mixed LLW and solid and liquid LLW	19	Operational; RCRA interim status. Termination date: April 1, 2020.

Hazardous Waste. As a research facility, SNL generates a variety of hazardous wastes, many in relatively small quantities. All RCRA-regulated wastes generated (except mixed wastes) are transported offsite for disposal at RCRA-permitted treatment, storage, and disposal facilities. Chemical wastes generated by R&D activities are collected from generator locations, segregated according to DOT hazard class, and transported to the SNL RCRA-permitted Hazardous Waste Management Facility for storage. At the Hazardous Waste Management Facility, the wastes are consolidated and packaged according to DOT and EPA requirements. Packaged wastes are transported by DOT-certified carriers to RCRA-permitted treatment, storage, and disposal facilities or recyclers for final disposition.

During 1994, 691,700 kg (1,524,000 lb) of chemical wastes were managed by SNL's Chemical Waste Management Program, including 86,300 kg (190,300 lb) of RCRA-regulated hazardous waste and 605,000 kg (1,333,800 lb) of solid and recycled materials. A total of 29,780 packages were collected from SNL generators in 1994, packaged into 4,223 containers, and sent to treatment, storage, and disposal facilities and recyclers. The volume of RCRA hazardous waste processed in 1994 decreased from that reported in 1993; however, the quantity of solid and recycled material increases. The volume was influenced by the Kirtland Air Force Base solid waste landfill closure, Environmental Restoration Project remediation activities, and recycling operations (SNL 1995g:3-3).

SNL's Thermal Treatment Facility was issued a treatment permit in November 1994 by the New Mexico Environment Department to thermally treat residual explosives. In 1994, the Thermal Treatment Facility did not treat any residual explosives generated at SNL (SNL 1995g:3-3).

Hazardous waste quantities shipped offsite from SNL in 1994 are shown in table H.2.7-4. A summary of the hazardous waste treatment and storage facilities is shown in tables H.2.7-5 and H.2.7-6.

Table H.2.7-4. Hazardous Waste Quantities Shipped Offsite in 1994, Sandia National Laboratories

Description	Number of Shipments Containing Description	Quantity (kg)	Estimated Volume [14] (m^3)
Aluminum chloride, anhydrous	1	3	< 0.1
Articles, explosive, n.o.s.	7	51	< 0.1
Batteries, wet, filled with alkali	2	5,461	3.6
Cartridges, power device	1	< 1	< 0.1
Combustible liquid, n.o.s.	21	1,179	1.2
Compressed gases, flammable, n.o.s.	18	572	1.1
Compressed gases, flammable, toxic, n.o.s.	2	< 1	<1
Compressed gases, n.o.s.	6	132	0.3
Corrosive liquids, flammable, n.o.s.	2	13	< 0.1
Corrosive liquids, n.o.s.	72	11,266	11.3
Corrosive liquids, poisonous, n.o.s.	5	316	0.3
Corrosive solids, n.o.s.	16	564	0.4
Cyanide solutions	3	224	0.2
Detonators, electric	1	< 1	< 0.1
Environmentally hazardous substances, liquid, n.o.s.	5	1,193	1.2
Environmentally hazardous substances, solid, n.o.s.	3	303	0.2
Flammable liquids, corrosive, n.o.s.	15	403	0.4
Flammable liquids, n.o.s.	87	9,775	9.8
Flammable liquids, poisonous, n.o.s.	3	60	< 0.1
Flammable solids, n.o.s.	24	358	0.2
Formaldehyde solutions	1	184	0.2
Hazardous waste, liquid, n.o.s.	58	18,611	18.6
Hazardous waste, solid, n.o.s.	84	56,202	37.5
Iron pentacarbonyl	1	4	< 0.1

Mercuric cyanide, solid	1	7	< 0.1
Mercury	4	175	0.1
Mercury compounds, liquid, n.o.s.	1	4	< 0.1
Oil	1	780	0.8
Oxidizing substances, liquid, corrosive, n.o.s.	17	677	0.7
Oxidizing substances, liquid, poisonous, n.o.s.	1	5	< 0.1
Oxidizing substances, liquid, n.o.s.	10	89	< 0.1
Oxidizing substances, solid, n.o.s.	12	116	< 0.1
Paint	1	3	< 0.1
Perchloric acid	2	19	< 0.1
Phosphorus pentafluoride	1	< 1	< 0.1
Phosphorus pentasulfide	1	3	< 0.1
Poisonous liquids, n.o.s.	24	1,751	1.8
Poisonous solids, n.o.s.	19	212	0.1
Polychlorinated biphenyls	3	1281	0.9
Propellant explosive, solid	4	1385	0.9
Pyrophoric liquids, n.o.s.	1	< 1	< 0.1
Pyrophoric solids, n.o.s.	1	12	< 0.1
Rocket motors	2	190	0.1
Substances, explosive, n.o.s.	5	22	< 0.1
Substances that when put in contact with water emit flammable gases, liquid	6	35	< 0.1
Substances that when put in contact with water emit flammable gases, solid	26	517	0.3

Table H.2.7-5. Hazardous Waste Treatment Capability at Sandia National Laboratories

Treatment Unit	Treatment Method	Input Capability	Output Capability	Total Capacity[15] (m^3/yr)	Comment
Elementary Neutralization Unit; (870)	Neutralization	Liquid hazardous waste, corrosive	Neutralized wastewater	Data not available at this time	Nonoperational due to upgrades/major repairs

Thermal Treatment Facility	Open Burning	Liquid and solid hazardous waste and reactive waste (absorbent materials, filters, paper, and rags)	Gas, solid hazardous waste, listed, TCLP, carbon ash/possible silver contamination	Limited to 9.1 kg/campaign	Standby mode, RCRA interim status

Table H.2.7-6. Hazardous Waste Storage Capability at Sandia National Laboratories

Storage Unit	Input Capability	Design Capacity[16] (m3)	Comment
PCB Storage Facility (958W)	Liquid and solid hazardous and sanitary waste (also sludge) and PCBs	10	Operational; date available: June 1, 1993
Hazardous Waste Management Facility (959)	Liquid and solid hazardous waste (also sludge and gas)	Data not available at this time	Operational; final RCRA Part B permit application submitted: July 31, 1992
Hazardous Waste Management Facility (958)	Liquid and solid hazardous waste (also sludge and gas)	Data not available at this time	Operational; final RCRA Part B permit application submitted: July 31, 1992

Nonhazardous Waste. SNL liquid sanitary waste is sent to municipal treatment facilities. SNL contains over 24 km (15 mi) of sewer lines interconnected with those of Kirtland Air Force Base. In June 1994, SNL activated the liquid effluent control system to retain process wastewater for radiological screening prior to disposal into the sanitary sewer. SNL's policy prohibits the disposal of radiological material above regulatory levels into the sanitary sewer system. Discharges by SNL to the publicly owned treatment works are regulated by the city of Albuquerque Public Works Department, Liquid Waste Division, under the authority of the city's Sewer Use and Wastewater Control Ordinance (SNL 1995g:6-1). Solid sanitary waste is collected and taken to the Albuquerque Sanitary Landfill on a regular basis. The total solid sanitary waste generated in 1994 as packaged for disposal was 13,600 t (14,990 tons) (SNL 1995f:7).

The classified waste landfill at SNL is a Class D landfill located in Technical Area III. The unit is an outdoor facility, 0.983 ha (2.43 acres) in size, used for the disposal of classified solid waste generated at SNL R&D facilities. The landfill currently operates under a notice of intent, submitted annually to the State of New Mexico Solid Waste Bureau. The industrial wastes (called classified solid waste) disposed of at this landfill originate from the classified reapplication yard. The waste stream consists of toner cartridges, computer tapes, crates and pallets, weapon components, and related hardware. The remaining capacity of this landfill is 9,635 m3 (12,600 yd^3) (DOE 1994k).

H.2.8 Nevada Test Site

After underground nuclear tests, radioactive and hazardous materials were extracted and analyzed.

These activities have resulted in the accumulation of low-level, hazardous, and mixed wastes that must be treated, stored, and disposed of. The Site Book for Waste Management< (May 1994), the Waste Management Plan for the Nevada Test Site (February 1995), and the NTS Site Treatment Plan and Federal Facility Compliance Act Consent Order (March 1996) and the NTS EIS (Draft, December 1995) detail waste management activities at NTS.

Radioactive and hazardous wastes (according to the current definition of hazardous wastes) generated from past nuclear testing activities were disposed of at Areas 2, 3, 5, 6, 8, 9, 12, and 23. These were mixed wastes and LLW composed of debris, drilling mud, decontamination wastes, laboratory, and classified wastes. Areas 3 and 5 are still currently active for waste storage and disposal. Area 3 receives offsite and onsite bulk waste for disposal in subsidence craters. A RCRA closure plan has been submitted to the Nevada Division of Environmental Protection for this facility. The Radioactive Waste Management Site in the north of Area 5 contains LLW management units and receives packaged classified and unclassified LLW. It also has TRU wastes from LLNL in storage, and a hazardous waste accumulation site. The NTS is not currently accepting mixed wastes from any locations. Mixed waste could be accepted from defense related generators within the State of Nevada; however, there is no mixed waste ready for disposal that meets the land disposal restrictions of RCRA. Mixed waste has been disposed of from out-of-state generators, and this practice is planned for the future contingent upon approval and permitting (RCRA Part B) of future mixed waste disposal units and on actions resulting from the Record of Decision (ROD) on the Waste Management PEIS.

In the past, waste disposal at NTS was accomplished through landfills, underground injection and leachfields on NTS, and through offsite disposal of hazardous wastes. A goal of the NTS Environmental Restoration Project is to remove or immobilize hazardous substances, pollutants, and contaminants, while achieving compliance with environmental laws and regulations. Environmental restoration activities will be guided by the ROD from the NTS EIS and be in accordance with the Site Treatment Plan.

Pollution Prevention The Nevada Operations Office is an active participant in DOE's National Waste Minimization and Pollution Prevention Program. A comprehensive Waste Minimization Plan for NTS was completed in 1991, which defines specific goals, methods, responsibilities, and achievements for organizations. A waste minimization organization promotes waste minimization and pollution prevention and assures compliance with DOE orders at NTS. A report on waste generation and waste minimization is published annually. DOE publishes site-wide plans and guidance, and each contractor develops its own implementation plan. Plans and procedures have been developed, limiting the number and types of hazardous materials used on the site.

Since the initiation of the waste minimization program, several steam-cleaning operations have been eliminated, and half of the hazardous solvents used at NTS have been replaced with nonhazardous solvents. Recycling and reclamation activities have been established to reuse lead, silver, lubricating oil, and trichlorotrifluoroethane. Automatic decontamination equipment, recycling fabrication tool coolant systems, and continuous oil change and reburn systems have been placed in service to reduce hazardous waste generation. Closed loop effluent recycling for steam cleaning has eliminated the production of 17.8 million L (4.7 million gal) of wastewater annually and has reduced hazardous waste generation by 90 percent. Two solvent waste stills recycle 85 percent of all solvents and thinners used. Nonhazardous aqueous solution parts cleaners have eliminated the need for parts cleaning solvents.

The procurement of all materials is also reviewed for the opportunity to reduce the purchase of

hazardous materials for NTS operations. In addition, an education and training program for all site personnel and for the surrounding community is helping to increase awareness of best practices and lessons learned in waste reduction.

Transuranic Waste TRU and mixed TRU waste is stored at NTS on the TRU waste storage pad in Area 5. This waste was generated at LLNL and shipped to NTS between 1974 and 1990. All NTS TRU and mixed TRU waste is expected to be certified for disposal at WIPP in Carlsbad, NM, or another suitable repository should WIPP prove to be unsatisfactory. The Nevada Operations Office has the option to construct a TRU Waste Certification Building for breaching, sampling, and certifying containers of TRU waste to meet the WIPP Waste Acceptance Criteria which is expected to be finalized by June 1997 (NT DOE 1996b:4-61, 4-62). Other technologies, such as mobile characterization capabilities, are also being considered. This waste inventory consists of 612 m^3 (800 yd^3) of heterogeneous debris. The TRU waste is stored in the TRU Pad Cover Building on the TRU Waste Storage Pad to protect the containers from the environment. In addition, TRU and suspected TRU waste from weapons tests were emplaced in boreholes. Decisions to retrieve this waste or leave it in place will be based on performance assessments required by 40 CFR 191 and/or risk assessments required by CERCLA or RCRA. Table H.2.8-1 lists the mixed TRU waste storage units at NTS.

Low-Level Waste Contaminated soils, created from past atmospheric nuclear weapons tests, occur at various locations on NTS. Some of this surface contamination has been and is planned to be removed and disposed of as waste. Although the debris from underground weapons tests remain underground, samples of this debris are brought to the surface for analysis and then must be disposed of as waste. The majority of LLW generated at NTS is disposed of in subsidence craters in Area 3. This area also receives substantial quantities of containerized bulk waste from other offsite DOE facilities. Some waste disposal units are being closed in this area, while others are being readied for future use. Area 5 receives low-level radioactive waste from both onsite and offsite generators. New disposal capacity is planned for this area, and the offsite generators will be required to meet the NTS Waste Acceptance Criteria (which includes periodic reviews by the Nevada Operations Office) to permit them to ship LLW for disposal at NTS.

Historically, the volume of waste received from offsite is approximately equal to or slightly greater than the volume of waste generated onsite. Recently onsite waste generation (other than environmental restoration waste) has declined due to cessation of nuclear testing. Offsite receipts currently dominate waste disposal activities at NTS. Remediation activities at NTS will produce waste streams that will have to be treated, stored, and disposed of. Offsite waste shipments must meet NTS Waste Acceptance Criteria that require that the waste be approved for disposal at NTS. Fifteen generators currently ship LLW to NTS, and an additional nine are applying for or are awaiting approval (NT DOE 1996c:4-61, 4-62). The LLW disposal capacity in use or planned at NTS is listed in table H.2.8-2.

Mixed Low-Level Waste. Mixed LLW is generated by DP-related support activities, environmental restoration activities, and activities supporting TRU waste disposal at WIPP or another suitable repository should the WIPP prove to be unacceptable. Wastes were generated by the analytical activities supporting weapons tests and consisted of drilling muds and debris generated from tunnel reentry and rehabilitation. Additional wastes result from radiochemical analysis and decontamination of equipment and facilities used in sample extraction and analysis. NTS has received mixed wastes from other DOE sites and may receive additional waste in the future, pending the completion of the site treatment plans for all DOE sites and once proper permits are obtained. Mixed waste generated in the State of Nevada that meets the land disposal restrictions of RCRA can be disposed of in the Area

5 mixed waste disposal unit, Pit 3. Mixed waste not meeting land disposal restrictions can be stored on the TRU waste storage pad. A RCRA Part B permit application for a new mixed waste storage unit was submitted in January 1995.

Mixed LLW streams are being characterized to determine what technologies and capabilities are required for safe, environmentally sound, and compliant disposal. Construction of the Liquid Waste Treatment System, a central facility for treating liquid LLW and mixed LLW (contaminated effluents from environmental restoration and DP activities), has been funded and is being designed. Receiving/hold- ing and evaporation reservoirs and associated mixed waste processes will be RCRA-permitted.

Table H.2.8-2 lists mixed LLW storage and disposal facilities at NTS. Table H.2.8-3 lists the mixed LLW streams inventory and 5-year projected generation at NTS. The total volume is 296 m 3 (388 yd 3), including a 20,425-kg (45,000-lb) empty spent shipping cask. Table H.2.8-3 lists mixed LLW waste streams at NTS.

Hazardous Waste. Hazardous wastes are generated from ongoing operations at NTS. Wastes consist of solvents, lubricants, fuel, lead, metals, and acids. Hazardous wastes are accumulated at various sites around NTS while they await shipment offsite to a RCRA-permitted facility. Over the next 5 years, addi-tional satellite storage locations are planned. A separate accumulation site across the road from Area 5 is provided to avoid potential cross-contamination with radioactive waste. The generation of hazardous wastes at NTS is expected to decrease significantly because of the cessation of nuclear testing, the com-pletion of environmental restoration activities, and the impact of waste minimization activities. Hazardous waste is stored on a 279-m 2 (3,000-ft 2) covered pad in Area 5 (NT REECO 1995a:33).

*Nonhazardous Waste.*Nonhazardous sanitary wastes are expected to be generated at the current rates for several years into the future, then decline due to the cessation of nuclear weapons testing. Recycling of paper, metals, glass, plastics, and cardboard has already resulted in some decreases in waste quantities.

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5 The quantities are estimates only.

6 The generation rate for lead solids may change significantly as the Lead Bank Program progresses.

7 A small amount may be generated at SNL (Livermore), and managed under the SNL Mixed Waste Site Treatment Plan at the Albuquerque location.

8 Because of the use of nonhazardous scintillation liquids, it is assumed that no organic liquid mixed waste will be generated in the next 5 years.

9 The generation rate of organic debris may greatly decrease because of the reduction of hazardous solvents.

10 It is assumed that the generation of inorganic debris will remain comparable to the current rate.

11 From the Environmental Restoration Program. GJPO - Grand Junction Projects Office, Colorado; MTU - Mobile Treatment Unit; TCLP - Toxicity Characteristic Leaching Procedure. DOE 1995gg; SNL 1995c.

12 Schedules and capacities for facilities under design or construction are subject to changes based on the availability of funds and permit issuance. DOE 1994n; DOE 1995gg.

13 Schedules and capacities for facilities under design or construction are subject to changes based on the availability of funds, permit issuance, etc. DOE 1994n.

14 For those shipments in which only a mass quantity was provided, a volume estimate was made based on density factors of 500 kg/m3 for gases, 1,000 kg/m^3 for liquids, and 1,500 kg/m^3 for solids. n.o.s. - not otherwise specified. DOE 1995h.

15 For those facilities in use, this is a normal operating capacity; whereas, for facilities under design or construction this is a design capacity. Schedules and capacities for facilities under design or construction are subject to changes based on the availability of funds, results of treatability studies, and permit issuance. DOE 1994n.

16 Schedules and capacities for facilities under design or construction are subject to changes based on the availability of funds and permit issuance. DOE 1994n.