APPENDIX F:

ASSESSMENT METHODOLOGIES

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In general, the activities assessed in this environmental impact statement (EIS) could affect workers, members of the general public, and the environment during construction of new facilities, during routine operation of facilities, during transportation, and during facility or transportation accidents. Activities could have adverse effects (e.g., human health impairment) or positive effects (e.g., regional socioeconomic benefits, such as the creation of jobs). Some impacts would result primarily from the unique characteristics of the uranium and other chemical compounds handled or generated under the alternatives. Other impacts would occur regardless of the types of materials involved, such as the impacts on air and water quality that can occur during any construction project and the vehicle-related impacts that can occur during transportation. The following sections describe the assessment methodologies that were used to evaluate potential environmental impacts associated with the no action alternative and the action alternatives.

F.1 HUMAN HEALTH AND SAFETY — NORMAL FACILITY OPERATIONS

F.1.1 Radiological Impacts

F.1.1.1 Receptors

For this EIS, radiation effects during normal (or routine) operations were assessed by first estimating the radiation dose to workers and members of the general public from the anticipated activities required under each alternative. The analysis considered three groups of people: (1) involved workers, (2) noninvolved workers, and (3) members of the general public. They are defined as follows:

- *Involved Workers:* Persons working at a site who are directly involved with the handling of radioactive or hazardous materials.
  - They might be exposed to direct gamma radiation emitted from radioactive materials, such as depleted uranium hexafluoride (DUF_6) or other uranium compounds.
  - The radiation doses they would receive from inhaling uranium would be very small when compared with the direct radiation doses that result from enclosed processes. Containment and ventilation controls would be used to reduce airborne radionuclides in workplaces. Furthermore, the requirement of wearing protective respirators would limit inhalation exposures to very low levels.

- Involved workers would be protected by a dosimetry program designed to control doses below the maximum regulatory limit of 5 rem/yr for workers (*Code of Federal Regulations*, Title 10, Part 835 [10 CFR Part 835]).

- *Noninvolved Workers:* Persons working at a site but not directly involved with the handling of radioactive or hazardous materials.

  - They might be exposed to direct radiation from radioactive materials (although at a great distance) and to trace amounts of uranium released to the environment through site exhaust stacks.

  - They could receive radiation exposure through inhalation of radioactive material in the air, external radiation from radioactive material deposited on the ground, and incidental ingestion of soil.

- *Members of the General Public:* Persons living within 50 mi (80 km) of the site.

  - They might be exposed to trace amounts of uranium released to the environment through exhaust stacks or wastewater discharges.

  - They could receive radiation exposure through inhalation of radioactive material in the air, external radiation from deposited radioactive material, and ingestion of contaminated water, food, or soil.

For the noninvolved workers and general public, doses were estimated for the group as a whole (population or collective dose) as well as for a maximally exposed individual (MEI). The MEI is defined as a hypothetical person who — because of proximity, activities, or living habits — could receive the highest possible dose. The radiation exposures of the MEIs would be bounded by the exposure calculated on the basis of maximum air concentrations for airborne releases and on the basis of maximum surface water or groundwater concentrations for waterborne releases. For involved workers, the average individual dose rather than the MEI dose was estimated because of the uncertainty about the activities of each involved worker. In addition to the average individual dose, the collective dose was also estimated for involved workers. Under actual conditions, all radiation exposures and releases of radioactive material to the environment are required to be as low as reasonably achievable (ALARA), a practice that has as its objective the attainment of dose levels as far below applicable limits as possible.

F.1.1.2 Radiation Doses and Health Effects

All radiological impacts were assessed in terms of committed dose and associated health effects. The calculated dose was the total effective dose equivalent (10 CFR Part 20), which is the sum of the deep dose equivalent from exposure to external radiation and the 50-year committed effective dose equivalent from exposures to internal radiation. Radiation doses were calculated in units of milliroentgen-equivalent man (mrem) for individuals and in units of person-rem for collective populations.

The potential radiation doses resulting from normal operations would be so low that the primary adverse health effects would be the potential induction of latent cancer fatalities (LCFs). Health risk conversion factors (expected LCFs per absorbed dose) from Publication 60 of the International Commission on Radiological Protection (ICRP 1991) were used to convert radiation doses to LCFs, that is, 0.0005 per person-rem for members of the general public and 0.0004 per person-rem for workers. Adverse health effects for individuals were assessed in terms of the probability of developing an excess LCF; adverse health effects for collective populations were assessed as the number of excess LCFs expected in the population.

F.1.1.3 Exposure Pathways

External radiation would be the primary exposure pathway for involved workers because they would directly handle radioactive materials and/or be at a close distance from radiation sources. Radiation exposures through inhalation and incidental ingestion of contaminated particulates would be possible; however, the exposure would probably be very small compared with exposures from external radiation. Operations that could result in potential airborne emissions would be confined and most likely would be automated and controlled remotely. Even if airborne emissions did occur, the use of high-efficiency particulate air (HEPA) filters and various air circulation systems would reduce the amount of airborne pollutants in the workplace to a minimal level. Exposures from inhalation could also be prevented by implementation of ALARA practices, as required. For example, workers could wear respirators while performing activities associated with potential airborne emissions. Potential exposure from incidental ingestion of particulates could be reduced if workers wore gloves and followed good working practices.

Inhalation of contaminated particulates and incidental ingestion of deposited particulates were considered for noninvolved workers who, because of being located farther away from the radiation sources handled in the facilities, would not be exposed to direct external radiation from those sources. However, secondary external radiation would be possible from the deposited radionuclides on ground surfaces and from airborne radionuclides when the emission plume from the stacks of the processing buildings passed the locations of the noninvolved workers. The potential radiation exposure would be bounded by the exposure associated with the largest downwind air concentration. To obtain conservative estimates of the bounded value, the noninvolved workers were assumed to be exposed to radiation caused by airborne emissions without any shielding from buildings or other structures.

Radiation exposures of members of the off-site general public were assessed for both airborne and waterborne pathways. The airborne pathways included inhalation of contaminated particulates, external radiation from deposited radionuclides and from airborne radionuclides, incidental ingestion of deposited radionuclides, and ingestion of contaminated food products (plants, meat, and dairy products). Plants grown in the area where the emission plume passed could become contaminated by deposition of radionuclides on leaves or ground surfaces.

Radionuclides deposited on leaves could subsequently translocate to the edible portions of the plants; those deposited on ground surfaces could subsequently be absorbed by plant roots. Livestock and their products could become contaminated if the livestock ate the contaminated surface soil and plants.

The waterborne pathways included ingestion of surface water and groundwater; ingestion of contaminated plant foods, meat, and dairy products; and potential radon exposure from using contaminated water. Plant foods and fodder could be contaminated from irrigation with contaminated water, and the livestock and their products could become contaminated if the livestock were fed with contaminated water and ate contaminated fodder. Potential indoor radon exposures would be possible if contaminated water was used indoors and radon gas emanated from the water. Because of the large dilution capability of surface water at the site, the estimated radionuclide concentrations in surface water were always very low, and potential radiation exposures from the food chain pathways associated with these low water concentrations would be negligible. Therefore, radiation exposures resulting from contaminated surface water were assessed only for the drinking water pathway. The dilution capability would be smaller for groundwater, resulting in higher groundwater concentrations. Therefore, if the groundwater was predicted to be contaminated, radiation exposures from the food chain pathways, radon pathway, and drinking water pathway were all estimated.

Radiation exposure of the off-site general public MEI would be bounded by the exposure associated with the maximum downwind air concentration and maximum water concentration.

F.1.1.4 Data Sources and Software Applications

Potential impacts associated with the operations of the conversion facility were estimated or calculated using measurement data or computer codes.

The external exposures incurred by the involved workers in the conversion facility were estimated on the basis of the measurement data for worker exposures at the Framatome Advanced Nuclear Power (ANP) facility in Richland, Washington. A dry conversion process is used to convert UF_6 into uranium oxide at the Framatome facility. A similar conversion process would be implemented at Portsmouth. According to Uranium Disposition Services, LLC (UDS 2003a), the key components of the conversion facility at Portsmouth would be similar to those at Framatome; therefore, conditions for potential worker exposures are expected to be similar at these two facilities. The worker exposure data from Framatome provided in the UDS National Environmental Policy Act (NEPA) data package (UDS 2003b) were used to obtain involved worker exposures at Portsmouth, with consideration of different specific activities in the processed uranium materials and different uranium processing rates. Potential external radiation exposure for employees working in the cylinder storage yards resulting from loading and unloading cylinders were estimated with the use of the MicroShield computer code (Negin and Worku 1992). To use MicroShield, potential exposure distances, duration of activities, and number of workers involved in each activity were developed. MicroShield is a commercial software program designed to estimate external radiation doses from a variety of sources; it is widely used for such applications. External exposures for cylinder yard workers from maintenance activities were estimated on the basis of past site-specific monitoring data. The increase in cylinder number resulting from arrival of the ETTP cylinders and decrease in cylinder number resulting from conversion of DUF_6 to U_3O_8 were both taken into account. In actuality, the radiation dose to the individual worker would be monitored and maintained below the DOE administrative control limit of 2,000 mrem/yr (DOE 1992), which is below the regulatory dose limit of 5,000 mrem/yr (10 CFR Part 835).

Radiological impacts from airborne pathways were estimated with the emission data provided in the UDS NEPA data package (UDS 2003b) and the use of the CAP88-PC computer code (Chaki and Parks 2003). CAP88-PC was developed under the sponsorship of the U.S. Environmental Protection Agency (EPA) and was designed for use in demonstrating compliance with regulatory requirements on air emissions. It uses site-specific or representative meteorological data (joint frequency data) to estimate the air concentrations at downwind locations, calculates the biota concentrations by using biotransfer models, and then estimates the corresponding radiation doses.

Depending on the location of the conversion facility, the on-site maximum air concentrations would be different from the off-site maximum air concentrations; however, on the basis of the small emission rate provided by UDS (UDS 2003b), both maximum concentrations would be very small. In this EIS, a bounding approach was used to find the potential exposures of the MEI of the noninvolved workers and the general public.

The absolute maximum downwind air concentrations determined solely by the meteorological data were used to find the bounding exposures of both MEIs. Because of the use of the bounding approach, the potential MEI impacts associated with the different conversion facility locations would be the same. This bounding approach was judged to be acceptable because the location of the conversion facility would not be determined on the basis of the MEI exposures, since such impacts would be insignificant.

According to the CAP88-PC results, the maximum downwind air concentrations would be located at approximately 380 m (1,247 ft) from the emission stack of the conversion facility. The bounding collective exposure of the noninvolved workers was estimated by multiplying the MEI dose with the population of noninvolved workers. The number of noninvolved workers was estimated by using year 2000 information on sitewide worker distribution. Collective off-site population exposure was calculated by using CAP88-PC with 2000 population distribution data. A range of 50 mi (80 km) around the site was considered.

Because no waterborne release of uranium is expected from the conversion facility process water (UDS 2003b), potential impacts resulting from the use of contaminated surface water were not estimated.

F.1.1.5 Source for the Derived Results

Results presented in this EIS for the no action alternative and cylinder preparation activities at ETTP under the action alternatives were derived from the site-specific data compilation reports prepared for the DUF_6 management program in support of NEPA requirements (Hartmann 1999a-c) and the programmatic EIS (PEIS) (U.S. Department of Energy [DOE] 1999). The receptors and exposure pathways for the data compilation report and the PEIS were the same as those described above. In addition, site-specific meteorological and aquatic environmental data at the Portsmouth and ETTP sites were used. The assumptions used for the no action alternative in the data compilation report were considered to bound the potential impacts. Detailed discussions on the assumptions are provided in Section 5.1.1 of this EIS. Worker activities for preparing cylinders for shipment (including retrieving cylinders, inspecting them, and loading them to a transportation vehicle) from ETTP to Portsmouth were assumed to be the same as those considered in the PEIS. Therefore, impacts for the involved workers presented for the cylinder preparation activities in the PEIS were used in this report.

For involved workers, radiation exposures were dominated by the external exposure pathway. Potential doses in the data compilation report (UDS 2003b) and PEIS (DOE 1999) were estimated with information on worker activities and with the use of the MicroShield computer code (Negin and Worku 1992). Radiation exposures of the noninvolved workers, on the other hand, would result mainly from the airborne release of depleted uranium. For cylinder preparation activities, air emissions are expected to be negligible. Therefore, no impact would be expected for the noninvolved workers. Under the no action alternative, the emissions locations and emissions rates assumed in the data compilation report (Hartmann 1999b) were adopted to bound the potential impacts. Consequently, the results that were obtained by using the emissions data and an air dispersion model from that report were used directly for the MEIs. For the collective exposure, an upper bound estimate was obtained by multiplying the MEI dose with the sitewide worker population. The upper bound values rather than the actual values were used because the potential level of radiation exposures would be very small (< 0.1 mem/yr).

Radiation exposures of the general public would result from both airborne and waterborne releases. For cylinder preparation activities, there would be negligible air emissions and waterborne releases. Therefore, no impact would be expected for the general public. For the no action alternative, because the bounding assumptions used in the data compilation report were adopted, results from that report were used directly in this EIS for the MEI. The collective exposures were obtained by scaling the results in the data compilation report with the population size. This scaling approach was used because of the very small exposures and the small change (less than 3%) in the total population within 50-mi (80-km) of the Portsmouth site between 1990 and 2000.

F.1.1.6 Exposure Parameters and Dose Conversion Factors

Inhalation rates for workers were assumed to be 1.2 m^3/h (ICRP 1994), with an exposure duration of 8 hours per day for 250 days per year. The inhalation rate for the general public was assumed to be 20 m^3/d, with an exposure duration of 24 hours per day for 365 days per year. The ingestion rate for drinking water for the public was assumed to be 2 L/d. No building shielding effect was considered for inhalation and external radiation exposures. Therefore, radiation doses estimated in this way would be greater than the actual doses, which would always be associated with some shielding from buildings.

Site-specific agriculture data (yield per unit area) for food crops and fodder were used. Default food consumption data for a rural setting from CAP88-PC were also used. Nevertheless, it was found that radiation doses from the food ingestion pathways constituted only a small fraction of the total dose, which is dominated (>90%) by doses from inhalation (for airborne pathways).

CAP88-PC uses the EPA internal dose conversion factors to estimate internal doses (EPA 1988). The inhalation doses depend strongly on the solubilities of the inhaled chemicals. With high solubility, a chemical would be excreted from the human body within a shorter period of time and would result in less internal exposure. For U_3O_8, it was assumed to remain in the human body for years, thus resulting in greater radiation exposures. The ingestion doses were estimated by assuming that the uranium compounds would be absorbed by the gastrointestinal tract to the largest extent possible for uranium compounds; this would result in the maximum internal exposure.

Key Concepts in Estimating Risks from Low-Level Chemical Exposures

Reference Level

- Intake level of a chemical below which adverse effects are very unlikely.

Hazard Quotient

- A comparison of the estimated intake level or dose of a chemical with its reference dose.
- Expressed as a ratio of estimated intake level to reference dose.
- Example:
  - The EPA reference level (reference dose) for ingestion of soluble compounds of uranium is 0.003 mg/kg of body weight per day.
  - If a 150-lb (70-kg) person ingested 0.1 mg of soluble uranium per day, the daily rate would be $0.1 \div 70 \approx 0.001$ mg/kg, which is below the reference dose and thus unlikely to cause adverse health effects. This would yield a hazard quotient of $0.001 \div 0.003 = 0.33$.

Hazard Index

- Sum of the hazard quotients for all chemicals to which an individual is exposed.
- A value less than 1 indicates that the exposed person is unlikely to develop adverse human health effects.

F.1.2 Chemical Impacts

The method used to assess the potential human health impacts from exposures to chemicals of concern emitted during normal operations was discussed in detail in the DUF_6 PEIS (DOE 1999). The chemicals of greatest concern are soluble and insoluble uranium compounds and hydrogen fluoride (HF). Uranium compounds can cause chemical toxicity to the kidneys; soluble compounds are more readily absorbed into the body and thus are more toxic to the kidneys. HF is a corrosive gas that can cause respiratory irritation in humans, with tissue destruction or death resulting from exposure to large concentrations. No deaths are known to have occurred as a result of short-term (i.e., 1 hour or less) exposures to 50 parts per million (ppm) or less of HF. Neither uranium compounds nor HF are chemical carcinogens; thus, cancer risk calculations were not applicable for this assessment.

For long-term, low-level (chronic) exposures to uranium compounds and HF emitted during normal operations, potential adverse health effects for the hypothetical MEI in the noninvolved worker and general public populations were calculated by estimating the intake levels associated with anticipated activities. Intake levels were then compared with reference levels below which adverse effects are very unlikely. Risks from normal operations were quantified as hazard quotients and hazard indices (see text box on previous page).

F.1.2.1 Receptors

The main source of impacts to noninvolved workers and members of the public would be the emission of trace amounts of uranium compounds or HF from exhaust stacks. Chemical exposures for involved workers would depend, in part, on detailed facility designs that have not yet been determined; however, the workplace environment would be monitored to ensure that airborne chemical concentrations were kept below applicable exposure limits.

F.1.2.2 Chemical Doses and Associated Health Effects

For normal operations, risks were expressed by using the hazard quotient concept for exposures to noncarcinogens (i.e., comparison of estimated receptor doses with reference levels or doses below which adverse effects would be very unlikely to occur). In general, the chemicals of concern for this EIS were uranium and fluoride compounds, especially HF gas. These substances would not be chemical carcinogens; thus, cancer risk calculations were not applicable. The toxicity of the exposures for relevant receptors was estimated through comparison with oral and inhalation reference levels (levels below which adverse effects would be very unlikely to occur). The oral reference dose of 0.003 mg/kg-d was used for evaluating risks from ingestion of soluble uranium compounds; the EPA derived this value on a the basis of a lowest-observed-adverse-effect level in rabbits of 3 mg/kg-d of uranyl nitrate hexahydrate, combined with an uncertainty factor of 1,000 (Maynard and Hodge 1949; EPA 2003a). Because of conflicting results concerning absorption of insoluble uranium compounds such as U_3O_8 from the gastrointestinal tract, the oral reference dose of 0.003 mg/kg-d was also used in this analysis for calculating hazard quotients for this compound. This assumption is conservative because the gastrointestinal tract would absorb a smaller amount of insoluble than soluble uranium compounds.

Inhalation reference concentrations for uranium compounds and HF are not currently available from standard EPA sources. To assess potential risks from inhalation of these compounds, derived reference levels were developed from proposed Occupational Safety and Health Administration (OSHA) permissible exposure limits (PELs) (29 CFR Part 1910.1000, Subpart Z, as of February 2003). The 8-hour time-weighted-average PEL for soluble uranium compounds is 0.05 mg/m^3; for insoluble uranium compounds, it is 0.25 mg/m^3; and for HF, it is 3 ppm (2.5 mg/m^3). These values were converted to assumed inhalation reference level values for noninvolved workers in mg/kg-d by assuming an inhalation rate of 20 m^3/d and a body weight of 70 kg (154 lb), resulting in derived worker inhalation reference level values of 0.014 and 0.71 mg/kg-d for soluble uranium compounds and HF, respectively.

The inhalation reference level calculated for soluble compounds was also used for insoluble uranium compounds. To generate derived inhalation reference level values for the general public, these worker values were adjusted to account for increased exposure duration of the general public (assumed to be 168 hours per week rather than 40 hours per week); an additional uncertainty factor of 10 was used to account for sensitive subpopulations in the general public. This results in derived inhalation reference levels for the general public of 0.0003 and 0.02 mg/kg-d for uranium compounds and HF, respectively.

The reference levels used for preliminary evaluation of general public hazard quotients and carcinogenic risks from the existing environment were obtained from the EPA's Integrated Risk Information System (IRIS) when available (EPA 2003a). The derived reference concentration levels for uranium compounds and HF discussed above were used as reference levels for evaluating inhalation of these substances.

F.1.2.3 Exposure Pathways and Parameters

As described in Section F.1.1 (radiological impacts for normal facility operations), the chemical exposures for the noninvolved worker and general public MEIs would result mainly from airborne releases from the conversion facility. The maximum downwind air concentrations of uranium compounds and HF emitted from the conversion facility were calculated. These maximum downwind concentrations would be the same for the three alternative locations at Portsmouth, although the exact location of the maximum level would be different. The maximum concentrations were used to estimate maximum exposures for both the noninvolved worker MEI and the general public MEI, although the maximum concentration location could be either within or outside the gaseous diffusion plant boundaries, depending on the location of the conversion facility. This simplified approach to the analysis of potential chemical impacts is justified because the exposures and hazard indices calculated on the basis of these maximum possible exposures are very low. In other words, the identification of very small differences in hazard indices for the MEI receptors for the three alternative locations at the site would not be helpful in differentiating chemical exposure impacts for the locations, because all the exposures would be very small and would not result in adverse effects (see the results in Chapter 5 of this EIS).

Differences in estimated exposures and hazard indices for the noninvolved worker MEI and the general public MEI result from differences in assumed exposure times (e.g., the general public MEI is assumed to be a resident exposed continually, whereas the noninvolved worker MEI would be exposed for only 8 hours per day) and from differences in reference doses for workers and the general public.

For the MEI receptors, it was also assumed that exposure could occur through incidental soil ingestion. Similar to the approach used to assess inhalation exposures, it was assumed that both the noninvolved worker MEI and the general public MEI could be exposed to the maximum estimated soil concentration of contaminants associated with conversion plant emissions, whether that location was inside or outside the gaseous diffusion plant boundaries. No waterborne release of uranium is expected from construction and operation of the conversion facility (UDS 2003b); therefore, potential impacts resulting from use of contaminated water were not estimated. For the no action alternative analyses, potential chemical exposures from runoff water contaminated through cylinder breaches were calculated by using the estimated surface or groundwater concentrations obtained through water quality analyses.

F.1.2.4 Exposure Modeling and Risk Evaluation

Media-specific concentrations of contaminants associated with the normal operation of the facility for the various options were modeled on the basis of effluent data provided in the NEPA data report (UDS 2003b). For airborne pathways, these effluent amounts were modeled by using either the CAP88-PC computer code (see Section F.1.1) or the Industrial Source Complex (ISC) computer code (see Section F.4.1).

Modeled concentrations of contaminants in the various environmental media were used to estimate average daily intakes for the various receptors examined. The ratios of the daily intakes to appropriate reference levels were calculated to generate hazard quotients. Hazard quotients were summed for individual contaminants and across all appropriate exposure routes (e.g., inhalation, soil ingestion) to generate hazard indices for the noninvolved worker MEI and the general public MEI. These hazard indices were compared with the reference hazard index of 1. A hazard index of less than 1 is interpreted to indicate that adverse noncancer effects are unlikely; a hazard index of greater than 1 indicates that adverse effects are possible for the MEI and that further investigation of potential exposures and additivity of individual contaminant toxicity are warranted.

When no adverse effects are expected for the MEI of a given population (i.e., the hazard index is less than 1), then, by definition, no adverse effects are expected in that population. Therefore, calculation of population risks is not applicable when MEI hazard indices are less than 1.

F.2 HUMAN HEALTH AND SAFETY — FACILITY ACCIDENTS

F.2.1 Radiological Impacts

The DUF_6 PEIS (DOE 1999) discussed in detail the analysis of facility accidents that potentially could cause radiological health impacts (PEIS Sections 4.3.2 and A.4.2). Specifically, it addressed the consequences, frequencies, and risks from the accident scenarios postulated to occur at a conversion facility as well as at the current cylinder storage locations. The analysis involved the application of the following three radiological and air dispersion software packages: GENII (Napier et al. 1988), HGSYSTEM (Hanna et al. 1994; Post et al. 1994a,b) and FIREPLUME (Brown et al. 1997).

In the DUF_6 PEIS (DOE 1999), the accident analyses assumed that the accident would occur in the center of the storage yard site (i.e., Portsmouth and ETTP). For collective exposures, radiation doses were assessed for the population within a distance of 50 mi (80 km) from the release point. Because the distance between the possible facility locations and the center point of the sites is much smaller than the assessment distance of 50 mi (80 km), the location of the conversion facility would have very little impact on the off-site collective exposures. Individual and population impacts were estimated for the public and noninvolved workers. Impacts to involved workers during accidents were not quantified because it was recognized that, depending on the accident conditions and the exact location and response of the workers, the involved workers would also be subject to severe physical and thermal (fire) hazards and that the impacts from such hazards might be greater than the impacts from radiological or chemical exposure. Therefore, injuries and fatalities among involved workers would be possible from chemical, radiological, and physical forces if an accident did occur.

Since the population distribution estimate would not vary significantly with the specific location of the conversion facility, the methodology used to analyze the collective public dose in the PEIS also would apply for this EIS analysis. Similarly, the assumptions made in the PEIS for estimating the MEI doses were kept the same. For ground-level releases, the MEI was assumed to be located at a distance of 328 ft (100 m) from the release point. For releases from a stack, the MEI was assumed to be at the point of maximum ground concentration. Current on-site and off-site population distributions were used to estimate the collective noninvolved worker and off-site public impact.

Since trace transuranic (TRU) elements were identified in the DUF_6 cylinder inventory after the PEIS analysis was performed, their contribution to additional radiological impact was considered in the analysis for this EIS. A conservative concentration was assumed for the accidents, since the TRU elements are not distributed evenly through the DUF_6 inventory. Comparisons of the relative hazards from this TRU concentration with the hazards from DUF_6 considered in the DUF_6 PEIS were used to determine their radiological impact in the accident analyses conducted for this EIS. Appendix B contains a discussion of the methodology used to assess the impacts associated with the presence of trace TRU contamination in cylinders.

F.2.2 Chemical Impacts

General data used in the accident predictions included the following:

- Release amount (source term) for each chemical released,
- Chemical-specific health impact levels,
- Number of workers on site and population off site by direction, and
- Locations of sources and receptors for both workers and members of the general public.

Two meteorological conditions, D stability with a 4-m/s (9-mph) wind speed and F stability with a 1-m/s (2-miles-per-hour [mph]) wind speed, were assumed for all scenarios except the tornado accident scenario, which assumed D stability and 20-m/s (45-mph) wind.

The same approach used for the DUF_6 PEIS was adopted in this EIS for the chemical facility accident analysis under the no action alternative and the action alternatives. Accident consequences were estimated by using the HGSYSTEM (Version 3) model for the nonfire scenarios and the FIREPLUME model for the fire scenarios. For each scenario and each of the two meteorological conditions, hazard zones were generated for two health indices (i.e., adverse effects and irreversible adverse effects). These zones were overlain on worker and general public geographic information system (GIS) layers, with the zone origin located at the centroid of each of the identified conversion plant site alternatives (Locations A, B, and C; see Figure 2.2-3). Updated data on current Portsmouth GDP workers (2002) and updated general population data (based on the 2000 census) were used to estimate the consequences and associated risk of each accident scenario. The dispersion conditions (i.e., meteorology, accident frequencies, and, for most scenarios, release quantities or source terms) were identical to those developed and used in the DUF_6 PEIS. For the estimated chemical accident risks for the proposed conversion facility, variations in this EIS from values reported in the DUF_6 PEIS are attributable to variations in the candidate locations for the conversion facility, changes in the numbers and locations of workers and the general public, and some changes in the source term values.

Of the nearly eight dozen postulated chemical accidents considered and evaluated in this EIS, a total of eight bounding chemical accidents were identified for detailed risk analysis. These accidents are listed in Table 5.2-8.

F.2.2.1 Nonfire Accident Scenario Modeling

The nonfire accident scenarios were treated as either liquid spills on the ground followed by evaporation and/or pressurized releases from tanks. The DUF_6 PEIS assumed the same temperature for both day and night spill conditions. This analysis differs in that it accounts for evaporation rate reduction not only due to the assumed very conservative (from an air dispersion perspective) low wind speed and F-stability condition combination but also due to what would be typically lower ambient air temperatures during these conditions. The evaporation rate from spilled chemical pools depends on pool temperature and saturation vapor pressure. The pool temperature was conservatively assumed to be constant for the entire release duration and was set equal to the assumed ambient temperature. The saturation vapor pressure was set equal to the partial pressure over the pool. The saturation vapor pressure or the partial pressures of the vapors emanating from the pool depend on the pool temperature. For the aqueous HF spill scenarios, the partial vapor pressures were determined for two temperatures, 77°F (25°C for the F-1 conditions, representative of nighttime conditions during July or August) and 95°F (35°C for D-4 conditions, representative of daytime conditions during July or August). For a 70% HF solution, the partial vapor pressure over the pool is 20 kPa (T_p = 77°F [25°C]) and 31.7 kPa (T_p = 95°F [35°C]), determined empirically. Table F-1 gives the spill assumptions and the source term for the bounding aqueous HF spill scenario.

TABLE F-1 Bounding Aqueous (70%) HF Spill Source Term

Berm Area (m^2)	Evaporative Spill Duration[a] (h)	Evaporation Rate (kg/s)		Spill Amount (kg)	
		F-1	D-4	F-1	D-4
412	2	0.13	0.58	933	4,211

[a] Unmitigated.

The evaporative emissions were estimated by using a simplified evaporative model (EPA 1999). The model uses the molecular diffusion of water and the kinematic viscosity of air to calculate the mass transfer coefficient. A less conservative estimate of the evaporative release rate would be expected if chemical-specific molecular diffusivities and kinematic viscosities were used. Because of the change in quantity and chemical composition of the spill, the spill hazard zone changed in this assessment. A scaling procedure was adopted to recalculate the hazard zone, as detailed below.

For a ground-level release, the simplified Gaussian expression for estimating downwind concentrations can be rearranged to solve for the product of horizontal and vertical plume spread. This expression is shown below:

$$\sigma_y \sigma_z = \frac{Q\ (\mathrm{mg/s})}{\pi u\,(\mathrm{m/s})\ \chi_{LOC}\ (\mathrm{mg/m^3})}\ . \qquad \text{(F.1)}$$

The level of concern, χ_{LOC}, is set to the HF Emergency Response Planning Guideline (ERPG)-1 and ERPG-2 levels. With the source term and wind speeds already known, the respective LOC $\sigma_y\ \sigma_z$ products can be calculated. The hazard distance can than be obtained from the already tabulated sigma products (Turner 1994, Table 2-5). The next step in identifying the hazard area or zone is to estimate the hazard width for each contour. This is done by estimating the approximate contour width at the mid-point or half the hazard distance. With these distances, the respective sigma product and σ_y values in Table F-1 can be used in Equation F.1 to solve for the midpoint centerline concentration. The hazard width can than be estimated by using the following expression:

$$HW = \sigma_y\ @\ 0.5\ HD\ \{2In[\chi(x,0,0)/\ \chi_{LOC}]\}^2\ . \qquad \text{(F.2)}$$

By using the same procedure described above, hazard zone dimensions can also be estimated for the HF tank release analyzed for the PEIS. The new hazard distances and hazard widths can than be calculated by multiplying the original model-derived values by the ratios of the new to old values calculated by using the above method.

F.2.2.2 Fire Accident Scenario Modeling

In the fire accident scenarios, the release quantities were presented as a function of time for the three phases of the release: puff, fire release, and cooldown. The 48G cylinder fire and vapor temperatures, as reported in Brown et. al. (1997), were used in the FIREPLUME simulations to estimate buoyant and smoldering plume rise and the resulting downwind concentration contours.

F.2.2.3 Pressurized Release Accident Scenario Modeling

The anhydrous ammonia (NH_3) rupture scenario was treated as a pressurized release tank rupture. Some of the key release parameters used for the scenario are listed in Table F-2 (Vincent 2003).

The pressurized release was modeled with the HGSYSTEM AEROPLUME source module and the HGSYSTEM HEGADAS dispersion module (Hanna et al. 1994; Post et al. 1994a,b), which handled the subsequent dispersion and transport of the dense liquid-vapor aerosol mixture emanating from the tank rupture. AEROPLUME is a multicomponent two-phase thermodynamic aerosol jet model that simulates steady-state release rates from a rupture or a leaking pressurized vessel and the near-field vapor cloud development of the flashed vapor and aerosol components in expelled jet release. Upon formation of the flow field from the release point and establishment of a heavy aerosol-laden cloud, the release is linked to the HEGADAS model to simulate dense vapor cloud dispersion and entrainment of ambient air as the cloud moves and disperses downwind.

F.2.2.4 Health Impact Levels

Assessing the consequences from accidental releases of chemicals differs from assessing routine chemical exposures, primarily because the reference doses used to generate hazard indices for long-term, low-level exposures were not intended for use in evaluating the short-term (e.g., duration of several hours or less), higher-level exposures that often accompany accidents. In addition, the analysis of accidental releases often requires the evaluation of different effects: for example, irritant gases can cause tissue damage at the higher levels associated with accidental releases but are not generally associated with adverse effects from chronic, low-level exposures.

TABLE F-2 Anhydrous NH_3 Tank Rupture Spill Parameters

Tank Size (gal)	Fill Level (%)	Tank Fill Amt. (gal)	Release Amt. (lb)	Tank Pressure (psig)[a]	Relief Valve (psig)	Berm Area (ft^2)
6,565	85%	5,580	29,500	209	265	324

[a] psig = pound(s) per square inch gauge.

To estimate the consequences of chemical accidents, two potential health effects endpoints were evaluated: (1) adverse effects and (2) irreversible adverse effects. Evaluation of these two health endpoints was consistent with the accident evaluations typically conducted to assess industrial risks (American Industrial Hygiene Association [AIHA] 2002). Potential adverse effects range from mild and transient effects — such as respiratory irritation, redness of the eyes, and skin rash — to more serious and potentially irreversible effects. Potential irreversible adverse effects are defined as effects that generally occur at higher concentrations and are permanent in nature — including death, impaired organ function (such as damaged central nervous system or lungs), and other effects that may impair everyday functions.

For uranium compounds, an intake of 10 mg or more was assumed to cause potential adverse effects (McGuire 1991). An intake of 30 mg of uranium was used as the health criterion for potential irreversible adverse effects for exposure to uranium as either U_3O_8 or as UO_2F_2. The background document for the U.S. Nuclear Regulatory Commission (NRC) regulations for the Certification of Gaseous Diffusion Plants (10 CFR Part 76) states that "in assessing the adequacy of protection of the public health and safety from potential accidents, the NRC will consider whether the potential consequences of a reasonable spectrum of postulated accident scenarios exceed 0.25 Sv (25 rem), or uranium intakes of 30 mg, taking into account the uncertainties associated with modeling and estimating such consequences" (NRC 1994). According to these regulations, the selection of the 30-mg uranium intake level as an evaluation guideline level for irreversible injury was based on information provided in Fisher et al. (1994).

In applying the 30-mg uranium intake to accident analysis for the uranium compounds, the following parameters were accounted for: molecular weight, solubility, inhalation rate, and duration of predicted exposure. On the basis of an inhalation rate of 1.5 m^3/h as the ventilation rate during light exercise (ICRP 1994), and on appropriate adjustments to account for the percent uranium in each compound, air concentrations corresponding to an intake level of 30 mg were calculated for modeled exposure durations. For example, the air concentration of 26 mg/m^3 of uranyl fluoride (UO_2F_2) corresponding to a 30-mg uranium intake for a 60-minute exposure to UO_2F_2 would be calculated as follows:

$$\frac{30 \text{ mg uranium} \times 308/238 \text{ (molecular weight } UO_2F_2\text{/molecular weight uranium)}}{1.5 \text{ m}^3\text{/h} \times \text{modeled exposure duration (h)}} \cdot \quad (F.3)$$

In addition, for the insoluble uranium compounds, an uptake factor was incorporated into the calculated air concentrations, on the basis of ICRP guidance that 0.2% absorption be assumed for inhalation of less soluble uranium compounds that have biological half-lives of years (i.e., triuranium octaoxide or U_3O_8), as compared with 5% absorption for soluble and slightly soluble compounds such as UO_2F_2 (ICRP 1979).

For HF and NH_3, potential adverse effect levels were assumed to occur at levels that correspond to ERPG-1 levels, and potential irreversible adverse effects levels were assumed to occur at levels that correspond to ERPG-2 levels. ERPG 1 levels are defined as "the maximum airborne concentration below which it is believed nearly all individuals could be exposed for up to 1 hour without experiencing or developing any but mild transient adverse health effects or perceiving a clearly defined objectionable odor" (AIHA 2002). ERPG 2 levels are defined as "the maximum airborne concentration below which it is believed nearly all individuals could be exposed for up to 1 hour without experiencing or developing irreversible or other serious health effects or symptoms that could impair their abilities to take protective action" (AIHA 2002). The ERPG values were generated by toxicologist teams who review all published (as well as some unpublished) data for a given chemical (AIHA 2002). The levels used in this assessment were as follows: ERPG-1 values of 2 ppm for HF and 25 ppm for NH_3 for adverse effects, and ERPG-2 values of 20 ppm for HF and 150 ppm for NH_3 for irreversible adverse effects (AIHA 2002).

The chemicals evaluated exhibit irritant characteristics; the toxicity of these substances is generally not linearly proportional to the intake amount. For example, the toxic effect of exposure to 32 mg/m^3 HF for 30 minutes would actually be greater than the toxic effect of exposure to 16 mg/m^3 HF for 60 minutes, because the irritant action of the HF is greater at higher air concentrations. Data on the appropriate adjustments of HF concentrations for evaluation of shorter exposure times are presented and discussed in various documents dealing with the toxicity of UF_6 (Fisher et al. 1994; McGuire 1991). On the basis of these data, for modeled exposure durations of between 5 and 60 minutes, the air concentrations of HF and NH_3 corresponding to the ERPG-2 value were calculated from:

$$C = C_{\text{ERPG-2}}(60/t)^{0.5} , \quad \text{(F.4)}$$

where:

C = adjusted exposure guideline value and

t = modeled exposure duration (min).

It was conservatively assumed that the 5-minute adjusted exposure guideline value would be applied even for modeled exposure durations of less than 5 minutes.

It should be noted that human responses do not occur at precise exposure levels but can extend over a wide range of concentrations. The values used as guidelines for potential adverse effects and potential irreversible adverse effects in this EIS should not be expected to protect everyone but should be applicable to most individuals in the general population. In all populations, there are hypersensitive individuals who will show adverse responses at exposure concentrations far below levels at which most individuals would normally respond (AIHA 2002). Alternatively, some individuals will show no adverse response even at exposure concentrations somewhat higher than the guideline levels.

F.2.2.5 Estimation of Population Impacted

Demographic data for the on-site worker population were compiled into a GIS layer by using building footprint polygons and records of the number of workers in the buildings. For the off-site population, 2000 U.S. Census Bureau TIGER (Topologically Integrated Geographic Encoding and Referencing) block group data were obtained. In each layer, population density was calculated for each building or block group by dividing the population for a polygon by the area of the polygon. The site boundary polygon was added to the off-site population layer, and the population inside the boundary was set to zero.

To estimate the population affected by a specific accident, its plume was loaded into the GIS as a polygon, moved to an origin location, and intersected with one of the population layers (either noninvolved worker or general public). The intersection process combined the plume polygon with the population data, thereby subdividing the polygons where the boundaries crossed and discarding portions of polygons falling outside the plume footprint. Next, the areas of the subdivided polygons were recalculated and multiplied by the population density to obtain a population total for each. These values were summed to obtain an estimate of the total population within the plume footprint. An assumption of this approach was that the population was uniformly distributed within each building or block group.

For each accident, the impacts on noninvolved workers and the general population were estimated. No quantitative predictions of impacts were made for involved workers. Noninvolved workers and members of the general public were considered to be at risk for a given health endpoint if they were located within the plume contour (based on ERPG level or uranium intake level) for the wind direction that would lead to the largest population count. Individuals were assumed to be in the locations where they work or live and, for conservatism, the protection provided by the building structure was not included. This computation involved the overlay of the plume contour from the source point at Location A, B, or C and the rotation of the plume 30 to 100 times to identify the direction with the highest number of workers or general population. Those counts were reported in the impact evaluation. In most cases, the direction leading to the maximum worker count did not match the direction for the maximum general population count. The adverse effects and irreversible adverse effects contours were predicted for each accident, with the adverse effects contour being the larger of the two. For UF_6 releases, both the UO_2F_2 contour and the HF contour were predicted for both adverse effects and irreversible adverse effects levels; in general, the HF contours were larger than the uranium contours and led to larger population risks.

The MEI worker was assumed to be located 328 ft (100 m) from the accident location. The MEI for the general population was assumed to be located at the nearest fence line position, although there are currently no residences at these locations at the three current storage sites. Impacts for MEIs are presented as “yes” or “no” in Chapter 5 of this EIS, depending on whether air concentrations of chemicals greater than or equal to corresponding adverse effects and irreversible adverse effects were modeled at the MEI locations.

F.2.3 Accident Frequencies

The expected frequency of an accident is an estimate of the chance that it might occur during operations. Frequencies range from 0.0 (no chance of occurring) to 1.0 (certain to occur). If an accident is expected to happen once every 50 years, the frequency of occurrence is 0.02 per year: 1 occurrence every 50 years = 1 ÷ 50 = 0.02 occurrence per year. A frequency estimate can be converted to a probability statement. If the frequency of an accident is 0.02 per year, the probability of the accident occurring sometime during a 10-year program is 0.2 (10 years × 0.02 occurrence per year).

The accidents evaluated in this EIS were anticipated to occur over a wide range of frequencies, from once every few years to less than once in 1 million years. In general, the more unlikely it would be for an accident to occur (the lower its probability), the greater the expected consequences. Accidents were evaluated for four frequency categories: likely, unlikely, extremely unlikely, and incredible (see text box). To interpret the importance of a predicted accident, the analysis considered the estimated frequency of occurrence of that accident. Although the predicted consequences of an incredible accident might be high, the lower consequences of a likely accident (i.e., one much more likely to occur) might be considered more important.

Accident Categories and Frequency Ranges

Likely (L): Accidents estimated to occur once or more in 100 years of facility operations (frequency of $\geq 1 \times 10^{-3}$/yr).

Unlikely (U): Accidents estimated to occur between once in 100 years and once in 10,000 years of facility operations (frequency from 1×10^{-2}/yr to 1×10^{-4}/yr).

Extremely Unlikely (EU): Accidents estimated to occur between once in 10,000 years and once in 1 million years of facility operations (frequency from 1×10^{-4}/yr to 1×10^{-6}/yr).

Incredible (I): Accidents estimated to occur less than one time in 1 million years of facility operations (frequency of $<1 \times 10^{-6}$/yr).

F.2.4 Accident Risk

The term "accident risk" refers to a quantity that considers both the severity of an accident (consequence) and the probability that the accident will occur. Accident risk is calculated by multiplying the consequence of an accident by the accident probability. For example, if a facility accident has an estimated frequency of occurrence of once in 100 years (0.01 per year) and if the accident occurred with an estimated consequence of 10 people suffering from irreversible health effects (IHEs), then the annual risk of the accident would be reported as 0.1 IHE per year (0.01 per year × 10 IHEs). If the facility was operated for a period of 20 years, the accident risk over the operational phase of the facility would be 2 IHEs (20 years × 0.1 IHE per year).

This definition of accident risk was used to compare accidents that have different frequencies and consequences. Certain high-frequency accidents that have relatively low consequences might pose a larger overall risk than low-frequency accidents that have potentially high consequences. In calculations of accident risk, the consequences are expressed in terms of IHEs and adverse health effects for chemical releases and in terms of expected LCFs for radiological releases.

F.2.5 Physical Hazard Accidents

Physical hazards, unrelated to radiation or chemical exposures, were assessed for each alternative by estimating the number of on-the-job fatalities and injuries that could occur to workers. The expected numbers of worker fatalities and injuries associated with each option were calculated on the basis of statistics available from the Bureau of Labor Statistics (BLS), as reported by the National Safety Council (2002), and on estimates of total worker hours required for construction and operational activities.

Construction and manufacturing annual fatality and injury rates were used for the construction and operational phases of each option, which were computed separately because these activities have different incidence statistics. The injury incidence rates were for injuries involving lost workdays, including days away from work and/or days of restricted work activity. The specific rates used in calculations for each option were as follows: fatalities during construction, 13.3 per 100,000 workers; fatalities during operations, 3.3 per 100,000 workers; injuries during construction, 4.1 per 100 full-time workers; injuries during operations, 4.5 per 100 full-time workers (National Safety Council 2002).

Fatality and injury risks were calculated as the product of the appropriate incidence rate (given above), the number of years for construction and operations, and the number of FTEs for construction and operations. The available fatality and injury statistics by industry are not refined enough to warrant an analysis of involved and noninvolved workers as separate classes.

The calculation of risks of fatality and injury from industrial accidents was based solely on historical industrywide statistics and therefore did not consider a threshold (i.e., any activity that would result in some estimated risk of fatality and injury). All DUF_6 activities would be implemented in accordance with DOE or industry best management practices, thereby reducing the risk of fatalities and injuries.

F.3 HUMAN HEALTH AND SAFETY — TRANSPORTATION

The methodology and assumptions used in this transportation risk assessment were based on two previous analyses conducted for the transportation of depleted uranium compounds (DOE 1999; Biwer et al. 2001). The approach is described below.

F.3.1 Scope of the Analysis

The transportation risk assessment involved estimating the potential human health risks to both crew members (i.e., truck drivers and rail crew) and members of the public during transportation of various forms of depleted uranium and other materials. Impacts that could arise from the radioactive or chemical nature of the cargo and also from the nature of transportation itself, independent of the cargo, were addressed. Transportation risks were evaluated for all of the materials that could potentially be transported for each alternative, including UF_6 cylinders, uranium conversion products, HF and other chemicals, and process waste. A summary of the materials transported is provided in Table F-3. Transportation impacts were estimated for shipment by both truck and rail modes for most materials. The impacts were assessed on a route-specific basis, but unit risks per kilometer were developed for shipments of the conversion

TABLE F-3 Potential Shipments of Material Analyzed for the DUF_6 Conversion EIS[a]

Material	Origin	Destination
Depleted U_3O_8	Portsmouth	Envirocare, NTS
LLW, empty cylinders	Portsmouth	Envirocare, NTS
CaF_2	Portsmouth	Envirocare, NTS
HF	Portsmouth	User facility
Non-DUF_6 cylinders	ETTP	Portsmouth
DUF_6 cylinders	ETTP	Portsmouth

[a] CaF_2 = calcium fluoride, ETTP = East Tennessee Technology Park, LLW = low-level radioactive waste, NTS = Nevada Test Site,.

products for use because the locations of user facilities are not yet known. In the latter case, the unit risk factors were used to estimate transportation impacts for sample distances of 250, 1,000, and 5,000 km (260, 620, and 3,100 mi); average route characteristics were assumed. In the case of depleted uranium conversion products, impacts from shipment to two alternate disposal sites were also estimated.

The transportation-related risks to human health were assessed from both vehicle- and cargo-related causes. Cargo-related risks arising from both the radiological and chemical hazards of the depleted uranium shipments were assessed when appropriate.

With regard to the radioactive nature of depleted uranium, the cargo-related impacts on human health during transportation would be caused by exposure to ionizing radiation. Exposures to radiation could occur during both routine (i.e., incident-free) transportation and during accidents. During routine operations, the external radiation field in the vicinity of a shipment must be below limits specified in federal regulations. During transportation-related accidents, human exposures may occur following the release and dispersal of radioactive materials via multiple environmental pathways, such as exposure to contaminated ground or contaminated air or ingestion of contaminated food.

In contrast, the chemical nature of depleted uranium and other hazardous chemicals does not pose cargo-related risks to humans during routine transportation-related operations. Transportation operations are generally well regulated with respect to packaging, such that small spills or seepages during routine transport are kept to a minimum and do not result in exposures. Potential cargo-related health risks to humans can occur only if the integrity of a container is compromised during an accident (i.e., if a container is breached). Under such conditions, some chemicals may cause an immediate health threat to exposed individuals, primarily through inhalation exposure.

Vehicle-related risks result from the nature of transportation itself, independent of the radioactive and chemical characteristics of the cargo. For example, increased levels of pollution from vehicular exhaust and fugitive dust emissions may affect human health. Similarly, accidents during transportation may cause injuries and fatalities from physical trauma.

Vehicle-related health impacts and health impacts from the radioactive and chemical nature of the depleted uranium are presented separately in the tables of this EIS. No attempt has been made (even in cases where both radioactive and chemical characteristics must be considered) to sum the estimated radioactive, chemical, and vehicle-related risks. To understand and interpret the estimated health impacts presented in this report, readers must keep in mind the fundamental differences between the radioactive, chemical, and vehicle-related hazards discussed below.

The technical approach for estimating transportation risks uses several computer models and databases. Transportation risks were assessed for both routine and accident conditions. For the routine assessment, risks were calculated for the collective populations of all potentially exposed individuals, as well as for a small set of MEI receptors. The accident assessment consisted of two components: (1) an accident risk assessment, which considered the probabilities and consequences of a range of possible transportation-related accidents, including low-probability accidents that have high consequences and high-probability accidents that have low consequences, and (2) an accident consequence assessment, which considered only the radiological consequences of low-probability accidents that were postulated to result in the largest releases of radioactive material. The release fractions used in the accident risk assessment were based on the data in NUREG-0170 (NRC 1977) and independent engineering analyses.

F.3.2 Radiological Impacts

All radiological impacts are calculated in terms of dose and associated health effects in the exposed populations. The radiation dose calculated is the total effective dose equivalent as specified in 10 CFR Part 20, which is the sum of the deep dose equivalent from exposure to external radiation and the 50-year committed effective dose equivalent (ICRP 1977) from exposure to internal radiation. Doses of radiation are calculated in units of rem for individuals and in units of person-rem for collective populations.

The potential exposures to the general population from transportation of radioactive materials, whether during routine operations or from postulated accidents, are usually at a low dose, such that the primary adverse health effect is the potential induction of latent cancers (i.e., cancers that occur after a latency period of several years from the time of exposure). The correlation of radiation dose and human health effects for low doses has been traditionally based on what is termed the "linear/no-threshold hypothesis," which has been described by various international authorities on protection against radiation. This hypothesis implies, in part, that even small doses of radiation cause some risk of inducing cancer and that doubling the radiation dose would mean doubling the expected number of cancers. The data on the health risk from radiation have been derived primarily from human epidemiological studies of past exposures, such as Japanese survivors of the atomic bomb in World War II and persons exposed during medical applications. The types of cancer induced by radiation are similar to "naturally occurring" cancers and can be expressed later in the lifetimes of the exposed individuals.

On the basis of the analyses conducted for this report, transportation-related operations are not expected to cause acute (short-term) radiation-induced fatalities or to produce immediately observable effects in exposed individuals. Acute radiation-induced fatalities occur at doses well in excess of 100 rem (ICRP 1991), which generally would not occur for a wide range of transportation activities, including routine operations and accidents.[1] For all severe accident scenarios analyzed, other short-term effects, such as temporary sterility and changes in blood chemistry, are not expected.

In this EIS, the radiological impacts are expressed as health risks in terms of the number of estimated LCFs for each alternative. The health risk conversion factors (expected LCFs per dose absorbed) were taken from ICRP Publication 60 (ICRP 1991). The health risk conversion factors used were 5×10^{-4} LCF per person-rem for members of the general public and 4×10^{-4} LCF per person-rem for occupational workers.

The RADTRAN 4 computer code (Neuhauser and Kanipe 1992) was used for the routine and accident cargo-related risk assessments to estimate the radiological impacts to collective populations. As a complement to the RADTRAN calculations, the RISKIND computer code (Yuan et al. 1995) was used to estimate scenario-specific radiological doses to MEIs during both routine operations and accidents and to estimate population impacts for the accident consequence assessment.

F.3.3 Chemical Impacts

In contrast to radioactive hazards, chemical hazards do not pose cargo-related risks to humans during routine transportation-related operations. Transportation operations are generally well regulated with respect to packaging, such that small spills or seepages during routine transport are kept to a minimum and do not result in exposures. With respect to chemical hazards, the cargo-related impacts to human health during transportation would be caused by exposure occurring as a result of container failure and chemical release during an accident (i.e., a collision with another vehicle or road obstacle). Therefore, chemical risks (i.e., risks that result from the toxicology of the chemical composition of the material transported) are assessed for cargo-related transportation accidents. The chemical risk from transportation-related accidents lies in the potential release, transport, and dispersion of chemicals into the environment and the subsequent exposure of people primarily through inhalation exposure.

An accidental release of UF_6 to the atmosphere would result in the formation of UO_2F_2 and HF from the reaction of UF_6 with moisture in the atmosphere. Both compounds are highly water soluble and toxic to humans.

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1 In general, individual acute whole-body doses in the range of 300 to 500 rem are expected to cause fatality in 50% of the exposed individuals within 30 to 60 days (ICRP 1991).

The risks from exposure to hazardous chemicals during transportation-related accidents could be either acute (immediate impact) or latent (result in cancer that would present itself after a latency period of several years). The severity of the immediate health effects would depend strongly on the toxicity and exposure concentration of the specific chemical(s) released. The severity of the immediate (i.e., acute) health effects could range from slight irritation to fatality for the exposed individuals. Neither the uranium compounds nor HF are carcinogens or suspected carcinogens. Therefore, latent cancer incidences and fatalities from chemical exposure are not expected and not assessed in this report for potential accidents.

In this assessment, the endpoint for acute health effects that was assessed is the potential for irreversible adverse health effects (from permanent organ damage or the impairment of everyday functions up to and including lethality). A nonlinear or threshold correlation between the exposure concentration and the toxicity was assumed for the evaluation of this acute effect; that is, it was assumed that some low level of exposure could be tolerated without affecting health. In many cases, data on human toxicity that relate acute health effects to chemical exposures did not exist. When data on toxicity in humans were not available, chemical risk estimators were derived from levels that are toxic to laboratory animals. The use of animal data to predict toxic concentrations in humans added uncertainty to the risk estimates.

In addition to understanding the results in terms of the health endpoint described above, it is of interest to understand how it relates to potential fatalities. Exposure to HF or uranium compounds is estimated to be fatal to approximately 1% or less of those persons experiencing irreversible adverse effects (Policastro et al. 1997).

The chemical transportation accident risk assessment was performed by using the HGSYSTEM and FIREPLUME models (Brown et al. 1997) for uranium compounds (DUF_6, U_3O_8, and cylinder heels) and the Chemical Accident Stochastic Risk Assessment Model (CASRAM) (Brown et al. 1996, 2000) for HF. Chemical accident consequences were assessed by using HGSYSTEM/FIREPLUME for uranium compounds and HGSYSTEM for HF.

F.3.4 Vehicle-Related Impacts

In addition to the cargo-related risks posed by transportation-related activities, vehicle-related risks were also assessed for the same routes. These risks, which are independent of the radioactive nature of the cargo, would be incurred for similar shipments of any commodity. The vehicle-related risks were assessed for both routine conditions and accidents.

Vehicle-related risks during routine transportation are incremental risks caused by potential exposure to airborne particulate matter from fugitive dust and vehicular exhaust emissions. These risks are based on epidemiological data that associate mortality rates with ambient air particulate concentrations. A discussion of the basis for the emissions risk factors and the uncertainty associated with them is provided in Section F.3.5.3.

The vehicle-related accident risk refers to the potential for transportation-related accidents that could result in fatalities due to physical trauma that are not related to the cargo in the shipment. State average rates for transportation-related fatalities were used in the assessment. Vehicle-related risks are presented here in terms of estimated fatalities for the truck and rail options considered.

F.3.5 Routine Risk Assessment Method

The RADTRAN 4 computer code (Neuhauser and Kanipe 1992) was used for the routine risk assessments to estimate the radiological impacts to collective populations. The RISKIND computer code (Yuan et al. 1995) was used to estimate scenario-specific doses to MEIs during routine operations. Routine risks from hazardous chemical shipments are not expected. It is assumed that the shipping packages would not leak during routine transportation operations.

F.3.5.1 Collective Population Risk

The radiological risk associated with routine transportation results from the potential exposure of people to low-level external radiation in the vicinity of loaded shipments. Because the radiological consequences (dose) occur as a direct result of normal operations, the probability of routine consequences is taken to be unity in the RADTRAN 4 code. Therefore, the dose risk is equivalent to the estimated dose.

For routine transportation, the RADTRAN 4 computer code considers all major groups of potentially exposed persons. The RADTRAN 4 calculations of risk for routine highway and rail transportation include exposures of the following population groups:

- *Persons along the route (off-link population).* Collective doses were calculated for all persons living or working within 0.5 mi (0.8 km) of each side of a transportation route. The total number of persons within the 1-mi (1.6-km) corridor was calculated separately for each route considered in the assessment.

- *Persons sharing the route (on-link population).* Collective doses were calculated for persons in all vehicles sharing the transportation route. This group includes persons traveling in the same or opposite directions as the shipment, as well as persons in vehicles passing the shipment.

- *Persons at stops.* Collective doses were calculated for people who might be exposed while a shipment was stopped en route. For truck transportation, these stops include stops for refueling, food, and rest. For rail transportation, stops were assumed to occur for purposes of classification.

- *Crew members.* Collective doses were calculated for truck and rail transportation crew members involved in the actual shipment of material.

The doses calculated for the first three population groups were added together to yield the collective dose to the general public; the dose calculated for the fourth group represents the collective dose to workers. The RADTRAN 4 models for routine dose are not intended for use in estimating specific risks to individuals.

For the DUF_6 cylinder shipments, route-specific data were used to estimate the collective routine risks using the input assumptions as given in Biwer et al. (2001). For this EIS, the route data were updated with population data from the 2000 census.

F.3.5.2 Maximally Exposed Individual Risk

In addition to assessing the routine collective population risk, RISKIND was used to estimate the risks to MEIs for a number of hypothetical exposure scenarios. Receptors included transportation crew members, departure inspectors, and members of the public exposed during traffic delays, while working at a service station, or while living near a facility.

RISKIND was used to calculate the dose to each MEI considered for an exposure scenario defined by an exposure distance, duration, and frequency specific to that receptor. The distances and durations of exposure were similar to those given in previous transportation risk assessments (DOE 1990b, 1995, 1996, 1997b, 1999) The scenarios were not meant to be exhaustive but were selected to provide a range of potential exposure situations.

The RISKIND external dose model considers direct external exposure and exposure from radiation scattered from the ground and air. RISKIND was used to calculate the dose as a function of distance from a shipment on the basis of the dimensions of the shipment (millirems per hour for stationary exposures and millirems per event for moving shipments). The code approximates the shipment as a cylindrical volume source, and the calculated dose includes contributions from secondary radiation scattering from buildup (scattering by the material contents), cloudshine (scattering by the air), and groundshine (scattering by the ground). The dose rate curve (relative dose rate as a function of distance) specific to depleted uranium was determined by using the MicroShield code (Negin and Worku 1992) for input into RISKIND. As a conservative measure, credit for potential shielding between the shipment and the receptor was not considered.

F.3.5.3 Vehicle-Related Risk

Vehicle-related health risks resulting from routine transportation might be associated with the generation of air pollutants by transport vehicles during shipment; such risks are independent of the radioactive or chemical nature of the shipment. The health endpoint assessed under routine transportation conditions was the excess latent mortality due to inhalation of vehicular emissions. These emissions consist of particulate matter in the form of diesel engine exhaust and fugitive dust raised from the road/railway by the transport vehicle.

Risk factors for pollutant inhalation in terms of latent mortality were generated by Biwer and Butler (1999) for transportation risk assessments. These risks are based on epidemiological data that associate mortality rates with particulate concentrations in ambient air. Increased latent mortality rates resulting from cardiovascular and pulmonary diseases have been linked to incremental increases in particulate concentrations in air. Thus, the increase in ambient air particulate concentrations caused by a transport vehicle, with its associated fugitive dust and diesel exhaust emissions, is related to such premature latent fatalities in the form of risk factors. In this EIS, values of 8.36×10^{-10} latent fatality/km for truck transport and 1.20×10^{-10} latent fatality/railcar-km for rail transport were used. The truck value is for heavy combination trucks (truck class VIIIB). Because of the conservatism of the assumptions made to reconcile results among independent epidemiological studies, the latent fatality risks estimated by using these values may be considered to be near an upper bound (Biwer and Butler 1999). The risk factors are for areas with an assumed population density of 1 person/km^2. One-way shipment risks were obtained by multiplying the appropriate risk factor by the average population density along the route and the route distance. The risks reported for routine vehicle risks in this EIS are for round-trip travel of the transport vehicle.

The vehicle risks reported here are estimates based on the best available data. However, as is true for the radiological risks, there is a large degree of uncertainty in the vehicle emission risk factors that is not readily quantifiable. For example, large uncertainties exist with regard to the extent of increased mortality that occurs with an incremental rise in particulate air concentrations and with regard to whether there are threshold air concentrations that are applicable. Also, estimates of the particulate air concentrations caused by transport vehicles depend on location, road conditions, vehicle conditions, and weather.

F.3.6 Accident Risk Assessment Methodology

The radiological transportation accident risk assessment used the RADTRAN 4 code for estimating collective population risks and the RISKIND code for estimating MEI and population consequences. The HGSYSTEM model (Post et al. 1994a,b) was used to assess the hazardous chemical transportation accident risks for both the collective population and individuals. The model is a widely applied code recognized by the EPA for chemical accident consequence predictions.

The collective accident risk for each type of shipment was determined in a manner similar to that described for routine collective population risks. For the DUF_6 cylinder shipments, route-specific data were used to estimate the collective accident risks on the basis of the input assumptions given in Biwer et al. (2001). For this EIS, the route data were updated with population data from the 2000 census.

F.3.6.1 Radiological Accident Risk Assessment

The risk analysis for potential accidents differs fundamentally from the risk analysis for routine transportation because occurrences of accidents are statistical in nature. The accident risk assessment is treated probabilistically in RADTRAN 4 and in the HGSYSTEM approach used to estimate the hazardous chemical component of risk. Accident risk is defined as the product of the accident consequence (dose or exposure) and the probability of the accident occurring. In this respect, both RADTRAN 4 and HGSYSTEM estimate the collective accident risk to populations by considering a spectrum of transportation-related accidents. The spectrum of accidents was designed to encompass a range of possible accidents, including low-probability accidents that have high consequences and high-probability accidents that have low consequences (such as “fender benders”). The total collective radiological accident dose risk was calculated as:

$$R_{Total} = D \times A \times \sum_{i=1,n} (P_i \times C_i) \ , \tag{F.5}$$

where:

R_{Total} = total collective dose risk for a single shipment distance *D* (person-rem),

D = distance traveled (km),

A = accident rate for transport mode under consideration (accidents/km),

P_i = conditional probability that the accident is in Severity Category *i*, and

C_i = collective dose received (consequence) should an accident of Severity Category *i* occur (person-rem).

The results for collective accident risk can be directly compared with the results for routine collective risk because the latter results implicitly incorporate a probability of occurrence of 1 if the shipment takes place.

The RADTRAN 4 calculation of collective accident risk employs models that quantify the range of potential accident severities and the responses of transported packages to accidents. The spectrum of accident severity is divided into a number of categories. Each category of severity is assigned a conditional probability of occurrence — that is, the probability that an accident will be of a particular severity if an accident occurs. The more severe the accident, the more remote the chance of such an accident. Release fractions, defined as the fraction of the material in a package that could be released in an accident, are assigned to each accident severity category on the basis of the physical and chemical form of the material. The model takes into account the mode of transportation and the type of packaging being considered. The accident rates, the definition of accident severity categories, and the release fractions used in this analysis are discussed further in Biwer et al. (1997, 2001). The approach for hazardous chemicals incorporates the same accident severity categories and release fractions as those used by RADTRAN 4.

For accidents involving the release of radioactive material, RADTRAN 4 assumes that the material is dispersed in the environment according to standard Gaussian diffusion models. For the risk assessment, default data for atmospheric dispersion were used, representing an instantaneous ground-level release and a small-diameter source cloud (Neuhauser and Kanipe 1995). The calculation of the collective population dose following the release and dispersal of radioactive material included the following exposure pathways:

- External exposure to the passing radioactive cloud,
- External exposure to contaminated ground,
- Internal exposure from inhalation of airborne contaminants, and
- Internal exposure from the ingestion of contaminated food.

For the ingestion pathway, national-average food transfer factors, which relate the amount of radioactive material ingested to the amount deposited on the ground, were calculated in accordance with the methods described by NRC Regulatory Guide 1.109 (NRC 1977) and used as input to the RADTRAN code. Doses of radiation from the ingestion or inhalation of radionuclides were calculated by using standard dose conversion factors (DOE 1988a,b).

F.3.6.2 Chemical Accident Risk Assessment

The risks from exposure to hazardous chemicals during transportation-related accidents can be either acute (result in immediate injury or fatality) or latent (result in cancer that would present itself after a latency period of several years). Both population risks and risks to the MEI were evaluated for transportation accidents. The acute health endpoint — potential irreversible adverse effects — was evaluated for the assessment of cargo-related population impacts from transportation accidents. Accidental releases during transport of UF_6, U_3O_8, and HF were evaluated quantitatively.

The acute effects evaluated were assumed to exhibit a threshold nonlinear relationship with exposure; that is, some low level of exposure could be tolerated without inducing a health effect. To estimate risks, chemical-specific concentrations were developed for potential irreversible adverse effects. All individuals exposed at these levels or higher following an accident were included in the transportation risk estimates. In addition to acute health effects, the cargo-related risk of excess cases of latent cancer from accidental chemical exposures could be evaluated. However, none of the chemicals that might be released in any of the accidents would be carcinogenic. As a result, no predictions for excess latent cancers are presented in this report for accidental chemical releases.

In addition, to address MEIs, the locations of maximum hazardous chemical concentrations were identified for shipments with the largest potential releases. Estimates of exposure duration at those locations were obtained from modeling output and used to assess whether MEI exposure to uranium and other compounds exceeded the criteria for potential irreversible adverse effects.

The primary exposure route of concern with respect to an accidental release of hazardous chemicals would be inhalation. Although direct exposure to hazardous chemicals via other pathways, such as ingestion or dermal absorption, would also be possible, these routes would be expected to result in much lower exposure than the inhalation pathway doses for the chemicals of concern in this assessment. The likelihood of acute effects would be much less for the ingestion and dermal pathways than for inhalation.

The chemical transportation risks for shipment of the depleted uranium compounds were estimated by using FIREPLUME and HGSYSTEM accident consequences multiplied by the appropriate accident rate probabilities, population densities, and distance traveled in a similar fashion to that used by RADTRAN, as discussed in Section F.3.6.1 for the radiological transportation risks.

The chemical accident transportation risk and consequences for shipment of aqueous HF were estimated using the CASRAM and HGSYSTEM models, respectively. For the risk assessment, 24 generic but representative routes were selected for hazardous commodity shipments in the region of interest (ROI). The generic HF routes were derived from historical shipments of five chemicals, in addition to HF, that are typically shipped in similar corrosive chemical container tank trucks. Temperature-dependent vapor pressures and densities for aqueous HF properties were derived with an empirically derived formulation (Pratt 2003) and experimentally generated plots (Honeywell International, Inc. 2002). The heat of vaporization was calculated from vapor pressure relationships. These parameters were used in estimating the evaporation rate from the HF pool and the HF that spilled onto the surface. Rail and highway accident rates, spill fraction, and population densities along the shipment routes were incorporated into CASRAM from statistics reported in the Hazardous Material Information System (HMIS) database and from census data. For each shipment, CASRAM calculates the probabilities of a release, given an accident and the risk of adverse (ERPG-1) and irreversible (ERPG-2) effects associated with the shipment. The overall risks are estimated by summing over all shipments and routes. The risks are normalized by shipment distance and weight, so that the calculations can be applied to specific shipment destinations and shipment quantities. For consequence assessment, procedures that are the same or similar to those used for fixed facilities are used (e.g., aqueous HF tank rupture). A description of the method can be found in Section F.2.2.1, Nonfire Accident Scenario Modeling. It was assumed for both the risk and consequence assessment that aqueous HF would be shipped in nonpressurized corrosive liquid tank cars with a 20,000-gal (76,000-L) capacity for rail shipments, and in corrosive liquid cargo tanker (MC312) trucks with a 5,000-gal (19,000-L) capacity.

F.3.7 Accident Consequence Assessment

Because predicting the exact location of a severe transportation-related accident is impossible when estimating population impacts, separate accident consequences were calculated for accidents occurring in three population density zones: rural, suburban, and urban. Moreover, to address the effects of the atmospheric conditions existing at the time of an accident, two atmospheric conditions were considered: neutral (i.e., unstable) and stable.

The MEI for severe transportation accidents was considered to be located at the point of highest hazardous material concentration that would be accessible to the general public. This location was assumed to be 100 ft (30 m) or farther from the release point at the location of highest air concentration as determined by the HGSYSTEM and FIREPLUME models. Only the shipment accident resulting in the highest contaminant concentration was evaluated for the MEI.

F.3.7.1 Radiological Accident Consequence Assessment

The RISKIND code was used to provide a scenario-specific assessment of radiological consequences from severe transportation-related accidents. Whereas the RADTRAN 4 accident risk assessment considered the entire range of accident severities and their related probabilities, the RISKIND accident consequence assessment focused on accidents that result in the largest releases of radioactive material to the environment. Accident consequences were presented for each type of shipment that might occur under any given option for each alternative. The accident consequence assessment was intended to provide an estimate of the potential impacts posed by a severe transportation-related accident.

The severe accidents considered in the consequence assessment were characterized by extreme mechanical and thermal forces. In all cases, these accidents would result in a release of radioactive material to the environment. The accidents correspond to those within the highest accident severity category, as described previously. These accidents represent low-probability, high-consequence events. The probability of accidents of this magnitude would depend on the number of shipments and the total shipping distance for the options considered; however, accidents of this severity are expected to be extremely rare.

The severe accidents involving solid radioactive material that would result in the highest impacts would generally be related to fire. The fire would break down and distribute the material of concern. Air concentrations of radioactive contaminants at receptor locations following a hypothetical accident were determined by using the FIREPLUME model. On the basis of these air concentrations, RISKIND was used to calculate the radiological impacts for the accident consequence assessment.

The accident consequences were calculated for both local populations and MEIs. The population dose included the population within 50 mi (80 km) of the site of the accident. The exposure pathways considered were similar to those discussed previously for the accident risk assessment. Although remedial activities after the accident (e.g., evacuation or ground cleanup) would reduce the consequences of an accident, these activities were not accounted for in the consequence assessment.

F.3.7.2 Chemical Accident Consequence Assessment

HGSYSTEM Version 3.0 was used to estimate the potential consequences from severe hazardous chemical accidents. FIREPLUME was used to predict the consequences of transportation accidents involving fires. The HGSYSTEM model is discussed in Section F.2.2.

F.3.7.3 Vehicle-Related Accident Risk Assessment

The vehicle-related accident risk refers to the potential for transportation-related accidents that could directly result in fatalities not related to the cargo in the shipment. This risk represents fatalities from mechanical causes. National-average rates for transportation-related fatalities (Saricks and Tompkins 1999) were used in the assessment for shipments without a defined origin or destination site (e.g., the use location of the conversion HF products). For truck transport, 1.49×10^{-8} fatality per truck-km was assumed. For rail transport, 7.82×10^{-8} fatality per railcar-km was assumed. State average fatality rates from Saricks and Tompkins (1999) were used in the assessment for the DUF_6 shipments that had known origin and destination sites. Vehicle-related accident risks were calculated by multiplying the total distance traveled by the rate for transportation-related fatalities. In all cases, the vehicle-related accident risks were calculated by using distances for round-trip shipment.

F.4 AIR QUALITY AND NOISE

F.4.1 Air Quality

Potential air quality impacts under each alternative were evaluated by estimating potential air pollutant emissions from the activities associated with facility construction and operations, followed by atmospheric dispersion modeling of these emissions to assess impacts on ambient air quality.

Air emissions resulting from activities associated with construction (e.g., construction equipment, engine exhaust, and fugitive dust emissions) and with operations (e.g., boiler[2] and emergency generator stack emissions) were estimated by using applicable emission factors (EPA 2002) and emission and activity level data provided by UDS (UDS 2003b). The significance of project-related emissions was evaluated by comparing the estimated project-related emissions with countywide or statewide emissions.

Atmospheric dispersion modeling of pollutant emissions was performed by using the EPA-recommended ISC short-term model (EPA 1995). In addition to project-related emission data, model input data included stack and building downwash data, meteorological data, receptor data, and terrain elevation data. Emissions from construction activities were assumed to occur during one daytime 8-hour shift, while the emissions from facility operations were assumed to occur 24 hours per day and 7 days per week.[3] Effects of building downwash on stack plumes

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2 UDS is currently proposing to use electrical heating in the conversion facility but is evaluating other options. If natural gas was used, either furnaces or boilers could be selected. The air emissions from boilers are greater than those for residential-type furnaces for carbon monoxide (CO) and nitrogen oxides (NO_x), and the same for other criteria pollutants and volatile organic compounds (VOCs). To assess bounding air quality impacts, a boiler option was analyzed.

3 The backup generator is assumed to be operating for 192 hours per year, which represents 4 hours per month for testing and 3 days of operation twice per year in response to a power outage.

were considered for the emission sources during the operational period. The meteorological data selected for the Portsmouth site are the 1999 on-site surface data (30-m [99-ft] level), combined with mixing height data at Wilmington, Ohio. For construction impact analysis, initial receptor grids were placed at distances of 100 m (328 ft) from the construction site (because heavy equipment operators would not allow public access any closer for safety reasons) and extended up 50 km (31 mi) beyond existing boundaries. For operation impact analysis, receptor grids were set along and beyond the existing and planned conversion facility boundaries up to 50 km (31 mi). The grid intervals ranged from 25 m (82 ft) near the facility to 5 km (3.1 mi) outmost. To model the effects of terrain elevation, elevation data for the emission sources and receptors were also input to the model.

For assessing potential air quality impacts, the estimated maximum ground-level concentration increments due to these pollutant emissions beyond site boundaries were compared with allowable PSD increments. Total maximum concentrations, obtained by adding the background concentration levels representative of the site to the estimated maximum ground-level concentration increments, were compared with applicable national and state ambient air quality standards.

F.4.2 Noise

Potential noise impacts under each alternative were assessed by estimating the sound levels from noise-emitting sources associated with facility construction and operations, followed by noise propagation modeling. Examples of noise-emitting sources include heavy equipment used in earthmoving and other activities during construction; process equipment and emergency generators during operations; and train whistles and on-site and off-site traffic during construction and operations. Potential noise levels due to these sources were obtained from the literature (Harris Miller Miller & Hanson, Inc. [HMMH] 1995) and data provided by UDS (UDS 2003b). For construction of the conversion facility, detailed information on the types and number of construction equipment required is not available. Therefore, for construction impact analysis, it was assumed that the two noisiest sources would operate simultaneously at the center of the construction site (HMMH 1995). For operations impact analysis, the highest noise levels (inside buildings) measured at the Framatome ANP Richland, Washington, facility, similar to the proposed facility at Portsmouth, were assumed to be those at a distance of 15 m (50 ft) from the facility.

Noise levels at the nearest residence from the alternative sites were estimated by using a simple noise propagation model on the basis of estimated sound levels at the source. The significance of estimated potential noise levels at the nearest residence was assessed by comparing them with the EPA noise guideline (EPA 1974) and measured background noise levels.

F.5 WATER AND SOIL

Potential impacts to surface water, groundwater, and soil during facility construction, normal operations, and potential accidents were evaluated. Methods of quantitative and qualitative impact analyses are described in the following paragraphs.

For surface water, impacts were assessed in terms of runoff, floodplain encroachment, and water quality. Changes in runoff were assessed by comparing runoff areas with and without the proposed facility. Floodplain encroachment was assessed by evaluating the location of the proposed facility in terms of known floodplains. Inputs to the floodplain evaluation included estimated facility effluent volumes and estimates of flow volumes in nearby streams and rivers. Water quality impacts were estimated by using the proposed drinking water standard of 30 μg/L (EPA 2003b) as a guideline. When data were unavailable, assessment models that account for the different types of contaminants and dilution estimates for the surface water features were used to estimate surface water conditions.

Potential impacts on groundwater were assessed in terms of changes in recharge to underlying aquifers, depth to groundwater, direction of groundwater flow, and groundwater quality. Changes to recharge of groundwater were evaluated by comparing the increase in the impermeable area produced by construction and operations with the recharge area available at actual or representative sites. Impacts on the depth to groundwater were evaluated by comparing existing water use with modified water needs. Changes in the direction of groundwater flow were evaluated by examining the potential effects produced by the increased water demand. A model that considers movement, dispersion, adsorption, and decay of the contaminant source material over time was used to estimate the migration of contaminants from source areas to the groundwater (i.e., groundwater quality). Details of the model are provided in Tomasko (1997).

Potential impacts to soil were assessed in terms of changes in topography, permeability, quality, and erosion potential. Erosion potential was evaluated in terms of disturbed land area. Changes in soil quality were evaluated on the basis of the amounts of contaminants deposited as a result of certain activities. No standard is available for limiting soil concentrations of uranium; a health-based guideline value of 230 μg/g (EPA 1995a), applicable for residential settings, was used as a guideline for comparison in this EIS.

F.6 SOCIOECONOMICS

F.6.1 Scope of the Analysis

For this EIS, the analysis of the socioeconomic impacts under the no action alternative and the action alternatives was based on the analysis performed for the DUF_6 PEIS (DOE 1999), which used cost engineering data provided by Dubrin et al. (1997), with additional information provided by UDS (UDS 2003b).

For the action alternatives and the no action alternative, impacts were estimated for the ROIs at Portsmouth and ETTP. The analysis estimated the impacts of continued storage and conversion on regional economic activity, including direct (on-site) and indirect (off-site) employment and income. In addition, the impact of each conversion technology on (1) population in-migration, (2) local housing markets, (3) local public service employment, and (4) local jurisdictional revenues and expenditures was also calculated. Additional details on the analysis of socioeconomic impacts undertaken for the DUF_6 PEIS are provided in Allison and Folga (1997). Updated data on the affected environment at each site were used to revise the impacts from continued storage and conversion facilities on the economy and community at each site that were described in the DUF_6 PEIS (DOE 1999) and in Hartmann (1999a,b,c).

An assessment of the socioeconomic impacts from transporting DUF_6 was not included in the DUF_6 PEIS analysis or in this EIS. The transportation of DUF_6 would likely not lead to significant en route socioeconomic impacts because the total expenditures for transportation related to DUF_6 would be small compared with expenditures related to total shipments of all other goods for any of the routes that might be used. The analysis might also have considered the socioeconomic impacts of potential accidents, particularly for DUF_6-related transportation activities. However, because it is unlikely that any potential accident would release large quantities of hazardous or radioactive material into the environment, accidents are expected to create only minor local economic disruption, and a substantial commitment of fiscal resources for accident remediation would probably not be necessary at any of the current storage sites or along transportation routes.

F.6.2 Technical Approach for the Analysis

F.6.2.1 Regional Economy

The analysis of regional economic impacts used engineering cost data for facilities that would be constructed and operated and input-output economic data for the ROI surrounding the site. The ROI was defined as the counties in which 90% of site employees currently reside (see Section 3.1.8). Additional data from the U.S. Bureau of the Census (2002a,b) were used to forecast economic data to provide the basis for the presentation of relative impacts.

The analysis was performed by using the engineering cost data of Dubrin et al. (1997) for the construction and operation of the conversion facility, which were then updated by using UDS data (UDS 2003b). Direct (on-site) employment and income impacts were then calculated on the basis of average total labor costs (i.e., fully loaded labor costs, including site overhead, contractor profit, and employee benefits) in each category. Estimates of direct income impacts were calculated by adjusting average fully loaded labor costs to exclude the various components of site overhead, state and federal income taxes, and other payroll deductions. This process produced a measure of disposable wage and salary income that would likely be spent in the regional economy at each of the sites.

Indirect (off-site) impacts were based on detailed item-specific procurement data for material and on adjusted direct and indirect labor costs. Cost information was associated with the relevant standard industrial classification (SIC) codes and construction and operation schedule information to provide estimates of procurement and wage and salary expenditures for each sector in the local economy for the year in which expenditures would be made. Information on the expected pattern of local and nonlocal procurement for the various materials and labor expenditures by SIC code was then calculated on the basis of local shares of national employment in each material and labor procurement category and information provided for the site. Expenditures by SIC code by year occurring in the ROI were then mapped into the Bureau of Economic Analysis (BEA) sectors used in an IMPLAN input-output model (Minnesota IMPLAN Group, Inc. 2003) specified for the ROI (see Section 3.1.1.8). Each model was used to produce employment and income multipliers for each sector where procurement and labor expenditures occur. Indirect impacts were then calculated by multiplying expenditures in each sector by the input-output multipliers produced by the model for the ROI.

Impacts were presented in terms of the (1) direct, indirect, and total employment impacts; (2) direct and total income impacts; and (3) relative employment impact, or the magnitude of the absolute impact compared with the growth in the local economic employment baseline. Construction impacts for the facility were presented for the peak construction year. Operations impacts were presented for the first year of operations.

F.6.2.2 Regional Economy Assessment Model

The analysis used county-level IMPLAN input-output economic data for 2000 (Minnesota IMPLAN Group, Inc. 2003) to measure the regional economic impacts of conversion facilities at the site. The IMPLAN input-output model is a microcomputer-based program that allows construction of input-output models for counties or combinations of counties for any location in the United States. Input-output data are the economic accounts of any given region and show the flow of commodities to industries from producers and institutional consumers. The accounts also show consumption activities by workers, owners of capital, and imports from outside the region. The model contains 528 sectors, representing industries in agriculture, mining, construction, manufacturing, wholesale and retail trade, utilities, finance, insurance and real estate, and consumer and business services. The model also includes information for each sector on employee compensation; proprietary and property income; personal consumption expenditure; federal, state, and local expenditures; inventory and capital formation; and imports and exports. The model can be used to produce accurate estimates of the impact of changes in expenditures in specific local activities on employment and income in any given year. The analysis of regional economic impacts used the model to calculate multipliers for each sector in the ROI for which procurement and wage and salary expenditures would be likely to occur. These multipliers were calculated for the year 2000, the latest year available.

For this EIS, data from the 2000 census were used to modify and update the data presented in the data compilation reports (Hartmann 1999a-c) for both the affected environment and impact sections. In addition to using 2000 population data to describe population trends in the ROI, counties, and important cities near the site, these data were used to provide information on per capita personal income at the county level and on the number of employees per capita at the county and city level for key public services, including police, fire protection, general government, education, medical facilities, and hospitals. Housing data from the 2000 census were also used to establish trends in housing growth over the period 1990 to 2000; details were presented for both the owner-occupied and rental markets, including vacancy rates. The 2000 census data were used in this EIS to update the impacts that were described in the data compilation reports for each alternative.

F.6.2.3 Population

The construction and operation of a conversion facility would likely lead to in-migration into the ROI. In-migration would be both direct, related to new employment created on site, and indirect, related to changes in employment opportunities in the ROI as a whole. In the DUF_6 PEIS (DOE 1999) analysis, the number of direct employees in-migrating was based on information on employment in existing DOE programs and on the level of contractor support. Indirect in-migration that would occur for each ROI was calculated by using assumed in-migration rates associated with changes in employment in the local industries most significantly affected indirectly by construction and operation expenditures, with residual in-migration rates assumed for the remaining industries in the economy indirectly affected. As in the DUF_6 PEIS, population impacts in this EIS are presented in terms of the (1) absolute total (direct and indirect) in-migration impact and (2) relative population impact, or the magnitude of the absolute impact compared with the growth in the local economic population baseline.

F.6.2.4 Local Housing Markets

In-migration that would occur with the construction and operation of a conversion facility could affect the local housing market in the ROI. The DUF_6 PEIS (DOE 1999) analysis considered these impacts by estimating the increase in demand for housing units in each year of construction and operation on the basis of the number of in-migrating workers to the area surrounding each site and average household size. The results were compared with forecasts for housing supply and demand and owner-occupied and rental vacancy rates for each year during construction and operation, on the basis of information provided by the U.S. Bureau of the Census (1994, 2002a).

F.6.2.5 Local Jurisdictions

The construction and operation of a conversion facility would likely lead to some in-migration into the area surrounding the site, which would change the demand for educational services provided by school districts and for public services (police, fire protection, health services, etc.) provided by cities and counties. The DUF_6 PEIS (DOE 1999) analysis used estimates of in-migration (see above) as the basis for estimating impacts on public service employment and impacts on revenues and expenditures for the various counties, cities, and school districts in the ROI. Revenue and expenditure data were based on the annual comprehensive financial reports produced by individual jurisdictions surrounding each site and on demographic information provided by the U.S. Bureau of the Census (2002a). Impacts were presented in terms of the number of (1) new public service employees required and (2) percentage change in forecasted revenues and expenditures for counties, cities, and school districts. Impacts were estimated for the peak year of construction and the first year of operation for the conversion facility.

F.7 ECOLOGY

Potential impacts on terrestrial and aquatic biota — including vegetation and wildlife, wetlands, and federal- and state-listed threatened and endangered species — were evaluated. The impact analysis focused on the radiological and chemical toxicity effects to biota that would result from exposure to DUF_6 and related compounds and from physical disturbance to biota and habitats. The conversion of DUF_6 was evaluated on the basis of the UDS technology for converting DUF_6 to depleted U_3O_8. The analysis considered potential impacts on biota in the vicinity of the Portsmouth site.

The analysis of impacts on wildlife addressed the effects of facility construction (including physical disturbance and habitat loss) and facility operations (including air quality, radiological, and chemical toxicity effects through the exposure pathways of inhalation, dermal contact, and ingestion). Exposures were based on predicted concentrations of contaminants in air, surface water, groundwater, and soil. Radiological dose rate estimates (in rad/d) were calculated for aquatic biota (fish and shellfish) on the basis of undiluted concentrations (in pCi/L), energy released per decay (MeV) for depleted uranium, and a bioconcentration factor (factors of 2 and 60 were applied for fish and shellfish, respectively). These dose rate estimates were compared with the dose limit of 1 rad/d specified in DOE Order 5400.5 (DOE 1990a). The screening level for potential ecological effects is 4.55×10^3 pCi/L for fish (Bechtel Jacobs Company LLC 1998). In addition, concentrations of uranium, uranium compounds, and HF in air, water, and/or soil were compared with published benchmark values (levels with no effects or lowest observed effects) to determine potential toxicity effects. Benchmark values for air concentration lowest observable effects due to inhalation were 7 mg/m^3 for HF and 17 mg/m^3 for U_3O_8. The benchmark values for aquatic toxicity were a screening level of 2.6 μg/L, the Tier II secondary chronic value for potential adverse effects (Suter and Tsao 1996), and a lowest observable effect level of 150 μg/L for total uranium (Hyne et al. 1992). Potential impacts analyzed included impacts on individuals (such as mortality, injury, or physical disturbance) and potential changes in biotic communities.

The analysis of ecological impacts on plant species addressed the effects of facility construction (such as effects from the removal of vegetation) and operations (such as chemical toxicity effects). Estimated concentrations of uranium in soil were compared with a benchmark value of 5 μg/g, which is the lowest observed effects concentration (Will and Suter 1994). Potential impacts analyzed included impacts on individuals (such as injury or mortality) and potential changes in biotic communities.

Physical disturbances to biota and habitats were also evaluated. The general guidelines used to assess impacts of habitat loss and wildlife disturbance were as follows: (1) negligible impacts were those that would affect less than 10 acres (4 ha) of required land; (2) moderate impacts would affect 10 to 100 acres (4 to 40 ha) of required land; and (3) potential large impacts would affect more than 100 acres (40 ha) of required land.

The potential impacts on wetlands were based on the direct impacts that could result from construction (such as filling) or the indirect impacts that could result from changes in water quality or the hydrologic regime or from soil compaction or runoff. The potential impacts on federal- and state-listed threatened and endangered species were based on the direct impacts that could result from habitat loss or modification or the indirect impacts that could result from disturbance.

Input for the impact analysis included data on plant and animal species either known to occur or that could potentially occur at the site and in ecosystems (such as wetland, forest, grassland) in the vicinity of the site.

F.8 WASTE MANAGEMENT

Potential impacts to waste management programs at Portsmouth and ETTP were evaluated for the alternatives considered in this EIS. The categories of waste evaluated were LLW, TRU, hazardous waste, and nonhazardous solid and liquid waste. Current (as of fiscal year [FY] 2002) projected total generation volumes for each of the categories of waste for the period covering FYs 2002 through 2025 were obtained from a database maintained by the DOE Oak Ridge Office for the site (Cain 2002). These volumes included wastes generated from routine site operations and from planned environmental restoration activities; they are summarized in Table F-4.

For this EIS, annualized generation volumes were derived for use in evaluating potential impacts from the conversion facility. These volumes were derived by dividing the forecasted total volumes from FY 2002 through FY 2025 by 24 years. These annualized generation volumes are included in Table F-4 and are also presented in Sections 3.1.9 and 3.2.9 for Portsmouth and ETTP, respectively. Potential impacts were then evaluated (see Chapter 5) by comparing the waste volumes that would be generated (from the conversion to U_3O_8 considered in this EIS) with the annualized generation volumes.

The majority of the wastes generated from the conversion facility would be LLW and nonhazardous wastes (wastewater and solids). At both Portsmouth and ETTP, all LLW is transported off site for disposal except Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) or environmental restoration LLW solid wastes generated at ETTP. (These wastes are disposed of at the disposal cell located within the Oak Ridge Reservation [ORR] complex.) Nonhazardous wastewater is treated at on-site treatment facilities and discharged to permitted outfalls. It appears that the wastewater treatment facilities at these sites would have adequate remaining capacities to treat the additional wastewater that

TABLE F-4 Environmental Management Waste Generation Forecast[a] for Fiscal Years 2002 through 2025

		Waste Volume (m³)			
Site	Waste Type	Inventory at End of FY 2001	Forecast of Newly Generated Waste, FY 2002–2025	Total Managed Waste, FY 2002–2025	Annualized Projection[c]
ETTP[b]	Hazardous	0	8,288	8,288	1,381
	LLW	20,595	953,059	973,654	162,276
	LLMW	2,572	62,608	65,180	10,863
	TRU	0	0	0	0
	Nonhazardous (sanitary/industrial)				
	Wastewater	0	1,131,169	1,131,169	188,528
	Solids	0	280,911	280,911	46,819
Portsmouth	Hazardous	0	2,587	2,587	112
	LLW	13,587	1,727,409	1,740,996	75,695
	LLMW	6,147	129,124	135,271	5,881
	TRU	0	0	0	0
	Nonhazardous (sanitary/industrial)				
	Wastewater	0	0	0	0
	Solids	0	76,358	76,358	3,320

[a] Source: DOE Oak Ridge Operations Office (Cain 2002). Volume projections include wastes from routine site operations and environmental restoration. A large portion of the waste would be from environmental restoration activities.

[b] For ETTP, it is projected that the majority of the waste would be generated by FY 2008, consistent with the site's accelerated schedule.

[c] Annualized projections were obtained by dividing volumes by 6 years for ETTP and 23 years for Portsmouth.

would be generated from the conversion facility (see Section 3). Nonhazardous solids at Portsmouth are disposed of at an on-site landfill. At ETTP, nonhazardous solids generated from environmental restoration activities are disposed of at the landfill located within the ORR complex, and the remaining waste (from other site activities) is transported to an off-site facility. All low-level mixed (radioactive and hazardous) waste (LLMW) and hazardous waste at these sites are transported off site for disposal, except for waste from environmental restoration activities at ETTP, which is sent to the disposal cell located within the ORR complex. TRU waste would most likely be transported to the Waste Isolation Pilot Plant (WIPP) in New Mexico.

F.9 RESOURCE REQUIREMENTS

The evaluation of resource requirements identified the major resources required that could be determined at this level of analysis. The commitment of material and energy resources during the entire life cycles of the facility considered in this EIS would include construction materials that could not be recovered or recycled, materials rendered radioactive that could not be decontaminated, and materials consumed or reduced to unrecoverable forms or waste. For construction, materials required would include wood, concrete, sand, gravel, steel, and other metals. Materials consumed during operations could include operating supplies, miscellaneous chemicals, and gases. Strategic and critical materials, or resources with small reserves, were also identified and considered.

Energy resources irretrievably committed during construction and operations would include the fossil fuels used to generate heat and electricity (if furnaces or boilers were used for heating; current plans are for electrical heating of facilities). Energy in the form of diesel fuel, gasoline, and oil would also be used for construction equipment and transportation vehicles.

The assessment of potential resource requirements for continued storage (no action) and the action alternatives was based on comparing the resource requirements needed for building and operating the proposed facility with the existing resource capacities of on-site infrastructure systems and with current off-site demand for resources at the three current storage sites. A variation of the methodology applied in the Waste Management Programmatic Environmental Impact Statement (WM PEIS) (DOE 1997a) was utilized in this EIS study. The effects of the various options on on-site infrastructure systems (such as electrical demand) were assessed qualitatively by comparing the new demand with the existing maximum capacity. The demand on the off-site infrastructure that would result from new resource requirements was compared with the estimated current demand.

F.10 LAND USE

The evaluation of land use impacts under the action alternatives and the no action alternative employed a similar approach. A baseline description for 2003 outlined the land use patterns currently occurring on the Portsmouth site, providing a sense of what is both typical and acceptable in this locale. A complementary description of land use in Pike County, based on available interpreted satellite imagery, provides a sense of land use tendencies in the vicinity of the site (which remained relatively unchanged over the past decade). An analysis of the alternatives, in turn, enabled an assessment of how compatible (or incompatible) the various potential development scenarios would be with existing land use patterns. Although the analysis employed quantitative data when available — such as summaries of land use activities by the size of the area involved — the assessment ultimately was qualitative, being based on comparisons with existing land use patterns and current zoning and planning guidelines.

The assumptions underlying the assessment of impacts on land use for this EIS include these:

- Baseline conditions are assumed to be those that are occurring in 2003, although, in some cases, information on land use was available from prior years.

- The projected operating life of the proposed facility is assumed to be 25 years, beginning in about 2006.

- Under the no action alternative, continued storage of DUF_6 is assumed to occur over a 40-year period.

F.11 CULTURAL RESOURCES

Cultural resources include those portions of the natural and man-made environment that have significant historical or cultural meaning. These resources include archaeological sites, historic structures, cultural landscapes, and traditional cultural properties.

The DUF_6 conversion project activities that would have the greatest potential for affecting significant cultural resources would be those related to construction. It is anticipated that the operation and decommissioning of the conversion facility would have far fewer effects.

Three alternative locations for the conversion facility have been proposed for Portsmouth. The area of potential effect at each construction location was determined. This area would include the land within the boundary of each facility construction location, including access roads, laydown areas, parking areas, and any locations where upgrades to infrastructure (e.g., roads, power lines, and water lines) would be necessary. The land use history of these areas was reconstructed and evaluated to determine to what extent recent construction or earthmoving has altered the landscape and thus affected the likelihood of cultural resources being present.

A records search was conducted for each proposed construction location to determine if either unevaluated cultural resources or cultural resources eligible for inclusion in the *National Register of Historic Places* (NRHP) were known to exist. All classes of cultural resources were considered, ranging in date from the prehistoric to the contemporary. Sources included published documents, cultural resource surveys on file at the site, and files maintained by the relevant State Historic Preservation Officer (SHPO). Consultation was undertaken with the SHPO and Native American groups with historical ties to the area. This information was placed within a broader cultural and historical context. If cultural resource information was lacking, requiring new field studies before construction, the potential for encountering cultural resources in the projected area of effect was evaluated on the basis of the known distribution of cultural resources in the surrounding area.

The potential effects of chemical and radiological releases on cultural resources were investigated. There is a potential for an adverse effect on historic structures when secondary air quality standards for criteria pollutants are exceeded. Secondary standards set pollution limits to protect public welfare and include protection against damage to buildings (EPA 2002). Air quality models were used to estimate the potential that construction and operation of the conversion facility would result in pollution beyond these limits. In this model, the projected increase in emissions was added to the background levels for the pollutant, and the sum was compared with state and national secondary standards. The potential for adverse effects on cultural resources from the accident scenarios considered in this EIS was also evaluated.

F.12 ENVIRONMENTAL JUSTICE

The methods used to evaluate environmental justice impacts emphasized issues identified in Executive Order 12898 ("Federal Actions to Address Environmental Justice in Minority Populations and Low Income Populations"), which defines environmental justice as a topic that must be evaluated for federal actions. As such, the methods focused on identifying high and adverse impacts on low-income and minority populations under the action alternatives and the no action alternative. The impacts examined under environmental justice included those impacts identified in all disciplines considered in this EIS (human health, air quality, socioeconomics, etc.).

The evaluation of impacts under environmental justice was based on the following basic assumptions:

- Baseline conditions are those occurring in 2002. However, the data used to identify minority populations were from 2000, and the data used to identify low-income populations were from 1999.

- The anticipated operating life of the proposed facility is 25 years, beginning in 2006.

- The ROI for environmental justice varies by impact area, ranging from 50 mi (80 km) from the proposed facility to geographic areas close to the facilities.

Because the environmental justice evaluation relied heavily on analyses in other disciplines, it also incorporated the assumptions underlying these other inquiries. The data used to evaluate impacts related to environmental justice were of two types: (1) census data used to define disproportionality and (2) data on anticipated effects under the action alternatives and the no action alternative. Data from the most recent decennial census of population and housing, conducted in 2000, provided a recent, detailed basis for evaluating the distribution of minority and low-income populations. These two population groups are defined as follows:

- *Minority:* Individuals who classify themselves as belonging to any of the following racial groups: Black (including Black or Negro, African American, Afro-American, Black Puerto Rican, Jamaican, Nigerian, West Indian, or Haitian); American Indian, Eskimo, or Aleut; Asian or Pacific Islander; or "Other Race" (U.S. Bureau of the Census 1991; see CEQ 1997). In the 2000 census, many individuals categorized themselves as belonging to more than one race. This EIS considers individuals of multiple races to be minority, regardless of the races involved. This study also includes individuals identifying themselves as Hispanic in origin, technically an ethnic category, under minority. To avoid double counting, the analysis included only White Hispanics, since the above racial groups already accounted for Non-white Hispanics.

- *Low-income:* Individuals falling below the poverty line. For the 2000 census, the poverty line was defined by a statistical threshold based on a weighted average that considered both family size and the ages of individuals in a family. For example, the 1999 weighted average poverty threshold annual income for a family of three with one related child younger than 18 years was $13,410, while the poverty threshold for a family of five with one child younger than 18 years was $21,024 (U.S. Bureau of the Census 2000). If a family fell below the poverty line for its particular composition, the census considered all individuals in that family to be below the poverty line. Low income figures in the 2000 census reflect incomes in 1999, the most recent year for which entire annual incomes were known at the time of the most recent census.

This EIS examined minority and low-income populations with census data collected and presented for counties and for census tracts. Census tracts are small, relatively permanent statistical subdivisions of a county, usually containing between 2,500 and 8,000 persons (U.S. Bureau of the Census 1991). Through the use of these geographic units, the environmental justice analysis is geographically commensurate with analyses in two other impact areas of particular concern with regard to minority and low-income populations: socioeconomics (which used counties) and human health (which used census tracts).

Environmental justice is not itself an impact area, per se. Rather, it considers other impacts that are both high and adverse and affect minority and low-income populations disproportionally. As such, the results of assessments in these other disciplines were crucial in the evaluation of environmental justice — essentially preceding the environmental justice evaluation. The key type of data required to identify environmental justice concerns was the result of these other analyses.

F.13 CUMULATIVE IMPACTS

Cumulative effects or impacts result from the incremental impact of the action alternatives when added to other past, present, and reasonably foreseeable future actions, regardless of what government agency or private entity undertakes such actions. Cumulative effects may result from impacts that are minor individually but that, when viewed collectively over space and time, can produce significant impacts. The approach used for cumulative analysis in this EIS was based on the principles outlined by the Council on Environmental Quality (CEQ 1997) and on the guidance developed by the EPA (1999) for independent reviewers of EISs.

The analysis of cumulative impacts focused on specific impacts on the human or natural environment that could result from multiple actions in the vicinity of the Portsmouth site and the ETTP site. Generally, the geographic area for each cumulative impact analysis was defined by the specific resource or receptor of concern and the spatial extent of the interacting (cumulative) impact generators. Although the cumulative analysis acknowledged the past history of impacts at each site, its emphasis was on future cumulative impacts that could occur during the life of a conversion facility. This focus allows the decision maker to place the direct and indirect impacts of the action alternatives within the context of other potential stressors.

The cumulative impact analysis for this EIS was not meant to be a review of all potential environmental impacts at and near a site, nor was it meant to be a sitewide impact analysis. As a starting point, the cumulative analysis used the direct and indirect impacts from the action alternatives as evaluated for each technical subject. Then similar impacts from other actions (including DOE actions, United States Enrichment Corporation (USEC) actions, and the actions of others) were identified. These were added to determine the cumulative impact from all activities occurring together. Then meaningful trends in past, present, and future cumulative impacts were discussed.

For each cumulative impact, the significance of the consequences was assessed on the basis of the (1) likelihood of the impact, (2) geographic or spatial extent of the impact, (3) duration in time of the impact, (4) applicable regulatory considerations, (5) potential for recovery if the impact was temporary, and (6) potential for effective mitigation.

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