3.5 GENERIC COMMERCIAL LIGHT WATER REACTOR SITE

Existing CLWRs use both pressurized water and boiling water technologies. Previous studies for the tritium supply program showed that, of the two types of commercial reactors, pressurized-water reactors are more readily adaptable than boiling-water reactors to the production of isotopes by target irradiation (DOE 1995b). DOE published a request for Expressions of Interest in the January 4, 1999, *Commerce Business Daily* for the production of plutonium-238 for space missions (DOE 1999n). No responses by the commercial nuclear industry to DOE's request for Expressions of Interest were provided by, or on behalf of, boiling-water reactor owners. The evaluation of CLWRs in this NI PEIS, therefore, will only be based on the use of pressurized-water reactors.

The use of CLWRs is not appropriate for the production of medical and industrial isotopes or to support civilian nuclear research and development because CLWRs operate on a 9- to 18-month cycle between refueling outages. Many medical and industrial isotopes have short half-lives and would decay before they could be removed from the reactors. In addition, CLWRs are not good irradiation sources for many civilian nuclear research tests because the range of neutron fluxes present in CLWR is limited, and the flux is optimized for power production rather than research. Accordingly, CLWRs are not appropriate irradiation sources for either medical and industrial isotope production or civilian nuclear research and development.

Because it is unreasonable for this NI PEIS to analyze all CLWRs, the environmental baseline was developed for a generic CLWR site description that is representative of existing reactor sites in the contiguous United States. The generic CLWR analysis in this NI PEIS is not site specific. Any one of the commercial, operating pressurized-water reactors is a potential candidate for the plutonium-238 production mission. Currently, 72 pressurized-water reactors are located at 42 sites in 27 states. The commercial, pressurized-water reactors operating in the United States that would be representative of the CLWR described and analyzed in this NI PEIS are shown in **Figure 3–22**. If an alternative were selected that involves the use of an existing CLWR site, site-specific environmental conditions would be identified in tiered NEPA documentation.

3.5.1 Land Resources

Land resources include land use and visual resources. Each of these resources is described below.

3.5.1.1 Land Use

Land may be characterized by its potential for the location of human activities (land use). Natural resource attributes and other environmental characteristics could make a site more suitable for some land uses than for others. Changes in land use may have both beneficial and adverse effects on other resources such as ecological, cultural, geological, aquatic, and atmospheric.

CLWR site areas within the United States range from 34 to 12,000 hectares (84 to 29,700 acres). Almost 60 percent of the plant sites encompass from 200 to 800 hectares (490 to 1,980 acres). Approximately half of the sites contain two or three nuclear units per site. Larger land use areas are associated with plant cooling systems that include reservoirs, artificial lakes, and buffer areas. Plant facilities are typically sited on 3 to 9 percent of the total site area. For sites that use cooling ponds instead of cooling towers, facilities could occupy a larger percentage, 67 to 76 percent, of the total site area (DOE 1996b). Typically, nuclear power plant sites are on and near flat-to-rolling countryside in wooded or agricultural areas. More than 50 percent of the sites have 80-kilometer (50-mile) population densities of fewer than 77 persons per square kilometer (200 persons per square mile) and more than 80 percent have 80-kilometer (50-mile) densities of fewer than 193 persons per square kilometer (500 persons per square mile) (DOE 1996b).

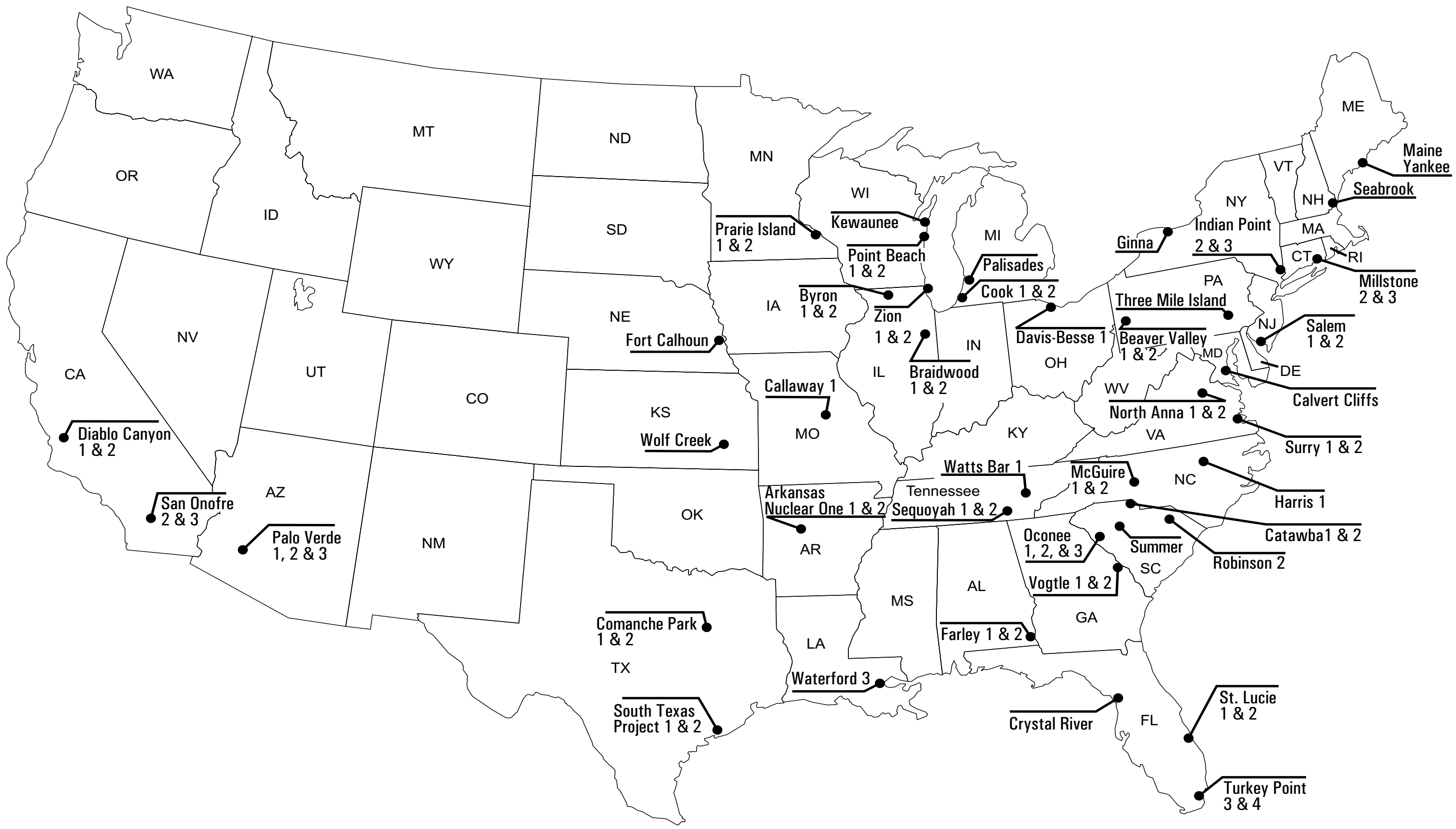

Figure 3–22 Commercial Pressurized-Water Reactors Operating in the United States

The location of a generic CLWR site would range between 3 and 55 kilometers (2 and 34 miles) from the nearest city, and most likely be further from the closest metropolitan area than 80 kilometers (50 miles). The site would likely be located adjacent to a large water body, such as a lake, river, or bay.

3.5.1.2 Visual Resources

Visual resources are natural and human-created features that give a particular landscape its character and aesthetic quality. Landscape character is determined by the visual elements of form, line, color, and texture. All four elements are present in every landscape. The stronger the influence exerted by these elements in a landscape, the more interesting the landscape.

The visual environment of a generic CLWR site would likely be characterized by flat to gently rolling topography adjacent to a large water body. The site would be a developed area that contains facilities and activities, surrounded by an undeveloped buffer area. The viewshed would likely include a small-to-medium sized urbanized area with surrounding forest and agricultural use. Depending on topography, atmospheric conditions, vegetation, and distance, the facilities of a generic existing CLWR site could be visible from adjacent viewpoints. Stack plumes from cooling towers could be visible under most meteorological conditions. Median visible plume lengths would usually range from less than 500 meters (1,640 feet) in summer to 1,000 meters (3,280 feet) in winter. The facilities would be brightly lit at night. The range of public viewpoints could include public access roadways, urbanized areas, and recreation and scenic areas with high user volumes. Since the site would be adjacent to a large water body, it would be likely that distance zones would range from foreground to middleground. The developed areas of a generic existing CLWR site would likely be consistent with a Bureau of Land Management Visual Resource Management Class IV rating indicating that the level of change to the characteristic landscape is high and that management activities dominate the view and are the major focus of view attention (DOE 1996b).

3.5.2 Noise

Principal noise sources at nuclear power plants include cooling towers and transformers. The impacts of these and other sources at the plants have been found to be small and generally not noticed by the public (NRC 1996:17). In most cases, noise sources are sufficiently distant from sensitive receptors that noise is attenuated to nearly ambient levels, although at some sites, sensitive receptors were identified during licensing at which noise levels would be greater than 10 decibels above ambient (NRC 1996:139). An area near a CLWR site would be essentially rural in character and would have typically low background sound levels. Typical day-night average sound levels in the range of 35 to 50 dBA can be expected for such a rural location where noise sources may include wind, insect activity, aircraft, and agricultural activity. Existing industrial noise sources and traffic noise at the site would result in higher background noise levels near the site and along site access routes (DOE 1996b:3-387).

3.5.3 Air Quality

Air pollution refers to the introduction, directly or indirectly, of any substance into the air that could endanger human health, harm living resources and ecosystems as well as material property, and impair or interfere with the comfortable enjoyment of life or other legitimate uses of the environment.

Ambient air quality conditions at CLWR sites in the United States could include a wide range of pollutants and conditions. The baseline air concentrations for criteria pollutants at a generic CLWR site are presented in **Table 3–38**. These concentrations are based on ambient monitoring data collected near a representative CLWR site. Some potential CLWR sites are near or within nonattainment areas for PM_{10}, ozone, and carbon monoxide. The maximum ground-level pollutant concentrations that would result from CLWR emissions are

Table 3–38 Comparison of Baseline Air Concentrations with Most Stringent Applicable Regulations or Guidelines at the Generic CLWR Site

Criteria Pollutant	Averaging Period	Most Stringent Regulation or Guideline[a] (micrograms per cubic meter)	Baseline Concentration (micrograms per cubic meter)
Carbon monoxide	8 hours	10,000	1,250
	1 hour	40,000	1,250
Lead	Calendar quarter	1.5	0.03
Nitrogen dioxide	Annual	100	26.3
Ozone	1 hour	235	(b)
PM_{10}	Annual	50	20.3
	24 hours	150	39.000
Sulfur dioxide	Annual	80	10.5
	24 hours	365	65.5
	3 hours	1300	204

a. The Federal standards are presented.
b. Ozone, as a criteria pollutant, is not directly emitted or monitored by the sites.
Key: PM_{10}, particulate matter with an aerodynamic diameter less than or equal to 10 microns.
Source: DOE 1999o.

low when compared to NAAQS. However, if the CLWR is in an area that may already have high background pollutant concentrations, resultant pollutant concentrations could approach or exceed NAAQS. As a result, regulatory compliance will need to be assesed on a case-by-case basis.

3.5.4 Water Resources

Major surface water features near a generic CLWR site could range from a large navigable river to a large lake. These surface waters would be classified and protected by regulation for specified uses, such as water supply. CLWRs would also have NPDES permits that specify the concentrations of pollutants and temperature permissible for liquid effluents and stormwater runoff discharged to surface waters. Other surface water bodies could include ponds and/or site-bordering ephemeral or perennial streams (DOE 1996b:3-388).

CLWRs withdraw large amounts of mainly surface water to meet a variety of plant needs. Water withdrawal rates from adjacent bodies of water for plants with once-through cooling systems are large. Flow through the condenser for a 1,000 megawatt plant may be 2.6 million to 3.8 million liters (700,000 to 1 million gallons) per minute. Water lost by evaporation from the heated discharge is about 60 percent of that which is lost through cooling towers. Additional water needs for service water, auxiliary systems, and radioactive waste systems account for 1 to 15 percent of that needed for condenser cooling (DOE 1995b:4-510).

Water withdrawal from adjacent bodies of water for plants with closed-cycle cooling systems is 5 to 10 percent of that with once-through cooling systems, with much of this water being used for makeup of water by evaporation. With once-through cooling systems, evaporative losses are about 40 percent less but occur externally in the adjacent body of water instead of in the closed-cycle system. The average makeup water withdrawals for several of the more recently constructed plants having closed-cycle cooling, normalized to 1,000 megawatts, are about 53,000 to 68,000 liters (14,000 to 18,000 gallons) per minute. Variation is due to cooling tower design, concentration factor of recirculated water, climate at the site, plant operating conditions, and other plant-specific factors. Consumptive loss normalized to 1,000 megawatts is about 42,400 liters (11,200 gallons) per minute, which is about 80 percent of the water volume taken in (DOE 1995b:4-510).

These consumptive water losses remove surface water from other uses downstream. In those areas experiencing water availability problems, nuclear power plant consumption may conflict with other existing or potential closed-cycle uses (e.g., municipal and agricultural water withdrawals) and in-stream uses (e.g., adequate in-stream flows to protect aquatic biota, recreation, and riparian communities) (DOE 1995b:4-510).

Some CLWRs use groundwater as an additional source of water. The rate of usage varies greatly among users. Many plants use groundwater only for the potable water system and require less than 380 liters (100 gallons) per minute; however, withdrawals at other sites can range from 1,500 to 11,000 liters (400 to 3,000 gallons) per minute (DOE 1995b:4-510).

3.5.5 Geology and Soils

The physiography of a CLWR site could range from a flat nearly featureless plain to a highly dissected plain of arid to humid environments. The geology could range from alluvium to thick sequences of unconsolidated marine sediments, glaciofluvial material, and crystalline and sedimentary bedrock. These materials could range in age from Cenozoic to Precambrian (recent to over 600 million years) (DOE 1996b:3-389).

The generic CLWR site could be located in regions that may have a low to moderate seismic risk as a result of an earthquake based on historical seismic activity. The location of the nearest capable fault could range from within the site boundaries to 350 kilometers (217 miles) away from CLWR sites. The nearest known epicenter of a damaging earthquake could be approximately 350 kilometers (217 miles) from existing CLWR sites (DOE 1996b:3-389).

The CLWR sites are not within a region of active volcanism; however, a generic CLWR site could be within 164 kilometers (102 miles) of a volcano (DOE 1996b:3-389).

The CLWR sites could be located where the predominant soil types are loamy clays to gravel silty loams. These soils range from moderate to well drained soils. The erosion potential could range from minor to severe in those areas with slopes greater than 25 percent and which have been eroded in the past. Shrink-swell potential could range from low to severe, which is acceptable for standard construction techniques, depending upon the engineering controls employed. Wind erosion potential ranges from minor to severe (DOE 1996b:3-389).

3.5.6 Ecological Resources

Ecological resources include terrestrial resources, wetlands, aquatic resources, and threatened and endangered species. The nature of these resources in the vicinity of a CLWR is highly dependent upon the specific location of an existing reactor. All CLWR sites were developed within the requirements of applicable Federal and state natural resource laws and regulations.

3.5.6.1 Terrestrial Resources

Terrestrial resources in the vicinity of a generic CLWR site would include those plant and animal communities typical of the ecoregion within which the facility is located. Ecoregions are characterized by distinctive flora, fauna, climate, landform, soil, vegetation, and ecological climax (Bailey 1976). Within such a region, ecological relationships between plant species, and soil and climate are essentially similar. Provinces are subdivisions that are a broad vegetation region with the same type or types of zonal soils. Provinces within which a CLWR could be located may include, but are not limited to the eastern deciduous forest; southeastern mixed forest; outer coastal plain forest; prairie parkland; Great Plains short-grass prairie; tall-grass prairie;

American desert; and California chaparral. These provinces are further subdivided by Bailey (1976) based on specific climax vegetation.

3.5.6.2 Wetlands

Since the need for cooling water is an important operational requirement, most CLWRs are constructed near rivers, lakes, reservoirs, or oceans. In each case, the presence of wetlands in the vicinity of the faciltiy may be expected. Major types of wetlands, which could occur near a generic CLWR, include tidal salt marshes, freshwater marshes, northern peatlands, shrub swamps, and forested wetlands. Wetlands serve a variety of important functions including maintaining water quality, controlling floodwaters, stabilizing shorelines, and providing recreational uses such as hunting and fishing. Wetlands are also important in providing habitat for terrestrial and aquatic organisms including migratory birds and threatened and endangered plants and animals.

3.5.6.3 Aquatic Resources

Nearly all CLWRs are constructed near a source of cooling water such as a river, lake, reservoir, or ocean. The abiotic and biotic characteristics of each type of water body vary with its geographic location.

3.5.6.4 Threatened and Endangered Species

Threatened and endangered species could be present in each of the ecoregions within which a generic CLWR could be located. At present, there are 1,233 federally listed threatened and endangered species in the United States (FWS 2000). States also typically identify threatened and endangered, as well as other special status species, found within their borders. Endangered plants and animals often rely on sensitive environments, such as wetlands, for habitat. Critical habitats, areas that are considered essential to the conservation of a species and that could require special management considerations or protection, can be designated and protected under the Endangered Species Act. Protection of threatened and endangered species and their habitat is important for maintaining biodiversity.

3.5.7 Cultural and Paleontological Resources

Cultural and paleontological resources include prehistoric resources, historic resources, Native American resources, and paleontological resources. The presence or absence of such resources is highly dependent upon the location of a specific existing CLWR. In accordance with applicable Federal and state laws and regulations, all existing sites would have been surveyed for such resources prior to site construction. Further, consultation with the State Historic Preservation Officer and tribal governments would have been required.

3.5.7.1 Prehistoric Resources

Prehistoric resources in the vicinity of the generic CLWR may include sites, districts, or isolated artifacts. Archaeological sites may represent occupation during the Archaic through later prehistoric periods and can include hunting and butchering sites, cemeteries, campsites, and tool manufacturing areas. They may yield artifacts such as stone tools and associated manufacturing debris, and ceramic potsherds. Some sites may be included on the National Register of Historic Places, while others may be eligible for listing.

3.5.7.2 Historic Resources

Historic resources may include cemeteries, remains of commercial or residential structures, or standing structures. While some sites may already be listed on the National Register of Historic Places, others may be eligible for listing.

3.5.7.3 Native American Resources

Native American resources can include cemeteries, geological or geographic elements such as mountains or creeks, certain species of animals or plants, architectural structures, such as pueblos; battlefields, or trails. Such resources are important to Native American groups for religious or historical reasons.

3.5.7.4 Paleontological Resources

Paleontological resources are the physical remains, impressions, or traces of plants or animals from a former geological age. Paleontological remains consist of fossils and their associated geological information. The presence of such resources at a generic CLWR site is dependent upon the past geologic history of the site.

3.5.8 Socioeconomics

The CLWR site could potentially affect the socioeconomic environment of a given regional economic area or region of influence. The characteristics of the regional economic area, region of influence, and community are dependent upon geographic location. For employment and income, the economic area would be based upon industry interaction and linkages in the region. The anticipated residential distribution of project-related employees and their families would determine the region of influence. This region of influence would contain all principal jurisdictions and school districts likely to be affected by the proposed activity.

Socioeconomic characteristics described for the generic CLWR site include employment and local economy, population and housing, and local transportation. Four hypothetical sites (A, B, C, and D) have been developed for the generic CLWR for purposes of making these characterizations. Site A, which had a nearby 1992 population of 2,604, was located about 160 kilometers (100 miles) from a large metropolitan area. Site B, with a nearby 1992 population of 5,236, was located approximately 8 kilometers (5 miles) from a small community and approximately 64 kilometers (40 miles) from a large metropolitan area. Site C, with a nearby 1992 population of 44,384, was located approximately 16 kilometers (10 miles) from a medium-size community and approximately 48 kilometers (30 miles) from a large metropolitan area. Site D, with a nearby 1992 population of 34,201 and a total urban population of more than 100,000. Statistics for employment and local economy were based on the regional economic area for each site. Statistics for the remaining socioeconomic characteristics were based on the sites' regions of influence (DOE 1996b).

3.5.8.1 Regional Economic Characteristics

Employment and regional economy statistics for each representative site's regional economic area are discussed in this section. Between 1980 and 1990, the civilian labor force in the region of economic area encompassing Site A increased 7.7 percent to the 1990 level of 4,811,800, and for Site B increased 49.6 percent to the 1990 level of 1,162,300. The civilian labor force for Site C, located near a large metropolitan area, increased 21.9 percent to the 1990 level of 862,500. The civilian labor force for Site D, located in an urbanized area, increased 9.9 percent to 254,800 persons. The 1994 unemployment rates in the two small hypothetical communities' (A and B) regional economic areas were 5.6 percent and 5.2 percent, respectively. Sites C and D had unemployment of 4.3 percent and 9.1 percent, respectively.

For the two small representative communities, the portions of total employment involving farming in the regional economic areas were about 1 percent. Governmental activities for Sites A and B represented about 12 percent and 14 percent, respectively. Manufacturing was 16 percent of the total employment for site A and 10 percent for site B. Retail trade accounted for 16 percent and 18 percent of the total sector employment for Sites A and B, respectively. Service activities represented a 30 percent share of the total employment for Sites A and B.

For Sites C and D, the portion of total employment was about 1 percent and 12 percent for farming and 11 and 15 percent for governmental activities, respectively. The nonfarm private sector activities of retail trade and services were 16 and 22 percent of total employment, respectively, for Site C and 16 and 26 percent, respectively, for Site D. Employments for manufacturing were 23 and 8 percent of total employment for Sites C and D, respectively (DOE 1996b).

3.5.8.2 Population and Housing

Between 1980 and 1994 the region of influence population increase for the two small hypothetical communities, A and B, was 6.4 percent (average annual increase of 0.5 percent) and 54.6 percent (average annual increase of 3.9 percent), respectively. The number of housing units in the region of influence increased 8.9 percent for Site A and 55.8 percent for Site B between 1980 and 1990. The 1990 region of influence homeowner vacancy rates were 1.1 and 3.9 percent, while the renter vacancy rates were 5.9 and 16.4 percent for Sites A and B, respectively.

The regions of influence surrounding Sites C and D experienced a 31.8 percent (average annual increase of 2.3 percent) and 19.8 percent (average annual increase of 1.4 percent) increase in population, between 1980 and 1994, and a 32.7 and 5.4 percent increase, respectively, in the number of housing units between 1980 and 1990.

The 1990 homeowner and renter vacancy rates were 2.0 and 8.9 percent for Site C and 1.3 and 5.6 percent for Site D (DOE 1996b).

3.5.8.3 Community Services and Local Transportation

These characteristics are dependent upon geographic location. The region of influence would determine all principal jurisdictions and school districts likely to be affected by the proposed activity. Local transportation would be the existing principal road, air, and rail networks required to support the project activities (DOE 1996b).

3.5.9 Existing Human Health Risk

3.5.9.1 Radiation Exposure and Risk

Major sources and levels of background radiation exposure to individuals in the vicinity of the CLWR site are shown in **Table 3–39.** Annual background radiation doses to individuals are expected to remain constant over time. The total dose to the population size changes as the population size changes. Background radiation doses are unrelated to CLWR site operations.

Releases of radionuclides to the environment from CLWR site operations provide another source of radiation exposure to individuals in the vicinity of CLWR sites. Types and quantities of radionuclides released from CLWR site operations are listed in the annual radiological effluent release reports for the reference sites. The doses to the public resulting from these releases are presented in **Table 3–40.** These doses fall within radiological guidelines and limits (10 CFR Part 50, Appendix I, and 40 CFR Part 190) and are small (less than 0.01 percent) in comparison to background radiation.

Based on a risk estimator of 500 cancer deaths per 1 million person-rem to the public, the latent cancer fatality risk to the maximally exposed member of the public due to radiological releases from operations at the CLWR site is estimated to range from 3.9×10^{-9} to 7.0×10^{-7} per year. That is, the estimated probability of this person

Table 3–39 Sources of Radiation Exposure to Individuals in the Vicinity Unrelated to Operation at the CLWR Site

Source	Effective Dose Equivalent (millirem per year)
Natural background radiation	
Cosmic radiation	27 to 29
Cosmogenic radiation	1
External terrestrial radiation	29 to 30
Radon in homes (inhaled)	200
Internal terrestrial radiation	39
Other background radiation	
Diagnostic x rays and nuclear medicine	53
Weapons test fallout	Less than 1
Air travel	1
Consumer and industrial products	10
Total	361 to 364

Note: Value of radon is an average for the United States.
Source: DOE 1996b.

Table 3–40 Radiation Doses to the Public from Normal Operation in 1994 at the Generic Existing CLWR Site (Committed Effective Dose Equivalent)

	Atmospheric Releases		Liquid Releases		Total	
Members of the Public	**Standard**[a]	**Actual**	**Standard**[a]	**Actual**	**Standard**[a]	**Actual**[b]
Maximally exposed individual (millirem)	5	0.0013 to 1.10	3 per reactor	0 to 0.29	25	0.0078 to 1.39
Population within 80 kilometers[c] (person-rem)	None	0.016 to 13.3	None	0 to 1.28	None	0.020 to 13.3
Average individual within 80 kilometers [d] (millirem)	None	6.3×10^{-5} to 6.8×10^{-3}	None	0 to 8×10^{-4}	None	7.9×10^{-5} to 6.8×10^{-3}

a. The standards for individuals are given in 10 CFR Part 50, Appendix I, and 40 CFR Part 190. As discussed in Appendix I of 10 CFR Part 50, the 5-millirem-per-year value is an airborne emission guideline, and the 3-millirem-per-year per reactor value is a liquid release guideline. Meeting these guideline values serves as a numerical demonstration that doses are as low as is reasonably achievable. The total dose of 25 millirem per year is the limit from all pathways combined as given in 40 CFR Part 190.
b. Totals cannot be obtained by summing the atmospheric and liquid release components since these component entries can be for different reactor sites.
c. This population ranges from 252,000 to 1,960,000.
d. Obtained by dividing the population dose by the number of people living within 80 kilometers (50 miles) of the site.

Source: DOE 1996b:3-398.

dying of cancer at some point in the future from radiation exposure associated with 1 year of CLWR site operation ranges from about 4 in 1 billion to 7 in 10 million. Note that it takes several to many years from the time of exposure to radiation for a cancer to manifest itself.

Based on the same risk estimator, a range of 1.0×10^{-5} to 6.7×10^{-3} excess fatal cancers is projected in the population living within 80 kilometers (50 miles) of the CLWR site from normal operations. To place these numbers into perspective, they can be compared with the numbers of fatal cancers expected in these populations from all causes. The 1990 mortality rate associated with cancer for the entire U.S. population was 0.2 percent per year. Based on this mortality rate, the number of fatal cancers expected from all causes in the population living within 80 kilometers (50 miles) of the CLWR site ranged from 505 to 3,920. These numbers of expected fatal cancers are much higher than the estimated range of 1.0×10^{-5} to 6.7×10^{-3} fatal cancers that could result from operations at the CLWR site.

At the CLWR site, workers receive the same dose as the general public from background radiation but also receive an additional dose from working at the site. The range of the average worker and total worker dose from operations at the generic existing CLWR site are presented in **Table 3–41**. These doses fall within radiological regulatory limits (10 CFR Part 20). Based on a risk estimator of 400 fatal cancers per 1 million person-rem among workers, the number of excess fatal cancers to CLWR site workers from operations is estimated to range from 0.16 to 0.34 per year (DOE 1996b).

Table 3–41 Annual Doses to Workers from Normal Operation at the Generic CLWR Site (Committed Effective Dose Equivalent)

Occupational Personnel	Onsite Releases and Direct Radiation	
	Standard[a]	**Actual**
Average worker (millirem)	ALARA[b]	114 to 322
Total workers[c] (person-rem)	ALARA	396 to 854

a. NRC's goal is to maintain radiological exposures as low as is reasonably achievable.
b. As low as is reasonably achievable.
c. The number of badged workers ranges from 2,650 to 4,370.
Source: DOE 1996b:3-399.

3.5.9.2 Chemical Environment

The background chemical environment important to human health consists of the atmosphere, which may contain hazardous chemicals that can be inhaled; drinking water, which may contain hazardous chemicals that can be ingested; and other environmental media with which people may come in contact (e.g., surface waters during swimming and soil through direct contact or via the food pathway).

Carcinogenic Effects. Health effects in this case are estimated as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to the potential carcinogen. This could be incremental or excess individual lifetime cancer risks.

Noncarcinogenic Effects. Health effects in this case are determined by the ratio between the calculated or measured concentration of the chemical in the air and the reference concentration or dose. This ratio is known as the Hazard Quotient. Hazard Quotients for noncarcingoens are summed to obtain the Hazard Index. If the Hazard Index is less than 1, no adverse health effects would be expected.

Effective administrative and design controls that decrease hazardous chemical releases to the environment and help achieve compliance with permit requirements, for example, air emissions and NPDES permit requirements contribute toward minimizing potential health impacts to the public. The effectiveness of these controls is verified through the use of monitoring information and inspection of mitigation measures. Health impacts to the public may occur during normal operations at CLWR sites via inhalation of air containing hazardous chemicals released to the atmosphere by site operations. Risks to public health from other possible pathways, such as ingestion of contaminated drinking water or direct exposure, are low relative to the inhalation pathway.

Exposure pathways for CLWR site workers during normal operation may include inhaling the workplace atmosphere and direct contact with hazardous material associated with work assignments. Occupational exposure varies from facility to facility and from worker to worker, and available information is not sufficient to allow a meaningful estimation and summation of these impacts. However, workers are protected from hazards specific to the workplace through appropriate training, protective equipment, monitoring, and management controls. At the CLWR site, workers are also protected by adherence to OSHA and EPA standards that limit workplace atmospheric and drinking water concentrations of potentially hazardous chemicals. Appropriate monitoring that reflects the frequency and amounts of chemicals used in the operational processes ensures that these standards are not exceeded (DOE 1996b).

3.5.9.3 Health Effects Studies

CLWRs have been operating for many years. Site-specific epidemiological studies may be available, and these studies would be reviewed for specific CLWR locations. Epidemiologic studies will be considered in the future.

3.5.9.4 Accident History

CLWRs have been operating in the United States for many years. Accident information for these reactors, where applicable, can be found in documentation available from NRC.

3.5.9.5 Emergency Preparedness

The CLWR site would have an NRC-approved emergency management program that would be activated in the event of an accident. The programs are compatible with other Federal, state, and local plans and are thoroughly coordinated with all interested groups.

3.5.10 Environmental Justice

As discussed in Appendix K, Executive Order 12898 directs Federal agencies to address disproportionately high and adverse health or environmental effects of alternatives on minority and low-income populations. The Executive order does not alter prevailing statutory interpretations under NEPA or existing case law. Regulations prepared by the Council on Environmental Quality remain the foundation for preparing environmental documentation in compliance with NEPA (40 CFR Parts 1500 through 1508) and the Council's guidelines for inclusion of environmental justice under NEPA (CEQ 1997). As the present document is a programmatic EIS, environmental justice issues would be addressed in a site-specific EIS if an option using a CLWR were to be selected.

3.5.11 Waste Management

Waste management includes minimization, characterization, treatment, storage, transportation, and disposal of waste generated from ongoing CLWR activities. The waste is managed using appropriate treatment, storage, and disposal technologies, and in compliance with all NRC and other applicable governmental regulations.

3.5.11.1 Waste Inventories and Activities

The amounts of waste generated are reported on a quarterly basis by each nuclear utility. The waste volumes of CLWRs are given in **Table 3–42**. These volumes are based on site-specific data (DOE 1996b and DOE 1999o). Because high-level radioactive waste as defined by DOE Order 435.1 would not be generated by neptunium-237 target irradiation activities at the generic CLWR site, it is not included in this table or discussed any further in this section.

Waste management and activities specific to each category of waste are discussed in the following sections.

Table 3–42 Existing Pressurized-Light Water Reactor Site Waste Management Characteristics

Characteristic	Range	Average
Low-level radioactive waste shipped (cubic meters per year)	57.04 to 636.85	178.22
Number of low-level radioactive waste shipments per year	6.00 to 31.00	16.17
Stored mixed low-level radioactive waste per 1,000 megawatt (cubic meters per year)	Not reported	101.90[a]
Hazardous waste generation (cubic meters per year)	11.4 to 29	23
Nonhazardous waste generation (cubic meters per year)		
Liquids	682 to 60,794	37,072
Solids	909 to 10,400	4,148

a. This is the average of both pressurized-water reactors and boiling-water reactors. A value was not specifically reported for the pressurized-water reactor category.

Note: To convert from cubic meters to cubic yards, multiply by 1.308.

Source: DOE 1996b:3-401 for low-level radioactive waste and mixed low-level radioactive waste; DOE 1999o:chap. 3 for hazardous and nonhazardous waste.

3.5.11.2 Transuranic Waste

Transuranic elements are contained within spent nuclear fuel. Transuranic waste is not generated or managed at CLWR sites.

3.5.11.3 Low-Level Radioactive Waste

Liquid low-level radioactive waste generated in CLWRs could be classified as either clean waste, dirty waste, turbine building floor drain water, or steam generator blowdown. Clean wastes come from equipment leaks and drains, certain valve and pump seal leakoffs not collected in the reactor coolant drain tank, and other aerated leakage sources. Primary coolant is also considered a clean waste. Liquid wastes collected in the containment building sump, auxiliary building sumps and drains, laboratory drains, sample station drains, and other miscellaneous floor drains are termed dirty wastes because of their moderate conductivity. Clean and dirty wastes will have variable radioactivity content. Detergent wastes, which consist of laundry wastes and personnel and equipment decontamination wastes, normally have a low radioactivity content. Turbine building floor drain water usually exhibits high conductivity with low radionuclide content. Depending on the amount of primary-to-secondary leakage, steam generator blowdown could have relatively high concentrations of radionuclides. The chemical and radionuclide content of the waste would determine the type and degree of treatment before storage for reuse or discharge to the environment. Operating plants have steadily increased the degree of processing, storing, and recycling of liquid radioactive waste (DOE 1996b:3-402).

Solid low-level radioactive waste is generated by removal of radionuclides from liquid waste streams, filtration of airborne gaseous emissions, and removal of contaminated material from various reactor areas. Liquid contaminated with radionuclides comes from primary and secondary coolant systems, spent-fuel pools, decontaminated wastewater, and laboratory operations. Concentrated liquids, filter sludges, waste oils, and other liquid sources are segregated by type, flushed to storage tanks, stabilized for packaging in a solid form by dewatering, and slurried into 208-liter (55-gallon) steel drums prior to disposal. High efficiency particulate air filters are used to remove radioactive material from gaseous plant effluents. These filters are compacted and disposed of as solid low-level radioactive waste. Other solid low-level radioactive waste includes contaminated protective clothing, paper, rags, glassware, compactible and noncompactible trash, and nonfuel irradiated reactor components and equipment. Tools and other material exposed to the reactor environment would also be considered solid low-level radioactive waste. Compactible solid low-level radioactive waste is taken to an offsite or onsite volume reduction facility before disposal. Solid low-level radioactive waste is stored in shielded prefabricated steel buildings or other facilities until suitable for disposal at an approved low-level radioactive waste disposal facility (DOE 1996b:3-402).

3.5.11.4 Mixed Low-Level Radioactive Waste

Mixed low-level radioactive waste generated by a nuclear power plant covers a broad spectrum of waste types. The vast majority of mixed waste in storage at nuclear plants is chlorinated fluorocarbons and waste oil. Mixed low-level radioactive waste is stored on site until treatment and disposal is available at an offsite RCRA-permitted facility. Because of the occupational exposure from testing radioactive wastes to determine if they are chemically hazardous, the utilities have been looking at ways to eliminate, or at least minimize, the generation of mixed wastes. These efforts include removing and separating hazardous constituents from radioactive streams by remote methods; minimizing the use of solvents exposed to the reactor environment; relying on substitute processes; and recycling and reusing cleaning materials, resins, and waste oils (DOE 1996b). Stored mixed low-level radioactive waste per 1,000 megawatt averages about 100 cubic meters (130 cubic yards) per year for the existing plants studied.

3.5.11.5 Hazardous Waste

Hazardous wastes are generated from nonradioactive materials such as wipes contaminated with oils, lubricants, and cleaning solvents that are used outside the reactor environment. Hazardous wastes are packaged and shipped to offsite RCRA-permitted treatment and disposal facilities.

3.5.11.6 Nonhazardous Waste

Nonhazardous wastes include boiler blowdown, water treatment wastes, boiler metal cleaning wastes, floor and yard drain wastes, storm water runoff, and sewage wastes. Depending on the design of the individual reactor, other small volumes of wastewater are released from other plant systems or combined with the cooling water discharges. Sanitary wastes that cannot be processed by onsite waste treatment systems are collected by independent contractors and trucked to offsite treatment facilities (DOE 1996b:3-402).

3.5.11.7 Waste Minimization

Because of the increased disposal costs for low-level radioactive waste, utility companies have undertaken major volume reduction and waste minimization efforts. These efforts include segregation, decontamination, minimizing the exposure of materials and tools to the contaminated environment, and sorting. Compacting, consolidating, and monitoring waste streams to reduce the volume of low-level radioactive waste requiring storage, and lessening the exposure of routine equipment to the reactor environment, have been the most effective volume reduction strategies. Current industry-wide volume reduction practices include ultra-high pressure compaction of waste drums, incineration of waste oils and resins, mobile thin-film evaporation, waste crystallization, and asphalt solidification of resins and sludges (DOE 1996b:3-400).

Nuclear power plants typically have waste minimization programs in place to minimize both the volume and cost impact of waste generation. In existing operating plants, a number of the design considerations that affect the plant waste streams are already in place, and improvements in waste management are continually being implemented. Waste minimization steps include more economical use of disposables or elimination of disposables in favor of recyclables. Process improvements aimed at more efficient use of ion exchange resins and reductions of waste streams from the waste processes are being implemented. In general, wastes generated by operating plants have been decreasing in recent years.