VOGTLE ELECTRIC GENERATING PLANT

Location: Burke County, Georgia
42 km (26 miles) SE of Augusta
latitude 33.1414°N; longitude 81.7625°W
Licensee: Georgia Power Co.

Unit Information	Unit 1	Unit 2
Docket Number	50-424	50-425
Construction Permit	1974	1974
Operating License	1987	1989
Commercial Operation	1987	1989
License Expiration	2027	2029
Licensed Thermal Power [MW(t)]	3411	3411
Design Electrical Rating [net MW(e)]	1101	1160
Type of Reactor	PWR	PWR
Nuclear Steam Supply System Vendor	WEST	WEST

Cooling Water System

Type: natural draft cooling towers
Source: Savannah River
Source Temperature Range: 4-30°C (39-86°F)
Condenser Flow Rate: 32.16 m^3/s (509,600 gal/min) each unit
Design Condenser Temperature Rise: 18°C (33°F)
Intake Structure: at river bank
Discharge Structure: single-point discharge pipe near the shoreline

Site Information

Total Area: 1282 ha (3169 acres)
Exclusion Distance: 1.09-km (0.68-mile) minimum
Low Population Zone: 3.22-km (2.00-mile) radius
Nearest City: Augusta; 1980 population: 47,532
Site Topography: rolling
Surrounding Area Topography: rolling, river flood plain
Land Use within 8 km (5 miles): Department of Energy Savannah River Plant, some farming and wooded
Nearby Features: The nearest town is Shell Bluff about 11 km (7 miles) W. The Seaboard Coast Line Railroad is about 6 km (4 miles) NE. The Department of Energy Savannah River Plant is about 16 km (10 miles) NNE.
Area of Transmission Line Corridor:
Population within an 80-km (50-mile) radius:

1990	2000	2010	2030	2050
630,000	690,000	750,000	840,000	930,000

WASHINGTON NUCLEAR PROJECT 2
(WNP-2)

Location: Benton County, Washington
19 km (12 miles) NW of Richland
latitude 46.4714°N; longitude 119.3331°W
Licensee: Washington Public Power Supply System

Unit Information	Unit 2
Docket Number	50-397
Construction Permit	1973
Operating License	1984
Commercial Operation	1984
License Expiration	2024
Licensed Thermal Power [MW(t)]	3323
Design Electrical Rating [net MW(e)]	1100
Type of Reactor	BWR
Nuclear Steam Supply System Vendor	GE

Cooling Water System

Type: mechanical draft cooling towers
Source: Columbia River
Source Temperature Range: 3-18°C (38-64°F)
Condenser Flow Rate: 35 m^3/s (550,000 gal/min)
Design Condenser Temperature Rise: 15.9°C (28.7°F)
Intake Structure: 2 perforated pipe inlets supported offshore above the river bed 270 m (900 ft) from pump structure on river bank
Discharge Structure: buried 5-km (3-mile) pipeline terminating at the river bed 53 m (175 ft) from the shoreline

Site Information

Total Area: on Department of Energy Hanford Reservation
Exclusion Distance: 1.95-km (1.21-mile) radius
Low Population Zone: 4.83 km (3.00 miles)
Nearest City: Spokane; 1980 population: 171,300
Site Topography: flat
Surrounding Area Topography: flat
Land Use within 8 km (5 miles): Hanford Reservation and agricultural
Nearby Features: The nearest town is Richland 14 km (9 miles) S. The site is in the SE part of the Hanford Reservation.
Area of Transmission Line Corridor: on Hanford Reservation
Population within an 80-km (50-mile) radius:

1990	2000	2010	2030	2050
280,000	310,000	330,000	370,000	410,000

WATERFORD STEAM ELECTRIC STATION

Location: St. Charles County, Louisiana
32 km (20 miles) W of New Orleans
latitude 29.9947°N; longitude 90.4711°W

Licensee: Louisiana Power and Light Co.

Unit Information	Unit 3
Docket Number	50-382
Construction Permit	1974
Operating License	1985
Commercial Operation	1985
License Expiration	2025
Licensed Thermal Power [MW(t)]	3390
Design Electrical Rating [net MW(e)]	1104
Type of Reactor	PWR
Nuclear Steam Supply System Vendor	CE

Cooling Water System

Type: once through
Source: Mississippi River
Source Temperature Range: 8-28°C (46-82°F)
Condenser Flow Rate: 61.53 m^3/s (975,100 gal/min)
Design Condenser Temperature Rise: 9°C (16°F)
Intake Structure: at river bank
Discharge Structure: at river bank

Site Information

Total Area: 1441 ha (3561 acres)
Exclusion Distance: 0.92-km (90.57-mile) radius
Low Population Zone: 3.22 km (2.00 miles)
Nearest City: New Orleans; 1980 population: 557,927
Site Topography: flat
Surrounding Area Topography: flat
Land Use within 8 km (5 miles): industrial, agricultural, recreational, and residential
Nearby Features: The nearest town is Killona 1.6 km (1 mile) WNW. U.S. Highway I-10 is about 11 km (7 miles) NE and I-90 about 11 km (7 miles) SE. Several active and abandoned gas and oil fields are with in 16 km (10 miles). Lake Pontchartrain is about 11 km (7 miles) NE. The Missouri Pacific Railroad is just S of the site and the Southern Pacific Railroad is about 13 km (8 miles) SE.
Area of Transmission Line Corridor: 110 ha (280 acres)
Population within an 80-km (50-mile) radius:

1990	2000	2010	2030	2050
1,970,000	2,130,000	2,290,000	2,520,000	2,780,000

WATTS BAR NUCLEAR PLANT

Location: Rhea County, Tennessee
11 km (7 miles) SSE of Spring City
latitude 35.6022°N; longitude 84.7894°W
Licensee: Tennessee Valley Authority

Unit Information	Unit 1	Unit 2
Docket Number	50-390	50-391
Construction Permit	1973	1973
Operating License	--	--
Commercial Operation	--	--
License Expiration	--	--
Design Thermal Power [MW(t)]	3411	3411
Design Electrical Rating [net MW(e)]	1170	1170
Type of Reactor	PWR	PWR
Nuclear Steam Supply System Vendor	WEST	WEST

Cooling Water System

Type: natural draft cooling towers
Source: Chickamauga Lake
Source Temperature Range: 6-28°C (43-82°F)
Condenser Flow Rate: 26 m^3/s (410,000 gal/min) each unit
Design Condenser Temperature Rise: 21°C (38°F)
Intake Structure: at lake bank
Discharge Structure: to lake via a holding pond

Site Information

Total Area: 716 ha (1770 acres)
Exclusion Distance: 1.21 km (0.75 mile) radius
Low Population Zone: 4.83 km (3.00 miles)
Nearest City: Chattanooga; 1980 population: 169,514
Site Topography: flat to rolling
Surrounding Area Topography: rolling to hilly
Land Use within 8 km (5 miles): wooded with some agricultural
Nearby Features: The nearest town is Peakland 3 km (2 miles) NE. Watts Bar Dam is 1.6 km (1 mile) N. A fossil-fired steam plant is just N of the site. U. S. Highway I-75 is about 18 km (11 miles) SE. The New Orleans and Texas Pacific Railroad is 11 km (7 miles) NW. Chickamauga Lake is on the Tennessee River.
Area of Transmission Line Corridor: 1281 ha (3165 acres)
Population within an 80-km (50-mile) radius:

1990	2000	2010	2030	2050
950,000	1,040,000	1,120,000	1,240,000	1,370,000

WOLF CREEK GENERATING STATION

Location:	Coffey County, Kansas 6 km (4 miles) NE of Burlington latitude 38.2386°N; longitude 95.6894°W
Licensee:	Wolf Creek Nuclear Operating Corp.

<u>Unit Information</u>	Unit 1
Docket Number	50-482
Construction Permit	1977
Operating License	1985
Commercial Operation	1985
License Expiration	2025
Licensed Thermal Power [MW(t)]	3411
Design Electrical Rating [net MW(e)]	1170
Type of Reactor	PWR
Nuclear Steam Supply System Vendor	WEST

<u>Cooling Water System</u>

Type: closed cycle cooling lake
Source: Wolf Creek
Source Temperature Range: 0-31°C (32-87°F)
Condenser Flow Rate: 30 m^3/s (500,000 gal/min)
Design Condenser Temperature Rise: 17.5°C (31.5°F)
Intake Structure: structure on shore of cooling lake
Discharge Structure: discharged to 2060-ha (5090-acre) cooling lake into an embayment separated from the intake

<u>Site Information</u>

Total Area: 3973 ha (9818 acres)
Exclusion Distance: 1.21-km (0.75-mile) radius
Low Population Zone: 4.02-km (2.50-mile) radius
Nearest City: Topeka; 1980 population: 118,690
Site Topography: flat to rolling
Surrounding Area Topography: flat to rolling
Land Use within 8 km (5 miles): agricultural and range land
Nearby Features: The nearest town is Sharpe about 3 km (2 miles) N. The Flint Hills National Wildlife Refuge is about 11 km (7 miles) W. The John Redmond Reservoir is about 6 km (4 miles) W. U.S. Highway I-35 is 23 km (14 miles) N. The cooling lake is formed by a dam on Wolf Creek.
Area of Transmission Line Corridor: 1200 ha (2900 acres)
Population within an 80-km (50-mile) radius:

1990	2000	2010	2030	2050
200,000	210,000	220,000	250,000	270,000

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YANKEE NUCLEAR POWER STATION

Location: Franklin County, Massachusetts
34 km (21 miles) NE of Pittsfield
latitude 42.7281°N; longitude 72.9289°W

Licensee: Yankee Atomic Electric Co.

Unit Information	Unit 1
Docket Number	50-029
Construction Permit	1957
Operating License	1960
Commercial Operation	1961
License Expiration	2000
Licensed Thermal Power [MW(t)]	600
Design Electrical Rating [net MW(e)]	175
Type of Reactor	PWR
Nuclear Steam Supply System Vendor	WEST

Cooling Water System

Type: once through
Source: Deerfield River
Source Temperature Range: 2-20°C (35-68°F)
Condenser Flow Rate: 8.8 m^3/s (140,000 gal/min)
Design Condenser Temperature Rise: 13°C (24°F)
Intake Structure: intake from Sherman Pond about 27 m (90 ft) below normal pond level.
Discharge Structure: discharge to Sherman Pond

Site Information

Total Area: 800 ha (2000 acres)
Exclusion Distance: 0.95 km (0.59 mile)
Low Population Zone: 8.05 km (95.00 miles)
Nearest City: Pittsfield; 1980 population: 51,974
Site Topography: hilly
Surrounding Area Topography: very hilly
Land Use within 8 km (5 miles): some maple syrup production
Nearby Features: The nearest town is Monroe Bridge 1.6 km (1 mile) WSW. Sherman Pond is adjacent to the site and discharges to the Deerfield River. A hydro station is just below the dam. Vermont Yankee Nuclear Power Station is about 32 km (20 miles) ENE. There are many ski resorts in the area.
Area of Transmission Line Corridor:
Population within an 80-km (50-mile) radius:

1990	2000	2010	2030	2050
1,720,000	1,760,000	1,800,000	1,870,000	1,950,000

ZION NUCLEAR PLANT

Location: Lake County, Illinois
10 km (6 miles) N of Waukegan
latitude 42.4456°N; longitude 87.8022°W
Licensee: Commonwealth Edison Co.

Unit Information	Unit 1	Unit 2
Docket Number	50-295	50-304
Construction Permit	1968	1968
Operating License	1973	1973
Commercial Operation	1973	1974
License Expiration	2013	2013
Licensed Thermal Power [MW(t)]	3250	3250
Design Electrical Rating [net MW(e)]	1040	1040
Type of Reactor	PWR	PWR
Nuclear Steam Supply System Vendor	WEST	WEST

Cooling Water System

Type: once through
Source: Lake Michigan
Source Temperature Range: 0-19°C (32-66°F)
Condenser Flow Rate: 46.4 m^3/s (735,000 gal/min) each unit
Design Condenser Temperature Rise: 11°C (20°F)
Intake Structure: Intake is located 790 m (2600 ft) offshore in water 6.7 m (22 ft) deep. Intake cap is 3 m (10 ft) below normal lake surface.
Discharge Structure: Each unit has a separate discharge structure 230 m (760 ft) from shoreline.

Site Information

Total Area: 100 ha (250 acres)
Exclusion Distance: 0.40-km (0.25-mile) radius
Low Population Zone: 1.61-km (1.00-mile) radius
Nearest City: Waukegan; 1980 population: 67,653
Site Topography: flat
Surrounding Area Topography: flat
Land Use within 8 km (5 miles): residential, industrial, agricultural, and recreational
Nearby Features: Site is bounded by the Illinois Beach State Park on the south, a city park on the north, the town of Zion on the west, and Lake Michigan on the east. A railroad runs along the western site boundary. U.S. Highway I-94 is 10 km (6 miles) W.
Area of Transmission Line Corridor: 58.7 ha (145 acres)
Population within an 80-km (50-mile) radius:

1990	2000	2010	2030	2050
7,480,000	7,720,000	7,900,000	8,200,000	8,520,000

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Appendix B

Definition of Impact Initiators for Nuclear Plant License Renewal Generic Environmental Impact Study

DEFINITION OF IMPACT INITIATORS FOR NUCLEAR PLANT LICENSE RENEWAL GENERIC ENVIRONMENTAL IMPACT STUDY

B.1 INTRODUCTION

Chapter 2 described the nuclear plant programs characterized for the purpose of assessing possible environmental impacts associated with license renewal. Both typical and conservative programs for both boiling-water reactors (BWRs) and pressurized-water reactors (PWRs) were described, together with the underlying assumptions and bases used in the development of these programs. Chapter 2 also presented estimates of the incremental environmental impact initiators associated with nuclear power plant license renewal.

This appendix provides additional discussion of impact initiator estimates. Additional factors and details are discussed, and comparisons are provided with license renewal-related impact initiator estimates derived from other sources. This appendix also compares the differences in impact initiators between the typical and conservative programs.

As noted in Chapter 2, license renewal for a particular plant will be based on ensuring compliance by the licensee with the current licensing basis for that plant (i.e., the original plant licensing basis as amended during the initial license term). In addition, the licensees will be required to demonstrate for certain important systems, structures, and components (SSC) that the effects of aging will be managed in the renewal period in a manner such that the important functions of these SSCs will be maintained. The SSCs of concern in the renewal period are those which traditionally do not have as readily monitorable performance or condition characteristics and include most passive, long-lived plant SSCs. Therefore, the Nuclear Regulatory Commission's (NRC's) license renewal rule requires a systematic review of, as a minimum, passive, long-lived SSCs that support safety or other critical functions of a nuclear power facility. To make these determinations regarding these SSCs, it is expected that licensees will implement aging management activities for SSCs for which current programs are not adequate to ensure continued functionality in the renewal term. These aging management activities are expected to include surveillance, on-line monitoring, inspections, testing, trending, and recordkeeping (SMITTR) as appropriate. This enhanced activity, together with updated aging assessments, is intended to ensure that aging-related degradation of important SSCs is detected and mitigated in a timely manner. The satisfactory fulfillment of NRC requirements for license renewal may necessitate repairs or modifications to the facility or its operations which are incremental to corresponding actions being performed during the term of the current license. Note that the license renewal rule does not require any specific modifications to a facility.

In addition to those actions required by 10 CFR Part 54 or other licensing requirements, licensees may undertake various refurbishment and upgrade activities at nuclear plants to better ensure economic and reliable power generation from these facilities. These activities performed for safety and/or economic reasons can result in environmental initiators which are different from those incurred in the original licensing term.

B.1.1 Purpose

The primary objective of the effort discussed here was the development of quantitative estimates of selected license renewal-related environmental impact initiators. The term "impact initiators" was defined in Chapter 2. The resulting impact initiator estimates were used in developing the Generic Environmental Impact Statement (GEIS) to support nuclear plant license renewal rulemaking. All initiators characterized in this appendix are incremental relative to those already experienced with current nuclear plant operation. The incremental environmental impact initiators expected to result from license renewal-related activities are as follows:

- labor hours and work force size;
- labor costs;
- occupational radiation exposure;
- capital costs; and
- radioactive waste types, volumes, and disposal costs.

As noted in Chapter 2, the impact initiators cited above are those which result from nuclear plant incremental aging management activities. These are the incremental activities performed to support license renewal and extended plant operation. Also, the focus is on changes in impact initiators originating from plant activities as opposed to changes in the plant environs or receptors (e.g., changes in the population affected by the plant). The impact initiators assessed herein form a sufficient set from which to assess most license renewal-related environmental impacts.

Two types of license renewal program estimates are developed herein. The first applies to "typical" license renewal programs and is intended to be representative of the type of programs that most plants seeking license renewal might implement. The second is more encompassing and is intended to be an upper bound as to the impacts likely to be generated at any particular plant.

Both types of estimates are useful. The typical scenarios are useful for estimating impacts from an "average" license renewal program and for estimating total nuclear plant population impacts on the nation as a whole. The typical programs are intended to be representative of plants that have been reasonably well maintained and that have already undertaken most major refurbishment activities that might have been necessary. The conservative scenario estimates, on the other hand, are useful for estimating the maximum impacts likely to result from any individual plant's license renewal program.

B.1.2 Scope and Organization

This appendix presents estimates of potential environmental impact initiators that may result from nuclear plant license renewal. These quantitative estimates apply to an assumed approach to aging management for two specific reactor plant types, BWRs and PWRs. Postulated sets of license renewal activities, with separate implementation schedules, have been defined for each reactor type and for both the typical and conservative scenarios. This appendix also presents the bases and assumptions used in developing the information.

More specifically, the results include the following:

- definition of reasonable license renewal programs, which include specific activities for specific SSCs, developed separately for a generic BWR and a generic PWR;
- estimates of the labor hours, work force size, labor cost, capital cost, occupational radiation exposure, and radioactive waste associated with each activity;
- summary estimates of impact initiators associated with the conduct of an entire license renewal program; and
- definition of the rates at which impacts are accrued for each program.

This appendix presents and describes all of these results. In addition, estimates are provided of the impact initiators attributable to satisfying the proposed revision to the license renewal rule [FR 59, no. 174, 46574 (September 9, 1994)]. Possible off-site labor costs are also quantified, as are replacement energy costs for the incremental downtime needed to perform aging management activities.

To encompass the full range of individual plant license renewal actions, additional candidate programs could have been defined and characterized. These could have been developed based on other approaches to plant aging management. For example, the programs used in this analysis are characterized by extensive refurbishment and replacement of SSCs as a means of managing aging. An alternative program might be one with reliance on more extensive SMITTR activities and less reliance on refurbishment. The approach followed in this evaluation is more conservative because it results in higher estimates of impact quantities. Alternative approaches to license renewal will likely be proposed by some nuclear utilities. However, the staff believes the programs characterized here are reasonably comprehensive and provide reasonable estimates of both typical program impacts characteristic of the reactor population as a whole, and upper bound impacts associated with what might be required by a few outlier plants seeking license renewal.

Section B.2 discusses the technical approach and bases used in the development of environmental impact initiator estimates. The specific SMITTR and major refurbishment activities included in the typical and conservative license renewal programs are reviewed in Section B.3, as are additional details of the data and information development. The results of the analysis are presented in Section B.4. That section also compares the results and estimates of license renewal-related costs developed here with similar information developed by industry.

B.2 TECHNICAL APPROACH AND BASES

The overall plan for support of the GEIS was to develop, by plant category, expert estimates for the various environmental impact initiators associated with nuclear plant license renewal. Plant categories were defined based on the characteristics deemed important in determining environmental impacts. The environmental impact initiators for the two basic plant categories of interest were estimated by first defining a representative set of activities to be pursued to achieve license renewal and extended plant operation. Impact initiators (labor, radiation exposure, radioactive wastes, etc.) were then identified and quantified for each activity. These activity impacts were summed to provide an estimate of overall environmental impacts associated with each plant type and each program type.

B.2.1 Technical Approach

The work undertaken to define and characterize impact initiators in support of the GEIS development was divided into three primary technical areas. These are briefly discussed below.

B.2.1.1 Definition of Information Requirements

This effort addressed two key aspects to ensure complete support for the GEIS: (1) development of candidate lists of activities with potential environmental consequences and (2) identification of environmental attributes (impact initiators) associated with those activities.

A comprehensive list of possible license renewal-related activities with potential environmental impacts was developed. Emphasis was placed on defining those activities clearly associated with license renewal (i.e., those activities which would not be included in a continuation or extrapolation of the activities that occurred during the original licensing term). The types of activities considered range from enhanced inspection programs to component replacement, and they include the list of activities originally developed for the License Renewal Rule Regulatory Analysis (NUREG-1362). The list of activities developed for that regulatory analysis was modified to reflect the proposed changes to the license renewal rule (10 CFR Part 54). In turn, the potential environmental impact initiators of each identified activity were examined and analyzed. Typical attributes included labor force requirements, low-level waste generation, capital costs, and worker radiation exposure.

B.2.1.2 Design of Database Extension and Application

Work performed in support of the 10 CFR Part 54 License Renewal Regulatory Analysis had initiated the development of a database of aging management and aging mitigation activities. To maintain control over the quality of the data and the effort required, the data were managed with a state-of-the-art relational database program on a microcomputer. This database application incorporated models of SMITTR effectiveness, permitting assessment of proposed aging management programs. The relational database facilitated the organization, archiving, and retrieval of the generic SMITTR data. The microcomputer database design was expanded to cover the more comprehensive information requirements related to assessing license renewal environmental impacts.

B.2.1.3 Review and Development of Data

Estimates of the potential incremental environmental attributes or challenges (i.e., impact initiators) created by license renewal-related activities were prepared for a generic BWR and a generic PWR. The plant features utilized were based on representative 1000-MW(e) plant designs. The plant designs were briefly discussed in Chapter 2. All attributes were quantified using actual data, industry estimates, or NRC's generic estimating methods. In addition, schedules were developed for implementing each activity of each program. Many activities carried out in support of license renewal and extended plant life are repeated at given intervals. For these types of activities, the repetition frequency and implementation schedule were also established.

The Part 54 Regulatory Analysis was reviewed for applicability and updated with more recent or more accurate information if available. New data requirements were evaluated and information sources identified.

All information was reviewed in detail to ascertain its accuracy and entered into a database system. The database was then sorted into the requisite plant categories and the information provided for performance of the environmental impact assessment.

B.2.1.4 Accounting for the Effects of Other NRC Regulations

All activities were reviewed for possible overlap with actions that may be undertaken to satisfy other licensee requirements, such as those imposed by the Maintenance Rule. For the typical license renewal programs, any activity potentially required by regulations other than the license renewal rule was deleted from the programs. In certain cases, activities which met this criterion were retained to encompass what licensees might do to better ensure reliable and economical plant performance, and thus to account for enhanced or additional actions performed on non-safety-related SSCs. Whenever such activities were retained, the numbers of SSCs to which these activities applied were reduced to reflect that fraction of the time that the actions would be performed in response to Maintenance Rule or other rule requirements.

Note that this type of review was performed for the typical scenarios only. For the conservative scenarios, this type of refinement to the programs would have had a negligible effect on the overall estimates of impact initiator quantities.

B.2.2 Assumptions and Bases

B.2.2.1 Bases for Reference License Renewal Programs

Most of the assumptions and bases used in developing the license renewal program environmental impact initiator estimates were discussed in Chapter 2. Additional aspects are presented here.

The typical and conservative license renewal programs characterize actions a licensee may take to ensure both safe and economic operation of its plant beyond the current 40-year license period. In reality, each plant's program and the specific refurbishment or repairs made for extended life will depend on many factors, including the original plant design, repairs already undertaken in the original license period, operating conditions and unusual occurrences, and plant management philosophy. The set of actions actually undertaken for license renewal, therefore, are expected to vary by plant because of specific plant designs, vintages, and classes. The staff believes the range of estimates developed here reasonably bound the impacts likely to actually accrue at any individual plant site.

The typical programs are intended to be representative of the typical or "average" plant's activities in support of license renewal. However, as noted in Chapter 2, the typical programs are still somewhat conservative.

The conservative license renewal scenarios are intended to capture what might occur for those outlier plants whose impacts will be considerably greater than what is typical of the reactor population as a whole. Because these conservative programs are quite comprehensive, they encompass impacts from more typical programs. The primary bases and assumptions used were discussed in Chapter 2.

The typical programs for both BWRs and PWRs are similar, except for the differences caused by reactor design and technology. This is also the case for the conservative programs.

B.2.2.2 Aging Management Programs: Descriptions, Assumptions, and Bases

Key aspects of the license renewal environmental impact assessments were discussed in Chapter 2. Additional factors and considerations are presented in the following discussions.

B.2.2.2.1 Sources of Information

Activities assumed to occur under each plant operational or outage mode were based on information available in industry lead and pilot plant life extension studies (EPRI NP-5181SP and NP-5181M; EPRI NP-5289P; EPRI NP-5002), NRC's Nuclear Plant Aging Research program results (NUREG/CR-5284; NUREG/CR-4731), previous and ongoing NRC license renewal regulatory analysis efforts (Sciacca 1989; MITRE 1988; Sciacca January 25, 1990; Sciacca February 20, 1990), discussions of major repair activities undertaken at operating nuclear power plants as reported in technical literature (Forest 1988; Katz 1988; Miselis 1988), and discussions with industry and nuclear equipment suppliers. Discussions were also held with lead plant personnel to further ascertain the results of their life extension and license renewal evaluations (Sciacca January 3, 1993; Attachment 1). Estimates of labor and routine occupational exposure incurred in the performance of these activities were largely based on information provided in those sources. Where such estimates were not available, they were derived using the generic estimating methods developed by the NRC (NUREG/CR-4627; NUREG/CR-5236; NUREG/CR-5035; NUREG/CR-4555). The assessment of available information included an extensive literature search of actual industry data of relevant SMITTR and refurbishment/replacement activities. The information found, and the sources investigated, are discussed in Attachment 1 to this appendix. The Maintenance Rule (10 CFR 50.65) was also reviewed to assess the effects of this requirement relative to detecting and mitigating aging degradation of important SSCs.

B.2.2.2.2 Major Refurbishment Schedules

Impact initiators were initially developed for two different schedules for major refurbishment or replacement activities (Sciacca 1990). The reference schedule assumes that major refurbishment activities associated with license renewal are started shortly after the new license is granted and that these are accomplished over several successive outages. They are completed by the time the plant completes its 40th year of operation, which is about 10 years into the new license term. A second schedule was explored which was based on the assumption that all major activities of this type occur at the end of the current 40-year license period, either by preference or because the license renewal is not expected in time to schedule activities earlier during the current period. This major refurbishment outage would necessitate a longer duration than that called for by the reference schedule. Because of the complexity of accomplishing all of the major refurbishment activities called for in the example aging management programs at a single outage, this latter scenario was dropped from consideration.

The schedule for performing any major refurbishment activities will undoubtedly be highly plant-specific, and such activities could well be spread throughout the term of the renewed license. Earlier timing of these activities provides the utilities with more time to recover the cost of the investment through the sale of energy produced. Thus, the schedules utilized for the present evaluations are reasonable, but alternative schedules are also possible.

The schedules utilized were similar for both the BWR and PWR programs. However, typical programs have little need for an extended outage because the extent of major refurbishment activities is relatively modest. The "major refurbishment outage" duration for typical programs was reduced compared with that deemed necessary for the conservative case scenarios.

B.2.2.2.3 Outage Types and Durations

Chapter 2 noted that activities carried out in support of license renewal and extended plant life were assumed to be performed primarily during selected outages. Five types of outages were used; they are referred to as normal refueling, 5-year in-service inspection (ISI) refueling, 10-year ISI refueling, current term refurbishment outages, and major refurbishment outages.

Outage types and durations were established to allow estimation of the rates at which environmental impacts might be generated as a result of license renewal activities. Of greatest concern from this standpoint are the projections of the number of temporary workers needed to accomplish license renewal activities. The number of workers required at a site for a given outage depends on the amount of work to be performed (labor hours), the time available to accomplish the work, and the number of labor hours expended per person-week or person-day. The number of workers so identified, in turn, allows estimation of potential socioeconomic and other impacts to affected communities.

Certain aging management activities were assumed to be performed during full power operation. These activities will add to the plant full-time staff requirements.

In the reference BWR and PWR programs, the initial period of the renewed license was characterized by the major refurbishment outage as well as by several shorter outages referred to as current-term outages. The duration of the major refurbishment outage for the conservative case scenarios was set at 9 months for both reactor types. This duration was established based on the most limiting activity taking place during that period. For the PWRs, the most limiting activity was steam generator replacement. The limiting activity for the BWRs was the replacement of reactor recirculation piping. Recent experience indicates that both of these major activities can be accomplished in 9 months or less.

For the conservative scenarios, the 10-year ISI was given a duration of 4 months, with other 5-year ISIs lasting 3 months. Most other refuelings were assumed to be 2-month outages. Current-term outages were assumed to have a duration of 4 months each.

For the typical scenarios, the duration of the major refurbishment outage was set at 4 months. This duration was adequate to accomplish the limited number of major refurbishment activities included in these programs. For these scenarios the 10-year and 5-year ISIs, as well as current-term outages, were given a duration of 3 months each.

Assignments of outage duration were based on experience prevalent in the nuclear industry.

In reality, all outage durations will be established based on both economic considerations (e.g., cost of replacement power) and what can practically be accomplished during each outage. The short outages in which many major activities (including refueling, ISIs, major component replacement, etc.) are assumed to be undertaken simultaneously may require very large (possibly unreasonably so) labor forces. No attempt was made in this limited effort to optimize outage schedules or durations. However, preliminary work schedules were developed for the conservative scenario major refurbishment outages for both BWRs and PWRs to assess whether the major activities slated for this period could reasonably be accomplished in the allotted time. This assessment indicated it is feasible to accomplish the example refurbishment during the 9-month duration assumed.

B.2.2.2.4 Labor Categories

Labor necessary to accomplish the inspection, surveillance, testing, maintenance (ISTM), and major refurbishment/ replacement activities associated with license renewal and plant life extension (PLEX) were estimated separately for each activity. Labor was subdivided into the categories of engineering, administrative, skilled crafts, and laborers. Each labor category's hours in different radiation fields were estimated by activity. In addition, health physics-related support service labor was separately estimated for all activities performed in a radioactive environment.

B.2.2.2.5 Activity Repetitions

The number of times a given activity was performed was determined based on the intervals between the times when a given activity (such as a particular inspection or refurbishment) would be performed on a given component and the number of such components in the plant subject to those actions. Quantities of similar components were determined from reviews of representative plant piping and instrumentation diagrams, key system schematics, plant descriptions, and detailed material take-offs available for various plants. Frequencies for activities such as major refurbishment or replacements might occur only once in the plant's lifetime (e.g., BWR recirculation pipe replacement), or they might occur several times (e.g., valve refurbishment or replacement). Only incremental aging management activities, those which are in addition to those currently performed, were included here. Lead plant program information was also used in establishing activity repetitions and frequencies.

B.2.2.2.6 Radioactive Waste Generation

Volumes and types of waste generated were estimated on an activity-by-activity basis. For refurbishment, overhaul, or replacement activities, estimates of noncompactible wastes were based on the size of the items involved (i.e., the physical dimensions of the target items). Associated compactible wastes were estimated based on typical ratios of compactible-to-noncompactible volumes. In addition, compactible and noncompactible waste volumes were derived from information found in published reports of major repairs undertaken at nuclear power plants. Fluid volumes generated as a result of decontamination activities were estimated based on typical volumes generated for similar activities. All fluids used in these processes were assumed to be processed through filters or resin beds to remove contamination so that no radioactive liquids needed to be disposed of. The resulting resins or filters are disposed of as dry wastes.

All inspection, surveillance, and test activities conducted on radioactive systems or in radiation areas were also assumed to generate radioactive wastes. For such activities, compactible dry active wastes (DAW) were assumed to be generated at the rate of 0.012 m^3 (0.4 ft^3) per craft labor hour (as-generated volume). These result from the laundering and disposal of anti-contamination clothing and other protective equipment.

B.2.2.2.7 Waste Disposal Costs

Costs associated with the disposal of low-level radioactive wastes generated from license renewal-related activities were estimated separately for BWRs and PWRs. These estimates took into account the projected volumes of noncompactible and compactible DAW generated by each reactor type in the conduct of license renewal-related activities. The disposal costs were calculated using the NRC's generic estimating methodology (NUREG/CR-4555), but the bases were updated to reflect the rapid escalation in burial costs arising from the formation of regional compacts and the likely closure or limited availability of the existing low-level waste disposal sites. The basis for estimating waste disposal costs is discussed more fully in Section B.3.2.4.

B.2.2.3 Approach to Estimating Impact Initiators

The estimation of impact initiators first required that the generic license renewal programs be defined in terms of the specific activities and activity repetitions making up each program. Next, the median value of each impact for each individual SMITTR or refurbishment activity was estimated for that activity taken over the full range of plants and potential circumstances. For major refurbishment activities, however, surveys were performed of pertinent, recent industry experience. Experience has shown that strong learning curve effects exist (i.e., subsequent work benefits from the experience of prior similar activities), even when the activities of interest are performed by different nuclear plant licensees. These learning curve effects suggest that, especially for major repair/refurbishment activities, it is appropriate to use information reflecting recent experience rather than median or average experience. Impact estimates for activities of this type were based on recent experience. Once values were established for each activity included in a license renewal program, the values were summed for all activities making up the program.

The particular aging management approach assumed for assessing environmental impact initiators relies more heavily on refurbishment, replacement, and monitoring than on extensive inspection, surveillance, and testing. The approach taken for these example programs tends to concentrate the impact initiators during initial refurbishment periods. For the conservative case outages, they represent an envelope that captures the activities that might be performed at essentially any U.S. nuclear power plant in support of license renewal and extended plant life. They are intended to present fairly robust scenarios in terms of environmental impacts incurred during the refurbishment outages.

B.3 DATA DEVELOPMENT

The primary objective of this effort was to provide quantitative estimates for license renewal-related initiators which could produce incremental environmental hazards or impacts because of extended operation of nuclear power plants beyond the original 40-year term. That objective was accomplished using the following basic approach. First, candidate lists of plant SSCs susceptible to aging degradation were identified. Next, prototypic license renewal and aging management programs were defined in terms of the activities which could be carried out to manage the aging of these SSCs. These were the incremental activities carried out to support license renewal and extended plant life but not required or impacted by other NRC requirements. Each activity performed on each SSC was evaluated to estimate the potential impact initiators resulting from the conduct of that activity. Finally, total program impacts were estimated by summing the impacts from the individual activities making up a license renewal program. As noted previously, these programs of activities were defined and evaluated separately for BWRs and PWRs, each with both a typical and a conservative scenario. This section discusses the methods and bases used to establish the quantitative estimates of impact initiators.

As indicated in Section B.2.2.2.1, many different sources of information were drawn upon to establish the characteristics and content of the prototypic license renewal aging management programs and to estimate the impacts associated with each. These sources helped, in particular, to characterize the types of aging management programs that might be needed to support extended plant life during the license renewal term. The activities carried out under these programs will be needed to maintain the current licensing basis of the plants and to provide for their economical operation, as well as to satisfy the aging management requirements stipulated in the license renewal rule.

In the discussions which follow, Section B.3.1 describes the key aging management programs used to assess potential environmental impacts, and Section B.3.2 presents the specific impact initiators and describes the quantification of each initiator.

B.3.1 Aging Management Activities

The SSCs of interest for the example license renewal programs were presented in Chapter 2. The following discussions elaborate on representative aging management activities likely to be carried out on these SSCs.

The incremental aging management activities carried out to allow operation of a nuclear power plant beyond the original 40-year license term will be from one of two broad categories. These two categories of activities are (1) SMITTR actions, most of which are repeated at regular intervals, and (2) major refurbishment or replacement actions that usually occur fairly infrequently, or possibly only once, in the life of the plant for any given item.

B.3.1.1 SMITTR Aging Management Activities

Most of the SMITTR activities included in the present assessment were taken from the Safety-Centered Aging Management program defined previously and utilized for the 10 CFR Part 54 License Renewal Regulatory Analysis (NUREG-1362). However, the current effort includes additional items and activities, because the previous analysis focused only on SSCs important to safety, whereas licensees will also perform actions aimed at ensuring reliable and efficient electrical power production. Thus, many balance-of-plant SSCs are included here which were not included in the 10 CFR Part 54 evaluations.

In certain cases an SMITTR activity could involve replacement or refurbishment of the SSC being addressed. Any such SMITTR replacement/refurbishment activities for a particular item typically occurred more than once in the extended life of the plant.

Table B.1 lists the incremental SMITTR actions used as the basis for estimating license renewal environmental impacts. It indicates the specific aging detection and mitigation actions performed on each SSC of concern. The table also indicates the actions included in the typical scenarios, as well as those in the conservative case scenarios.

Table B.1 indicates the specific SMITTR activities included in each type of program, but it does not indicate the number of SSCs subject to a particular activity. The programs defined for the conservative case scenarios in all instances match or exceed the number of SSCs included in the corresponding typical license renewal programs.

B.3.1.2 Major Refurbishment Aging Management Activities

The list of major replacement and refurbishment activities included here was derived largely from areas of concern identified in the industry pilot and lead plant life extension studies, for both the conservative and typical scenarios. Those studies did not necessarily indicate that all of the items addressed should be replaced or undergo major overhauls. However, for all items addressed there was sufficient concern over their long-term integrity that investigators thought that, as a minimum, additional analysis was warranted.

Although replacement may not have been indicated for the pilot and lead plants, at least a few plants may well face extensive actions of this type to ensure safe and economical operation throughout the renewal term. Therefore, regardless of the specific determinations for the pilot and lead plants, the SSCs of concern identified in those studies form a representative list of candidate items for inclusion in major replacement and refurbishment actions for outlier plants, and thus for the conservative scenarios. Other items included in this list were drawn from actions that have already occurred at one or several operating power plants. BWR recirculation piping replacement and PWR steam generator replacement fall into this category. Although many plants will undertake the replacement of such items during the current license term, there may well be other plants which would undertake such tasks only to allow for extended plant operation. Inclusion of these activities in the conservative case scenario evaluations provides for a conservative estimate of what at least a few plants may require.

Table B.2 lists the major refurbishment or replacement activities used to estimate environmental impacts. Both typical and conservative case activities are indicated. The table indicates the fractions or portions of the SSCs involved which are subject to the stated actions. Unless otherwise noted, 100 percent of an SSC was assumed to be replaced or refurbished. As with the list of actions cited in Table B.1, the quantities assumed were based in part on the information provided in the industry pilot and lead plant studies (EPRI NP-5181SP;

Table B.1 Incremental SMITTR[a] enhancement activities

SMITTR action	Conservative/typical program
BWR[b] SMITTR Enhancements	
Bellows	
Inspect one refueling and dry well bellows assembly	Both
Control Rod Drive Mechanism	
Discharge and vent value tests of one mechanism	Both
Recirculation Pump and Motor	
Conduct detailed inspection (disassembly/reassembly) of one pump and motor	Both
Metal Containment Including Suppression Chamber	
Inspect suppression pool and vent system exterior	Both
Renew protective coating on containment structure	C
RPV[c] Internals	
Conduct underwater inspection of core plate for IGSCC,[d] jet pump brace and safe ends, shroud-to-shroud flange and access hold cover, bolt inspection method, and ultrasonic testing of top guide.	Both
Conduct ultrasonic testing of top guide in central core region for IGSCC, shroud-shroud support cylinder welds, core spray inlet tee attachment, jet pump riser elbow to thermal sleeve weld region, and jet pump diffuser-to-adapter weld joint	Both
PWR[e] SMITTR Enhancements	
Critical Concrete Structure—Containment	
Renew all concrete protective coating on containment structure	Both
Reactor Coolant pump	
Conduct detailed inspection (disassembly, reassembly) of PWR coolant pump, shaft, and motor	Both

See footnotes at end of table

Table B.1 (continued)

SMITTR action	Conservative/typical program
RPV Internals	
Inspect core support plate, core shroud, top guide using visual and ultrasonic testing or similar methods, and welds and critical areas	Both
Enhancements to Components of Both PWRs and BWRs	
AC or DC Bus	
Inspect one medium-voltage breaker per manufacturer's recommendations	Both
Actuation and Instrumentation Channel	
Inspect connectors and penetrations for one channel	Both
Building Crane	
Perform load lift program on one crane, comprehensive SMITTR of crane or hoist	Both
Check Valve	
Re-grind one valve seat; replace moving parts mechanisms	Both
Compressed Air System	
Perform frequent inspection of compressed air system elements, including filter ΔP and leakage checks	Both
Containment	
Examine fabrication welds (ultrasonic testing and visual) and base and concrete core sample (remove and replace a 6-in. square of concrete)	Both
Emergency Diesel Generator	
Inspect main bearings for wear and connecting rods for fatigue damage; also check for gear fatigue and wear	Both
Conduct turbocharger drive gearing surveillance for one emergency diesel generator	Both

See footnotes at end of table

Table B.1 (continued)

SMITTR action	Conservative/typical program
Fan Cooler	
Inspect one fan motor for break down during run (megger); perform visual check of fan running, vibration	Both
Fuel Pool	
Conduct visual inspection of liner	Both
Heat Exchanger	
Conduct comprehensive efficiency test on one heat exchanger	Both
Heating, Ventilation, and Air Conditioning (HVAC)	
Inspect ducting, fans and motors, flex-joints, and dampers for degradation	Both
Conduct SMITTR of HVAC of one building	Both
Hydraulic or Air-Operated Valve	
Refurbish operator on one valve; regrind valve seat	Both
Main Condenser	
Inspect wall thickness of condenser	Both
Main Generator	
Inspect rotor of one main generator	Both
Main Turbine	
Conduct ultrasonic test of casing for one turbine	C
Motor Operated Valve	
Refurbish one valve, replacing internals	Both
Motor-Driven Pump and Motor	
Conduct detailed disassembly-inspection-reassembly for one pump and motor internals	Both

See footnotes at end of table

Table B.1 (continued)

SMITTR action	Conservative/typical program
Nuclear Steam Supply System Supports	
Torque statistical sample of component support anchor bolts	Both
RPV	
Visually assess condition of entire vessel exterior; inspect/evaluate one specimen for fracture toughness and tensile strength	Both
Inspect condition of dry lubricants in sliding foot area	Both
Turbine-Driven Pump and Turbine	
Conduct detailed disassembly-inspection-reassembly of one pump and turbine internals	Both

[a]SMITTR = Surveillance, On-Line Monitoring, Inspections, Testing, Trending, and Recordkeeping
[b]BWR = boiling-water reactor
[c]RPV = reactor pressure vessel
[d]IGSCC = intergranular stress-cracking corrosion
[e]PWR = pressurized-water reactor

Table B.2 Major refurbishment/replacement activities

Refurbishment/replacement action	Conservative/typical program
Activities Common to Both BWRs[a] and PWRs[b]	
• General refurbishment and repair of turbine building, primary auxiliary building, waste processing building, fuel storage building, and feedwater pipe enclosures	C
• Major overhaul and upgrade for buildings	C
• Major repair/refurbishment of main generator	Both
• Overhaul one crane	C
• Refurbish 25 percent of liquid rad waste system	C
• Refurbish coating of one condensate storage tanks	C
• Refurbish main station switchgear	C
• Refurbish main steam valves	C
• Renew protective coating on containment structure	Both
• Repair/refurbish 5 percent of reactor containment building interior concrete (or equivalent repairs)	C
• Repair/refurbish turbine pedestal	C
• Repair/replace major concrete imbedments in reactor containment building	C
• Repair/replace portions of nuclear steam supply system major piping and component supports	C
• Repair ultimate heat sink structure	C
• Repair/replace 20 percent of main steam, feedwater, condensate, and circulating water system piping	C
• Replace approximately half of the feedwater heaters	C
• Replace closure stud bolts	Both
• Replace containment electrical penetrations	Both
• Replace containment sensors and instrumentation	C
• Replace diesel generators	C
• Replace turbine rotor	Both

Table B.2 (continued)

Refurbishment/replacement action	Conservative/typical program
• Replace portions of electrical cabling both inside and outside of containment	C
• Replace/repair electrical raceways and supports	C
Activities Unique to BWRs	
• Replace all shroud head bolts in reactor vessel	C
• Replace recirculation pump shaft and impeller, refurbish casing—of each pump	C
• Replace entire BWR recirculation piping system and safe-ends	C
• Replace one-half of the jet pump assemblies in the reactor vessel	C
• Replace upper and lower core structure	Both
Activities Unique to PWRs	
• Anneal the reactor vessel	C
• Replace approximately half of reactor pressure vessel lower internal structures	Both
• Replace steam generators	C
• Replace pressurizer	C
• Replace reactor coolant pump internals and refurbish pump	C

[a]BWR = boiling-water reactor
[b]PWR = pressurized-water reactor

EPRI NP-5181M) and from reported existing industry experience on major refurbishment (Forest 1988; Katz 1988; Miselis 1988; North Anna-1 1993; Rippon 1990). In other cases, engineering judgment provided the basis for the portions of the systems or structures being replaced or refurbished. The actual industry experience to date with similar activities indicates that theactions listed and quantities represented in Table B.2 for the conservative case scenarios are quite conservative in that no individual plant has had to undertake the comprehensive set of actions shown. An even more conservative approach could have been taken whereby the list of activities could have been expanded and/or the portions of the SSCs involved could have been increased (e.g., replace 100 percent of feedwater heaters rather than 50 percent). However, such an approach was judged to be highly unrealistic and would have resulted in unrealistically high estimates of license renewal environmental impacts.

Table B.2 indicates that relatively few major refurbishment activities have been included in the typical license renewal programs. The activities of this type that were retained were based in part on a review of the lead plant license renewal program plans. The typical programs are based on the assumption that most plants will be maintained and operated in a manner that reduces the need for all but a few major refurbishment activities that must be undertaken sometime during the term of the renewed license. In reality, many plants will have undertaken various major refurbishment activities during the term of the current license.

B.3.1.3 Outage and Operational Modes

The bulk of the incremental activities making up the example license renewal programs must be performed when the plants are shut down. As indicated in Section B.2.2.2.3, five different types of outages were used for defining the schedule for conducting these activities. These modes are referred to as current-term outages, refurbishment outages, 5-year ISI outages, 10-year ISI outages, and normal refueling outages. In addition, certain incremental inspection and surveillance activities were assumed to be conducted during power operation. This is referred to as the full power mode. The five outage modes are characterized in the following sections.

Figure 2.3 in Chapter 2 indicated the points in a representative license renewal schedule at which these various outage modes were assumed to occur.

B.3.1.3.1 Current Term Outages

Many of the major refurbishment and replacement activities undertaken to support license renewal can be performed in stages and need not be accomplished in a single outage. This would apply, for example, to activities such as electrical cable replacement and structural upgrades. For the example programs used herein, such activities are assumed to commence shortly after the renewed license is granted by the NRC. The current analysis assumes that four current-term outages occurring within the first 10 years under the new license will be used to accomplish the bulk of the major upgrades that can be spread out in time. These outages had an assumed duration of 4 months each for the conservative case scenarios and 3 months each for the typical scenarios.

B.3.1.3.2 5-Year In-service Inspections

Two 5-year ISIs will be performed during the renewal term, corresponding to years 5 and 15 of the extended period. Certain incremental activities are assumed to be performed in addition to the 5-year ISI actions currently required of nuclear plant licensees. The incremental SMITTR activities performed during the normal refueling outages of the extended term are also carried out for the 5-year ISI outages. These outages have durations of 3 months each for all programs.

B.3.1.3.3 10-Year In-service Inspection

A single 10-year ISI is assumed to be performed midway through the extended license period. The activities assumed to occur at this outage are incremental to current 10-year ISI requirements, and also include all actions undertaken during normal outages of the extended term of plant operation. A 4-month outage duration is assumed for the conservative case scenarios, and 3 months each for the typical scenarios.

B.3.1.3.4 Refueling Outages

In addition to the 5- and 10-year ISI outages, the 20-year renewal term is assumed to be characterized by eight normal refueling outages with a duration of 2 months each for each license renewal program. Incremental SMITTR activities are performed at each of these outages.

B.3.1.3.5 Refurbishment Outage

Certain major plant upgrades, replacements, and refurbishment must realistically be accomplished during a single outage period. Replacement of steam generators in a PWR and recirculation piping in a BWR fall into this category. To accommodate major activities such as these, a single extended outage is assumed to occur at the end of the 40-year current term of operation for the conservative scenarios. For both BWRs and PWRs this conservative case outage was assumed to have a duration of 9 months. The refurbishment activities in the typical license renewal scenarios are modest compared to those in the conservative case scenarios and can be accomplished in less time. A 4-month duration was judged to be adequate for this outage for the typical scenario. Other major activities that were initiated during the current-term outages are assumed to be completed at this refurbishment outage.

A preliminary check was performed as to the reasonableness of the 9-month duration for the major refurbishment outages of both the BWR and the PWR conservative case license renewal programs. This check entailed identifying the critical path activities slated for accomplishment at this outage, assessing the time required to perform each activity, and developing an overall schedule. Figures B.1 and B.2 display the results of this evaluation. Figure B.1 shows a possible schedule for the PWR for completing the critical path activities. The comparable information for the BWR is displayed in Figure B.2. Recent industry experience, where available, was used to estimate the duration requirements for each critical path activity. These assessments also focused primarily on in-containment activities, and the assumption was made that outside-containment work was less limiting and allowed greater scheduling flexibility than the in-containment work. Both schedules allow for complete defueling of the reactor before initiating major refurbishment activities in the containment buildings. These assessments, although preliminary, suggest that the assumed 9-month duration for the conservative case major refurbishment outages is feasible.

Note that recent industry experience with major refurbishment activities such as steam generator replacement indicates that these large efforts can be accomplished in periods ranging from about 3 to 5 months, rather than the 9 months assumed for the current conservative program evaluations (North Anna-1 1993; Rippon 1990). The 9-month major refurbishment outage duration was retained to more realistically accommodate the large number of refurbishment activities assumed to proceed simultaneously during this outage.

For the typical license renewal scenarios, the most limiting activities undertaken during the major refurbishment outage were replacement of certain reactor vessel internal components and repairs to the main turbine-generator. A 4-month outage duration was judged to be sufficient to accomplish these activities.

Table B.3 summarizes the different outage types and durations for both reactor types

ORNL DWG 95M-10359

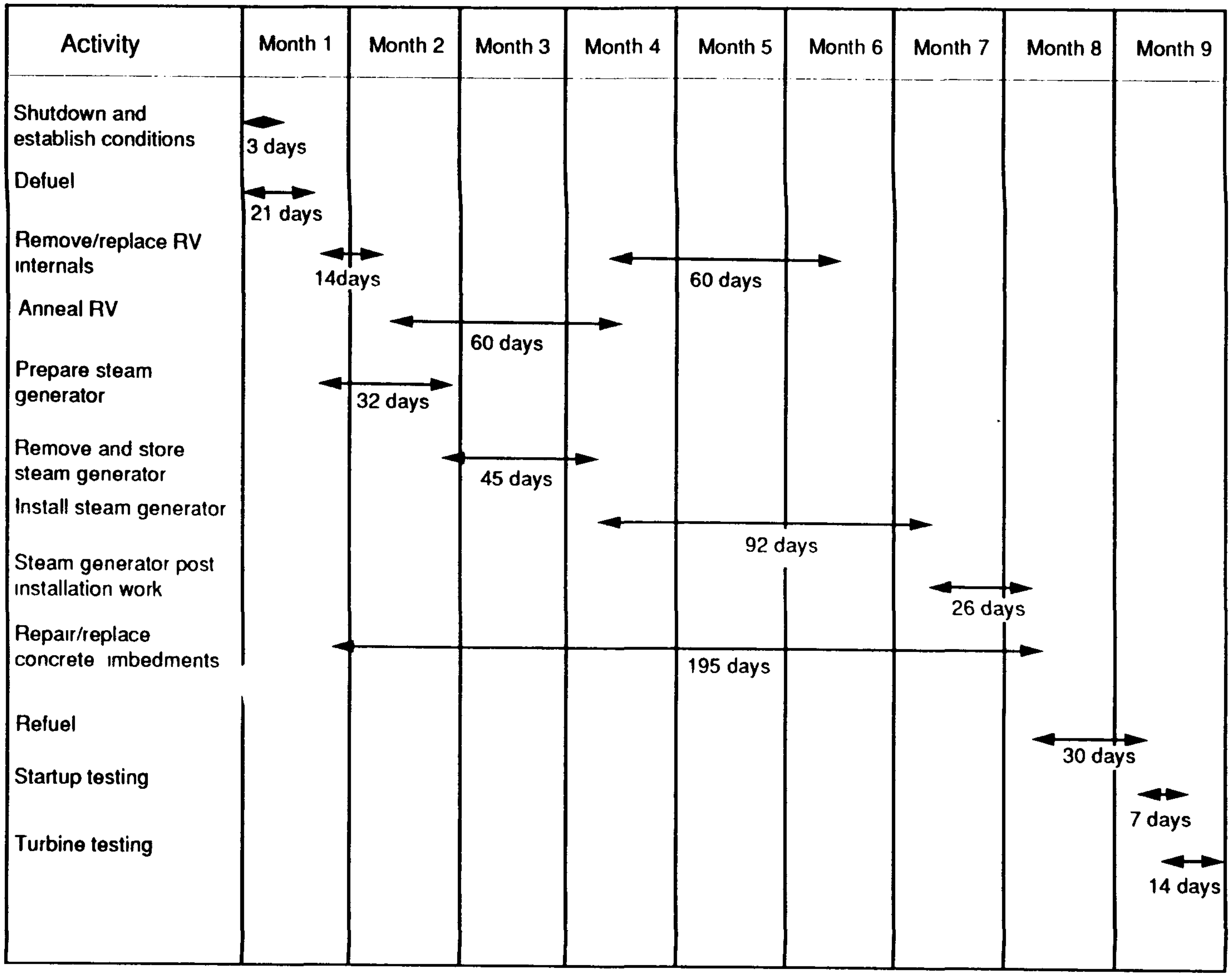

Figure B.1 PWR major refurbishment outage schedule.

ORNL DWG 95M-10360

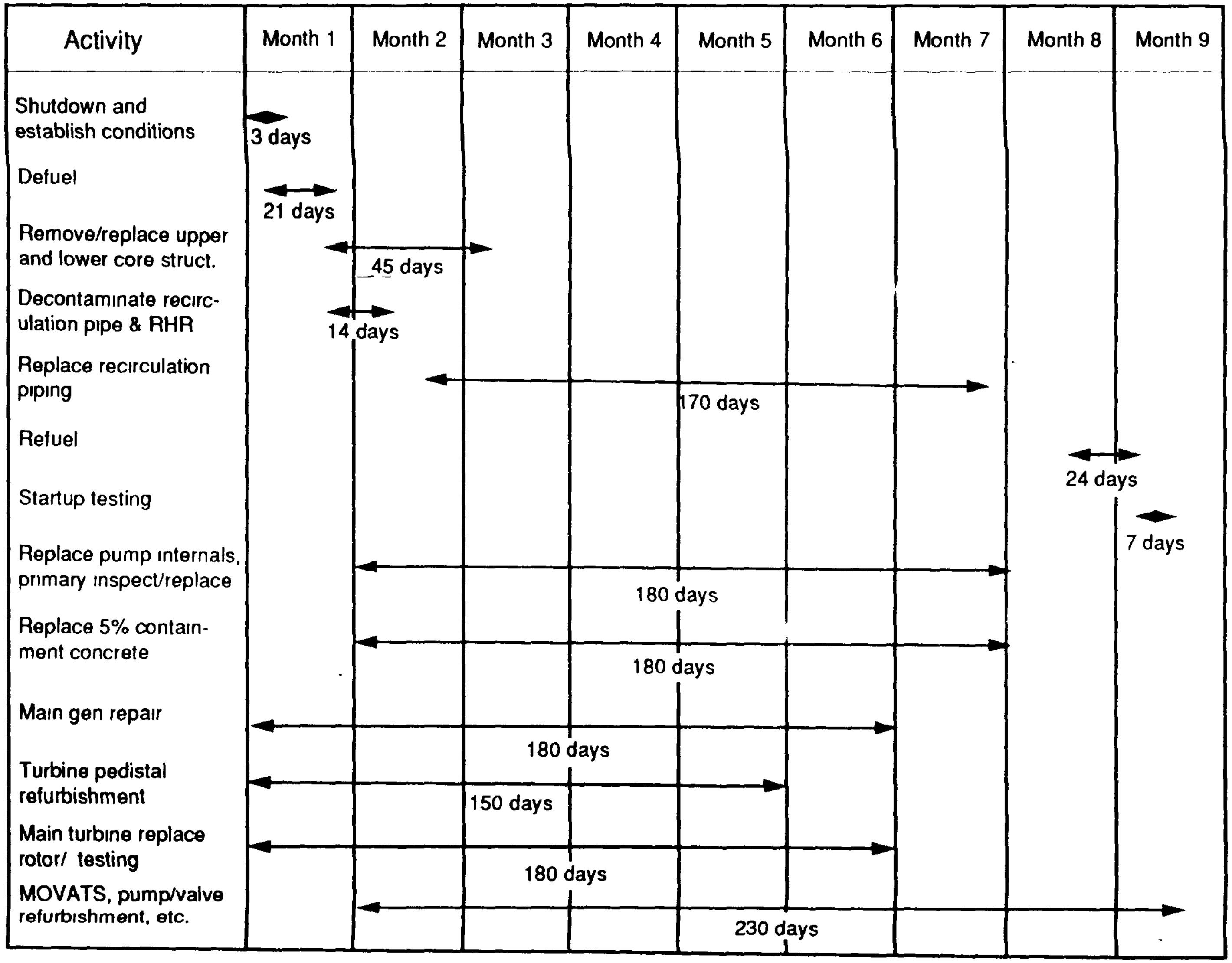

Figure B.2 BWR major refurbishment schedule.

Table B.3 Outage duration summary

Outage type	Outage duration (months)	
	Conservative	Typical
Refueling	2	2
5-year in-service inspection	3	3
10-year in-service inspection	4	3
Current-term outage (refurbishment)	4	3
Major refurbishment outage	9	4

and for both the typical and conservative license renewal scenarios.

In addition to the aging assessment and management activities performed during plant shutdown, certain incremental SMITTR activities can also be performed during full power operation. The current assessment identified only a limited number of activities of this type. This activity mode is referred to as the full power mode.

B.3.2 Quantification of Impact Initiators

Three primary types of impact initiators related to license renewal activities were quantified in this assessment: on-site labor, occupational radiation exposure, and radioactive waste generation. Other possible contributors to socioeconomic and/or environmental impacts were also assessed: capital costs, radioactive waste disposal costs, additional off-site labor requirements, and plant down time and replacement energy costs. The following sections discuss the basis for the impact quantification associated with conducting the license renewal-related activities.

B.3.2.1 Labor

This assessment developed three aspects of labor required to carry out aging management activities in support of license renewal. These aspects include labor hours, labor costs, and the number of individuals needed during a given period to perform the activities. In addition, the five labor categories of administrative personnel, engineering, craft workers, unskilled laborers, and health physics support staffing were treated.

This labor quantification effort first defined the number of craft and/or unskilled labor hours needed to perform each specific activity encompassed by any of the aging management programs. The labor estimates associated with the conduct of the SMITTR activities were taken largely from the license renewal regulatory analysis developed previously (Sciacca January 25, 1990; Sciacca February 20, 1990). The labor estimates for each activity were reviewed. Changes to the original estimates were made if new information indicated the need for revision. In many cases, the number of times a given activity was carried out was increased relative to the estimates used in the regulatory analysis. This approach was taken because the current effort encompasses actions undertaken to address both plant safety and economics, whereas the regulatory analysis dealt strictly with safety-related activities. This is particularly true for the conservative scenarios. Also, the broader scope of the current effort required the inclusion of many balance-of-plant SSCs that need to be addressed to provide economical and reliable electrical power generation over the extended term of operation.

The labor estimates required to accomplish major refurbishment or replacements were derived in two ways. If the activity of concern had already been performed in U.S. nuclear plants, and if the actual labor expenditures were reported in available documentation, this actual experience was used as a basis. Adjustments were made in certain cases to reflect learning curve effects where future repetitions of that activity could benefit from the earlier examples. However, many major refurbishment/replacement activities postulated in the current assessment have not been performed previously, or if they have, the labor required to accomplish these actions is not available. For activities in this category, NRC's generic cost estimation methods were used (NUREG/CR-4627; NUREG/CR-5236). This method uses "greenfield" or new construction labor estimates as a starting point. Labor to remove and replace given SSCs is then estimated by factoring in operating plant constraints which affect labor productivity. These constraints include factors such as access restrictions, congestion, interference with non-target systems and structures, radiation impacts, and manageability aspects. For those activities for which this method was used, the present estimates of labor requirements to accomplish major refurbishment and replacement activities took into account the specific environment under which the work would be performed. This included area-specific radiation dose rates if the work had to be performed in a radioactive environment (NUREG/CR-5035).

Distinctions between craft and unskilled workers were also developed on an activity-by-activity basis. Most of the SMITTR activities are assumed to be performed by trained technicians, who were treated as being the equivalent of skilled craftsmen. Unskilled labor was assumed to be used for some of the major replacement/refurbishment work. The ratio of craft to unskilled labor was estimated based on engineering experience. This ratio was determined separately for each activity for which some mix of both craft and unskilled labor could realistically be assumed.

Estimates of on-site administrative and engineering labor requirements for each activity were derived from the estimates of craft and unskilled labor hours. For most activities, engineering labor was assumed to be 15 percent of the craft and unskilled labor hours, and administrative efforts were taken to be 5 percent. However, engineering labor for certain activities was based on estimates presented in the industry pilot and lead plant studies on plant life extension.

Health physics (HP) support labor efforts were estimated based on the occupational radiation exposure incurred in the conduct of activities performed in a radiation environment. Previous studies (NUREG/CR-5236) indicated that typical nuclear plant expenditures for radiation protection services are in excess of $10,500 per person-rem[1] of radiation exposure incurred. Of this amount, about 85 percent is labor expenditures, and the balance is attributable to materials, equipment, etc. The hourly cost of providing HP support was assumed to be $63.00 (NUREG/CR-4627). Using these figures, an estimate of 127 person-hours per person-rem of exposure was established and used in estimating HP labor hours.

All labor estimates reflect incremental on-site personnel requirements only. Additional engineering and administrative support would very likely be required for some activities, especially for major refurbishment and replacement efforts. These efforts are assumed to take place at locations remote from the reactor plant sites and would not contribute to local environmental or socioeconomic impacts. However, these off-site costs are separately accounted for to make the estimates of license renewal costs more comprehensive.

Labor costs were derived once the labor hour estimates were established. The hourly rates used for each labor category were as follows:

Administrative	$40.80
Craft	$41.30
Engineering	$45.80
Health Physics	$63.00

These hourly rates are fully burdened to reflect fringe benefits and indirect or overhead costs. They are based on electric utility wage surveys conducted by the Bureau of Labor Statistics and reflect 1994 dollars. The rates used are U.S. averages; higher or lower rates may prevail in specific geographic regions.

B.3.2.2 Occupational Radiation Exposure

Occupational radiation exposures were estimated for all activities involving radioactive systems or work in radioactive areas. Three equivalent average dose rates were assumed for the activities considered in this assessment. These rates were 0.015 rem/h for high radiation zone activities, 0.0075 rem/h for average or medium conditions, and 0.0025 rem/h for low radiation zones. These dose rate ranges were derived from a review of actual experience for both major replacement/refurbishment activities and routine surveillance and inspection activities. The rates as derived are based on the total labor hours taken to accomplish a task and the total exposure recorded for that task. As such, they take into account both the time spent in radiation zones and that spent in nonradioactive areas associated with the conduct of a particular activity. They also reflect actions taken to reduce exposures, such as application of shielding and decontamination. Exposures were determined by multiplying the total labor hours for craft and unskilled workers for a given activity by the high, medium, or low dose rates.

Estimates of occupational radiation exposure for most of the SMITTR activities included in the present assessment used the foregoing average exposure rates. Particular dose rates were assigned to a given activity based on the location and relative radiation levels of the SSC addressed by the SMITTR action.

Exposure estimates for major refurbishment/replacement actions were typically handled on an activity-by-activity basis. Estimates for activities for which data from actual experience were available used that actual experience. Steam generator replacement and recirculation piping replacement provide examples of activities for which actual radiation exposure data are available. For such cases, the total labor hours were spread among the three standard dose rates in a manner which resulted in total job exposures matching those from actual experience.

Major activities for which no actual exposure data were available employed a slightly different approach for exposure estimates. For most of these activities total labor estimates were derived using NRC's generic cost estimation methods (NUREG/CR-4627; NUREG/CR-5236). Job-specific radiation dose rates prevalent for each activity were assessed based on surveys of typical conditions for both BWRs and PWRs (NUREG/CR-5035). These estimates took into account the likelihood of decontamination or other dose-reduction measures being applied, and the raw dose rate data were adjusted accordingly. Similarly, these cases took into account the time actually spent in the radiation field.

B.3.2.3 Radioactive Waste Generation

This effort initially sought to define radioactive waste generation according to classical designations of dry wastes, Class A, B, or C; dry mixed wastes (radioactive wastes mixed with hazardous chemicals); wet wastes, Class A, B, or C; or wet mixed wastes. A review of current practices for the nuclear industry indicated that essentially none of the radioactive wastes presently shipped from nuclear plants for burial are wet wastes. Radioactive liquids are decontaminated or solidified on-site or at contractor facilities, eliminating the need for burial of the liquids. A review of the types of dry wastes likely to be generated by the activities carried out in support of license renewal and plant life extension indicated that most of these could be considered as dry Class A waste. No Class B or C wastes were identified. However, certain activities are expected to produce some greater-than-Class C (GTCC) dry wastes. This waste will result from the removal of neutron-activated materials from the reactor vessel or from the removal of materials located sufficiently close to the reactor core that activation is a problem.

The assessment of the volumes of radioactive waste to be disposed of, and the estimation of labor requirements associated with the in-plant handling of the waste, requires that DAW be defined or classified as compactible or noncompactible. Compactible DAW is amenable to significant volume reduction by compaction, incineration, or other processes. The as-shipped or as-processed volume of this waste is typically factors of 5 to 100 less than the as-generated volume. Noncompactible DAW, on the other hand, typically has an as-packaged volume which is greater than the as-generated volume because of the difficulty of achieving high packing factors with the noncompactible materials involved. The extent of volume reduction achieved is typically referred to as the volume reduction factor (VRF). This factor is defined as:

$$VRF = \frac{\text{untreated (as-generated) waste volume}}{\text{packaged (as-shipped) volume}}$$

The current assessment used a VRF of 10 for compactible DAW to estimate as-shipped volumes from the as-generated values. This VRF is reasonably representative of current industry experience, and it assumes a modest amount of improvement in waste processing in the future for the industry as a whole. A VRF of 0.8 (i.e., a volume increase) was used for estimating the as-shipped volume of noncompactible DAW requiring disposal. This factor also assumes the use of state-of-the-art technology in the packaging of the noncompactible wastes.

Volumes and types of waste generated were estimated on an activity-by-activity basis. For refurbishment, overhaul, or replacement activities, estimates of noncompactible wastes were based on the size of the items involved (i.e., the physical dimensions of the target items). Associated compactible wastes were estimated based on typical ratios of compactible-to-noncompactible volumes. In addition, compactible and noncompactible waste volumes were derived from information found in published reports for major repairs undertaken at nuclear power plants.

Fluid volumes generated as a result of decontamination activities were estimated based on typical volumes generated for similar activities. All fluids used in these processes were assumed to be processed through filters or resin beds to remove contamination, with the result that no radioactive liquids needed to be disposed of. The resulting resins or filters are solidified and disposed of as dry wastes.

All inspection, surveillance, and test activities conducted on radioactive systems or in radiation areas were also assumed to generate radioactive wastes. For such activities, compactible DAW was assumed to be generated at the rate of 0.0113 m^3 (0.4 ft^3) per craft or unskilled worker labor hour (as-generated volume). This generation rate represents a rough average of waste production based on experience with both major replacement activities and with more routine SMITTR activities. These wastes result from the laundering and disposal of anti-contamination clothing and other protective equipment, from plastic sheeting used to restrict the spread of airborne contamination, and from the use of other such materials.

Some site labor must be expended in handling and processing the wastes generated by the activities performed in support of license renewal. In addition, some incremental radiation exposure will be incurred by those workers handling these wastes. The current assessment estimated the labor using the following rates:

Noncompactible DAW	10.6 h/m^3 (0.3 h/ft^3)
Compactible DAW	17.7 h/m^3 (0.5 h/ft^3)

These rates apply to the as-generated volumes of wastes. Similarly, radiation exposure incurred in the in-plant handling of radioactive wastes was estimated using a rate of 0.0012 person-rem per cubic foot of waste in the as-shipped form, and this rate applies to both compactible and noncompactible types of waste. (These rates were obtained from NUREG/CR-4627).

At least some of the waste processing activities can occur during reactor operating periods rather than being completed during the outage times when the wastes are generated. Such processing will reduce (or at least not add to) the labor burden on-site during the outages when large work forces are needed. However, the current estimates assume that the waste handling efforts occur during the same periods that the wastes are generated. This approach adds somewhat to the conservatism of the impact production rates presented here.

B.3.2.4 Waste Disposal Cost

Costs associated with the disposal of low-level radioactive wastes generated as a result of license renewal-related activities were estimated separately for BWRs and PWRs, taking into account the projected volumes of noncompactible and compactible DAW generated by each reactor type for each license renewal program. The estimates utilized the base information developed in NUREG/CR-4555, Rev. 1. However, the costs were modified to reflect the rapid escalation in burial costs resulting from the formation of regional compacts and the likely closure or limited availability of the existing low-level waste disposal sites. The analysis performed indicated that burial costs at the regional compact sites are projected to be in the range of \$7,000 to \$16,000/m^3 (\$200 to \$450/ft^3). The current estimates used \$12,000/m^3 (\$340/ft^3) for burial. The costs associated with handling, on-site temporary storage, and transportation of the DAW were added to the burial costs. These generic estimates were based on an assumed plant-to-burial-site distance of 1,600 km (1000 miles) and the wastes were assumed to have relatively high activity levels for the purpose of estimating costs.

Steam generators replaced as part of the PWR conservative case license renewal program are contaminated and could be disposed of as low-level radioactive waste. Their volume is quite large (approximately 1,130 m^3 or 40,000 ft^3), however, and the spent units are typically stored on-site rather than buried at an approved waste disposal site. Special storage buildings have been constructed at the affected reactor sites to house the spent steam generators. The cost of the storage buildings is estimated to be about \$1 million and is included in the overall waste disposal cost estimates.

B.3.2.5 Capital Costs

Capital costs were estimated for those activities involving the application or installation of new equipment, materials, and hardware. Wherever available, the estimates were established based on recent industry experience for the addition or replacement of the items of concern. Where such cost information was not available, two other approaches were used. The first relied on NRC's generic cost estimation methods and databases (NUREG/CR-4627). This methodology draws on the Energy Economic Data Base (EEDB) developed by the U.S. Department of Energy (DOE/NE-0051/1; DOE/CR-5764). The EEDB provides estimates of both labor and material/equipment quantities and cost. This information has been developed for modern, large PWR and BWR plant designs. The EEDB presents reasonably detailed information which covers most areas of the plant, including both the nuclear steam supply system (NSSS) and the balance of plant. However, this cost base does not include any detail of the NSSS equipment or hardware capital costs. The second alternative approach to estimating capital cost where no recent industry experience was available was based on the use of detailed, actual construction cost breakdowns from a U.S. nuclear plant constructed several years ago. This cost base provided sufficient breakdown of the entire plant, including detail on the NSSS component and subcomponent cost. Where this base was used, the costs reported were escalated to 1994 dollars, and, where appropriate, the costs were adjusted to reflect size differences between this base plant and the 1000-MW(e) reference size adopted for the current estimates.

B.3.2.6 Other Costs

Two other cost elements were considered to define license renewal-related costs in a more comprehensive manner: home office costs and replacement energy costs. The home office costs account for off-site engineering and quality assurance (QA) expenditures. This category of costs accounts for the design, analysis, safety review, and documentation efforts typically associated with modifications at nuclear power plants.

Home office costs also allow for QA functions and activities carried on to support these modifications. Home office engineering and QA efforts were estimated using NRC's generic cost estimation methodology (NUREG/CR-4921). Based on surveys of a wide range of actual physical modifications made to operating nuclear power plants, this methodology has established that, on average, the engineering and QA functions typically amount to about 25 percent of the direct modification costs. This basis accounts for both on-site and off-site engineering and QA functions. The direct costs include direct (unburdened) labor as well as the cost of materials, equipment, and hardware associated with a particular modification. Because the on-site efforts were separately accounted for as described in Section B.3.2.1, estimates of the off-site work were developed using the 25 percent of direct costs approach and subtracting from this the estimate of on-site engineering costs.

Replacement energy costs can be a major contributor to overall project cost if plants remain out of service for extended periods. An assessment was made of replacement energy costs as they relate to the example license renewal programs. This evaluation reviewed the replacement energy costs per day of plant downtime (NUREG/CR-4012 1992) separately for BWRs and PWRs. Weighted averages were taken for several plants whose electrical generating capacity was nearest to 1000 MW(e). For PWRs, the daily replacement energy cost estimated on this basis was $342,000 (1994 dollars). For BWRs, this figure was estimated to be $287,000 (1994 dollars) per day. Replacement energy cost depends on several factors, including plant size, location and load pool, season, and cost fluctuations in non-nuclear alternative energy sources. However, the estimates cited here are representative of U.S. plants in the 1000-MW(e) size range.

B.4 RESULTS

This section summarizes the quantitative results developed in this evaluation. All key impact initiators are discussed, including labor, occupational radiation exposures, capital costs, radioactive waste generation, and waste disposal costs associated with the conduct of activities carried out in support of license renewal and extended plant life. This section also discusses elements of license renewal which do not necessarily contribute to environmental or socioeconomic impacts but which play important roles in assessing the overall economic viability of license renewal. These are the elements of off-site costs and replacement energy costs. Finally, this section provides a comparison of industry-developed license renewal cost estimates with those developed in this assessment. Both typical and conservative case scenario results are discussed.

B.4.1 BWR and PWR License Renewal Program Impact Initiators

As noted previously, the typical license renewal program scenarios presented herein are intended to be representative of those the majority of nuclear plants seeking license renewal might experience regarding major refurbishment and enhanced SMITTR activities needed to satisfy NRC requirements and better ensure reliable and economical plant life extension. The conservative case scenarios, on the other hand, are intended to reflect what might occur at a few outlier plants requiring much more extensive refurbishment/replacement activities than are typical of the reactor population as a whole. As such, the typical programs are estimated to have rather modest environmental impacts compared with those expected for the conservative case scenarios.

Tables B.4 and B.5 present summaries of the license renewal program impact initiator quantities for the typical and conservative case license renewal scenarios, respectively. Each table shows the quantities separately for BWRs and PWRs. Similarly, each table shows the impact quantities generated during the different plant modes. Note that the impact quantities are presented on a per-occurrence basis for refueling outages, current-term outages, and the 5-year ISI outage, each of which occurs more than once. The totals, however, reflect the summation over all occurrences of all activities performed in support of license renewal. Tables B.4 and B.5 also show the labor and costs associated with incremental activities performed during full-power plant operation. The labor hours and costs for this category represent the totals accrued over the entire period of the renewed licenses. All values shown are intended to capture only incremental effects associated with license renewal, and they exclude baseline activities which represent a continuation or evolution of current practices related to the operation and maintenance of nuclear power plants.

The types and extent of activities included in the conservative case programs, especially the extensive major replacement/refurbishment activities included and their resulting impact initiator estimates as reflected in Table B.5, are thought to reasonably bound what might be needed for any individual nuclear plant site in pursuit of license renewal and plant life extension.

The values in Tables B.4 and B.5 indicate that most of the environmental impact initiators accrue during the major refurbishment outages. For the conservative scenarios, the current-term outages also result in considerably higher levels of impact quantities being generated compared with the more routine outages. The current-term and major refurbishment outages are the periods when major replacement and refurbishment activities performed in support of license renewal and extended plant life are assumed to occur. For the conservative case scenarios, the impacts produced are primarily from activities performed to ensure that current safety and licensing bases are maintained, as well as to help ensure that plant economic and availability/reliability goals are met. Relatively few of the conservative case impacts are attributable to the enhanced aging management of SSCs important to license renewal called for by the License Renewal Rule. The rule requirements have a relatively greater impact on the typical programs, because these programs have fewer major refurbishments compared with the conservative case scenarios. The specific effects of the 10 CFR 54 rulemaking on the impact quantities are discussed in Section B.4.3.

A comparison of the figures in Tables B.4 and B.5 shows that the typical license renewal program impact initiators are on the order of 15 to 25 percent of the quantities estimated for the conservative case scenarios. Figure B.3 graphically illustrates the overall fraction of the total impacts for the typical programs relative to the conservative case scenario totals. The values shown represent a linear, composite average of the various impact category totals listed in Table B.4 relative to the totals presented in Table B.5. Thus, the conservative case scenarios are estimated to have five to six times the impact quantities of typical license renewal programs. This result is to be

Table B.4 Typical license renewal program environmental impact initiators

Outage type	Labor hours	Additional on-site personnel	Waste volumes (as-shipped) (m^3)	Occupational rad exps (person-sievert)	Waste disposal costs (1994$)[a]	Labor costs (1994$)[a]	Capital costs (1994$)[a]	Total on-site costs (1994$)[a]	Off-site costs (1994$)[a]	Total costs (1994$)[a]
Boiling-water reactors										
Full power operation (20 yrs)	0	0	0	0.00	0	0	0	0	0	0
Normal refueling[b]	4,148	10	2	0.04	23,000	196,940	215,460	435,400	47,751	483,151
5-yr ISI[c] refueling[d]	38,675	63	17	0.71	244,000	1,789,900	314,100	2,348,000	0	2,348,000
10-yr ISI refueling[e]	68,208	110	30	0.91	424,000	3,082,450	589,550	4,096,000	0	4,096,000
Current term refurbishments[f]	45,294	71	17	0.10	345,000	1,715,040	578,360	2,539,400	177,347	2,716,747
Major refurbishment outage[g]	298,375	361	69	1.53	976,000	12,585,040	57,589,360	71,150,400	13,804,688	84,955,088
Total all occurrences	660,000	—	220	4.57	3,052,000	27,700,000	62,800,000	93,600,000	14,900,000	108,500,000
Pressurized-water reactors										
Full power operation (20 yrs)	0	0	0	0.00	0	0	0	0	0	0
Normal refueling[b]	3,488	8	1	0.03	18,000	166,265	145,635	329,900	27,179	357,079
5-yr ISI refueling[d]	20,935	33	11	0.30	153,000	953,750	185,250	1,292,000	13,886	1,305,886
10-yr ISI refueling[e]	37,482	60	22	0.51	313,000	1,691,600	309,400	2,314,000	831	2,314,831
Current term refurbishments[f]	45,924	72	18	0.11	272,000	1,741,880	580,920	2,594,800	176,530	2,771,330
Major refurbishment outage[g]	219,018	264	44	0.79	1,631,000	9,108,830	49,380,970	60,120,800	12,068,028	72,188,828
Total all occurrences	510,000	—	170	2.61	3,482,000	21,000,000	53,500,000	78,000,000	13,000,000	91,000,000

[a]All cost figures are undiscounted 1994 dollars
[b]8 occurrences, 2-month duration each
[c]ISI = in-service inspection
[d]2 occurrences, 3-month duration each
[e]1 occurrence, 3-month duration
[f]4 occurrences, 3-month duration each
[g]1 occurrence, 4-month duration
Note: Multiply m^3 x 35.32 to find ft^3 Multiply person-sievert x 100 to find person-rem.

Table B.5 Conservative license renewal program environmental impact initiators

Outage type	Labor hours	Additional on-site personnel	Waste volumes (as-shipped) (m^3)	Occupational rad exps (person-sievert)	Waste disposal costs (1994\$)[a]	Labor costs (1994\$)[a]	Capital costs (1994\$)[a]	Total on-site costs (1994\$)[a]	Off-site costs (1994\$)[a]	Total costs (1994\$)[a]
Boiling-water reactors										
Full power operation (20 yrs)	49,900	1	0	0.00	0	2,089,856	0	2,089,856	0	2,089,856
Normal refueling[b]	11,352	27	5	0.10	64,182	556,407	612,043	1,232,632	131,856	1,364,488
5-yr ISI[c] refueling[d]	48,406	78	21	0.78	290,508	2,258,137	712,251	3,269,896	0	3,260,896
10-yr ISI refueling[e]	101,308	122	38	1.08	537,102	4,585,522	1,250,536	6,373,160	0	6,373,160
Current term refurbishments[f]	732,280	866	233	1.91	3,303,684	28,170,043	10,843,605	42,317,332	3,122,803	45,440,135
Major refurbishment outage[g]	1,642,760	867	814	15.61	11,525,736	73,719,268	119,968,099	205,213,104	28,546,104	233,759,207
Total all occurrences	4,910,000	—	1,900	26.66	26,372,000	202,000,000	170,900,000	399,300,000	42,100,000	441,400,000
Pressurized-water reactors										
Full power operation (22 yrs)	49,900	1	0	0.00	0	2,089,856	0	2,089,856	0	2,089,856
Normal refueling[b]	8,733	21	3	0.07	46,166	406,936	410,540	863,642	79,897	943,539
5-yr ISI refueling[d]	28,550	46	13	0.35	185,790	1,294,224	451,076	1,931,090	50,734	1,981,824
10-yr ISI refueling[e]	62,295	75	29	0.66	416,620	2,867,021	845,401	4,129,042	74,282	4,203,324
Current term refurbishments[f]	768,460	909	264	2.00	3,889,204	29,607,382	9,687,766	43,184,352	2,821,826	46,006,178
Major refurbishment outage[g]	3,241,260	1,713	1,324	13.80	20,204,944	139,806,842	110,947,895	270,959,681	26,185,773	297,145,454
Total all occurrences	6,550,000	—	2,500	23.74	36,919,300	269,000,000	154,700,000	460,700,000	38,300,000	499,000,000

[a]All cost figures are undiscounted 1994 dollars
[b]8 occurrences, 2-month duration each
[c]ISI = in-service inspection
[d]2 occurrences, 3-month duration each
[e]1 occurrence, 4-month duration
[f]4 occurrences, 4-month duration each
[g]1 occurrence, 9-month duration
Note: Multiply m^3 x 35.32 to find ft^3 Multiply person-sievert x 100 to find person-rem.

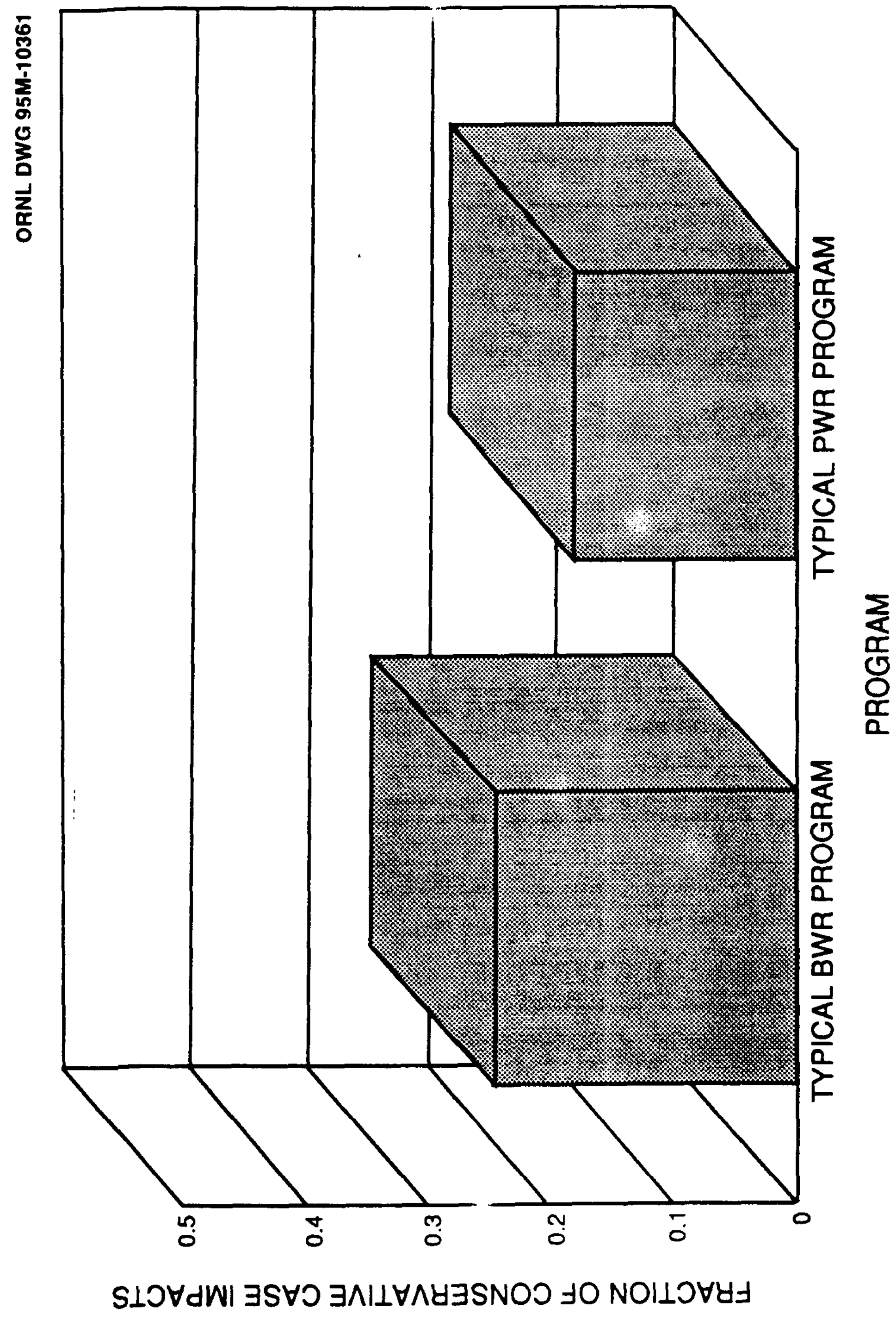

Figure B.3 Typical program impacts relative to corresponding conservative case impacts.

expected because of the extensive major refurbishment activities assumed to be undertaken by a few outlier plants represented by the conservative case scenarios.

Note that the additional on-site personnel figures cited in Tables B.4 and B.5 represent the average incremental work force sizes needed to accomplish license renewal-related activities assuming this work is uniformly spread over the entire duration of each separate outage. Peak work force sizes for each outage will be higher, as discussed in Section B.4.1.1.

B.4.1.1 Labor Hours and On-Site Staffing

The estimates of incremental labor shown in Tables B.4 and B.5 indicate that roughly 0.5 to 0.8 million labor hours could be expended for typical license renewal activities for both BWRs and PWRs, whereas the corresponding labor hour estimates for the conservative case scenarios are on the order of 5 to 7 million. These estimates include administrative, engineering, health physics, craft, and nonskilled labor. For the conservative case scenarios of Table B.5, about 95 percent of the labor hours for both BWRs and PWRs are attributable to the major activities that occur during the current-term outages and the major refurbishment outage. Thus, for the conservative case scenarios, these major activities tend to dominate the impact quantities compared with the more routine activities occurring at normal refueling and at the 5- and 10-year ISI outages. The labor values shown are greater for the conservative case PWR than for the corresponding BWR primarily because of the large amount of labor associated with the replacement of all four steam generators assumed in the reference PWR plant design.

Table B.4 indicates that the typical case BWR labor hours are about 30 percent greater than the corresponding PWR estimates. The differences here are primarily the result of a few additional SMITTR activities being performed for the BWR over the remaining life of the plant, as well as a greater number of components that are subject to these activities.

The labor hour estimates for the different license renewal scenarios are illustrated in Figure B.4.

The additional on-site personnel estimates reflect both the labor estimates and the assumed outage durations. The conservative case license renewal programs assumed that the major refurbishment outage would be 9 months long. As discussed in Section B.3.1.3, this duration appears to be reasonable. The conservative case major refurbishment outage would require about 870 additional on-site staff for the BWR and about 1700 incremental on-site personnel for the PWR to accomplish the example program aging management activities in the allotted time. As previously noted, the larger work force required for the PWR primarily results from the large effort associated with steam generator replacement. These estimates address personnel needed over and above those who would be on-site to perform normal refueling and maintenance tasks. Most of the other outages require roughly the same number of incremental on-site personnel for both reactor types. Note that for each type of outage, the staffing indicated is in all cases incremental to the staff needed to carry out current practices. Also, these estimates reflect average incremental staff assuming the work is spread uniformly over the entire outage duration.

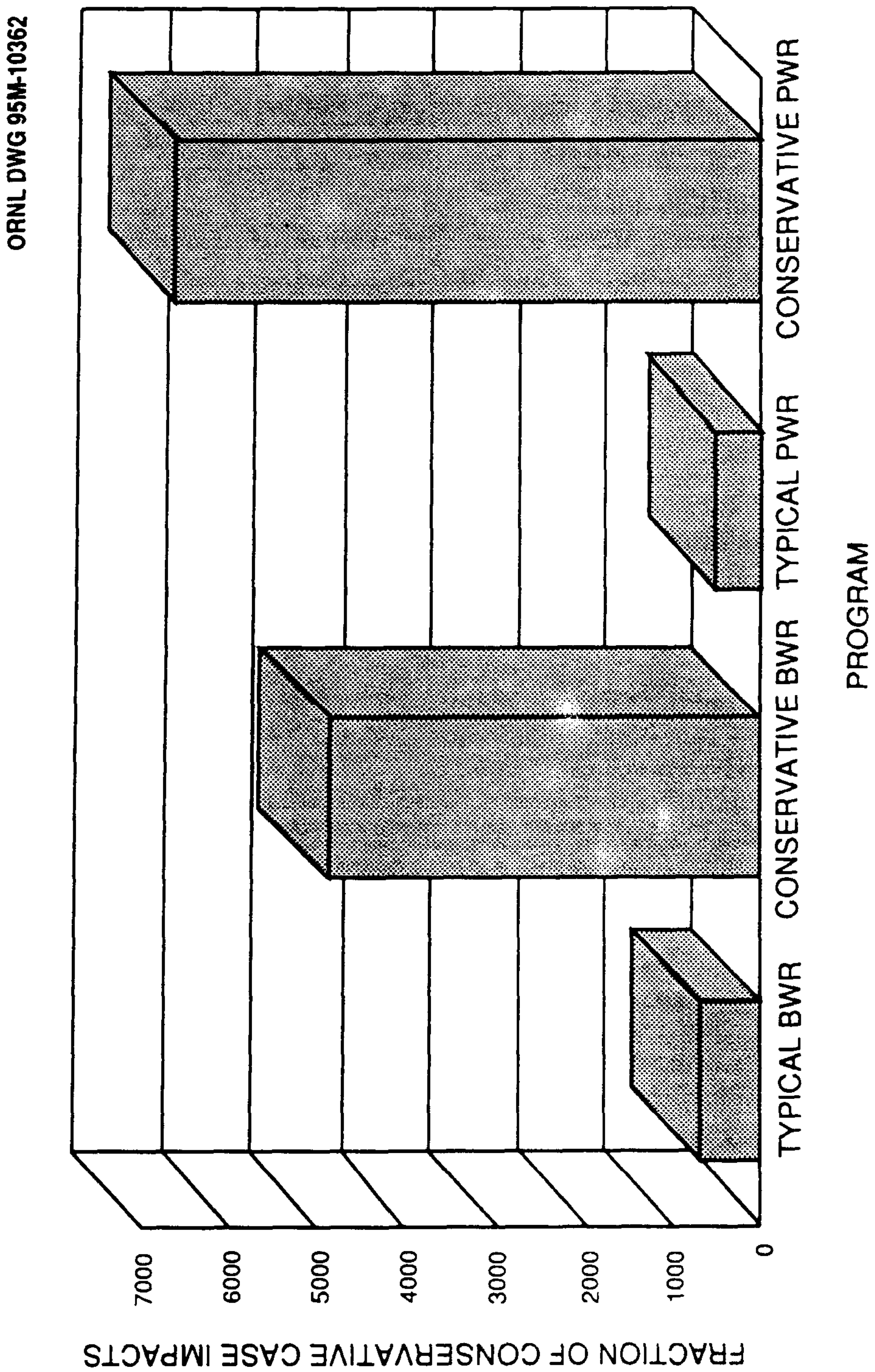

Figure B.4 Incremental labor hours.

For the typical scenarios, the incremental on-site staffing requirements are relatively modest. The largest staff increment is required for the major refurbishment outage, as this is the time when the few major refurbishment or replacement activities in these programs are assumed to be carried out.

The number of on-site personnel estimated in Tables B.4 and B.5 is not strictly proportional to the outage duration and the total labor hours expended during a given outage. This is because a 50-hour work week was assumed for craft, health physics, and nonskilled workers, whereas the engineering and administrative personnel were assumed to have a 40-hour work week. Also, the ratio of engineering and administrative hours to craft, health physics, and nonskilled worker hours varied from activity to activity.

Figure B.5 graphically indicates the highest average number of temporary workers needed to carry out license renewal-related activities for each of the four license renewal scenarios. This figure shows the largest requirement for each scenario as identified in Tables B.4 and B.5. Note that all estimates of incremental on-site personnel displayed in Tables B.4 and B.5, and in Figure B.5, were arrived at assuming level staffing for the entire duration of a given outage.

The extent of certain socioeconomic impacts such as housing will depend on peak numbers of personnel on-site rather than on the average numbers employed over a given outage. Therefore, additional analyses were performed to define probable staffing profiles throughout the major outages. Because the outages of interest would also include defueling/refueling and work typically conducted during present-day outages (e.g., ISIs, routine maintenance), the temporary workers needed to accomplish these routine activities must also be considered in estimating peak work force sizes. Table 2.4 of Chapter 2 noted that, based on a recent industry survey, there are typically 750 to 800 additional workers on-site at a nuclear plant during routine planned outages. The assumption was made that these workers are needed for a period of 2 months per outage. Therefore, these more routine efforts performed by temporary workers add up to a total of about 1600 person-months of effort. This effort needed to accomplish more routine outage activities was added to the license renewal-related labor efforts identified in Tables B.4 and B.5 to arrive at estimates of peak work force sizes.

Figures B.6 through B.9 present monthly projections of temporary worker staffing needed to carry out both license renewal activities and routine refueling, and ISTM activities. The most limiting cases are shown for each license renewal scenario. Figure B.6 shows the projected number of temporary personnel needed during the major refurbishment outage for the conservative PWR license renewal scenario. This outage was assumed to require 9 months. The monthly staffing needs were arrived at by developing a schedule for carrying out each of the different activities to be accomplished during this outage. These schedules were similar to those presented in Figures B.1 and B.2, but they were more complete in that all activities slated for the outage of interest were included. An effort was made to average out the work force over the entire outage duration to the extent possible. However, considerable peaking does occur because not all activities can proceed simultaneously. Figure B.6 separately identifies temporary personnel needed to accomplish license renewal activities versus those needed for more routine outage

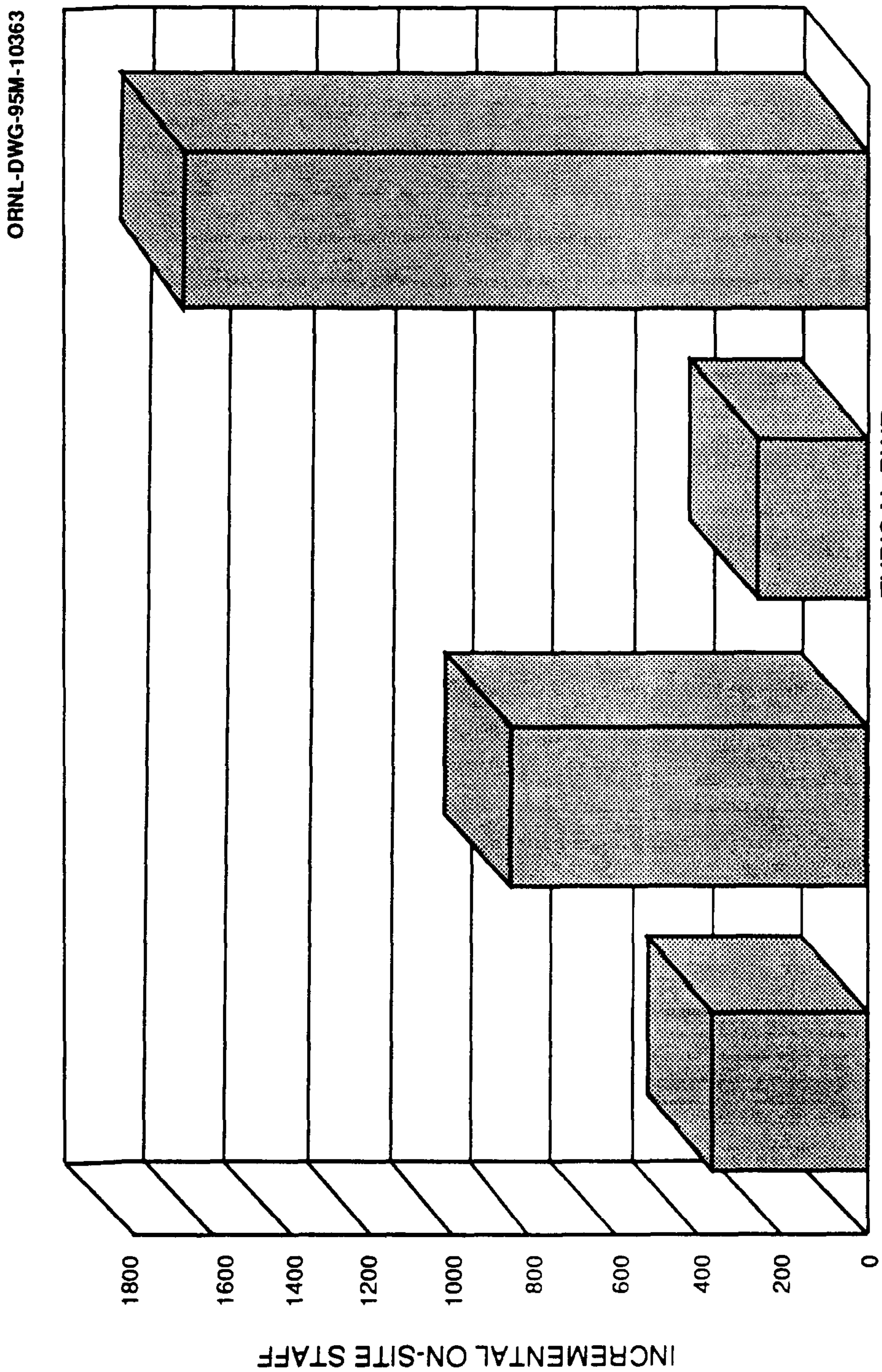

Figure B.5 Outage average incremental on-site staff.

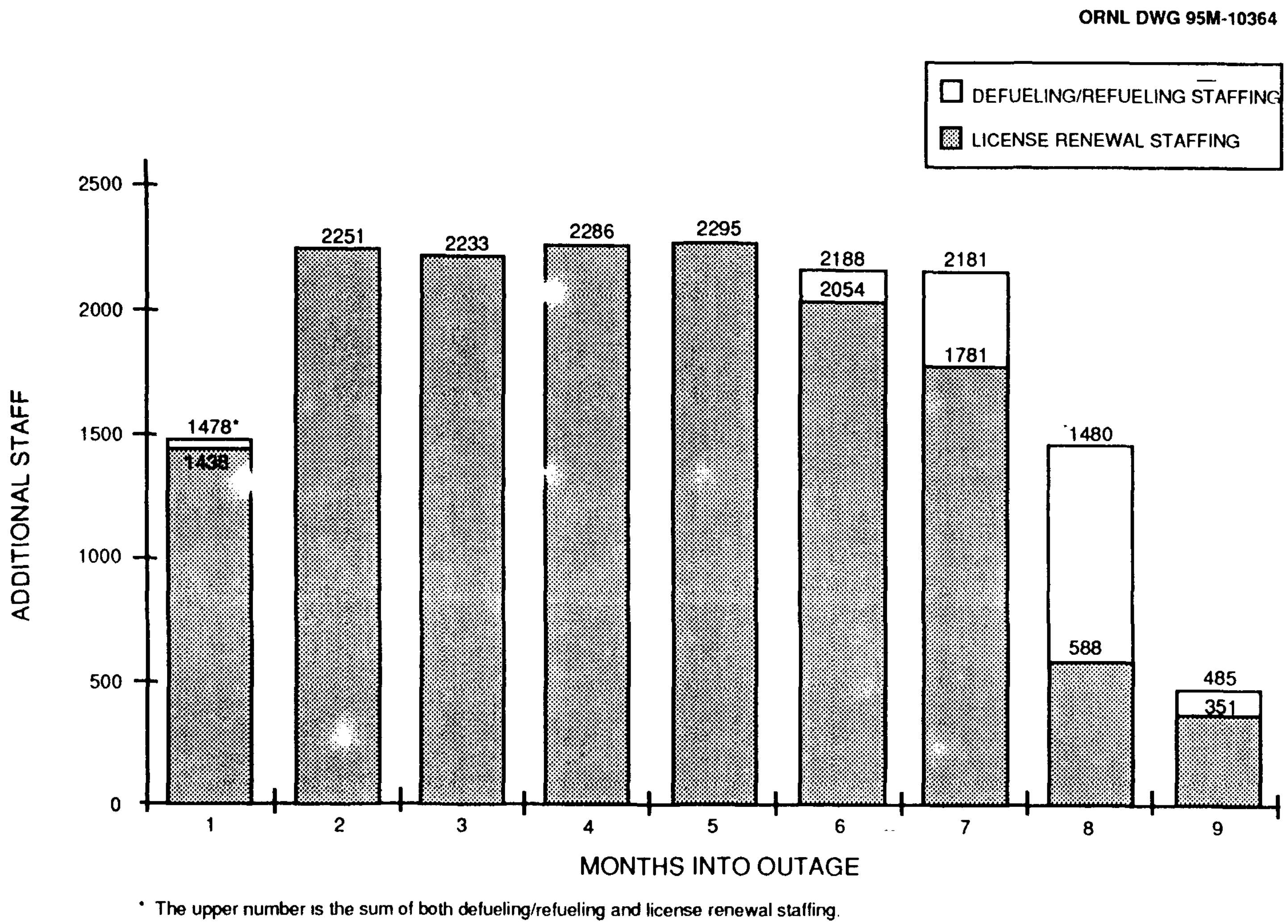

Figure B.6 Additional personnel required to perform conservative case pressurized-water reactor license renewal major refurbishment outage activities.

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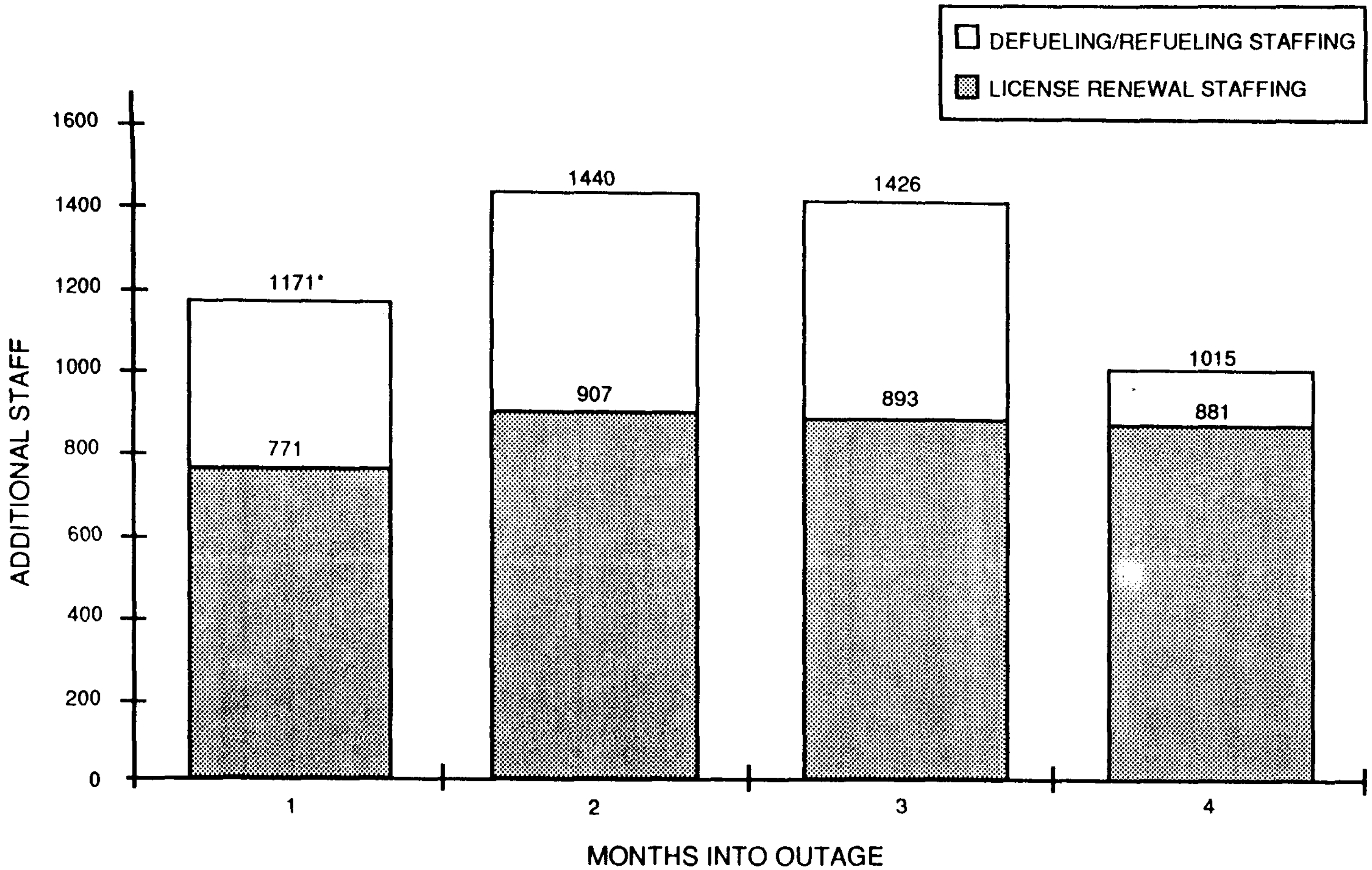

* The upper number is the sum of both defueling/refueling and license renewal staffing.

Figure B.7 Additional personnel required to perform conservative case boiling-water reactor license renewal current-term outage activities.

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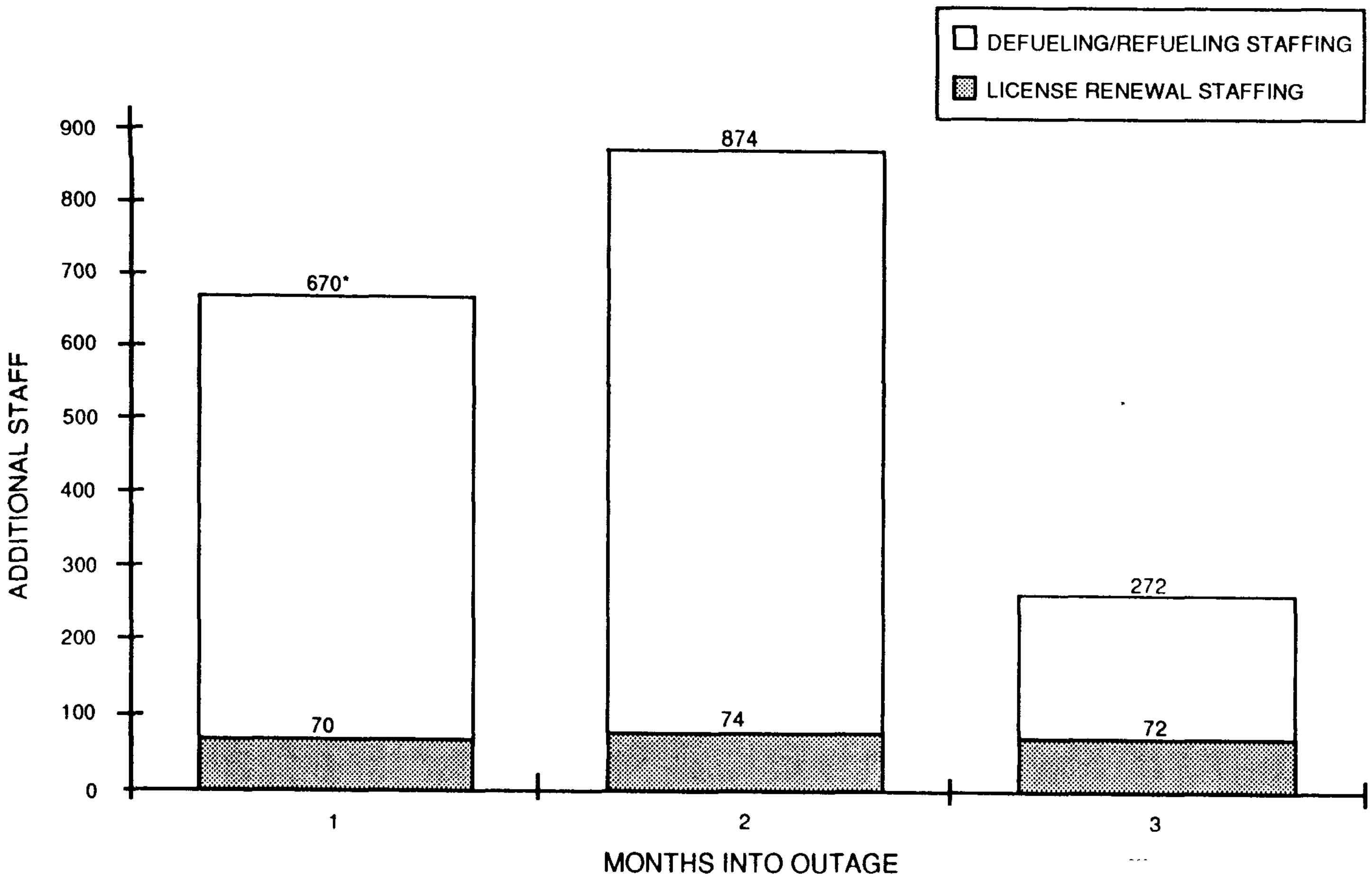

* The upper number is the sum of both defueling/refueling and license renewal staffing.

Figure B.8 Additional personnel required to perform typical case pressurized-water reactor license renewal current-term outage activities.

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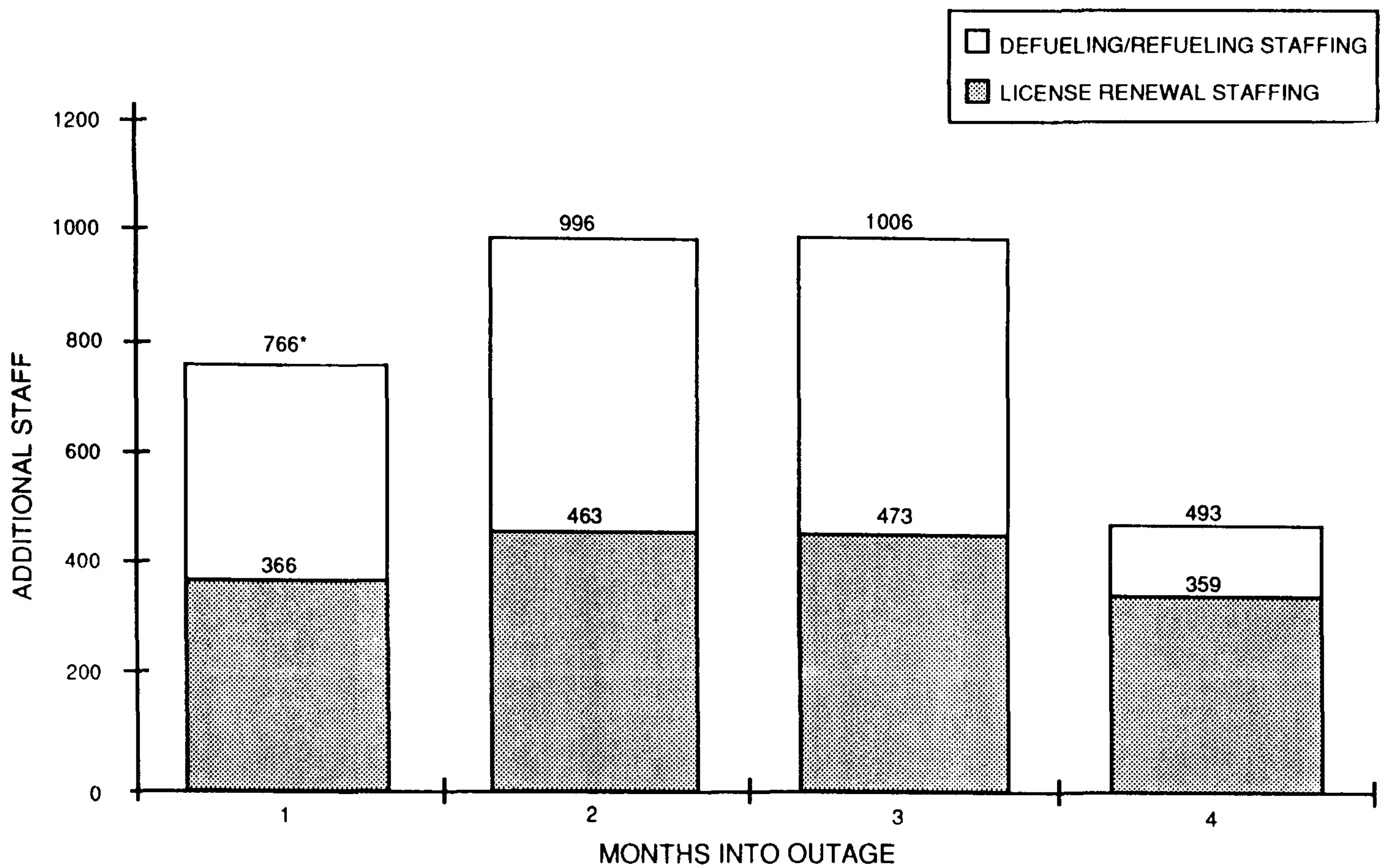

* The upper number is the sum of both defueling/refueling and license renewal staffing.

Figure B.9 Additional personnel required to perform typical case boiling-water reactor license renewal major refurbishment activities.

activities. The upper figures on the bars in Figure B.6 represent the total number of temporary workers needed during each particular month of the outage; the lower figure, where present, is the number needed to accomplish the incremental license renewal-related activities only. Based on this projection, the temporary work force needed during the major refurbishment outage for the conservative PWR license renewal scenario is estimated to be about 2300. This contrasts with the 1700 additional workers averaged over the entire outage as identified in Table B.5, which excluded consideration of the work force needed to carry out refueling and other routine activities. The month-to-month temporary staffing needs presented in Figure B.6 are by no means optimized, but they do indicate that the peak numbers of workers considerably exceeds estimates based on averages over the entire outage duration.

Figure B.7 presents estimates of peak temporary worker staffing needs for the BWR conservative license renewal scenario. In this case, the highest staffing needs are projected to occur during the current-term outages rather than during the major refurbishment outage. This is the most limiting BWR outage, because although the number of temporary workers on-site needed to accomplish incremental license renewal-related activities was about equal for both the current-term outage and the major refurbishment outage (see Table B.5), the 1600 person-months of effort needed for refueling and routine outage tasks must be accomplished in a 4-month period rather than a 9-month period, giving a greater overall total for the current-term outages. The projections in Figure B.7 indicate that the peak temporary work force needed for this BWR license renewal scenario is 1440 personnel.

Temporary worker needs for the typical license renewal scenarios are shown in Figures B.8 and B.9 for PWRs and BWRs, respectively. The peak staffing needs for the PWR occur during the 3-month current-term outage. In this scenario, the number of temporary workers needed during this outage to accomplish incremental license renewal-related activities is very modest, and the majority of the temporary staff would be needed to carry out refueling and more routine outage activities. The peak staffing needs are only about one-third of those needed for the conservative PWR license renewal scenario. Figure B.9 for the typical BWR license renewal scenario indicates that slightly more than 1000 temporary workers would be needed during the peak period of the major refurbishment outage. This is the most limiting outage staffing need for the typical BWR case.

B.4.1.2 Radioactive Waste Volumes

The waste volumes shown in Tables B.4 and B.5 include all types of low-level radioactive waste generated as a result of incremental license renewal and plant life extension activities. The volumes are those which remain after the wastes have been processed for storage or burial, and they include the volume of the burial or storage containers. The compactible waste items are assumed to undergo volume reduction. An average VRF of about 10 was used. This VRF is consistent with the use of currently available supercompactor technology. Even higher VRFs are achievable with incineration techniques, but these were not assumed here to preserve the conservative nature of the overall estimates. The noncompactible items of waste, on the other hand, are assumed to require a burial or storage volume which is about 20 percent greater than the initial volume of the solid article resulting from less-than-perfect packing factors associated with this type of waste.

Table B.4 indicates that the typical case BWR scenario is estimated to produce about 226 m^3 (8000 ft^3) of low-level radioactive waste as a result of license renewal-related activities. The corresponding volume for the PWR is about 170 m^3 (6000 ft^3). The greater volume for the BWR is because of the slightly greater number of SMITTR activities and the greater number of SSCs subject to these activities compared with the PWR. In addition, activities on turbine plant equipment for the BWR generate radioactive waste, whereas similar activities for the PWR do not.

The considerably larger volume of waste noted in Table B.5 for the PWR conservative case compared to the BWR conservative case is almost solely due to the effects of steam generator replacement in the PWR. These very large items contribute about 1,130 m^3 (40,000 ft^3) to the total PWR waste volume, and there are no comparable items in the BWR. The steam generators that have been removed to date from operating reactors have typically been stored on-site in special facilities constructed for that purpose rather than being disposed of at licensed burial facilities.

Total waste generation quantities are illustrated in Figure B.10 for both the typical and conservative case scenarios for each plant type. The example license renewal programs generated small amounts of GTCC wastes. These wastes are neutron-activated materials removed from the reactor vessels and/or reactor internals. The estimated amounts for the typical scenarios are 28 m^3 (1000 ft^3) for BWRs and 14 m^3 (500 ft^3) for PWRs, and for the conservative case scenarios about 44 m^3 (1540 ft^3) for BWRs and 14 m^3 (500 ft^3) for PWRs. These GTCC wastes were not included in the volumes cited in Tables B.4 or B.5. They are assumed to be retained on-site rather than shipped off-site for burial.

B.4.1.3 Occupational Radiation Exposure

Figure B.11 displays the estimates of incremental occupational radiation exposure incurred in carrying out license renewal activities. As shown in Figure B.11 and as indicated in Tables B.4 and B.5, incremental radiation exposure is projected to be on the order of 250 to 450 person-rem for the typical case scenarios and about 2500 person-rem for both reactor types for the conservative case scenarios. Because current average annual exposures for U. S. nuclear power plants are about 500 person-rem, the license renewal-related incremental occupational exposure for the typical scenarios represents the equivalent of about one additional year of operation. Given a 20-year incremental operating period, the license renewal-related activities appear to add about 5 percent to the cumulative exposure that would otherwise be expected over that period of extended plant life. For the conservative case scenarios of Table B.5, the estimated incremental exposure of roughly 2500 person-rem represents about five times the currently experienced annual exposure. However, the estimates from the conservative case license renewal programs are highly conservative because they encompass a greater variety and extent of activities than is expected from most plants pursuing license renewal. The largest fraction of the radiation exposure is expected to accrue from the major refurbishment activities for both reactor types. The bulk of the exposure is estimated to occur during the major refurbishment outage, and to a lesser extent during the current-term outages. The BWRs are expected to incur somewhat greater

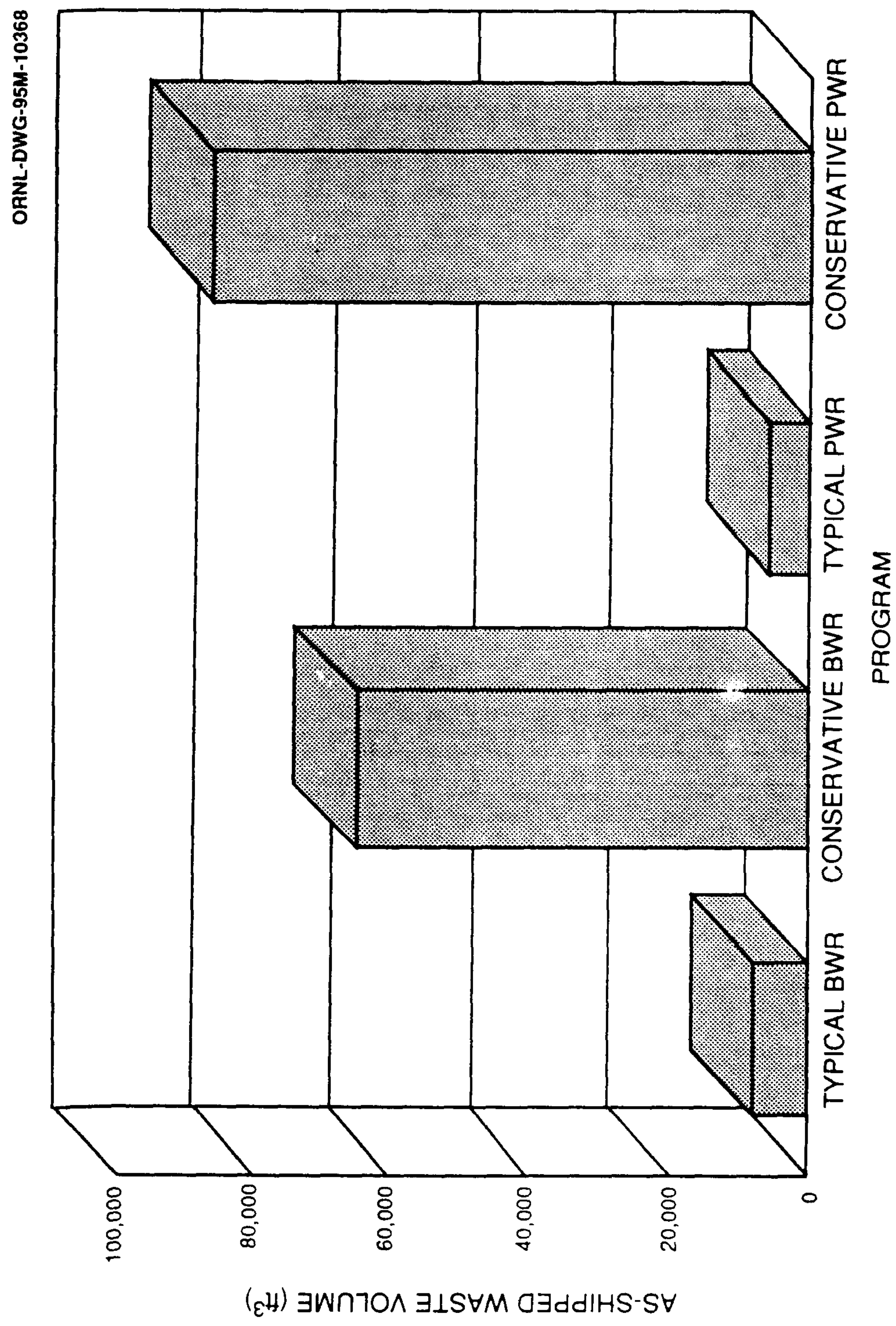

Figure B.10 Incremental low-level waste generated.

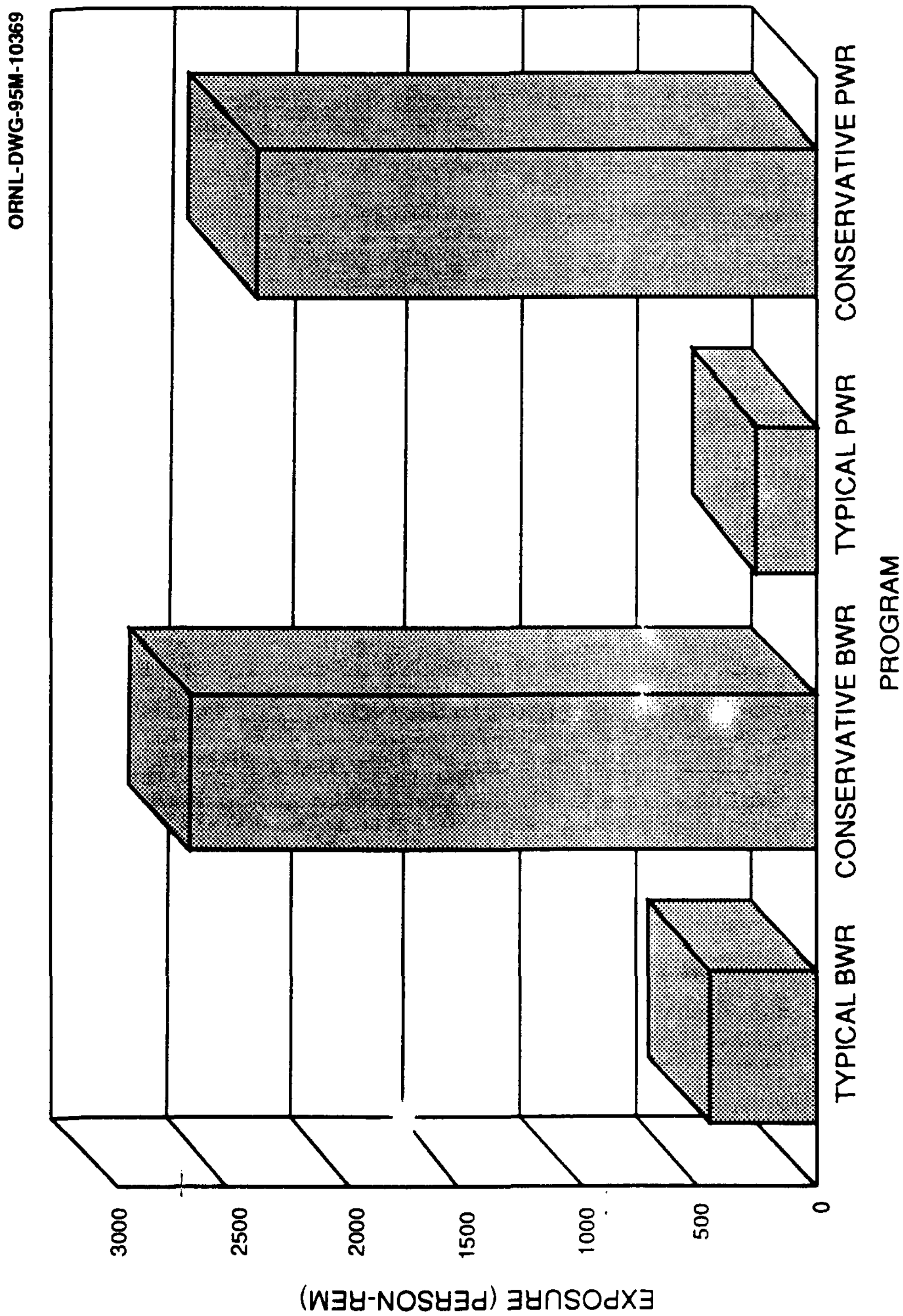

Figure B.11 Incremental occupational radiation exposure.

occupational radiation exposures than are the PWRs.

B.4.1.4 Waste Disposal Costs

The costs for disposing of low-level radioactive wastes generated as a result of license renewal-related activities are estimated to be about $3 million for the typical case scenarios and about $26 million to $37 million for the conservative case scenarios. Relative to the total costs associated with license renewal activities, these costs represent about 3 to 4 percent of the totals. As noted in Section B.3.2.4, waste disposal costs include charges for waste handling and packaging, short-term on-site storage, transportation, and burial. For the PWR conservative case scenario, the spent steam generators are assumed to be stored on-site rather than sent to an approved burial site for permanent disposal.

A cost of roughly $1 million has been assumed for the on-site steam generator storage facility, and this cost has been added to the overall waste disposal cost for the conservative case PWR. Waste disposal costs are graphically displayed in Figure B.12.

B.4.1.5 Capital Costs and On-Site Labor Costs

In addition to waste disposal costs, Tables B.4 and B.5 display labor costs and capital costs (costs associated with the purchase of materials, equipment, and hardware). The labor costs include those attributable to all categories of on-site labor, including administrative, engineering, craft, unskilled, and health physics. The costs are based on wage rates appropriate to each labor category and the labor mix as discussed in previous sections.

The values in Table B.4 indicate that, for the typical cases, capital costs are roughly twice the labor costs. Total on-site (labor plus capital) costs are estimated to be about $90 million for the typical BWR and about $80 million for the typical PWR. The higher costs for the BWR are consistent with the greater number of incremental SMITTR activities and greater number of SSCs included in the BWR program.

For the conservative case results displayed in Table B.5, the trends of capital versus labor costs are essentially reversed. That is, labor costs are higher than the capital costs for both reactor types. This relatively higher labor cost is attributable to the fact that many of the major refurbishment/replacement activities of the conservative cases involve radioactive SSCs and work in radiation zones. Work in radiation zones is less productive than work in nonradiation zones, and relatively more labor hours must be expended to accomplish a given activity. Capital costs, on the other hand, are essentially independent of whether the equipment or materials involved are in radiation zones. The combined labor and capital costs for the conservative case are estimated to be about $400 million for the BWR and about $460 million for the PWR. The higher costs for the PWR are primarily due to the large labor cost associated with steam generator replacement.

Labor and capital costs for both the typical and conservative case license renewal scenarios are illustrated in Figure B.13.

B.4.1.6 Off-Site Labor Costs

Off-site engineering and QA work are estimated to cost about $13 million–$15 million for the typical cases and about $38 million–$42 million for the conservative case scenarios. These are the off-site costs in this

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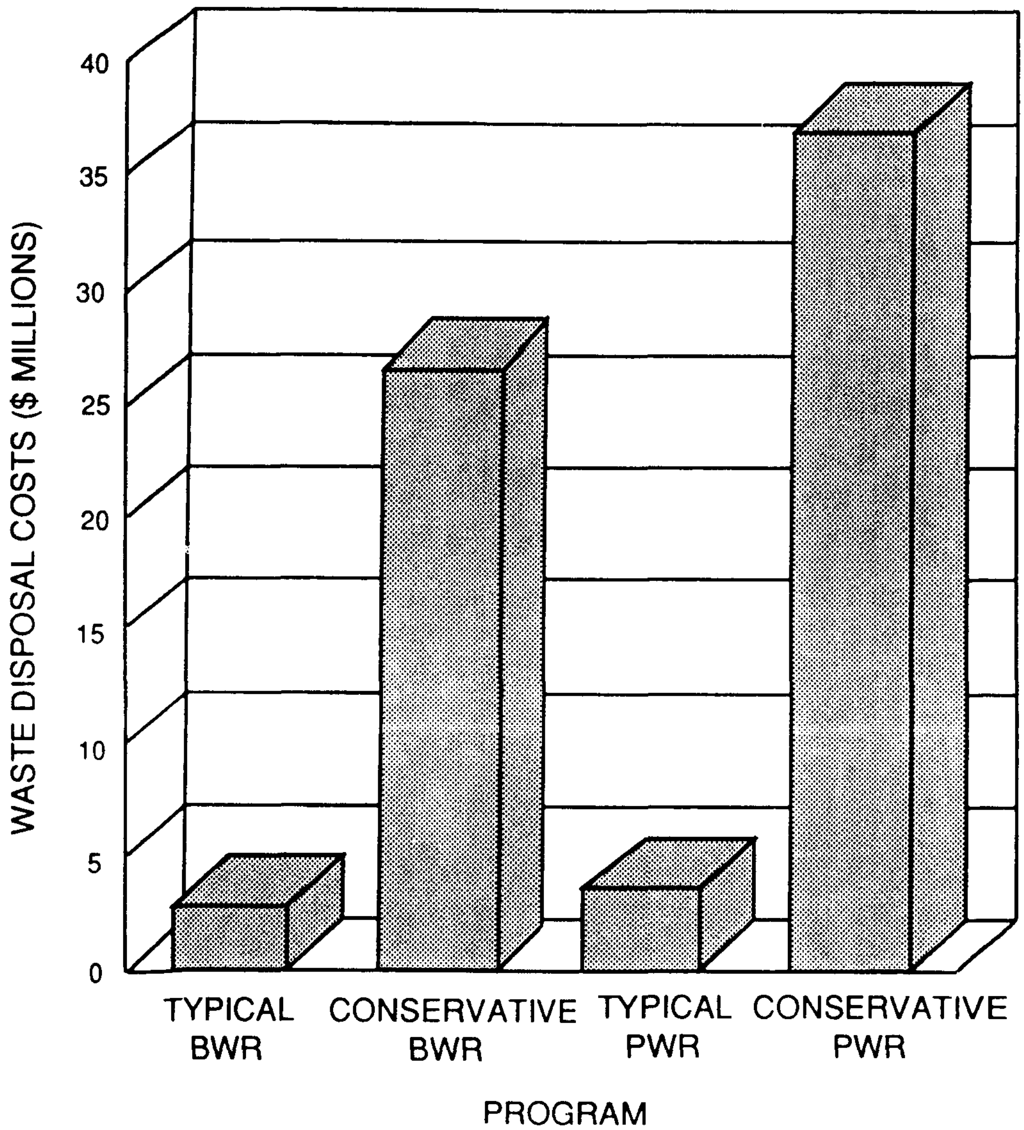

Figure B.12 Incremental waste disposal costs.

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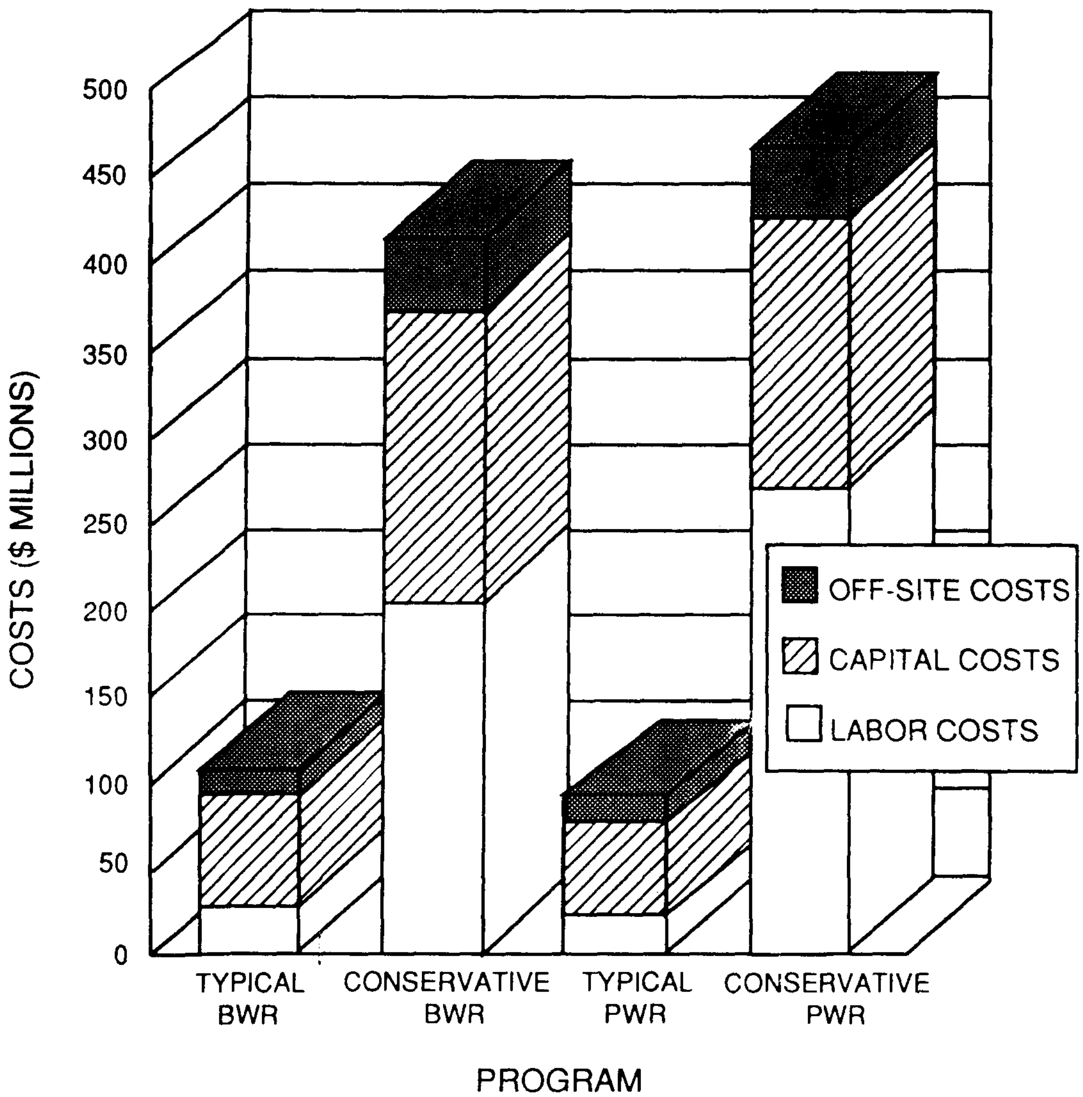

Figure B.13 Incremental capital and labor costs.

category carried out in support of the SMITTR and refurbishment activities. Off-site labor costs are depicted in Figure B.13.

B.4.1.7 Total Costs

All costs shown in Tables B.4 and B.5 are in 1994 dollars. They also are presented as "overnight" (undiscounted) costs. That is, they represent costs as if all activities of each program were performed in a very short period of time rather than being spread over approximately 28 years as is envisioned for the actual scenarios. Time-value-of-money effects are not included in Tables B.4 or B.5, and no allowance has been included for costs of financing during the construction/refurbishment stages. Also, replacement energy costs are excluded from the figures presented in these tables. Those costs are discussed below.

Table B.4 indicates that the total program costs for the typical BWR are estimated to be about $110 million, and the corresponding PWR costs are about $90 million. Based on a 1000-MW(e) reference plant size, these estimates indicate license renewal-related costs of roughly $100/KW(e) for the typical renewal cases. Table B.5 indicates that the conservative case program costs are estimated to be in the range of $440 million to $500 million, with corresponding unit costs between $440/KW(e) and $500/KW(e).

B.4.1.8 Replacement Energy Costs

Replacement energy costs were estimated based on a rate of $290,000 per day of plant downtime for BWRs and $340,000 per day for PWRs (NUREG/CR-4012 1992). The typical BWR and PWR license renewal programs have a cumulative incremental downtime of 5 months, whereas for the conservative case scenarios the incremental downtime is estimated to be about [illegible] months. This is the time required to accomplish the SMITTR and major refurbishment activities making up the programs. Cumulative downtime costs, therefore, are estimated to be about $44 million for BWRs and $52 million for PWRs for the typical scenarios and about $130 million to $155 million per plant for BWRs and PWRs, respectively, for the conservative case scenarios (overnight costs).

Figure B.14 illustrates the total estimated license renewal-related costs previously discussed, including replacement energy costs. This figure indicates the relative magnitude of the major cost components.

B.4.1.9 Local Purchases

Of the capital costs reported in Tables B.4 and B.5, a small fraction may possibly be spent locally. Items such as concrete, rebar, formwork, certain electrical wire and cables, and similar materials could conceivably be purchased from local suppliers in the vicinity of nuclear plants. The cost of these items used here for the typical programs was estimated to be less than $1 million for each plant type, and possibly about $5 million total for each conservative case scenario. These purchases occur for activities performed during the current-term outages and the major refurbishment outage.

B.4.2 Comparisons to Industry Costs for Plant Life Extension

The nuclear power industry, the U. S. Department of Energy, and other entities have evaluated the benefits and costs of nuclear plant life extension. They have estimated both the likely costs associated with plant life extension and the break-even costs. The break-even costs indicate the point at which nuclear plant life extension is

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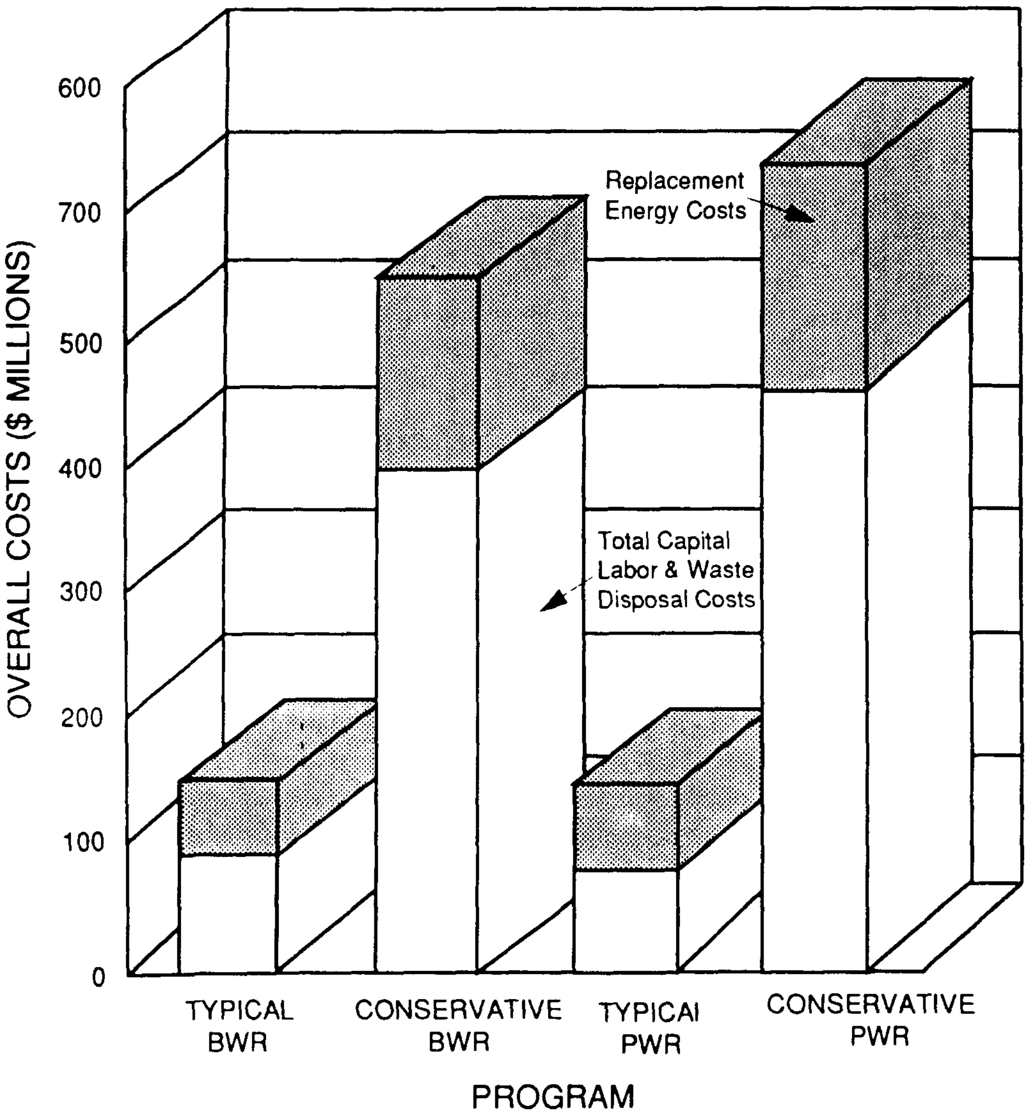

Figure B.14 Total license renewal costs.

as costly as would be the construction of alternative power sources such as a new coal plant or a new nuclear plant.

Table B.6 compares the costs of license renewal and extended plant life developed for the GEIS with estimates prepared by industry. The table includes both typical and conservative case estimates. The GEIS estimates as presented in the table are all given on an overnight basis (i.e., both financing costs and present-worth effects have been excluded from the figures). The GEIS estimates include all cost elements presented in Tables B.4 and B.5, and they include replacement energy costs as well. These are shown separately for BWRs and PWRs. Table B.6 indicates that the GEIS estimates for plant lift extension costs range from about $150 million to $570 million for the BWR typical and conservative case license renewal programs, respectively, and about $140 million to $650 million for the corresponding PWR programs. On a dollar per kilowatt basis, and based on the reference 1000-MW(e) plant size, these costs are in the range of $140 to $150/kw for the typical scenarios and from about $570 to $650/kw for the conservative case scenarios. The available industry estimates for plant life extension are shown in Table B.6 in dollars per kilowatt (SAND88-7095 1988; McCutchan 1988). They range from about $230/kw to almost $700/kw. The GEIS estimates fall roughly within the range developed by the industry sources. The typical case scenarios fall somewhat below the industry estimates, whereas the conservative case estimates are at the higher end of the industry estimates.

B.4.3 Other Impacts and Considerations

This section briefly discusses two aspects related to license renewal program costs. These are the time-value-of-money effects (present worth) and the portions of the programs directly attributable to meeting the new aging management requirements imposed by 10 CFR Part 54, Rules for Nuclear Plant License Renewal.

B.4.3.1 Present Worth Considerations

The estimates presented in Tables B.4, B.5, and B.6 were given on an "overnight" cost basis, and did not account for the fact that the expenditures are spread out in time over a considerable period. Table B.7 shows the effects of considering the time-value-of-money on the total program costs. Present value program costs are shown for three discount rates: 0 percent, 5 percent, and 10 percent. All costs are given in 1994 dollars. The datum time used to develop the values in Table B.7 is a representative point in a program at which a licensee would submit the application for license renewal to the NRC. As was shown in Figure 2.3 of Chapter 2, this point is assumed to occur 12 years before the expiration of the initial 40-year license period, and is 32 years before the end of plant life, assuming a total plant life of 60 years. The figures shown for the 0 percent discount rate are the same as those presented in Tables B.4, B.5, and B.6, and they include off-site labor costs and replacement energy costs.

The example license renewal programs incurred the major portion of the costs in the first 12 years following the submittal of a license renewal application. This is the period when major refurbishment/replacement activities are assumed to take place. In spite of the fact that these expenditures are not assumed to occur further out in time relative to the datum time point used, discounting does significantly reduce the effective cost of the license renewal programs.

Table B.6 Comparisons of industry plant life extension cost estimates (all costs in millions of 1994 dollars)

	PWR[a]		BWR[b]	
	Conservative	Typical	Conservative	Typical
GEIS estimates (million dollars)				
On-site labor cost	269	21	202	28
Capital costs	155	54	171	63
Total on-site costs	461	78	399	92
Off-site labor	38	13	42	15
Incremental replacement energy costs[c]	155	52	132	44
Total estimated costs	**654**	**143**	**573**	**151**
$/kw	654	143	573	151
Industry estimates ($/kw)[d]				
Monticello				634
General Electric				230
Surry		1331		
Westinghouse		698		

[a]PWR = pressurized-water reactor
[b]BWR = boiling-water reactor
[c]@$287,000 per day (BWR) or $342,000 per day (PWR)
[d]SAND88-7095, escalated to 1994 dollars

Table B.7 Time-value-of-money effects on nuclear plant license renewal program costs

	Program costs (million dollars)			
	PWR[a]		BWR[b]	
Discount rate (%)	Conservative	Typical	Conservative	Typical
0	694	183	605	186
5	436	107	381	107
10	291	68	256	67

[a]PWR = pressurized-water reactor
[b]BWR = boiling-water reactor

B.4.3.2 10 CFR Part 54 Impacts

Certain of the aging management activities making up the example programs used here are incremental requirements called for by 10 CFR Part 54. The example list of activities assumed attributable to the Part 54 rule are identified in Table B.8, and they represent a subset of those presented in Tables B.1 and B.2. The list of activities in Table B.8 was derived from the 10 CFR Part 54 Regulatory Analysis (NUREG/CR-1362) and from evaluations of the actions contemplated for the lead plant programs (Sciacca January 3, 1993; January 13, 1993). Other interpretations of these sources could yield different results. However, the example lists of activities presented in Table B.8 are thought to be reasonably representative of what might be needed to satisfy the requirements of the license renewal rule. This list is adequate for estimating impacts attributable to 10 CFR Part 54.

Many of the activity descriptions in Table B.8 are presented on a per-SSC basis, but the total program includes many repetitions of each activity to cover multiple similar SSCs as well as repeat actions on the same SSC. The activities listed are all SMITTR actions, as opposed to major refurbishment activities. Also, these actions address only those SSCs which are important to license renewal, and the Part 54 impacts exclude actions likely to be taken by licensees solely for economic and plant availability purposes.

Table B.9 presents estimates of the impact initiators attributable to the enhanced aging management activities called for by 10 CFR Part 54. The figures indicate that the impacts attributable to the Part 54 rule are only a small fraction of the conservative values shown in Tables B.4 and B.5. The costs shown in Table B.9 represent overnight costs, and do not reflect any discounting for expenditures incurred over the 30 or more years assumed for the conduct of the subject activities.

The capital costs reflect the addition of new or enhanced monitoring and surveillance systems and equipment, as well as the costs of replacement hardware for SSCs

Table B.8 Example list of activities attributable to the proposed changes to 10 CFR Part 54 activities

Component	Activity
	Boiling-water reactor
Actuation	Inspect connectors and penetrations for channels
Bellows	Inspect refueling and dry well bellows assembly
Compressed air	Inspect wall thickness of tanks and piping of compressed air system
Containment	Examine fabrication welds (ultrasonic testing and visual) and base and concrete core sample (remove and replace a 6-in. square of concrete)
	Conduct enhanced inspection for entire containment structure: reinforcing steel condition, boroscopic examination of surface next to penetrations, exterior and interior concrete surfaces, ground water properties, etc.
Containment	Renew protective coating on containment structure
	Inspect suppression pool and vent system exterior
EDG[a]	Inspect wall thickness and welds of 5 percent of susceptible areas for diesel generator fuel and oil support systems for emergency diesel generator
Fuel pool	Visually inspect liner
HVAC[b]	Inspect ducting, fans and motors, flex-joints, and dampers for degradation
	Conduct ISTM[c] of HVAC of building with radiation.
Main piping	Install on-line vibration and dynamic efficiency monitoring system to monitor condition of recirculation and feedwater piping system, including piping vibration and dynamic effects measurements
NSSS[d] supports	Torque a statistical sample of component support anchor bolts
Pipe	Install humidity sensor system in main reactor building compartment or HVAC intakes for leak detection
	Add fatigue monitoring system to reactor vessel nozzles and safe ends and to key piping locations
RCB[e]	Replace containment electrical penetrations
Recirculation pump	Conduct detailed inspection (disassembly/reassembly) of pump and motor

See footnotes at end of table

Table B.8 (continued)

Component	Activity
RPV[f]	Visually assess condition of entire vessel exterior; inspect/evaluate specimen for fracture toughness and tensile strength
	Install excore neutron dosimeters near one of the predicted peak fluence locations at beltline
	Replace closure stud bolts
RPV internals	Conduct underwater inspection of core plate for IGSCC, inspect jet pump brace and safe ends, inspect shroud-to-shroud support flange and access hold cover, bolt inspection method, and ultrasonic testing of top guide
	Install an enhanced system for monitoring loose parts throughout reactor internals in accordance with proposed ASME OM-12
	Conduct ultrasonic testing of top guide in central core region for IGSCC, shroud-shroud support cylinder welds, core spray inlet tee attachment, jet pump riser elbow to thermal sleeve weld region, and jet pump diffuser-to-adapter weld joint
Structures	Conduct one-time inspection of structures, anchors, and protective coatings in spray pond, cooling tower bases, intake structure, and other pools
	Conduct enhanced inspection of entire structures: reinforcing steel condition, boroscopic examination of surface next to penetrations, exterior and interior concrete surfaces, ground water properties, etc.
	Pressurized-water reactor
Actuation	Inspect connectors and penetrations for channels
Compressed air	Inspect wall thickness of tanks and piping of compressed air system
Containment	Examine fabrication welds (ultrasonic testing and visual) and base and concrete core sample (remove and replace a 6-in. square of concrete)
	Conduct enhanced inspection of entire containment structure: reinforcing steel condition, boroscopic examination of surface next to penetrations, exterior and interior concrete surfaces, ground water properties, etc.
Containment	Renew all concrete protective coating on containment structure

See footnotes at end of table

Table B.8 (continued)

Component	Activity
EDG	Inspect wall thickness and welds of 5 percent of susceptible areas for diesel generator fuel and oil support systems EDG
Fuel pool	Visually inspect liner
HVAC	Inspect ducting, fans and motors, flex-joints, and dampers for degradation; conduct ISTM of HVAC of building with radiation
NSSS supports	Torque a statistical sample of component support anchor bolts
Pipe	Add fatigue monitoring system to reactor vessel nozzles and safe ends and to key piping locations
	Install humidity sensor system in main reactor building compartment or HVAC intakes for leak detection
RCB	Replace containment electrical penetrations
Reactor coolant pump	Conduct detailed inspection (disassembly, reassembly) of reactor coolant pump, shaft, and motor
RPV	Visually assess condition of entire vessel exterior; inspect/evaluate specimen for fracture toughness and tensile strength
	Inspect condition of dry lubricants in sliding foot area
	Replace closure stud bolts
	Install excore neutron dosimeters near one of the predicted peak fluence locations at beltline
RPV internals	Install reactor internals vibration monitoring system
	Inspect core support plate, core shroud, and top guide using visual and UT or similar methods; inspect welds and critical areas
	Install on-line loose parts monitoring system
Steam generator	Add secondary side transducers to incorporate generator into loose parts monitoring system

See footnotes at end of table

Table B.8 (continued)

Component	Activity
Structures	Conduct enhanced inspection of entire structures: reinforcing steel condition, boroscopic examination of surface next to penetrations, exterior and interior concrete surfaces, ground water properties, etc. Conduct one-time inspection of structures, anchors, and protective coatings in spray pond, cooling tower bases, intake structure, and other pools

[a]EDG = emergency diesel generator
[b]HVAC = heating, ventilating, and air conditioning
[c]ISTM = inspection, surveillance, testing, and maintenance
[d]NSSS = nuclear steam supply system
[e]RCB = reactor containment building
[f]RPV = reactor pressure vessel
[g]IGSCC = intergranular stress-cracking corrosion

Table B.9 Contributions to the license renewal environmental impact initiators from Part 54 activities

	BWR[a]	PWR[b]
Labor hours	24,000	150,000
Exposure (person-rem)	340	170
Labor cost (million 1994 dollars)	11.0	6.5
Capital cost (million 1994 dollars)	4.2	3.7
Waste volume (m^3)	105	74

[a]BWR = boiling-water reactor
[b]PWR = pressurized-water reactor

Note: Multiply person-rem by 0.01 to find sieverts.
Multiply m^3 by 35.32 to find ft^3.

on a routine basis. An example of the latter is valve internal components.

B.4.4 Consideration of Other License Renewal Programs

The current effort focused on license renewal environmental impact initiators for two generic light-water reactor types: BWRs and PWRs. The resulting estimates are believed to encompass a high percentage of the potential environmental impact initiators which may accrue as plants undertake license renewal and plant life extension activities. The estimates of environmental impacts associated with nuclear plant license renewal can be refined in a number of ways.

Because no commercial light-water reactors have yet applied for license renewal, the nature and characteristics of actual programs have yet to be fully defined. As noted previously, each plant's program is expected to be somewhat unique.

Alternative programs for license renewal and plant life extension are certainly likely, and the impacts of these alternative programs could be evaluated. Differences from the reference programs used to develop the current estimates are likely for both major refurbishment activities and SMITTR activities. The SMITTR programs used here are based on the safety-centered approach developed for the License Renewal Regulatory Analysis (Sciacca January 25, 1990; Sciacca February 20, 1990). Other ISTM programs are certainly possible, some of which may have greater impacts than those defined herein. Similarly, different major refurbishment programs can also produce significantly different environmental impacts from the representative programs used here. For example, a program could be based on a much more extensive use of ISTM, with less reliance on major refurbishment, than the programs used in the current assessments.

Although alternative programs could have been evaluated, the license renewal programs used to develop the current estimates of environmental impact initiators are believed to bound what might actually occur at most plants.

B.5 ENDNOTES

1. A discussion of the SI units used in measuring radioactivity and radiation dose is given in Appendix E, Section E.A.3.

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APPENDIX B—ATTACHMENT 1

RECENT INDUSTRY EXPERIENCE FOR MAJOR REFURBISHMENTS AND ESTIMATES FOR PLANT LIFE EXTENSION COSTS

A literature search for plant life extension and license renewal related cost information was conducted in support of the draft Generic Environmental Impact Statement published for comment in August 1991. That literature search focused on obtaining industry-derived data on inspection, surveillance, test, and maintenance (ISTM) actions and on major repair, replacement, or refurbishment actions undertaken in the past or planned in support of license renewal and plant life extension (PLEX) activities. The information collected is discussed in this attachment. Since the search was performed in 1991, all information cited dates from 1991 or earlier. The cost information has not been updated to 1994 dollars.

For each activity of interest to this evaluation (e.g., reactor pressure vessel replacement, steam generator replacement), information such as capital cost, labor, radiation exposure incurred, radioactive waste type and volume generated, and outage duration was obtained, if available. This search resulted in the identification of numerous references; however, most did not provide the needed detail on the aforementioned items. Many of the references presented overall PLEX cost in dollars per kilowatt but did not provide a breakdown of individual activities. It is important to note that most references recognized that the PLEX costs will vary significantly depending upon the reactor type and the vintage.

The following sections present information organized by specific component or topic. Following these sections is a list of references reviewed.

STEAM GENERATORS

Although several utilities have replaced their steam generators, the majority are searching for ways to extend the life of their operating steam generators, such as heat treating and sleeving to avoid the cost of replacement. In "Steam Generator Replacement at Dampierre 1, France," *Nuclear Plant Journal* May/June 1990, it is reported that a steam generator replacement at Dampierre 1, France, had a cost estimate of $106 million, including $3.5 million for three steam generators. Additionally, Rippon 1990 reported the steam generator replacement took 200,000 work hours and resulted in an exposure of 220 person-rem.

In Eckert (1987), the replacement of steam generators in a two-loop plant was estimated by Kraftwerk Union to require 2.5 months using 140,000 work hours and result in a total dose of 700 person-rem. Additionally, the planning of the steam generator replacement took 45,000 work hours.

In SAND88-7095, the replacement of steam generators is assigned a probability. This probability will be zero if the component has been replaced, or low if the component is of current design. However, older plants will have a high probability of replacement. The cost of steam generator replacement has been estimated at $20 million (1986 dollars) multiplied by the number of loops multiplied by the probability of replacement.

Item	Palisades	Turkey Point	Surry
Direct cost (million dollars)	75	102	81
Replacement power cost (million dollars)	200	124	—
Total (million dollars)	275	226	—
Outage time	2 yrs	207 days	8.5 mos

EPRI NP-2418 provides the following information on steam generator replacement or partial steam generator replacement at three plants.

For Turkey Point and Surry, the operation involved a partial replacement of the steam generators.

In EPRI NP-4208, the following table outlines steam generator replacement cost, outage time, and the collective dose.

In NYPA 1989, information was presented on worker exposure in person-rem for the steam generator replacement at Indian Point 3. For an outage which included

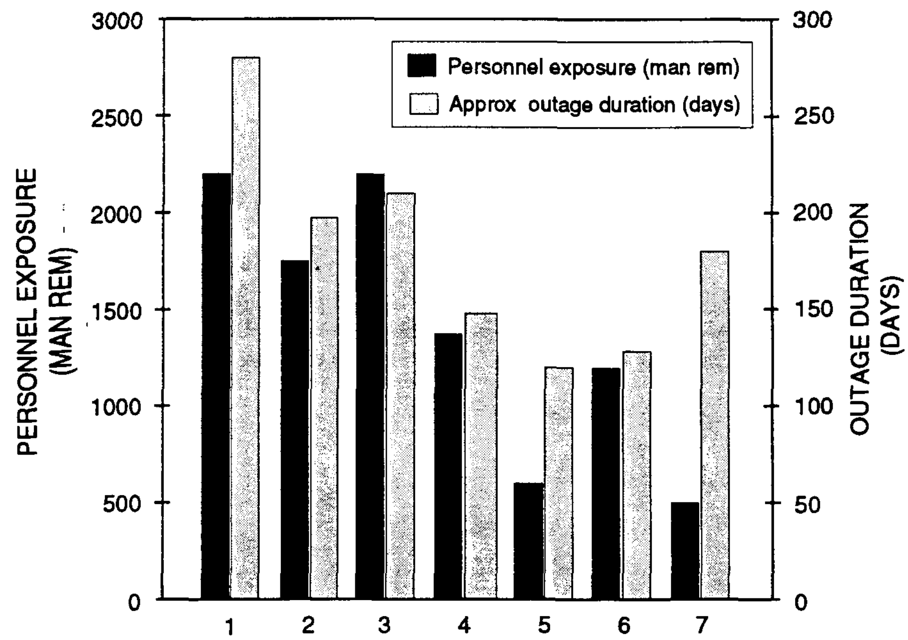
Plant	Rating [MW(e)]	Replacement year	Outage (months)	Cost (million dollars)	Collective dose (person-rem)
Surry 2	775	1979–80	10	80	2140
Surry 1	775	1980	—	—	1760
Turkey Point 3	666	1981–82	10		2150
Turkey Point 4	666	1982–83	7	190[a]	1305
Point Beach 1	497	1983–84	6	50	590
Robinson 2	665	1984–85	8	85	1207

[a]For both Turkey Point 3 and 4.

refueling and maintenance and steam generator replacement, the total dose was 852 person-rem. Of the 852 person-rem, 541 person-rem were attributed to the steam generator replacement.

Figure B-1.1 presents a comparison of seven steam generator replacement projects with respect to outage duration and personnel exposure. It was presented in Morency and McGough 1989.

ORNL-DWG 96M-2902



1. Surry 2 1979 3-loop plant
2. Surry 1 1981 3-loop plant
3. Turkey Point 3 1982 3-loop plant
4 Turkey Point 4 1982 3-loop plant
5 Point Beach 1984 2-loop plant
6. H.B. Robinson 1986 3-loop plant
7 D C. Cook 1988 4-loop plant
Outage adjusted to deduct duration of 10-year ISI

Figure B-1.1. Outage duration and personnel exposure in seven steam generator replacement projects.

Katz (1988) indicates that for steam generator replacement in a two-loop plant, the exposure in person-rem and the labor in work hours are estimated to be 1,387 and 624,000, respectively. The estimated cost for on-site storage of the steam generator is $735,000.

The cost to immediately cut up and ship the steam generator is estimated to be $20,980,000.

The following table provides information on steam generator size, weight, and storage volumes.

Plant	Length (ft)	Diameter min/max (ft)	Nozzle size (in)	Dry weight (tons)	Total storage volume (ft^3)	Portion of storage allotment[a] (%)
Plant A (4 loop)	46	10/12	29	209	37,340	56
Plant B (2 loop)	63	10.6/13/6	31	305	31,653	48
Plant C (3 loop)	63	10.6/13/6	31	305	47,470	67
Plant D (3 loop)	67.6	11.3/14/6	31	331	57,864	82

[a]The portion of storage allotment refers to allocations for the disposal of low-level radioactive wastes at existing U.S. civilian disposal sites.
Note: To convert ft to m, multiply by 0.305.
To convert in. to cm, multiply by 2.54.
To convert ft^3 to m^3, multiply by 0.03.

BWR RECIRCULATION PIPE REPLACEMENT

Eckert (1987) has estimated that the exchange of two recirculation loops and six risers will require 2.5 months, 50,000 work hours for the preplanning, and 220,000–380,000 work hours to execute the activities (including training) and will result in 500–800 person-rem of total dose.

In Zachary et al. (September 1989), the radiation exposure for BWR major pipe replacement was reported for Peach Bottom 2 and 3 and compared with other plants.

In SAND88-7095, the replacement of piping is assigned a probability. This probability will be zero if the component has been replaced, or low if the component is of current design.

Radiation exposure incurred for boiling-water major pipe replacement (person-rem)	
Peach Bottom 2	2200
Peach Bottom 3	1074
PL-A	1900
PL-B	1785
PL-C	1785
PL-D	1638
PL-E	1580

Note: To convert person-rem to person-sievert, multiply by .01.

However, older plants will have a high probability of replacement. The cost of boiling-water reactor (BWR) piping replacement costs were estimated to be $75 million multiplied by the probability of replacement. BWRs with Mark I designs probably will be more problematic to refurbish than those with Mark II or Mark III designs. A rough estimate is that refurbishment of the Mark I design will cost $25 million more than refurbishment of the Mark II or Mark III.

In EPRI NP-4208, the following table is presented which outlines BWR piping estimated replacement cost and outage time.

The costs and downtime that have been reported for BWR recirculation pipe replacements range from $19 million to $65 million and from 6 to 10 months, respectively.

According to McBrien (April 1987), during a 9-month refueling outage in 1986 at Vermont Yankee, the entire recirculation piping and part of the plant's residual heat removal system were replaced at a cost of approximately $60 million dollars. Workers at the plant acquired a total exposure of 1786 person-rem.

Plant	Rating [MW(e)]	Estimated costs (million dollars)	Estimated outage (months)
Browns Ferry	1067	42 (budget)	6
Dresden 3	794	40 (budget)	9–10
Hatch 2	806	—	6
Monticello	536	19 (budget)	6
Nine Mile Point 1	610	65	10
Pilgrim 1	670	40 (budget)	9–10

PRESSURE VESSEL COSTS AND THERMAL ANNEALING

In EPRI-4208, it is reported that a dry anneal at 850°F for 168 hours will restore most fracture toughness properties lost during irradiation embrittlement. However, this indicates that the vessel internals must be removed and a heating system installed. However, there are problems related to post-anneal behavior that need to be resolved. These include the following.

- Re-irradiation rates of embrittlement as a function of impurity and alloying element concentrations need to be better established to determine probable time effectiveness of annealing during re-irradiation.
- The vessel needs to be requalified in accordance with applicable codes and standards, including nondestructive examination of the vessel after annealing.

In EPRI NP-2418, the following reactor pressure vessel replacement information is presented. The total cost is in 1979 dollars and excludes the cost of money and replacement power. The total time of replacement is approximately 5 months.

Reactor pressure vessel replacement costs
(million dollars)

Direct costs	
Material	34
Labor ($25–35/h)	17
Indirect costs	
Occupational exposure	13
Project supervisors	17
Consultants, management ($40 h)	
Subtotal	81
Contingency (50%)	41
Total	122

In EPRI NP-4208, reactor pressure vessel replacement has been estimated to cost $100 million to $150 million (1979 dollars) and to require 2–3 years.

Abbot et al. (1988) report a cost of $20 million to $50 million for three potential tasks as outlined:

- modified/radical fuel assemblies to reduce vessel fluence,
- lower internals replacement, and
- thermal annealing of vessel.

In Lott and Mager (1984), the estimated costs for a severely embrittled reactor vessel and a moderately embrittled vessel are presented. In some circumstances it may be advantageous to anneal the vessel earlier in plant life to accrue the benefits of annealing immediately. A severely embrittled vessel is one in which the embrittlement surpasses reasonably acceptable limits. For the severely embrittled reactor vessel, if the vessel can be annealed for less than $200 million then the cost of annealing is less than the savings associated with deferring the construction of a replacement plant by 1 year. This assessment is based upon a modest replacement cost of $2 billion for the power station and an annual cost of capital of $200 million, based upon financing rates of 10 percent. The moderately embrittled vessel is one for which embrittlement is projected to exceed acceptable limits before the end of the useful life of the reactor. There is a clear savings from deferring the large costs associated with the annealing. However, if the annealing can be used to increase the plant availability, then there is a clear benefit to annealing. An analysis conducted indicates that an increase in total plant availability of 1 day is approximately equivalent to $500,000. To make performing an early anneal financially advantageous, the annual cost benefit from annealing should exceed the financing costs associated with the anneal. Assuming an interest rate of 10 percent, the plant availability would have to increase by 2 days per year to justify a $10 million expense on annealing.

NUPLEX CAPITAL COSTS AND REPLACEMENT POWER COSTS

In SAND88-7095, a range of $250–$500/kW (1986 dollars) for nuclear plant-life extension (NUPLEX) refurbishment on an overnight basis ($300–$600/kW including financing) is reported. The overnight costs for Surry Unit 1 pressurized-water reactor have been estimated at $250/kW and for the Monticello BWR the costs have been estimated at $500/kW. More recent information presented in Moore (1990), indicates that the Monticello overall cost for extending operation is estimated to be $200/kW. That same source cites $150/kW as the capital cost for the Yankee Rowe plant for running a 20-year renewal term. Westinghouse has estimated the cost of NUPLEX refurbishment as ranging from $240/kW to $900–$1000/kW based upon the amount of refurbishment needed. The higher estimate is a result of replacement of most major components and annealing of the pressure vessel.

McCutchen et al. (1988) reports a life extension program cost of $270/kW or $318 million.

Massie et al. (1985) assumed in their calculations a typical Westinghouse three-loop plant rated at 775 MW(e), with a mid-life in year 1992, and replacement power costs of $350,000/day in 1985 dollars.

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APPENDIX C

SOCIOECONOMICS

SOCIOECONOMICS

C.1 RESEARCH METHODS

The social impact assessment methods employed in this project were designed to identify the significance level of potential socioeconomic impacts during refurbishment and the license renewal term and to identify relationships between key social factors (impact predictors) and the intensity of impacts. The research methods used consisted of a literature review, a search of newspaper citations, a survey of all nuclear utilities, and seven detailed case studies.

The impact categories examined were limited primarily to those socioeconomic effects associated with project-induced employment (direct and indirect), population growth, expenditures, and tax payments. This approach is traditionally followed in preparing environmental impact statements (EISs) involving the construction and operation of nuclear power plants. The key socioeconomic topics suggested for in-depth examination by the literature search and citation review were (1) population, (2) housing, (3) taxes, (4) public services, (5) off-site land use, (6) economic structure, and (7) historic and aesthetic resources.

The following sections provide additional detail on the literature review, the review of newspaper citations, the utility survey, the seven case studies, and the techniques used to analyze the past and projected impacts associated with nuclear power plants.

C.1.1 Literature Review

The purpose of the literature review was to identify important socioeconomic issues, to obtain an industry-wide summary of the impacts that had occurred in those subject areas as a result of past nuclear plant construction and operations, and to identify possible causal factors related to those impacts. The literature review focused largely on EISs prepared for nuclear power plants at the time of their application for an operating license [Atomic Energy Commission (AEC) and U.S. Nuclear Regulatory Commission (NUREG) final environmental statements]. In addition to projecting the future impacts of plant operation, many of these documents summarize the impacts that occurred during plant construction. Along with these EISs, several detailed retrospective studies of impacts that had occurred at specific nuclear power plants were examined. Section C.2.1 provides a detailed discussion of the literature review.

C.1.2 Review of Newspaper Citations

Citations from five major metropolitan newspapers and a national wire service were examined to check the completeness of the socioeconomic impact categories suggested through the literature review. The newspapers were the *Atlanta Constitution*, the *Houston Post*, the *Los Angeles Times*, the *New York Times*, and the *Washington (D.C.) Post*. The wire service was United Press International. The search spanned 1989 and the first 5 months of 1990. Potentially relevant articles were identified through a computer database search, using the key words "nuclear power" and "nuclear power plant" in conjunction with a number of other words and phrases including "public reaction," "public concern," and "public opinion." Over 400 articles were identified through this search, although upon review, many were found to be irrelevant for this study. Overall, the traditional socioeconomic impact areas described have received little recent attention in the print media.

C.1.3 Survey of Utilities

Two written surveys of the nation's nuclear utilities were conducted. The survey instruments were designed by Oak Ridge National Laboratory (ORNL), with substantial input from the Nuclear Regulatory Commission (NRC) and the Nuclear Management and Resources Council (NUMARC). Both were administered by NUMARC.

The first survey instrument, sent to all U.S. nuclear utilities, was designed to elicit important descriptive information on plant operations. The respondents provided an industry-wide picture of current and past numbers of plant workers and of nuclear plant financial contributions to host communities. Usable data were received for some portion of these questions for 66 of the 74 nuclear plant sites nationwide.

The second survey instrument was sent to the utilities that operate the seven socioeconomic case study plants, and responses were received from all seven utilities. The purpose of these items was to gather detailed information on worker residential location, plant expenditures, and tax payments to local communities so that the causal factors related to past impacts could be identified and future impacts could be predicted.

C.1.4 Case Studies

The seven nuclear plants were chosen for detailed study as representative of all U.S. nuclear plants in terms of the socioeconomic characteristics of their host communities. The site-selection methodology and the plants chosen are described below. The case study examination was designed to provide detailed information on past impacts at a sample of nuclear power plants that represent the range of plants nationwide and to allow the projection of future impacts in key issue areas.

Detailed information was obtained on the seven case study sites through a review of EISs and site-specific NUREG reports, as well as through telephone interviews conducted with state and local officials and other expert sources. The sources were chosen for their expertise in the socioeconomic issue areas addressed (e.g., housing, land use) and included employees of local planning agencies, chambers of commerce, and economic development agencies; local tax assessors and treasurers; officials at state employment offices; and local media personnel. Nearly 300 telephone interviews were conducted at the seven case study sites. A detailed telephone protocol was used to collect data at the five sites previously studied by Mountain West Research, Inc. (NUREG/CR-2749, vols. 1, 4, 5, 7, 12), in a postlicensing study conducted for the NRC. A more exhaustive protocol was used for the two case study sites that had not been studied previously by Mountain West and for which more information was needed. Section C.7 contains the questions asked in these interview protocols.

The seven case study sites chosen represent roughly 10 percent of the U.S. nuclear power plant sites. The primary factor considered when selecting sites for socioeconomic study was the population of the area surrounding the plant. Population was chosen as the primary factor because the literature reviewed and other previous experience suggested a strong relationship between an area's remoteness and the magnitude of impacts related to population growth, employment, expenditures, and taxes. Plant age and location were also considered so that the sample includes sites representing various licensing dates, population characteristics, and geographic sections of the United States.

In considering plants for this study, preference was given to those sites for which detailed historical data about socioeconomic impacts were available. Thus, 12 plants studied by Mountain West Research, Inc. (NUREG/CR-2749), and 2 plants studied by the Electric Power Research Institute (EPRI) were considered first: Arkansas Nuclear One (ANO), Bellefonte, Calvert Cliffs, D. C. Cook, Crystal River, Diablo Canyon, Nine Mile Point, Oconee, Peach Bottom, Rancho Seco, St. Lucie, San Onofre, Surry, and Three Mile Island (TMI).

Each of these plants was classified according to the remoteness of its location, based on a classification scheme developed by Battelle Human Affairs Research Centers for Sandia National Laboratories (NUREG/CR-2239). Site remoteness involves population density in the area near the plant and the plant's distance from large cities. Battelle combined both these factors to measure "sparseness" and "proximity." Sparseness measures population density and city size within 32 km (20 miles) of the site, whereas proximity focuses on density and city size within 80 km (50 miles). Each measure involves four categories. Although Battelle expressed these categories in terms of numbers of people within 32- and 80-km (20- and 50-mile) radii, the absolute numbers were converted to the number of persons per square kilometer so that 1986 census data could be used for comparison and site selection. The sparseness and proximity measures used to classify potential case study sites are shown in Table C.1.

Three population classifications take into account the combination of the four-point sparseness and proximity scales. The three population classes are low, medium, and high population. Low corresponds to the most sparse population category and sites not in close proximity to large cities, whereas high corresponds to the least sparse population category and sites that *are* in close proximity to large cities. The bounds of each population classification are shown in Figure C.1.

Because only 1 of the 14 previously studied plants listed earlier fell into the low population category, 4 additional low-population sites were considered for inclusion in this study: Big Rock Point, Cooper, Wolf Creek, and Hatch. The Indian Point site also was added because it is located in an area with high population density and in close proximity to New York City. The applicable population classification for each of the 19 potential case study sites is shown in Table C.2.

The seven case study sites selected from those listed above were chosen to represent a broad range of population remoteness, geographic location, and plant age. The major characteristics of the plants chosen are shown in Table C.3. Their geographic distribution is illustrated in Figure C.2. All the sample plants have pressurized water reactors (PWRs), which in the bounding case scenario will require 84 percent more workers for refurbishment than will boiling water reactors (BWRs). The main analysis of potential socioeconomic impacts is based on this bounding case scenario. In the typical case scenario, the work force required to refurbish BWRs is projected to be 72 percent larger than that required for PWRs. (See Section 3.3.1.1 for details about work force projections.)

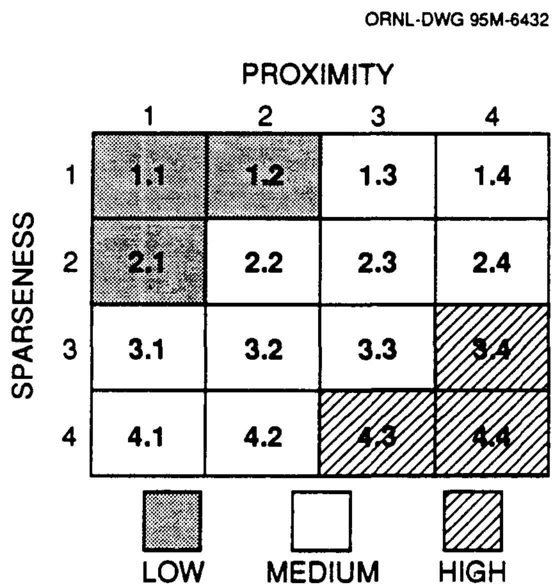

Figure C.1 Population categories, by sparseness and proximity.

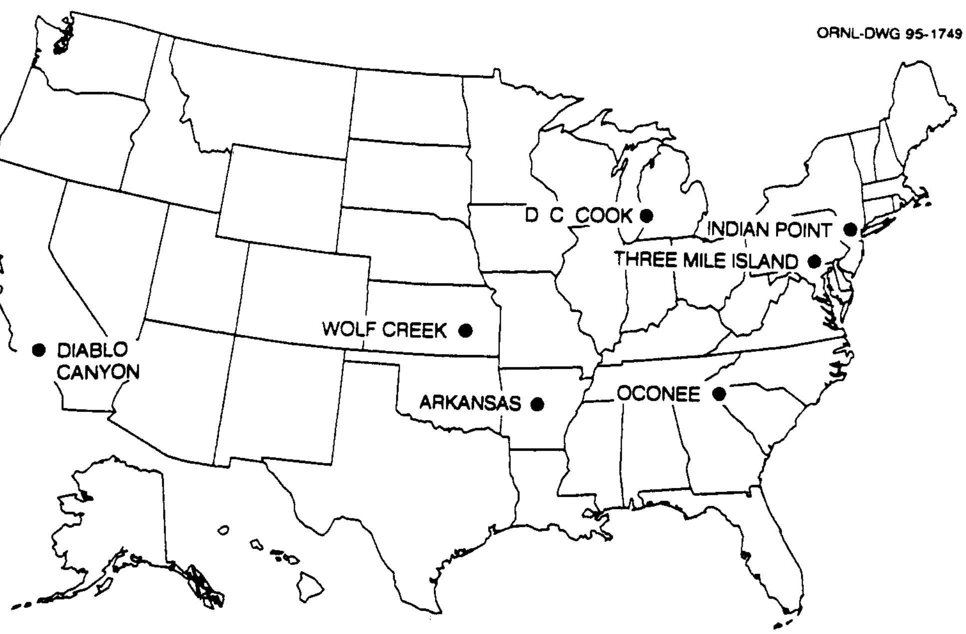

Figure C.2 The seven case study nuclear plants.

C.1.5 Analysis of Impacts

C.1.5.1 Defining Significance Levels for Each Impact Category

For each socioeconomic topic, the characteristics of small, moderate, and large levels of impact were defined. These definitions were developed on the basis of Council on Environmental Quality regulations (40 CFR Part 1500), information from site-specific nuclear EISs and NUREG studies, interviews with local information sources, studies concerning nity response to nuclear and non-nuclear technologies, and best professional judgment. The definitions of significance for each socioeconomic topic are presented in Sections 3.7.2 through 3.7.7 and Sections 4.7.2 through 4.7.7.

C.1.5.2 Characterizing Past Impact Levels and Identifying Impact Predictors

Descriptions of past impacts in all socioeconomic issue areas were gathered through the data-collection methods described in Sections C.1.1 through C.1.4. These impacts then were characterized as small, moderate, or large on a site-specific basis, using the significance level definitions discussed in Chapters 3 and 4. A description of past impacts for each of the case study sites is presented in Sections C.4.1 through C.4.7. From these site-specific characterizations of the representative case study plants, generalizations were made concerning the range of past impacts for all nuclear plants nationwide.

In examining the impacts identified in available reports and EISs and through the detailed case studies, it is apparent that the extent to which socioeconomic impacts are experienced at a given project site would depend on several factors. These factors, which will be referred to as impact "predictors," consist of characteristics of the project (called "drivers" in Appendix B) as well as characteristics of the area in which a plant is located. The specific predictors identified include local population characteristics; the employment, expenditures, and tax revenues generated by the project; and the existing infrastructure of the project's host community or communities. By looking at impact predictors and the resulting impacts that occurred at many different sites during plant construction and operations, the relationships between predictor magnitude and impact significance were identified. These relationships are discussed in Sections 3.7.2.3 through 3.7.7.3 and in Sections 4.7.2.3 through 4.7.7.3.

C.1.5.3 Projecting Future Impacts

The first step in projecting impacts was to obtain projections of the number of direct workers required for refurbishment-related activities and for operations during the license renewal term. Projections of the *refurbishment work force* were prepared by Science and Engineering Associates, Inc. (SEA 1994); they are presented in Chapter 2 and in greater detail in Appendix B, and are discussed in Section C.3.1.1. The number of *refueling and maintenance workers* employed at a typical plant during past outages was obtained from the survey of all U.S. nuclear utilities (Section C.1.3) and verified by SEA. SEA used information from the survey and the literature regarding the number of person-months required for normal refueling outages to develop an estimate of the number of refueling workers likely to be on-site during current-term and final refurbishment outages. The number of *operations workers* currently employed at each case study plant was obtained from the survey of all U.S. nuclear utilities, whereas the number of additional permanent workers required for plant operation during the license renewal term came from descriptions of proposed inspection, surveillance, testing, maintenance (ISTM) tasks (Section C.3.1.2). Additional detail about work forces required during refurbishment outages and the license renewal term are provided in Sections C.3.1.1 and C.3.1.2, respectively.

To project the maximum impacts likely to result from a plant's license renewal refurbishment activities, the staff based its socioeconomic impact analysis on the bounding case work forces projected by SEA (1994). The conservative nature of the bounding case scenario is described in Appendix B. Because the bounding case work force estimate for PWRs (2273 workers at peak) is larger than the estimate for BWRs (1482 workers), the staff conducted its primary analysis of potential socioeconomic impacts using the projected PWR work force. This analysis has identified some issues for which moderate or large adverse impacts are possible. For these issues, the potential for less severe impacts associated with the bounding case work force at BWR sites has been considered. For these issues, an analysis of the potential impacts at BWR sites is provided and is based on the 1500-person work force associated with the bounding case BWR refurbishment scenario. For those issues where moderate or large adverse impacts were determined to be possible with 1500 workers, an analysis of the typical case refurbishment work force (1017 workers at BWR sites) has been conducted. Those issues for which moderate or large adverse impacts were found to be possible with a work force smaller than 1017 (i.e., operations-period refueling work forces) have not been subjected to these additional analysis.

Using the work force projections, the staff determined the number of indirect jobs that would be created as a result of refurbishment and license renewal. Indirect employment was projected using the Regional Industrial Multiplier System (RIMS) direct/indirect job ratios calculated for each plant in the NUREG/CR-2749 study. Using the employment projections for direct and indirect workers, projected changes in local population were calculated based on patterns of worker residential location, in-migration, and family size identified in the site-specific NUREG reports. Patterns for refurbishment and refueling/maintenance workers were assumed to follow those established by plant construction workers, and patterns for additional permanent license renewal term workers were assumed to follow those established by current term plant staff (Section C.4.1.1). Population changes caused by temporary refueling and maintenance workers involved in periodic plant outages during the license renewal term were not studied in detail because these workers would be employed for very short periods of time, but evidence about past effects during such outages was collected and considered in the analysis.

The projections of direct and indirect employment associated with refurbishment and routine (nonoutage) operations were used to assess the economic impacts of refurbishment and license renewal. Economic impacts were projected by comparing estimated plant-related employment (direct and indirect) with projections by the National Planning Association (NPA) of total employment for the study areas during the refurbishment period and the license renewal term (Section C.4.1.6). For the refurbishment period, employment estimates for all refurbishment-related workers (including refueling/maintenance workers) were used. For the operations period, estimates of all permanent (nonoutage) workers were used; this includes additional jobs and those continuing from past operations.

Because many socioeconomic impacts are driven by population growth, the next step in projecting the impacts of refurbishment and license renewal was to use the population growth projected for each case study area in assessing impacts to housing, public services, and off-site land use. For each of these topic areas, impact predictions were made by comparing levels of impact significance associated with past plant-related population growth to projected population growth and by examining projected conditions of key infrastructure components. The analysis assumes that no other major construction project will occur concurrently with plant refurbishment and subsequent refueling and maintenance activities. If other large construction projects are ongoing when these activities occur, impacts could be greater than those predicted. Housing impacts were projected for refurbishment and continued operations, respectively, by comparing the housing demand expected to result from the in-migration of refurbishment-related workers and of additional permanent operations workers with projections concerning local housing markets (number of units and vacancies) generated from U.S. Census data (Section C.4.1.2). In addition, evidence concerning past impacts associated with the influx of refueling and maintenance workers during plant outages was gathered and used as an indicator of possible outage-related impacts during the license renewal term at the one site where significant growth-induced housing impacts were predicted for the refurbishment period. Public service impacts were projected by comparing the number of refurbishment-related workers and additional permanent operations workers expected to in-migrate with the local communities' projected capacity to provide public services, as indicated by local information sources (Section C.4.1.4). As with housing, evidence was gathered at one site concerning outage-induced transportation impacts. For off-site land use, impacts were projected by examining the size of anticipated population growth resulting from refurbishment-related workers and additional permanent operations workers relative to state data center projections of a study area's total population. Potential changes in land-use patterns caused by plant tax payments were also considered in projecting the impacts of license renewal (Section C.4.1.5).

Unlike the subjects already discussed, impacts to taxes and to historic resources and aesthetic resources are not driven primarily by changes in employment and population. For these three topics, impacts examined for the refurbishment period are those that result solely from changes induced by refurbishment-related activities (i.e., increased tax assessments and modified plant structure). In contrast, the assessment of license renewal term impacts includes continuing impacts from past operations and the new impacts already discussed. A detailed discussion of the methods used to predict impacts in each of these subject areas is presented in Sections C.4.1.3 and C.4.1.7, respectively.

Socioeconomic impacts identified and analyzed here are site-specific; they have no statewide or nationwide consequence. Therefore, simultaneous relicensing of several nuclear power plants will not result in cumulative regional or national impacts.

Judgments on whether or not potential environmental impacts in each subject area would need to be further addressed in each individual license renewal application were made based on the nature of the projected impact and its level of significance. These conclusions are not discussed in Appendix C but are presented in the body of the Generic Environmental Impact Statement (GEIS). Because of uncertainty surrounding the number of workers that would actually be required for plant refurbishment, a sensitivity analysis was performed wherein socioeconomic impacts were predicted in response to a work force roughly 50 percent larger than the estimated peak work force for the major refurbishment outage provided in Section C.3.1.1 (even though the estimate given in that section was designed to be an upper bound for a typical plant). The discussion of conclusions for each socioeconomic topic in the body of the GEIS states whether or not the conclusion category (1 or 2) expected for the preferred estimate would change in response to the larger work force.

Sections C.4.1 through C.4.7 present a detailed discussion of projected socioeconomic impacts in each of the above subject areas for each case study site, and Sections 3.7.2 through 3.7.7 and Sections 4.7.2 through 4.7.7 summarize these impacts and project impacts for all nuclear plant sites based on the case study predictions. These nationwide predictions are considered valid because the impacts predicted at the case study sites represent the range of potential impacts at existing nuclear plants. Population, which is considered an impact predictor rather than an actual impact, is discussed in Sections C.4.1.1 through C.4.7.1, 3.7.1, and 4.7.1.

C.2 BASELINE DESCRIPTION

C.2.1 Overview of Past Population- and Tax-Driven Nuclear Plant Impacts

C.2.1.1 Objectives

This literature review summarizes the results of previous case studies that examined the socioeconomic impacts of nuclear power plants. The objective of the review was to identify

- kinds of impacts that have occurred (e.g., schools, government expenditures);
- causal factors behind those impacts (e.g., size of work force, extent of existing community infrastructure); and
- impact thresholds, if any (e.g., taxes from plant as a disproportionate share of local tax base, no city of a certain size within commuting distance of the plant).

Socioeconomic impacts occurring during either construction or operation are of interest. Construction impacts provide an upper bound to what might happen during a major plant refurbishment, whereas operations impacts typify what would occur after license renewal, allowing for adjustments for refurbishment-induced changes in work forces, taxes, or other impact drivers.

C.2.1.2 Literature Reviewed

Several categories of literature were reviewed. One major category is EISs for nuclear plant operating licenses (OLs) (Section C.5.3 lists the EISs reviewed). This category is potentially useful because the EISs not only consider impacts from plant operations but often summarize impacts that occurred during construction. They are official documents in support of the NRC's regulatory process and, presumably, carry a measure of credibility in respect to what the regulatory process requires in terms of data, findings, and content. The second category of literature includes case studies commissioned by organizations closely involved with the nuclear industry. The NRC has conducted several such plant-specific studies (NUREG/CR-2750, ORNL/NUREG/TM-22, and NUREG/CR-0916). EPRI also conducted a series of case studies of power plants, two of which were nuclear (EPRI/EA-2228). The third category of literature encompasses studies of single nuclear plants that are usually sponsored by utilities as part of the regulatory process or by some other organization interested in documenting socioeconomic impacts.

C.2.1.3 Types of Impacts

This literature review reveals no population- or tax-driven socioeconomic impacts other than those typically assessed in environmental impact documents. Those documents written in support of the National Environmental Policy Act of 1969 (NEPA) process almost always focus on readily quantifiable impacts to public services, housing, the economy, and land use. Exceptions in which the assessment is qualitative include aesthetic and cultural resources impacts, which are almost always considered in EISs, and recreational impacts, which are discussed in 44 of the 78 (56 percent) OL EISs examined. Impacts to these resources, however, are seldom found to be population- or tax-driven. Consequently, they are defined by general statements about appearances of the plant, transmission lines (sometimes the lines are rerouted to avoid negative impact to residents in the vicinity), and compatibility with nearby cultural resources. Recreation impacts are generally defined as positive contributions such as visitor centers; boating, fishing, and hiking activities; and dedication of land on the plant site to natural resources conservation and education. Typically, non-NEPA documents do not examine these resources.

Among public service impacts identified, the assessments focus on schools, transportation, and public safety; less emphasis is placed on utilities, water and sewer facilities, and health and welfare services. These same impacts are covered in the other case studies examined in the literature, and there is a strong consensus that all should be treated as valid kinds of socioeconomic impacts under NEPA. Housing is another impact that understandably receives considerable emphasis in NEPA and non-NEPA assessments, with residential distribution being foremost in importance, followed by housing type and costs. Generally, housing impacts are treated before public service impacts because most services generally support people by place of residence.

Economic impacts are almost always assessed in environmental documents and related case studies. They are readily quantifiable and tangible impacts that are easy to understand. Minimally, the project work force total and annual payrolls are included (although early NRC EISs did not note these basic impacts). Emphasis normally is on totals of direct employment and payroll generated by the nuclear plant, indirect jobs in the local economy, amounts of money contributed to the regional economy, and tax contributions to the local tax base—particularly property and sales taxes. Additional types of taxes and amounts of revenue that flow to the state governments generally are not considered in NEPA documentation, although case study reports produced by NRC more adequately assess these latter impacts.

Land-use impacts created directly by the plant itself and its transmission lines are assessed in 78 percent of OL EISs. Generally, such impacts are considered in terms of acres disturbed, people relocated, and land flooded for cooling lakes. Only rarely is attention directed at what effect plant siting would have on broader community land use and associated growth. These generalizations hold true for the other literature categories reviewed, with the exception of the NRC's series of 12 case studies, which gives considerable attention to land use and associated community growth and finds that land-use changes related to plant siting and worker in-migration "strengthened overall patterns of change and development" (NUREG/CR-2750).

C.2.1.4 Causal Factors of Impacts

Most of the socioeconomic impacts created by nuclear plants are driven by the plant-related population or taxes. Nuclear power plants require large numbers of workers to construct and, to a lesser extent, operate, and they generally pay significant amounts of taxes. The amounts of jobs and taxes tend to correlate fairly directly with the size of the plant. In many communities where nuclear plants are located, the plant is very likely to be one of the largest, or even the largest, employer and contributor to the tax base. Therefore, its workers create impacts on schools, public services, housing, utilities, transportation, and health and welfare services. Of particular importance are in-migrating workers and their families, who must be accommodated by expansion of such services. If the communities are small and the plant site is located beyond commuting distance of a reasonably large population center, then worker in-migration would be higher and resulting demands of services would be increased—perhaps to the point that major expansion is required.

Taxes from the plant and its workers provide a major benefit to local communities in helping to pay for public services. Once built, a nuclear plant typically contributes millions of dollars annually to the local tax base. The range may be as low as $1 or 2 million and as high as $42 million (1990 dollars), depending upon the assessed plant value and tax structure, according to the 69 percent of OL EISs that discuss the issue. An even broader range of tax payments was reported by utility respondents to a recent questionnaire (Section C.2.2). Although the effects of plant tax payments are primarily positive, potentially negative tax-related issues can involve (1) the timing of tax revenues that may be too late to pay for construction-period impacts caused by in-migrating workers; (2) discontinuities between jurisdictions that can tax the plant and jurisdictions in which many of the employees reside; and (3) the disproportionately large amount of the tax base represented by the power plant, which can pose a major problem in the future for local real estate tax revenues. A fourth issue is how to pay for public services in the case of nuclear plants owned by the government that pay no local property taxes and only small payments in lieu of taxes. As in the case of population impacts, tax-related impacts have the potential for being much larger in rural areas with small tax bases.

C.2.1.5 Impact Thresholds

In developing a license renewal rule, the emphasis is on identifying socioeconomic impacts that could be particularly problematic for local communities and the conditions under which these could occur. For example, is the labor requirement so large and the community so remote from a population center that in-migration to the plant's area would be large enough to significantly stress the public infrastructure?

Or, in regard to taxes, is the assessed value of the plant so large relative to the existing tax base that local governments would be highly dependent on plant-related revenues? An impact threshold can be thought of as the set of conditions (e.g., a particular number of plant-related workers in conjunction with a host community's population and distance from major urban areas) under which significant impacts can be expected.

Before addressing the issue of thresholds, it is useful to generalize very briefly about the severity of these kinds of impacts that could result from nuclear plants. The literature that specifically deals with the issue (NUREG/CR-2750; NUREG/CR-0916) notes that nuclear plants seldom, if ever, create massive (boomtown-level) impacts to community infrastructure on the scale of mine-mouth coal plants or hydroelectric dams because nuclear plants are not sited in remote western regions of the country where such severe impacts can occur. This finding is supported by the OL EISs, which fail to identify any potential or actual case of a boomtown-level impact from a nuclear plant. Indeed, the overall findings from the literature reviewed argue strongly for the proposition that population- and tax-driven impacts of nuclear plants during the construction period overwhelmingly are small to noticeable for affected communities and well below boomtown proportions. Significant negative impacts have occurred, however, at a few plant sites. During plant operation, employment and tax revenues can be a substantial benefit for local communities, and their loss would be equally significant. Of particular concern would be cases in which nuclear plants make up a large percentage of the tax base.

In regard to the identification of impact thresholds during plant refurbishment and continued operations, the literature alone does not give any clear answers. However, in conjunction with the case studies detailed in Section C.4, a number of impact predictors were identified that can be used to indicate whether significant impacts are likely to occur at a given site in several socioeconomic subject areas. These impact predictors are discussed in Sections 3.7 and 4.7.

C.2.2 Overview of Current and Past Socioeconomic Characteristics for All Plants

This section summarizes information on selected socioeconomic characteristics for U.S. nuclear plants. Specific topics include the plants' operating period employment; characteristics of typical planned outages, in-service inspections (ISIs), and largest single outages; assessed value; and tax payments. The section is intended to provide an overview of the entire U.S. commercial nuclear industry. Information used to prepare this report was obtained through questionnaires mailed to all utilities that operate nuclear plants.

Considerable differences exist among nuclear plants in terms of the size of their operating work forces. Table C.4 provides a summary of data concerning current operating-period employment at nuclear plants grouped by the number of units at each plant. Although the employment figures are intended to represent the number of permanent personnel on-site, they might overstate that figure because it is likely that temporary workers were included in some utilities' responses. The incremental increase in the mean number of workers per unit is not linear, because the mean for one-unit plants constitutes over 66 percent of the mean for two-unit plants, whereas the mean for two-unit plants represents only 52 percent of the mean at three-unit plants. The number of units at each station represents those licensed by 1990; therefore, for some two- and three-unit plants, employment may have been considerably lower in past years depending upon the number of units that were actually on-line and their levels of operation. Table C.5 depicts changes in mean operating-period employment at the plants from 1975 to 1990.

U.S. nuclear plants also differ in the number of workers, the costs, and the length of time required per unit for various types of outages. Table C.6 depicts the minimum, maximum, and mean number of workers, costs, and time required per unit for a typical planned outage during which refueling and other routine tasks are performed. Table C.7 presents the same information for an ISI outage. The two tables should be read in columns, not rows, because the plant that had the minimum number of workers, for example, is not necessarily the same as the plant with the lowest cost or the shortest outage. The numbers presented in Tables C.6 and C.7 might be high because some utilities probably included permanent operations workers in their count of workers used during outages, even though they were asked to list only *additional* on-site workers. Also, the numbers count each worker who came on-site at some time during the outage, regardless of the duration of the stay. These numbers, therefore, are almost certainly higher than the peak number of workers on-site during a single day or week. The maximum number of 2600 is particularly suspect; the next highest number of workers given for a typical planned outage was 1500.

Table C.8 summarizes information on the largest single outage experienced for one unit at those nuclear plants providing data for this topic. The tasks performed during these large outages vary but can include steam generator replacement, core support barrel repair, recirculation system piping replacement, and refueling. The table, which contains data on the number of additional workers, the total costs, and the time involved in the responding plants' largest outages, is designed to be read in columns. As with preceding tables, Table C.8 presents numbers that are higher than actual work force peaks because some utilities included operations workers in their count of *additional* workers and because the numbers count each worker who came on-site, regardless of the duration of the stay. In general, the amount by which these numbers overstate actual peaks can be expected to increase with the length of the outage.

Sizeable differences also exist among nuclear plants in terms of their assessed values. Table C.9 provides a summary of data concerning current assessed values at nuclear plants grouped by the number of units at each plant. The incremental increase in the mean assessed value per unit is not linear, because the mean for one-unit plants constitutes almost 66 percent of the mean for two-unit plants, whereas the mean for two-unit plants represents only 26 percent of the mean at three-unit plants. The number of units at each plant represents those licensed by 1990; therefore, for some two- and three-unit plants, assessed values may have been considerably lower in past years depending upon the number of units actually on-line. Table C.10 depicts changes in the minimum, maximum, and mean assessed values from 1980 to 1985.

The amount of local and state taxes paid on nuclear plants by the utilities that own them also varies considerably. Table C.11 depicts information about the local and state taxes paid on nuclear plants grouped by the number of units at each plant. Once again, the incremental increase in the mean total amount of taxes paid is not linear, because the mean for one-unit plants constitutes over 65 percent of the mean for two-unit plants, whereas the mean for two-unit plants represents only 28 percent of the mean at three-unit plants. For some two- and three-unit plants, tax payments were probably lower in past years because one or more of the plants' units may not have been on-line. Table C.12 depicts changes in the minimum, maximum, and mean amounts of local and state taxes paid from 1980 to 1985. A relatively small number of utilities explicitly mentioned paying state taxes; however, where such taxes are paid, the mean payment is substantially greater than the mean for local taxes. Because a large number of utilities reported only *total* tax payments without specifying the jurisdictions to which the taxes are paid, it is possible that the utilities pay more state taxes than are indicated here.

C.3 DESCRIPTION OF LICENSE RENEWAL

C.3.1 Work Force and Expenditures Required for Plant Refurbishment and the License Renewal Term

License renewal for a commercial nuclear power plant will involve two time periods: the refurbishment period and the license renewal term. The length of the refurbishment period, the number of additional workers who would be on-site to perform refurbishment tasks, and the costs of refurbishment would vary among nuclear plants. The license renewal term will be 20 years, but the number of additional personnel that will be required to operate a plant will vary. This section describes the estimates of refurbishment period length, costs, and work force sizes used in the GEIS to assess the socioeconomic impacts of license renewal. Section C.3.1.1 describes the estimates of refurbishment outage length, work force, and costs provided by SEA (Appendix B; SEA 1994). Section C.3.1.2 describes the estimates of the license renewal term work force.

C.3.1.1 The Refurbishment Period

For a nuclear power plant, the refurbishment period is expected to begin several years before a unit's original operating license expires. Plant refurbishment would probably involve bringing additional workers to the site to perform certain tasks during four regularly scheduled current term outages and one major refurbishment outage. GEIS predictions are based on a bounding case (conservative) refurbishment work force scenario prepared by SEA (1994). The scenario provides refurbishment work force estimates that are expected to represent the upper bound of work force requirements for a typical plant. The impact assessment performed for the GEIS is based on the projected work force required to refurbish a PWR because that represents the worst-case situation and because all the socioeconomic case study plants are equipped with PWRs. It is assumed that refurbishment activities for multiple units at a nuclear power plant would be performed sequentially, even where two units' licenses expire in the same year (Table 2.1), because the utilities are not expected to shut down more than one unit at a time. For a PWR, the peak number of 2273 refurbishment workers is expected to be reached during the major refurbishment outage (SEA 1994). For a BWR, the peak work force (1500 persons, including refurbishment and refueling workers) would be on-site during the current term outages (Chapter 2, Appendix B).

A second work force scenario—the typical case—has been developed by SEA (1994). In this scenario, the peak work force at PWRs (874 persons) will occur during current term outages, while the BWR peak work force (1017 persons) will occur during the final refurbishment outage.

Four current term outages per unit are expected, starting 8 to 10 years before the original operating license expires (Figure C.3). Each outage would last approximately 4 months in the bounding case scenario, and it is assumed that outages would be separated from each other by 18 months of normal operation. All the current term outages would consist of refurbishment activities conducted while the reactor is shut down for refueling and routine maintenance.

During current term outages, only the refurbishment workers required for license renewal can be expected to cause *new* impacts, because the refueling and maintenance workers' presence is related to continued operations under the original license. However, normal plant staff and refueling and maintenance workers who are on-site during refurbishment can be expected to contribute to the overall magnitude of impacts.

One major outage is assumed in the year before the expiration of a unit's operating license, to allow performance of any remaining refurbishment tasks not completed during the previous four current term outages. This assumed refurbishment outage is expected to last 9 months and require, at its peak, approximately 2273 direct refurbishment workers at a PWR.[1]

C.3.1.2 The License Renewal Term

The license renewal term for a nuclear power plant would begin 10 years before the end of the initial 40-year license period (see Figure 2.3). The renewed operating license would allow 20 additional years of plant operation subsequent to the 40-year operating license. The license renewal term work force is expected to include those personnel on-site during the original operating period. In addition, it is expected that continued operations during the license renewal term could require some additional workers because of the requirement for more frequent surveillance and inspection (NUREG-1398). Past descriptions of proposed ISTM tasks indicate that these are likely to require between 20 and 60 additional workers per unit. To provide a realistic upper bound to potential population-driven impacts associated with continued plant operations, the high end of the projected range of ISTM workers (60 per unit) is used to approximate the number of additional permanent workers required for ongoing ISTM tasks during the license renewal term.[2]

As with the original operating period at all nuclear power plants, periodic refueling and maintenance would be performed during the license renewal term. In addition, each unit would undergo two 5-year ISIs and one 10-year ISI during the license renewal term. The conditions under which renewed operating licenses would be granted are expected to require more maintenance and ISI workers to perform these tasks than during the term of the original licenses. It is estimated that each of the 8 normal refueling outages that would occur during the license renewal term for both PWRs and BWRs would require approximately 30 more workers for refueling and maintenance than are currently required. In addition, it is

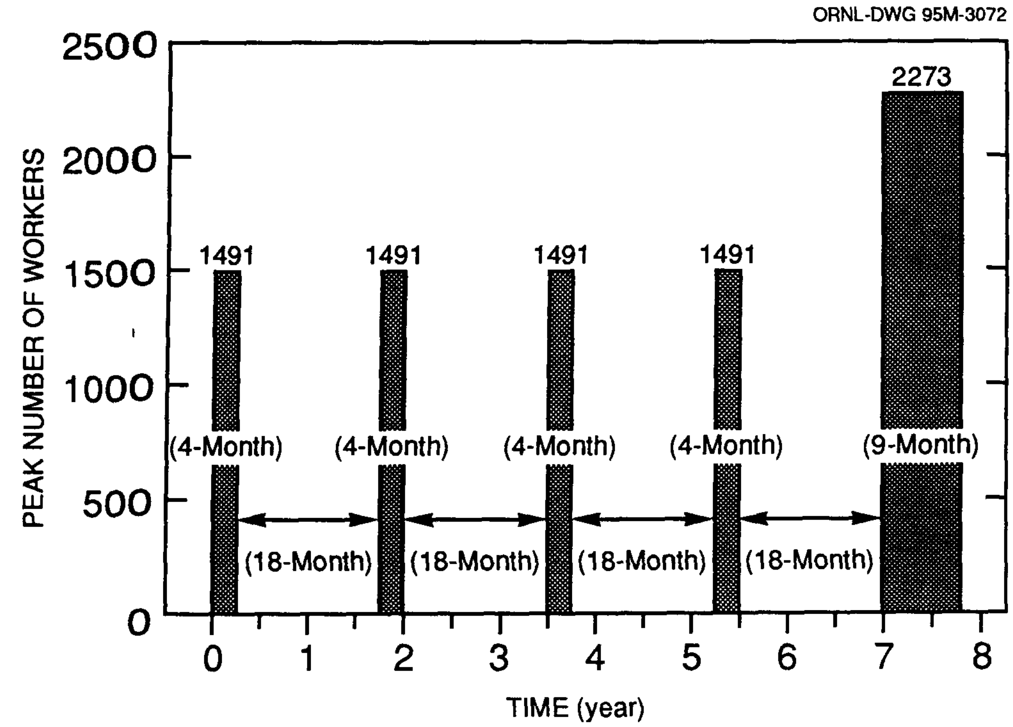

Figure C.3 Conservative scenario refurbishment work force estimates (PWR).

estimated that each license renewal term refueling would cost approximately $1 million more than refueling during the original term. Further, it is projected that each of the two license renewal term 5-year ISI outages (1) would require approximately 30 more workers at a PWR and 70 more workers at a BWR and (2) would cost approximately $1.5 million more at a PWR and $3 million more at a BWR than 5-year ISIs during the original term. Finally, it is estimated that the one license renewal term 10-year ISI outage (1) would require about 50 more workers at a PWR and 110 more workers at a BWR and (2) would cost approximately $2.5 and $5 million more, respectively, than a 10-year ISI outage during current operations. The GEIS does not systematically assess the impacts associated with these periodic outage workers because such workers would not be permanent plant staff and their presence in the community is likely to be very short-lived. However, as noted earlier, evidence about past effects during such outages was collected and considered in the analysis.

C.3.2 Changes in Taxable Value of the Plant and in Tax Distributions Following Refurbishment

The taxable value of nuclear power plants is expected to increase early in the license renewal term because of improvements made during refurbishment. Subsequent depreciation is possible, although this depends on the basis of the assessed value and is likely to be gradual during the 20-year license renewal term. Furthermore, inflation would offset the effects of depreciation so that the assessed value may decrease some in real terms but would increase or remain stable in nominal terms. Overall, tax payments to local jurisdictions are expected to remain roughly similar (with some increase) to those made during current plant operations. Also, future increases in value would accompany any additional plant improvements.

Two case study sites in this evaluation illustrate past increases in the taxable assessed value of nuclear plants during normal operation. The ANO facility had a taxable assessed value of $139 million in 1980, which rose to $184 million in 1989. This increase is 3.2 percent compounded yearly and is close to the inflation rate of this time period [the implicit price deflator of the gross national product (GNP) for this 9-year period is 4.4 percent]. The D. C. Cook nuclear facility increased in taxable assessed value from $365 million to $520 million during this same time period, for a compounded growth rate of 4.0 percent. These annual increases in assessed value are the result of the continued maintenance and replacement of equipment and the general inflation level driving replacement value and income-earning ability of the plant higher.

Taxing policies of the relevant state and local governments also affect the taxable assessed value of a nuclear plant. For example, the Oconee plant is exempt from payment of property taxes on pollution control equipment installed at the plant during its operation, resulting in somewhat smaller tax payments than would otherwise be required. Although county governments often assess the taxable value of nuclear plants, their assessments are frequently based on state guidelines. Additionally, some nuclear plant sites are assessed only by the state, and the local taxing authorities apply their own millage rates to these assessments.

The ANO, Diablo Canyon, and Wolf Creek nuclear plants are typical of plants that are assessed by rules mandated by state tax departments. The local taxing authorities of Arkansas, California, and Kansas employ the unitary approach method to develop the annual taxable assessed value for nuclear plant sites. This method bases the plant valuation on a reasonable value that an investor or business would pay for the plant. The assessed value is based on the following weighted factors: the cost that the parent utility would need to acquire the plant assets, the income-earning ability of the plant, and the stock market valuation of the parent utility (with the market value of the plant apportioned from the value of the utility). The taxable assessed value determined by the state is then multiplied by the individual millage rates of the local taxing authorities to calculate the nuclear plant tax payment.

The increase in taxable assessed value resulting from refurbishment is likely to be greater than past increases in the taxable value of nuclear plants. Although capital expenditures for replacement of plant equipment and maintenance expenditures have occurred during normal operation of the plant, expenditures are likely to be made at a higher level during refurbishment. This would cause the assessed value of the plant to increase at a higher-than-normal growth rate immediately following refurbishment.

The trend in distribution of property taxes paid by the case study nuclear plants to local taxing authorities varies considerably depending on the particular circumstances affecting each plant. If the growth of the local economy is sufficiently large, as in the case of the Oconee plant, the proportion of total local property taxes contributed by the plant would probably decrease. In some cases, the millage levy for various taxing authorities changes over time. For example, the property taxes assessed on the Wolf Creek nuclear facility have been increased at a 17.7 percent annual rate by Coffey County over the past decade, whereas the Burlington School District has had its property tax assessments increase at a smaller, 8.0 percent annual rate since 1980. At the ANO site, tax rates on the nuclear plant for the county and the local school district have been lowered. This was the result of changes in state tax laws in 1986 that caused a rollback on millages, resulting in lower property taxes. This has caused the county and the local school district to receive lower property tax payments in the past 4 years and to consider general tax increases to avoid deficits. In most cases, however, periodic capital expenditures made by the case study nuclear plants have allowed their property tax payments to remain at least stable in real terms over the past decade and to increase in nominal terms.

C.4 DESCRIPTION OF CASE STUDY SITES

The following sections detail impacts that occurred during construction and operation of each case study plant and project impacts for the refurbishment period and operations during the 20 years following the expiration of the initial license. The ANO case study includes a discussion of the methodology used to assess each impact category at each case study site.

C.4.1 Arkansas Nuclear One

The impact area (those places in which the most pronounced socioeconomic impacts might result from refurbishment and license renewal) for the ANO plant consists of Pope County, Arkansas, and the largest community within Pope County, Russellville. The selection of this area is based on worker residence patterns, employment, expenditures, and tax payments. Figure C.4 depicts the impact area, and Figure C.5 shows the region in which it is located.

C.4.1.1 Population

This section discusses the local population growth associated with the construction, operation, and license renewal of the ANO plant. Plant-related population growth is driven by the number of workers who migrate into nearby communities to work at a nuclear plant. These individuals and their families, and other persons and their families who move into the area to work in indirect jobs generated by the plant's presence, add to the communities' population totals. Such increases in population constitute the main driver of public service, housing, and land-use impacts, as well as many local economic impacts. Thus, to predict the socioeconomic impacts of a nuclear plant's license renewal, it is necessary to calculate projections of plant-related population growth.

The projections of population growth calculated in the GEIS are based on a number of assumptions. First, it is assumed that certain key characteristics of the refurbishment and license renewal term work forces would be analogous to those of the original construction and operating work forces, respectively. These key characteristics are (1) the percentage of the work force residing in the study area, (2) the percentage

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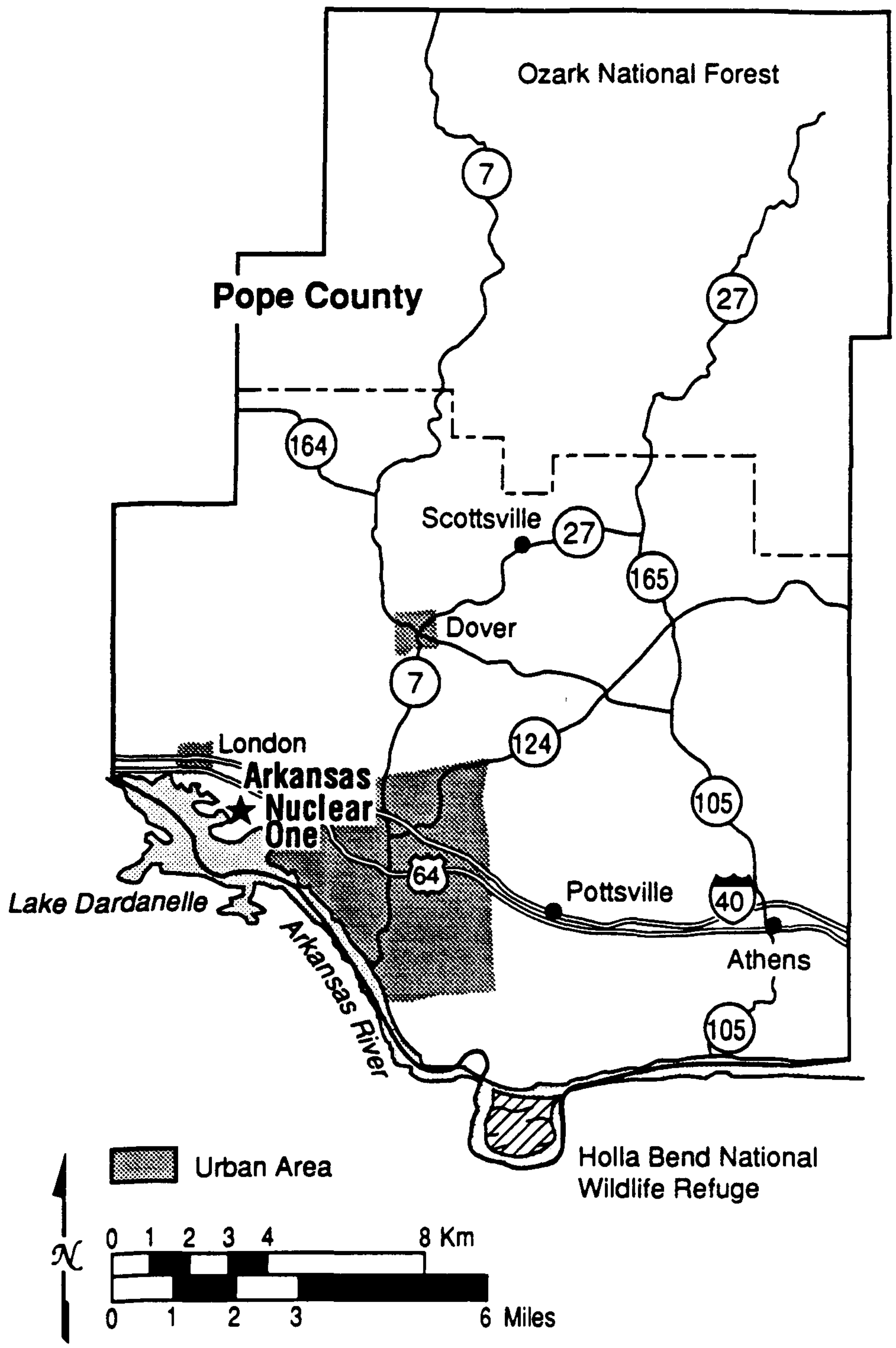

Figure C.4 **Socioeconomic impact area associated with Arkansas Nuclear One refurbishment: Pope County.**

ORNL-DWG 90M-14814

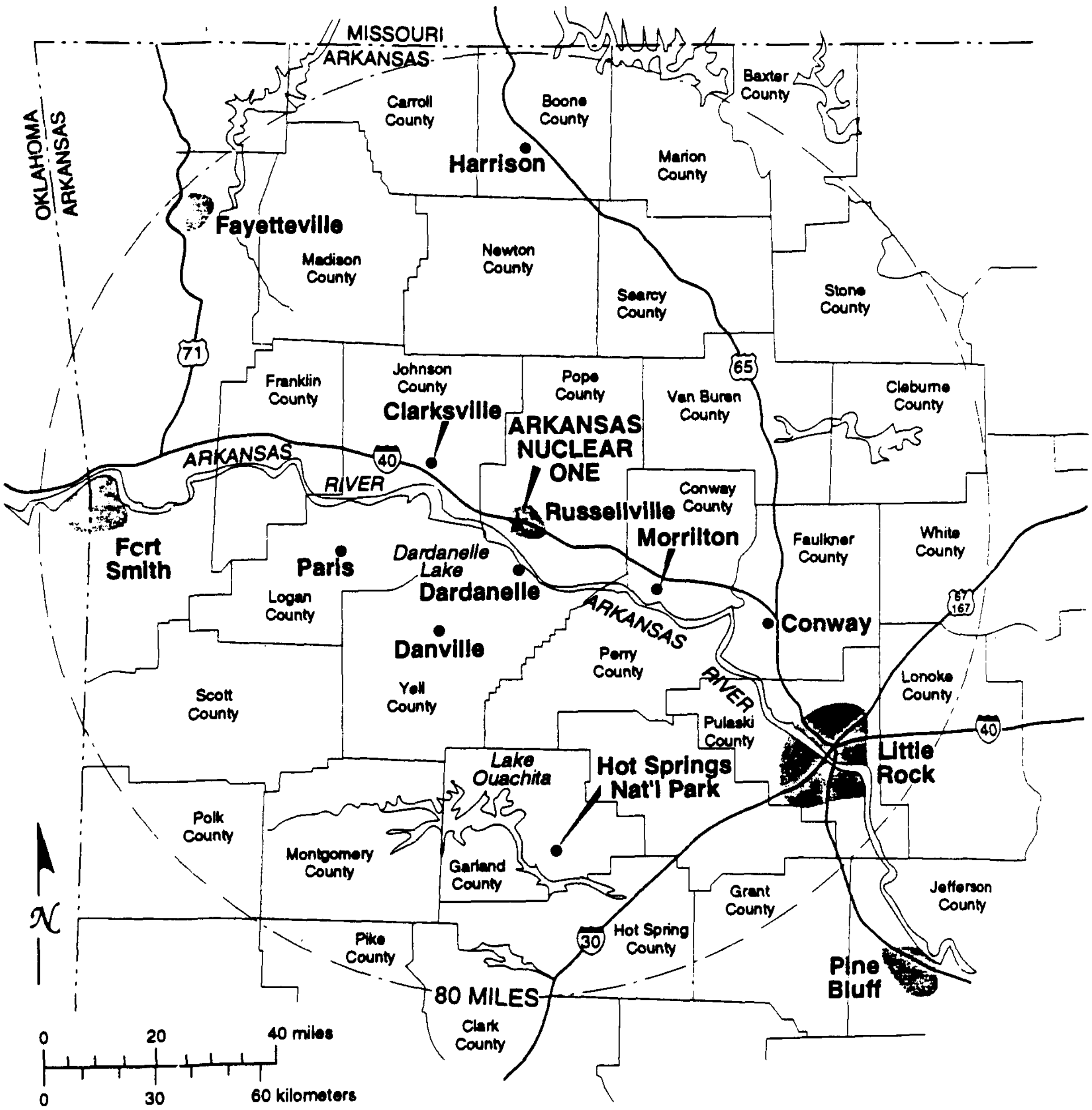

Figure C.5 Region surrounding the Arkansas Nuclear One nuclear plant.

of the work force who in-migrated to the study area, (3) the percentage of in-migrants accompanied by their families, and (4) the ratio of direct to indirect jobs created by work force in-migration. Second, future population growth is represented as occurring during the peak refurbishment year and in the first year of the license renewal term. The population growth because of license renewal would result from the influx of workers over the entire license renewal period, which could last up to 30 years (10 years for refurbishment and 20 years for the license renewal term). But population growth is projected for a single year to provide a worst-case estimate for predicting population-driven impacts. Finally, population growth is projected using U.S. Census 1990 estimates of average family size for the case study states.

Given these assumptions, data concerning construction and operating work force characteristics, and estimates of refurbishment and license renewal term work force sizes, the staff has projected population growth associated with license renewal. Tables throughout this section illustrate the calculations involved in making the projections. Data used to prepare this section were obtained from *Socioeconomic Impacts of Nuclear Generating Stations: Arkansas Nuclear One Station Case Study* (NUREG/CR-2749, vol. 1); *Environmental Assessment Proposed Rule for Nuclear Plant License Renewal* (NUREG-1398); SEA refurbishment work force estimates (Appendix B); population projections by the Arkansas State Data Center; and the Arkansas Power and Light Company (AP&L) (AP&L 1990).

The discussion of population growth is organized into two time periods. Section C.4.1.1.1 identifies the population growth that Pope County experienced as a result of the construction and operation of ANO from 1969 to 1989. Section C.4.1.1.2 projects the population growth expected to result from ANO's refurbishment period and license renewal term operations beginning in 2014 (Unit 1) based on the growth associated with the plant's initial construction. Also, Section C.4.1.1.2 projects the population growth expected to result from ANO's license renewal term based on the growth associated with operations in the past.

C.4.1.1.1 Growth Resulting from Plant Construction and Operations

ANO's construction resulted in large population increases in Pope County (Table C.13). During the peak construction year, 1974, ANO personnel and their families who migrated to the area to work at the plant, and others who moved into the area to work in jobs generated by the plant's presence, totalled approximately 2756 persons. This influx of new residents represented 8.3 percent of Pope County's total population in 1974 (NUREG/CR-2749, vol. 1, p. 86).

Operations at the ANO plant also have resulted in large population increases in Pope County. In 1989, 2205 permanent plant staff were on-site at ANO; additional contract workers were on-site during outages, but they have not been included because their presence at the plant was temporary. Of the permanent work force, 90 percent (1985) lived in Pope County (AP&L 1990). Based on the residential settlement pattern of ANO's 1977 work force, the staff estimated that 43.8 percent (869) of those residing in Pope County in 1989 were prior residents who obtained jobs and that 56.2 percent (1116) were workers who migrated into the area for jobs (Table C.14). Also following the pattern set during plant operations, it is estimated that 60 percent of the in-migrants (670) were accompanied by their families. Assuming the 1990 Arkansas average family size of 3.06 persons, this represents a total in-migration of 2496 residents for the county. Based on the ratio of nonplant jobs created in Pope County in 1977, it is estimated that ANO's 1989 operations created an additional 860 indirect jobs in service industries supported by the spending of ANO workers (NUREG/CR-2749, vol. 1, pp. 56–86). As a result of these indirect jobs, an estimated 454 additional workers and their families (a total of 922 persons) moved into Pope County (Table C.14). In all, approximately 3418 new residents are estimated to have moved into Pope County as a result of ANO's 1989 operations. These new residents made up about 7.7 percent of Pope County's 1989 population of 44,534 (NUREG/CR-2749, vol. 1, pp. 56–86; McFarland 1990).

C.4.1.1.2 Predicted Growth Resulting from License Renewal

As discussed in Section C.3.1, ANO's license renewal would require the completion of a number of refurbishment tasks for Units 1 and 2. Many of the refurbishment tasks are expected to be completed during scheduled refueling outages at each unit during the 10 years that precede the expiration of the initial license. However, the final refurbishment work is expected to be completed during one large refurbishment outage scheduled for each unit in the year before the unit's initial operating license expires.

Assuming the refurbishment schedule as described in Section C.3.1, the peak refurbishment year for ANO Unit 1 is expected to be 2013, and the peak refurbishment year for ANO Unit 2 is expected to be 2017. For each unit, the on-site refurbishment work force would be about the same size, and the work force would be on-site for approximately the same period of time. However, because uncertainties exist concerning the length of the outage and the size of the work force required to complete the refurbishment of a given unit, this section examines a bounding case work force scenario as described in Section C.3.1.

Given the work force scenario detailed in Section C.3.1, it is estimated that 2273 workers would be on-site to complete refurbishment of ANO 1 in 2013 and ANO 2 in 2017 (SEA 1994). Further assuming that the residential distribution of refurbishment workers would be similar to that of the 1974 ANO construction work force, it is estimated that 65 percent (1477) would reside in Pope County. Based on plant construction and operating experience, it is projected that 43.8 percent (516) of those residing in Pope County would be prior residents who obtain refurbishment jobs and that 56.2 percent (830) would be workers who migrate into the area for refurbishment jobs (Table C.15). Also following the pattern set during plant construction and operations, it is assumed that 60 percent of the in-migrants (498) would be accompanied by families. Using the Arkansas average family size of 3.06 persons, total refurbishment worker in-migration would result in 1856 new residents for the county. Based on the ratio of nonplant jobs created in Pope County in 1974, ANO's refurbishment is projected to create an additional 473 indirect jobs in service industries supported by the spending of ANO refurbishment workers. As a result of these indirect jobs, an estimated 246 additional workers and their families (a total of 499 persons) would be projected to move into Pope County (Table C.15). In all, approximately 2355 new residents would be expected to move into Pope County as a result of ANO's refurbishment under the work force scenario. That would represent a 3.7 percent increase in Pope County's projected population of 63,395 in 2014 (NUREG/ CR-2749, vol. 1, pp. 58–71, 82–83).

Once plant refurbishment is completed for ANO Units 1 and 2, the work force would consist mostly of permanent plant staff. There would be additional refurbishment/refueling workers temporarily on-site approximately every 2 years, but they would not be permanent, on-site plant staff; and many of them are expected to commute from outside the study area. It is expected that a maximum of 60 additional permanent workers per unit would be required during the license renewal term, adding 120 workers to ANO's existing work force. Assuming that the new workers' residential distribution would be the same as that of the current workers, approximately 90 percent (108) would reside in Pope County. Based on worker in-migration in 1977, it is expected that 43.8 percent (47) of those residing in Pope County would be prior residents who obtain jobs and 56.2 percent (61) would be workers who migrate into the area for jobs (Table C.16). Also following the pattern set during plant operations, 60 percent of the in-migrants (37) would be accompanied by their families. Using the Arkansas average family size of 3.06 people, total in-migration would result in 137 new residents for the county. Based on the ratio of nonplant jobs created in Pope County in 1977, ANO's license renewal term is projected to create an additional 47 indirect jobs in service industries supported by the spending of ANO workers. As a result of these indirect jobs, an estimated 25 additional workers and their families (a total of 52 persons) would be projected to move into Pope County (Table C.16). In all, approximately 189 new residents would be expected to move into Pope County as a result of ANO's license renewal term. That would represent 0.3 percent of Pope County's projected population in 2014 (NUREG/ CR-2749, vol. 1, pp. 58–71, 80–82).

C.4.1.2 Housing

The following sections examine the housing impacts that occurred in Pope County during construction and operation of the ANO plant and predict housing impacts that would result from refurbishment activities and continued operation. Possible impacts to housing include changes in the number of housing units, particularly the rate of growth of the housing stock; changes in occupancy rates; changes in the characteristics of the housing stock; and changes in rental rates or property values. The general methodology used to assess past impacts and predict refurbishment- related housing impacts is discussed in Section C.1.5. U.S. Census information; local agencies' housing data; and interviews with local government officials, planners, and realtors provided information about impacts that resulted from the construction and operation of the seven nuclear power plants used as case study sites. These sources provided information about past impacts of a known magnitude that resulted from a known number of in-migrating workers. This provided a basis of comparison when predicting future impacts of refurbishment.
Refurbishment-related housing impacts are predicted by comparing refurbishment-related housing demand to the projected housing market (number of units and vacancies). Project-related housing demand is based on the assumption that some unaccompanied workers would share accommodations and is determined by the following equation:

project-related housing demand = workers with families + 0.85 × unaccompanied workers.

Projections of the number of housing units present in the study area at peak refurbishment time are based on historical growth rates of the local housing market. This assumes that average growth rates would remain constant. Non-project-related housing demand at the time of refurbishment is determined by dividing projected population by average household size. The 1990 household size is used in this calculation. Household size is expected to continue its gradual decline, thus suggesting a greater demand for housing. It is believed, however, that the housing market would adequately respond to such a gradual change; therefore, housing vacancies, even though household size decreases, would be very much the same as those predicted using the known 1990 household size.

C.4.1.2.1 Impacts from Plant Construction and Operation

The following discussion begins with a description of the housing market at the time of ANO construction and details project-related housing demand in the study area. A discussion of changes that occurred in the housing market and impacts on housing induced by plant construction follows. Finally, impacts from the operation of ANO on local housing are assessed.

Between 1970 and 1978, 4361 new housing units were added to the existing housing stock of Pope County (based on the number of electrical connections), bringing the total number of units to 14,243 (NUREG/CR-2749, vol. 1; U.S. Bureau of the Census 1972). This 44.3 percent increase represents a rate of growth consistent with census reports of a 50.8 percent increase in housing in Pope County during the 1970–80 intercensal period. Nine hundred of these new units, or 21 percent, were located in Russellville (Figure C.4).

Project-related demand for housing in Pope County has been estimated according to the number of construction workers who moved to the area (NUREG/CR-2749, vol. 1). The ANO work force peaked in 1977 at an average annual employment of 1445 persons. Project-related demand for housing in Pope County peaked in 1977 at 858 units (6.25 percent of the 1977 housing). At this time, ANO Unit 1 had begun commercial operation and ANO Unit 2 was under construction. New housing units added to the Pope County market totaled 3486 between 1969, when the project began, and 1977, when it peaked. In 1970, 391 housing units were either for rent or for sale in Pope County. In Russellville, the homeowner vacancy rate was 2.6 percent and the rental vacancy rate was 10.4 percent. Housing shortages may have occurred infrequently and lasted for only a short duration (NUREG/CR-2749, vol. 1), but the existing vacancies and the rapidly expanding housing stock for the most part kept pace with project- and non-project-related demand.

The construction of ANO was an important factor in the rapid growth of the Pope County housing stock. Other factors included non-project-related population growth resulting from economic opportunities and the expansion of Arkansas Tech University in Russellville (NUREG/CR-2749, vol. 1). Several housing projects were undertaken during and possibly in response to ANO construction. A 35-ha (87-acre), multi-unit project was begun in 1967 after the announcement of ANO. Widely held local belief is that this development was linked to ANO; however, developers and local realtors indicated that it occurred in response to general population growth that had begun to occur before ANO (NUREG/ CR-2749, vol. 1). Five new mobile home parks were established during plant construction and, along with existing mobile home parks, accommodated as many as one-third of the construction workers and their families. Another development related to construction workers' demand for rental units was the conversion of old single-family homes into apartments (NUREG/CR-2749, vol. 1).

Between 1970 and 1977, considerable construction of multifamily units occurred. In Russellville, where approximately 75 percent of the construction workers located, 50 percent of the new units were multifamily units. Although single-family housing increased 16 percent between 1970 and 1977, multifamily units increased by 42.7 percent.

During the 1970s, when the project-related demand for housing might have affected housing values, the increase in the median value and median rent of housing in Pope County was comparable to that experienced in the state. Median value rose 181 percent in Pope County and 190 percent in the state of Arkansas, whereas median rent rose 73.3 percent in Pope County and 76.4 percent in Arkansas. However, local residents and officials have indicated that during peak ANO construction years, housing values escalated to levels above national trends and rents increased in response to construction workers' demands for housing (NUREG/CR-2749, vol. 1). The addition of multifamily structures in the middle and late 1970s brought housing values and rental rates once again in line with normal inflationary increases occurring statewide.

The end of construction at ANO did not have a destabilizing effect on the housing market. The project-related demand declined gradually and was abated by the gradual in-migration of the operations work force. By 1980, when both units were in commercial operation, housing vacancy rates in Pope County were comparable to those in the state of Arkansas. The home-owner vacancy rate was 2.1 percent in Pope County and 1.6 percent in Arkansas, whereas rental vacancy rate was 8.0 percent in Pope County and 8.8 percent in Arkansas.

Operation of ANO has had little effect, if any, on housing in the area. The roads and water and gas lines associated with the plant have facilitated residential development in areas neighboring the plant but have not been as big an attraction as the aesthetic quality of Lake Dardanelle. Indirectly, the plant may have had some effects on property values because the good wages employees receive have enabled them to buy or build homes that are considered expensive relative to other homes in the area.

In summary, substantial changes occurred in the housing market, housing characteristics, and property values during the construction period of ANO. The conversion of large homes into apartments, the increase in multifamily housing, and the temporary increase in housing values and rental rates are examples of this change. ANO may have been the impetus for, or a contributing factor to, these changes; however, other industrial development and the growth of the local college also spawned some of this change. For example, the tremendous growth in the housing market had begun before the construction of ANO. Also, housing occupied by construction workers was absorbed into the market and occupied by non-project-related population. Considering all these factors, the impact on housing during ANO construction was moderate.

C.4.1.2.2 Predicted Impacts of License Renewal

Project-related population increase and the commensurate housing demand would be the cause of new housing-related impacts during refurbishment activities. A summary of recent and anticipated growth in housing is provided. This is followed by predictions of possible impacts during refurbishment and the license renewal term.

In the period 1980–90, housing in Pope County increased 23.8 percent above the 1980 level. Assuming this rate of growth will continue, there would be approximately 30,900 housing units in Pope County in 2014. Based on a projected population of 63,395 and a 1990 average household size of 2.61 persons, 24,259 housing units would be required to accommodate Pope County's 2014 population. This suggests that there will be available housing, possibly as many as 6500 units in 2014. Even if Pope County's growth were to slow considerably, e.g., to 1.6 percent annually (a rate equal to the average annual rate that occurred between 1980 and 1986), there will be about 25,650 housing units in 2014 and over 1300 vacancies.

According to the estimate of the number of refurbishment workers required for the project and based on plant construction experience, 830 workers of the total work force of 2273 are expected to migrate to Pope County for refurbishment jobs. Of these in-migrants, 498 are expected to be accompanied by families. Some doubling-up is expected to occur among the 332 unaccompanied workers, so that each unaccompanied mover would require 0.85 housing unit. In 2013, the refurbishment-related housing demand would be 780 housing units (where *refurbishment-related housing demand* = *workers with families* + 0.85 × *unaccompanied workers*). In addition, numerous indirect jobs are expected to result from project workers' spending. An additional 196 indirect workers are projected to move to Pope County, bringing the total project-related housing demand in the peak year of refurbishment to 976 units.

The projected refurbishment-related housing demand is larger than the original construction-related housing demand of 858 units, but the number of housing units in the study area will have increased 86 to 117 percent under the conservative and current growth rates, respectively, between peak construction and refurbishment periods. Refurbishment-related housing demand would account for 3.8 or 3.2 percent (under the conservative and current growth rates, respectively) of the projected housing units in the study area in 2014, compared to construction- related demand in 1977 accounting for 6.25 percent of the housing units. Changes in the characteristics of the Pope County housing market that have occurred during or since plant construction should improve the accommodation of refurbishment-related workers. These changes include a greater proportion of multifamily units and the addition of mobile home parks. Some of the demand may be met by construction workers' recreational vehicles or mobile homes; this may require, however, the temporary addition or expansion of mobile home parks. However, no substantial construction of new housing units is expected to occur during refurbishment activities unless other economic and industrial growth warrants it, as was the case before and during ANO construction. Because housing demand would be small relative to the existing housing market, would not exceed projected vacancies, and would be even less than that experienced during construction, refurbishment-related housing demand is expected to have a small new impact on the study area housing market.

Housing impacts related to refueling activities and housing value and marketability that would occur as a result of continued plant operation during the license renewal term are the same as those currently being experienced (Section C.4.1.2.1). The 120 additional operations workers (60 per unit) and the commensurate housing demand would cause only small new housing impacts.

C.4.1.3 Taxes

The local impact of plant-related property taxes is presented here and in the other six case study presentations. Where information is available, the assessed valuation of the nuclear plant and the study area is presented to show the importance to the tax base from the start of construction to the current period. The impact of taxes on specific taxing authorities, such as local school districts, is presented. For these jurisdictions, the magnitude of plant-related property taxes relative to total local jurisdiction revenues is shown, again from the beginning of construction to the latest tax period in which information was available.

Each case study lists (1) the taxing authorities receiving revenues from the nuclear plants and (2) the property tax payments and tax or millage rates from the nuclear plants. At case study sites where the state assesses the value of the nuclear plant, the state tax valuation method is described. Tax reform legislation affecting the tax revenues from nuclear plants has been enacted in a few of the states where case study nuclear plant sites are located. The impact on total tax revenues and the taxing authority in general is described in sites where such legislation has been passed.

Tax and total revenue information was obtained directly from the governments that tax the case study nuclear plants. This information was obtained, where available, for the years 1980, 1985, and 1989. This longitudinal tax and revenue data allowed the evaluation of trends in nuclear plant tax revenue impacts over the past decade.

C.4.1.3.1 Impacts from Plant Construction and Operation

The jurisdictions that receive the bulk of the taxes paid by AP&L for ANO station are Pope County and the Russellville School District. Property taxes are the principal source of revenue for Arkansas counties and municipalities. Table C.17 shows AP&L's annual tax payments to Pope County for ANO during the 1968–89 period (NUREG/CR-2749, vol. 1).

From 1968 through 1989, Pope County's assessed valuation increased at an annual rate of 10.1 percent in real terms. During this same time period, ANO had its assessed valuation increase at a 21.9 percent real annual rate. ANO's portion of Pope County's total assessed valuation increased sharply from 1968 to 1980, from 5.4 to 73.6 percent. Thereafter, ANO's portion has dropped to 46.2 percent in 1989. Taxes paid to Pope County increased considerably as construction of the plant progressed in the early 1970s and more than tripled between 1972 and 1976 once construction was completed.

In 1980, the state legislative passed Amendment 59, which prevented reduction in taxes on utility properties for the first

5 years after the amendment's passage. It required a gradual reduction (to occur over the succeeding 5 years) in the millage rates assessed against utility property. Because of Amendment 59, ANO's tax revenues to the county have steadily decreased from approximately $1.6 million in 1985 to $1.2 million in 1989.

The recipient of the largest tax payments within Pope County was the Russellville School District. In 1978, property within the jurisdiction of the Russellville School District was assessed at a tax rate of 50 mills, whereas the tax rate for Pope County was 9 mills (Arkansas State Department of Education 1990). However, this millage rate for the school district has been falling throughout the 1980s. In 1985 the combined millage rate for real estate and personal property components in the Russellville School District was 48.1, but by 1989 it had fallen to 22.5. During the 1980s, the assessed value of property within the district rose steadily from $176.5 million in 1980 to $275.6 million in 1985 and to $341.1 million in 1989. In real terms, the assessed valuation in the Russellville School District grew at an annual rate of 3.1 percent. Table C.18 shows the revenue impact of ANO.

To compare the amount of taxes paid to the Russellville School District in real terms during the 1980s, the assessed valuation of the school district is deflated in real terms by the GNP deflator and then multiplied by the millage rate for the school district for the year in question. The resulting estimated taxes for Russellville School District increased at a 3 percent annual real rate from 1980 through 1985 but then declined at a 15.4 percent annual real rate from 1985 to 1989. Decreased millage rates resulting from Amendment 59 are largely the cause for the decreased revenue. As tax revenues decline, the school district will likely seek a tax increase in the future.

The Russellville School District ranked 66th out of the 329 school districts in the state of Arkansas for expenses per student in 1989. This is up from a ranking of 132 in 1988. The district is currently ranked 7th out of 329 in teachers' salaries in 1989 (the comparable ranking in 1988 was 25th).

Currently, Pope County is in a period of transition from a farm-oriented community to an area of light industrial development. Industrial development has increased substantially over the last 20 years. Undoubtedly, some of the development in the county is associated with the substantial tax revenues from ANO; however, the introduction of Interstate 40 through the county has had a major impact on development in the area. Officials at Pope County and Russellville School District have indicated that improvements in the county and school district and substantially reduced tax rates were possible because of ANO.

C.4.1.3.2 Predicted Impacts of License Renewal

A new tax-related impact is expected to occur during refurbishment of ANO. This new impact does not involve capital improvements that take place during the final refurbishment outage. Rather, it results from capital improvements that are undertaken during the current term outages, which would increase the assessed value of the plant during this time and, thus, increase ANO's tax payments to local jurisdictions. The magnitude of the impact depends on AP&L's decision about which improvements would occur early on and which would be done during the final outage. For example, if the steam generator is replaced during a current term outage, the assessed value may increase considerably before the license renewal term begins. If steam generator replacement and other major capital improvements are not undertaken early on, the increase in assessed valuation may be only minor. The increase, in either case, is expected to cause only an small to moderate new tax impact.

During the license renewal term, the tax-related impact would be primarily the continuation of tax payments ANO is currently making to local jurisdictions. A new impact would result from the increase in tax payments from improvement made at ANO during the final refurbishment period. Thus, tax revenues would increase in absolute terms but may remain constant as a percentage of total revenues of Pope County and the Russellville School District. ANO's contribution to the county's total revenues has fallen during the past decade, from 49 percent of the total revenues in 1980 to 26 percent in 1989. The additional tax payments during the license renewal term may halt this trend. Based on current conditions, ANO tax revenues—the continuing and additional payments combined—are expected to continue to make up a large share of the total revenues. Decreased millages that have resulted from ANO's substantial tax contributions may remain, although Amendment 59 does allow for millage increases. The large tax-related impact currently being experienced would continue during the license renewal term.

C.4.1.4 Public Services

The general methodological approach used to predict future impacts is discussed in Section C.1. For most public services, impacts were calculated based on the projected number of in-migrating workers and on the projected state of the local infrastructure. The expected number of in-migrants was calculated separately for each case study site, based on the in-migration patterns observed in past studies at these same sites. Where historic data were not available, in-migration rates were estimated on the basis of comparisons with sites that were similar in terms of population density and proximity to metropolitan areas. Only in the area of transportation was in-migration considered unimportant, since all project workers (and plant-related equipment) will use local roads to access the project site.

To project impacts to local educational systems, two important factors were the number of in-migrating workers accompanied by their families and the associated family size. Assumptions about these key variables were based on past patterns observed at the case study sites. Specifically, the number of in-migrating workers expected to bring their families with them at any given site was calculated based on the percentage of past workers accompanied by their families at the same site. Refurbishment workers were assumed to follow the same pattern as past construction workers, and future operations workers were assumed to be the same as past operation workers. Average household size for each site was determined from current state- specific data. For each family at a given site, the number of children was considered to be this average family size minus the two parents. The total number of additional children of plant workers was calculated by multiplying the number of in-migrating families by the expected number of children per family. Assuming that dependent children were equally distributed between the ages of 0 and 18, 68.4 percent of the children were projected to be of school age (6–18 years). This was the number of additional children expected to be enrolled in local schools.

C.4.1.4.1 Impacts from Plant Construction and Operations

ANO has affected public services in several surrounding counties, municipalities, and school districts, but three jurisdictions have been affected more than others: the Russellville School District, Pope County, and the city of Russellville. Each entity provides different services and has been affected in varying ways by ANO, as discussed below. A few construction impacts were noticeable in education and public utilities, but projected impacts from relicensing should be less significant. Information regarding expenditures is discussed in detail in Section C.4.1.3.

Education

The Russellville School District has seen much change as a result of the ANO plant. During the 1960s, the school district was facing severe financial difficulty and overcrowding. Even though Russellville's economy was growing and the population was growing with it, the Russellville School District had problems coping with the rise in enrollment. Student/teacher ratios reached as high as 35 to 1 during the 1960s, and a tax hike was approved to fund the building of a new high school.

Local residents saw the ANO plant as a solution to the problem. Taxes from ANO in its first 3 years of construction helped to pay for the new high school, but it was not until several years later (about 1973) that the Russellville School District's situation stabilized. It was difficult to accommodate new students brought in by ANO's construction and other growth, but once the high school was complete, assimilation was easy (NUREG/CR-2749, vol. 1, p. 116).

The student/teacher ratio began falling steadily after 1968; by 1980, it had fallen to 20 to 1 and the Russellville School District teachers were being paid more than others in Arkansas. Through ANO's tax payments, the biggest impact on the system, the district was able to recruit highly qualified teachers, which played a part in encouraging further economic growth in Russellville (NUREG/CR-2749, vol. 1, p. 116).

Like the plant's construction, operations have generated economic growth in Russellville, which in turn has affected the Russellville School District. Several informants noted that firms have transferred employees to Pope County, and some new businesses have appeared because of ANO's location. For instance, one recent company move into Russellville is expected to increase school enrollment in the area by 50 to 100 students. Refueling activities also have an effect on the Russellville School District, but the concurrent rises in enrollment are minor and short-lived.

Although the positive financial impacts of the ANO plant were tremendous, the district is once again experiencing financial difficulty. The state's constitution was amended in 1980 to modify its taxation policies. The new taxation policies caused a reduction in utility tax payments beginning in 1985. This resulted in lower revenues for the school district. As ANO taxes are a major source of monies for the Russellville School District, the drop in funds has left the school system in a financial dilemma. The district will likely seek a tax increase in the future, because of program expansion during the affluent years.

Transportation

The transportation network in Pope County, which was already a well-developed system, did not suffer as a result of ANO's construction. In fact, taxes paid by ANO by 1980 aided in the resurfacing of approximately one-third of all county roads. AP&L improved and extended the highway system to the ANO site and port facilities, both of which are on the Lake Dardanelle peninsula. Informants also reported that unloading facilities were constructed near the plant and that port activity increased during construction.

Key information sources indicated that ANO's construction created no problems with traffic congestion. Commuters to the plant generally bypassed the city, and construction workers who moved into Russellville were well dispersed throughout the community, which further diminished traffic impacts (NUREG/CR-2749, vol. 1, p. 119).

The city was also well served with a rail system, since it is a regional rail hub. A rail spur was constructed from the main east-west county line to the plant site for the shipment of construction equipment (NUREG/CR-2749, vol. 1, p. 118).

Since ANO began operations, no sources indicated problems with traffic congestion nor have sources reported impacts from maintenance and refueling at the plant.

Public Safety

Public safety services in Pope County have benefitted fiscally from ANO. Expenditures for public protection increased rather steadily during construction, enabling Pope County's police force to approximately double during that period, and the county ambulance service was expanded during construction. The Russellville Police Department also added several employees, but the relatively large full-time fire department, which was established before ANO was built, was less affected (NUREG/CR-2749, vol. 1, p. 119).

No countywide fire protection system exists, but the county does assist communities financially to establish municipal systems, and there are numerous rural volunteer fire companies. AP&L also undertook the development of a countywide emergency communications system, linking ANO directly to hospitals, police, and fire departments. ANO also funded emergency programs and drills (NUREG/CR-2749, vol. 1, p. 119). Also, the city has a nuclear emergency contingency plan as part of its comprehensive plan. One source stated the emergency plan has been tested and proven successful.

No impacts from ANO's operations and maintenance/refueling outages were reported by any public safety official.

Social Services

Social services have not been affected by the plant. There is no evidence attributing increased demands on social services to the construction of ANO (NUREG/CR-2749, vol. 1, p. 120). No informant reported impacts on services because of plant operations or refurbishments.

Public Utilities

In Pope County, sources noted that public utilities have not been affected by ANO, except that the water system was described as very inadequate. Other informants stated that demands on sewer and water increased at that time, but the strain on the system was manageable.

In much of the county area outside Russellville, water is currently provided by wells on-site. However, part of rural Pope County is in a water district north of Russellville, and there are plans to expand the system farther into the rural areas of the county.

Russellville's water supply is getting smaller, which will affect water availability and recreation in the county. New water sources will be sought in the future. Meanwhile, ANO is currently the third largest individual consumer of water in Russellville; thus, its operations do affect the system moderately. The plant's demand is increasing also.

Tourism

Reports indicated that the ANO plant has had only small effects on tourism in the area. There is some tourism on Lake Dardanelle, one of the largest recreational resources in the area, and across the reservoir from the plant is the popular Lake Dardanelle State Park. One official from the chamber of commerce stated that during construction there was a short-lived increase in visitors to Pope County. Another noted that a number of travelers on nearby I-40 still stop to see the plant.

Recreation

Recreation was not affected by construction activities at ANO as much as it has been from operations. However, these impacts have still been small. One official noted a short-lived increase in water recreation during construction, but the city recreation director was uncertain about effects on organized recreation.

It was also reported that operations at the plant have had only slight effects on recreation, although the city is experiencing much growth in its recreation programs. Another source reported that Lake Dardanelle and its corresponding state park are popular sites for fishing, boating, and other activities. Loop also indicated that fishing near the plant was very good and that no recreational areas along the reservoir had been affected adversely by ANO. The chamber of commerce also noted an increase in outdoor recreation and tourism attributable to operations at ANO, but these effects have been insignificant.

No impacts on recreation from refurbishments were reported. The water supply in Russellville, previously mentioned, is also becoming an issue with water recreation in some areas.

C.4.1.4.2 Predicted Impacts of License Renewal

Based on the estimated 2273 direct workers required during peak refurbishment, the staff estimates that 498 direct workers and 123 indirect workers will migrate with their families to Pope County (Section C.4.1.1.2). The number of children accompanying these workers is estimated using the Arkansas average family size (3.07) and assuming that all families include two adults. Children are expected to be evenly distributed in age from ≤1 to 18 years. Assuming 72.2 percent of these children are school-age (5 to 18 years), there will be an average of 0.77 school-age children per in-migrating family, or a total of 478 new students in Pope County. This represents a 4.0 percent increase above the projected number of school-age children in Pope County in 2014 (assuming the 1990 age distribution of the population) and equates to an average of 37 students per grade level. Moderate impacts could result, especially if the students are concentrated geographically (e.g., in Russellville).

An analysis of the projected BWR bounding case work force (1500 persons) was conducted to determine if a smaller work force would result in a lesser impact. (This is a hypothetical scenario because ANO is a PWR.) The 411 in-migrating direct and indirect workers who bring their families to Pope County would be accompanied by 321 school-age children (or 25 per grade). This would result in a 2.6 percent increase in the projected number of school age children in Pope County in 2013. Although only small impacts are likely, moderate impacts could result if the children are concentrated geographically or if facilities and classes are already at their peak capacity.

An analysis of potential impacts to education under the BWR typical work force scenario (1017 workers) finds that there would be 279 direct and indirect workers migrating to Pope County with their families. The associated 215 new school-age children (or 16.5 per grade level) would result in a 1.8 percent increase in the projected number of school-age children in Pope County in 2013. This increase in enrollment will likely cause only small impacts to the education system.

During ANO construction, when the number of in-migrants peaked at 2756 (an 8.3 percent increase in Pope County population), there were small impacts on transportation, social services, public utilities, tourism, and recreation. Projected refurbishment-related in-migration (15 percent less than construction in-migration) will increase the population 3.7 percent. Therefore, projected impacts on these public services from refurbishment will be small. Public safety, which has been fiscally affected by ANO, also should see only minor changes during the refurbishment period.

Impacts to all public services from continued operations also should be small because only a slight increase in population will occur. However, the public water system may be moderately affected because of the diminishing local water supply and increasing water usage by the plant.

C.4.1.5 Off-Site Land Use

This section describes the off-site land-use impacts of the construction, operation, and license renewal of the ANO plant. The discussion of impacts is primarily concerned with land use in the immediate vicinity of the plant, but impacts for the remainder of Pope County are described where appropriate. Land-use impacts are examined for two time periods. First, Section C.4.1.5.1 identifies the land-use impacts of ANO's construction and operation. Next, Section C.4.1.5.2 projects the land-use impacts of ANO's refurbishment period based on the impacts that occurred during the plant's construction. Also, Section C.4.1.5.2 projects the land-use impacts of the plant's license renewal term based on the impacts that have occurred during operations. Information sources for this report include the *Final Environmental Statement Related to the Arkansas Nuclear One, Units 1 and 2* (AEC Dockets 50-313 and 50-368); the *Final Environmental Statement Related to Operation of Arkansas Nuclear One, Unit 2* (NUREG-0254); *Socioeconomic Impacts of Nuclear Generating Stations: Arkansas Nuclear One Station Case Study* (NUREG/CR-2749, vol. 1); and interviews with key information sources in Pope County.

The assessment of land-use impacts began with a review of EISs for a number of nuclear plants and site-specific reports on the seven case studies. This review identified land-use impacts that had occurred during plant construction and operations and key issues that would be addressed in assessing the impacts of license renewal. The key land-use issues identified were

- changing land-use patterns influenced by plant location, plant-related population growth, and plant tax payments;
- changing residential, commercial, and industrial development rates and patterns influenced by plant location, plant-related population growth, and plant tax payments; and
- changing land-use regulations or zoning patterns resulting from plant-induced changes in land use and development patterns.

With these key issues, telephone survey forms were developed and administered to local planners, economic development specialists, and realtors in the seven case study areas (Section C.7). By combining the results of the literature review with those of the telephone survey, the factors most useful in predicting land-use impacts were identified. By comparing the impact predictors to the impacts that had been observed at the seven case studies, conclusions could be drawn concerning the relationships between predictor magnitude and impact significance. The impacts of plant refurbishment and license renewal were projected for each case study on the basis of relationships between the magnitude of impact predictors, the local areas' existing land-use and development patterns, and the significance of the land-use impacts that occurred in the past.

C.4.1.5.1 Impacts from Plant Construction and Operation

ANO was constructed on a rural 471-ha (1164-acre) site situated on a peninsula on the northern bank of Lake Dardanelle near Russellville. The land upon which the plant was built previously had been used for marginal farming and livestock grazing. In 1968, when plant construction began, the land in the immediate vicinity of the ANO site was almost wholly undeveloped and not under any form of zoning or land-use regulation. Some rural residences were on the peninsula, but primary land uses there included commercial forestry, agriculture, and recreational uses associated with Lake Dardanelle.

The construction and operation of ANO have had moderate direct impacts on land use in the immediate vicinity of the plant. The rural character of the peninsula upon which ANO is located has been altered somewhat because the plant has served as a direct impetus for much of the mixed-use development that has occurred there. This mixed-use development has been fairly limited, but it consists mostly of buildings used by contractors and engineering firms (such as Bechtel) associated with ANO. In addition, the Pope County Evacuation Team is located on the peninsula near the nuclear plant. However, ANO has neither directly encouraged nor impeded large-scale commercial or industrial development of the peninsula.

ANO's presence on the peninsula also has resulted in moderate indirect land-use impacts. Before ANO was constructed, a number of small houses and cabins were on the peninsula with no discernable pattern of subdivision or residential development. Since plant construction began, rural subdivisions with single family homes have been built near the ANO site [some within 0.4 km (0.25 mile)]. Many of these homes, especially those with lakefront lots, are relatively expensive in the context of the local real estate market. Key information sources indicated that the primary reason for this residential development was the availability of lakefront property with scenic mountain vistas. But ANO's presence also encouraged residential land use on the peninsula indirectly, as builders began to take advantage of the roads and water lines put in place for the plant's use to develop lakefront residential properties.

ANO's construction and operation have also had moderate direct and indirect impacts on land use in other parts of Pope County. In the early 1970s, developers further subdivided the western section of Russellville for single family residential use. The subdivision and development were the result, in part, of the influx of residents associated with ANO, as construction-related population growth represented as much as 8.3 percent of Pope County's total population in 1974. This growth, combined with the economic benefits the plant brought to the county, helped create additional housing demand. However, the residential construction that occurred did not create significant changes in land-use or development patterns.

The economic benefits of ANO's operation, such as the generation of both direct and indirect jobs, salaries, and tax expenditures in the local economy, continue to help shape Russellville's residential and commercial growth rates and development patterns. Key informants agreed that ANO's direct and indirect residential and commercial land-use impacts had been very positive for Russellville and Pope County but that ANO's impacts in terms of helping recruit new industries to the area had been only neutral or slightly positive (NUREG/CR-2749, vol. 1, p. 140).

C.4.1.5.2 Predicted Impacts of License Renewal

With the plant-related population increase projected for Pope County, the land-use impacts of ANO's refurbishment are expected to be small. Using the bounding-case work force scenario, refurbishment-related population growth is projected to represent approximately a 9.3 percent increase in the county's projected population in 2014. Increases of this size would result in small new impacts to land-use and development patterns, especially when compared to those driven by the construction-related growth peak of 8.3 percent in 1974. ANO's refurbishment and operation would continue to attract some plant-related mixed-use development to the peninsula directly, but this development is not expected to cause major changes in local land-use patterns.

The indirect land-use impacts of ANO's license renewal term are expected to be moderate. Population growth associated with the plant's continued operation is projected to represent only a 0.3 percent increase in Pope County's projected 2014 population, so the new land-use impacts of worker in-migration are expected to be minimal. However, key sources expect residential development to continue on the peninsula because of the availability of desirable lakefront property. As in the past, this continued residential development would be guided by the provision of roads and water service, an indirect impact of ANO's presence. The plant's operation also would result in continued economic benefits such as direct and indirect salaries and tax contributions for Pope County. But the tax benefits may be less than those previously available because of Amendment 59, which in the mid- to late 1980s caused reductions in tax payments on utility property.

Nonetheless, ANO's operation would provide Pope County with economic benefits that would continue to shape land-use and development patterns in Russellville and the rest of the county through the provision of municipal services.

C.4.1.6 Economic Structure

Employment and income effects on the nuclear plant case study areas were identified using historical data generated by Mountain West Research, Inc., in site-specific studies (NUREG/CR-2749, vols. 1-12) and from time series information (from 1968 and forecasted to 2010) on county employment and income provided by NPA. Past plant-related employment was estimated by Mountain West using the RIMS methodology; employees were classified as direct basic, indirect basic, other basic, or nonbasic; and the number of jobs filled by current residents and by in-migrants was identified.

To determine the magnitude of plant-related employment relative to total local employment, the projected number of plant-related jobs filled by people living in the study area (prior residents or in-migrants) was divided by the NPA employment projections. The NPA county-level figures describe employment by place of work rather than by place of residence; however, these values were used as a surrogate for employment by place of residence. This approach was chosen to avoid the substantial error that could be introduced by projecting employment, in light of the large uncertainties concerning future population, family size, family work patterns, and other important parameters. If the study area makes up only part of a county, future study area employment was projected from the current work force of the study area using the same growth rate NPA projected for the county in which the plant is sited. Projected employment effects are presented for the refurbishment scenario and for continued operations during the license renewal term.

For descriptive purposes, the magnitude of plant-related income relative to total study area income also was determined. Projected income for direct basic workers residing in the study area was calculated by multiplying the projected number of direct workers in the study area by the projected average wage for transportation, communication, and public utility workers for the study area county. This average wage was determined by dividing the NPA projection of total county income for that sector by the projected number of workers in that sector countywide.

Projected income for indirect basic and nonbasic workers (employed in jobs produced by plant expenditures and spending by direct employees in the study area) was calculated by multiplying the projected number of these workers residing in the study area by the projected average wage for this type of employment. Plant-related indirect basic and nonbasic workers were assumed to be largely retail and service workers, so their average wage was calculated by summing the projected average wages in those two sectors, weighting the retail salary as 30 percent and the service salary as 70 percent. The average wage in each of these sectors was determined in the manner described above for transportation, communication, and public utility workers.

The magnitude of future plant-related income relative to total study area income was calculated by summing projected incomes for direct, indirect basic, and nonbasic workers and dividing by the total income that NPA projected for the study area.

C.4.1.6.1 Impacts from Plant Construction and Operation

ANO's construction and operation have had moderate and large impacts, respectively, on Pope County's economic structure. Pope County's labor pool has provided employees for the plant, both during construction and operations, and the plant has provided county residents with jobs that have higher incomes than were previously available. Secondary employment and income have also resulted from the spending of ANO workers in local communities, and the taxes paid to the Pope County government and the Russellville School District by ANO have led to increased employment and income.

Table C.19 gives the estimated employment and expenditure effects of ANO for residents of Pope County. Construction employment at ANO rose steadily from 1969 to 1974, gaining fivefold from 215 to 1100. The operations work force increased at a slower pace; from 196 in 1972 to 462 in 1980. Operations employment in 1989 was about 2205 workers, of whom 1985 were Pope County residents.

C.4.1.6.2 Predicted Impacts of License Renewal

The work force scenario detailed in Section C.3.1 was used to estimate the employment effects of refurbishment at ANO. Table C.20 shows the total direct and indirect plant-related employment of Pope County residents during refurbishment.

It is projected that in 2013 ANO would employ 1477 county residents as refurbishment workers (Section C.4.1.1.2). Indirect employment that would result from purchases of goods and services during refurbishment is projected to create 454 additional jobs for Pope County residents.

The total direct and indirect employment affecting Pope County during the peak refurbishment year is therefore projected to be 1931. This employment is projected to be 5.8 percent of the total Pope County work force in 2013, resulting in moderate impacts.

Relatively few new plant-related jobs would be created at ANO during the license renewal term. Nearly all plant-related employment (and associated impacts) expected during that time period would represent a continuation of employment (and impacts) from past operations. Table C.21 shows the impact of the increased labor requirements at ANO after 2013.

The license renewal term work force for ANO would require an estimated 120 additional employees (Section C.4.1.1.2). Of these additional employees, 108 are projected to be Pope County residents. An estimated 47 indirect jobs would also be created because of the license renewal term, and 45 of the jobs are expected to be filled by Pope County residents. With the continued effects of the plant's current employment and the additional jobs to be created, total direct and indirect license renewal term employment is projected to represent 8.9 percent of Pope County employment in 2013. Because Pope County meets the conditions described in Section 4.7.6.1, license renewal term employment represents a large impact to Pope County.

C.4.1.7 Historic and Aesthetic Resources

The assessment of the impacts of (1) past construction and operation and (2) projected refurbishment and postrelicensing operation of nuclear power plants on historic and aesthetic resources began with a review of the original license application documents, the professional literature, and the popular literature. From these, the staff gleaned a sense of the projected and realized impacts at the various power plants. These experiences were examined in some detail through use of case studies conducted at seven representative nuclear power plants across the United States.

By using the original license application documents and telephone interviews with key local informants (see Section C.7 for a sample of the questions asked), those factors most useful in projecting impacts were identified. By examining the associations between these impact predictors and the resulting impacts at the seven sites, the staff drew conclusions concerning the relationships between predictor magnitude and impact significance. The staff then made projections about the impacts of power plant refurbishment and post-relicensing operation for each case study site based on relationships among the magnitude of these impact predictors, the current and anticipated states of critical infrastructure components, and the significance of impacts observed during analogous past periods.

The assessment varies from more traditional aesthetic analyses in that it relies heavily on the opinions and representations of key local sources of information as proxies for the lay local residents' and other users' feelings and preferences. Because of the selection of only these few sources, there could be errors of commission or omission in communicating these values or in the staff's interpretations of the elicited concerns.

This section describes the impacts that the construction and operation of the ANO power plant have had on historic and aesthetic resources and projects the expected impacts of the plant's refurbishment and post-relicensing operations. Information sources include the *Final Environmental Statement Related to the Arkansas Nuclear One, Unit 1* (AEC Docket 50-313); the *Final Environmental Statement Related to Operation of Arkansas Nuclear One, Unit 2* (NUREG-0254); and interviews with key information sources in Pope County, Arkansas.

C.4.1.7.1 Impacts from Plant Construction and Operation

ANO is located in the Arkansas Valley, an area that contains many important American Indian archaeological sites, and key sources indicated that ANO's construction did disturb some of the sites. In addition, one respondent (Dr. Stewart-Abernathy of the Arkansas Archaeological Survey and Arkansas Technological University) stated that ANO's operation, particularly the use of service roads to access the station's transmission lines, had caused the erosion of archaeological sites. The respondent did not know the extent to which the sites had been researched or the relative significance of the sites. He was not sure of the extent to which they had been damaged by ANO's construction and operation, and did not know whether mitigation had been attempted at all or, if attempted, whether it had been unsuccessful. However, all respondents agreed that Lake Dardanelle's—impoundment, which predated and was not related to ANO's construction—had inundated a number of relatively significant archaeological sites and that the lake's creation had had a much greater impact than ANO's construction. The Arkansas Archeological Survey Coordinating Office, the Arkansas State Parks and Tourism Commission, and the Arkansas State Historic Preservation Office all determined that the construction and operation of the station would not affect any historic structures or sites listed in the *National Register of Historic Places* (AEC Docket 50-313, p. 2-15; NUREG-0254, p. 2-2). In general, local sources felt that ANO's construction and operation had disturbed some American Indian archaeological sites, but they agreed that the power plant had no effect on other historic resources in Pope County. Overall, the construction and operation of the ANO plant have had generally small impacts on historic resources in Pope County.

ANO's construction and operation have also had small to moderate impacts on aesthetic resources in Pope County. The most noticeable aesthetic impact of ANO's operation results from the presence of Unit 2's 140-m (450-ft) high, natural-draft cooling tower and the steam plume it emits (staff observation and Stewart-Abernathy). The station's cooling tower is visible from at least 16 km (10 miles) away, and its plume can be seen from a much greater distance (AEC Docket 50-313). The cooling tower and its plume have adverse effects on the natural beauty of the area, but key informants indicated that the station's appearance had not discouraged residential or recreational land uses on Lake Dardanelle and had not been a subject of protest.

C.4.1.7.2 Predicted Impacts of License Renewal

Because ANO's refurbishment is not expected to change the visible profile of the plant, the impacts of refurbishment on aesthetic resources would be much smaller than those experienced during construction. However, the impacts of post-relicensing operations are likely to be the same as those experienced during the original operating period. Operations impacts would result from the presence of ANO's cooling tower and steam plume. As in the past, the station would have small to moderate impacts on aesthetic resources.

ANO's refurbishment is not expected to involve the physical conversion of additional land for the station's use; however, any disturbance of land (e.g., grading an area for storage of refurbishment equipment or parts, or constructing a new service road) introduces the potential for impacts to archaeological resources. Although impacts to historic resources (including archaeological resources) are expected to be small during both refurbishment and operations, this determination must be made according to the National Historic Preservation Act of 1966 through consultation with the state historic preservation officer (SHPO). Impacts, if any, during the license renewal term are expected to be small; however, consultation with the SHPO is required.

C.4.2 D. C. Cook

The impact area—the area in which the most pronounced socioeconomic impacts might result from refurbishment and license renewal for D. C. Cook—consists of Berrien County, the city of Bridgman, and Lake Township, Michigan. For the purpose of assessing the impacts of D. C. Cook on taxes and economic structure, the impact area is limited to Bridgman and Lake Township. Both of these are jurisdictions within Berrien County that are close to the plant. The selection of this area is based on worker residence patterns, employment, expenditures, and tax payments. Figure C.6 depicts the impact area, and Figure C.7 shows the region in which it is located.

C.4.2.1 Population

This section discusses the local population growth associated with the construction, operation, and license renewal of the D. C. Cook Nuclear Plant. Section C.4.1 describes the methodology used to project population growth for all plants. Data used to prepare this section were obtained from *Socioeconomic Impacts of Nuclear Generating Stations: D. C. Cook Case Study* (NUREG/CR-2749, vol. 4); *Environmental Assessment Proposed Rule for Nuclear Plant License Renewal* (NUREG-1398); SEA refurbishment work force estimates (Appendix B; SEA 1994); population projections by the Southwestern Michigan Regional Planning Commission; and the Indiana and Michigan Power Company.

The discussion of population growth is organized into two time periods. Section C.4.2.1.1 identifies the population growth that the study area experienced as a result of the construction and operation of D. C. Cook from 1969 to 1990. Section C.4.2.1.2 projects the population growth that is expected to result from D. C. Cook's refurbishment period and license renewal term operations beginning in 2015 (Unit 1) based on the growth associated with the plant's initial construction. Section C.4.2.1.2 also projects the population growth expected to result from D. C. Cook's license renewal term based on the growth associated with operations in the past.

C.4.2.1.1 Growth Resulting from Plant Construction and Operation

D. C. Cook's construction resulted in noticeable population increases in the Bridgman/Lake Township area surrounding the plant (Table C.22). During the peak construction year, 1972, D. C. Cook personnel and their families who migrated to the area to work at the plant and others who moved into the area to work in jobs generated by the plant's presence, totalled approximately 175 persons. This influx of new residents represented 4.6 percent of the two communities' populations.

In 1990, 1252 permanent plant staff were on-site at D. C. Cook. (Additional contract workers have been on-site during outages, but they are not included because their presence at the plant was temporary.) Based on the residential settlement pattern of D. C. Cook's 1978 work force, it was estimated that 10.6 percent (133) of the permanent work force in 1990 resided in Bridgman/Lake Township (NUREG/CR-2749, vol. 4, pp. 88–89). Also based on previous plant operating experience, it was estimated that 54 percent (72) of those residing in Bridgman/Lake Township in 1990 were previous residents who obtained jobs and that 46 percent (61) were workers who migrated into the area for jobs. Following the pattern set during plant operations, it was estimated that 60 percent of the in-migrants (37) were accompanied by their families (Table C.23). Using the 1990 Michigan average family size of 3.16 persons, this represented a total in-migration of 141 new residents for Bridgman/Lake Township. Based on the ratio of nonplant to plant jobs created in 1978, D. C. Cook's 1990 operations created an additional 424 indirect jobs in industries supported by the spending of D. C. Cook workers. Approximately 15 of these indirect jobs were filled by current

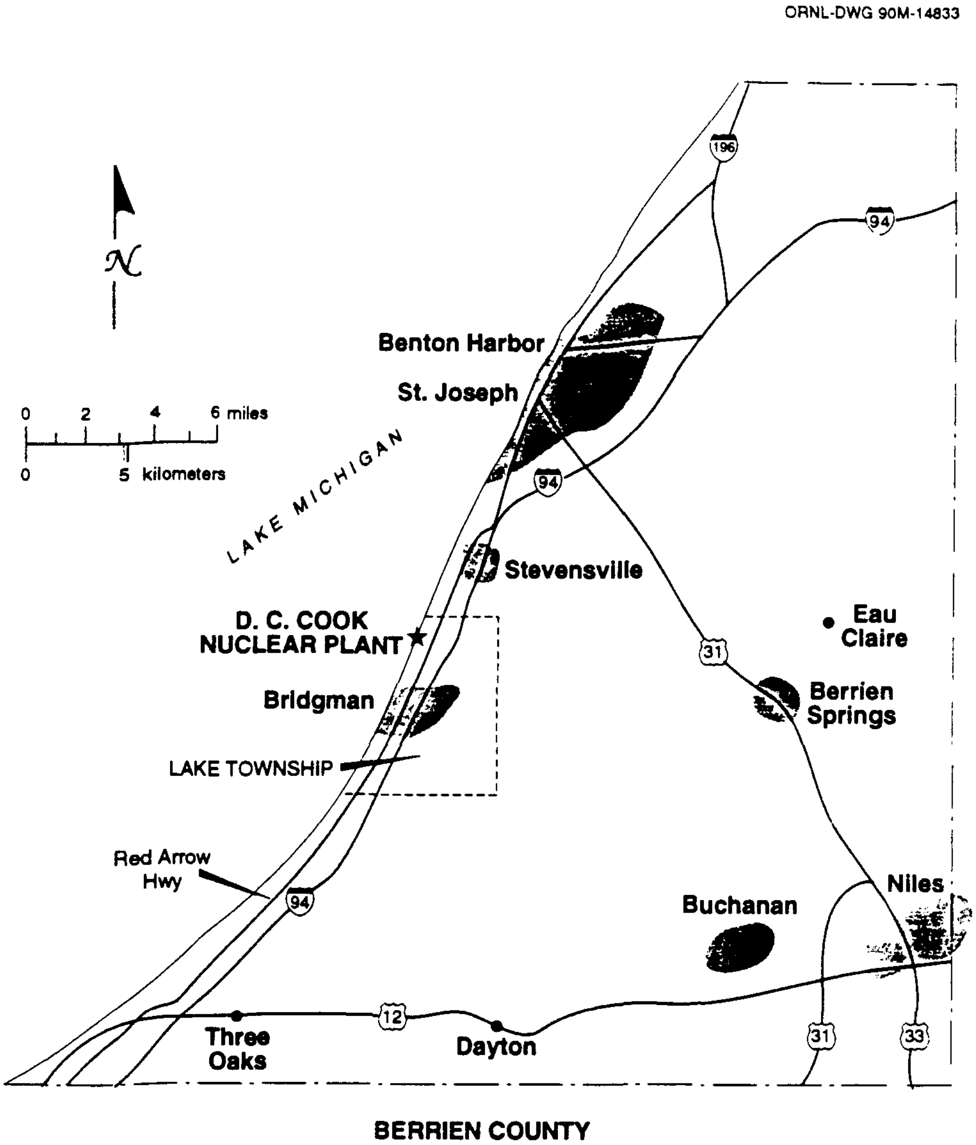

Figure C.6 Socioeconomic impact area associated with D. C. Cook refurbishment, including Berrien County, Lake Township, and Birdgman.

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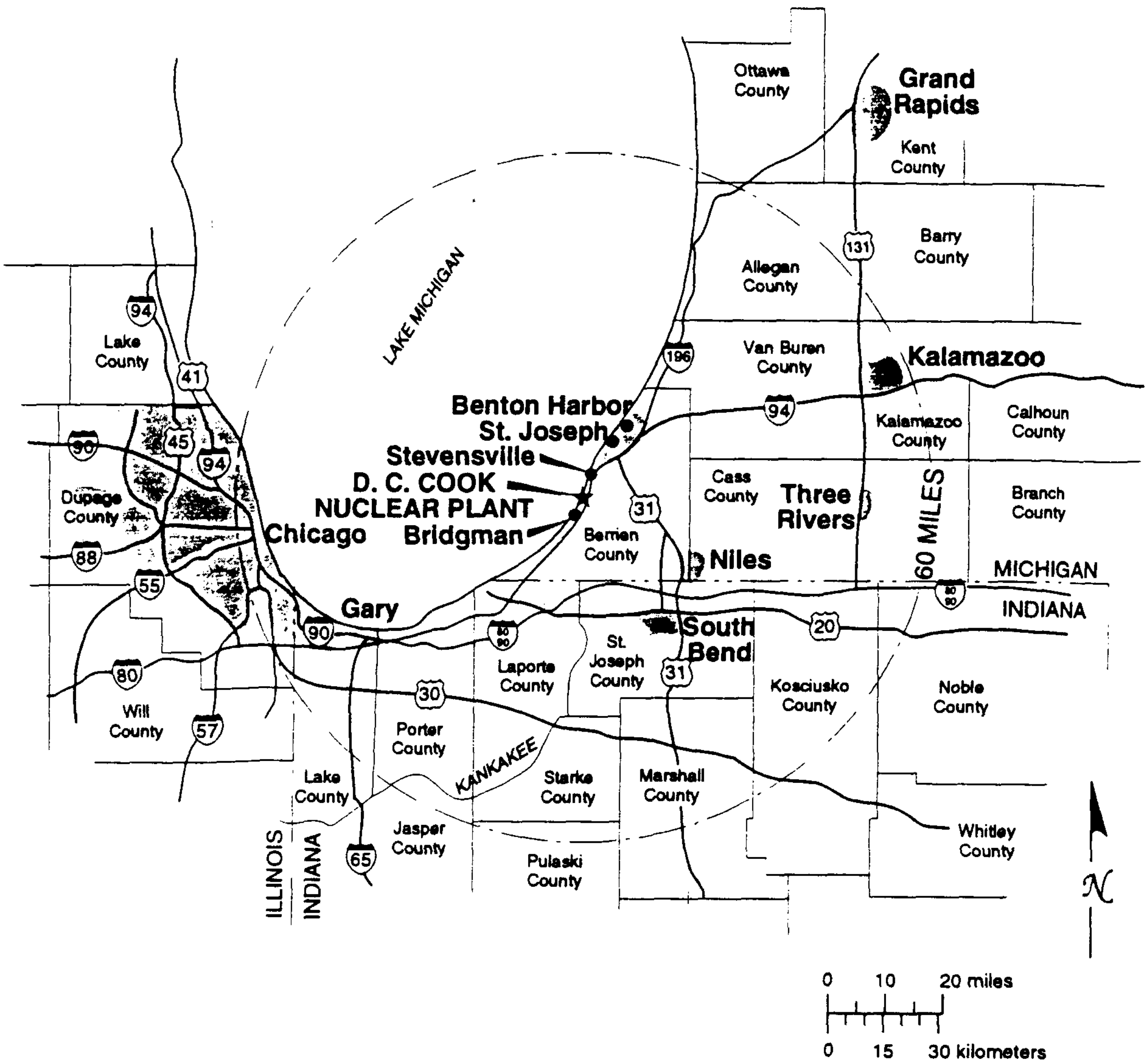

Figure C.7 Region surrounding the D. C. Cook nuclear plant.

residents of Bridgman/Lake Township; no additional in-migration resulted from indirect employment. In all, approximately 141 new residents moved into Bridgman/Lake Township as a result of D. C. Cook's 1990 operations (Table C.23). These new residents make up about 3.0 percent of the communities' 1990 population of 4627 (NUREG/CR-2749, vol. 4, p. 88–115).

The larger jurisdiction of Berrien County has experienced proportionally less population growth as a result of the D. C. Cook plant. In 1972, D. C. Cook personnel and their families who migrated to the county to work at the plant and others who moved into the area to work in jobs generated by the plant's presence totalled approximately 2193 persons, representing only 1.3 percent of the county's population. In 1990, based on the residential pattern of D. C. Cook's 1978 work force, it was estimated that 80 percent (1002) of the permanent plant staff of 1252 resided in Berrien County (NUREG/CR-2749, vol. 4, pp. 88–89). Also based on previous plant operating experience, it was estimated that 54 percent (541) of those residing in Berrien County in 1990 were prior residents who obtained jobs and that 46 percent (461) were workers who migrated into the area for jobs. Also following the pattern set during plant operations, about 60 percent of the in-migrants (277) were accompanied by their families. Assuming the 1990 Michigan average family size of 3.16 persons, this represents a total in-migration of 1059 new residents for Berrien County (Table C.24). Based on the ratio of nonplant to plant jobs created in 1978, D. C. Cook's 1990 operations created an additional 424 indirect jobs. As a result of these indirect jobs, an estimated 22 additional workers and their families (a total of 50 persons) moved into the county. In all, approximately 1109 new residents moved into Berrien County as a result of D. C. Cook's 1990 operations (Table C.24). These new residents made up about 0.7 percent of the county's 1990 population of 161,378 (NUREG/CR-2749, vol. 4, pp. 88–115).

C.4.2.1.2 Predicted Growth Resulting from License Renewal

As discussed in Section C.3.1, D. C. Cook's license renewal would require the completion of a number of refurbishment tasks for Units 1 and 2. Many of the refurbishment tasks are expected to be completed during scheduled refueling outages at each unit during the 10 years that precede the expiration of the initial operating license. However, the final refurbishment work is expected to be completed during one large refurbishment outage scheduled for each unit in the year before the unit's initial operating license expires. Because the final refurbishment outage would involve more workers on-site over a longer period of time than any of the preceding refueling outages, it represents the peak refurbishment period. For other assumptions concerning the refurbishment work force, refer to Section C.3.1 and Section C.4.1.1.2.

Given the refurbishment schedule previously described and in Section C.3.1, the peak refurbishment year for D. C. Cook Unit 1 is expected to be 2014, and the peak refurbishment year for D. C. Cook Unit 2 is expected to be 2017. For each unit, the on-site refurbishment work force would be about the same size, and the work force would be on-site for approximately the same period of time (Section C.4.1.1.2 for other work force assumptions). However, because there are uncertainties concerning the length of the outage and the size of the work force required to complete the refurbishment of a given unit, this section examines a bounding case work force scenario as described in Section C.3.1.

Given the work force scenario detailed in Section C.3.1, it is estimated that 2273 workers would be on-site to complete refurbishment of D. C. Cook Unit 1 in 2014 and D. C. Cook Unit 2 in 2017 (SEA 1994). Further, assuming that the residential distribution of refurbishment workers would be similar to that of the 1972 D. C. Cook construction work force, it is estimated that 66 percent (1500) would reside in Berrien County and that 5.4 percent (123) would reside in Bridgman/Lake Township (NUREG/CR-2749, vol. 4, pp. 69, 80). Based on plant construction experience, it is estimated that 44.7 percent (534) of those residing in Berrien County would be prior residents who obtain refurbishment jobs and 55.3 percent (830) would be workers who migrate into the area for refurbishment jobs (Table C.25). Also following the pattern set during plant construction, half of the in-migrants (415) would be accompanied by families. Using an average family size of 3.16 persons, total refurbishment worker in-migration would result in 1726 new residents for Berrien County (of whom 141 would reside in Bridgman/Lake Township) (Tables C.25 and C.26). Based on the ratio of nonplant jobs created in Berrien County in 1972, D. C. Cook's refurbishment is projected to create an additional 832 indirect jobs in service industries supported by the spending of refurbishment workers. As a result of these indirect jobs, an estimated 43 additional workers and their families (a total of 99 persons) would be projected to move into Berrien County (Table C.25). In all, approximately 1825 new residents would be expected to move into Berrien County and 141 new residents into Bridgman/Lake Township (Table C.26) as a result of D. C. Cook's refurbishment under the bounding case work force scenario. That would represent 1.0 percent of Berrien County's projected population of 186,626 in 2015 and 3.1 percent of Bridgman/Lake Township's projected population of 4548 in 2015 (NUREG/CR-2749, vol. 4, pp. 69–109).

Once plant refurbishment is completed for D. C. Cook Units 1 and 2, the work force would consist mostly of permanent plant staff. Additional refurbishment/refueling workers would be temporarily on-site approximately every 2 years, but they would not be permanent, on-site plant staff, and many of them are expected to commute from outside the study area. It is expected that a maximum of 60 additional permanent workers per unit would be required during the license renewal term, adding 120 workers to D. C. Cook's existing work force (NUREG-1398). Assuming that the new workers' residential distribution would be the same as that of current staff, approximately 80 percent (96) would reside in Berrien County, of whom 13 would reside in Bridgman/Lake Township (NUREG/CR-2749, vol. 4, pp. 88–89). Based on worker in-migration in 1978, it is expected that 54 percent (52) of those residing in Berrien County would be prior residents who obtain operations jobs and that 46 percent (44) would be workers who migrate into the area for jobs (Table C.27). Also following the pattern set during plant operations, 60 percent of the in-migrants (26) would be accompanied by their families. Using an average family size of 3.16 people, total in-migration would result in 100 new residents for Berrien County (of whom 15 would reside in Bridgman/Lake Township) (Tables C.27 and C.28). Based on the ratio of nonplant jobs created in Berrien County in 1978, D. C. Cook's continued operation is projected to create an additional 41 indirect jobs in service industries supported by the spending of plant workers. As a result of these indirect jobs, an estimated two additional workers and eir families (a total of about four persons) would be projected to move into Berrien County (Table C.27). In all, approximately 104 new residents would be expected to migrate into Berrien County as a result of D. C. Cook's license renewal term, 15 of whom would live in Bridgman/Lake Township (Table C.28). That would represent less than 0.1 percent of Berrien County's projected population of 186,626 in 2015 and 0.3 percent of Bridgman/Lake Township's population of 4548 in 2015 (NUREG/CR-2749, pp. vol. 4, 88–113).

C.4.2.2 Housing

The following sections examine the housing impacts that occurred in Bridgman, Lake Township, and Berrien County during construction and operation of D. C. Cook Nuclear Plant and predict housing impacts that would result from refurbishment activities and continued operation. Possible impacts to housing include changes in the number of housing units, particularly the rate of growth of the housing stock; changes in occupancy rates; changes in the characteristics of the housing stock; and changes in rental rates or property values.

Section C.4.1.2 includes a complete discussion of methodology and assumptions used to predict housing impacts.

C.4.2.2.1 Impacts from Plant Construction and Operation

The following discussion begins with a description of the housing market at the time of D. C. Cook's construction and details project-related housing demand in the study area. A discussion follows of changes that occurred in the housing market and impacts on housing induced by plant construction. Finally, impacts from the operation of D. C. Cook on local housing are assessed.

During plant construction, 1969 through 1978, 10,073 new housing units were built in Berrien County (based on the number of permits issued), approximately 1090 of which were subsidized housing units (NUREG/CR-2749, vol. 4). Of these new units, 320 were in Bridgman and 146 were in Lake Township. This represents a 16.9 percent increase in the 1970 housing stock. For comparison, in the 1960s and 1950s, respectively, 11,720 and 11,165 housing units were constructed in Berrien County (NUREG/CR-2749, vol. 4). Fewer new housing units were added to the housing stock during the construction period than in the two previous decades.

Project-related demand for housing in Berrien County and the study area has been estimated according to the number of plant construction workers who moved to the area (NUREG/CR-2749, vol. 4). In 1972, project-related work force peaked at 2377, while commensurate housing demand peaked at 902 and 81 units, respectively, in Berrien County and the study area. Housing starts during 1969, 1970, and 1971 were over 3000 (2510 excluding subsidized units) for Berrien County and 87 for the study area. Vacancy rates in Berrien County, of units either for sale or for rent, were 2.2 percent in 1960, 2.8 percent in 1970, and 10.3 percent in 1975. Homeowner vacancy rates went from 1.3 percent in 1970 to 1.4 percent in 1974, whereas rental vacancy rates fell from 7.1 percent in 1970 to 5.6 percent in 1974. (The discrepancy between 1974 and 1975 vacancy rates is consistent with a decline in project-related demand for housing.) This demonstrates that the housing stock was expanding faster than project-related demand.

During the project construction period, a substantial number of multifamily units were built in Bridgman and Berrien County. There were 230 multifamily units built in Bridgman in the period from 1969 through 1978—70 percent of all units constructed. In Berrien County, 4460, or 44.3 percent, of all units constructed during this period were multifamily units. This contrasts with 1970 census figures that report that 21.3 percent of the year-round units in Bridgman and 18.7 percent of the year-round units in Berrien County were multifamily units. Lake Township did not experience a great increase in the number of multiunit structures. The in-migration of project-related workers either induced or accelerated the construction of apartment buildings. Another source of housing during the plant construction period was mobile homes. However, local ordinances of Bridgman and Lake Township prohibited the establishment of mobile home parks. Because of poor land drainage, septic tanks required large areas of land. However, in the neighboring Baroda and Lincoln Townships, mobile home parks were built or expanded and accommodated many project-related residents.

Property values have changed little as a result of the D. C. Cook plant. Between 1970 and 1980, comparable increases in the median value of houses occurred in Berrien County and the state of Michigan (U.S. Bureau of the Census 1978, 1988). The median value of houses in Bridgman increased 146 percent between 1970 and 1980, whereas the value increased 126 percent and 122 percent in Berrien County and Michigan, respectively. Property values in the study area have increased more because of the public water and sewer system and because of high prices paid by seasonal residents for lakefront property than because of the plant's presence. During construction of the D. C. Cook plant, the Bridgman area had a lower average selling price for residential units than did the neighboring areas of St. Joseph and Lincoln Township (NUREG/CR-2749, vol. 4). Rental rates increased between 1970 and 1980 by 126 percent in Bridgman and by 154 percent in Michigan (U.S. Bureau of the Census 1972, 1982).

In summary, peak project-related demand for housing in the study area and Berrien County and Bridgman/Lake Township was 6.6 percent and 1.8 percent, respectively, above the existing 1970 housing stock. This demand may have brought on or hastened construction of apartments in the area and increased the occupancy rates of short-term rental units, but the large pool of available housing within the county meant there was little or no impact on property and rental values.

C.4.2.2.2 Predicted Impacts of License Renewal

Project-related population increase and the commensurate housing demand would bring about the new housing-related impacts during refurbishment activities. A summary of recent and anticipated growth in housing is provided. This is followed by predictions of possible impacts during refurbishment and the license renewal term.

Between 1980 and 1990, the number of housing units in Berrien County increased 1.1 percent (U.S. Bureau of the Census 1988, 1990). If this growth rate remains constant, there may be about 71,500 housing units in Berrien County in 2014.

Population projections for Berrien County in 2015 estimate a county population of 186,626. Based on the average household size of 2.6 persons (U.S. Bureau of the

Census 1990), this is the equivalent of 71,779 households. Although adjustment in housing growth will be made according to population growth, the current rate of growth suggests that housing availability will be limited in the study area during refurbishment activities.

According to the estimate of the number of workers required for plant refurbishment and based on plant construction experience, 830 workers of the projected work force of 2273 are expected to migrate to Berrien County for refurbishment jobs; 68 of these would locate in Bridgman/Lake Township. Of these in-migrants, 415 are expected to be accompanied by families. Some doubling-up is expected to occur among the 415 unaccompanied workers, so that each unaccompanied mover would require 0.85 housing unit. In-migration of these workers to Berrien County would result in a total refurbishment-related housing demand in the peak year of refurbishment of 768 housing units. In addition, numerous indirect jobs are expected to result from the spending of refurbishment workers. An additional 43 workers are projected to move to Berrien County, bringing the total project-related housing demand in the peak year of refurbishment to 811 units.

Refurbishment-related housing demand is less than the original construction-related housing demand of 902 units, and the number of housing units in Berrien County will have increased about 25 percent between peak construction and refurbishment periods. Refurbishment-related housing demand would account for 1.1 percent of the possible 71,500 housing units in the study area in 2014. However, based on the current housing growth rate there remains the possibility that availability will only slightly exceed non-refurbishment-related housing demand. Therefore, even a 1.1 percent increase in demand may result in moderate impacts to housing during refurbishment. If the growth rate accelerates only slightly to 2 percent per 10 years (a very low rate compared to state and national averages), sufficient housing should be available in Berrien County, and only small impacts would occur.

Housing impacts related to housing value and marketability that would occur during the license renewal term are the same as those that have occurred during current plant operation (Section C.4.2.2.1). As during current operations, housing values would not be affected in the license renewal term. The 120 additional operations workers (60 per unit) required during the license renewal term and the commensurate housing demand would cause only small new housing impacts.

C.4.2.3 Taxes

C.4.2.3.1 Impacts from Plant Construction and Operation

The D. C. Cook plant had an important effect on taxes during construction and operation. As the state equalized value (SEV) of the D. C. Cook plant increased during construction, it became the predominant source of funds in Lake Township and the Bridgman Public School District. It also became the largest single SEV property for Berrien County.

The jurisdictions that tax the D. C. Cook Nuclear Plant are the state of Michigan, Berrien County, Lake Township, and the Bridgman Public School District. Although the city of Bridgman does not tax the D. C. Cook plant, it is within the Bridgman Public School District, so the total property tax bill of city residents is affected by the school district. The revenues for Berrien County shown in Table C.29 have been adjusted by the GNP implicit price index to 1988 dollars so that amounts can be compared without being distorted by inflation. Data are included for 1967, the year before plant construction; 1972, the peak year of construction; 1978, the first year in which both units were operating; and 1988, the most recent year for which data are available. Note that from 1967 until 1988, the price index changed by greater than a factor of 3.

Table C.30 presents the assessed valuation of the D. C. Cook plant as a percentage of the total assessed valuation of each taxing jurisdiction. Note that D. C. Cook's contribution to the local tax base increased rapidly during construction. D. C. Cook's share of the total assessed value of the three local tax jurisdictions has continued to increase since commercial operation began.

The large assessed value of D. C. Cook resulted in two effects on local government—lower tax burdens and better public services. These effects were limited, primarily occurring within Lake Township and the Bridgman School District but to a lesser extent in Berrien County. Because the value of the nuclear plant and equipment was so large relative to the total assessed value, property tax rates yielded very high revenues per resident in these taxing jurisdictions. This resulted in millage rates much lower than otherwise required for the level of services provided. For instance, the Bridgman School District levies about one-fourth of average property tax rate (millage) for all Michigan school districts. At the same time, its expenditures are about twice the Michigan average per pupil ($7000 vs $3500). Average teacher salaries are considerably higher than the state average, and the school district has built a swimming pool, an unusual occurrence for a school district that has only 850 pupils for grades kindergarten through 12. Lake Township has a more limited ability to levy property tax. However, it does have its own water supply and participates in a sewer system. These services are unusual for a township and can be attributed to the large value of the D. C. Cook plant. The levies for sewer and water systems would be 10 times as high without D. C. Cook in the tax base.

In both Lake Township and the Bridgman School District, revenues from property tax increased as a source of total revenues from about 50 percent before construction began on D. C. Cook to more than 90 percent. There was a large real increase in the total revenues. Bridgman School District revenues increased by more than four times, going from approximately $1.2 million in 1967, to $4.2 million in 1978, to $5.5 million in 1988. Lake Township revenues increased from about $137,000 in 1968 to $1.4 million in 1978 (NUREG/CR-2749, vol. 4) and $3.2 million in 1989.

Berrien County revenues from property taxes have doubled between 1967 and 1988. However, much less of this increase can be attributed to D. C. Cook than in the case of Lake Township and Bridgman School District. Property taxes as a percentage of total revenues have fluctuated considerably in Berrien County (Table C.29).

The total current property tax millage levied on D. C. Cook is slightly over 24 mills. D. C. Cook's contribution to taxes is most important within the school district, which levies about 8.4 mills on the SEV. Berrien County levies about 5.4 mills for its general fund. No other levy is more than 3 mills. Table C.31 presents the most recent millage rates that apply to D. C. Cook's most recent SEV of $532 million and the revenues provided by D. C. Cook to various county and subcounty jurisdictions. D. C. Cook provided 14 percent of Berrien County's $20.3 million revenues in 1989, 88 percent of Lake Township's $3.2 million revenues, and 81 percent of the Bridgman School District's $5.5 million revenues.

In general, the Bridgman School District and Lake Township are quite dependent on revenues from the D. C. Cook plant. The school district has low tax rates and excellent facilities as a result of the plant. It receives almost no aid from the state of Michigan because of its high valuation per pupil. Lake Township receives much higher than average property tax revenues per resident. As a result, it can provide more and better township services, including water and sewer services.

Revenues from D. C. Cook have had a noticeable impact for Berrien County and a significant impact for the school district and Lake Township, which have a much smaller total tax base and much smaller populations.

C.4.2.3.2 Predicted Impacts of License Renewal

The new tax-related impact expected to occur during refurbishment of D. C. Cook results from capital improvements undertaken during the current term outages. The assessed value of the plant would increase during this time, thus increasing D. C. Cook's tax payments to local jurisdictions. This new impact does not involve capital improvements that take place7 during the final refurbishment outage and that would be reflected in the plant's assessed value during the license renewal term. The magnitude of the new impact depends on which improvements would occur at D. C. Cook early on and which would be done during the final outage. For example, if the steam generator is replaced during a current term outage, the assessed value may increase considerably before the license renewal term begins. If steam generator replacement and other major capital improvements are not undertaken early on, the increase in assessed valuation may be only minor. The increase, in either case, is expected to cause only an small to moderate new tax impact.

During the license renewal term, the tax-related impact primarily would be the continuation of tax payments D. C. Cook is currently making to local jurisdictions. D. C. Cook currently provides 14 percent of Berrien County's revenues, 86 percent of Lake Township's, and 80 percent of Bridgman School District's. A new impact would also result from the increase in tax payments because of improvements made at D. C. Cook during the final refurbishment period. Thus, tax revenues would increase in absolute terms but may remain constant or increase as a percentage of total revenues of the taxing jurisdictions. The assessed valuation may continue to increase slightly throughout the license renewal term because it is based partly on replacement costs. Based on current conditions, D. C. Cook tax revenues—the continuing and additional payments combined—are expected to continue to make up a large share of the total revenues in the smaller taxing jurisdictions of Lake Township and Bridgman School District and a noticeable share of revenue in Berrien County. During the license renewal term, tax-related impacts would continue to be large in Lake Township and Bridgman School District.

C.4.2.4 Public Services

C.4.2.4.1 Impacts from Plant Construction and Operation

Before the construction of the D. C. Cook plant, the majority of public services in the study area were provided by Berrien County. Lake Township and the city of Bridgman, which provided some limited services, have benefitted most from the D. C. Cook plant because of the amount and distribution of the plant's property tax payments. For example, per capita public service expenditures nearly doubled between 1967 and 1978. Since operations at D. C. Cook began, existing facilities have been upgraded in the area and new ones have been built.

Because Berrien County and the city of Bridgman do not receive direct property tax benefits from the plant, they have not realized the same positive economic impacts as Lake Township and the Bridgman School District. Information pertaining to expenditures is discussed in detail in Section C.4.2.3.

Education

The D. C. Cook plant's construction labor force had only a minor impact on enrollment in the Bridgman School District, as total enrollment increased from 774 in 1968 to 788 in 1972, the year of peak construction. Annual enrollment continued to increase for several years during construction and operations. However, the total enrollment increase of 114 students from 1968 to 1978 indicates that the plant's construction and operations work forces have not affected the demand for educational services in the Bridgman School District (NUREG/CR-2749, vol. 4, p. 161).

The D. C. Cook plant has had a positive impact on the availability of funds for educational services and facilities in the school district. Before the construction of the D. C. Cook plant, approximately 40 percent of the district's revenues came from state funding; by 1978, state funds made up only 3.6 percent of the district's revenues. Currently, the state of Michigan does not contribute funds to the Bridgman School District because the district's expenditure per student is $7000, twice the average for the state (NUREG/CR-2749, vol. 4, pp. 163–164). Funds from the D. C. Cook plant's tax contributions allowed the construction of school facilities and a swimming pool, an increase in per student expenditures, and a reduction in the student-staff ratio from 19 to 1 in 1969 to 9 to 1 in 1978 (NUREG/CR-2749, vol. 4, p. 164).

Local officials mentioned the quality of the Bridgman School District's curriculum and facilities as a source of community pride and a factor that has attracted home buyers.

Transportation

Transportation has been affected by the D. C. Cook plant in varying ways. During construction, the increase in traffic was substantial, as it has been with operations. The most heavily affected areas were county roads in the vicinity of the plant. Most of the problem was alleviated by installing a traffic light at the intersection of the plant's access road and Red Arrow Highway. Traffic has also been affected moderately in Bridgman, but impacts have not caused increases in the demand for city road maintenance.

Bridgman, which does not collect revenues directly from the plant, made improvements in its road system between 1968 and 1978, but it did so with monies from the state motor vehicle highway fund, not from revenues of the D. C. Cook plant (NUREG/CR-2749, vol. 4, p. 167). Berrien County's Road Commission is responsible for the maintenance of county roads and contracts to provide road maintenance and repair for Lake Township. The county also contracts with the city of Bridgman to maintain its portion of the Red Arrow Highway. Local highway officials "thought that the construction and operation of the project did not have a substantial effect" on highway maintenance or repair in Berrien County, although the increased traffic was substantial (NUREG/CR-2749, vol. 4, p. 166).

In Lake Township, however, some major road improvements have been undertaken. Plant-related revenues helped finance the upgrades (NUREG/CR-2749, vol. 4, p. 167), which were made even though the D. C. Cook plant did not create additional needs in terms of road maintenance. These improvements amount to a positive economic impact of the D. C. Cook plant.

Public Safety

Construction, operations, and refurbishments at the D. C. Cook plant have had insignificant impacts on the demand for public safety. However, the fiscal impacts on public safety have been positive. Police, fire, and rescue units in the area all grew and improved after the plant's construction began (NUREG/CR-2749, vol. 4, pp. 170–171).

When construction began, the Berrien County Sheriff's Department contracted to provide police protection for Lake Township. During D. C. Cook's construction, Lake Township worked with Baroda Township to create a joint police department with three officers and one elected constable. However, this increase was not related to any increased demand for police services caused by the plant, and no taxes from D. C. Cook were specifically marked for police services. Like the Lake/Baroda Department, the county sheriff's department's services have not been affected by the plant's presence, as no changes in demand have been attributed to the D. C. Cook project.

Similarly, in Bridgman the plant did not affect demand for services or availability of revenues related to the expansion. Between 1967 and 1978, the Bridgman Police Department expanded from one part-time and one full-time officer to four full-time officers. In addition, the police department began to offer 24-hour service in 1977.

Bridgman's expenditures for fire and ambulance services doubled (in constant 1972 dollars) between 1967 and 1978. By 1978, the Bridgman Fire Department was manned by 16 part-time firefighters. The city also participated with Lake Township and the city of Baroda in providing emergency rescue service. Similarly, the property tax contributions from the D. C. Cook plant probably provided for a great percentage of the cost of upgrading the emergency rescue service operated jointly by Bridgman, Baroda, and Lake Township. Other than the participation of members of the Bridgman Fire Department in training at the D. C. Cook plant, there is no indication that the plant's presence has affected the demand for or provision of the city of Bridgman Fire Department or emergency rescue services.

By the time D. C. Cook was completed in 1978, the Lake Township Fire Department was manned by 17 part-time firefighters. The township had just purchased two new fire trucks, upgraded the fire department's communications system, and installed hydrants throughout the township. Although the additional funds Lake Township derived from the D. C. Cook plant helped fund its purchases for fire-fighting improvements, the actual impact of the plant is not clear because it would be impossible to accurately measure the plant's influence.

The D. C. Cook plant's construction and operations have had no effects on demand or the availability of funds for civil defense and emergency preparedness in Berrien County.

Social Services

During construction and operations, the Berrien County Department of Social Services administered social programs in the study area. Because no property tax revenue was allocated for this department, there was no notable impact on social services during either the construction or operation periods because of increased tax revenues (NUREG/CR-2749, vol. 4, pp. 172). Also, no impacts were reported from project-related personnel.

Public Utilities

The director of the County Planning Commission and of the County Department of Public Works reported that the construction and operations of the D. C. Cook plant have had no direct effect on the county's public services. Tax revenues have supported the provision of a number of services and amenities, however. These include the township's water and sewer system and copper-roofed Township Hall.

In the late 1960s, the township had no water system, so residents relied on individual wells. The local geology also created problems in terms of quality, quantity, and location of water. A system was in demand. This desire was strengthened in 1969 when a large firm expressed interest in locating a plant in Bridgman or Lake Township but indicated that its location decision was dependent on the availability of public water (NUREG/CR-2749, vol. 4, p. 173).

Lake Township has now installed an $8.5 million water system, financing it through a bond issue. Although the water system was not built because of added demands created by the D. C. Cook plant or its employees, the availability of property tax revenues from the plant "made feasible the financing of the project" (NUREG/CR-2749, vol. 4, p. 173). The Lake Township supervisor confirmed this, stating that if the plant had not been located there, public water or sewers would have been unavailable in the township (Wasko 1990). This substantially improved the availability of a public service but had relatively low costs to the average resident of the township (NUREG/CR-2749, vol. 4, p. 173).

The D. C. Cook plant continues to have positive effects on the township. The Lake Township supervisor reported that the township recently made a $4.5 million expansion to the water plant. The township sold bonds to finance the expansion and will repay the debt with revenue earned from selling surplus water to neighboring jurisdictions. He also stated that the D. C. Cook plant's presence did not require an expansion but that extra millage from the plant enabled the township to expand the system and sell water. The upgrade has increased the plant's output from 7600 to 23,000 m^3 (2 million to 6 million gallons) of water per day (Wasko 1990).

Recreation and Tourism

The construction and operation of the D. C. Cook plant have had positive effects on recreation and tourism in Berrien County. The plant is located in an area that attracts tourism because of its natural beauty and proximity to Interstate 94 between Chicago and Detroit. Many tourists visit the D. C. Cook plant's Energy Information Center, which provides information on nuclear energy and technology and offers an auditorium, a canteen, and a picnic pavilion overlooking Lake Michigan. Key information sources indicated that the center is one of the county's top tourist attractions, hosting over 740,000 registered visitors between 1970 and 1979. Some visitors, such as school groups, come from as far away as Chicago and Grand Rapids to visit D. C. Cook's Energy Information Center. But the center is also popular with local area residents, and its auditorium is frequently used for community events such as arts and crafts shows. Key local informants agreed that the D. C. Cook plant has had positive impacts on tourism and recreation in Berrien County (NUREG/CR-2749, vol. 4, p. 28).

C.4.2.4.2 Predicted Impacts of License Renewal

Based on the estimated 2273 direct workers required during peak refurbishment, the staff estimated that 415 direct workers and 26 indirect workers will migrate with their families to Berrien County (Section C.4.2.1.2). The number of children accompanying these workers is estimated using the Michigan average family size (3.16) and assuming that all families include two adults. Children are expected to be evenly distributed in age from ≤1 to 18 years. Assuming 72.2 percent of these children are school age (5 to 18 years), there will be an average of 0.84 school-age children per in-migrating family, or a total of 370 new students in Berrien County. This represents a 1.0 percent increase above the projected number of school-age children in Berrien County in 2015 (assuming the 1990 age distribution of the population). This slight increase will result only in small impacts to education.

During the construction of D. C. Cook, there were insignificant increases in demands for social services, public utilities, and public safety. Because refurbishment would bring in fewer people (1825) than the initial construction (2193) and the population in the study area in 2015 would be larger, any impacts on these public services would be small.

The fact that the Lake Township/Bridgman area will be better able to provide public service for future population growth reflects one of the D. C. Cook plant's indirect impacts on public service in the study area. In the past, the Lake Township/Bridgman area has been able to expand and upgrade its public service programs and facilities because of the plant's contribution to the jurisdictions' property tax base. This would continue with license renewal, and the overall economic benefits the Lake Township/Bridgman area would accrue with the plant's continued operations. This could change, however, if Michigan state laws were revised to require distribution of taxes on the plant throughout the entire state.

Transportation experienced small to moderate impacts during the construction of D. C. Cook. The refurbishment work force would be less than it was during construction, leading toward smaller impacts, but a continuation of impacts associated with past operations coupled with the additional refurbishment-induced impacts could create moderate future impacts.

Based on past operations, impacts of future operations on public services are expected to be small except for transportation impacts, which would range from small to moderate. The positive small impacts to recreation and tourism will continue.

C.4.2.5 Off-Site Land Use

This section describes the off-site land-use impacts of the construction, operation, and license renewal of the D. C. Cook Nuclear Plant. The discussion of impacts is primarily concerned with land use in the immediate vicinity of the plant, but impacts for the remainder of Berrien County are described where appropriate. Land-use impacts are examined for two time periods. First, Section C.4.2.5.1 identifies the land-use impacts of D. C. Cook's construction and operation. Next, Section C.4.2.5.2 projects the land-use impacts of D. C. Cook's refurbishment period based on the impacts that occurred during the plant's construction. Also, Section C.4.2.5.2 projects the land-use impacts of the plant's license renewal term based on the impacts that have occurred during operations. Information sources for this report include the *Final Environmental Statement Related to the Operation of Donald C. Cook Nuclear Plant, Units 1 and 2* (AEC Dockets 50-315 and 50-316); *Socioeconomic Impacts of Nuclear Generating Stations: D. C. Cook Case Study* (NUREG/CR-2749, vol. 4); and interviews with key information sources in Berrien County. Section C.4.1.5 describes the methods used to assess and project land-use impacts for all case study plants.

C.4.2.5.1 Impacts from Plant Construction and Operation

The 260-ha (650-acre) site upon which the D. C. Cook plant is located includes 1326 m (4350 ft) of beach property on the eastern shore of Lake Michigan near Bridgman. The plant is situated in a waterfront area known for its geologically and ecologically unique wooded sand dunes. At the time construction began in 1968, the D. C. Cook property was bounded by a residential area to the north, the Red Arrow Highway to the east, land that was zoned for agricultural use to the south, and Lake Michigan to the west. The general area in which the plant is located was used primarily as agricultural land, with no large-scale development in the immediate vicinity of the plant site.

The construction of the D. C. Cook plant had an immediate direct impact on shoreline land use in Berrien County. Because the plant site had to be rezoned before construction could begin, it became the first lakeshore property zoned for industrial use within Lake Township. Thus, the construction of the D. C. Cook plant started the industrialization of the previously undeveloped lakefront dune area (AEC Dockets 50-315 and 50-316).

Overall, however, the construction and operation of the D. C. Cook plant have not had significant direct impacts on land use in the plant's immediate vicinity or in Berrien County. Population increases resulting from the plant's construction and operation have been relatively small and have not created significant changes in local land use or residential development patterns. Before the plant's construction, the adjacent lands to the north and south were developing as residential-use areas along the lakeshore, and the plant's construction and operation has neither impeded nor encouraged that development. Residential land-use is well established in the Rosemary Beach area north of the plant, with a combination of new houses and older second-home cottages. In the Livingston Hills and Wildwood Dunes areas south of the plant, residential development has continued throughout D. C. Cook's operations period. Many of the residences south of the plant in Livingston Hills are refurbished second-home cottages, but most of the development in Wildwood Dunes has been made up of new, relatively expensive homes. To the east of the D. C. Cook property, between Red Arrow Highway and Jericho Road, there is a mixture of light industrial and commercial land uses. Much of this land was rezoned from agricultural to industrial in 1984, and a few industries have located there. However, key sources said that the D. C. Cook plant had neither positive nor negative direct impacts in terms of recruiting industrial development to Berrien County. In general, key informants indicated that the land in the immediate vicinity of the D. C. Cook plant had good development potential for residential and light industrial uses and that the plant's presence had only neutral direct impacts on such development.

The D. C. Cook plant has had moderate indirect impacts on land use around the plant and in other parts of Berrien County. Key sources cited Lake Township's 1984 decision to rezone land east of the plant (an area on both sides of Livingston Road, between Jericho Road and Red Arrow Highway) to industrial use as an example. The rezoning was not solely because of the D. C. Cook plant's presence, but the plant was a factor in the decision. Also, because it receives the benefits of the D. C. Cook plant's property tax payments, Lake Township has been able to extend its water and sewer services to almost all parts of the township. According to key informants, the provision of water and sewer services has helped guide residential development in the township. The water and sewer system also has been an impetus to industrial land use, as was the case in siting the Hoover-Ugine plant in Lake Township in the early 1970s. In addition, the Bridgman School District's above-average curriculum and facilities, which would not have been possible without the D. C. Cook plant's tax contributions, are said to have helped encourage residential land use in Lake Township.

C.4.2.5.2 Predicted Impacts of License Renewal

The land-use impacts of the D. C. Cook plant's refurbishment in the immediate vicinity of the plant and in Berrien County are expected to be small. Refurbishment-related population growth is predicted to represent approximately 3.1 percent of Bridgman/Lake Township's projected population in 2015 and approximately 1.0 percent of Berrien County's projected population in 2015. Increases of this size would result in minimal new impacts to land-use and development patterns, especially when compared to those driven by the peak construction-related growth in 1972.

The indirect impacts of D. C. Cook's license renewal term are expected to be greater than the direct impacts of refurbishment. Population growth associated with D. C. Cook's license renewal term is projected to represent only 0.3 percent and less than 0.1 percent of Bridgman/Lake Township's and Berrien County's respective populations in 2015, so new population-driven land-use impacts are expected to be small. However, moderate indirect impacts might continue as a result of the benefits Lake Township and the Bridgman School District receive from the plant's property tax payments. Sewer and water system improvements and expansion, lower property taxes, and improved educational services and facilities are all likely to continue guiding land-use and development patterns in the future, as they have during D. C. Cook's operation thus far.

The D. C. Cook plant's license renewal is not expected to attract or discourage new residential or commercial development directly. Key sources agree that some areas south of the plant, particularly the Wildwood Dunes area, would continue to develop residentially. Certain areas along Jericho Road also are likely to develop as residential-use properties because water and sewer lines are in place and because the area has not been heavily developed. Light industrial development is expected to continue in the area zoned for industrial use just east of the D. C. Cook plant, and continued commercial development is expected along the Red Arrow Highway. As during the D. C. Cook plant's construction and operation, the plant's refurbishment and license renewal are not likely to have large impacts on land use or development.

C.4.2.6 Economic Structure

C.4.2.6.1 Impacts from Plant Construction and Operation

The construction and operation of the D. C. Cook plant have resulted in direct and indirect jobs and income for Berrien County and Bridgman/Lake Township (Table C.32). It is estimated that, in 1972, approximately 137 Bridgman/Lake Township residents were employed directly or indirectly as a result of the project (NUREG/CR-2749, vol. 4). These residents earned an estimated income of $6.3 million (1989 dollars). For all of Berrien County, construction employment represented 2569 jobs and $90 million in income for residents. These figures represented about 8.8 percent of Bridgman/Lake Township's total employment (noticeable impact) and 3.6 percent of Berrien County's total employment (insignificant impact). This income represented 5.3 percent of Berrien County's total income. (*Note:* No data exist on total income for Bridgman/Lake Township.)

In 1978, the plant created an estimated 90 jobs for Bridgman/Lake Township residents and 854 for Berrien County residents. This represented about 4.7 percent of total employment in Bridgman/Lake Township and 1.1 percent of total employment in Berrien County, resulting in insignificant impacts to both areas. In 1978, income from the plant was about $24 million for Berrien County, or 1.4 percent of total income (NUREG/CR-2749, vol. 4).

The income and employment reported in Table C.32 were directly linked to the construction and operation of the D. C. Cook plant. Employment includes (1) persons who already lived in Bridgman/Lake Township or Berrien County and who were hired to work at the plant and (2) persons who moved into the area to gain employment. Additional income and jobs were generated through wages and salaries, as employees spent part of their incomes in Berrien County.

C.4.2.6.2 Predicted Impacts of License Renewal

The impacts of refurbishment and license renewal are expected to be similar in type to the impacts of initial construction and operation. Employment generated by the D. C. Cook plant after license renewal would, for the most part, represent a continuation of the levels generated before refurbishment.

The work force scenario detailed in Section C.3.1 was used to estimate the employment effects of refurbishment at

D. C. Cook. Table C.33 shows the total direct and indirect plant-related employment of residents in Bridgman/Lake Township and Berrien County during refurbishment. Rows 4 and 6 of Table C.33 give the percentage of employment and income, respectively, for Bridgman/Lake Township (column 1) and Berrien County (column 2).

It is projected that D. C. Cook would employ 1500 county residents as refurbishment workers in 2014 (Section C.4.2.1.2). Indirect employment that would result from purchases of goods and services during refurbishment is projected to create 790 additional jobs for Berrien County residents.

The total direct and indirect employment affecting Berrien County during the peak refurbishment year is therefore projected to be 2290. This employment is projected to be 3.3 percent of the total Berrien County work force in 2014, resulting in small impacts.

There would be a moderate employment impact on the Bridgman/Lake Township area assuming the refurbishment work force scenario. The projected number of Bridgman/Lake Township residents employed in plant-related jobs in 2014 is 152. Of these workers, 123 would be conducting refurbishment activities and 23 would be in indirect jobs created by refurbishment. It is estimated that this would represent 7.5 percent of the employment generated in the Bridgman/Lake Township area.

Relatively few new plant-related jobs would be created at D. C. Cook during the license renewal term. Nearly all plant-related employment (and associated impacts) expected during that time period would represent a continuation of employment (and impacts) from past operations. Table C.34 shows the impact of the increased labor requirements at D. C. Cook after 2014.

The license renewal term work force for D. C. Cook would require an estimated 120 additional employees (Section C.4.2.1.2). Of these additional employees, 96 are projected to be Berrien County residents. An estimated 41 indirect jobs would also be created because of the license renewal term, and 39 of the jobs are expected to be filled by Berrien County residents. With the continued effects of the plant's current employment and the additional employment to be created, total direct and indirect license renewal term employment is estimated to represent 1.8 percent of Berrien County employment in 2014. This would result in small impacts.

A greater impact would be felt by the Bridgman/Lake Township area because of license renewal term employment, as 13 of the 120 additional plant staff are projected to reside there. It is also estimated that one indirect job would be created in the area by the additional personnel. Total direct and indirect license renewal term employment in Bridgman/Lake Township is expected to represent 8.1 percent of total employment, resulting in moderate impacts.

C.4.2.7 Historic and Aesthetic Resources

This section describes the impacts that the construction and operation of the D. C. Cook Nuclear Plant have had on historic and aesthetic resources and projects the expected impacts of the plant's refurbishment and post-relicensing operations. Information sources include the *Final Environmental Statement Related to Operation of Donald C. Cook Nuclear Plant, Units 1 and 2* (AEC Dockets 50-315 and

50-316) and interviews with key information sources in Berrien County, Michigan.

C.4.2.7.1 Impacts from Plant Construction and Operation

The construction and operation of the D. C. Cook power plant have had insignificant impacts on historic resources in Berrien County. In the early 1970s, the state of Michigan liaison officer for historic preservation determined that "the construction of the station will not result in an adverse impact on the historic and archaeological resources of the state other than what may have occurred during the already completed construction work" (AEC Dockets 50-315 and 50-316, pp. II-24). The 1973 *Final Environmental Statement* concluded that the construction work had no impact on historical or archaeological resources and projected that the plant's operation also would have no impacts. Key local respondents agreed that the construction and operation of the D. C. Cook plant have not affected historic resources in Berrien County.

The D. C. Cook plant's construction and operation have also had insignificant impacts on aesthetic resources in Berrien County, although the impacts have been slightly more pronounced than those on historic resources. Because of the natural beauty of the lakefront area's geologically and ecologically distinctive wooded sand dunes, the D. C. Cook plant was designed with aesthetic compatibility as a high priority. In addition, the power plant was constructed among trees and high sand dunes so that it could not be seen from adjacent properties, and all of the plant's buildings (except for the reactor containment buildings) were painted to blend with the natural landscape. Key sources indicated that the plant is visible from Lake Michigan, but that it is not visible from Interstate 94 or from adjacent properties. The informants added that they had rarely heard anyone mention the plant in terms of its physical appearance, and that the impacts of its visual presence were neutral. Because of its remote siting and because the D. C. Cook station was designed and constructed to blend with the natural environment to the maximum extent possible, its aesthetic impacts have been minimal.

C.4.2.7.2 Predicted Impacts of License Renewal

The impacts of the D. C. Cook plant's refurbishment and post-relicensing operation on historic and aesthetic resources in Berrien County would likely be less pronounced than those that have occurred during construction and would be a continuation of the minor impacts from current operations. As in the past, the plant, which is not highly visible and is not near any historic sites, likely would have only small impacts. However, a determination of potential impacts to historic resources must be made through consultation with the SHPO.

C.4.3 Diablo Canyon

The impact area—those places where the most pronounced socioeconomic impacts might result from refurbishment and license renewal—for Diablo Canyon consists of San Luis Obispo County, California. Emphasis is placed on those jurisdictions within the county closest to the plant site, where many workers reside. These include Avila Beach, Pismo Beach, and the city of San Luis Obispo. The selection of this area is based on worker residence patterns, employment, expenditures, and tax payments relative to the surrounding region. Figure C.8 depicts

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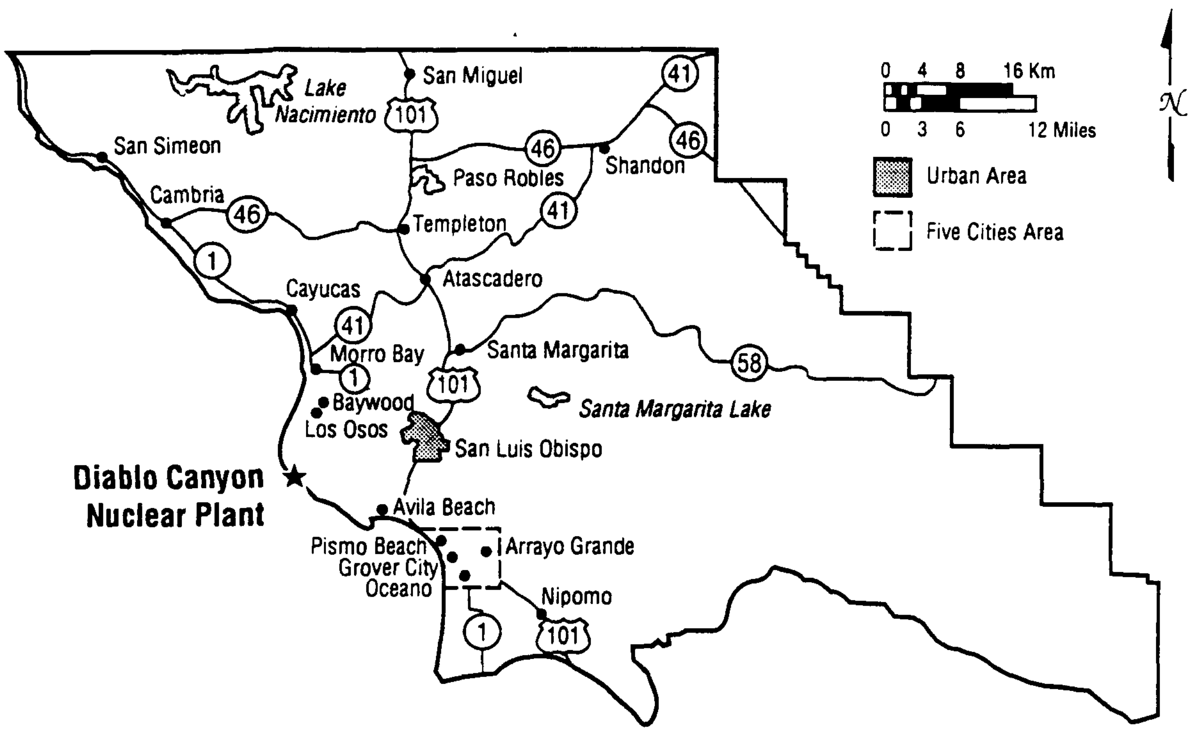

Figure C.8 Socioeconomic impact area associated with Diablo Canyon refurbishment: San Luis Obispo County.

the impact area, and Figure C.9 shows the region where it is located.

C.4.3.1 Population

This section discusses the local population growth associated with the construction, operation, and license renewal of the Diablo Canyon Nuclear Generating Station. Section C.4.1 describes the methodology used to project population growth for all plants. Data used to prepare this section were obtained from *Socioeconomic Impacts of Nuclear Generating Stations: Diablo Canyon Case Study* (NUREG/CR-2749, vol. 5); *Environmental Assessment Proposed Rule for Nuclear Plant License Renewal* (NUREG-1398); SEA refurbishment work force estimates (Appendix B; SEA 1994); population projections by the California Department of Finance (Demographic Research Unit); and the Pacific Gas and Electric Company (PG&E).

The discussion of population growth is organized into two time periods. Section C.4.3.1.1 identifies the population growth that San Luis Obispo County experienced as a result of the construction and operation of Diablo Canyon from 1969 to 1990. Section C.4.3.1.2 projects the population growth that is expected to result from Diablo Canyon's refurbishment period and license renewal term operations beginning in 2024 (Unit 1) based on the growth associated with the plant's initial construction. Also, Section C.4.3.1.2 projects the population growth expected to result from Diablo Canyon's license renewal term based on the growth associated with operations in the past.

C.4.3.1.1 Growth Resulting from Plant Construction and Operation

Diablo Canyon's construction resulted in noticeable population increases in San Luis Obispo County (Table C.35). During the peak construction year, 1975, Diablo Canyon personnel and their families who migrated to the area to work at the plant and others who moved into the area to work in jobs generated by the plant's presence totalled approximately 3308 persons. This influx of new residents represented 2.6 percent of San Luis Obispo County's total population in 1975 (NUREG/CR-2749, vol. 5, p. 89).

Operations at the Diablo Canyon plant have resulted in smaller population increases than did the plant's construction. In 1990, 1300 permanent plant staff were on-site at Diablo Canyon (additional contract workers were on-site during an outage, but these workers have not been included because their presence at the plant was temporary). Of the permanent work force, approximately 89.2 percent (1160) reside in San Luis Obispo County (PG&E 1990). Because Diablo Canyon is located in a relatively rural area, based on residential settlement patterns of the plant's 1975 work force, it is estimated that approximately 30 percent (348) of those residing in San Luis Obispo County in 1990 were prior residents who obtained jobs and that 70 percent (812) were workers who migrated into the area for jobs. Based on experience during operations at other nuclear plants, it is estimated that approximately 66 percent of the 1990 in-migrants (536) were accompanied by their families. Assuming the 1990 California household size of 3.32 persons, this represents a total in-migration of 2056 new residents for the county (Table C.36). Based on work force in-migration and the ratio of nonplant jobs created at other nuclear plants during operating periods, Diablo Canyon's

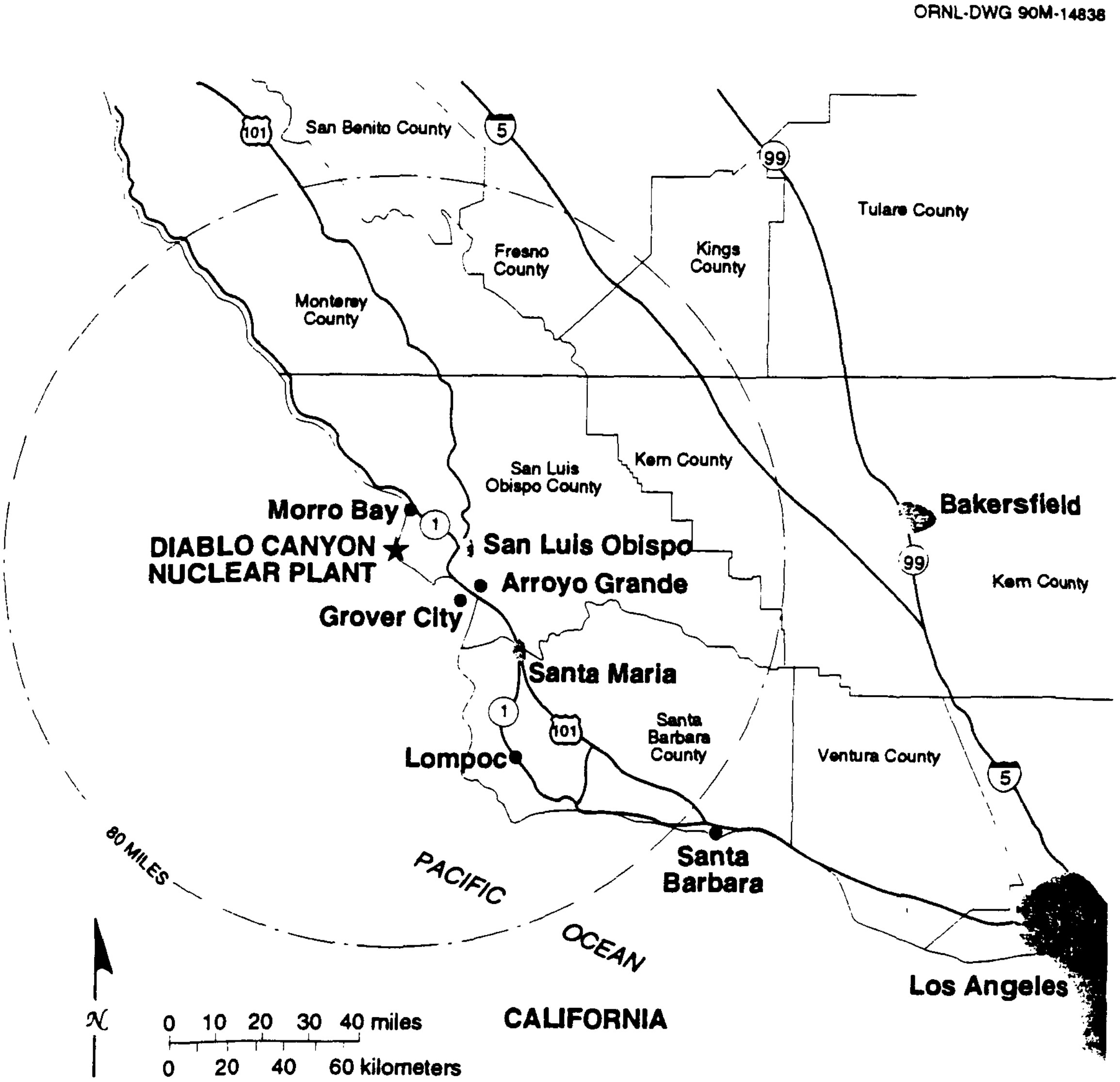

Figure C.9 Region surrounding the Diablo Canyon nuclear plant.

1990 operations created an additional 832 indirect jobs in service industries supported by the spending of Diablo Canyon workers. As a result of these indirect jobs, an estimated 37 additional workers and their families (a total of 93 persons) moved into San Luis Obispo County (Table C.36). In all, approximately 2149 new residents moved into San Luis Obispo County as a result of Diablo Canyon's 1990 operations. These new residents made up about 1.0 percent of San Luis Obispo County's 1990 population of 217,162 (U.S. Bureau of the Census 1990).

C.4.3.1.2 Predicted Growth Resulting from License Renewal

As discussed in Section C.3.1, Diablo Canyon's license renewal would require the completion of a number of refurbishment tasks for Units 1 and 2. Many of the refurbishment tasks are expected to be completed during scheduled refueling outages at each unit during the 10 years that precede the expiration of the initial operating license. However, the final refurbishment work is expected to be completed during one large refurbishment outage scheduled for each unit in the year before the unit's initial operating license expires. Because the final refurbishment outage would involve more workers on-site over a longer period of time than any of the preceding refueling outages, it represents the peak refurbishment period. For other assumptions concerning the refurbishment work force, refer to Section C.3.1 and Section C.4.1.1.2.

Assuming the refurbishment schedule as described in Section C.3.1, the peak refurbishment year for Diablo Canyon Unit 1 is expected to be 2023, and the peak refurbishment year for Unit 2 is expected to be 2024. For each unit, the on-site refurbishment work force would be about the same size, and the work force would be on-site for approximately the same period of time (refer to Section C.4.1.1.2 for other work force assumptions). However, because uncertainties exist concerning the length of the outage and the size of the work force required to complete the refurbishment of a given unit, this section examines a bounding case work force scenario as described in Section C.3.1.

Given the work force scenario detailed in Section C.3.1, it is estimated that 2273 workers would be on-site to complete refurbishment of Diablo Canyon Unit 1 in 2023 and Unit 2 in 2024 (SEA 1994). Further assuming that the residential distribution of refurbishment workers would be similar to that of the 1975 Diablo Canyon construction work force, it is estimated that 85 percent (1932) would reside in San Luis Obispo County. Based on plant-construction experience, it is projected that 531 (27.5 percent) of those residing in San Luis Obispo County would be prior residents who obtain refurbishment jobs and that 1401 (72.5 percent) would be workers who migrate into the area for refurbishment jobs (Table C.37). Also following the pattern set during plant construction, 61.7 percent of the in-migrants (864) would be accompanied by families. Using the California average family size of 3.32 persons, total refurbishment worker in-migration would result in 3405 new residents for the county. Based on the ratio of nonplant jobs created in San Luis Obispo County in 1975, Diablo Canyon's refurbishment is projected to create an additional 1455 indirect jobs in service industries supported by the spending of refurbishment workers. As a result of these indirect jobs, an estimated 68 additional workers and their families (a total of 226 persons) would be projected to move into San Luis Obispo County (Table C.37). In all, approximately 3631 new residents would be expected to move into San Luis Obispo County as a result of Diablo Canyon's refurbishment under the work force scenario. That would represent 0.8 percent of San Luis Obispo County's projected population of 445,180 in 2024 (NUREG/CR-2749, vol. 5, pp. 55–85).

Once plant refurbishment is completed for Diablo Canyon Units 1 and 2, the work force would consist mostly of permanent plant staff. Additional refurbishment/refueling workers would be temporarily on-site approximately every 2 years; however, they would not be permanent, on-site plant staff, and many of them are expected to commute from outside the study area. It is expected that a maximum of 60 additional permanent workers per unit would be required during the license renewal term, adding 120 workers to Diablo Canyon's existing work force. Assuming that the new workers' residential distribution would be the same as current workers', approximately 89.2 percent (107) would reside in San Luis Obispo County. Based on worker in-migration at nuclear plants in comparable locales and construction experience at Diablo Canyon, it is estimated that 32 (30 percent) of those residing in San Luis Obispo County would be prior residents who obtain jobs and that 75 (70 percent) would be workers who migrate into the area for jobs (Table C.38). Also, following the pattern set by personnel in-migrating to work at other nuclear plants, 66 percent of the in-migrants (50) would be accompanied by their families. Using the California average family size of 3.32 people, total in-migration would result in 191 new residents for the county. Based on work force in-migration and the ratio of nonplant jobs created at other nuclear plants during operating periods, Diablo Canyon's license renewal term is projected to create an additional 77 indirect jobs in service industries supported by the spending of plant workers. As a result of these indirect jobs, an estimated three additional workers and their families (a total of about eight persons) would be projected to move into San Luis Obispo County (Table C.38). In all, approximately 199 new residents would be expected to move into San Luis Obispo County as a result of Diablo Canyon's license renewal term. That would represent less than 0.1 percent of San Luis Obispo County's projected population in 2024.

C.4.3.2 Housing

The following sections examine the housing impacts that occurred in San Luis Obispo County during construction and operation of Diablo Canyon and predict housing impacts that would result from refurbishment activities and continued operation. Possible impacts to housing include changes in the number of housing units, particularly the rate of growth of the housing stock; changes in occupancy rates; changes in the characteristics of the housing stock; and changes in rental rates or property values.

Section C.4.1.2 includes a complete discussion of the methodology and assumptions used to predict housing impacts.

C.4.3.2.1 Impacts from Plant Construction and Operation

The following discussion begins with a description of the housing market at the time of Diablo Canyon's construction and details project-related housing demand in the study area. A discussion of changes that occurred in the housing market and impacts on housing induced by plant construction follows.

Construction at Diablo Canyon began in 1969 and continued through 1980. During this time, approximately 29,000 year-round units were added to San Luis Obispo's housing stock (U.S. Bureau of the Census 1982; NUREG/CR-2749, vol. 5), bringing the total number of year-round units in San Luis Obispo to 66,070. The new units represent very rapid growth, a full 77 percent increase in the 1970 housing stock. This rate of growth compares to a 32 percent increase in California between 1970 and 1980 (U.S. Bureau of the Census 1972, 1982) and a 28 percent increase in housing units in San Luis Obispo County during the intercensal 1960–1970 period (U.S. Bureau of the Census 1967, 1972). Areas within the county that experienced the greatest growth were the Baywood/Los Osos, area with a 167.6 percent increase in housing units between 1970 and 1978; Nipomo, with a 74.4 percent increase; Atascadero (and the surrounding area), with a 65.8 percent increase; and Arroyo Grande, with a 64.8 percent increase (NUREG/CR-2749, vol. 5). The 40.5 percent increase in housing units in the city of San Luis Obispo was relatively low during this period; however, the 4183 housing units added there represent the greatest increase in absolute number.

Several factors influenced this housing growth commensurate to the increase in population in the county. One factor was the expanding student population associated with California State Polytechnic University in the city of San Luis Obispo. During the 1970s, enrollment increased by more than 4000 students (Cass 1969, 1979). The need for housing suitable for the student population at least partly explains why both the percentage of rental units in the city of San Luis Obispo and the percentage of multifamily units increased between 1970 and 1980, from 37.9 to 46.5 percent and from 49.2 to 53.5 percent, respectively. The county, particularly the coastal communities, was also developing as a retirement community and popular tourist area. These factors, combined with the in-migration of Diablo Canyon construction workers, were the causes for the rapid growth that occurred in San Luis Obispo County.

Project-related housing demand in San Luis Obispo County peaked in 1975 at 1297 units when the construction work force was 2116 (NUREG/CR-2749, vol. 5). New housing units added to San Luis Obispo County housing stock between 1970 and 1975 totalled 9898 (NUREG/CR-2749, vol. 5). Based on a average of 2.7 persons per household (U.S. Bureau of the Census 1972), these new units could accommodate approximately 26,725 persons. The non-project-related population increase through 1975 was approximately 23,500 [derived by subtracting project-related population increase from 1976 population (NUREG/CR-2749, vol. 5)], requiring approximately 8703 housing units. The remaining 1195 new housing units are approximately 100 units less than the project-related demand for 1297. In 1970, 1040 housing units were vacant in San Luis Obispo County. These vacancies might have supplied the 100 units required for project-related demand not supplied by new construction. Nonetheless, the growing population and project-related demand resulted in a vacancy rate of approximately 2.5 percent.

Because of the limited availability of housing in the area, occupancy density increased, particularly in the Five Cities area of San Luis Obispo County, where approximately 48 percent of the construction workers resided (NUREG/CR-2749, vol. 5). The small hotels in the Five Cities area were filled with construction workers (Morrow 1990), as were most recreational vehicle parks. The combined pressures of increased population resulted in occasions when people slept in cars or lived in parks. Housing conversions that resulted from combined housing demand included garages that were rented as apartments and the rental of privately owned seasonal homes (NUREG/CR-2749, vol. 5).

Both the median value of owner-occupied units and the median contract rent increased dramatically during the construction of the Diablo Canyon plant. Between 1970 and 1980, median value and median rent increased 329 percent and 181 percent, respectively, in San Luis Obispo County. For comparison, in the state of California, median value and median rent increased 266 percent and 124 percent. Some local realtors and planners indicated that the demand for rental units associated with plant construction did have an effect on rental rates, but in the city of San Luis Obispo, the presence of Section 8 (government-subsidized) and non–Section 8 renters in the same properties kept rental rates from soaring even higher. Local realtors and developers attribute the increase in housing values, like rental rates, to the combined population pressures of construction contractors and in-migrating retirees and workers from Southern California to this popular rural beach area.

The housing market did not experience a sudden drop when construction at Diablo Canyon was completed. Construction declined gradually, and some workers sought other jobs in the area. Also, non–project-related growth continued in San Luis Obispo County. However, the departure of construction workers allowed rental vacancies to increase to 4–5 percent, and rental rate increases slowed.

The operation of Diablo Canyon has had little effect on housing in San Luis Obispo County. Residential development closest to the plant is in the unincorporated Avila Beach, approximately 8 km (5 miles) away. Neither housing values nor quality have been affected by the proximity of Diablo Canyon.

In summary, project-related population increase and commensurate housing demand accounted for only 12 percent of the total increase in population between 1970 and 1975. However, it appears that at times during construction, demand for housing (particularly reasonably priced housing) exceeded availability. Also, rental rates and housing values increased 63 percent and 57 percent more, respectively, than in the state of California during the same time. The contribution of project-related demand to the net effect on housing was great enough to have been a causal factor in these impacts.

C.4.3.2.2 Predicted Impacts of License Renewal

Project-related population increase and the commensurate housing demand would bring about new housing impacts during refurbishment activities. A summary of recent and anticipated growth in housing is provided. This is followed by predictions of possible impacts during refurbishment and the license renewal term.

If housing in San Luis Obispo County continues to expand at the 1980–90 rate of 35.1 percent (U.S. Bureau of the Census 1982, 1990), then it is possible that by 2023, when the operating license of Unit 1 expires, there would be about 246,000 housing units in San Luis Obispo County. This greatly exceeds the 175,960 units that will be required in 2025, based on population projections and average household size (U.S. Bureau of the Census 1990; Section C.4.3.1).

However, it is conceivable that the growth rate could be cut by half or more as a result of growth-control measures enacted partly because of severe water shortages. If this is the case, the number of housing units in the county in 2023 will be 154,250, far short of those necessary to accommodate the projected population in 2023. Thus, housing availability would be very limited, and competition for existing housing would be greatly increased.

This slower growth rate is a reasonable assumption because local governments are concerned with recent rapid growth and have taken steps to address this. Local community leaders named growth (i.e., a too-rapid rate of growth and associated water shortages) as the issue currently causing greatest concern. Communities throughout San Luis Obispo County are acting to slow the rate of growth that has occurred in past years. Arroyo Grande is now aiming for an annual growth rate of 2.5 percent, down from the previous annual rate of 5 percent. Morro Bay has enacted a "no-growth measure" that allows only 77 housing starts per year if adequate water is available. As of June 1990, because water was not available, no new housing starts had been allowed since the beginning of the calendar year. The comprehensive plan of the city of San Luis Obispo suggests a growth rate of 1 percent or less per year. Pismo Beach has grown so fast that an override of Proposition 13 spending limits was required to provide basic fire and protection services. Also, there is a countywide moratorium on development that will remain in effect until two initiatives limiting countywide growth are deliberated and enacted by the county board of supervisors. These growth-control measures could easily prevent the continuation of the 1980–90 growth rate of 35.1 percent.

According to the estimate of the number of workers required for plant refurbishment and based on plant construction experience, 1401 workers of the total work force of 2273 are expected to migrate to San Luis Obispo County for refurbishment jobs. Of these in-migrants, 864 are expected to be accompanied by families. Some doubling-up (sharing of living accommodations) is expected to occur among the 537 unaccompanied workers, so that each unaccompanied mover would require 0.85 housing unit. In-migration of these workers to San Luis Obispo County would result in refurbishment-related housing demand in the peak year of refurbishment of 1320 housing units. In addition, numerous indirect jobs are expected to result from the spending of project workers. An additional 68 workers are projected to move into San Luis Obispo County, bringing the total project-related demand for housing to 1388 units.

Refurbishment-related housing demand is greater than the original construction-related housing demand of 1297 units, but the number of housing units in the study area may have increased by as much as 415 percent—or, in a slower growth scenario, by 223 percent—between peak construction and refurbishment periods. Refurbishment-related housing demand would account for between 0.56 and 0.9 percent of the possible number of units in the study area of 2023, compared to construction-related demand in 1975, accounting for 2.7 percent of the housing units. Demand would be small relative to the existing housing market. In the absence of growth-control measures, impacts to housing are expected to be small. However, project-related housing demand in the presence of growth-control measures that limit housing development may exacerbate an already competitive housing market, particularly for reasonably priced housing.

Increased demand may increase rental rates and housing values and seriously reduce the already limited housing availability. Housing conversions, such as making apartments out of a single-family home or converting garages to apartments, may occur if allowed under the growth-control restrictions. It is thus possible that moderate—possibly even large—new housing impacts could occur.

Housing impacts related to housing value and marketability that would occur during the license renewal term are the same as those currently being experienced (Section C.4.3.2.1). The 120 additional workers (60 per unit) required during the license renewal term and the commensurate housing demand would cause only small housing impacts.

C.4.3.3 Taxes

C.4.3.3.1 Impacts from Plant Construction and Operation

PG&E pays taxes on the Diablo Canyon plant primarily to taxing authorities in San Luis Obispo County; only a relatively small amount of sales and use taxes have been paid to the state of California.

In California, the State Board of Equalization assesses public utility property. In most other states, this function is carried out by local county assessors. The State Board of Equalization currently allocates the utility system's assessed value among county tax code areas weighing three indices. A reproduction cost net less depreciation allocation procedure is used to determine the value of the facility and property. Cost estimates of the Diablo Canyon plant and all other facilities owned by PG&E are estimated on a yearly basis. The utility is required to report any construction or refurbishment of the facilities annually to the State Board of Equalization. These improvements add to the assessed valuation of the plant. In addition, utility income reported for the plant and common stock indices are used as weights to arrive at a final assessed valuation by the state. The local tax rate is then applied to the utility's assessed value within each tax code area to determine tax liability.

Before California's tax reform of 1978, an assessment ratio of 25 percent was applied to an estimate of the market value of the facility to obtain the assessed value, upon which ad valorem taxes are levied. Because of the passage of Proposition 13 in 1978, the taxable portion of the assessed value has risen to 100 percent, and the levy of a single tax rate of $4 per $100 of assessed valuation was applied to all property. Also, largely because of Proposition 13, the county's basic tax rate has declined from a high of 3.33 percent in 1972 to 1.07 percent in 1989. Table C.39 provides the San Luis Obispo County basic tax rate from 1967 to 1989, the estimated basic property tax levy, and total county general revenues. In addition, property tax as a percentage of the total county general revenues is shown in the last column. The county property tax levy had increased at a 10.2 percent annual rate from 1967 to 1968 and from 1977 to 1978. From 1977 to 1978 and from 1988 to 1989, the property tax levy increased at an 8.8 percent annual rate. Property taxes currently make up 36.0 percent of the county's total revenues. Diablo Canyon's property taxes provide 10.6 percent of San Luis Obispo County's total revenues.

Approximately 12 taxing authorities within San Luis Obispo County are included within the distribution of property tax payments by the Diablo Canyon plant. The recipients of the largest tax payments were the San Luis Obispo Coastal Unified School District and

San Luis Obispo County. Table C.40 presents the distribution of property tax payments to the major taxing authorities in San Luis Obispo County. Total property taxes paid by the Diablo Canyon plant were approximately $6.3 million in 1974–75, $12.4 million in 1977–78, and $34.1 million in 1988–89. Proportional distribution of Diablo Canyon's total tax payment has varied during this time period. Currently, San Luis Obispo County and the San Luis Coastal Unified School District receive 36.1 percent and 38.9 percent, respectively, of the total tax payment. The Diablo Canyon property tax payments, adjusted in real terms by the GNP implicit price deflator, have substantially increased during the 1974–75 to 1988–89 time period. The property tax payments paid by Diablo Canyon have increased in real terms by 7.32 percent annually from 1974–75 to 1988–89. This annual rate of increase slowed to 4.66 percent from the 1977–78 period to 1990.

The San Luis Coastal Unified School District has relied heavily on property taxes as a major portion of its income. Table C.41 gives the amounts of local property tax income and total school district income for the school district between 1969 and 1989. From 1969 to 1970 through 1988–89 the percentage of total school district income that came from property taxes rose from 75.9 to 80.1 percent. The share of total local revenues provided by the Diablo Canyon plant have increased over time, from 31.1 percent in 1977–78 to 38.9 percent in 1988–89.

C.4.3.3.2 Predicted Impacts of License Renewal

During refurbishment of Diablo Canyon, a new tax-related impact is expected to occur. This new impact involves increases in tax payments that would result from capital improvements that take place during the current term outages. Tax increases resulting from improvements made in the final refurbishment outage would affect taxes only during the license renewal term. The magnitude of the impact depends on PG&E's decision about which improvements would occur early on and which would be done during the final outage. For example, if the steam generator is replaced during a current term outage, the assessed value may increase considerably before the license renewal term begins. If steam generator replacement, and other major capital improvements, are not undertaken early on, the increase in assessed valuation may be only minor. The increase, in either case, is expected to cause only a small to moderate new tax impact.

During the license renewal term, the primary tax-related impact would be the continuation of tax payments that Diablo Canyon is currently making to San Luis Obispo County and San Luis Coastal Unified School District. There would also be a new impact resulting from the increase in tax payments because of improvements made at Diablo Canyon during the final refurbishment period. Thus, tax revenues would increase in absolute terms, although they may not provide a proportionally larger share of the total revenues of either taxing jurisdiction. Based on current conditions, Diablo Canyon tax revenues—the continuing and additional payments combined—are expected to continue to make up a substantial share of the total revenues. The large tax-related impact currently being experienced in the school district and the moderate impact occurring in the county would continue during the license renewal term.

C.4.3.4 Public Services

C.4.3.4.1 Impacts from Plant Construction and Operation

For public services, the study area consists of the municipalities of Pismo Beach, Arroyo Grande, Grover City, San Luis Obispo City, and San Luis Obispo County. The governments in these municipalities are mostly of the city council/administrative officer type (NUREG/CR-2749, vol. 5, p. 103). This area has experienced rapid population growth, primarily because of being located between the large cities of Los Angeles and San Francisco. The period of construction and operations of the Diablo Canyon Nuclear Plant was characterized by political conflict, not only because of the plant but also because of the allocation of the increased revenues from the plant (NUREG/CR-2749, vol. 5, p. 103). County planning commissions were also very active during the 1970s. The major public services that are most responsive to public demand are education, public safety, and transportation. These services received the most impact from the construction and operation of the Diablo Canyon Nuclear Plant.

Education

Public education in San Luis Obispo County is provided by the San Luis Coastal Unified School District. Funding for public education comes from federal, state, and local sources, with the local property tax being the largest source of funding. During the construction phase, the major educational impacts of the Diablo Canyon plant were concentrated on two public school districts—the San Luis Coastal Unified School District and the Lucia Mar Unified School District (NUREG/CR-2749, vol. 5, p. 112).

While Diablo Canyon Nuclear Plant is situated in the San Luis Coastal Unified School District, impacts from the plant affected two school districts. In the San Luis Coastal Unified School District, the impact was related to the large tax revenues generated by the facility. In the Lucia Mar Unified School District, the impact occurred in relation to the influx of school-age children accompanying Diablo Canyon construction workers (NUREG/CR-2749, vol. 5, p. 112).

The Lucia Mar Unified School District was at overcapacity during the peak construction period and was forced to add portable classrooms to accommodate the additional student population. Funding was an impact that had a positive effect on the San Luis Coastal Unified School District while creating a negative impact on the Lucia Mar Unified School District. This inequity in funding resulted because new school districts were established shortly before the final siting decision on Diablo Canyon was made. Several factors were considered before the districts were created. Estimates of wealth, or assessed valuation, were based on the plant being sited in the Lucia Mar school district. However, the plant was built in the San Luis school district. Therefore, Lucia Mar gained additional students without the additional revenues from the construction that went to the San Luis school district (NUREG/CR-2749, vol. 5, p. 113).

Local officials indicated that many construction workers moved into the area for short periods with no major impact. Currently, a change is occurring in the schools. The emphasis continues to be on academics, but a need is growing for a vocational/technical curriculum.

Transportation

The major roads in the study area that provide access to the Diablo Canyon Nuclear Plant are State Highway 101, Avila Road, and San Luis Bay Drive. The county maintains all county-designated roads, while California Transportation (CalTrans) supports all state roads. Any city-designated roads are maintained by the municipality in which they are located (NUREG/CR-2749, vol. 5, p. 115).

During peak construction, over 2000 workers were employed at the site. To accommodate additional traffic, San Luis Obispo County made several improvements to Avila Road and San Luis Bay Drive. PG&E aided in the funding of these improvements (NUREG/CR-2749, vol. 5, p. 116).

Local officials gave no indication of any major problems stemming from the construction or operation of the Diablo Canyon Nuclear Plant.

Public Safety

Public safety expenditures remained constant from 1967 to 1973 and then rose by 6 percent from 1973 to 1978. The municipalities within the study area provide police protection within their boundaries. Police protection in the rural areas is provided by the county sheriff and the California Highway Patrol. Diablo Canyon projects' tax contributions enabled the expansion of public safety services (NUREG/CR-2749, vol. 5, p. 116).

The California Department of Forestry is located in San Luis Obispo County regional office. The San Luis Obispo County contracts with the Department of Forestry for local fire protection (NUREG/CR-2749, vol. 5, p. 116). The majority of fire departments for the other municipalities in the study area are a combination of volunteer and paid full-time people. There is a countywide emergency management plan, and each municipality also has its own plan. Local officials contacted gave no indication of any problems arising about public safety during either construction or operation of the plant.

Social Services

Social services are provided by the counties in the study area. Local officials stated that a whole range of services was provided from homeless shelters to "Meals on Wheels" for the elderly. One municipality has a senior citizens' advisory committee that works with the city council and assists in making decisions for the seniors in its jurisdiction.

Public Utilities

Public utilities are provided in a variety of combinations in the county. The county provides some services, and there are special districts with privately provided services. In the majority of municipalities, sewer and water are provided by the municipality itself. One local official interviewed indicated that water availability was a problem. Currently, the county is trying to implement a water conservation program. Local offices indicated that it is hard to specify which services were specifically affected by the construction and operation of the plant and that it was a major difficulty to absorb some of the changes.

Tourism and Recreation

Local leaders indicated that no adverse impacts resulted from the construction or operation of the Diablo Canyon Nuclear Plant. Some officials indicated that during the construction phase it was a "site to see":