Applicant's Environmental Report – Operating License Renewal Stage

Palisades Nuclear Plant

Nuclear Management Company

Docket No. 50-255

License No. DPR-20

March 2005

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ACRONYMS AND ABBREVIATIONS

°F	degrees Fahrenheit
AC	alternating current
AADT	annual average daily traffic volume
AEC	U.S. Atomic Energy Commission
AEP	American Electric Power
AOC	Area of Concern
Btu/hr	British thermal units per hour
CEQ	Council on Environmental Quality
CFR	*Code of Federal Regulations*
cfs	cubic feet per second
CLB	current licensing basis
CO_2	carbon dioxide
CO	carbon monoxide
Consumers	Consumers Energy Company
CT	combustion turbine
CWA	(Federal) Clean Water Act
CZMA	Coastal Zone Management Act
DBA	design basis accident
DOE	U.S. Department of Energy
ECAR	East Central Area Reliability Coordination Agreement
EIA	Energy Information Agency
EPA	U.S. Environmental Protection Agency
EPRI	Electric Power Research Institute
ER	environmental report
FERC	Federal Energy Regulatory Commission
FES	Final Environmental Statement
fps	feet per second
FSAR	Final Safety Analysis Report
GEIS	*Generic Environmental Impact Statement for License Renewal of Nuclear Plants*
GIS	Geographic Information System
GLSC	Great Lakes Science Center

ACRONYMS AND ABBREVIATIONS (CONTINUED)

gpm	gallons per minute
GWD/MTU	gigawatt-days per metric ton uranium
HCP	Habitat Conservation Plan
HRSG	heat recovery steam generator
IGCC	integrated gasification combined-cycle
IJC	International Joint Commission
IPA	Integrated Plant Assessment
IPE	Independent Plant Examination
ISFSI	Independent Spent Fuel Storage Installation
ISO	Independent System Operator
kV	kilovolt(s)
kV/m	kilovolt(s) per meter
LOS	level of service
mA	milliampere(s)
MCGI	Michigan Center for Geographic Information
MCL	Michigan Compiled Laws
MDEQ	Michigan Department of Environmental Quality
MDNR	Michigan Department of Natural Resources
METC	Michigan Electric Transmission Company
MISO	Michigan Independent System Operators
MMBtu	million British thermal units
MPSC	Michigan Public Service Commission
MSA	metropolitan statistical area
msl	mean sea level
MW	megawatt(s)
MWe	megawatts electric
MWh	megawatt hours
MWt	megawatts thermal
NA	not applicable
NEPA	National Environmental Policy Act
NESC®	National Electrical Safety Code®
NMC	Nuclear Management Company, LLC
NMFS	National Marine Fisheries Service

ACRONYMS AND ABBREVIATIONS (CONTINUED)

NOAA	National Oceanic and Atmospheric Administration
NOx	nitrogen oxides
NPDES	National Pollutant Discharge Elimination System
NPPOSA	Nuclear Power Plant Operating Services Agreement
NPS	National Park Service
NRC	U.S. Nuclear Regulatory Commission
NREPA	Natural Resources and Environmental Protection Act
NSSS	Nuclear Steam Supply System
NWI	National Wetland Inventory
PA	Public Acts
PCB	polychlorinated biphenyl
PCS	Primary Coolant System
PM_{10}	particulates having diameter less than 10 microns
Palisades	Palisades Nuclear Plant
psig	pounds per square inch gage
RCS	reactor coolant system
RIMS II	Regional Input-Output Modeling System
ROW	right(s)-of-way
RTO	Regional Transmission Operators
SAMA	severe accident mitigation alternative
SCDHEC	South Carolina Department of Health and Environmental Control
SHPO	State Historic Preservation Officer
SMITTR	surveillance, on-line monitoring, inspections, testing, trending, and recordkeeping
SOx	sulfur oxides
USC	*United States Code*
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VSCs	ventilated storage casks
yr	year

1.0 PURPOSE OF AND NEED FOR ACTION

1.1 INTRODUCTION AND BACKGROUND

NRC

"Each application must include a supplement to the environmental report that complies with the requirements of Subpart A of 10 CFR Part 51." 10 CFR 54.23

"…The purpose and need for the proposed action (renewal of an operating license) is to provide an option that allows for power generation capability beyond the term of a current nuclear power plant operating license to meet future system generating needs, as such needs may be determined by State, utility, and, where authorized, Federal (other than NRC) decisionmakers…" (NRC 1996a, Section 1.3; NRC 1996b, page 28472).

"...The NRC's NEPA decision standard for license renewal would require the NRC to determine whether the environmental impacts of license renewal are so great that preserving the option of license renewal for future decisionmakers would be unreasonable." (NRC 1996b, 28471)

The U.S. Nuclear Regulatory Commission (NRC) licenses the operation of domestic nuclear power plants in accordance with the Atomic Energy Act of 1954, as amended, and NRC implementing regulations. Nuclear Management Company, LLC (NMC), operates Palisades Nuclear Plant (Palisades) pursuant to NRC Operating License DPR-20. The license will expire March 24, 2011 (NMC 2003, Section 1.1.2). NMC has prepared this Environmental Report (ER) in conjunction with its application to NRC to renew the Palisades operating license, as provided by the following NRC regulations:

- Title 10, Energy, *Code of Federal Regulations* (CFR), Part 54, Requirements for Renewal of Operating Licenses for Nuclear Power Plants, Section 54.23, Contents of Application-Environmental Information (10 CFR 54.23)
- Title 10, Energy, CFR, Part 51, Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions, Section 51.53, Post-Construction Environmental Reports, Subsection 51.53(c), Operating License Renewal Stage [10 CFR 51.53(c)]

These regulations provide for an operating license renewal period for up to 20 years beyond the initial 40-year license term.

1.2 STATEMENT OF PURPOSE AND NEED

NMC adopts for this ER the following NRC definition of purpose and need for the proposed action, as stated in NRC's *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (GEIS), NUREG-1437 (NRC 1996a, Section 1.3; NRC 1996b, page 28472):

> The purpose and need for the proposed action (renewal of an operating license) is to provide an option that allows for power generation capability beyond the term of a current nuclear power plant operating license to meet future system generating needs, as such needs may be determined by State, utility, and, where authorized, Federal (other than NRC) decision makers.

The proposed action would provide NMC the option to operate Palisades for up to an additional 20 years beyond the current 40-year operating license term, i.e., until March 24, 2031.

1.3 ENVIRONMENTAL REPORT SCOPE AND METHODOLOGY

NRC regulations for domestic licensing of nuclear power plants require environmental review of applications to renew operating licenses. NRC regulation 10 CFR 51.53(c) requires that an applicant for license renewal submit with its application a separate document entitled, *Applicant's Environmental Report - Operating License Renewal Stage*. This appendix to the Palisades License Renewal Application fulfills that requirement. In determining what information to include in Palisades' ER, NMC relied on NRC regulations and the following supporting documents, which provide additional insight into the regulatory requirements:

- NRC supplemental information in the *Federal Register* (NRC 1996b; NRC 1996c; NRC 1996d; NRC 1999a)
- The *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (GEIS) (NRC 1996a; NRC 1999b)
- *Regulatory Analysis for Amendments to Regulations for the Environmental Review for Renewal of Nuclear Power Plant Operating Licenses* (NRC 1996e)
- *Public Comments on the Proposed 10 CFR Part 51 Rule for Renewal of Nuclear Power Plant Operating Licenses and Supporting Documents: Review of Concerns and NRC Staff Response* (NRC 1996f)

NMC also obtained general guidance regarding format and content of the ER from the following NRC documents:

- Supplement 1 to NRC Regulatory Guide 4.2, *Preparation of Supplemental Environmental Reports for Applications to Renew Nuclear Power Plant Operating Licenses* (NRC 2000)
- Supplement 1 to NUREG-1555, *Standard Review Plans for Environmental Reviews for Nuclear Power Plants (Operating License Renewal)* (NRC 1999c)

NMC developed Table 1.3-1 to verify conformance with regulatory requirements. Table 1.3-1 indicates where the ER addresses each requirement of 10 CFR 51.53(c). Additionally, key excerpts from applicable regulations and supporting documents preface each responsive section of the ER.

1.4 PALISADES NUCLEAR PLANT LICENSEE AND OWNERSHIP

Palisades is owned by Consumers Energy Company (Consumers), a subsidiary of CMS Energy Corporation. NMC operates Palisades on behalf of Consumers. With respect to the Palisades operating license, Consumers is the owner licensee and NMC is the licensed operator of the facility.

The *Nuclear Power Plant Operating Services Agreement* (NPPOSA) between Consumers and NMC establishes NMC as the sole operator of Palisades and defines the owner-operator relationship. NMC and its employees are obligated to comply with all corporate policies listed in Exhibit D of the NPPOSA including CMS Energy's Code of Conduct and Environmental Policy, which provide for safe and environmentally sound operation of Palisades (Consumers 2000). Implementation of the agreement is achieved by continuance of functional relationships among owner/operator organizations regarding environmental matters. These functional relationships provide for close coordination among corporate and plant staff for efficient and effective environmental management (CMS 2004a, b).

TABLE 1.3-1
ENVIRONMENTAL REPORT RESPONSES TO LICENSE RENEWAL ENVIRONMENTAL REGULATORY REQUIREMENTS

Regulatory Requirement	Responsive Environmental Report Section(s)	
10 CFR 51.53(c)(1)		Entire Document
10 CFR 51.53(c)(2), Sentences 1 and 2	3.0	The Proposed Action
10 CFR 51.53(c)(2), Sentence 3	7.2.3	Environmental Impacts of Alternatives
10 CFR 51.53(c)(2) and 10 CFR 51.45(b)(1)	4.0	Environmental Consequences of the Proposed Action and Mitigating Actions
10 CFR 51.53(c)(2) and 10 CFR 51.45(b)(2)	6.3	Unavoidable Adverse Impacts
10 CFR 51.53(c)(2) and 10 CFR 51.45(b)(3)	7.0 8.0	Alternatives to the Proposed Action Comparison of Environmental Impact of License Renewal with the Alternatives
10 CFR 51.53(c)(2) and 10 CFR 51.45(b)(4)	6.5	Short-Term Use Versus Long-Term Productivity of the Environment
10 CFR 51.53(c)(2) and 10 CFR 51.45(b)(5)	6.4	Irreversible or Irretrievable Resource Commitments
10 CFR 51.53(c)(2) and 10 CFR 51.45(c)	4.0 6.2 7.3 8.0	Environmental Consequences of the Proposed Action and Mitigating Actions Mitigation Environmental Impacts of Alternatives Comparison of Environmental Impact of License Renewal with the Alternatives
10 CFR 51.53(c)(2) and 10 CFR 51.45(d)	9.0	Status of Compliance
10 CFR 51.53(c)(2) and 10 CFR 51.45(e)	4.0 6.3	Environmental Consequences of the Proposed Action and Mitigating Actions Unavoidable Adverse Impacts
10 CFR 51.53(c)(3)(ii)(A)	4.1	Introduction
10 CFR 51.53(c)(3)(ii)(B)	4.1	Introduction
10 CFR 51.53(c)(3)(ii)(C)	4.1	Introduction
10 CFR 51.53(c)(3)(ii)(D)	4.1	Introduction

TABLE 1.3-1 (CONTINUED)
ENVIRONMENTAL REPORT RESPONSES TO LICENSE RENEWAL ENVIRONMENTAL REGULATORY REQUIREMENTS

Regulatory Requirement	Responsive Environmental Report Section(s)	
10 CFR 51.53(c)(3)(ii)(E)	4.2 4.3	Impacts of Refurbishment on Terrestrial Resources Threatened or Endangered Species
10 CFR 51.53(c)(3)(ii)(F)	4.4	Air Quality During Refurbishment (Nonattainment Areas)
10 CFR 51.53(c)(3)(ii)(G)	4.1	Introduction
10 CFR 51.53(c)(3)(ii)(H)	4.5	Electric Shock from Transmission Line-Induced Currents
10 CFR 51.53(c)(3)(ii)(I)	4.6 4.7 4.8 4.9	Housing Impacts Public Utilities: Public Water Supply Availability Education Impacts from Refurbishment Offsite Land Use
10 CFR 51.53(c)(3)(ii)(J)	4.10	Transportation
10 CFR 51.53(c)(3)(ii)(K)	4.11	Historic and Archaeological Resources
10 CFR 51.53(c)(3)(ii)(L)	4.12	Severe Accident Mitigation Alternatives
10 CFR 51.53(c)(3)(iii)	4.0 6.2	Environmental Consequences of the Proposed Action and Mitigating Actions Mitigation
10 CFR 51.53(c)(3)(iv)	5.0	Assessment of New and Significant Information
10 CFR 51, Appendix B to Subpart A, Table B-1, Footnote 6	2.5.3	Minority and Low Income Populations

CFR = Code of Federal Regulations

1.5 REFERENCES

CMS (CMS Energy Corporation). 2004a. "CMS Energy Code of Conduct and Statement of Ethics Handbook."

CMS (CMS Energy Corporation). 2004b. "A Close-Up Look at Our Environmental Commitment."

Consumers (Consumers Energy Company). 2000. "Nuclear Power Plant Operating Services Agreement between Consumers Energy Company and Nuclear Management Company, LLC." November 7.

NMC (Nuclear Management Company, LLC). 2003. *Final Safety Analysis Report - Palisades Nuclear Plant*. Revision 24. October.

NRC (U.S. Nuclear Regulatory Commission). 1996a. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*. NUREG-1437. Volume 1. Office of Nuclear Regulatory Research. Washington, D.C. May.

NRC (U.S. Nuclear Regulatory Commission). 1996b. "Environmental Review for Renewal of Nuclear Power Plant Operating Licenses." *Federal Register*. Vol. 61, No. 109. (June 5, 1996): 28467-97.

NRC (U.S. Nuclear Regulatory Commission). 1996c. "Environmental Review for Renewal of Nuclear Power Plant Operating Licenses; Correction." *Federal Register*. Vol. 61, No. 147. (July 30, 1996): 39555-6.

NRC (U.S. Nuclear Regulatory Commission). 1996d. "Environmental Review for Renewal of Nuclear Power Plant Operating Licenses." *Federal Register*. Vol. 61, No. 244. (December 18, 1996): 66537-54.

NRC (U.S. Nuclear Regulatory Commission). 1996e. *Regulatory Analysis for Amendments to Regulations for the Environmental Review for Renewal of Nuclear Power Plant Operating Licenses*. NUREG-1440. Office of Nuclear Regulatory Research. Washington, D.C. May.

NRC (U.S. Nuclear Regulatory Commission). 1996f. *Public Comments on the Proposed 10 CFR Part 51 Rule for Renewal of Nuclear Power Plant Operating Licenses and Supporting Documents: Review of Concerns and NRC Staff Response*. NUREG-1529. Office of Nuclear Regulatory Research. Washington, D.C. May.

NRC (U.S. Nuclear Regulatory Commission). 1999a. "Changes to Requirements for Environmental Review for Renewal of Nuclear Power Plant Operating Licenses; Final Rules." *Federal Register*. Vol. 64, No. 171. (September 3, 1999): 48496-508.

NRC (U.S. Nuclear Regulatory Commission). 1999b. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants.* Section 6.3, "Transportation," and Table 9-1, "Summary of Findings on NEPA Issues for License Renewal of Nuclear Power Plants." NUREG-1437, Vol. 1, Addendum 1. Office of Nuclear Reactor Regulation. Washington, D.C. August.

NRC (U.S. Nuclear Regulatory Commission). 1999c. *Standard Review Plans for Environmental Reviews for Nuclear Power Plants (Operating License Renewal)*. NUREG-1555, Supplement 1. Office of Nuclear Reactor Regulation. Washington, D.C. October.

NRC (U.S. Nuclear Regulatory Commission). 2000. *Preparation of Supplemental Environmental Reports for Applications to Renew Nuclear Power Plant Operating Licenses*. Supplement 1 to Regulatory Guide 4.2. Office of Nuclear Regulatory Research. Washington, D.C. September.

2.0 SITE AND ENVIRONMENTAL INTERFACES

2.1 GENERAL SITE DESCRIPTION

The Palisades Nuclear Plant (Palisades) is located on the eastern shore of Lake Michigan in Covert Township on the western side of Van Buren County, Michigan (parts of Sections 4 and 5, T2S, R17W), approximately 4.5 miles south of the city limits of South Haven, Michigan (NMC 2003, Section 1.2.1). Major features within the Palisades region (i.e., within 50 miles) and site vicinity (i.e., within 6 miles) are illustrated in Figures 2.1-1 and 2.1-2, respectively. Figure 2.1-3 shows the Palisades site and its immediate environs. General regional, vicinity, and site features are highlighted in the following subsections. Nuclear Management Company, LLC (NMC) discusses characteristics of particular interest to this Environmental Report (ER) in Sections 2.2 through 2.10.

2.1.1 FEATURES IN THE 50-MILE REGION AND 6-MILE VICINITY

The region within 50 miles of the site is primarily agricultural. The larger, more heavily industrialized cities in the region include Kalamazoo and Portage, Michigan, and Elkhart, Mishawaka and South Bend, Indiana, situated inland 30 to 50 miles from the site. Smaller cities in the region include South Haven, Benton Harbor, and St. Joseph, Michigan, located on the Lake Michigan shore (see Figure 2.1-1).

During the summer, the area experiences an influx of tourists and summer residents, particularly in communities along Lake Michigan, attracted by the recreational opportunities offered by the lake and the region's inland lakes and rivers (NMC 2003, Section 2.1; VBCP Undated). Numerous public recreational and natural areas are located within 50 miles of the Palisades site. None of these are on federal lands, but state facilities are numerous in the region and include eight parks, two recreation areas, seven game areas, one fish and wildlife area, and seven wilderness and natural areas (MDNR 2004a-c; see Figures 2.1-1 and 2.1-2). The closest state park to Palisades is Van Buren State Park on the northern border of the site. Encompassing approximately 400 acres with 1 mile of shoreline along Lake Michigan, the park features the high dune formations characteristic of the area and offers camping and picnic facilities and beach access. It is also the location of a trail head for the Van Buren Trail State Park, one of two linear state parks in the region. Van Buren Trail State Park is a dirt or gravel multi-use trail between South Haven and Hartford, Michigan. Kal-Haven Trail State Park is a 34-mile crushed limestone path between South Haven and Kalamazoo. Both trails are located on abandoned railroad grades (MDNR 2004a). Yankee Springs and Fort Custer State Recreation Areas, both approximately 50 miles from the site, are equipped with camping, picnic, and boat access facilities, and also offer hunting, fishing, swimming, hiking, horseback riding and winter sport use (MDNR 2004a).

Allegan State Game Area, which occupies 50,000 acres of land approximately 20 miles northeast of the site in Allegan County, is the largest of these state public recreation areas in the region. Allegan State Game Area and Augusta Creek Fish and Wildlife Area, located in the northeast corner of Kalamazoo County, are the closest facilities of their type to the site. Both facilities offer opportunities for public hunting and fishing and non-consumptive use such as bird watching (MDNR 1997; MDNR 2002; MDNR 2004b). Many of the state's natural areas are located on or near state parks or game areas. Seven state-designated natural areas are located within 50 miles of Palisades, none are in the vicinity of the site or the transmission lines addressed in this ER (MDNR 2004c).

Municipal recreational facilities in the region include county, township, and city parks. There are 225 municipal parks and open spaces occupying approximately 6,718 acres in Berrien County (Berrien 2003). Van Buren County and the City of South Haven together list nine municipal recreational facilities in the site vicinity; the closest of these to Palisades is Covert Township Park, 1.5 miles south-southwest (NMC 2003, Section 2.1; South Haven 2004; VBCO 2004; see Figure 2.1-2). Four municipal harbors offering lake access and services to recreational boaters are located within 50 miles of the site, the nearest of which is the South Haven Municipal Marina on Lake Michigan (MCGI 2003).

The region is drained by tributaries of Lake Michigan, including the Galien and St. Joseph Rivers, which outflow to the lake in Berrien County; the Black River, which outflows at South Haven, Van Buren County; and the Kalamazoo River, which outfalls to the lake in Allegan County (see Figure 2.1-1). The lower Kalamazoo River, downstream from Otsego, Michigan is the only stream in the region designated as a state Natural River (MDNR 2004d).

In the area near the Palisades site, sand dunes rise from the beach level at an approximate elevation of 582 feet above mean sea level (msl) to a maximum elevation of 780 feet msl and then drop off abruptly to 610 feet msl approximately 5,000 feet east of the lakeshore. Topography inland from the dunes is slightly rolling. The land is partly wooded with many open fields, berry farms, and orchards (NMC 2003, Section 2.1). Palisades Park and Country Club, a private residential and lakefront recreational community, borders the site on the south.

These and other land uses in the immediate environs of the Palisades site remain largely as described by the Atomic Energy Commission (AEC) in the Final Environmental Statement (FES) for Palisades, with the notable exception of the recent construction of the neighboring Covert Generating Plant by Covert Generating Company, LLC, which began commercial operation in 2004. The Covert Generating Plant is a 1,100-megawatt (MW) merchant generating facility that connects to the transmission grid at the Palisades Substation, and is situated on approximately 155 acres immediately east of I-196. The three natural gas-fired combined cycle electric generating units and associated support facilities and infrastructure occupy an estimated 35 acres of the tract; the remainder serves as buffer (see Figures 2.1-2 and 2.1-3). Cooling water for the facility, primarily makeup for evaporative losses from the plant's mechanical draft cooling towers, is obtained from Lake Michigan via two infiltration galleries and associated pipeline buried beneath the bottom of Lake Michigan approximately 1,200 feet offshore of the Van Buren State Park and approximately 5,000 feet northeast of the Palisades intake structure (USGS 1981). Cooling tower blowdown from the facility is discharged to the lake via a diffuser located approximately 800 feet further offshore from the plant's intake structure.

2.1.2 PALISADES SITE FEATURES

The Palisades site consists of approximately 432 acres situated between Lake Michigan and the Blue Star Memorial Highway and adjacent I-196, which parallel the lakeshore immediately east of the site (see Figure 2.1-3). Consistent with contiguous lands to the north and south, the site consists primarily of sand dunes, mostly forested, that extend inland approximately 5,000 feet. As a result of this local topography, site drainage is independent of Brandywine Creek, a small lake tributary that drains areas immediately east and south of the plant site. Surface water and percolating runoff drains directly to the lake (NMC 2003, Sections 2.1, 2.2).

Approximately 80 acres of the site are developed or maintained. The developed or maintained area includes power production and support facilities, roads, and related infrastructure. The power corridor from the main station transformer to the Palisades Substation and transmission rights-of-way from the Substation extending offsite are also included in this developed or maintained acreage. No residences exist on the site (NMC 2003, Section 2.1).

The current Palisades site acreage, all of which is owned by Consumers Energy Company (Consumers), is 55 acres less than the 487 acres reported in previous National Environmental Policy Act (NEPA) documentation for Palisades (e.g., Michigan Department of Natural Resources). This is attributable to realignment of the eastern site boundary to exclude land owned by Consumers that lies on and eastward of the Blue Star Memorial Highway and I-196, none of which is needed to meet NRC's site criteria at 10 CFR 100. The site boundary is the designated exclusion area over which Consumers has control for the purpose of excluding personnel or property. The minimum exclusion area distance to an uncontrolled area is 677 meters, from the reactor to the southern site boundary (NMC 2003, Section 2.1 and Figure 2-2).

Consumers has granted easements to the Michigan Electric Transmission Company, LLC (METC), which owns the transmission lines from the Palisades Substation and certain equipment in the Substation, but Consumers retains authority to exercise complete control over the Substation and associated easements located within the exclusion area, including evacuation and exclusion of METC personnel, contractors, visitors, guests, and other persons. There is a fence around the immediate plant area with a locked gate under the control of plant personnel and the site boundary is posted

(NMC 2003, Section 2.1). Additional access controls instituted in recent years include exclusion of the public from the lakeshore bordering the plant site through the use of vehicle barriers and signs posted by NMC at the north and south site boundaries. The U.S. Coast Guard has established a security zone extending 1,500 yards along the lakeshore frontage of the site and 1,000 yards into Lake Michigan. The U.S. Coast Guard order, in effect for an indefinite period, prohibits entry into the security zone unless authorized by the U.S. Coast Guard Captain of the Port, Chicago or the designated Patrol Commander (USCG Undated).

2.2 HYDROLOGY, WATER QUALITY AND USE, AND RELATED ISSUES

2.2.1 LAKE MICHIGAN

Lake Michigan is the only Great Lake entirely within the United States and is the second largest of the Great Lakes by volume (1,180 cubic miles). Approximately 118 miles wide and 307 miles long, the lake has a surface area of 22,300 square miles and 1,638 miles of shoreline. Average and maximum depths are 279 feet and 925 feet, respectively (Fuller, Shear, and Wittig 1995, Factsheet No. 1). Based on bathymetry and bottom sediment studies conducted in 1978, the lake bottom at Palisades slopes from the sand beach at the shoreline to a depth of approximately 10 feet within 500 feet of shore, then to a depth of approximately 50 feet 1 mile offshore (Wapora 1979). Bottom sediments in this zone exhibit evidence of sorting by wave action, and consist of coarse and very coarse sand in the surf zone, medium sand at the 5-foot depth contour, and fine sands elsewhere in this zone.

The northern part of Lake Michigan lies in the relatively cold upper Great Lakes region, and is sparsely populated except for the Fox River Valley, which drains into Green Bay. This large bay supports one of the most productive Great Lakes fisheries, and also receives wastes from the world's largest concentration of pulp and paper mills. Palisades is located in the more temperate southern part of the Lake, which drains an area that is among the most urbanized of the Great Lakes system, including the Milwaukee and Chicago metropolitan areas on Lake Michigan’s southwestern shore (Fuller, Shear, and Wittig 1995, Chapter 1).

Major rivers entering Lake Michigan are the Fox-Wolf, the Grand and the Kalamazoo (GLIN 2004a). Water from the lake flows to Lake Huron through the Straits of Mackinac with a net outflow of approximately 52,000 cubic feet per second (cfs). Approximately 3,000 cfs of the total outflow from the lake is through the Chicago Sanitary and Ship Canal to the Mississippi River basin (Fuller, Shear, and Wittig 1995, Great Lakes Water System Map). Since the Straits of Mackinac are deep and wide, Lake Michigan and Lake Huron remain at the same elevation; as a result, they are often referred to as a single hydrological unit (GLIN 2004b). Lake levels in the Lakes Michigan–Huron system are determined by the combined influence of these and other inflows and outflows. Inflows in addition to its tributary streams include precipitation (the primary source of natural water supply to the Great Lakes), the discharge from Lake Superior to Lake Huron via the St. Mary’s River, and groundwater inflows. Lakes Michigan-Huron outflows to Lake Erie via the St. Clair River, Lake St. Clair, and Detroit Rivers at a rate of approximately 187,000 cfs (Fuller Shear, and Wittig 1995, Great Lakes Water System Map). Additional losses from Lake Michigan include evaporation from the lake surface and various consumptive uses (GLIN 2004b; MDEQ 2004a). Consumptive use of Lake Michigan has been estimated to be approximately 1,310 cfs from all sources, of which 240 cfs is attributable to power production (Fuller, Shear, and Wittig 1995, Factsheet No. 3).

No flow or level controls have been established on the St. Clair River, Lake St. Clair, and Detroit Rivers outlet, so the water level in Lakes Michigan-Huron is the result of the factors discussed above (Fuller, Shear, and Wittig 1995, Chapter 2). As with the other Great Lakes, the lake level exhibits substantial changes over time, primarily in response to precipitation and air temperatures in the basin. For a period of record extending back to 1860, annual average lake levels (International Great Lakes Datum, or IGLD of 1955) have averaged approximately 580 feet IGLD and have ranged from a minimum of approximately 576 feet IGLD in the early 1960s to a maximum of approximately 582 feet IGLD in the late 1800s. Lake levels in recent years have been within about 1 foot of the record low as a result of significantly above average air temperatures and decreased precipitation in the upper Great Lakes basin (NOAA 2004).

Circulation patterns in Lake Michigan tend to be cyclonic (counterclockwise) resulting in a net northerly flow in the eastern portion of the lake near Palisades (Beletsky, Saylor and Schwab 1999). Nearshore currents at Palisades are caused principally by the cumulative effect of winds over a prolonged period. Meteorological monitoring and a study of lake currents at Palisades indicate that north and northwesterly winds predominate in winter and spring, which tend to produce currents flowing southward, while south and southwesterly winds predominate in summer and fall, tending to produce northerly-flowing alongshore currents (AEC 1972, Section II.E.2; NMC 2003, Section 2.5.3.1).

Water temperature in the open lake ranges from a low of approximately 35°F in January or February to a high of about 75°F in mid-August. Inshore waters (within the 100 foot depth contour, approximately 5 miles offshore) range from approximately 32°F to over 75°F in summer (AEC 1972, Section II.E.2). Ambient lake water temperature measurements taken from the Palisades' intake crib, located approximately 3,300 feet offshore at a depth of approximately 35 feet for a recent year (1999), are in reasonable agreement with these general observations, ranging from 33°F (minimum daily average) and 34°F (minimum monthly average) in January to 80°F (maximum daily average) and 70°F (maximum monthly average) in August. In early winter and early spring, water in the Lake Michigan becomes isothermal, and water is mixed from top to bottom. In summer, thermal stratification occurs in which warmer water overlies cold water at depth. Inshore waters may become substantially warmer than offshore waters in early winter or colder in early spring, inhibiting mixing of inshore and offshore waters during these periods. Ordinarily, there is intermittent ice cover extending 1-2 miles offshore in the southern basin of the lake during winter months (AEC 1972, Section II.E.2).

Concern about the protection and use of the Great Lakes and other waters shared by the U.S. and Canada have led to the creation of institutions that foster joint management of these water bodies. Experience with this arrangement over the years has led to an ecosystem approach to management of the Great Lakes (Fuller, Shear, and Wittig 1995, Chapter 5). The International Joint Commission (IJC), established by the 1909 Boundary Waters Treaty between the two nations, plays a central role in this joint management arrangement. With the advice of related technical organizations (e.g., Water Quality Board, Science Advisory Board, Council of Great Lakes Research Managers), the IJC has the responsibility to approve actions affecting natural lake levels or flows, conduct studies of specific problems affecting the lake, and arbitrate disputes. The IJC also provides a procedure for monitoring and evaluating progress with respect to provisions of the Great Lakes Water Quality Agreement. Established in 1972 (the time frame that Palisades began operation) and last amended in 1987, this agreement establishes common water quality objectives and means of achieving these objectives, including target loadings for phosphorus (identified as a principal contributor to eutrophication in the Great Lakes) and, more recently, other critical pollutants; pollution controls using each country's respective laws (e.g., Clean Water Act and implementing regulations in the U.S.); and both separate and collaborative research and monitoring efforts. The ecosystem approach was particularly strengthened by the 1987 amendment, which included an agreement to develop remedial action plans for geographic areas of concern and Lakewide Management Plans for critical pollutants for each of the lakes (Fuller, Shear, and Wittig 1995, Chapter 5).

As a result of these and related initiatives, substantial progress has been made in improving the water quality of Lake Michigan since the initial operation of Palisades in the early 1970s. Indicators of this progress include the slowing of eutrophication as evidenced by reduction in phosphorus and chlorophyll concentrations in the open lake and reductions of polychlorinated biphenyls (PCBs) in lake trout during this period. At present, Lake Michigan provides safe drinking water for 10 million people and supports many other beneficial uses, including: internationally significant habitat and natural features, food production and processing, valuable commercial and recreational activities, and fish for food, sport and culture (EPA 2000, Chapter 4, Appendix E, Table 1; EPA 2004, Chapter 1).

The open waters of Lake Michigan are considered by the Michigan Department of Environmental Quality (MDEQ) to have excellent water quality with the exception of a few impaired nearshore zones affected by large, densely populated, and heavily industrialized urban areas. In addition, the trophic status of the lake remains oligotrophic with low nutrient levels (MDEQ 2004b, Chapter 2, Appendix VIII). Lake Michigan waters in Michigan meet the state's water quality standards and, with exception of fish consumption advisories that remain in effect, are assumed by MDEQ to support the "aquatic life" designated use. The fish consumption advisories in effect for the lake concern 13 species or species groups, including five important salmonid species, smelt (*Osmerus mordax*), walleye (*Stizostedion vitreum*), burbot (*Lota lota*), whitefish, yellow perch (*Perca flavescens*), carp, catfish, and lake sturgeon (*Acipenser fulvescens*) (MDCH 2003). Consumption concerns are for persistent toxic chemicals, including PCBs for all of these species and dioxin, pesticide residues, and mercury in one to a few of them. Similar advisories are in effect for the South Branch Black River to the Black River mouth and the mainstems of other major rivers in the Palisades region, including the St. Joseph and Kalamazoo River (MDCH 2003). The lower 80 miles of the Kalamazoo River, which outflows to Lake Michigan at Saugatuck, is the only IJC-designated Area of Concern (AOC) in the Lake Michigan watershed within the Palisades 50-mile region. A remediation plan for PCB-contaminated sediments in the designated river segment is being developed (EPA 2000, Appendix F; MDEQ 2004b, page 16).

Another cooperative international institution that has taken formal initiatives to manage waters of the Great Lakes, including Lake Michigan, is the Council of Great Lakes Governors (CGLG 2004a). The Council assists in coordinating activities under the Great Lakes Charter of 1985, an agreement by which the Great Lakes States and Canadian Provinces cooperatively manage the Great Lakes. Governing authority is granted under the U.S. Federal Water Resources Development Act of 1986, which requires unanimous approval by the Governors (representing Great Lakes States) and the Premiers (representing Canadian Provinces) for any diversion or export of water from the Great Lakes Basin (CGLG 2004a). In 2001, the Council approved a Charter amendment, Charter Annex 2001, directing the development of new binding agreements to further the Governors' and Premiers' objectives to "protect, conserve, restore and improve the Waters and Water-Dependent Natural Resources of the Great Lakes Basin" (CGLG 2001). The Council issued the draft Annex 2001 Implementing Agreements for public review and comment on July 19, 2004 (CGLG 2001, 2004b, 2004c). Changes to the implementing agreements are expected following the close of the comment period, but are not expected to affect continued compliant operation of the plant in the license renewal term. The Annex agreements are proposed only for new or increased water use, which is not planned for Palisades in the license renewal term.

2.2.2 GROUNDWATER

Regional geology in Van Buren County consists of 300-400 feet glacial and post-glacial deposits overlying sedimentary bedrock consisting of lower Mississipian Age Coldwater Shale or Limestone (STS 1987, Section 3.1; NMC 2003, Section 2.3.2). Results of the drilling program conducted at Palisades in the 1960s indicate these deposits to consist of dune sand underlain sequentially by dense to very dense gray silty sand or sandy silt, stiff gray clay, and stiff to hard gray glacial till. The study also found that the dune sand layer varies in thickness from about 10 feet in the switchyard area to well over 100 feet near the lake (NMC 2003, Figures 2.11 and 2.12).

These early site studies indicate that unconfined groundwater in these deposits in the vicinity of Palisades exhibits a hydraulic gradient of approximately 13 feet per mile in a westerly direction, flowing to Lake Michigan at an estimated rate of 650 feet per year. Field permeability tests during exploratory drilling in 1965 yielded values ranging from 30-1,720 feet per year in the site area. Groundwater elevations averaged 580 feet above mean sea level (msl) beneath what is now the power block area, corresponding to the approximate mean level of Lake Michigan, approximately 604 feet msl beneath the Palisades Substation, and approximately 601 feet msl near the eastern site boundary (NMC 2003, Section 2.2.1). Based on current ground surface elevations at these locations, these elevations correspond to depths below ground surface of approximately 45 feet at the power block to approximately 10-15 feet near the eastern end of the site (NMC 2003, Figures 1-1, 1-7, 2-3). More recent hydrogeologic studies performed in 1987 in connection with the sanitary drainfield located just south of the power block found the water table to be approximately 30 feet below the surface of the drainfield and indicated groundwater moves toward the lake in that area at an estimated rate of approximately 23 feet per year. Groundwater analyses found no metals, halogenated or aromatic hydrocarbons above detection limits; all parameters detected were present at concentrations well below recommended maximum contaminant levels (STS 1987).

2.3 BIOLOGICAL RESOURCES

2.3.1 LAKE MICHIGAN AQUATIC COMMUNITIES

2.3.1.1 Pre-Operational Characterization

Lake Michigan biota comprise a food web conveniently viewed as having two related components, a pelagic food web associated with open water and a benthic food web associated with the lake bottom (Eshenroder et. al 1995, page 3). Both of these components are based on primary production from photosynthesis by planktonic algae (phytoplankton) in surface waters of the lake (i.e., photic zone).

The benthic food web is based on the consumption of decomposing algae and other organisms that fall from the water column by organisms that inhabit the lake bottom (Eshenroder et. al 1995, pages 3-5). Among the most important members of the benthic community in the lake are the opossum shrimp (*Mysis relicta*), which migrate vertically in the water column at night to feed on zooplankton. Also important are members of a closely related group of amphipods (*Diporeia spp*.). These organisms are glacial relict species characterized by relatively large size and high lipid levels that provided survival advantage in the prolonged cold waters of late Pleistocene-era lakes. As a result, *Mysis relicta* and *Diporeia* are important sources of high-energy food for fish species comprising the upper trophic levels in pelagic and benthic food webs of the lake (Eshenroder et. al 1995, pages 3-5).

The pelagic food web is based on consumption of phytoplankton by small invertebrates inhabiting the water column (zooplankton), mostly cladocerans and copepods, including species of the latter that prey on other small invertebrates (Eshenroder et. al 1995, page 3). Important species originally comprising the native fish community in Lake Michigan included several species of deepwater ciscoes (*Coregonus spp*.), lake herring (*Coregonus artedii*), lake whitefish (*Coregonus clupeaformis*), deepwater sculpin (*Myxocephalus thompsoni*), and burbot (*Lota lota*) (Eshenroder et. al 1995, pages 4-7). All of these species have pelagic larvae, and both larvae and juveniles were dependent on cladocerans and copepods that comprised principal zooplankters in the pelagic zone. Lake herring adults also used the pelagic food web, feeding on zooplankton. Adult deepwater ciscoes and whitefish, considered benthivores, were dependent on *Mysis* and *Diporeia*. Burbot and lake trout (*Salvelinus namaycush*) were at the highest trophic level, feeding on both benthic and pelagic prey fish, including the ciscoes and deepwater sculpin. At the time of European settlement in the mid-1800s, 79 fish species reportedly inhabited Lake Michigan. Whitefish were reportedly extremely abundant in the nearshore community; other important inshore fish reportedly included emerald shiner (*Notropis atherinoides*), a planktivore; lake sturgeon and suckers (e.g., *Catostomus spp*.), both benthivores; yellow perch, an omnivore; and walleye (*Stizostedion vitreum*), a piscivore (Eshenroder et. al 1995, pages 4-7).

The Lake Michigan ecosystem and the species comprising the food web noted above have experienced significant changes in the past 140 years as a result of a number of human activities. These include commercial fishing, pollution, modifications (e.g., damming) of tributary streams, nutrient loading, and introduction of non-native species (EPA 2000, Section 4.2.2.1; Eshenroder et. al 1995, page 7; Madenjian et. al 2002, page 737). Commercial fishing and tributary degradation were two major sources of ecological stress in the late 1800s and early 1900s. Commercial fishing resulted in a noticeable decline in fish populations by the 1870s. Industrial pollution and damming of rivers adversely affected fish species dependent on tributary streams for spawning; species affected included brook trout (*Salvelinus fontinalis*), various minnows (*Notropis spp*.) and redhorse suckers (*Moxostoma spp*.). However, introduction of two exotic species to the Great Lakes, the sea lamprey (*Petromyzon marinus*) and alewife (*Alosa pseudoharengus*), resulted in the most profound early impacts to native Lake Michigan fish communities (Madenjian et. al 2002, page 737).

The sea lamprey believed to have gained access to the upper Great Lakes via the Welland Canal was first found in Lake Michigan in 1936 and had contributed to the collapse of burbot and lake trout populations by the late 1940s (Eshenroder et. al 1995; Fuller, Nico, and Maynard 2000). The alewife invaded the lake in the 1940s via the same pathway and proliferated in the absence of pressure from the burbot and lake trout, two top predators, achieving nuisance proportions during the 1960s (Eshenroder et. al 1995, pages 7-8; Madenjian et. al 2002, pages 741-742). The large abundance of alewife likely affected plankton populations and, as a result of pelagic fish larvae consumption, is believed to have contributed – along with overfishing – to the extinction of three species of deepwater cisco and the suppression of emerald shiner, lake herring, yellow perch, and deepwater sculpin populations (Eshenroder et. al 1995, pages 7-8; Madenjian et. al 2002, pages 737, 741-742). Rainbow smelt, a non-native prey species intentionally introduced to the lake in the early 1900s, also greatly increased in population as a result of the virtual elimination of the top predators and, by the 1960s, the lake was dominated by the alewife and, to a lesser extent, rainbow smelt (EPA 2000, Section 4.2.2.1).

Subsequent efforts to rehabilitate the fish community in the lake included implementation of a lamprey control program in 1960 and stocking of lake trout, non-native coho salmon (*Oncorhynchus kisutch*), and non-native chinook salmon (*O. tshawytscha*) in 1965-67; non-native brown trout (*Salmo trutta*) and “steelhead” a variety of rainbow trout (*O. mykiss*) were also stocked. Specific objectives included control of alewife populations, establishment of a put-grow-take fishery, and re-establishment of naturally reproducing lake trout populations (Eshenroder et. al 1995, page 8). By the time Palisades initiated operation in 1972, these efforts were well underway and apparent success was evidenced by declining alewife populations and establishment of introduced salmonines in the sport fishery (AEC 1972, Appendix V-2).

2.3.1.2 Post-Operational Characterization

The status of key fish species in Lake Michigan and associated food web components in the vicinity of Palisades in the late 1960s and early 1970s are summarized in NEPA documentation associated with initial operation, efforts to obtain a full term operating license for the plant, and associated supporting documentation (AEC 1972, Sections V.C, Appendices II-I and V-2; NRC 1978, Section 2.2.1; Consumers 1975). As noted in Section 2.3.1.1 of this ER, accelerated eutrophication of the Great Lakes from nutrient loadings was a concern at the time Palisades began operation. In the mid-twentieth century, phosphorus loading in Lake Michigan was evidenced by algae blooms in some nearshore areas, including the extreme southern crescent of the lake from Chicago to Benton Harbor (EPA 2000, page 4-18). Such blooms were not reported from the Palisades studies cited above, although the standing crop of phytoplankton noted in those studies was highest in June 1974, the last year of these early studies (Consumers 1975). Diatoms dominated the phytoplankton community at that time, and blue-green algae formed only a small part of the community. No obvious algal growths or rooted aquatic plants were found to exist in the Palisades area, a finding attributable to the sandy substrate, which is too unstable to provide suitable attachment (Consumers 1975; NRC 1978, Section 2.2.1).

The zooplankton community at Palisades in the early 1970s was dominated by cyclopoid and calanoid copepods and, in the summer, cladocerans of the genus *Bosmina*. *Daphnia retrocurva*, a medium-sized cladoceran, and *Limnocalanus*, a large-bodied glacial relict copepod, were among the dominant forms present (Consumers 1975; NRC 1978, Section 2.2.1; Eshenroder et. al 1995, page 4). *D. retrocurva* was also noted as dominating the zooplankton community at another nearby industrial facility on Lake Michigan (Madenjian et. al 2002, page 740). The benthic macroinvertebrate community near Palisades was consistent with that found in other shallower regions of the lake by other researchers, consisting predominantly of *Chironomidae* (midges), *Sphaeriidae* (fingernail clams), the glacial relict amphipod *Pontoporeia hoyi*, and oligochaetes (segmented worms). Inshore, wave disturbed areas were sparsely populated; fingernail clams and *Pontoporeia* were more numerous at greater depths, and *Pontoporeia* was codominant with oligochaetes at the deepest station sampled (NRC 1978, Section 2.2.1).

The Lake Michigan food web has undergone substantial changes since 1970 (Madenjian et. al 2002, pages 736-741). Control programs have substantially reduced phosphorus loadings to the lake, and likely contributed to the decrease in phytoplankton abundance and production in nearshore waters observed during the past 30 years. The reduction in alewife abundance between 1970 and 2000 is implicated in the changing composition of the zooplankton community, and invasion of the lake in 1986 by the spiny water flea (*Bythotrephes cederstroemi*) a predatory cladoceran. *Bythotrephes* appears also to have changed the zooplankton community structure, including reductions in *D. retrocurva* abundance. *Bythotrephes* also reportedly consumes a substantial portion of zooplankton production in the lake and is not a preferred prey for many fish species, therefore reducing energy transfer to the fish community (EPA 2000, Section 4.2.2.1).

Overall abundances of *Diporeia*, oligochaetes, and fingernail clams increased through the early 1980s, but exhibited substantial decreases in nearshore areas from 1980 to 1993, a phenomenon attributed to reduced phytoplankton production in the nearshore zone brought about by reduced phosphorus loadings. Continued decline of *Diporeia* in the nearshore region, including the Palisades area, occurred during the 1990s, coinciding with the invasion of yet another exotic species, the zebra mussel (*Dreissena polymorpha*). The specific mechanism by which zebra mussels may be affecting *Diporeia* populations is unclear; however, if the drastic reductions in *Diporeia* density continue to spread, the effects on the Lake Michigan food web may be substantial. An invasive species from the Ponto-Caspian region, zebra mussels had colonized hard substrates in the nearshore region of southern Lake Michigan by 1993 and continued to increase in density between 1992 and 1999. Another dreissenid, the quagga mussel (*Dreissena bugensis*), apparently invaded the lake more recently (Madenjian et. al 2002, pages 736-741). In addition to being an apparent causative factor in disappearance of *Diporeia*, these organisms divert energy from the pelagic food web by filtering out a significant portion of the plankton at the expense of fry from nearshore species, including yellow perch (Madenjian, Desorcie, and Holuszko 2004, page 8).

Fish species collected as a result of the studies noted above, which included pre-operational studies from 1968-72 and operational-phase studies through October 1973, are listed in Table 2.3-1. During this period, alewife and rainbow smelt populations in the lake remained high, and bloater, the principal surviving species of deepwater cisco (referred to as “chubs” in the commercial fishery), were abundant in deeper waters. All three were significant components of the commercial fishery at that time. Collections at Palisades found alewife to be a major component of the catch and rainbow smelt to be one of the most common species encountered lakewide. However, relatively few bloaters were collected in the Palisades studies, as would be expected, considering their propensity to inhabit deeper waters of the lake (AEC 1972, Appendix V-2; Consumers 1975, Section D).

Three species that were important components of the commercial fishery prior to the siting of Palisades were no longer so. In particular, the lakewide population of lake whitefish, which suffered greatly from sea lamprey predation, remained low. Few whitefish were noted during surveys at Palisades, likely reflecting low lakewide populations and the fact that whitefish is at the southern limit of its range near Palisades. Lakewide populations of lake herring, traditionally the most productive commercial species in the lake, and yellow perch, also an important commercial species, had declined to insignificant components of the commercial harvest by 1970 as a result of the alewife invasion, as previously discussed. Very few lake herring were collected at Palisades during the surveys, reflecting conditions lakewide. However, yellow perch was taken in considerable numbers during monitoring studies at Palisades and was the most numerous game fish in the Palisades area in the summer and fall (AEC 1972, Appendix V-2; Consumers 1975, Section D).

Studies conducted at Palisades generally reflect the introduction of salmonines to the lake in the mid-1960s. Coho and chinook salmon, steelhead, lake trout, and brown trout were all collected during preoperational studies, but constituted a very small proportion of the catch (AEC 1972, Appendix V-2; Consumers 1975, Section D). Species noted in relatively high numbers at Palisades in these early study reports not mentioned above consisted of the following:

- spottail shiner (*Notropis hudsonius*), a small prey species common in shallow waters of the Great Lakes and reported as likely the most abundant minnow in Lake Michigan (Becker 1983, pages 540-543);
- slimy sculpin (*Cottus cognatus*), found to inhabit rip-rap around the intake crib;
- trout-perch (*Percopsis omiscomaycus*), a forage fish;
- longnose dace (*Rhinichthys cataractae*), among the dominant species in seine collections; and
- two suckers, longnose sucker (*Catostomus catostomus*) and white sucker (*Catostomus commersoni*), both bottom dwelling species that exhibit spring spawning runs following the shoreline to tributary spawning streams.

The populations of salmonine species introduced or reestablished (as in the case of lake trout) in the lake by stocking have more or less stabilized. Chinook salmon and, to a lesser extent, lake trout and rainbow trout (steelhead) have comprised most of the salmonine biomass and exhibited the greatest consumption of prey during this period (Madenjian et. al 2002, Figures 4(b) and 8, pages 744-746). Natural reproduction has been significantly established for rainbow trout, chinook salmon, and coho salmon; however, natural reproduction of brown trout has been very limited, and evidence of natural reproduction of lake trout has been only sporadic. Continuous intensive stocking has supported all of these salmonines; total numbers planted during 1976-1994 ranged from 11 million to 17 million annually (Eshenroder et. al 1995, pages 8-10).

The effectiveness of salmonine stocking in Lake Michigan had a profound effect on the food web, evidenced directly by the decrease and then stabilization in alewife populations during the 1970s and early 1980s. During this same period, populations of many fish species that were depressed by the alewife, including bloater, deepwater sculpin, and yellow perch increased substantially. Similarly, populations of burbot and lake whitefish, which had been heavily affected by sea lamprey predation, increased as a result of effective lamprey control measures (Madenjian et. al 2002, pages 741-748).

Other factors affecting populations of important species such as bloater, lake herring, and lake sturgeon have been evident since 1970 (Madenjian et. al 2002, pages 741-

748). The bloater population, after exhibiting a large increase from the 1970s through 1989, has since declined as a possible result of a density-dependant natural cycle. Populations of lake herring, a once important commercial species whose population had crashed as a result of overexploitation and impaired reproductive success from the introduced rainbow smelt, has exhibited some limited recovery in the northern part of the lake. The population of lake sturgeon, a long-lived species that spawns in tributary streams connecting waters and shoal areas in the Great Lakes, was decimated in the early 1900s as a result of overexploitation and habitat degradation; their numbers are expected to increase with continued removal of dams on tributary streams and associated increase in spawning habitat (Madenjian et. al 2002, pages 741-748; Zollweg et. al 2003).

Although lake whitefish populations have increased, their condition and size-at-age have exhibited decreases, a suspected result of zebra mussel-induced decline in *Diporeia*, a substantial part of the whitefish diet (Madenjian et. al 2002, page 746-747; NOAA 2002). Similar concerns have been raised regarding other important fish species for which *Diporeia* is a main diet component, including bloater and three fish found to be numerous nearshore at Palisades: slimy sculpin, yellow perch, and trout-perch (Brandt 2004). There is also evidence that declines of *Diporeia* in nearshore areas, including the area near Palisades, may be focusing more predation pressure on other large macroinvertebrates, including *Mysis* (Brandt 2004).

Invasion of Lake Michigan in the 1990s by yet another Ponto-Caspian species, the round goby (*Neogobius melanostobus*), may further change this dynamic. Declines in mottled sculpin (*Cottus bairdi*) populations in Lake Michigan's Calumet Harbor and in Johnny darter (*Etheostoma nigrum*) and logperch darter (*Percina caprodes*) populations in Lake St. Clair are linked to this species (Madenjian et. al 2002, page 748). The round goby feeds to a substantial extent on zebra mussels and is itself preyed upon by several fish species in Lake Michigan. Although initially found only in Lake Michigan harbors, several individuals were collected in 2003 near Manistique and Saugatuck, Michigan at depths of 9 to 27 meters (Madenjian, Desocie, and Holuszko 2004, page 8). The effect of the round goby invasion on Lake Michigan's food web is yet unknown.

The status of the biological communities in the lake and results of the management efforts described above are monitored by a number of agencies and institutions that are active participants in programs implemented under the Great Lakes Water Quality Agreement discussed in Section 2.2 of this ER (e.g., see EPA 2000, 2004) and related programs. For example, the status and trends of prey fish populations in Lake Michigan are monitored by the U.S. Geological Survey (USGS) Great Lakes Science Center (GLSC) in annual surveys to obtain data on relative abundance, size structure, and fish condition (Madenjian, Desorcie, and Holuszko 2004, page 1). The statistics are then used to estimate various population parameters used by states and tribal agencies to manage fish stocks.

Results of the management efforts noted above indicate that prey species or species groups of importance lakewide include alewife, bloater, rainbow smelt, and sculpins, all of which were collected during the Palisades monitoring programs, and are also reflected in commercial and recreational harvest statistics for the lake. Fish species collected in the vicinity of Palisades during studies by Consumers and others are also represented in recent commercial and recreational harvests (see Table 2.3-1). The 2002 commercial harvest from the lake totaled 6.9 million pounds valued at approximately $6 million, nearly all for human consumption; lake whitefish, chubs (i.e., bloater, the only remaining deepwater cisco in the lake), and rainbow smelt were predominant, respectively comprising 56 percent, 29 percent, and 7 percent of the harvest (USGS 2004a). Salmon and trout and, to a lesser extent, yellow perch, are the focus of the Lake Michigan sport fishery (Hanson 2004). The total recreational harvest for the lake in 2000 amounted to 7.2 million pounds, about the same as observed each year since 1995. As in previous years, salmon and trout as a group comprised by far the largest component of the harvest in 2000 (92 percent), consisting mostly of chinook salmon and coho salmon (47 percent and 16 percent of total harvest, respectively). Yellow perch comprised 5 percent of the harvest, about the same as in 1997-99, but down substantially from about 20 percent of the harvest in 1995. Although Michigan harvests since 2000 are not represented, currently compiled harvest statistics indicate that lake trout harvest in all regions of the lake declined in 2001-2003 (Hanson 2004).

In summary, the species composition and dynamics of the Lake Michigan food web are the products of a complex interplay of factors. The current Lake Michigan food web is a testament to the legacy of several historical events and activities. These include overexploitation of fish stocks in the lake and destruction of habitat, particularly in tributary streams and disruptions caused by exotic species that have invaded the lake either directly or via ocean-going vessels as a result of the removal of natural barriers (e.g., Welland Canal). Intensive management efforts, including habitat restoration, control of invasive species by direct means (i.e., sea lamprey), restoration of balance, and maintenance of viable fisheries through fish stocking programs (e.g., salmonine stocking) were also important factors influencing the food web as it now exists. In contrast, impact assessments and monitoring of other food web components in the vicinity of Palisades during its initial operation, (once-through cooling system utilized) indicated that impacts were localized and of little significance on a lakewide basis (AEC 1972, pages i-iii; NRC 1978, page ii). Recent monitoring of the plant, which now uses a closed-cycle cooling system, provided additional substantiation for this conclusion by confirming that fish impingement and entrainment losses from plant operation are extremely low (Consumers and NMC 2001).

2.3.2 TERRESTRIAL COMMUNITIES

2.3.2.1 Regional Overview

The Palisades site and western portion of the Palisades-Argenta 345-kV transmission line addressed in this report (see Figures 2.1-1 and 3.1-1) lie in the glacial lake plain of Lake Michigan. The region is characterized by sand dunes up to 200 feet high in a band along the lakeshore, lacustrine deposits, and generally flat to gently rolling, fine-textured end and ground moraine eastward (Albert 1995, Subsection VI.3.2). Subject to past timbering, particularly for hemlock (*Tsuga spp.*) in the hemlock-beech forest that once predominated in this region, sand mining along the lake shore, and drainage of poorly-drained areas, most of the region is now agricultural land, including blueberry farming on poorly-drained sites and orchards and vineyards on better drained soils. Some of the draughtiest and most poorly drained sandy soils in this region remain as wildlife management areas or recreational lands, either forested or wetland; large portions of the coastal sand dunes are protected, though some sections of the dunes exhibit heavy residential development (Albert 1995, Subsection VI.3.2).

The eastern portion of the Palisades-Argenta line in Van Buren County traverses an area regionally characterized by ground moraine and mostly moderately to steeply sloped end moraine ridges with well drained soils, with some poorly drained soils in the ground moraine and very poorly drained soil in kettle depressions. Predominant pre-settlement vegetation consisted of forest dominated by beech (*Fagus grandifolia*), sugar maple (*Acer sacchaum*), and/or white oak (*Quercus alba*). Swamp hardwoods, tamarack (*Larix laricina*), wetland shrubs, and bogs occurred in kettle depressions in the area, and wet prairie and emergent marsh occupied large areas of ground moraine (Albert 1995, Subsection VI.3.1). Except for some steep ravine slopes and wetlands, the area is now farmed. Eastward through northwestern Kalamazoo County, the line traverses a glacial outwash plain regionally characterized by flat to gently sloping outwash deposits of sand and gravel with small areas of end moraine and ground moraine (Albert 1995, Subsection VI.2.1). In presettlement times, tallgrass prairie and oak savannahs occupied well drained areas of outwash and moraine, respectively, and wet prairies, marshes, and extensive wet meadows were present on poorly drained areas in the outwash plain. Most uplands and large areas of wetland in this region have been converted to agriculture. Although prairie fens remain common in the region, tallgrass prairie, wet prairie, and oak savannah are now quite rare (Albert 1995, Subsection VI.2.1).

NMC provides more specific characterization of terrestrial communities that exist on the site and along the associated transmission lines addressed in this ER in the following subsections.

2.3.2.2 Palisades Site

Palisades occupies the site of a former sand mining operation situated in the dunes bordering Lake Michigan (AEC 1972, Section II.A). Terrestrial ecological communities on the site are well-known as a result of three Consumers-sponsored site-wide surveys conducted prior to and after initial operation of the plant and from numerous more narrowly focused studies by Consumers or its consultants. The initial survey of the site, conducted in 1971 prior to plant operation, resulted in the identification and mapping of on-site plant communities and provided estimates of wildlife species presence and abundance (Reichard 1971). In 1978 and 1979, Asplundh (1979) performed more detailed vegetation surveys and mapping and, in each major vegetation community, performed seasonal bird censuses and surveyed amphibians, reptiles, and mammals using active observation and collection techniques, including trapping. Specific efforts to identify plant and animal species considered endangered, threatened, or of special concern were undertaken as part of that study. Vital Resources Consulting conducted an additional intensive survey and mapped vegetation communities on the site in 1990 (Higman and Goff 1991). This latter survey refined and updated plant community characterizations (e.g., species composition, age structure) and mapping conducted by Asplundh (1979), assisted in the identification of site areas subject to the provisions of Michigan's "Critical Sand Dune Act," and clarified the nature and extent of an "exemplary dune-associated plant community" along the southern border of the site, discussed further below and in Section 2.3.2.4 of this ER.

Based on the most recent of these surveys, plant communities on the Palisades site and NMC estimates of respective acreages are listed in Table 2.3-2 (Higman and Goff 1991). As indicated in the table and by inspection of Figure 2.1-3, most of the site is forested. Red Oak-Sassafras-Sugar Maple-Beech Hardwoods (see Table 2.3-2, Community 2) is the most extensive forest type on the site, comprising nearly all of the forested area lying west of the site access road extending northward to the north security gate (see Figure 2.1-3). This forest, characterized as a typical Beech-Maple back dune forest by Asplundh (1979), is typical of many complex rear dune areas along the Lake Michigan shoreline and appears to have a well balanced, all-age structure. A portion of this community situated near the southern site boundary occurs on a dune with steeply sloping topography characterized by ridges and hollows. At least a part of this latter area, apparently extending southward to and beyond Brandywine Creek on Palisades Park and Country Club property, is recognized important habitat by the Michigan Natural Features Inventory (i.e., MNFI)(Higman and Goff 1991, Goff 1992). Most of the remaining forest on the site, which lies east of the site access road northward to a short distance beyond the site meteorological tower, is typed as Red Oak-White Ash-Sassafras-Sugar Maple (see Table 2.3-2, Community 1) and was apparently logged in the 1930s. Young Oak-Sassafras-Prunus and Red (*Pinus resinosa*), White (*P. strobus*), and Jack Pine (*P. banksiana*) communities (see Table 2.3-2, Communities 3 and 4, respectively) predominate in forested areas on either side of the abandoned railroad bed northward to the site boundary (Higman and Goff 1991).

Areas typed as Upland Shrub-Scrub on the site by Higman and Goff (1991) include portions of transmission line rights-of-way (ROW), forest openings, and borders of forested areas and dune blow-outs where saplings [e.g., of red oak (*Quercus rubra*), sassafras (*Sassafras albidium*), *Prunus spp*.] and shrubs (e.g., brambles, grape, *Smilax*) have become established. Areas typed as Old Field denote similarly disturbed sites that lie on relatively flat areas where grasses and weedy species dominate, including the abandoned railroad bed and disturbed sites around buildings.

Steep dune areas and flats at the base of dunes on or adjacent to developed areas of the site have been stabilized by plantings of beach grass (*Ammophila breviligulata*) and dune grass (*Calamovilfa longifolia*) or are stabilized by natural colonization of these species. These areas include the power transmission corridor from the plant to the Substation, areas adjacent to the secure area surrounding the power block and main parking lot, former dune blow-out area immediately west of the outage building, and an unforested dune area in the northwest corner of the site. These sites are designated Beach Grass Stabilized Dune Community or Flats, depending on topography (see Table 2.3-2, Communities 8 and 9, respectively). Sand Dune Blow-out Communities (see Table 2.3-2, Community 10) occur where wind action has resulted in dune destabilization. These unforested dunes are not yet stabilized by beach grass but exhibit a scattering of other colonizing plant species. Vegetation-free areas and beach along the lakeshore are classified as Open Sand (Higman and Goff 1991; see Table 2.3-2, Community 11).

Wetland communities on the site are few, small, and scattered, totaling less than 10 acres (see Table 2.3-2, Community 12). The largest of these, situated in a depression immediately north of the Palisades Substation (see Figure 2.1-3), was characterized in 1991 as Black Gum-Willow-*Calamogrostis* Shrub (Higman and Goff 1991). Similar small wetland sites occur in the transmission ROW on the eastern border of the site, and a small (< 0.2 acres) forested wetland dominated by black gum (*Nyssa sylvatica*) is located north of the Outage Building sanitary drainfield (Higman and Goff 1991).

Approximately 5 acres of vegetation on dune ridges adjacent to and southeast from the cooling towers (see Table 2.3-2, Community 13) are impacted by condensate plumes and drift from the towers. The resulting disturbance, including ice damage in winter, is evidenced by dead crown trees (Higman and Goff 1991). Related impacts were addressed by NRC in its *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (i.e., GEIS; NRC 1996, Section 4.3.5.1.2).

Studies by Asplundh (1979) documented the presence of 14 mammal species and seven amphibian or reptile species on the site; approximately 113 bird species were observed on or overhead the site or adjacent areas (e.g., lakeshore). Mammals consisted of several game species and furbearers, including white-tailed deer (*Odocoileus virginianus*), eastern cottontail rabbit (*Silvilagus floridanus*), raccoon (*Procyon lotor*), red fox (*Vulpes vulpes*), and three squirrel species. Small mammal prey species sighted or trapped in relatively high numbers included the white-footed mouse (*Peromyscus leucopus*), eastern chipmunk (*Tamias striatus*), and thirteen-line ground squirrel (*Spermophilus tridecemlineatus*). Reptiles noted on the site included the eastern box turtle (*Terrapene carolina*) – a species of special concern in Michigan, eastern hognose snake (*Heterodon platyrhinos*), and blue racer (*Coluber constrictor*). Amphibians included northern leopard frog (*Rana pipiens*), spring peeper (*Pseudacris crucifer*), American toad (*Bufo americanus*), and red-backed salamander (*Plethodon cinereus*). A total of 66 and 83 bird species were recorded in bird censuses conducted during fall and spring migration periods, respectively; 49 bird species were recorded in a summer census when most songbirds in the area would be expected to be nesting or at least territorial.

NMC discusses those plant and animal species considered threatened or endangered at the federal and state level and which have been noted as occurring on or near the site in Section 2.3.3 of this ER.

2.3.2.3 Transmission Lines

Transmission lines addressed in this ER consist of the Palisades-Argenta 345-kV line, which extends approximately 40 miles eastward from the Palisades Substation to the Argenta Substation near Plainwell, north of Kalamazoo, Michigan, and the initial 0.6 mile segment of the Palisades-Cook 345-kV line, which parallels the Palisades-Argenta line as it exits the Palisades Substation (see Section 3.1.4 and Figures 2.1-3 and 3.1-1 of this ER). Both of these transmission lines are owned by METC. Consumers owns the land on which the lines are located (i.e., as “fee strips”) and currently maintains vegetation on transmission ROW within these fee strips for METC. Compatible land uses (e.g., cropland, pastureland) are allowed to persist on the ROW. Areas of natural vegetation traversed by the lines are maintained to ensure compatibility with the line using the border zone – wire zone technique, which involves periodic selective removal of woody vegetation to promote and maintain open habitat comprised of an herbaceous plant community beneath the conductors and low-growing shrubs and other compatible vegetation in the border zones. Vegetation maintenance beyond the border zone is limited to selective removal of “danger trees” (see Section 3.1.4 and Table 3.1-1 of this ER).

Much of the offsite portion of the Palisades-Cook line segment consists of highway crossings. The offsite portion of the Palisades-Argenta line segment traverses exclusively rural landscape typical of this area of southwestern lower Michigan. With the exception of the nearby Van Buren State Park and crossings of the Kal-Haven and Van Buren State Trails (see Section 2.1 and Figures 2.1-1 through 2.1-3 of this ER), these transmission lines do not traverse on or near any known federal or state lands managed for natural habitat values or related recreational activities.

NMC provides an indication of habitats present in the general area traversed by the Palisades-Argenta line in Table 2.3-3. The table provides an acreage tabulation of land use and vegetation cover on the Consumers fee strips on which the ROW is situated based on Michigan Center for Geographic Information (MCGI) State Land Use data. As indicated, the Consumers fee strip acreage along the line totals nearly 2,200 acres, approximately 38 percent of which is classified as active agricultural land. Approximately 28 percent and 25 percent of the fee strip area, respectively, are classified forest (mostly central hardwoods) and rangeland (mostly shrubland). Approximately 2 percent (43 acres) is classified as wetland (primarily shrub-scrub). The remaining area consists of urban and built-up areas, which, from inspection of aerial photographs and maps, primarily represent roadways.

Although this tabulation provides a representative indication of habitats along the corridor, resolution of the MCGI data is not sufficient to distinguish maintained open habitat within the transmission line ROW. In particular, ROW through forest is accounted as forest, though such areas are maintained as herbaceous and scrub-shrub communities as a result of vegetation management practices discussed above. In addition, wetland acreage estimates from MCGI State Land Use data are low compared to NMC's estimates using MCGI National Wetland Inventory (NWI) files. Approximately 403 acres (18 percent) of the total fee strip area is mapped by the U.S. Fish and Wildlife Service (USFWS) as wetland in the following classes and approximate amounts: Palustrine Forest (211 acres), Palustrine Emergent (145 acres), Palustrine Scrub-Shrub (45 acres), Riverine Lower Perennial (1 acre), Palustrine Excavated (1 acre). The difference is largely explained by NWI forested, emergent, and scrub-shrub wetlands that are mapped as non-wetland forested areas on the MCGI State Land Use maps. On the basis of linear tabulation from NWI maps (USFWS 1994) and vegetation management practices discussed above, approximately 16 percent of the cleared ROW length traverses wetlands, nearly all of which consists of seasonally or temporarily flooded Palustrine Emergent and, to a lesser extent, seasonally flooded Palustrine Scrub-Shrub habitat.

These wetlands generally lie on poorly drained areas associated with more or less defined drainage courses along the transmission corridor, mostly small unnamed tributaries in the Brandywine Creek, South Branch Black River, Paw Paw River, and Kalamazoo River watersheds. Perennial named streams crossed by the line include the South Branch Black River, its Extension Drain, and a tributary, Pine Creek, in Van Buren County; Veley Drain (a Clear Lake tributary) and Pine Creek, a Kalamazoo River tributary, both in northeastern Van Buren County; and the Kalamazoo River mainstream as the line approaches the Argenta Substation (USGS 1981; see Figure 3.1-1). The lower Kalamazoo River and tributaries from the Otsego area downstream to near

Saugatuck are recognized in Michigan's Natural Rivers Program; however, none of the streams crossed by the line are so designated (MDNR 2002, 2004a).

2.3.2.4 Critical and Important Habitats

No critical habitat for any species listed on the federal level as threatened or endangered exists in Michigan counties where Palisades and associated transmission lines addressed in this ER are located. Other areas on or in the general vicinity of the plant and associated transmission lines that are recognized as important wholly or partly as a result of their habitat values include the Lake Michigan Coastal Zone, Lake Michigan shorelands, designated dune areas, and MNFI-recognized natural communities.

The entire western portion of Covert Township, including all of the Palisades site and areas extending approximately 2 miles eastward lie within the Coastal Zone Management Area subject to protection under the federal Coastal Zone Management Act (CZMA) and Michigan's Coastal Zone Management Program (MDEQ 2004a). NMC's certification of compliance with provisions of the CZMA with respect to Palisades license renewal is addressed in Chapter 9 and Attachment D of this ER.

Michigan's Natural Resources and Environmental Protection Act (NREPA) Part 323 provides for designation of specific "Environmental Areas" and associated protection measures for sensitive fish and wildlife habitat along the shorelands of the Great Lakes in the state (MDEQ 2004b). No Environmental Areas are designated in areas on or near the Palisades site or associated transmission lines (MDEQ 2004c). However, the entire area lying west of I-196 in Covert Township, including the entire Palisades site, is a designated Environmentally Sensitive Area by the Township. This area is subject to specific land use prohibitions, and new projects require permits and environmental impact statements, including special status species assessments (Covert Township 2001, Section 1818).

Michigan's sand dunes, distributed along virtually the entire eastern shoreline of Lake Michigan and coastal areas elsewhere in the state, are the largest assemblage of fresh water dunes in the world and provide habitat for numerous threatened and endangered species (MDEQ 2004d, 2004e). About 80,000 acres of these dunes, including dunes along the entire length of shoreline in Covert Township, are classified and protected as Critical Dune Areas under authority of NREPA, Part 353 (MDEQ 2004d, 2004e). Designated Critical Dune Areas on the Palisades site are shown in Figure 2.1-3. Development activities in Designated Critical Dune Areas, including those on the site, require an environmental impact assessment and permit from MDEQ (MDEQ 2004d).

A portion of the Red Oak-Sassafras-Sugar Maple-Beech Hardwoods community (see Table 2.3-2, Community 2), noted above in Section 2.3.2.2, is on and adjacent to the Designated Critical Dune Area along the southern boundary of the Palisades site. The portion of this community that lies outside of the Critical Dunes Area boundary is recognized as an "exemplary dune associated plant community" in MDEQ's Atlas of

Critical Dune Areas (MDEQ 2004e). Approximately 46 acres of this community, apparently inclusive of forested areas within the Critical Dunes Area boundary, is recognized as an exemplary mesic southern forest, one of two such communities that occur on or within 1 mile of the Palisades site and associated transmission lines addressed in this ER (Goff 1992). The other tract of this forest type specifically recognized by MNFI lies in South Haven Township (see Table 2.3-4).

As suggested by the above discussion, the MNFI, a cooperative program of the Michigan State University Extension and the MDNR, catalogs the occurrence of natural features in the state, including exemplary terrestrial communities and special status species that are often associated with these communities (MDNR 2004b). NMC lists in Table 2.3-4 the MNFI-recognized exemplary communities that occur in Van Buren County and townships in Kalamazoo County and Allegan County traversed by the Palisades-Argenta transmission line. In addition to the southern mesic forest tracts noted above, recognized important communities in this area include bog (1 occurrence), coastal plain marsh (5 occurrences), mesic sand prairie (1 occurrence), oak barrens (1 occurrence), prairie fen (3 occurrences), and wet-mesic prairie (1 occurrence) (see Table 2.3-4).

With exception of the southern mesic forest tract on the Palisades site and a prairie fen in Alamo Township, Kalamazoo County, none of these communities are located within townships where the plant or transmission lines are located. Only the two forest tracts lie within 1 mile of the Palisades site or associated transmission lines addressed in this ER (see Table 2.3-4).

2.3.3 THREATENED OR ENDANGERED SPECIES

The USFWS has listed several species with ranges that include Michigan as threatened or endangered at the federal level or candidates for such listing (USFWS 2004a, 2004b) but has not designated any areas within the Palisades region (i.e., 50-mile radius; see Figure 2.3-1) as critical habitat for listed species (USFWS 2003, 2004c). Similarly, threatened and endangered species have been designated at the state level under programs administered by the Michigan Department of Natural Resources (MDNR 1999). NMC lists in Table 2.3-5 those with potential to occur in the general area of the Palisades site or associated transmission lines addressed in this ER on the basis of criteria described in footnote “a” to the table. Table 2.3-5 also includes an indication of occurrence potential based on MNFI Biological and Conservation Database occurrence records (MNFI 2001, 2004a), and a summary of additional information about occurrence, habitat affinities, and related topics.

In the following sections, NMC provides a general summary of information presented in Table 2.3-5 in the context of previous discussion about aquatic communities of Lake Michigan and terrestrial communities, including important terrestrial habitats in areas of concern.

2.3.3.1 Aquatic Species

Table 2.3-5 includes only four species with known occurrence in Lake Michigan now or in the past, shortjaw cisco (*Coregonus zenithicus*), mooneye (*Hiodon tergisus*), lake sturgeon, and lake herring; all of which are state-listed threatened fish species. The shortjaw cisco, one of several deepwater cisco species that once inhabited the lake, is thought now to exist in the Great Lakes only in Lake Superior. The mooneye was apparently never common in Lake Michigan near Palisades. Neither of these species was collected in preoperational (1968-1972) and early post-operational (1972-73) monitoring studies at Palisades, when the plant operated in a once-through cooling mode (Consumers 1975).

As discussed in Section 2.3.1 of this ER, lake sturgeon populations were decimated in the early 1900s from overexploitation and degradation of tributary streams used for spawning. Occurrence of this species near Palisades was documented in early post-operational monitoring at Palisades (1972-73), but no adults or young were noted in impingement or entrainment samples collected at the time. Restoration of this species depends on effective control of harvest and rehabilitation of spawning tributaries such as the Kalamazoo River. If successful, these efforts would presumably result in increased occurrence in the nearshore areas of the lake near Palisades during the license renewal period. Populations of lake herring, decimated by the alewife invasion by the time Palisades began operation, remain low in the area of the plant. Only a few individuals were collected at Palisades during early post-operational monitoring (see Table 2.3-5). This species has exhibited some recovery only in the northern part of the lake and, while some recovery may also be evident southward in the future, Palisades lies near the southern limit of the range of this species, likely limiting its future abundance in the area. None of these four fish species were noted in impingement or entrainment monitoring at Palisades conducted in 1999-2000 (Consumers and NMC 2001).

Table 2.3-5 includes three additional aquatic species NMC examined with respect to occurrence potential in areas of concern to this ER: two mussel species, the tubercled-blossom pearly mussel (*Epioblasma torulosa torulosa*) and clubshell (*Pleurobema clava*), both endangered at the federal level, and a state-endangered fish species, the creek chubsucker (*Erimyzon oblongus*). Considering that the USFWS (2004a) does not indicate that the tubercled blossom pearly mussel occurs in Michigan, the clubshell is not known from the Lake Michigan drainage, and neither is indicated by MNFI (2004a) as having occurrence records that include Van Buren, Kalamazoo, or Allegan Counties, NMC concludes that occurrence potential for both of these mussel species is low to none in areas of concern. Based on historical occurrence records and habitat affinities (see Table 2.3-5), there may be moderate potential for occurrence of the creek chubsucker in the Kalamazoo River or its tributaries crossed by the Palisades-Argenta transmission line, depending on historical events and current habitat conditions in these drainages.

In the following subsection, NMC addresses other species listed in Table 2.3-5 that may occur in or near inland aquatic habitats, including rooted aquatic or wetland plants and animals that are dependent on aquatic or wetland habitats for at least part of their life cycle.

2.3.3.2 Terrestrial Species

Table 2.3-5 includes a total of 66 terrestrial species that NMC evaluated for occurrence potential in areas of concern to this ER. Of these, 3 plant, 3 insect, 2 reptile, 2 bird, and 1 mammal species are listed or are candidates for listing at the federal level; the remainder are listed on the state level by the MDNR. All of these species, by virtue of their listing, are considered rare in the general area. However, NMC used MNFI records of occurrence within Covert Township and other townships traversed by the Palisades-Argenta transmission line, and within 1 mile of the site or transmission line, as an initial indication of occurrence potential for these 66 originally-evaluated species in areas of concern to this ER. Result of this general screening are provided in Table 2.3-5 and are summarized here as follows:

Group	Number of Species[a]			Species with MNFI Occurrence Record within ±1-mile and Status[a]	
	Total	Twp	±1-mi.		
Plants	40	16	5	Federal:	Pitcher's thistle (T)
				State:	Cut-leaved water parsnip (T), *Carex seorosa* sedge (T), Scirpus-like rush (T), Toadshade (T)
Insects	8	0	0	Federal:	None
				State:	None
Amphibians	1	0	0	Federal:	None
				State:	None
Reptiles	4	2	2	Federal:	Eastern massasauga (C)
				State:	Spotted turtle (T)
Birds	10	1	1	Federal:	None
				State:	Prairie warbler (E)
Mammals	3	0	0	Federal:	None
				State:	None
Totals:	66	19	8		

a. Source: Table 2.3-5. E = Endangered; T = Threatened; C = Candidate

In the remainder of this section, NMC briefly discusses those species judged to have the greatest potential for occurrence in the area on the basis of this screening information, habitat affinities presented in Table 2.3-5 and summarized in Table 2.3-6, habitat availability as presented in Section 2.3.2, and results of Consumers-sponsored field surveys noted in Table 2.3-5. Also discussed are the habitats on the site or along transmission ROW with highest potential to harbor species of concern.

Species listed in Tables 2.3-5 and 2.3-6 that have an affinity for the lakeshore and open dune habitat present on the Palisades site include one plant species, the federally threatened Pitcher's thistle (*Cirsium pitcheri*), and four bird species, the federally endangered piping plover (*Charadrius melodus*), the state-threatened Caspian tern (*Sterna caspia*) and common tern (*Sterna hirundo*), and the state-endangered prairie warbler (*Dendroica discolor*). Pitcher's thistle occurs on the Palisades site in various open habitats on the dunes, including dune blowouts, and is the only federal or state listed species known to exist on the Palisades site on the basis of reviews of vegetation surveys by Asplundh (1979) and others. Although the prairie warbler has not been documented as occurring on site, it is documented by MNFI as nesting recently in the vicinity of Palisades, and vegetation surveys of the Palisades site in 1991 indicates that some scrub-shrub habitat potentially suitable for nesting of this species exists on site dunes (see Section 2.3.2.2 of this ER).

The other major habitat type that occurs on the site with reasonable likelihood to harbor species of concern is the relatively mature Red Oak-Sassafras-Sugar Maple-Beech Hardwoods community as described in Section 2.3.2 of this ER, particularly that part included in the 46-acre tract recognized by MNFI as exemplary Mesic Southern Forest. However, none of the Federal or State listed species associated with this habitat are known to occur within 1 mile of the site or transmission lines.

Several plant and animal species noted in Table 2.3-5 have an affinity for floodplain forest habitat that exists along the transmission corridor (see Table 2.3-6). Those likely to have a relatively higher occurrence potential as indicated by having MNFI occurrence records within the last 40 years in townships traversed by the line are:

- sedge (*Carex seorsa*), noted within 1 mile of the Palisades site in South Haven Township as recently as 1996,
- eastern massasauga rattlesnake (*Sistrurus catenatus catenatus*), noted in several townships along the line, including locations within 1 mile of the line as recently as 1995, and
- log fern (*Dryopteris celsa*), noted in Cooper Township, Kalamazoo County, most recently in 1983 (MNFI 2004a).

The federally endangered Indiana bat (*Myotis sodalis*) could potentially utilize floodplain forest occurring along the transmission corridor in summer.

As discussed in Section 2.3.2 of this ER, wetlands on the site are few, small, and scattered. No listed or candidate plant or animal species were found to occur in these habitats during Consumers-sponsored ecological surveys (e.g., Asplundh, 1979; Higman and Goff, 1991). Nearly all of the NWI wetland habitat traversed by the cleared ROW for the Palisades-Argenta line, aside from rivers and streams, is classified as seasonally or temporarily flooded emergent and, to a lesser extent, scrub-shrub wetlands. Although much of the cleared ROW is bordered by seasonally or temporarily flooded forest, herbaceous and shrub-scrub communities predominate within the ROW as a result of vegetation management practices discussed in Sections 2.3.2.3 and 3.1.4 of this ER. Threatened or endangered species that have some likelihood of occurrence in these open wetlands include those found in Coastal Plain Marsh or other open wetlands (except species more exclusively associated with Prairie Fen and Wet Mesic Prairies, discussed below). Potential for occurrence is reduced for those species with very high affinities for coastal plain marsh because no recognized examples of this habitat type occur within 1 mile of the transmission line (see Table 2.3-4).

Several species noted in Tables 2.3-5 and 2.3-6 are associated with MNFI Wet Mesic Prairie or Prairie Fen communities. Wet Mesic Prairies in Michigan are well inventoried and Prairie Fens are glacially and biologically unique (Albert and Kost 1998, Spieles et. al 1999). A review of the MNFI inventory records specifically recognizes 5 wet mesic prairies and 13 prairie fens in the Van Buren, Kalamazoo, and Allegan County areas (MNFI 2001, 2004a). However, as indicated in Table 2.3-4, a prairie fen is the only one of these that occurs in townships traversed by the Palisades-Argenta transmission line (Alamo Township, Kalamazoo County), beyond 1 mile from the line. Therefore, NMC concludes that there is little or no occurrence potential along the line for any of the species indicated in Table 2.3-6 as uniquely associated with these community types. Few species associated with these habitats have records of occurrence in townships traversed by the line and none are recent.

Several species not previously discussed are associates of Oak Barrens or savannah habitats. Like prairie, this habitat in Michigan exists as degraded remnants of what formerly existed in the state, and its present occurrence is relatively well-known; only a few hundred acres of oak barrens remain in Michigan, including small, restorable remnants in six counties, including Van Buren County (Cohen 2001). A review of the MNFI inventory records specifically recognizes only one oak barrens in the three-county area - in Van Buren County - located beyond townships traversed by the line (MNFI 2001; MNFI 2003). No species listed in Table 2.3-6 have records of occurrence in townships traversed by the line. On this basis, NMC concludes there is little potential for occurrence of any of these species along the line. The federally endangered Karner blue butterfly (*Lycaeides melissa samuelis*), an associate of barrens habitat, is indicated by MNFI as occurring in Allegan County within the counties of interest. Palisades owner, Consumers, is participating in partnership with MDNR, the Nature Conservancy, and others to develop a habitat conservation plan for this species (MDNR 2004c; see Table 2.3-5).

2.4 METEOROLOGY AND AIR QUALITY

The climate of the lower peninsular area of Michigan (the location of the Palisades site) is generally characterized as humid continental featuring cool summers, with rainfall most prevalent in autumn, and about 80 days of snow cover per year. The annual cooling and heating cycle of the lake moderates weather over and adjacent to Lake Michigan (AEC 1972, Section II.E.5). The lower peninsular area is also located on the route of major air movements from the northwest to the southeast in the colder months. With numerous fronts moving through the area and the lake influence, the area experiences considerable cloudiness and favorable overall atmospheric dispersion characteristics throughout the year (AEC 1972, Section II.E.5; NMC 2003, Section 2.5.1).

Based on annual climatological data from the National Climatic Data Center South Haven Station (207690/99999) for the years 1970 through 2004, the average of mean daily high and low temperatures in July are 77 degrees Fahrenheit (°F) and 61°F, respectively. The average mean daily high and low temperatures in January are 32°F and 19°F, respectively. Average annual precipitation was 34.8 inches for that period of record (NCDC 2004).

Palisades is located in an area designated by EPA (effective August 3, 2004) as marginal non-attainment for 8-hour ozone. Surrounding counties were also designated as marginal non-attainment for 8-hour ozone, with the exception of Cass County, which was designated as moderate non-attainment (EPA 2004).

2.5 DEMOGRAPHY

In this section, NMC describes demographic characteristics of the area within 50 miles of the Palisades site. Year 2000 U.S. Census data were used for the population classification determination presented below in Section 2.5.1 and the determination of minority and low-income populations described in Section 2.5.3. Census block groups within the 50- and 20-mile radii from the center point of the containment building were identified using ArcView® geographic information system software. Census block groups with greater than 50 percent of their area outside the 50- and 20-mile radii were not included in calculating total population, minority or low-income estimates.

2.5.1 GENERAL DEMOGRAPHY

The U.S. Nuclear Regulatory Commission's (NRC's) *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (GEIS) presents a population classification method using degrees of "sparseness" and "proximity" to characterize the remoteness of the area surrounding a site. Sparseness measures population density and city size within 20 miles of a site; proximity measures population density and city size within 50 miles (NRC 1996, Section C.1.4). NRC's model for population by sparseness and proximity measures, as presented in the GEIS, is shown below:

Sparseness	Category	Criterion
Most sparse	1.	Fewer than 40 persons per square mile and no community with 25,000 or more persons within 20 miles
	2.	40 to 60 persons per square mile and no community with 25,000 or more persons within 20 miles
	3.	60 to 120 persons per square mile or fewer than 60 persons per square mile with at least one community with 25,000 or more persons within 20 miles
Least sparse	4.	Greater than or equal to 120 persons per square mile within 20 miles

Proximity	Category	Criterion
Not in close proximity	1.	No city with 100,000 or more persons and fewer than 50 persons per square mile within 50 miles
	2.	No city with 100,000 or more persons and between 50 and 190 persons per square mile within 50 miles
	3.	One or more cities with 100,000 or more persons and fewer than 190 persons per square mile within 50 miles
In close proximity	4.	Greater than 190 persons per square mile within 50 miles

Source: NRC 1996, page C-159.

In the GEIS, NRC then uses the following matrix to rank the population category as low, medium, or high:

		Proximity			
		1	**2**	**3**	**4**
Sparseness	**1**	**1.1**	**1.2**	**1.3**	**1.4**
	2	**2.1**	**2.2**	**2.3**	**2.4**
	3	**3.1**	**3.2**	**3.3**	**3.4**
	4	**4.1**	**4.2**	**4.3**	**4.4**

Low **Medium** **High**

Source: NRC 1996, page C-6.

Using data from the U.S. Census Bureau’s Census 2000 (Census 2001), NMC estimates that 118,667 persons live within 20 miles of Palisades. With a population density of 175 persons per square mile within 20 miles, Palisades falls into Category 4 of the GEIS sparseness classification. There are an estimated 1,287,558 persons living within 50 miles of Palisades, which equates to a population density of 293 persons per square miles within 50 miles. Palisades falls into Category 4 of the GEIS proximity classification. According to the GEIS sparseness and proximity matrix, Palisades’ sparseness Category 4 and proximity Category 4 indicate that the Palisades site is ranked in a high population category.

All or portions of nine counties in Michigan are within 50 miles of the Palisades site: Allegan, Barry, Berrien, Cass, Kalamazoo, Kent, Ottawa, St. Joseph, and Van Buren. In Indiana, all or parts of three counties are within 50 miles of the Palisades site: Elkhart, La Porte, and St. Joseph. There are nine Metropolitan Statistical Areas (MSAs) located at least partially within a 50-mile radius of Palisades. The most populous is the Grand Rapids-Wyoming, Michigan MSA, located approximately 50 miles northeast of the Palisades site. The Niles-Benton Harbor Michigan MSA encompasses all of Berrien County with its northern border less than ten miles from the site (Census 2003a, b; AEC 1972, Figure II-3). Van Buren County, in which Palisades is located, is part of the Kalamazoo-Portage Michigan MSA. Table 2.5-1 lists these MSAs and associated 2000 populations.

Approximately 77 percent of the Palisades workforce lives in Berrien and Van Buren Counties (see Section 3.4 of this ER for workforce description). Table 2.5-2 presents decennial population estimates and annual growth rates for these counties of interest. Berrien County's population increased from 149,865 in 1960 to a high of 171,276 in 1980. After declining in 1990, year 2000 population levels increased slightly (Census 1995; Census 2000a). By comparison, Van Buren County has experienced steady population growth, increasing from 48,395 in 1960 to 76,263 in the year 2000 (Census 1995; Census 2000a). This trend of growth is projected to continue through 2020. Population projections by Michigan's Office of the State Demographer reveal a continued decline in Berrien County population (MOSD 1996). However, Berrien County notes in its County Development Plan such projections can vary, and cites regional model estimates indicating populations will continue to increase in 2010 and 2020 as they have during the last decade (Berrien 2003).

Berrien County contains 22 townships, 8 cities, and 9 villages, with the county seat located in the City of St. Joseph (Berrien 2003). Van Buren County contains 18 townships, 4 cities, and 7 villages with the village of Paw Paw serving as the County Seat (VBPC Undated; MEDC 2004b). South Haven, with a year 2000 census population of 5,013, is both the most populous city in Van Buren County and the closest to the Palisades site. The largest municipality in Berrien County is the City of Niles with a year 2000 census population of 12,199 (Census 2003c, Table 10). Table 2.5-3 presents year 2000 census estimated populations for selected municipalities in Berrien and Van Buren Counties.

The Palisades site is located in an area composed of small urban areas and rural communities. In Van Buren County, most of the population lives outside of the cities and villages in the townships and projections are for this trend to continue (VBPC Undated). Similarly, Berrien County has experienced declines in urban populations, while overall population has increased slightly, indicating that the number of persons in the townships has increased. New housing construction and numbers of building permits issued relative to current population suggest that new homes may be attracting buyers for whom the county is not their primary residence (Berrien 2003). Lake Michigan and the many other lakes in the region draw numerous seasonal visitors to both Berrien and Van Buren Counties (VBCO 2004; MEDC 2004a, b). The U.S. Census Bureau estimates indicate a substantial amount of seasonal or recreational use housing units, 5,259 or 7.2 percent of total housing in Berrien County and 3,857 or 11.4 percent of total housing in Van Buren County (Census 2000b, Table QT-HI).

The populations of both Berrien and Van Buren Counties are more aged than the State of Michigan, with median ages of 37.4 and 36.6 years, respectively as compared to the state median age of 35.5 years. According to U.S. Census Bureau estimates, approximately 16.9 percent and 14.7 percent of the year 2000 population are over the age of 62 in Berrien and Van Buren Counties, respectively as compared to 14.5 percent in the state as a whole (Census 2000a, DP-1).

2.5.2 TRANSIENT POPULATIONS

Small daily and seasonal fluctuations in regional population occur due to the number of colleges and recreational facilities that attract visitors (see Section 2.1 of this ER). Within 10 miles of Palisades, there are seven campgrounds and beaches (municipal and private), 13 motel and rental cottage establishments, and seven bed and breakfasts drawing visitors primarily during the summer season, although the bed and breakfasts are also full in the fall and on weekends in the spring and winter. NMC estimates the potential peak transient population to be 9,622 individuals associated with the campground and beach facilities. The potential daily transient population associated with the motels and rental cottages is 1,557, and the potential weekly transient population associated with the bed and breakfasts is over 152 (NMC 2003, Table 2-2).

Temporary housing for seasonal, recreational, or occasional use is relatively strong in both Berrien and Van Buren Counties, accounting for 7.2 and 11.4 percent of all housing units or 5,259 and 3,857 units, respectively. By comparison, temporary housing accounts for only 5.5 percent of total housing units in the State of Michigan (Census 2000a, Table DP-1). In addition, Berrien and Van Buren Counties host moderate numbers of migrant workers. According to 2002 Census of Agriculture estimates, 3,677 and 6,733 temporary farm laborers (defined as employed for less than 150 continuous days) were employed in Berrien and Van Buren Counties, respectively (USDA 2004).

Area colleges and universities attract thousands of students to the region. Western Michigan University, with its main campus in Kalamazoo, offers 151 undergraduate majors, 70 master's, two specialist and 30 doctoral degree programs. Enrollment at the main campus is about 27,000 students from across the U.S. and over 100 foreign countries. The University has six other campuses collectively serving 3,000 students each semester, two of which are located within Palisades' 50-mile region (Benton

Harbor/St. Joseph and Holland) (Western Michigan University 2004). Andrews University, located in Berrien Springs, is operated by the Seventh-day Adventist Church and has over 3000 students from between 80 to 100 different countries (Andrews 2004). In South Bend, Indiana, the University of Notre Dame had a 2003 enrollment of 8,400 undergraduate and 2,300 graduate students and Indiana University South Bend had a 2003 enrollment of 7,457, 94 percent of which were Indiana residents (IUSB 2003; Notre Dame 2004).

2.5.3 MINORITY POPULATIONS

2.5.3.1 Minority Populations

Demographic data were compiled in Census 2000 to the block group level for the following minority categories: Black or African American, American Indian or Alaskan Native, Asian, Native Hawaiian or Other Pacific Islander, Other Single Race Minority, Two or More Races, and Hispanic or Latino origin (Census 2001). In addition to these groups, NRC guidance also states that the minority population as a whole (aggregate minority category) should be included in the analysis. This minority percentage is calculated by aggregating all minority individuals in the block group (NRC 2004, Appendix D). This minority population determination for the Palisades ER includes an evaluation of the six racial minority categories used in the census, in addition to the Hispanic or Latino ethnicity and the aggregate minority categories as indicated by NRC.

NRC guidance (NRC 2004) specifies that a minority population exists in either of the following cases:

> <u>Exceeds 50 Percent</u> – the minority population of the environmental impact site exceeds 50 percent, or
>
> <u>More than 20 Percentage Points Greater</u> – the minority population percentage of the impact site is significantly greater (typically at least 20 percentage points) than the minority population percentage in the geographic area chosen for comparative analysis.

A 50-mile radius, drawn from the center point of the containment building, was used in this analysis to define the area of potential environmental impact. Census block groups with greater than 50 percent of their area located outside the 50-mile radius, as defined above, were not included in the analysis. The 50-mile radius area includes parts of Indiana and Michigan, and encompasses all or part of 12 counties (see Figure 2.1-1). The geographic area for comparative analysis consists of each county with at least one census block group located within the 50-mile radius. The population demographic data from these counties were added together to derive average regional numbers for both the aggregate minority population and for each minority category for comparison (see Table 2.5-4).

The percentage of each minority group in an individual census block group was calculated using the following:

[minority group population / total population] * 100

Using the entire States of Michigan and Indiana as the region of comparison was originally considered, but was rejected on the basis that the percentage of the population in the minority categories of particular interest (African American and Aggregate) would be higher; therefore, using the States as the comparative geographic areas would produce a less conservative analysis.

To calculate the aggregate minority population in an individual census block group, the populations of each of the six minority racial groups (Black or African American, American Indian or Alaskan Native, Asian, Native Hawaiian or Other Pacific Islander, Other Single Race, and Two or More Races) and those persons identifying themselves as white Hispanic or Latino ethnicity designation were added together and used in the above equation. Since Hispanic or Latino ethnicity is not a racial designation and persons identifying themselves as such may be of any race, this population may also be included within the other racial categories. So, only the number of persons identified as white Hispanic or Latino ethnicity was used in the calculation of aggregate minority population.

Census 2000 data to the block group level from the two states located within the 50-mile radius of the Palisades site (Indiana and Michigan) were analyzed to determine which block groups meet either or both of the above criteria (exceed 50 percent or more than 20 percentage points greater). The 50-mile radius includes 988 census block groups. Table 2.5-4 shows the number of census block groups in each county with a minority population, and the threshold values for determining if a minority population exists. The threshold values were calculated by adding 20 percentage points to the regional percentages.

There were no census block groups with a minority population of American Indian or Alaskan Native, Native Hawaiian or other Pacific Islander, or Two or More Races within the 50-mile radius of the Palisades site. There were 145 census block groups with an aggregate minority population (see Figure 2.5-1).

For the individual minority categories,

- 101 census block groups had a minority population of Black or African Americans (see Figure 2.5-2, Table 2.5-4),
- 31 census block groups had a minority population of Hispanics or Latino ethnicity, one of which qualified as a White Hispanic or Latino minority population (see Figure 2.5-3, Table 2.5-4),
- 12 census block groups had a minority population of “other” single race (see Figure 2.5-4, Table 2.5-4), and

- 1 census block group had a minority population of Asians (see Figure 2.5-5, Table 2.5-4).

Kalamazoo County, Michigan is the only county within the 50-mile radius to have a block group with an Asian minority population (1 block group). Three counties (Ottawa, Elkhart, and St. Joseph) had an Other Single Race Minority population in Census 2000. This racial category was included in Census 2000 to accommodate people who did not identify with the five race categories (White, Black or African American, Asian, Native Hawaiian or other Pacific Islander, and American Indian or Alaska Native) calculated in the census. Two block groups in Elkhart County, 4 in Ottawa County, and 6 in St. Joseph County have a minority population of people of a single race other than those included in the five census categories.

The minority populations in the 50-mile radius are concentrated in areas that are urban centers with high population densities. Most block groups with aggregate minority populations are located in five counties (St. Joseph and Elkhart Counties in Indiana; and Kalamazoo, Berrien, and Ottawa Counties, in Michigan) (see Table 2.5-4), in the cities of South Bend and Elkhart, Indiana; and Kalamazoo, Benton Harbor-St. Joseph, and Holland, respectively.

2.5.3.2 Low-Income Populations

Information about the percentage of low-income households within a 50-mile radius of Palisades was compiled in Census 2000 to the block group level (Census 2002). NRC guidance (NRC 2004) specifies that a low-income population exists in either of the following cases:

> Exceeds 50 Percent – the percentage of households below the poverty level in the census block group or environmental impact site exceeds 50 percent, or
>
> More than 20 Percentage Points Greater – the percentage of households below the poverty level in the census block group or environmental impact site is significantly greater (typically at least 20 percentage points) than the percentage of households below the poverty level in the geographic area chosen for comparative analysis.

A 50-mile radius, drawn from the center point of the containment building, was used in this analysis to define the area of potential environmental impact. Census block groups with greater than 50 percent of their area located outside the 50-mile radius, as defined above, were not included in the analysis. The 50-mile radius encompasses all or part of 12 counties (see Figure 2.1-1). The geographic area for comparative analysis consists of each county with at least one census block group located within the 50-mile radius. The percentages of households below the poverty level from these counties were added together to derive average regional numbers for comparison (see Table 2.5-4).

Data for both the total number of households and the number of households with an income below the poverty level were obtained for each census block group within the

50-mile radius of the Palisades site. The number of households below the poverty level in each census block group was then calculated as a percentage using the following:

[households below poverty / total households] * 100

Any census block group with a percentage of households below the poverty level greater than 28.8 percent (8.8 regional percent + "20 percentage points greater criterion;" see Table 2.5-4) was considered a low-income population in this assessment.

A total of 62 census block groups within the 50-mile radius of the Palisades site meet the criteria for low-income populations (see Table 2.5-4 and Figure 2.5-6). The distribution of the census block groups with a low-income population is similar to those with a minority population. The three counties with the greatest number of census block groups with a low-income population were Kalamazoo County, Michigan (28 block groups), St. Joseph County, Indiana (14 block groups), and Berrien County, Michigan (13 block groups). Block groups with low-income populations were primarily located in or near the largest cities located in each county: South Bend, Indiana, and Kalamazoo and Benton Harbor-St. Joseph, Michigan. Only one block group with a low-income population is located in Van Buren County. This block group is located in the western portion of Covert Township, which is a largely rural area.

2.6 AREA ECONOMIC BASE

NMC focuses on Van Buren and Berrien Counties in this section because 77 percent of the Palisades site workforce resides in these counties (see Section 3.4 of this ER). The Niles-Benton Harbor MSA encompasses all of Berrien County with population concentrations in the cities of Niles, Benton Harbor, and St. Joseph (see Table 2.5-3). Van Buren County and Kalamazoo County make up the Kalamazoo-Portage MSA. Van Buren County is much less densely populated than Berrien County, with 124.8 versus 284.5 persons per square mile (Census 2000, GCT-PH-1), and has less than half the total population of Berrien County (Census 2000, GCT-PH-1; and Table 2.5-2 of this ER). The City of South Haven and the Village of Paw Paw, the County Seat, are the largest population centers in Van Buren County (see Table 2.5-3).

An extensive transportation network aids the area economy. Interstates 94 and 196, U.S. Highway 31 and 33, and several state highways traverse the two-county area, providing access to major east-west and north-south corridors. Rail lines are an important form of transportation for materials and cargo. CSX Transportation, Conrail, and C&O provide primary freight services (MEDC 2004a; MEDC 2004b). Amtrak also offers daily passenger service in the area with three trains: the Blue Water, traveling between Chicago and Port Huron, Michigan; the Wolverine, traveling between Pontiac, Michigan and Chicago; and the Pere Marquette, traveling between Grand Rapids, Michigan and Chicago. Stations within the 50-mile radius of Palisades include Niles, Dowagiac, Kalamazoo, St. Joseph-Benton Harbor, Bangor, Holland, and Grand Rapids (Amtrak 2004). The Benton Harbor/St. Joseph Commercial Port in the St. Joseph River Harbor accommodates deep-draft freighters that traverse the Great Lakes and St. Lawrence Seaway, and also supports river barge shipping via the Chicago Sanitary and Ship Canal, which links the Great Lakes to the Illinois Waterway and Mississippi River. Approximately one million tons of materials were received at the commercial docks in 2001 (Berrien 2003). Air traffic is also an important contributor to the regional economy, providing transportation and access to national and international markets. The Kalamazoo/Battle Creek International airport located east of the plant serves more than one-half million passengers annually with 63 daily arrivals and departures on eight carriers. General aviation services are also available through two fixed-base operators (KALCO 2004). Two regional airports provide general aviation services: South Haven Area Regional Airport located 3 miles south of South Haven, Michigan and Southwest Michigan Regional Airport located in Benton Harbor, Michigan (SHVB 2004; SMRA 2004). The Jerry Tyler Municipal Airport in Niles, the Andrews University Airpark in Berrien Springs, and the Watervliet Airpark in Watervliet are smaller facilities offering general aviation services to the public (Berrien 2003; Fltplan 2004; Niles 2004).

In 2000, the services sector was the largest employment sector in both Van Buren and Berrien Counties, accounting for 22.8 percent and 30.4 percent of the non-agricultural employment, respectively. Manufacturing was the second largest employment sector in both counties, accounting for 20.4 percent and 22.1 percent in Van Buren and Berrien Counties, respectively. Employment in the government sector is strong in both counties and represents primarily state and local jobs. Table 2.6-1 details year 2000 employment by selected industries for both counties (MEDC 2004a, MEDC 2004b).

In an employment sector analysis done by the Southwestern Michigan Commission, comparison of 1990 and year 2000 employment by major economic sectors revealed an increase in total employment of 3,861 or 29.3 percent in Van Buren County for the period. The largest increases were in the employment subcategories of health care (124.8 percent) followed by manufacturing (64.1 percent) and accommodations and food services (34 percent). In Berrien County, total employment increased during the period (835 or 1.4 percent), but not to the same level as had occurred in Van Buren County. The manufacturing employment subcategory decreased by 5,666 or 26 percent. Both wholesale and retail trade decreased during the period, 38.5 and 33.8 percent respectively while health care and accommodations and food services employment increased by 38 and 10.6 percent, respectively. In its report, the Southwestern Michigan Commission noted that the traditional dependence on manufacturing and related employment is transitioning to a reliance on health care and tourism related businesses in the three-county region (Berrien, Cass, and Van Buren Counties) (SWMC 2003, pages 36-39).

Industrial production in Van Buren County exceeds one billion dollars annually (VBCO 2004a). Principle manufacturing employers in the county are engaged in the production of plastic electrical engine equipment; plastic injection molding; juices, jellies and jams, fruit fillings, canned fruits and vegetables; fabricated metals; report covers, binders, and portfolios; and tooling design and manufacturing (MSUE 2004).

Berrien County has a strong manufacturing base with several manufacturers ranking among the top ten employers in the county. These leading employers produce residential home appliances, auto parts, and determinators for gases in metals (Berrien 2004).

Although agriculture is not a significant contributor to area employment (see Table 2.6-1), it is an important source of income in the region. According to the 2002 Census of Agriculture, 1,160 farms in Van Buren County and 1,093 farms in Berrien County sold agricultural products with market values of $96,724,000 and $96,716,000, respectively (USDA 2004). Van Buren and Berrien Counties are leaders in the state in the production of fruit and vegetables. Berrien County ranks fifth in the state for production of tart cherries, with 1,608 bearing acres (USDA 2004). Van Buren County ranks first in the state for harvesting and processing cucumbers. Both counties rank in the top five counties for apples, blueberries, grapes, and asparagus. Van Buren County leads Michigan in blueberry production for which Michigan ranks first in the nation (NASS 2003). In 2002, Michigan's blueberry production was 64 million pounds, valued at $52,240,000, and comprised 33.4 percent of the total U.S. production (Kleweno 2003).

Van Buren County's civilian labor force has grown steadily over the period from 1990 to 2003, increasing from 33,650 to 36,725, or 9.1 percent. Average annual unemployment rates have varied widely, from 8.9 percent in 1990 to 4.4 percent in 2000, then increasing to 7.9 in 2003. Average annual unemployment rates have varied widely in Berrien County as well, but have been slightly lower than in Van Buren County, ranging from 7.2 percent in 1990 to 3.8 percent in 2000 and increasing to 7.3 percent in 2003. Berrien County's civilian labor force has decreased by 0.8 percent from 80,950 to 80,300 over the period from 1990 to 2003 (DLEG 2004).

2.7 TAXES

Consumers is assessed annual property taxes by Van Buren County, Covert Township, Van Buren District Library, South Haven Community Hospital District, Michigan State Education Tax, Covert School District, Van Buren Intermediate School District, and Lake Michigan College. Property taxes are paid directly to Covert Township, which in turn distributes the money to the aforementioned taxing jurisdictions. Property taxes are a significant source of revenue for the State of Michigan and local governments, comprising 20.5 percent and 29.5 percent of total state and local revenues and taxes, respectively in 1999 (MDT 2002). Revenues received by Van Buren County support such programs as engineering, planning, recreation, public safety, public works, and emergency services. Revenues received by Covert Township support such programs as planning and zoning, for fire protection and public safety (VBCO 2004a).

Table 2.7-1 compares property taxes paid by Consumers for Palisades to the annual total revenues and operating budgets of the local taxing jurisdictions; Van Buren County, Covert Township, Van Buren District Library, South Haven Community Hospital District, Covert School District, and Van Buren Intermediate School District for the years 1994 through 2003. Property taxes are also paid to the Michigan State Education Tax and Lake Michigan College. However, the amounts paid to these jurisdictions by Consumers represent less than one percent of their respective 2003 budgets and so are not included on the table. For this period, Palisades property taxes paid to Van Buren County decreased 6 percent and comprised less than 6.6 percent of the Van Buren County total operating budget.

Property taxes paid to Covert Township by Consumers for Palisades have increased 36 percent during the period. These payments have represented a smaller percentage of the operating budget, decreasing from 50.3 percent to 35.1 percent, and a larger percentage of total revenues, increasing from 49.9 percent to 59.9 percent.

Property taxes paid to the District Library and the South Haven Community Hospital District have decreased slightly during the period, 6.6 percent and 2.3 percent, respectively. These payments have represented a decreasing percentage of both the annual operating budgets and total revenues for the Library and the Hospital District. These tax payments currently represent less than one percent of the Hospital District's annual operating budget and 8.6 percent of the District Library's annual operating budget.

Property taxes paid to Covert School District by Consumers for Palisades have decreased 23 percent during the period. These payments have represented a decreasing but large percentage of both the operating budget and total revenues. Payments to the Van Buren Intermediate School District have decreased over the period as well, but represent a small percentage, less than 10 percent, of either the operating budget or total revenues.

The amount of future property tax payments for Palisades and the proportion those payments represent of the operating budgets of the taxing jurisdictions (Van Buren County, Covert Township, Covert School District, Van Buren Intermediate School District, Michigan State Education Tax, Lake Michigan College, the Van Buren District Library, and the South Haven Community Hospital District) are dependent on future market value of the plant, future valuations of other properties in these jurisdictions, and other factors. Consumers assumes property taxes will increase at the rate of Michigan's calculated Consumer Price Index or 5 percent, whichever is less as mandated under state law. Consumers assumes that the values presented in Table 2.7-1 are substantially representative of conditions that would exist in the license renewal term of the plant.

2.8 SOCIAL SERVICES AND PUBLIC FACILITIES

2.8.1 PUBLIC WATER SUPPLY

This discussion of public water systems focuses on Van Buren and Berrien Counties because approximately 77 percent of the Palisades site workforce resides in these counties (see Section 3.4 of this ER for workforce description). Potable water service is provided to residents of the counties by a combination of public and private water supply systems. The major municipal water supply systems listed in Table 2.8-1 provide potable water to 28 percent and 57 percent of Van Buren and Berrien County residents, respectively. Those residents of the counties not served by a major municipal supply system utilize individual onsite wells and small private systems supplied by onsite wells (MDEQ 2004a; EPA 2004).

There are approximately 189 and 234 regulated water systems in Van Buren and Berrien Counties, respectively. Of these, approximately 28 and 50 systems in Van Buren and Berrien Counties respectively are community water systems serving the same people year-round (EPA 2005). These providers are subject to regulation under the Federal Safe Drinking Water Act, as implemented by the Michigan Department of Environmental Quality (MDEQ 2003).

Table 2.8-1 identifies the major municipal water systems in Van Buren and Berrien Counties along with information on system usage and capacity. The data illustrates that all systems in the two-county area are operating below maximum capacity and have the capability to absorb additional demand.

NMC did not identify any reasonably foreseeable new large water users in the area as a result of information gathering efforts for this section, Section 2.9 (Land Use), or Chapter 5 (New and Significant Information).

2.8.2 TRANSPORTATION

Road access to the Palisades site is via the Blue Star Memorial Highway (Blue Star Highway), a two-lane state paved road running north south along the Lake Michigan shore and west of Interstate 196 (I-196)/U.S. Highway 31 (US 31). The main access road connects to the Blue Star Highway at the southeast corner of the Site Exclusion Area Boundary (see Figure 2.1-3). Another access road that is currently used only during outages, runs north through the center of the site, past the Outage Building and a Security Gate on the northern boundary of the Site Exclusion Area, through Van Buren State Park to connect with the Blue Star Highway north of the site. Outage workers park in the State Park and are transported via buses to the site facilities.

Regular site employees commuting to and from work enter and leave the Palisades site via the Blue Star Highway, which provides direct access to the Benton Harbor/ St. Joseph area (southwest) and to the South Haven area (northeast). Along with the Blue Star Highway, likely commuting routes include I-196 and M-140, which both provide ready access to areas north and south of the site and CR 378 and 380 which run east and west. South of the site, County Route (CR) 378, runs west from the Blue Star Highway allowing commuters to connect with I-196 and M-140. North of the site, commuters can connect with I-196 via CR 380 and M-140 (see Figure 2.1-2). The Van Buren County Road Commission, which is charged with regulating and maintaining county roads, considers the Blue Star Highway, CR 378, and CR 380 to be in good condition and have adequate capacity to absorb additional traffic.

The U.S. Transportation Research Board has developed a commonly used indicator, called "level of service" (LOS), to measure roadway traffic volume. LOS is a qualitative assessment of traffic flow and how much delay the average vehicle might encounter during peak hours. Table 2.8-2 presents the LOS definitions used by local and state agencies, as well as by NRC in the GEIS (NRC 1996, Section 3.7.4.2).

The Michigan Department of Transportation maintains level-of-service designations for state trunkroads only, dividing them into four categories: LOS D, LOS E, LOS F and a grouping that combines LOS A, B, and C into one rating. State trunklines likely to be used by commuting Palisades employees are I-196/U.S. 31 and M-140, both of which are designated by the State as LOS A, B, C in Van Buren County. M-140 is designated as LOS E in the city of South Haven (MDOT 1999). Average daily traffic counts, determining the average number of vehicles per day, are available for selected routes. Table 2.8-3 lists roadways likely to be used as commuting routes to the Palisades site, and average annual daily traffic volume (AADT) values, as determined by the Southwestern Michigan Regional Planning Commission and the Van Buren County Road Commission. The AADT values represent traffic volumes for a 24-hour period factored by both day of week and month of year.

2.9 LAND USE PLANNING

In the State of Michigan, local governments provide such services as police and fire protection, roads and highways, public sewer and water facilities, parks and open space, planning and zoning, and social services. Local governments are comprised of counties and their subdivisions, including townships, cities and villages.

The State of Michigan, under County Planning, Act 282 of 1945, authorizes counties to prepare and adopt comprehensive growth management plans for purposes of characterizing current conditions and setting standards, policies, and goals for land development (Michigan 2004a). The municipalities, townships, cities, and villages are authorized but not required to develop these plans under Michigan's Municipal Planning Act and Township Planning Act (APA 2004; Michigan 2004b). Land use regulations such as zoning and subdivision and land development controls are enacted, administered, and enforced by local municipalities. Land not incorporated into a village or city is subject to regulation under county and township ordinances (MLULC 2003; Michigan 2004c). In the State of Michigan, there are three zoning acts – the Township Zoning Act, the County Zoning Enabling Act, and the City-Village Zoning Act (APA 2004). Zoning ordinances established by these local governments are used to regulate and guide development.

This section focuses on Van Buren and Berrien Counties because 77 percent of the Palisades site workforce resides in these two counties and because Consumers pays Palisades property taxes to eight jurisdictions in Van Buren County: the County, Covert Township, the Covert School District, the Van Buren Intermediate School District, the Michigan State Education Tax, Lake Michigan College, the Van Buren District Library, and the South Haven Community Hospital District (see Section 3.4 of this ER for workforce description and Section 2.7 of this ER for tax information).

Comprehensive planning is in various stages in the two counties. There are 29 municipalities in Van Buren County and 39 in Berrien County (Berrien 2003, page 3). All but one municipality in the two-county area have developed zoning ordinances to regulate development and growth. All municipalities in Berrien County and over half of the municipalities in Van Buren County have some type of land use plan in place. Both Van Buren and Berrien Counties have comprehensive development plans that have been recently updated. Van Buren County's plan was adopted in 2001, and Berrien County's plan was adopted in June of 2003. County-level planning documents encourage development in areas that can be served by existing infrastructure, while preserving open space and environmentally sensitive areas (VBPC Undated, pages 3-8 & 10; Berrien 2003, Chapter 6), and county planning officials were not aware of any growth control measures in the municipalities in their respective counties.

Van Buren County land use is primarily agricultural and residential (Thar 2004). Van Buren County planning officials expect continued growth around the City of South Haven and along the Interstate 94 (I-94) and Michigan State Highway 43 corridors. The areas in Antwerp and Paw Paw Townships in the I-94 corridor, including the villages of Mattawan and Paw Paw, are growing and experiencing development pressure as people working in the Kalamazoo area seek housing in Van Buren County. The county's overall proximity to the Lake Michigan shore make it susceptible to development pressure with the attendant potential for negatively impacting natural resources, including productive farmland (VBPC Undated, page 10). Growth and development pressure is evident in the City and Township of South Haven due to their lakefront location.

Berrien County estimates that land categorized as agricultural/vacant accounts for 84.2 percent (314,538 acres) of all land in the county, while residential land accounts for 9.4 percent (35,197 acres). Public and semi-public lands account for 3.5 percent (13,063 acres), while industrial and commercial land uses account for 2.8 percent (10,552 acres) of the county's land area (Berrien 2003, page 9). Development is concentrated along the shore of Lake Michigan and in the larger villages and cities (Berrien 2003, Map 3). County planning officials foresee continuing development pressure in the lakeshore area as people from the Chicago area seek vacation home properties in Berrien County and do not anticipate any significant changes to existing land use trends (Berrien 2003, Chapter 5).

Housing stocks in both Van Buren and Berrien Counties are relatively old. According to year 2000 U.S. Census Bureau estimates, approximately 51.4 percent of Van Buren County's total housing stock of 33,975 units was built before 1970. Approximately 64.9 percent of Berrien County's housing stock of 73,445 units is 30 years or older (Census 2000a, DP-4). Homeowner vacancy rates are low, 2.1 percent and 1.9 percent in Van Buren and Berrien Counties, respectively. The rental vacancy rates are 8.0 percent and 8.1 percent in Van Buren and Berrien Counties, respectively (Census 2000b, GCT-H5).

2.10 HISTORIC AND ARCHAEOLOGICAL RESOURCES

The National Park Service (NPS) indicates that 5 properties in Van Buren County, Michigan, are listed on the National Register of Historic Places (NPS 2004). Of these, the following two properties are located within six miles of the Palisades site: the Liberty Hyde Bailey Birthplace, located approximately six miles north of Palisades in the city of South Haven; and the Navigation Structures at South Haven Harbor, located approximately six miles north of the Palisades site in the mouth of the Black River at Lake Michigan. None of these sites are close enough to Palisades to be potentially affected by normal plant operations.

NMC's review of NPS listings indicate that only one property listed on the National Register of Historic Places or recognized as eligible for such listing is located near the Palisades - Argenta 345kV transmission corridor addressed in this ER (NPS 2004). This property is the James Noble Sherwood House at 768 Riverview Drive in the Town of Plainwell, Allegan County, which is located approximately 1/2 mile west of the transmission corridor.

The AEC, in the Final Environmental Statement (FES) for Palisades, noted no known archaeological or historical resources on or near the Palisades site. The FES indicates on the basis of review by the U.S. Department of the Interior and the Michigan State Liaison Officer for Historic Preservation that operation of Palisades would have no effect on significant historic or archaeological sites (AEC 1972, Appendix A). In the Terrestrial Ecological Survey done for Consumers in 1979, it was noted that no significant historical or archaeological resources were known to occur in the study area. Communication with the Director of Michigan History Division in October 1979 confirmed the absence of significant historic or archaeological sites in the immediate vicinity of Palisades. Paw Paw and Lawrence Townships were where most artifacts had been discovered (Consumers 1979, Section 3).

Correspondence with the Michigan State Historic Office regarding archaeological or historic properties located in areas potentially affected by Palisades license renewal is provided in Attachment C of this ER.

TABLE 2.3-1
FISH SPECIES COLLECTED IN PRE- AND POST-OPERATIONAL STUDIES AT PALISADES NUCLEAR PLANT WITH AN INDICATION OF IMPORTANCE[a]

Family (Subfamily) and Species		**Importance[b]**		
Scientific Name	**Common Name**	**Commercial**	**Sport**	**Prey**
Petromyzontidae:	Lampreys:			
Petromyzon marinus	Sea lamprey			
Acipenseridae:	Sturgeons:			
Acipenser fulvescens	Lake sturgeon			
Lepisosteidae:	Gars:			
Lepistoseus osseus	Longnose gar			
Amiidae:	Bowfins:			
Amia calva	Bowfin			
Clupeidae:	Herrings, Shads, Sardines:			
Dorosoma cepedianum	Gizzard shad	X		
Alosa pseudoharengus	Alewife	X		X
Salmonidae (Salmoninae):	Trout and Salmon:			
Oncorhyncus kisutch	Coho salmon		X	
Oncorhyncus tshawytscha	Chinook salmon	X	X	
Oncorhyncus mykiss	Rainbow trout		X	
Salmo trutta	Brown trout		X	
Salvelinus namaycush	Lake trout	X	X	
Salmonidae (Coregoninae):	Ciscos:			
Coregonus clupeaformis	Lake whitefish	X		
Coregonus artedii	Lake herring (cisco)	X		
Coregonus hoyi	Bloater	X		X
Prosopium cylindraceum	Round whitefish	X		
Osmeridae:	Smelt:			
Osmerus mordax	Rainbow smelt	X		X
Umbridae:	Mudminnows:			
Umbra limi	Central mudminnow			
Esocidae:	Pikes:			
Esox lucius	Northern pike			
Esox niger	Chain pickerel			

TABLE 2.3-1 (CONTINUED)
FISH SPECIES COLLECTED IN PRE- AND POST-OPERATIONAL STUDIES AT PALISADES NUCLEAR PLANT WITH AN INDICATION OF IMPORTANCE[a]

Family (Subfamily) and Species		**Importance[b]**		
Scientific Name	**Common Name**	**Commercial**	**Sport**	**Prey**
Cyprinidae:	Minnows and Carps:			
Couesius plumbeus	Lake chub			
Cyprinus carpio	Common carp			
Nocomis micropogon	River chub			
Notropis spilopterus	Spotfin shiner			
Notropis atherinoides	Emerald shiner			
Notropis hudsonius	Spottail shiner			
Rhinichthys cataractae	Longnose dace			
Semotilis atromaculatus	Creek chub			
Luxilus cornutus	Common shiner			
Catostomidae:	Suckers:	X		
Carpiodes cyprinus	Quillback			
Catostomus catostomus	Longnose sucker			
Catostomus commersoni	White sucker			
Ictiobus spp.	Buffalofishes			
Moxostoma erythrurum	Golden redhorse			
Moxistoma macrolepidotum	Shorthead redhorse			
Ictaluridae:	Catfishes:			
Ameiurus melas	Black bullhead			
Ameiurus natalis	Yellow bullhead			
Ameiurus nebulosus	Brown bullhead	X		
Ictalurus punctatus	Channel catfish	X		
Percopsidae:	Trout-perches:			
Percopsis omiscamaycus	Troutperch			
Gadidae:	Burbot:			
Lota lota	Burbot	X		
Gasterostiidae:	Sticklebacks and Tubesnouts:			
Culaea inconstans	Brook stickleback			
Pungitius pungitius	Ninespine stickleback			

TABLE 2.3-1 (CONTINUED)
FISH SPECIES COLLECTED IN PRE- AND POST-OPERATIONAL STUDIES AT PALISADES NUCLEAR PLANT WITH AN INDICATION OF IMPORTANCE[a]

Family (Subfamily) and Species		**Importance[b]**		
Scientific Name	**Common Name**	**Commercial**	**Sport**	**Prey**
Cottidae:	Sculpins:			
Cottus bairdii	Mottled sculpin			
Cottus cognatus	Slimy sculpin			X
Centrarchidae:	Sunfishes:			
Ambloplites rupestris	Rock bass			
Lepomis cyanellus	Green sunfish			
Lepomis gibbosus	Pumpkinseed			
Lepomis machrochirus	Bluegill			
Micropterus dolomieu	Smallmouth bass		X	
Micropterus salmoides	Largemouth bass			
Pomoxis annularis	White crappie			
Pomoxis nigromaculatus	Black crappie			
Percidae:	Perches:			
Etheostoma nigrum	Johnny darter			
Percina caprodes	Logperch			
Perca flavescens	Yellow perch	X	X	

a. Species listed are those collected during preoperational field studies (1968-71) and post-operational (1972-73) field studies in Lake Michigan near the Palisades Nuclear Plant and post-operational impingement monitoring at the plant (1972-73) as reported by Consumers (1975).

b. Species indicated as commercially important are those reported in the 2002 Lake Michigan commercial fishing harvest (USGS 2004a). Species indicated as important sport fish are those reported in the 2003 Lake Michigan recreational fishing harvest (Hanson 2004). Species indicated as prey are those indicated as monitored key components of the Lake Michigan prey fish community (Madenjian, Desorcie, and Holuszko 2004).

TABLE 2.3-2
PLANT COMMUNITIES ON THE PALISADES SITE[a]

Community Number, Type, and Description		Acreage	Percent
1.	Red Oak-White Ash-Sassafras-Sugar Maple Second Growth	55	14
2.	Red Oak-Sassafras-Sugar Maple-Beech Hardwood Forest	175	46
3.	Young Oak-Sassafras-Prunus Forest	23	6
4.	Red, White and Jack Pine Community	6	2
5.	Red Pine Forest	<1	<1
6.	Upland Shrub-Scrub	23	6
7.	Old Field Community	15	4
8.	Beach Grass Stabilized Dune Community	26	7
9.	Beach Grass Stabilized Flats	13	3
10.	Sand Dune Blow-out Community	14	4
11.	Open Sand	13	3
12.	Wetland Communities	9	2
13.	Vegetation Damaged Community due to Cooling Towers	5	1
	Totals[b]	**378**	**100**

a. Community designations and descriptions from Consumers Power Company-sponsored studies of the Palisades site by Vital Resources Consulting (Higman and Goff, 1991). Acreages are estimates derived from a paper map produced as a result of that study and subsequently digitized. Values are approximate and do not reflect minor changes resulting from natural succession and minor site developments and maintenance activities since 1991 (e.g., independent spent fuel storage installation development, clearing of right-of-way for the Palisades-Covert transmission line) results of which include acreage changes for Communities No. 1, 6, 7, and 8 from that indicated.

b. Sum of individual percentages total <100 due to rounding.

TABLE 2.3-3
LAND USE ALONG PALISADES-ARGENTA TRANSMISSION CORRIDOR[a]

State of Michigan Standard Land Use Type/Subtype		Acreage	Percent
Agricultural		**829**	**38**
21	Cropland, Rotation, and Permanent Pasture	689	32
22	Orchards, Vineyards, and Ornamental	95	4
23	Confined Feeding Operations	< 1	<1
24	Permanent Pasture	45	2
Rangeland		**546**	**25**
31	Herbaceous Rangeland	98	5
32	Shrub-Rangeland	448	21
Water		**2**	**<1**
52	Lakes	2	<1
Urban and Built Up		**150**	**7**
113	Single Family, Duplex	3	<1
146	Utilities, Waste Disposal	147	7
Forest Land		**599**	**28**
412	Central Hardwood	497	23
413	Aspen, Birch	4	<1
414	Lowland Hardwood	86	4
421	Pine	12	1
Wetlands		**43**	**2**
612	Shrub/Scrub Wetland	42	2
623	Flats	1	<1
	Totals[b]	**2,169**	**100**

a. Land use types and acreages from geographic information system (GIS) data downloaded from the Michigan Center for Geographic Information, Department of Technology at http://www.mcgi.state.mi.us/mgdl/. Acreages denote the area by land use type/subtype, as mapped by MCGI, within Consumers fee strips upon which the Palisades-Argenta transmission line is located.

b. Sum of individual percentages total >100 due to rounding.

TABLE 2.3-4
RECOGNIZED MNFI NATURAL COMMUNITIES
PALISADES NUCLEAR PLANT AND ASSOCIATED TRANSMISSION LINES VICINITY[a]

Community Type **Subtype**	**MNFI Occurrence[b]** **Co.**	**Twp.**	**1 mi.**	**Description/Remarks[c]**
Bog	V			A peatland characterized by a sedge or sedge-*Sphagnum* floating mat and/or deep *Sphagnum* peat dominated by *Sphagnum* and low ericaceous shrubs often occurs on margins of lakes and ponds, located in depressions in glacial outwash and sandy glacial lake plains and in kettles on end moraines or pitted outwash. Saturated peat is extremely acid, but elevated slightly by neutral to slightly alkaline lakewater and groundwater in southern lower Michigan. Fire occurs naturally during drought periods and can alter the hydrology, mat surface, and flora. Dominant plants: *Sphagnum* spp. (*S. magellanicu*m, *S. cuspidatu*m), *Carex oligosperm*a, *C. lasiocarp*a, *C. trisperm*a, and *Chamaedaphne calyculat*a. Characteristic plants: Typical plants include *Andromeda glaucophyll*a, *Calla palustri*s, *Drosera rotundifoli*a, *Eriophorum* spp., *Kalmia polifoli*a, *Vaccinium macrocarpo*n, *V. oxycocco*s. Typical *Sphagnum* species are *S. papillosu*m, *S. tere*s, *S. recurvu*m, *S. russowi*i, *S. fuscu*m, and *S. capillifoliu*m. *Rhynchospora alb*a, *Carex paucifior*a, and *C. paupercula* can be common. Kettle hole bogs, if limited in area, include later successional states of shrub swamp (*Vaccinium corymbosu*m, *Aronia melanocarp*a, *Nemopanthus mucronat*a, etc.), and poor conifer swamp (*Picea marian*a, *Larix laricin*a, etc.)

TABLE 2.3-4 (CONTINUED)
RECOGNIZED MNFI NATURAL COMMUNITIES
PALISADES NUCLEAR PLANT AND ASSOCIATED TRANSMISSION LINES VICINITY[a]

	MNFI Occurrence[b]			
Community Type **Subtype**	**Co.**	**Twp.**	**1 mi.**	**Description/Remarks[c]**
Coastal plain marsh Infertile Pond/marsh, Great Lakes Type	V	Cv		A grass and rush dominated wetland on shores of softwater seepage lakes, ponds, or depressions, where water levels fluctuate yearly and during each season. Located nearly always in sandy glacial outwash or on sandy glacial lake plains. Soil ranges from sand to peaty sand to peaty muck and is very strongly to strongly acid. Dominant plants: Community shows distinct zonation in concentric bands: open water (when present); shallow water to recently emerged shore dominated by annual plant species and emergents; moist meadow typically dominated by *Calamagrostis canadensis* and sometimes *Cladium mariscoide*s, *Rhynchospora capitellat*a, Carex scoparia, etc.; and shrub-tree margin (when present), often with *Acer rubru*m, *Nyssa sylvatic*a, *Quercus palustri*s, *Aronia melanocarp*a, *Vaccinium corymbosu*m, *Cornus* spp., *Cephalanthus occidentali*s. Characteristic plants: Indicators are species found on the northern Atlantic coastal plain, either disjunct or ranging west into the Lower Great Lakes region, the commoner ones being *Aster dumosu*s, *Eleocharis melanocarp*a, *Fuirena squarros*a, *Lycopodium appressu*m, *Panicum spretu*m, *Polygala cruciat*a, *Psilocarya scirpoides, Rhynchospora macrostachy*a, *Rotala ramosio*r, *Solidago remot*a, *Scleria reticularis*, *Stachys hyssopifoli*a, and *Triadenum virginicu*m. About forty-eight species, eleven of them indicators, are common components of this community, including *Eriocaulon septangular*e, *Fibristylis autumnali*s, *Hemicarpha micranth*a, *Panicum meridional*e, *Rhexia virginic*a, *Scirpus smithi*i, *Viola lanceolat*a, and *Xyris difformi*s. Natural processes: Many of the characteristic species of this community are annuals. They are favored by and persist because of periodic draw-down of pond or lake levels which exposes bare substrate for germination.

TABLE 2.3-4 (CONTINUED)
RECOGNIZED MNFI NATURAL COMMUNITIES
PALISADES NUCLEAR PLANT AND ASSOCIATED TRANSMISSION LINES VICINITY[a]

Community Type **Subtype**	**MNFI Occurrence[b]**			
	Co.	**Twp.**	**1 mi.**	**Description/Remarks[c]**
Mesic sand prairie Moist Sand Prairie, Midwest Type	V			Mesic, native grassland, mostly relicts of mesic sand savanna, prone to summer drought but sometimes inundated in early spring; consequently, species more typical of lowland prairies thrive next to ones of upland prairies. On level sandy glacial outwash, which experiences seasonally high water tables. Soils, principally sandy loam to sand, are strongly acid (ave. pH 5.5; rarely circumneutral) with poor water retaining capacity. Dominant plants: Dominant species are *Andropogon scoparius*, *Carex* spp., and *Andropogon gerardii*. Characteristic plants: Some typical plant species are *Acer rubrum*, *Aletris farinosa*, *Baptisia tinctoria*, *Equisetum arvense*, *Juncus tenuis*, *Lechea villosa*, *Liatris spicata*, *Lobelia spicata*, *Populus tremuloides*, *Polygala sanguinea*, *Pycnanthemum virginianum*, *Quercus palustris*, *Scleria triglomerata*, *Spiraea alba*, *Viola sagittata*. Disturbed sites may include considerable amounts of *Poa compressa* and *Agrostis gigantea*.

TABLE 2.3-4 (CONTINUED)
RECOGNIZED MNFI NATURAL COMMUNITIES
PALISADES NUCLEAR PLANT AND ASSOCIATED TRANSMISSION LINES VICINITY[a]

Community Type Subtype	MNFI Occurrence[b] Co.	Twp.	1 mi.	Description/Remarks[c]
Mesic southern forest Rich Forest, Central Midwest Type	V	Cv	X	A southern hardwood forest type on moist ground with little oak, lying mostly south of the transition zone. Three subtypes can be recognized: one on the eastern lake plains, one in the western sand dunes, and one on the glacial materials between these areas. Occurs principally on medium- or fine-textured ground moraine, on fine-textured end moraine, and on silty/clayey glacial lake plains. Within 10-20 miles of the shores of the Great Lakes, due to improved evapotranspiration conditions, can also occur on sandy lake plains and sand dunes. Soils are variable, with a predominance of clay to loam texture. Dominant plants: *Acer saccharum*, *Fagus grandifolia*; occasionally, *Quercus rubra* or *Liriodendron tulipifera* codominates. Other important canopy species are *Fraxinus americana*, *Tilia americana*, *Prunus serotina*, *Carya cordiformis*, and sometimes *Acer rubrum*, *Quercus alba*, and *Q. macrocarpa*. Characteristic plants: The spring flora of this mesophytic woods shows striking diversity, typified by large colonies of such herbs as *Allium tricoccum*, *Asarum canadense*, *Dentaria laciniata*, *Dicentra cucullaria*, *Erythronium americanum*, *Hydrophyllum virginianum*, *Isopyrum biternatum*, *Phlox divaricata*, *Trillium grandiflorum*. A natural preponderance of *Fagus* could possibly signify a longer time in mature forest conditions, but it could also be the result of heavy selective cutting of sugar maple or of moderately poor drainage conditions for which beech has better tolerance.

TABLE 2.3-4 (CONTINUED)
RECOGNIZED MNFI NATURAL COMMUNITIES
PALISADES NUCLEAR PLANT AND ASSOCIATED TRANSMISSION LINES VICINITY[a]

Community Type **Subtype**	**MNFI Occurrence[b]** **Co.**	**Twp.**	**1 mi.**	**Description/Remarks[c]**
				Two MNFI-recognized plant communities of this type exists within 1 mile of the Palisades site or associated transmission lines, one of which lies partly on the Palisades site: an exemplary 46-acre sugar maple (*Acer saccarum*)-red oak (*Quercus rubra*)-American beech (*Fagus grandifolia*) forested tract within designated Michigan Critical Dunes. About half of the tract occupies the southeastern portion of the Palisades site west of the site access road (south-facing dune slope); the remainder extends to just south of Brandywine Creek on adjoining Palisades Park and Country Club property (Higman and Goff, pages 3-6, 1991; Goff, 1992). The other MNFI-recognized community of this type lies in South Haven Township.
Oak barrens Barrens, Central Midwest Type	V			A savanna type of scattered and clumped trees and shrubs in a matrix of grass, as well as thin woods surrounding dry sand prairie openings. On nearly level to slightly undulating ground in well-drained sandy glacial outwash, sandy glacial lake plains, and less often sandy areas in coarse-textured moraines. Soils are sandy or loamy sand of medium to slightly acid pH and low water retaining capacity. Soils typically lack the fine-textured illuvial horizon associated with soils of the oak openings, and are thus droughtier. Dominant plants: *Quercus velutina* and *Q. alba* in canopy; *Andropogon scopariu*s, *Carex pensylvanica, A. gerardii*, the sedge replacing the bluestems in shaded places and toward the transition zone. *Carya glabra* is a constant species in the canopy. Certain species may be favored by the ecotonal conditions of savanna; e.g. *Aureolaria* spp., *Cacalia atriplicifoli*a, *Ceanothus americanu*s, *Helianthus divaricatu*s, *Lathyrus ochroleucu*s, *Lespedeza hirt*a, *Stipa avenace*a, *Swertia caroliniensi*s. Dense cover by *Poa compressa* indicates past disturbance, usually grazing.

TABLE 2.3-4 (CONTINUED)
RECOGNIZED MNFI NATURAL COMMUNITIES
PALISADES NUCLEAR PLANT AND ASSOCIATED TRANSMISSION LINES VICINITY[a]

Community Type Subtype	MNFI Occurrence[b] Co.	Twp.	1 mi.	Description/Remarks[c]
Prairie fen Alkaline Shrub/herb Fen, Midwest Type	V, K	Al		An herb or herb-shrub wetland on muck (sapric peat), through which flows groundwater rich in calcium and magnesium carbonates, restricted to the southern oak region and absent from the glacial lake plains. Sites typically lie next to lakes, less commonly along streams and rivers, all of which occur in glacial outwash, ice contact topography, or coarse-textured end moraines. Soils consist of saturated muck; neutral to slightly alkaline with excessive water retaining capacity. Dominant plants: Three successionally-related phases of vegetation, each with distinct dominants and characteristic species, intimately commingle at most prairie fens. The wettest portion--called sedge flats because members of the sedge family dominate them--is located at spring discharge areas or along lakeshores, where it can cover extensive areas. Dominant species in this most sparsely vegetated phase include *Eleocharis elliptic*a, *E. rostellat*a, *Scirpus acutu*s, and *Cladium mariscoide*s. Fen meadow is the most diverse, diagnostic, and usually largest portion of prairie fen, its distinctness owing to the presence of many species typical of lowland prairie. Dominance varies between three general associations: sedge-shrub, sedge-composite, and grass-sedge. Dominant plants include *Potentilla fruticos*a, *Carex strict*a, *C. aquatili*s, *C. sterili*s, *Andropogon scopariu*s, *Sorghastrum nutan*s, and sometimes *A. gerardi*i, *Sporobolus heterolepi*s, *Muhlenbergia richardsoni*s. Slightly elevated areas support shrub and shrub-tree associations of chiefly *Larix laricin*a, *Cornus racemos*a, *C. stolonifer*a, Salix discolor and other willows. (If large enough, these areas represent shrub swamp and relict conifer swamp.) *Larix laricina* often invades fens, but in the past may have been naturally removed by flooding during high water periods or by beaver dams or by major infestations of larch sawfly.

TABLE 2.3-4 (CONTINUED)
RECOGNIZED MNFI NATURAL COMMUNITIES
PALISADES NUCLEAR PLANT AND ASSOCIATED TRANSMISSION LINES VICINITY[a]

Community Type Subtype	MNFI Occurrence[b] Co.	Twp.	1 mi.	Description/Remarks[c]
Wet-mesic prairie Tallgrass Prairie, Central Midwest Type	V			Native lowland grassland on moist, level, occasionally inundated sites. Near streams and rivers, near the margins of lakes and sometimes around depressions; nearly exclusively in glacial outwash, usually near moraines. In loam (less commonly sandy loam); neutral (ave. pH 6.9) with good water retaining capacity. Dominant plants: *Andropogon gerardi*i, *Spartina pectinat*a, *Carex* spp. *(C. bebbi*i, *C. strict*a, etc.). Characteristic plants: Typical species include *Anemone virginian*a, *Eryngium yuccifoliu*m, *Galium boreal*e, *Ratibida pinnat*a, *Silphium terebinthinaceu*m, *Thalictrum dasycarpu*m, and *Veronicastrum virginicu*m.

a. Tabulated natural communities consist of those currently recognized by the Michigan Natural Features Inventory (MNFI 2003) on sites listed in the MNFI's Biological and Conservation Database (MNFI 2004a) for Van Buren County, northwestern Kalamazoo County (Alamo and Cooper Townships), and southeastern Allegan County (Gun Plain Township), in which Palisades or associated transmission lines addressed in this ER are located.

b. Occurrence in county, township, and within 1 mile of the Palisades site or transmission line as listed by MNFI (2004a).

c. Except as otherwise noted, from (MNFI 2001; MNFI 2003; MNFI 2004a).

Al = Alamo Township
Co. = County
Cv = Covert Township
K = Northwest Kalamazoo County (Alamo and Cooper Townships)
MNFI = Michigan Natural Features Inventory
Twp. - Township
V = Van Buren County

TABLE 2.3-5
THREATENED, ENDANGERED, AND CANDIDATE SPECIES OCCURRENCE POTENTIAL PALISADES NUCLEAR PLANT AND ASSOCIATED TRANSMISSION LINES VICINITY[a]

	Status[b]		MNFI Occurrence[c]			
Scientific Name **Common Name**	**U.S.**	**MI**	**Co.**	**Twp.**	**1 mi.**	**Habitat/Remarks**
Plants						
Aristida tuberculosa Beach three-awned grass		T	V			Known only from two collections in sandy barrens in southwestern Lower Michigan. May have occurred in dry sand prairie/oak barrens landscapes. Requires early successional or open habitat and local disturbance; fire may be important in maintaining habitat. (MNFI 2004b) Associated MNFI-recognized habitats in Michigan include: Coastal Plain Marsh (Kost and Penskar 2000)
Aristolochia serpentaria Virginia snakeroot		T	V			Occurs in rich dry-mesic, southern floodplain forests; sometimes on slopes; often in proximity to river systems. Only 10 of 17 known occurrences in MI confirmed extant since 1980. May be vulnerable to excessive logging, and is likely adversely affected by invasive species establishment. (MNFI 2004b) Associated MNFI-recognized habitats in Michigan include: Mesic Southern Forest (Cohen 2004), Floodplain Forest (Tepley, Cohem, and Huberty 2004).
Bartonia paniculata Panicled screw-stem		T	V, A			Associated with patterned fen complexes, the margins of shallow lakes/intermittent wetlands, along coastal plain marshes, and lakeplain wet-mesic prairies. Atlantic coastal plain disjunct in MI. MNFI management suggestions include maintaining moist, open habitat. (MNFI 2004b) Associated MNFI-recognized habitats in Michigan include: Coastal Plain Marsh (Kost and Penskar 2000), lakeplain wet-mesic prairie (MNFI 2004b).

TABLE 2.3-5 (CONTINUED)
THREATENED, ENDANGERED, AND CANDIDATE SPECIES OCCURRENCE POTENTIAL PALISADES NUCLEAR PLANT AND ASSOCIATED TRANSMISSION LINES VICINITY[a]

	Status[b]		MNFI Occurrence[c]			
Scientific Name **Common Name**	**U.S.**	**MI**	**Co.**	**Twp.**	**1 mi.**	**Habitat/Remarks**
Berula erecta Cut-leaved water-parsnip		T	V, K, A	Al	X	Cold spring-fed drainages, typically occurring within prairie fens; unshaded marshy borders of cold streams and lakes, and spring channels in fens and bogs. Primary ecological need is protection of hydrology and perpetuation of cool groundwater sources. (MNFI 2004b) Associated MNFI-recognized habitats in Michigan include: Prairie Fen (Spieles et. al 1999) One MNFI record of occurrence within 1 mile of Palisades-Argenta transmission line, recorded only in 1940s (MNFI 2004a).
Besseya bullii Kitten-tails		T	V, K			Oak savanna remnants on steep hillsides, especially those adjacent to large rivers and lakes in southern Lower Michigan. MNFI management recommendations include maintenance of grassland/savanna community, brush removal. (MNFI 2004b)
Calamagrostis stricta Narrow-leaved reedgrass		T	K	Al		Status poorly known; has been found in southern Michigan streams and marshes, a prairie fen, and on stream mudflat. Primary management need is the conservation of wetlands supporting this species. (MNFI 2004b) Associated MNFI-recognized habitats in Michigan include: Prairie Fen (Spieles et. al 1999).
Carex lupuliformis False hop sedge		T	V, K			Deciduous swamps to mixed swamps in southern Lower Michigan, including kettlehole depressions. Requires maintenance of hydrological regime; likely sensitive to overstory removal and other types of artificial disturbance. (MNFI 2004b) Associated MNFI-recognized habitats in Michigan include: Floodplain Forest (Tepley, Cohen, and Huberty 2004).
Carex platyphylla Broad-leaved sedge		T	V	Cv		Mesic forests formed on dunes. MNFI management suggestions include maintaining healthy intact, mature forests. (MNFI 2004b) Associated MNFI-recognized habitats in Michigan include: Mesic Southern Forest (Cohen 2004).

TABLE 2.3-5 (CONTINUED)
THREATENED, ENDANGERED, AND CANDIDATE SPECIES OCCURRENCE POTENTIAL PALISADES NUCLEAR PLANT AND ASSOCIATED TRANSMISSION LINES VICINITY[a]

Scientific Name **Common Name**	**Status[b]**		**MNFI Occurrence[c]**			**Habitat/Remarks**
	U.S.	**MI**	**Co.**	**Twp.**	**1 mi.**	
Carex seorsa Sedge		T	V, K	Cv	X	Hummocks in hardwood or hardwood-conifer swamps, red maple woods, and buttonbush depressions. Often found at edges of woodland pools or at swamp-upland border. MNFI management suggestions include maintaining healthy intact, mature floodplain forests. (MNFI 2004b) One MNFI record of occurrence within 1 mile of Palisades site, in South Haven Township, recorded only in 1985 (MNFI 2004a).
Cirsium pitcheri Pitcher's thistle	T	T	V, A	Cv	X	Great Lakes shorelines, sand dunes, dune fields contiguous with shorelines. Typically grows on open sand dunes and occasionally on lag gravel associated with shoreline dunes. All habitats are along the Great Lakes shores or in very close proximity. Requires protection of habitat and maintenance of natural dune processes such as shoreline fluctuation (limit number of sea walls), erosion, sand deposition, wind, water level fluctuation, and sand movement that create the necessary microsites. MNFI management suggestions include protecting habitat from residential development. (MNFI 2004b; Albert 1999) Occurrence within 1 mile of Palisades site denotes MNFI record of occurrence on Palisades site, last recorded observation in 1994 (Albert 1999; MNFI 2004a). Documented as occurring dune blowout areas on the Palisades site as a result of Consumers-sponsored studies, initially by Asplundh (1979) and subsequently, in 1991, by Vital Resources Consulting (Higman and Goff, 1991; Goff 1992).
Coreopsis palmata Prairie coreopsis		T	V, K			Mesic prairie remnants along railroad rights-of-way. This species likely requires natural disturbances associated with prairie habitat such as brush removal to prevent woody plant succession. (MNFI 2004b)

TABLE 2.3-5 (CONTINUED)
THREATENED, ENDANGERED, AND CANDIDATE SPECIES OCCURRENCE POTENTIAL PALISADES NUCLEAR PLANT AND ASSOCIATED TRANSMISSION LINES VICINITY[a]

	Status[b]		MNFI Occurrence[c]			
Scientific Name **Common Name**	**U.S.**	**MI**	**Co.**	**Twp.**	**1 mi.**	**Habitat/Remarks**
Cypripedium candidum White lady-slipper		T	V, K			Alkaline wetlands in southern Lower Michigan. Primarily in prairie fens and other marly, alkaline sites with groundwater seepage, often adjacent to stream and lake systems and, in southwestern MI, in wet prairie communities of clay lakeplain regions. Species benefits from fen management that includes brush removal, which maintains open habitat and reduces competing woody vegetation. (MNFI 2004b) Associated MNFI-recognized habitats in Michigan include: Prairie Fen (Spieles et. al 1999), Lakeplain Wet-Mesic Prairie (Albert and Kost 1998).
Dryopteris celsa Log fern		T	V, K	Cp		Acidic, humus-rich soils in hardwood swamps and floodplain forests. MNFI management suggestions include maintaining natural habitat and disturbance processes, including hydrological regime; excessive timber cutting may have impacts. (MNFI 2004b) Associated MNFI-recognized habitats in Michigan include: Floodplain Forest (Tepley, Cohen, and Huberty 2004).
Eryngium yuccifolium Rattlesnake-master		T	V, K	Al		Occurs in sedge and grass-dominated portions of prairie fen complexes, including thickets along stream drainages. MNFI suggested management includes maintaining openings, reducing vigorous woody plant competition. (MNFI 2004b) Associated MNFI-recognized habitats in Michigan include: Prairie Fen (Spieles et. al 1999).
Fuirena squarrosa Umbrella-grass		T	V, K, A			Areas with a fluctuating water table: coastal plain marshes, sandy lake edges, dune swales, seepages, sandy marshes, sandy and peaty edges of wetlands, intermittent wetlands. MNFI management suggestions include maintaining moist, open habitat. (MNFI 2004b) Associated MNFI-recognized habitats in Michigan include: Coastal Plain Marsh (Kost and Penskar 2000)

TABLE 2.3-5 (CONTINUED)
THREATENED, ENDANGERED, AND CANDIDATE SPECIES OCCURRENCE POTENTIAL
PALISADES NUCLEAR PLANT AND ASSOCIATED TRANSMISSION LINES VICINITY[a]

Scientific Name **Common Name**	**Status[b]** U.S.	**Status[b]** MI	**MNFI Occurrence[c]** Co.	**MNFI Occurrence[c]** Twp.	**MNFI Occurrence[c]** 1 mi.	**Habitat/Remarks**
Galearis spectabilis Showy orchis		T	V, K			Rich deciduous woods, often near temporary spring ponds in sandy clay or rich loam soils, or in shady, rich microhabitats alongside common spring ephermerals; vigorous colonies can spread into more open habitat. Management suggestions include conservation of rich forest habitat, avoid excessive logging and change in hydrology. (MNFI 2004b) Associated MNFI-recognized habitats in Michigan include: Mesic Southern Forest (Cohen 2004) and Floodplain Forest (Tepley, Cohen, and Huberty 2004).
Hydrastis canadensis Goldenseal		T	V, K, A			Southern hardwood forests, as well as moist ravines and portions of riparian forests; usually under a canopy of beech-sugar maple or red oak-sugar maple. Management recommendations include maintenance of healthy intact, mature forests. (MNFI 2004b) Associated MNFI-recognized habitats in Michigan include: Mesic Southern Forest (Cohen 2004) and Floodplain Forest (Tepley, Cohen, and Huberty 2004).
Isotria medeoloides Small whorled pogonia	T	E				Inhabits low flat woods. Known from a single locality in southwestern lower Michigan where it may no longer extant. MNFI management recommendations include preventing excessive logging (MNFI 2004b) No MNFI record of occurrence in Van Buren, Kalamazoo, or Allegan Counties, but noted by Sackschewsky (1997) as having potential for occurrence in the area.
Isotria verticillata Whorled pogonia		T	V, K			Succession oak and red maple forest in lower slope position. Monitoring and avoidance of cutting in the immediate area of colonies is recommended. (MNFI 2004b)

TABLE 2.3-5 (CONTINUED)
THREATENED, ENDANGERED, AND CANDIDATE SPECIES OCCURRENCE POTENTIAL
PALISADES NUCLEAR PLANT AND ASSOCIATED TRANSMISSION LINES VICINITY[a]

Scientific Name Common Name	Status[b]		MNFI Occurrence[c]			Habitat/Remarks
	U.S.	MI	Co.	Twp.	1 mi.	
Juncus scirpoides Scirpus-like rush		T	V, K, A	Cv	X	Areas with a fluctuating water table: coastal plain marshes, sandy lake edges, dune swales, seepages, sandy marshes, sandy and peaty edges of wetlands, intermittent wetlands. Requires conservation and protection of hydrology of intermittent wetlands. May require fire to maintain prairie habitat. (MNFI 2004b) Associated MNFI-recognized habitats in Michigan include: Coastal Plain Marsh (Kost and Penskar 2000). One MNFI record of occurrence within 1 mile of Palisades-Argenta transmission line, recorded only in 1983 (MNFI 2004a).
Linum virginianum Virginia flax		T	V, K			Open oak forests, upland woods, dry and mesic lakeside and riparian forests, meadows in southern Lower Peninsula. A plant primarily of open woodlands; may suffer from canopy closure as well as clearcutting. (MNFI 2004b)
Ludwigia sphaerocarpa Globe-fruited seedbox		T	V, A	Cv		Muddy shores of lakes, marshes, streams, and interdunal flats; sandy-peaty margins of coastalplain marshes; swamps. Suggested management includes maintaining moist, open habitat. (MNFI 2004b)
Muhlenbergia richardsonis Mat muhly		T	K	Al		Occurs in limestone pavement communities, where it often forms part of the turf with prairie dropseed, flattened spike-rush, and sedges. Benefits from fen management that includes brush removal, which maintains open habitat and reduces competing woody vegetation. (MNFI 2004b) Associated MNFI-recognized habitats in Michigan include: Prairie Fen (Spieles et. al 1999).

TABLE 2.3-5 (CONTINUED)
THREATENED, ENDANGERED, AND CANDIDATE SPECIES OCCURRENCE POTENTIAL
PALISADES NUCLEAR PLANT AND ASSOCIATED TRANSMISSION LINES VICINITY[a]

Scientific Name **Common Name**	**Status[b]**		**MNFI Occurrence[c]**			**Habitat/Remarks**
	U.S.	**MI**	**Co.**	**Twp.**	**1 mi.**	
Panax quinquefolius Ginseng		T	V, K, A			Rich shaded forests with loamy soils and heavy canopies, often on slopes or ravines, even ranging into swampy portions. Also on wooded dune hollows on leeward slopes along the Lake Michigan shoreline. Suggested management practices include preservation of intact forests, avoiding clear cutting, preventing poaching. (MNFI 2004b) Associated MNFI-recognized habitats in Michigan include: Mesic Southern Forest (Cohen 2004) and Floodplain Forest (Tepley, Cohen, and Huberty 2004)
Panicum leibergii Leiberg's panic-grass		T	V, K			Dry prairies and open areas in savannas. Likely requires natural disturbances associated with prairie habitat such as brush removal to prevent woody plant succession (MNFI 2004b). Associated MNFI-recognized habitats in Michigan include: Lakeplain Wet-Mesic Prairie (Albert and Kost 1998).
Panicum verrucosum Warty panic-grass		T	V			Areas with a fluctuating water table: coastal plain marshes, sandy lake edges, dune swales, seepages, sandy marshes, sandy and peaty edges of wetlands, intermittent wetlands. Requires conservation and protection of hydrology of intermittent wetlands. (MNFI 2004b) Associated MNFI-recognized habitats in Michigan include: Coastal Plain Marsh (Kost and Penskar 2000)
Platanthera ciliaris Orange or yellow fringed orchid		T	V, K, A			Acid swamps dominated by bog vegetation. Suggested management includes protection of wetland hydrology and natural disturbance regime. (MNFI 2004b) Associated MNFI-recognized habitats in Michigan include: Coastal Plain Marsh (Kost and Penskar 2000) and Lakeplain Wet-Mesic Prairie (Albert and Kost 1998).

TABLE 2.3-5 (CONTINUED)
THREATENED, ENDANGERED, AND CANDIDATE SPECIES OCCURRENCE POTENTIAL PALISADES NUCLEAR PLANT AND ASSOCIATED TRANSMISSION LINES VICINITY[a]

	Status[b]		MNFI Occurrence[c]			
Scientific Name **Common Name**	**U.S.**	**MI**	**Co.**	**Twp.**	**1 mi.**	**Habitat/Remarks**
Platanthera leucophaea Eastern prairie fringed orchid	T	E				In Michigan, occurs in two distinct habitats, wet prairies and bogs. Extant in fewer than 10 counties in Michigan, mostly in the southcentral and southeastern lower peninsula. Likely requires open conditions. MNFI management suggestions include preservation of habitat, shrub removal. (MNFI 2004b) No MNFI record of occurrence in Van Buren, Kalamazoo, or Allegan Counties, but noted by Sackschewsky (1997) as having potential for occurrence in the area. Associated MNFI-recognized habitats in Michigan include: Lakeplain Wet-Mesic Prairie (Albert and Kost 1998)
Polygonum careyi Carey's smartweed		T	V, A	Cv		Known from exposed lakeshores, sandy marshes, and beaver ponds. Suggested management includes maintaining moist, open habitat. (MNFI 2004b)
Potamogeton bicupulatus Waterthread pondweed		T	V, A			Seasonally flooded wetlands formed in shallow depressions and potholes in glacial lakeplain and outwash landscapes. Requires protection of habitat and maintenance of hydrology. (MNFI 2004b)
Psilocarya scirpoides Bald-rush		T	V, K, A	Cv		Areas with a fluctuating water table: coastal plain marshes, sandy lake edges, dune swales, seepages, sandy marshes, sandy and peaty edges of wetlands, intermittent wetlands. Suggested management includes maintaining moist, open habitat. (MNFI 2004b) Associated MNFI-recognized habitats in Michigan include: Coastal Plain Marsh (Kost and Penskar 2000).
Sabatia angularis Rose-pink		T	V, K			Moist sandy shores, depressions in dunes, marshy ground, edges of lakes. Suggested management includes maintaining moist, open habitat. (MNFI 2004b) Associated MNFI-recognized habitats in Michigan include: Coastal Plain Marsh (Kost and Penskar 2000).

TABLE 2.3-5 (CONTINUED)
THREATENED, ENDANGERED, AND CANDIDATE SPECIES OCCURRENCE POTENTIAL PALISADES NUCLEAR PLANT AND ASSOCIATED TRANSMISSION LINES VICINITY[a]

Scientific Name Common Name	Status[b] U.S.	Status[b] MI	MNFI Occurrence[c] Co.	MNFI Occurrence[c] Twp.	MNFI Occurrence[c] 1 mi.	Habitat/Remarks
Scleria pauciflora Few-flowered nut-rush		E	V			Occurs in sandy soil on the edges of seasonally inundated intermittent wetlands and moist depressions. Suggested management includes maintaining moist, open habitat. Likely responds to management that maintains and perpetuates openings within oak barrens landscapes. (MNFI 2004b) Associated MNFI-recognized habitats in Michigan include: Coastal Plain Marsh (Kost and Penskar 2000), Lakeplain Wet-Mesic Prairie (Albert and Kost 1998)
Scleria reticularis Netted nut-rush		T	V, A	Cv		Seasonally flooded wetlands formed in shallow depressions and potholes in glacial lakeplain landscapes. Suggested management includes maintaining moist, open habitat. (MNFI 2004b) Associated MNFI-recognized habitats in Michigan include: Coastal Plain Marsh (Kost and Penskar 2000).
Silphium integrifolium Rosinweed		T	V, K			Prairie remnants along roads and railroad tracks or in cemeteries; wet-mesic prairies and fens on peaty mucks and loams; dry-mesic to mesic loams and sandy loams. Likely requires natural disturbances associated with prairie habitat such as fire or brush removal to prevent woody plant succession. (MNFI 2004b)
Stellaria crassifolia Fleshy stitchwort		T	K	Al		Cold springs and seepy areas along river edges. Primarily requires maintenance of hydrological regime. (MNFI 2004b)
Trichostema dichotomum Bastard pennyroyal		T	V, K, A			Oak savannah areas in southern lower Michigan. Requires open habitat. Active management (prescribed selected harvesting). To maintain open habitat will likely benefit this species. (MNFI 2004b)

TABLE 2.3-5 (CONTINUED)
THREATENED, ENDANGERED, AND CANDIDATE SPECIES OCCURRENCE POTENTIAL PALISADES NUCLEAR PLANT AND ASSOCIATED TRANSMISSION LINES VICINITY[a]

	Status[b]		MNFI Occurrence[c]			
Scientific Name **Common Name**	**U.S.**	**MI**	**Co.**	**Twp.**	**1 mi.**	**Habitat/Remarks**
Trillium sessile Toadshade		T	V, K	B	X	Floodplains and mesic forests, especially moist ravines; rich moist woods and bluffs; most frequent on limestone derived soils, but occurring elsewhere. MNFI management suggestions include maintaining healthy, intact mature forest habitat, control of invasive species such as garlic mustard, dame's rocket (MNFI 2004b) Associated MNFI-recognized habitats in Michigan include: Mesic Southern Forest (Cohen 2004) and Floodplain Forest (Tepley, Cohen, and Huberty 2004). One MNFI record of occurrence within 1 mile of Palisades-Argenta transmission line, last recorded observation in 1981.
Triphora trianthophora Three-birds orchid		T	V, K, A	Gp		Rich oak-hickory forests and old wooded dune forests with well developed humus layers. May require large forest tracts where natural disturbance processes are allowed to proceed unhindered. (MNFI 2004b) Associated MNFI-recognized habitats in Michigan include: Mesic Southern Forest (Cohen 2004a).
Valeriana edulis var. ciliata Edible valerian		T	V, K			Alkaline prairie fens in southern Lower Michigan. Benefits from fen management that includes prescribed fire and brush removal, which maintains open habitat and reduces competing woody vegetation. (MNFI 2004b)

TABLE 2.3-5 (CONTINUED) THREATENED, ENDANGERED, AND CANDIDATE SPECIES OCCURRENCE POTENTIAL PALISADES NUCLEAR PLANT AND ASSOCIATED TRANSMISSION LINES VICINITY[a]

	Status[b]		MNFI Occurrence[c]			
Scientific Name **Common Name**	**U.S.**	**MI**	**Co.**	**Twp.**	**1 mi.**	**Habitat/Remarks**
Mollusks						
Pleurobema clava Clubshell	E	E				No MNFI record of occurrence in Van Buren, Kalamazoo, or Allegan Counties, but noted by Sackschewsky (1997) as having potential for occurrence in the area. Occurs in small rivers and streams in clean sweep sand and gravel; has been found buried in clean, loose sand to a depth of 2 to 4 inches. Historical range in the Ohio River Basin and in the Maumee River Basin and other tributaries of western Lake Erie. Current known occurrence in Michigan is the Fork of the West Branch of the St. Joseph River in Hillsdale County, in the Lake Erie drainage basin (USFWS 1995; Badra 2001).
Epioblasma torulosa torulosa Tubercled-Blossom Pearly Mussel	E					Noted by Sackschewsky (1997) as having potential for occurrence in the area. However, not listed by USFWS (2004a) as occurring in Michigan and no MNFI record of occurrence in Van Buren, Kalamazoo, or Allegan Counties (MNFI 2004a).
Insects						
Erynnis persius persius Persius duskywing		T	K, A			Opler et. al (1995) indicate species inhabits open areas including mountain grasslands, marshes, sand plains, seeps, streamsides. Caterpillar hosts: Lupine (*Lupinus*), golden banner (*Thermopsis*), Lotus, and other legumes. Populations in the Midwest and Northeast found in pine-oak barrens should be monitored and conserved; habitat of lupine-feeding populations should be managed by mechanical disturbance or infrequent burns (Opler et. al 1995). Associated MNFI-recognized habitats in Michigan include: Oak Barrens (Cohen 2001).
Hesperia ottoe Ottoe skipper		T	A			In Michigan, occurs in remnant, dry sand prairies and open oak barrens where native warm season grasses occur (Cuthrell 2001). Caterpillar host plants apparently include fall witchgrass (*Leptoloma cognatum*),

TABLE 2.3-5 (CONTINUED)
THREATENED, ENDANGERED, AND CANDIDATE SPECIES OCCURRENCE POTENTIAL
PALISADES NUCLEAR PLANT AND ASSOCIATED TRANSMISSION LINES VICINITY[a]

Scientific Name Common Name	Status[b] U.S.	 MI	MNFI Occurrence[c] Co.	 Twp.	 1 mi.	Habitat/Remarks
						little bluestem (*Andropogon scoparius*), and other grasses. Protection and management to maintain open habitats are essential to conservation and long-term survival in Michigan (Cuthrell 2001, Opler et. al 1995). Reported from 17 sites in 6 counties in Michigan, not including Van Buren, Kalamazoo Counties. Only 1 confirmed population known to exist – in Allegan County (Cuthrell 2001). Associated MNFI-recognized habitats in Michigan include: Oak Barrens (Cohen 2001).
Callophrys [Incisalia] irus Frosted elfin		T	K			Opler et. al (1995) indicate species inhabits open woods and forest edges, fields, scrub. Populations are often small and local. Caterpillar hosts are members of the pea family (Fabaceae): wild indigo (*Baptisia tinctoria*) and lupine (*Lupinus perennis*); occasionally blue false indigo (*B. australis*) and rattlebox (*Crotalaria sagittalis*). Management needs include maintaining habitat by controlled burns or other physical means. (Opler et. al 1995). Associated MNFI-recognized habitats in Michigan include: Oak Barrens (Cohen 2001).
Lepyronia gibbosa Great plains spittlebug		T	V			Considered a prairie endemic species that, in Michigan, occupies rare sand prairies and oak savannah habitats. Habitats that sustain this species are in decline due to invasion of woody plants and invasion of alien plant species. Recent studies suggest that adults in Michigan may feed only on big and little bluestem grasses, and that the species may be much more abundant in Michigan than previously thought. (Dunn et. al 2002) Associated MNFI-recognized habitats in Michigan include: Coastal Plain Marsh (Kost and Penskar 2000), Oak Barrens (Cohen 2001).

TABLE 2.3-5 (CONTINUED)
THREATENED, ENDANGERED, AND CANDIDATE SPECIES OCCURRENCE POTENTIAL PALISADES NUCLEAR PLANT AND ASSOCIATED TRANSMISSION LINES VICINITY[a]

Scientific Name / Common Name	Status[b]		MNFI Occurrence[c]			Habitat/Remarks
	U.S.	MI	Co.	Twp.	1 mi.	
Lycaeides melissa samuelis Karner blue	E	T	A			This butterfly is usually associated with landscapes pre-settlement oak or oak-pine savannah or barrens, occurring now in openings, old fields, and rights-of-way surrounded by closed-canopied oak forest. Larvae feed exclusively on wild lupine (Lupinus perennis) (Rabe 2001a). Persists in Michigan in remnants of savannah and barrens, degraded openings, old fields, and utility and highway rights-of-way. Adults feed on the nectar of a variety of flowers, such as blue lupine, New Jersey tea, dogbane, and butterfly weed. Females only lay their eggs on or near lupine plants upon which the young caterpillars feed. In Michigan, lupine is found in oak savannas, oak-pine barrens, and other open areas with sandy soil. These areas declined subsequent to the arrival of European settlers because of reduced incidence of fire, which was important in maintaining prairies, savannas, and barrens by killing trees and shrubs and allowing ground forbs like wild lupine, butterfly weed, and coreopsis to grow. Consumers is participating in partnership with MDNR, the Nature Conservancy, and others to develop a Habitat Conservation Plan (HCP) for this species. The focus of the HCP is ecosystem-based management practices that protect, enhance, or restore savanna, barrens, and other community types upon which the Karner blue and other species-at-risk depend. (MDNR 2004c). Associated MNFI-recognized habitats in Michigan include: Oak Barrens (Cohen 2001).

TABLE 2.3-5 (CONTINUED)
THREATENED, ENDANGERED, AND CANDIDATE SPECIES OCCURRENCE POTENTIAL
PALISADES NUCLEAR PLANT AND ASSOCIATED TRANSMISSION LINES VICINITY[a]

	Status[b]		MNFI Occurrence[c]			
Scientific Name **Common Name**	**U.S.**	**MI**	**Co.**	**Twp.**	**1 mi.**	**Habitat/Remarks**
Neonympha mitchellii mitchellii Mitchell's satyr	E	E	V, K			Inhabits prairie fens, shrub and herb peatlands in which calcium-rich groundwater seeps through the surface maintaining wet and calcareous conditions. Surveys in the mid-1990's identified only twelve populations in southern Michigan and northeastern Indiana. Searches, frequently concentrated in areas ecologically similar to and systems contiguous with known populations, are on-going and have been successful in recent years. Conservation of prairie fen is essential for protection (MDNR 2004c; Lee 2000a) Associated MNFI-recognized habitats in Michigan include: Prairie Fen (Spieles et. al 1999).
Nicrophorus americanus American burying beetle	E	E	K			Currently, American burying beetle sightings have occurred in Nebraska, Rhode Island, Oklahoma, and Arkansas. It was officially listed as a state and federal endangered species in 1989. No recent sightings have occurred in Michigan (MDNR 2004c). Last MNFI recorded observation in Kalamazoo County in 1961 (MNFI 2004a).
Speyeria idalia Regal fritillary		E	K			Opler et. al (1995) indicates species inhabits tall-grass prairie and other open sites including damp meadows, marshes, wet fields, and mountain pastures. Caterpillar host plants include violets, including bird's foot violet (*Viola pedata).* Management needs include monitoring and managing populations on public lands and preserves (Opler et. al, 1995). Associated MNFI-recognized habitats in Michigan include: Oak Barrens (Cohen 2001).

TABLE 2.3-5 (CONTINUED)
THREATENED, ENDANGERED, AND CANDIDATE SPECIES OCCURRENCE POTENTIAL PALISADES NUCLEAR PLANT AND ASSOCIATED TRANSMISSION LINES VICINITY[a]

Scientific Name Common Name	Status[b] U.S.	 MI	MNFI Occurrence[c] Co.	 Twp.	 1 mi.	Habitat/Remarks
Fish						
Acipenser fulvescens Lake sturgeon		T	A			Collected during Palisades early post-operational monitoring studies (1972-73) by gill net (Consumers 1975) Occurs in surrounding Great Lakes and several inland rivers in Michigan. Long-lived bottom dwelling/feeding species occurring in large rivers and shallow areas of large lakes where small benthic organisms that serve as food are abundant. Spring spawner. Preferred spawning habitat consists of gravelly tributary streams of rivers and lakes, though will spawn in rocky, wave-swept areas of lake shores in absence of preferred habitat. Historically have spawned along the Lake Michigan shoreline near South Haven and in the Kalamazoo and St. Joseph Rivers, though no recent reports. Current spawning populations are known from only a few areas, particularly in northern Michigan. Threats include physical barriers to migration, loss of spawning and nursery areas, and fishing pressure, which are conditions addressed for effective conservation and management. Late maturity (spawning seldom occurs before age 20) and infrequent reproduction (3-7 year intervals for females) are significant contributing factors to threatened status. (Goforth 2000) MDNR's Restoration Strategy Report for this species (Hay-Chmielewski, and Whelan, 1997, page 14) indicates that larvae may begin to drift downstream of riverine spawning sites about 18 days after peak spawning, and are about 0.8 inch in length within 3 weeks of spawning. The nearest rivers to the Palisades site currently known to support sturgeon are the lower Kalamazoo River, Allegan County, and in the St. Joseph River, Berrien County, both of which are considered highly suitable for rehabilitation (Hay-Chmielewski, and Whelan 1997, Tables 4 and 6).

TABLE 2.3-5 (CONTINUED)
THREATENED, ENDANGERED, AND CANDIDATE SPECIES OCCURRENCE POTENTIAL
PALISADES NUCLEAR PLANT AND ASSOCIATED TRANSMISSION LINES VICINITY[a]

	Status[b]		MNFI Occurrence[c]			
Scientific Name **Common Name**	**U.S.**	**MI**	**Co.**	**Twp.**	**1 mi.**	**Habitat/Remarks**
Coregonus artedii Cisco or lake herring		T				No MNFI record of occurrence in Van Buren, Kalamazoo, or Allegan Counties, but noted by Becker (1983) as once an important commercial species in Lake Michigan, particularly in Green Bay, and having a historical range that included all of Lake Michigan. Decline of this species in the lake, beginning in 1957, has been attributed to increases in rainbow smelt and alewife populations, overexploitation, and pollution in southern Green Bay (Goodyear et. al, 1982; Becker 1983). Collected during Palisades early pre- and post-operational monitoring studies (1968-73), including 3 individuals collected on traveling screens (AEC, 1972, Appendix II-1, Table 6; Consumers 1975; NRC 1978, Table 2.2). Requires deep inland lakes, generally more than 10 meters deep, preferably with infertile waters but, of all the cisco species, is most frequently associated with inshore shoals and shallow water where it occurs of a wide variety of bottom types. Prefers cold water; in Wisconsin, is rarely found at water temperatures above 63-64°F (Becker 1983). A pelagic spawner reported to have spawned in inshore areas of Lake Michigan during November to mid-December; some spawning near Palisades probably occurred, but most the extensive spawning areas were in Green Bay and Traverse Bay. The nearest known concentrated spawning site to Palisades was 3-4 miles offshore of the Kalamazoo River outfall near Saugatuck (Goodyear et. al, 1982).
Coregonus zenithicus Shortjaw cisco		T				No MNFI record of occurrence in Van Buren, Kalamazoo, or Allegan Counties, but noted by Sackschewsky (1997) as having potential for occurrence in the area and noted by Becker (1983) as having a historical range that includes Lake Michigan in the vicinity of Palisades. However, it apparently now occurs in the Great Lakes only in Lake Superior where its status is currently unknown (USGS 2004b). Becker (1983) reports that the last known occurrence in Lake Michigan was near Racine, Wisconsin, in 1975.

TABLE 2.3-5 (CONTINUED)
THREATENED, ENDANGERED, AND CANDIDATE SPECIES OCCURRENCE POTENTIAL
PALISADES NUCLEAR PLANT AND ASSOCIATED TRANSMISSION LINES VICINITY[a]

	Status[b]		MNFI Occurrence[c]			
Scientific Name **Common Name**	**U.S.**	**MI**	**Co.**	**Twp.**	**1 mi.**	**Habitat/Remarks**
Erimyzon oblongus Creek chubsucker		E	K, A			At the northern edge of its range in the Palisades area, where it has historically been reported in the Kalamazoo River. In the last 20 years, has been reported in Michigan only from the Kalamazoo River in Allegan, Calhoun, and Jackson Counties. Prefers headwaters and clear creeks with moderate currents; most often found over sand-gravel substrates, and sometimes near aquatic vegetation. In Michigan, typically found in moderately swift streams up to 3-5-feet deep, with sand-gravel-mud bottom. Highly sensitive to siltation (e.g., from agricultural runoff) and pollution. (Carman 2001)
Hiodon tergisus Mooneye	-	T				Not reported in pre-operational or post-operational monitoring studies at Palisades (AEC 1972; NRC 1978; Consumers 1975). No MNFI record of occurrence in Van Buren, Kalamazoo, or Allegan Counties, but noted by Becker (1983) as having a historical range that includes Lake Michigan in the vicinity of Palisades. Historical range in Lake Michigan apparently confined to Green Bay, and nearshore areas of the western and southern portions of the lake, where it is noted as rare (Becker 1983). Though often found in non-flowing waters, feeds mostly in swift waters, such as occur below dams (Trautman 1981). Adults migrate up large, clear streams in spring to spawn. Siltation cited as reason for shrinking range and density (Becker 1983).

TABLE 2.3-5 (CONTINUED)
THREATENED, ENDANGERED, AND CANDIDATE SPECIES OCCURRENCE POTENTIAL
PALISADES NUCLEAR PLANT AND ASSOCIATED TRANSMISSION LINES VICINITY[a]

Scientific Name Common Name	Status[b] U.S.	MI	MNFI Occurrence[c] Co.	Twp.	1 mi.	Habitat/Remarks
Amphibians						
Ambystoma opacum Marbled salamander		T	V, A			A fall breeder. During spring and summer, adults occupy sandy upland deciduous forests. In autumn, they congregate in groups near lowland forested habitat to breed. Michigan population is restricted to scattered populations in southwestern counties. Not reported in Michigan for many years, and may be extirpated. Threatened due primarily to habitat fragmentation, wetland drainage, channelization, and filling. Since shallow woodland ponds often freeze completely during typical winters, it is likely that the fall breeding habits of this species are not well adapted to Michigan's present climate. Survival of this species in Michigan will rely on identification and conservation of sites found to have marbled salamander populations. (MDNR 2004c) Associated MNFI-recognized habitats in Michigan include: Mesic Southern Forest (Cohen 2004), Floodplain Forest (Tepley, Cohen, and Huberty 2004).
Reptiles						
Clemmys guttata Spotted turtle		T	V, K, A	Co, Bl, Cp	X	Inhabits bogs or boggy ponds, fens, sphagnum seepages, and grassy marshes, preferring shallow, clean water with mud bottom, clumps of sedge or marsh grass. Often inactive or dormant in hot weather. Begins to decrease activity when water temperatures cool to 32 degrees Fahrenheit. Enters hibernation in muskrat burrows or loafs through the winter on the bottom of pools with flowing water. Threatened by wetland drainage and collecting. (MDNR 2004c; Lee 2000b) Associated MNFI-recognized habitats in Michigan include: Coastal Plain Marsh (Kost and Penskar 2000), Prairie Fen (Speileg et. Al 1999). One MNFI record of occurrence within 1 mile of Palisades-Argenta transmission line, recorded only in 2002 (MNFI 2004a).

TABLE 2.3-5 (CONTINUED)
THREATENED, ENDANGERED, AND CANDIDATE SPECIES OCCURRENCE POTENTIAL PALISADES NUCLEAR PLANT AND ASSOCIATED TRANSMISSION LINES VICINITY[a]

	Status[b]		MNFI Occurrence[c]			
Scientific Name **Common Name**	**U.S.**	**MI**	**Co.**	**Twp.**	**1 mi.**	**Habitat/Remarks**
Clonophis kirtlandii Kirtland's snake		E	V, K			Inhabit damp meadows, vacant lots, and open swampy woodlands. These earthworm and slug eating snakes stay underground much of the time, frequently using rodent or crayfish burrows. (MDNR 2004c) Associated MNFI-recognized habitats in Michigan include: Floodplain Forest (Tepley, Cohen, and Huberty 2004), Prairie Fen (Spieles et. al 1999).
Nerodia erythrogaster neglecta Copper-bellied water snake	T	E				No MNFI record of occurrence in Van Buren, Kalamazoo, or Allegan Counties, but noted by Sackschewsky (1997) as having potential for occurrence in the area. Inhabits wooded floodplains, shrub wetlands, and adjacent to slow moving rivers. Excellent swimmers; hunt aquatic species including tadpoles, frogs, salamanders, insect larvae, and crayfish. Wetlands drainage and development in preferred habitat has limited distribution to only a few small populations. It has been found only in the southern third of the Lower Peninsula. Conservation requires protection of remaining habitat and management of lowland hardwoods. (MDNR 2004c) Associated MNFI-recognized habitats in Michigan include: Mesic Southern Forest (Cohen 2004), Floodplain Forest (Tepley, Cohen, and Huberty 2004).

TABLE 2.3-5 (CONTINUED)
THREATENED, ENDANGERED, AND CANDIDATE SPECIES OCCURRENCE POTENTIAL
PALISADES NUCLEAR PLANT AND ASSOCIATED TRANSMISSION LINES VICINITY[a]

Scientific Name / Common Name	Status[b] U.S.	Status[b] MI	MNFI Occurrence[c] Co.	MNFI Occurrence[c] Twp.	MNFI Occurrence[c] 1 mi.	Habitat/Remarks
Sistrurus catenatus catenatus Eastern massasauga	C	SC	V, K, A	Cv, Co, Bl, Cp	X	Four MNFI records of occurrence within 1 mile of Palisades-Argenta transmission line, last recorded observation in 1995 (MNFI 2004a). Michigan's only venomous snake, historically, found in a variety of wetlands and nearby upland woods throughout the lower peninsula. During the late spring, move from their winter hibernation sites (e.g., crayfish chimneys and other small mammal burrows in swamps and marshlands) to hunt on the drier upland sites. Becoming rare in many parts of their former range, throughout the Great Lakes area, due to wetland habitat loss and persecution by humans. (MDNR 2004c; Lee and Legge 2000) Associated MNFI-recognized habitats in Michigan include: Coastal Plain Marsh (Kost and Penskar 2000), Floodplain Forest (Tepley, Cohen, and Huberty 2004), Prairie Fen (Spieles et. al 1999).
Birds						
Buteo lineatus Red-shouldered hawk		T	A			Currently, most breeding occurs in northern lower Michigan (Cooper 1999). Noted by Asplundh (1979) as unlikely to occur near Palisades site. Nests in deciduous forests and swamps, generally in the branches of hardwood trees in wet woodland areas. Diet consists primarily of small mammals, but also reptiles (e.g., snakes) and amphibians, small birds and large insects. Eastern North America population densities substantially declined through most of the 20th century, probably due to destruction of wet hardwood forest habitat, and hunting. (Miller 2000) Associated MNFI-recognized habitats in Michigan include: Coastal Plain Marsh (Kost and Penskar 2000), Mesic Southern Forest (Cohen 2004), Floodplain Forest (Tepley, Cohen, and Huberty 2004).

TABLE 2.3-5 (CONTINUED)
THREATENED, ENDANGERED, AND CANDIDATE SPECIES OCCURRENCE POTENTIAL
PALISADES NUCLEAR PLANT AND ASSOCIATED TRANSMISSION LINES VICINITY[a]

	Status[b]		MNFI Occurrence[c]			
Scientific Name **Common Name**	**U.S.**	**MI**	**Co.**	**Twp.**	**1 mi.**	**Habitat/Remarks**
Charadrius melodus Piping plover	E	E				No MNFI record of occurrence in Van Buren, Kalamazoo, or Allegan Counties, but noted by Sackschewsky (1997) as having potential for occurrence in the area. Since 1986, only 30 nesting sites have been recorded in Michigan, all in the upper peninsula and northern lower peninsula. Protection of nesting sites is important to recovery (Hyde 1999). Preferred habitat is a wide, sandy beach along the Great Lakes shore in areas that have scant vegetation and scattered stones. Nesting territories often include a small stream or interdunal wetland. Piping plovers lay four eggs in a small scrape on the ground and depend on the coloration of their eggs and feathers for protection. Winter on the Atlantic and Gulf of Mexico coasts. (MDNR 2004c) Associated MNFI-recognized habitats in Michigan include: Open Dunes (Albert 1999).
Dendroica discolor Prairie warbler		E	V, A		X	One MNFI record of occurrence within 1 mile of Palisades site, in South Haven Twp., recorded only in 1997 (MNFI 2004a). Prefers upland scrub-shrub habitats, those optimal for breeding usually associated with poor soils and include brushy dune/lakeshore communities, fallow field with scattered trees, pine plantations, oak clearcuts, and powerline rights-of-way. Major threats include habitat loss and cowbird parasitism. Beneficial management practices include creation of large cutover areas. (Cooper 2000) Associated MNFI-recognized habitats in Michigan include: Oak Barrens (Cohen 2001), Open Dunes (Albert 1999).

TABLE 2.3-5 (CONTINUED)
THREATENED, ENDANGERED, AND CANDIDATE SPECIES OCCURRENCE POTENTIAL
PALISADES NUCLEAR PLANT AND ASSOCIATED TRANSMISSION LINES VICINITY[a]

	Status[b]		MNFI Occurrence[c]			
Scientific Name **Common Name**	**U.S.**	**MI**	**Co.**	**Twp.**	**1 mi.**	**Habitat/Remarks**
Gavia immer Common loon		T	A			Breeds throughout northern North America and northern Europe, in a range that generally equates to the extent of boreal coniferous and northern hardwood forests. Breeding habitat consists of inland lakes that have an abundant population of fish and a large proportion of undeveloped shoreline, with preference to those with a small island or bog mat to hold the nest (inaccessible to raccoons and other egg-eating predators), in an area of little or no high speed boat traffic. Require undisturbed habitat, and are very sensitive to human activity while nesting or rearing young. Now known to breed In Michigan only in the Upper Peninsula and the very northern portions of the Lower Peninsula. (MDNR 2004c)
Falco peregrinus Peregrine falcon		E				No MNFI record of occurrence in Van Buren, Kalamazoo, or Allegan Counties, but noted by Sackschewsky (1997) as having potential for occurrence in the area. Requires large areas of open air for hunting, so not found in areas that are heavily forested. Often use the same nest site (called “eyries” in natural settings) in successive years. Eyries usually on a ledge in high cliffs or an escarpment where the nest will be inaccessible to predators. In urban areas, may nest on tall buildings or bridges, which simulate the high cliffs, including updrafts. Nest sites usually have an encompassing view of the surrounding area, often near or over a lake or river with a nearby gravel shoreline or shoal for bathing. Historically, there were 13 known eyries in Michigan, all located in the cliffs of the Upper Peninsula or steep sand dunes on the Fox Islands in northern Lake Michigan. Populations were decimated during the 1950s, primarily from use of pesticides containing DDT. MDNR surveys in 1999 found nine nesting pairs in Michigan, including five in the Southeast region, one in Lansing and three in the Upper Peninsula. Diet includes a variety of small birds, including pigeons, seabirds, shorebirds, songbirds, and ducks. (MDNR 2004c)

TABLE 2.3-5 (CONTINUED)
THREATENED, ENDANGERED, AND CANDIDATE SPECIES OCCURRENCE POTENTIAL PALISADES NUCLEAR PLANT AND ASSOCIATED TRANSMISSION LINES VICINITY[a]

Scientific Name Common Name	Status[b]		MNFI Occurrence[c]			Habitat/Remarks
	U.S.	MI	Co.	Twp.	1 mi.	
Haliaeetus leucocephalus Bald eagle	T	T	A			Noted by Reichard (1971) and in the initial FES for Palisades (AEC 1972, Appendix II-1, Table I) as having rare occurrence on or near the Palisades site. Nests usually near lakes or large rivers to be near their most common food supply, fish. When fish are not available, such as in winter, also feed on waterfowl, small mammals (up to rabbit-size) and carrion. Occur throughout the state (almost all counties) in winter, but nest mainly in the Upper Peninsula (especially the western portion) and the northern portion of the Lower Peninsula. Populations were decimated during the 1950s, primarily from use of PCBs and pesticides containing DDT. The Michigan population has increased since the 1970s when only about 86 nesting pairs occurred in the state; a 1999 survey found 343 nests that produced 321 young. (MDNR 2004c) Associated MNFI-recognized habitats in Michigan include: Coastal Plain Marsh (Kost and Penskar 2000). On July 6, 1999 (64 FR 36454), USFWS published a proposed rule to remove the bald eagle in the Lower 48 States From the List of Endangered and Threatened Wildlife (USFWS 1999).
Pandion haliaetus Osprey		T	A	Gp		Noted by Reichard (1971) and in the initial FES for Palisades (AEC 1972, Appendix II-1, Table I) as having rare occurrence on or near the Palisades site; however, no suitable nest sites appear to exist on or near Palisades site (Asplundh 1979, Table 6-6). With fish as their only prey, usually select tall trees in marshes along streams, lakes or man made floodings for nesting, but will adapt to artificial nesting platforms. Nesting platforms and restriction of certain harmful pesticides, has helped ospreys recover from the drastic population reductions seen in the 1950s and '60s. MDNR's Nongame Wildlife Fund located 166 pairs in 1988, up from the 81 counted in 1975. Heavy use of pesticides on its winter range in Central and South America remain a threat. (MDNR 2004c)

TABLE 2.3-5 (CONTINUED)
THREATENED, ENDANGERED, AND CANDIDATE SPECIES OCCURRENCE POTENTIAL
PALISADES NUCLEAR PLANT AND ASSOCIATED TRANSMISSION LINES VICINITY[a]

	Status[b]		MNFI Occurrence[c]			
Scientific Name **Common Name**	**U.S.**	**MI**	**Co.**	**Twp.**	**1 mi.**	**Habitat/Remarks**
Rallus elegans King rail		E	V, A			Michigan lies on the northern edge of its breeding range, which historically in Michigan extended south of a line from Bay City to Muskegon. A marsh inhabitant, it was once abundant in the marshes along the western shore of Lake Erie. Declines have been primarily caused by loss of extensive sedge and cattail marshes, with additional concerns over impacts of pesticide residues that may be limiting recolonization of rails into suitable habitat. Conservation requires continued protection of wetlands and research into possible pesticide contamination. (MDNR 2004c) Reported from Van Buren or Allegen County prior to 1805 (Rabe 2001b). Wetlands on and near Palisades site do not appear to be large enough to support this species (Asplundh 1979, Table 6-7). Associated MNFI-recognized habitats in Michigan include: Coastal Plain Marsh (Kost and Penskar 2000), Lakeplain Wet-Mesic Prairie (Albert and Kost 1998).
Sterna caspia Caspian tern		T				No MNFI record of occurrence in Van Buren, Kalamazoo, or Allegan Counties. Caspian terms were sighted overhead along Lake Michigan during terrestrial studies at Palisades in 1978-79, but not likely to nest on site (Asplundh 1979, pages 6-7). Associated MNFI-recognized habitats in Michigan include: Open Dunes (Albert 1999). Currently reported to nest in only 8 counties in Michigan, none on west coast of southern Michigan south of Traverse Bay (Hyde 1996). Nesting habitat is open sandy or pebble beaches, usually on islands in large bodies of water (Hyde 1996).

TABLE 2.3-5 (CONTINUED)
THREATENED, ENDANGERED, AND CANDIDATE SPECIES OCCURRENCE POTENTIAL
PALISADES NUCLEAR PLANT AND ASSOCIATED TRANSMISSION LINES VICINITY[a]

	Status[b]		MNFI Occurrence[c]			
Scientific Name **Common Name**	**U.S.**	**MI**	**Co.**	**Twp.**	**1 mi.**	**Habitat/Remarks**
Sterna hirundo Common tern		T				Noted by Reichard (1971) and in the initial FES for Palisades (AEC 1972, Appendix II-1, Table I) as having common occurrence on or near the Palisades site, but not observed by Asplundh (1979) during 1978-79 site surveys. No MNFI record of occurrence in Van Buren, Kalamazoo, or Allegan Counties, but noted by Sackschewsky (1997) as having potential for occurrence in the area. No recent nest sites recorded from west coast of lower Michigan (Hyde 1997). Associated MNFI-recognized habitats in Michigan include: Open Dunes (Albert 1999). Arrive on breeding grounds in May, nesting in colonies of 10 to 1,000 breeding pairs. Prefer sandy, well drained areas away from mammalian predators and human disturbances. Currently use natural and human made islands in the Great Lakes with a few nesting on inland lakes. Construct their nests by creating a depression in the sand. Once numbering over 6,000 breeding pairs in Michigan, common terns were found on every Great Lakes shore. Data from 1992 suggest that the population has decreased to an estimated 1,400 breeding pairs. (MDNR 2004c)
Mammals						
Cryptotis parva Least shrew		T	K, A			Populations in Michigan are at the northern limit of species range where it prefers grassy, weedy or brushy fields (Fox 1999). Requires open prairie and savannah ecosystems (Lehr 2004) Associated MNFI-recognized habitats in Michigan include: Coastal Plain Marsh (Kost and Penskar 2000), Oak Barrens (Cohen 2001).

TABLE 2.3-5 (CONTINUED)
THREATENED, ENDANGERED, AND CANDIDATE SPECIES OCCURRENCE POTENTIAL PALISADES NUCLEAR PLANT AND ASSOCIATED TRANSMISSION LINES VICINITY[a]

	Status[b]		MNFI Occurrence[c]			
Scientific Name **Common Name**	**U.S.**	**MI**	**Co.**	**Twp.**	**1 mi.**	**Habitat/Remarks**
Microtus ochrogaster Prairie vole		E	V, K			Two individuals collected in 1978 during terrestrial studies of Palisades site in open habitat dominated by marram grass; not found in collections in the same area the following year (Asplundh 1979). Requires open prairie and savannah ecosystems (Lehr 2004) Associated MNFI-recognized habitats in Michigan include: Oak Barrens (Cohen 2001).
Myotis sodalis Indiana bat	E	E				No MNFI record of occurrence in Van Buren, Kalamazoo, or Allegan Counties, but noted by Sackschewsky (1997) as having potential for occurrence in the area. Hibernates in caves and abandoned mines outside of Michigan. Less than 400,000 bats remain in the U.S., 85 percent of which are concentrated at seven hibernation sites, creating a potential for species loss. Summer habitat in Michigan includes use by females and young of streamside or forested floodplains under the loose bark of trees. (MDNR 2004c; Newell 1999). Associated MNFI-recognized habitats in Michigan include: Floodplain Forest (Tepley, Cohen, and Huberty 2004).

a. Tabulated species consist of: (a) Federally designated threatened (T), endangered (E), and candidate (C) species reported by the USFWS for Michigan (USFWS 2004a, 2004b) that have a record of occurrence in the three-county area in which Palisades and associated transmission lines addressed in this ER are located (i.e., Van Buren, Kalamazoo, Allegan) as indicated by MNFI (2004a), or are indicated by Sackschewsky (1997) as potentially occurring in the area. (b) State-designated (MDNR 1999) threatened and endangered animal species that have an MNFI record of occurrence in the three-county area, indicated by Sackschewsky (1997) as potentially occurring in the area or, for fish species, indicated by Becker (1983) as having a historical range that includes Lake Michigan in the general area of Palisades. (c) State-designated (MDNR 1999) threatened and endangered plant species that have an MNFI record of occurrence in Van Buren County, northwestern Kalamazoo County (Alamo and Cooper Townships) or southeastern Allegan County (Gun Plain Township), in which Palisades or associated transmission lines addressed in this ER are located. Also included in the table are any federally listed or candidate species and state-listed species noted on or near the Palisades site based on NMC's review of Palisades monitoring reports.

b. Status as indicated by USFWS (2004a, 2004b) and MDNR (1999).

c. Occurrence in county, township, and within 1 mile of the Palisades site or transmission line as listed by MNFI (2004a).

TABLE 2.3-5 (CONTINUED)
THREATENED, ENDANGERED, AND CANDIDATE SPECIES OCCURRENCE POTENTIAL PALISADES NUCLEAR PLANT AND ASSOCIATED TRANSMISSION LINES VICINITY[a]

	Status[b]		MNFI Occurrence[c]			
Scientific Name **Common Name**	**U.S.**	**MI**	**Co.**	**Twp.**	**1 mi.**	**Habitat/Remarks**

Al = Alamo Township (Kalamazoo County)
Bl = Bloomingdale Township (Van Buren County)
C= Candidate for listing
Cv = Covert Township (Van Buren County)
Co = Columbia Township (Van Buren County)
Co. = County
Cp = Cooper Township (Kalamazoo County)
Gp = Gun Plain Township (Allegan County)
HCP = Habitat Conservation Plan

E = Endangered
K = Kalamazoo County
MDNR = Michigan Department of Natural Resources
MNFI = Michigan Natural Features Inventory
SC = Special Concern
T = Threatened
USFWS = U.S. Fish and Wildlife Service
V = Van Buren County

TABLE 2.3-6
TERRESTRIAL THREATENED, ENDANGERED, AND CANDIDATE SPECIES HABITAT SUMMARY[a]

		MNFI-Recognized Habitat							
Scientific Name[b]	**Common Name**	**Open Dune**	**Mesic Southern Forest**	**Coastal Plain Marsh**	**Prairie Fen**	**Wet-Mesic Prairie**	**Oak Barrens/ Savannah**	**Flood-plain Forest**	**Other Potential Habitats in General Area**
Plants									
A. tuberculosa	Three-awned grass			X					Sandy barrens
A. serpentaria	Virginia snakeroot		X					X	
B. paniculata	Panicled screw-stem			X		X			
B. erecta	Cut-leaved water-parsnip				X				
B. bullii	Kitten-tails						X		
C. stricta	Narrow-leaved reedgrass				X				Streams, marshes
C. lupuliformis	False hop sedge							X	
C. platyphylla	Broad-leaved sedge		X						
C. seorsa	Sedge							X	Red maple woods
C. pitcheri	Pitcher's thistle	X							
C. palmata	Prairie coreopsis								Railroad rights-of-way
C. candidum	White lady-slipper				X	X			
D. celsa	Log fern							X	
E. yuccifolium	Rattlesnake-master				X				
F. squarrosa	Umbrella-grass			X					0pen intermittent wetlands
G. spectabilis	Showy orchis		X					X	

TABLE 2.3-6 (CONTINUED)
TERRESTRIAL THREATENED, ENDANGERED, AND CANDIDATE SPECIES HABITAT SUMMARY[a]

		MNFI-Recognized Habitat							
Scientific Name[b]	**Common Name**	**Open Dune**	**Mesic Southern Forest**	**Coastal Plain Marsh**	**Prairie Fen**	**Wet-Mesic Prairie**	**Oak Barrens/ Savannah**	**Flood-plain Forest**	**Other Potential Habitats in General Area**
Plants (cont'd)									
H. canadensis	Goldenseal		X					X	
I. medeoloides	Small whorled pogonia								Low flat woods
I. verticillata	Whorled pogonia								Oak, maple forest
J. scirpoides	Scirpus-like rush			X					Open intermittent wetlands
L. virginianum	Virginia flax								Open woods
L. sphaerocarpa	Globe-fruited seedbox								Muddy shores
M. richardsonis	Mat muhly				X				
P. quinquefolius	Ginseng		X					X	
P. leibergii	Leiberg's panic-grass					X			Dry prairies, savannahs
P. verrucosum	Warty panic-grass			X					Intermittent wetlands
P. ciliaris	Orange or yellow fringed orchid			X		X			Acid swamps
P. leucophaea	Eastern prairie fringed orchid					X			Bogs
P. careyi	Carey's smartweed								Shores, marsh, ponds

TABLE 2.3-6 (CONTINUED)
TERRESTRIAL THREATENED, ENDANGERED, AND CANDIDATE SPECIES HABITAT SUMMARY[a]

		MNFI-Recognized Habitat							
Scientific Name[b]	**Common Name**	**Open Dune**	**Mesic Southern Forest**	**Coastal Plain Marsh**	**Prairie Fen**	**Wet-Mesic Prairie**	**Oak Barrens/ Savannah**	**Flood-plain Forest**	**Other Potential Habitats in General Area**
Plants (cont'd)									
P. bicupulatus	Waterthread pondweed								Seasonal wetlands
P. scirpoides	Bald-rush			X					Open intermittent wetlands
S. angularis	Rose-pink			X					Dune depressions
S. pauciflora	Few-flowered nut-rush			X		X			Open intermittent wetlands
S. reticularis	Netted nut-rush			X					Open seasonal wetland
S. integrifolium	Rosinweed								Prairie remnants along roads, railroads
S. crassifolia	Fleshy stitchwort								Cold springs, seeps.
T. dichotomum	Bastard pennyroyal						X		
T. sessile	Toadshade		X					X	
T. trianthophora	Three-birds orchid		X						Rich oak-hickory woods
V. edulis	Edible valerian				X				

TABLE 2.3-6 (CONTINUED)
TERRESTRIAL THREATENED, ENDANGERED, AND CANDIDATE SPECIES HABITAT SUMMARY[a]

		MNFI-Recognized Habitat							
Scientific Name[b]	**Common Name**	**Open Dune**	**Mesic Southern Forest**	**Coastal Plain Marsh**	**Prairie Fen**	**Wet-Mesic Prairie**	**Oak Barrens/ Savannah**	**Flood-plain Forest**	**Other Potential Habitats in General Area**
Insects (cont'd)									
Insects									
E. persius	Persius duskywing						X		
H. ottoe	Ottoe skipper						X		
I. irus	Frosted elfin						X		
L. gibbosa	Great plains spittlebug			X			X		
L. melissa	Karner blue						X		
N. mitchellii	Mitchell's satyr				X				
N. americanus	American burying beetle								
S. idalia	Regal fritillary						X		
Amphibians									
A. opacum	Marbled salamander		X					X	Woodland ponds
Reptiles									
C. guttata	Spotted turtle			X	X				
C. kirtlandii	Kirtland's snake				X			X	
N. erythrogaster	Copperbelly water snake		X					X	
S. catenatus	Eastern massasauga			X	X			X	Wetlands, adjacent woods

TABLE 2.3-6 (CONTINUED)
TERRESTRIAL THREATENED, ENDANGERED, AND CANDIDATE SPECIES HABITAT SUMMARY[a]

		MNFI-Recognized Habitat							
***Scientific Name*[b]**	**Common Name**	**Open Dune**	**Mesic Southern Forest**	**Coastal Plain Marsh**	**Prairie Fen**	**Wet-Mesic Prairie**	**Oak Barrens/ Savannah**	**Flood-plain Forest**	**Other Potential Habitats in General Area**
Birds (cont'd)									
B. lineatus	Red-shouldered hawk		X	X				X	
C. melodus	Piping plover	X							
D. discolor	Prairie warbler	X					X		
G. immer	Common loon								None
F. peregrinus	Peregrine falcon								None
H. leucocephalus	Bald eagle			X					Lake shore
P. haliaetus	Osprey								Marsh along streams, lakes
R. elegans	King rail			X		X			
S. caspia	Caspian tern	X							
S. hirundo	Common tern	X							
Mammals									
C. parva	Least shrew			X			X		
M. ochrogaster	Prairie vole						X		Open prairie
M. sodalis	Indiana bat							X	

a. Source information from Table 2.3-5 and information sources cited therein.
b. See Table 2.3-5 for complete scientific names.

TABLE 2.5-1
METROPOLITAN STATISTICAL AREAS LOCATED WITHIN 50 MILES OF PALISADES

MSA Name	Area	National Population Ranking	2000 Population	1990 Population
Grand Rapids-Wyoming	MI	63	740,482	645,914
South Bend-Mishawaka	IN-MI	145	316,663	296,529
Kalamazoo-Portage	MI	146	314,866	293,471
Holland-Grand Haven	MI	172	238,314	187,768
Elkhart-Goshen	IN	205	182,791	156,198
Muskegon-Norton Shres	MI	219	170,200	158,983
Niles-Benton Harbor	MI	231	162,453	161,378
Michigan City-La Porte	IN	340	110,106	107,066
Allegan	MI	356	105,665	90,509

Source: Census 2003a, b, Tables 2a and 3a.

MSA = Metropolitan Statistical Area
MI = Michigan
IN = Indiana

TABLE 2.5-2
ESTIMATED POPULATIONS AND ANNUAL GROWTH RATES IN BERRIEN AND VAN BUREN COUNTIES, 1970 TO 2040

	Berrien County		Van Buren County	
Year	Population[a]	Percent[b]	Population[a]	Percent[b]
1970	163,875	-	56,173	-
1980	171,276	0.4	66,814	1.7
1990	161,378	-0.6	70,060	0.5
2000	162,453	-0.6	76,263	0.9
2010	160,800	-0.1	87,100	1.3
2020	158,900	-0.1	95,800	1.0
2030	157,022	-0.1	105,369	1.0
2040	155,167	-0.1	115,894	1.0

a. Source: Population estimates for years 1970, 1980, 1990 from Census 1995; for year 2000, from Census 2000a, DP-1; for years 2010 and 2020, from MOSD 1996; for 2030 and 2040, from equation in footnote b, using rate of growth from previous decade.
b. Source: Annual percent growth rate in previous decade calculated using the equation $N[t] = N_{[o]} (1+r)^t$ where N is population, t is time in years, and r is the annual growth rate expressed as a decimal.

TABLE 2.5-3
CENSUS 2000 POPULATIONS FOR NOTABLE MUNICIPALITIES IN BERRIEN AND VAN BUREN COUNTIES

Municipality	2000 Population
Berrien County[a]	
City of Niles	12,199
City of St. Joseph	8,789
City of Benton Harbor	11,182
City of Buchanan	4,681
City of Bridgman	2,428
Benton Charter Township	16,404
Lincoln Charter Township	13,952
Niles Township	13,325
St. Joseph Charter Township	10,042
Oronoko Township	9,843
Van Buren County	
City of Bangor[a]	1,933
City of South Haven[a]	5,013
City of Hartford[a]	2,476
Village of Paw Paw[b]	3,363
Village of Mattawan[b]	2,536
South Haven Township[a]	4,046
Almena Township[a]	4,226
Antwego Township[a]	10,813
Geneva Township[a]	3,975
Decatur Township[a]	3,916
Paw Paw Township[a]	7,091

a. Source: Census 2000a.
b. Source: Census 2003c, Table 10.

TABLE 2.5-4
MINORITY AND LOW-INCOME POPULATION CENSUS BLOCK GROUPS

		Black or African American	American Indian and Alaska Native	Asian	Native Hawaiian or Other Pacific Islander	Other Single Race	Two or More Races	Hispanic or Latino	Aggregate Minority	Low Income	
	Regional Percent[a]	**7.7**	**0.45**	**1.40**	**0.04**	**1.90**	**2.70**	**5.50**	**16.4**	**8.8**	
	Threshold for Minority Population[b]	**27.7**	**20.5**	**21.4**	**20.0**	**22.7**	**21.9**	**25.5**	**36.4**	**28.8**	
State	**County**	**Number of Minority or Low-Income Block Groups in Category**									**Total**
MI	Allegan	0	0	0	0	0	0	4	1	0	5
MI	Barry	0	0	0	0	0	0	0	0	0	0
MI	Berrien	26	0	0	0	0	0	0	28	13	67
MI	Cass	5	0	0	0	0	0	0	5	1	11
MI	Kalamazoo	19	0	1	0	0	0	0	27	28	75
MI	Kent	0	0	0	0	0	0	0	0	0	0
MI	Ottawa	0	0	0	0	4	0	9	10	1	24
MI	St. Joseph	0	0	0	0	0	0	0	0	2	2
MI	Van Buren	3	0	0	0	0	0	1	4	1	9
IN	Elkhart	6	0	0	0	2	0	10	18	2	38
IN	La Porte	1	0	0	0	0	0	0	1	0	2
IN	St. Joseph	41	0	0	0	6	0	7	51	14	119

Source: Census 2000 Summary Files 1 (SF1) and 3 (SF3) for Indiana and Michigan (Census 2001; Census 2002)

a. Regional percent calculated using the summary data from each county with at least one block group located within the 50-mile radius.
b. At least 20 percentage points greater than the regional percent.
c. Aggregate Minority percentage (i.e., 16.4) is less than the total of percentages indicated for racial and ethnic categories (i.e., 16.7). Difference is attributable to inclusion of only those persons in the Hispanic or Latino ethnicity category identified in the census as white Hispanic or Latino (to avoid double-counting).

IN = Indiana
MI = Michigan

TABLE 2.6-1
YEAR 2000 EMPLOYMENT BY COUNTY AND SELECTED INDUSTRIES[a]

Type of Job	Number of Jobs	
	Van Buren	Berrien
Agricultural Services, Forestry, Fishing	604	929
Mining	0	163
Construction	1,763	4,208
Manufacturing	5,813	19,522
Transportation and Public Utilities	1,476	3,909
Trade	6,192	18,883
Finance, Insurance, and Real Estate	0	4,635
Services	6,504	26,895
Government	5,295	9,304
Non-Farm	28,513	88,448
Farm Employment	2,217	2,259
Total Employment	30,730	90,707

a. Source: MEDC 2004a and b

TABLE 2.7-1
PALISADES NUCLEAR PLANT PROPERTY TAX CONTRIBUTION TO REVENUES AND OPERATING BUDGETS OF LOCAL JURISDICTIONS

Year	Property Tax Paid for Palisades[a]	Operating Budget	Percent of Operating Budget	Total Revenue	Percent of Total Revenue
Van Buren County (VBCO 2004b)					
1994	871,798	11,297,046	7.7	10,713,093	8.1
1995	884,066	11,258,233	7.9	11,066,568	8.0
1996	931,752	11,756,356	7.9	11,762,924	7.9
1997	931,752	12,344,658	7.5	12,382,981	7.5
1998	929,963	13,610,347	6.8	13,525,071	6.9
1999	922,323	14,127,672	6.5	14,533,739	6.3
2000	915,016	15,279,487	6.0	15,147,694	6.0
2001	882,689	15,810,523	5.6	16,193,382	5.5
2002	830,670	16,824,110	4.9	16,775,725	5.0
2003	819,524	17,269,135	4.7	17,777,818	4.6
Covert Township (Stuckum 2004)					
1994	644,065	1,280,500	50.3	1,290,839	49.9
1995	553,930	1,611,200	34.4	1,325,363	41.8
1996	590,544	1,903,500	31.0	1,383,898	42.7
1997	829,276	1,839,500	45.1	1,452,134	57.1
1998	822,440	1,654,500	49.7	2,253,589	36.5
1999	822,280	1,672,000	49.2	2,209,945	37.2
2000	822,107	1,917,500	42.9	1,471,810	55.9
2001	793,754	2,027,000	39.2	1,652,690	48.0
2002	860,692	2,295,550	37.5	1,481,325	58.1
2003	878,130	2,500,850	35.1	1,466,195	59.9
Covert School District (Bettis-Cooper 2004)					
1994	3,382,111	5,881,231	57.5	5,496,824	61.5
1995	3,473,117	6,246,231	55.6	7,158,112	48.5
1996	3,660,452	7,390,642	49.5	7,142,536	51.2
1997	3,726,867	6,880,838	54.2	7,432,302	50.1
1998	3,047,465	6,871,847	44.3	7,664,227	39.8
1999	3,047,465	6,770,429	45.0	7,466,882	40.8

TABLE 2.7-1 (CONTINUED)
PALISADES NUCLEAR PLANT PROPERTY TAX CONTRIBUTION TO REVENUES AND OPERATING BUDGETS OF LOCAL JURISDICTIONS

Year	Property Tax Paid for Palisades[a]	Operating Budget	Percent of Operating Budget	Total Revenue	Percent of Total Revenue
Covert School District (Bettis-Cooper 2004) (Continued)					
2000	3,047,465	7,680,863	39.7	7,472,990	40.8
2001	2,609,420	7,676,461	34.0	7,930,747	32.9
2002	2,620,287	7,706,504	34.0	7,061,795	37.1
2003	2,615,172	8,649,071	30.2	8,324,922	31.4
Van Buren Intermediate School District (Mills 2004)					
1995	869,319	14,056,605	6.2	14,995,231	5.8
1996	916,208	15,715,733	5.8	15,936,584	5.7
1997	916,208	16,344,487	5.6	17,185,997	5.3
1998	913,824	17,049,497	5.4	18,399,250	5.0
1999	906,392	17,778,724	5.1	19,169,834	4.7
2000	897,837	19,784,738	4.5	21,740,259	4.1
2001	865,867	21,130,563	4.1	22,097,322	3.9
2002	810,521	23,806,709	3.4	25,028,589	3.2
2003	798,827	24,618,219	3.2	25,646,758	3.1
District Library (Tate 2004)					
1994	124,556	815,667	15.3	858,536	14.5
1995	124,585	822,964	15.1	891,468	14.0
1996	131,305	886,008	14.8	974,399	13.5
1997	131,305	993,248	13.2	995,762	13.2
1998	131,305	967,170	13.6	1,037,560	12.7
1999	130,348	1,187,061	11.0	1,221,663	10.7
2000	129,821	1,390,317	9.3	1,415,185	9.2
2001	125,705	1,224,099	10.3	1,280,473	9.8
2002	117,629	1,311,372	9.0	1,292,279	9.1
2003	116,366	1,358,193	8.6	1,282,872	9.1

TABLE 2.7-1 (CONTINUED)
PALISADES NUCLEAR PLANT PROPERTY TAX CONTRIBUTION TO REVENUES AND OPERATING BUDGETS OF LOCAL JURISDICTIONS

Year	Property Tax Paid for Palisades	Operating Budget	Percent of Operating Budget	Total Revenue	Percent of Total Revenue
South Haven Community Hospital District (Urbanski 2004)					
1994	51,893	10,759,000	0.5	11,518,000	0.5
1995	52,623	13,571,000	0.4	14,227,000	0.4
1996	55,461	12,788,000	0.4	14,347,000	0.4
1997	55,461	13,821,000	0.4	13,805,000	0.4
1998	55,461	13,417,000	0.4	14,998,000	0.4
1999	55,461	14,992,000	0.4	16,894,000	0.3
2000	55,461	17,453,000	0.3	19,839,000	0.3
2001	53,789	19,169,000	0.3	19,422,000	0.3
2002	49,735	19,950,000	0.2	20,930,000	0.2
2003	50,678	21,523,000	0.2	20,866,000	0.2

a. Property tax paid for Palisades does not include the amount paid by NMC to the local jurisdictions for nuclear fuel. Property taxes for nuclear fuel amounts to an additional contribution of approximately nine percent.

TABLE 2.8-1
MAJOR MUNICIPAL WATER SYSTEMS;
VAN BUREN AND BERRIEN COUNTIES USAGE AND CAPACITY

Water System	Population Served	Source	System Capacity[a] (MGD)	Average Daily Demand (MGD)	Peak Demand (MGD)
		Van Buren[b]			
Bangor	1,933[c]	GW	2.93	0.194	0.484
Decatur	1,838[c]	GW	1.08	0.239	0.511
Hartford	2,476[c]	GW	1.95	0.238	0.342
Lawrence	1,059[c]	GW	1.44	0.093	0.185
Lawton	1,859[c]	GW	3.89	1.293	2.269
Mattawan	2,536[c]	GW	1.64	0.797	0.329
Paw Paw	3,363[c]	GW	2.90	0.429	1.187
South Haven[d]	6,421[c]	SW	4.0	1.652	3.230
		Berrien County[e]			
Benton Harbor	17,800	SW	12.00	4.85	8.4
Berrien Springs	3,530	GW	3.54	0.45	0.77
Bridgeman	2,400	SW	1.44	0.34	0.81
Buchanan	4,980	GW	2.16	0.51	1.11
Chikaming Township[f]	3,800	GW&SW	0.94	0.50	1.38
Coloma	1,595	GW	1.73	0.19	0.41
Lake Charter Township	3,300	SW	5.00	1.6	4.17
New Buffalo	5,440	SW	2.00	0.50	1.14
Niles	13,000	GW	9.54	1.70	3.48
Niles Township	1,800	GW	3.89	0.34	0.82
St. Joseph	30,465	SW	16.00	5.17	12.82
Three Oaks	1,829	GW	1.44	0.19	0.37
Watervliet	1,843	GW	1.73	0.28	0.43

a. System Capacity for GW Sources refer to Firm Well Capacity, defined as the total well capacity excluding the largest well capacity. The Michigan Safe Drinking Water Act (Act 399) requires that firm well capacity meet or exceed the maximum daily demand. System Capacity for SW Sources is the maximum treatment rate. Act 399 requires that maximum treatment rate does not exceed the approved rate of filter plant capacity.

b. MDEQ 2004b.

c. Source: EPA 2004.

d. In addition to serving their own population, South Haven sells water to the South Haven/Casco Township Authority and Covert Township.

e. Source: Wozniak 2004.

f. Chikaming Township buys water from the Lake Charter Township to meet daily demand.

SW = surface water
GW = groundwater
MGD = million gallons per day

TABLE 2.8-2
LEVEL OF SERVICE DEFINITIONS

Level of Service	Conditions
A	Free flow of the traffic stream; users are unaffected by the presence of others.
B	Stable flow in which the freedom to select speed is unaffected, but the freedom to maneuver is slightly diminished.
C	Stable flow that marks the beginning of the range of flow in which the operation of individual users is significantly affected by interactions with the traffic stream.
D	High-density, stable flow in which speed and freedom to maneuver are severely restricted; small increases in traffic will generally cause operational problems.
E	Operating conditions at or near capacity level causing low, but uniform, speeds and extremely difficult maneuvering that is accomplished by forcing another vehicle to give way; small increases in flow or minor perturbations will cause breakdowns.
F	Defines forced or breakdown flow that occurs wherever the amount of traffic approaching a point exceeds the amount that can traverse the point. This situation causes the formation of queues characterized by stop-and-go waves and extreme instability.

Source: NRC 1996, Section 3.7.4.2.

TABLE 2.8-3
MAJOR COMMUTING ROUTES IN THE PALISADES VICINITY AND AVERAGE TRAFFIC VOLUMES[a]

Roadway	Average Annual Daily Traffic Volumes (Vehicles Per Day)
Blue Star Highway	
• From CR 380 South to CR 378	2,389
M-140	
• North of I-196/U.S. 31 into South Haven	6,000[a]
• From I-196 South almost to Berrien County Line	6,700[a]
• Vicinity of Berrien County Line	5,100[a]
• South to I-94	11,000[a]
I-196/U.S. 31	
• From Phoenix Road south to M-140 Interchange	18,100[a]
• From M-140 Interchange South to CR 378	18,300[a]
• From CR 378 Interchange South to M-63	15,300[a]
CR 378	
• From $77^{1/2}$ St. West to 76th St.	1,585
CR 380	
• From Blue Star Highway West to 76th St.	1,032

a. Source: MDOT 2004.

FIGURE 2.1-1
50-MILE REGION

FIGURE 2.1-2
6-MILE VICINITY

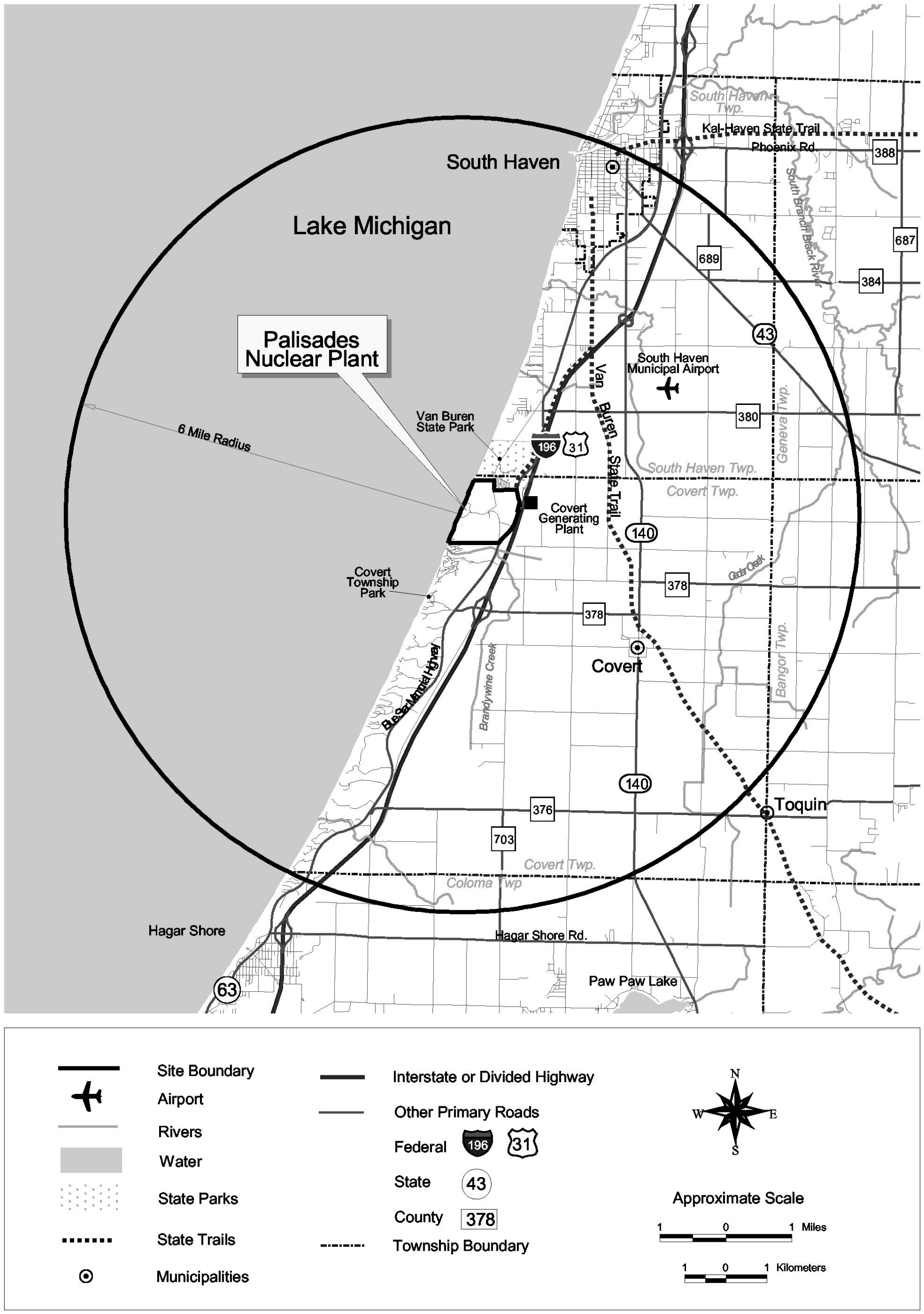


FIGURE 2.1-3
SITE MAP

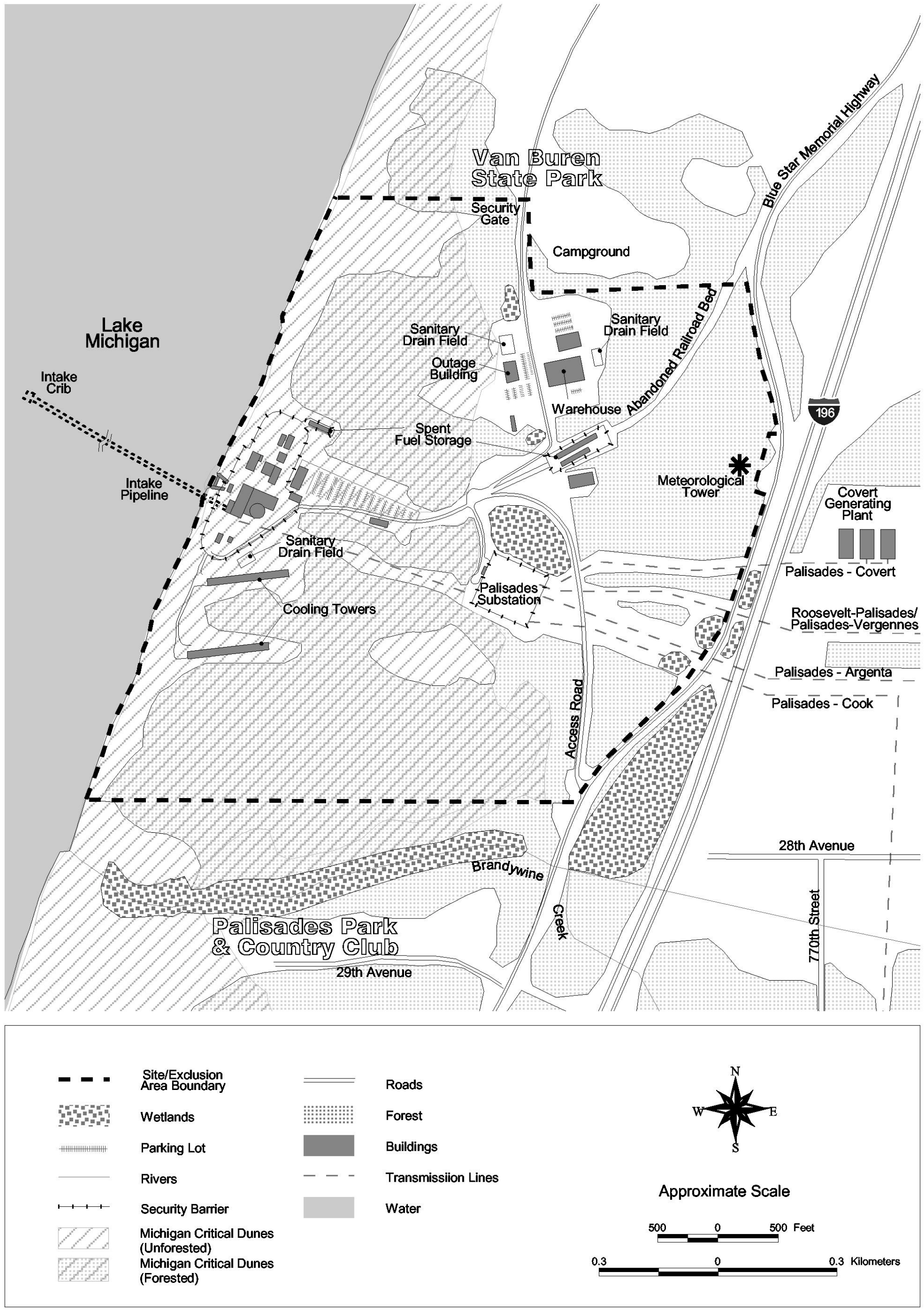


FIGURE 2.5-1
AGGREGATE MINORITY POPULATION

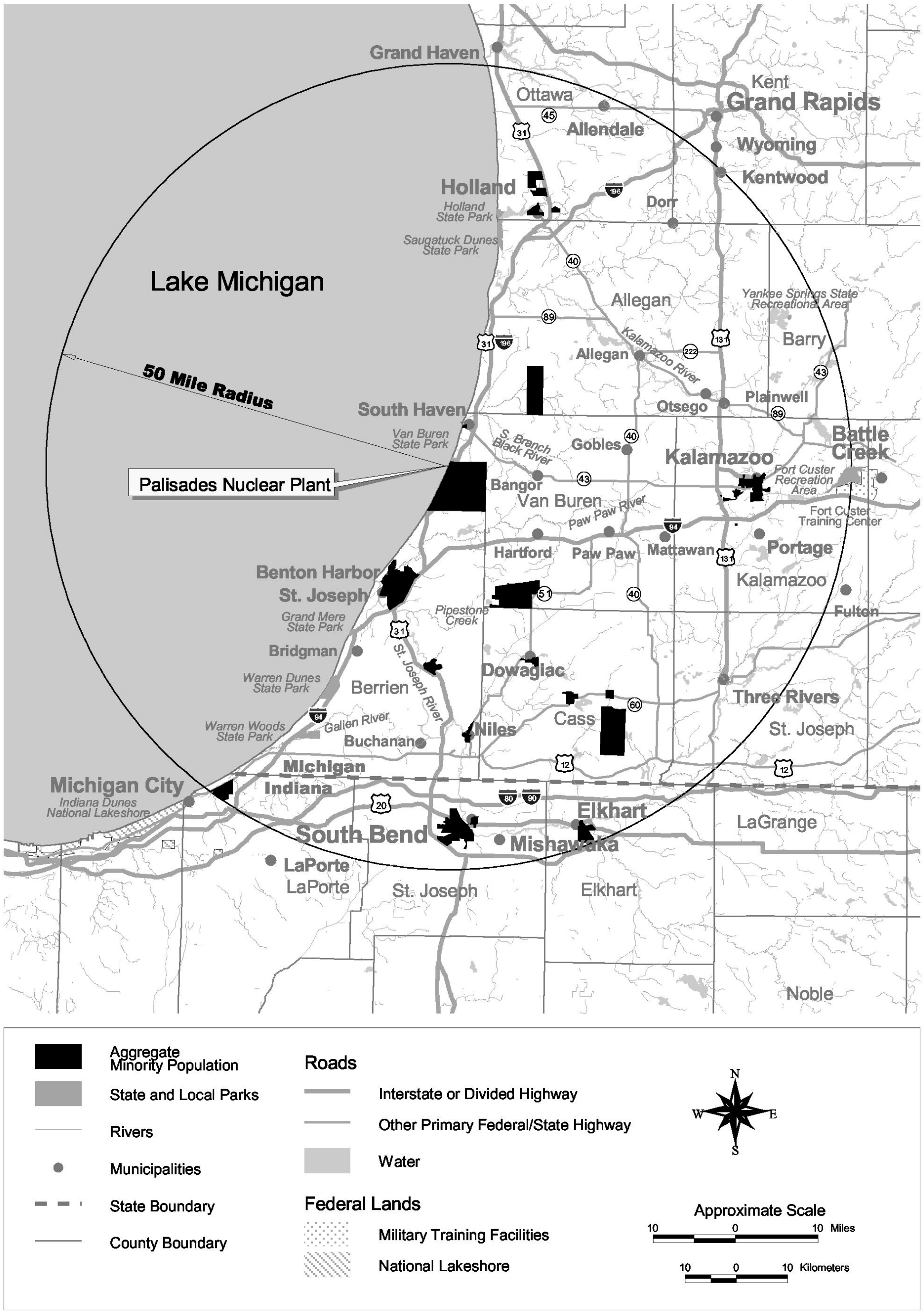


FIGURE 2.5-2
BLACK OR AFRICAN AMERICAN MINORITY POPULATION

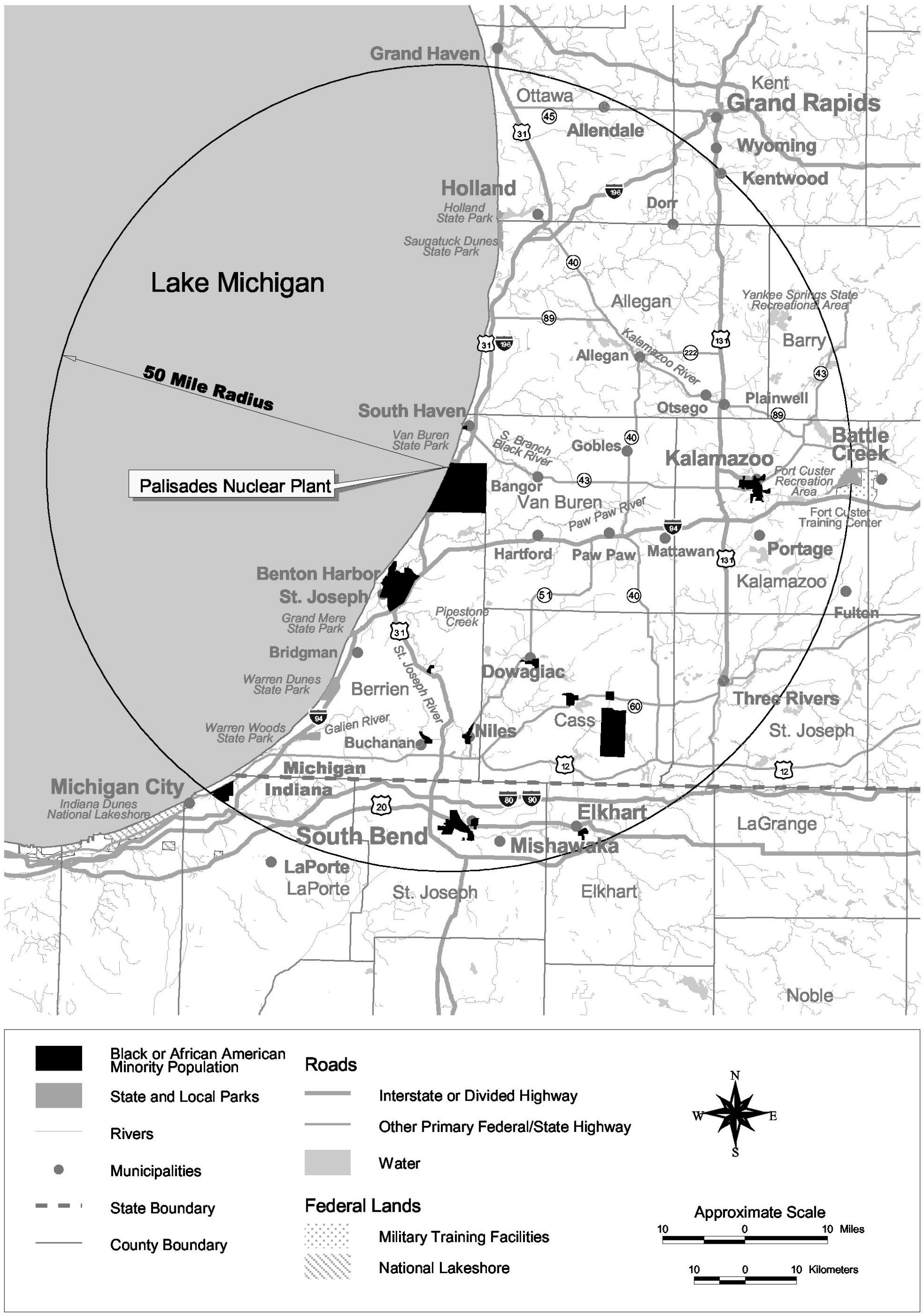


FIGURE 2.5-3
HISPANIC OR LATINO POPULATION

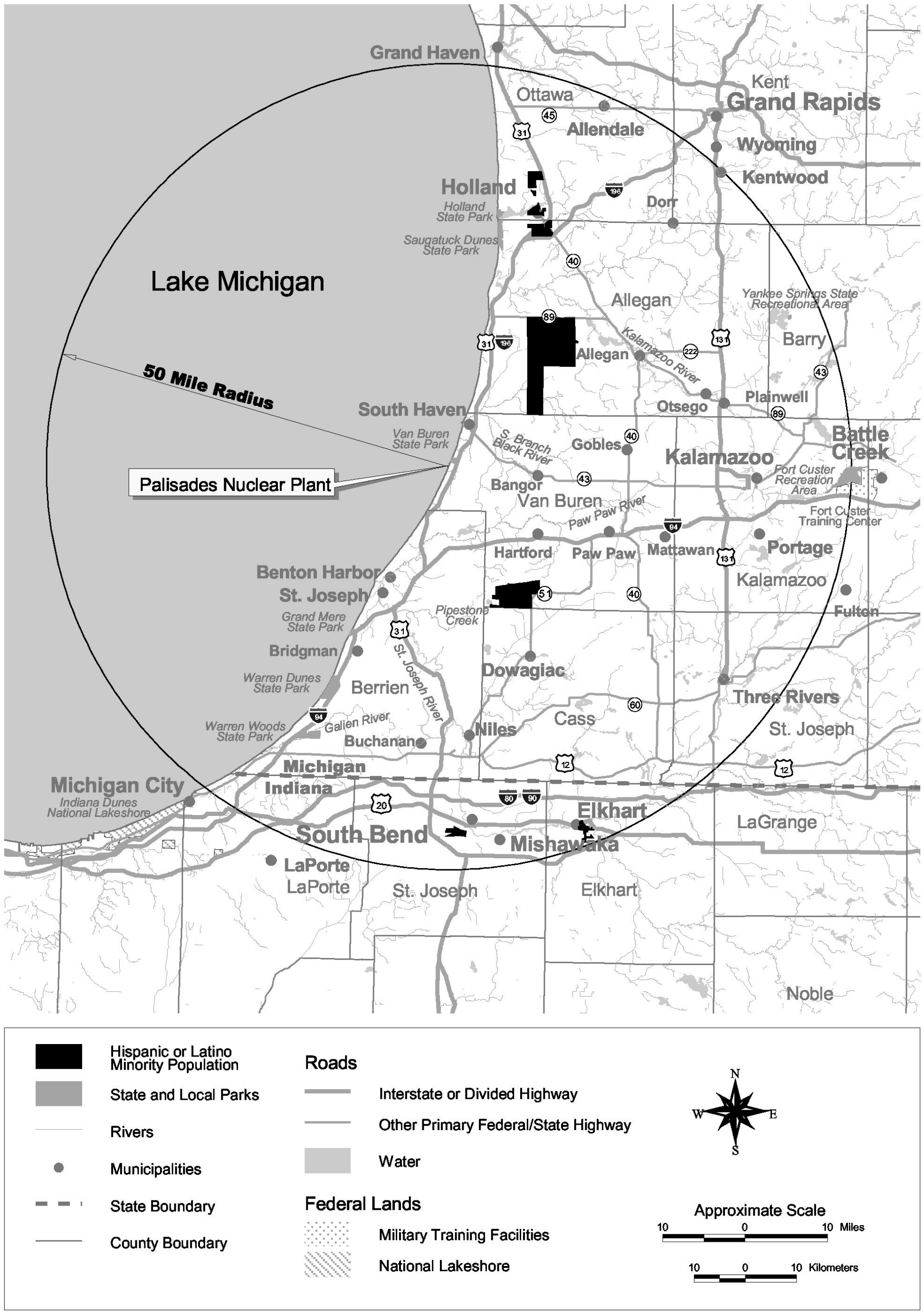
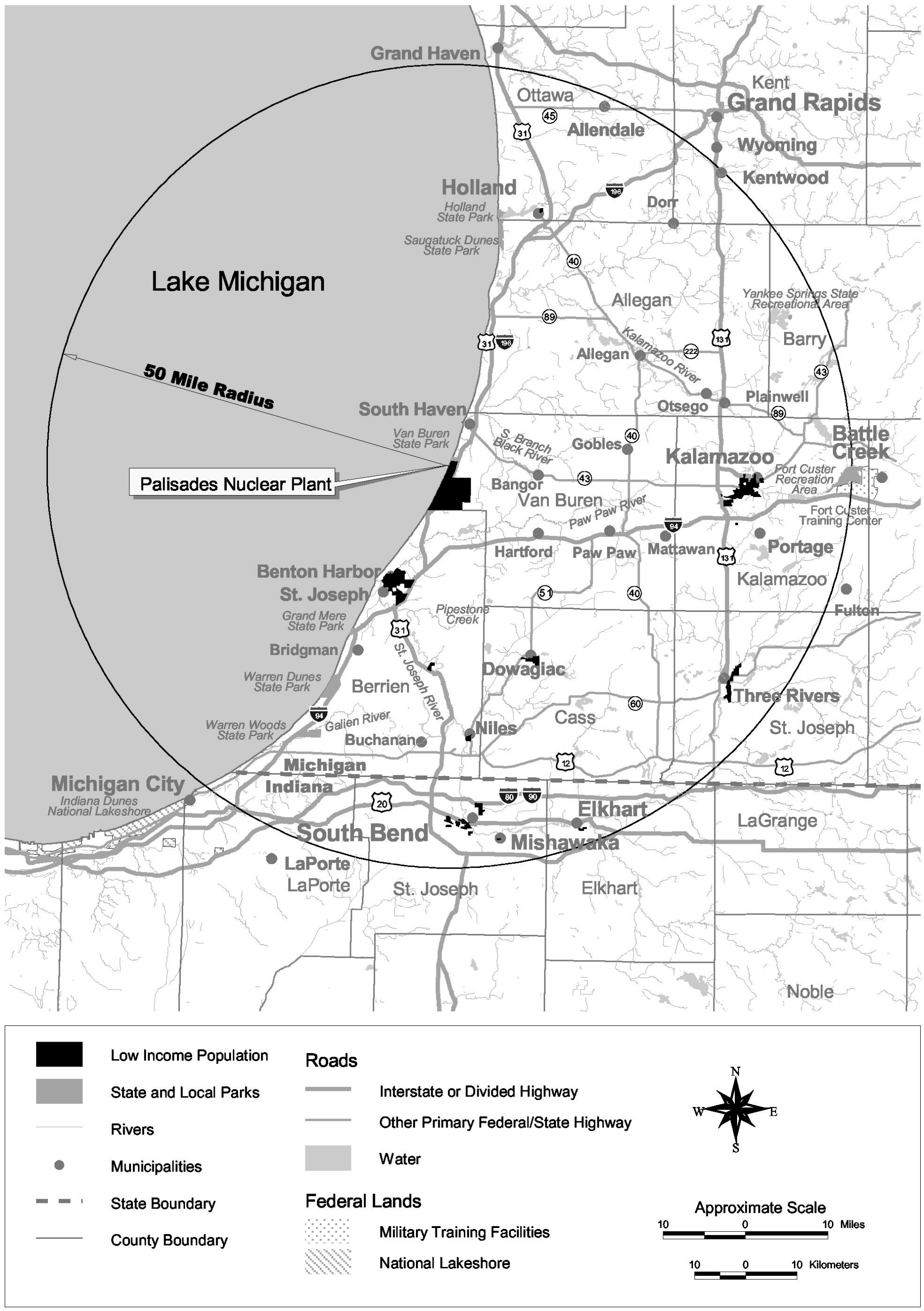


FIGURE 2.5-4
OTHER SINGLE RACE MINORITY POPULATION

FIGURE 2.5-5
ASIAN MINORITY POPULATION

FIGURE 2.5-6
LOW-INCOME POPULATION



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Note to reader: This list of references identifies web pages and associated URLs where reference data was obtained. Some of these web pages may likely no longer be available or their URL address may have changed. NMC has maintained hard copies of the information and data obtained from the referenced web pages.

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3.0 THE PROPOSED ACTION

NRC

"The report must contain a description of the proposed action, including the applicant's plans to modify the facility or its administrative control procedures… .This report must describe in detail the modifications directly affecting the environment or affecting plant effluents that affect the environment…." 10 CFR 51.53(c)(2)

Nuclear Management Company, LLC (NMC) proposes the U.S. Nuclear Regulatory Commission (NRC) renew the Palisades Nuclear Plant (Palisades) operating license for the maximum period currently allowable under the Atomic Energy Act of 1954 and NRC's implementing regulations at 10 CFR 54.31. This action would provide the option to operate Palisades for up to 20 years beyond the current operating license expiration date of March 24, 2011 (NMC 2003, Section 1.1.2). Renewal of the operating license would thereby enable the State of Michigan, CMS Energy Corporation, its subsidiary companies (e.g., Consumers Energy, Inc.), and other participants in the wholesale power market to rely on Palisades to meet future demands for electric power through March 24, 2031.

NMC presents in the following sections of Chapter 3 a description of Palisades' facilities and activities relevant to assessments presented in Chapter 4 of this Environmental Report (ER). Section 3.1 provides a general description of selected plant design and operating features. Sections 3.2 through 3.4 address potential changes that could be required to support Palisades operation during the license renewal term.

3.1 GENERAL PLANT INFORMATION

General information about the design and operational features of the Palisades site of interest from an environmental impact standpoint is available from the primary National Environmental Policy Act (NEPA) documentation for the plant, including the following:

- Final Environmental Statement (FES) issued by U.S. Atomic Energy Commission (AEC) in 1972 in support of the initial provisional operating license for Palisades (AEC 1972). This document includes a description of the plant as initially constructed with a once-through cooling system (construction was largely completed in spring 1971), plans for construction of mechanical draft cooling towers and conversion to closed cycle cooling, and associated environmental impacts.

- Final Addendum to the FES issued by NRC in 1978 in support of the conversion of the provisional operating license for Palisades to a full-term operating license (NRC 1978). This document describes changes in plant design and operation since issuance of the FES and initial operation beginning in 1972, including conversion to the closed-cycle cooling system in 1974, and the environmental impacts of operating the plant at a higher power level, up to 2,638 megawatts-thermal (MWt).

- Environmental Assessment issued by NRC in 1990 in support of conversion of the provisional operating license for Palisades to a full-term operating license, an action which had been delayed by inception of NRC's Systematic Evaluation Program (NRC 1990). The environmental assessment documents a review of the FES and Final Addendum to the FES and describes relevant aspects of plant operation and associated environmental impacts.

The Final Safety Analysis Report (FSAR) for Palisades, which NMC routinely updates, provides relevant information about current plant design and operating features (NMC 2003). NMC relied on these sources and other relevant design and permit documentation as a basis for descriptions of Palisades presented in the remainder of Section 3.1.

3.1.1 MAJOR FACILITIES

As discussed in Section 2.1.2 of this ER, developed or maintained portions of the 432-acre Palisades site consist of approximately 80 acres. The developed and maintained portions include the power block area, two independent spent fuel storage installations (ISFSI) for dry storage, cooling towers, main parking lot, main access road, switchyard (Palisades Substation), and power transmission facilities and corridors, which extend eastward from the power block to the eastern site boundary at the Blue Star Memorial Highway. Other development on the site consists of waste storage and support facilities, including a radioactive waste storage building, an interim steam generator storage building for storage of old steam generators that were replaced in the early 1990s, a warehouse, an outage/training facility, and spent fuel services building. Most of these facilities are located along the north access road that leads to the north security gate. The site meteorological tower is located near the eastern site boundary (see Figure 2.1-3) (NMC 2003).

Major structures located in the power block area include the following:

- Turbine Building, oriented parallel and adjacent to the Lake Michigan shoreline, which houses the turbine generator, condenser, feedwater heaters, condensate and feed pumps, turbine auxiliaries and switchgear assemblies;

- Reactor Containment Building, located landward of the Turbine Building, which houses the nuclear steam supply system (NSSS), including the reactor, steam generators, primary coolant pumps and motors, pressurizer and quench tank, some reactor auxiliaries, hydrogen recombiners, and containment building air coolers;

- Auxiliary Building and Auxiliary Building Addition (Radioactive Waste Building), located north of the Containment Building, which houses the spent fuel pool, radioactive waste treatment facilities, engineered safeguards components, heating and ventilating system components, the emergency diesel generators, switchgear, laboratories, offices and the control room;

- Condensate and Makeup Demineralizer Building (feedwater purity building), located north of the Turbine Building, which houses the raw water filtration system, the reverse osmosis pretreatment system, the makeup demineralizer system, regeneration chemicals handling system, feedwater purity air compressors, and related facilities;

- Intake Structure, located on the west side of the Turbine Building, which houses the service water and fire protection pumps;

- The Cooling Tower Pump House, which contains two vertical pumps to circulate the tube side condenser cooling water to the cooling towers for the Circulating Water System, a warm water recirculation pump to allow circulating warm discharge effluent back to the intake structure for the service water pumps during winter months, and a chemical addition system to combat biofouling in the Circulating Water System.

In addition, on-site development also includes the area occupied by and surrounding the two Circulating Water System cooling towers for Palisades, which are respectively located approximately 500 and 1,000 feet south of the main power generating facilities (NMC 2003, Sections 1.2.2, 1.2.4, and 10.2.4, Figures 1-1, 2-2, and 10.6).

3.1.2 NUCLEAR STEAM SUPPLY, CONTAINMENT, AND POWER CONVERSION SYSTEMS

The NSSS for Palisades is a pressurized water reactor consisting of a reactor Primary Coolant System (PCS) and associated auxiliary systems (NMC 2003, Section 1.2.4). The PCS design features two closed loops in which reactor coolant is circulated, each of which includes two primary coolant pumps and a steam generator. The reactor coolant, demineralized water to which chemicals are added to control corrosion and moderate the nuclear reaction, circulates under high pressure through the reactor vessel and the tube side of the two steam generators in these closed loops. Heat from the reactor is transferred to conditioned, demineralized water in the shell side of the steam generators to produce high-pressure steam that is routed through the steam turbine, condensed back to water in the main condenser, and pumped back to the steam generators, thus comprising an isolated secondary cooling loop (i.e., the secondary system) (NMC 2003, Sections 1.2.4, 1.2.5). The steam turbine is a tandem-compound unit and is connected directly to the generator. The maximum calculated capacity of the turbine generator is 865 megawatts-electrical (MWe) gross. Heat transfer from the main condenser is accomplished by a third cooling loop, the Circulating Water System, which is discussed further in Section 3.1.3 of this ER (NMC 2003, Sections 1.2.5, 10.2.4).

Fuel for the Palisades reactor is low enriched uranium dioxide (less than 5 percent by weight of uranium-235) in the form of fuel pellets enclosed in zircaloy fuel rods; the fuel rods are fabricated into fuel bundles. A typical fuel bundle consists of a 15 x 15 array of 216 fuel rods, 8 guide bars, and an instrument tube in a cage assembly to support and limit motion of the fuel rods and other bundle components. The reactor contains 204 fuel bundles in addition to control rods and other components that control the nuclear reaction. The average burnup (irradiation) of the peak rod does not exceed 62 gigawatt-days per metric ton of uranium (GWD/MTU). Exposure limits for the plant allow replacement of approximately one-third of the fuel assemblies in the reactor core at intervals of approximately 18 months (NMC 2003, Sections 3.3.1 and 3.3.4.3).

The Palisades containment structure provides a protective enclosure for the reactor and PCS to minimize the release of radioactive material to the environment in the unlikely event a serious failure of the PCS occurs (NMC 2003, Sections 5.8.1, 5.8.2). The principal design basis for the structure ensures it is capable of withstanding internal pressure resulting from the design basis accident (DBA) with no loss of integrity. The structure consists of a 3.5-foot thick cylinder and 3-foot thick dome constructed of post-tensioned, reinforced concrete, connected to and supported by a massive, 8.5- to 13.5-foot thick reinforced concrete foundation slab. The entire interior surface of the structure is lined with 1/4-inch-thick welded steel plate to ensure a high degree of leak tightness. Inside diameter and height of the structure are 116 feet and 189 feet, respectively. These design provisions ensure leakage will not exceed 0.1 percent per day by weight at a design pressure of 55 pounds per square inch above standard ambient air pressure (psig) and a design temperature of 283°F, and ensure that adequate biological shielding is provided during both normal operation and accident situations (NMC 2003, Sections 5.8.1 and 5.8.2).

NRC issued the initial Interim Provisional Operating License IDPR-20 to Palisades on March 24, 1971, which authorized operation of the reactor up to 1 MWt (NMC 2003, Section 1.1.2). Subsequent amendments to the Provisional Operating License were issued during the period of November 1971 to March 1973, which increased authorized maximum power level for the plant to 2,200 MWt. On January 22, 1974, Consumers requested conversion of Provisional Operating License DPR-20 to a Full-Term Operating License and authorization to operate at 2,638 MWt (corresponding to 845 MWe gross) for a period of 40 years from the date of the issuance of the Construction Permit. Action on this request was delayed; however, NRC amended DPR-20 on November 1, 1977 to increase the maximum authorized power level from

2,200 MWt to 2,530 MWt based on re-analysis of safety evaluations and the improvements made with steam generator repairs. Corresponding gross and net summer generating capacities for Palisades at this uprated power level were approximately 812 MWe and 774 MWe (EIA 2002, page 111), respectively. On February 21, 1991, NRC issued the Full Term Operating License DPR-20 for Palisades, and on December 14, 2000, NRC issued Amendment 192, which extended the license expiration date from March 14, 2007 to March 24, 2011, recapturing the construction period and providing for 40 years of licensed operation (NMC 2003, Section 1.1.2).

On June 23, 2004, NRC issued Amendment 216 to Palisades Operating License DPR-20, increasing the maximum authorized power level of the reactor 1.4 percent from 2,530 MWt to 2,565.4 MWt. This increase was based on reduced core power measurement uncertainty resulting from the use of more accurate measurement instrumentation (NRC 2004). The corresponding increase in net generating capacity from this uprate is approximately 12 MWe, bringing the current net summer capacity of Palisades to its present level of approximately 786 MWe.

3.1.3 COOLING AND AUXILIARY WATER SYSTEMS

3.1.3.1 Water Use Overview

Water used for Palisades plant operation consists of raw water from Lake Michigan and potable water from the South Haven Municipal Water Authority (Crawford 2003, Exhibit I-10 and Section III, 2, Part A; NMC 2003, Sections 9.1, 10.1, Figures 9-1, 10-6). Water withdrawn from Lake Michigan amounts to approximately 98,000 gallons per minute (gpm) during normal full power operation, and is used primarily for waste heat removal in the plant's Service Water System and Circulating Water System. Consumptive losses due to evaporation from the two Circulating Water System cooling towers is estimated to range as high as 12,000 gpm in summer. Remaining water, approximately 86,000 gpm, is returned to Lake Michigan (Crawford 2003, Exhibit 1-10; NMC 2003, Sections 9.1, 10.1, Figures 9-1, 10-6). Water obtained from the South Haven Municipal Water Authority, for domestic use, averages approximately 12.5 gpm, most of which is ultimately disposed of onsite to two sanitary drain fields (Crawford 2003, Exhibit 1-10 and Section III, Part A). Onsite groundwater use is limited to potential withdrawals for grounds maintenance or other miscellaneous uses from three small production wells having a combined production capacity of 24 gpm. NMC does not expect to develop or use any additional groundwater resources at Palisades in the future.

3.1.3.2 Service Water and Circulating Water Systems

Under normal operating conditions, water for the Palisades Service Water System and Circulating Water System is withdrawn from Lake Michigan via pipeline from a submerged intake crib structure located 3,300 feet offshore at about the 35-foot water depth (Consumers and NMC 2001). The crib is a box structure, 57 feet wide, 57 feet long, and 13 feet high with a horizontal top consisting of steel plates and bar racks over 2/3 and 1/3 of its area, respectively. Water enters the crib on each of its four sides, which are constructed of 2-inch vertical steel bars spaced at 10-inch intervals (Consumers and NMC 2001, Section II). The crib was designed for a once-through cooling water flow rate of approximately 400,000 gpm. However, subsequent conversion to a closed-cycle cooling system reduced intake flow to approximately 98,000 gpm, resulting in very low approach velocities (approximately 0.1 foot per second) at the face of structure (Consumers and NMC 2001, Section II). Water from the intake crib flows through an 11-foot diameter pipe to the onshore Intake Structure where it passes through trash racks constructed of steeply sloped bars to prevent entry of coarse debris, then through vertical 0.375-inch mesh traveling screens for removal of finer debris (Consumers and NMC 2001, Figure 4 and page 4). Debris accumulated on the trash racks is removed by a mechanical rake or scoop (AEC 1972, page III-8). Debris accumulated on the traveling screens is removed by rotating and backwashing the screens as needed (automatic or manual operation) and sluicing the debris to a collection basket (AEC 1972, Section III.D.1.a-b; Consumers and NMC 2001). Accumulated debris is disposed of in accordance with provisions of the Palisades National Pollutant Discharge Elimination System (NPDES) permit issued by the Michigan Department of Environmental Quality (MDEQ 2004).

Three 8,000 gpm service water pumps, one of which is normally on standby, are located in the onshore Intake Structure and provide water to the Service Water System (NMC 2003, Section 9.1, Figure 9-1, Table 9-2). A small fraction of water withdrawn to the Service Water System is used as feedwater for production of demineralized water (for use in the NSSS primary and secondary cooling loops, etc.) and other purposes, but most is used to remove waste heat from the nuclear plant and steam plant auxiliary systems. After flowing through coolers, heat exchangers, and other plant components, this service water is discharged to the makeup basin, which is open to the suction basins for the Circulating Water System cooling tower pumps (NMC 2003, Sections 9.1, 10.2.4.2, Figures 9-1, 10-6).

The Circulating Water System removes waste heat from the main condenser by recirculating water from the hot side of the condenser through the two mechanical draft cooling towers where water is cooled by evaporation (NMC 2003, Section 10.2.4, Figure 10-6, Table 10-5). Cooling water circulation in this system is accomplished by two 164,000 gpm cooling tower pumps located in the cooling tower pump building. Evaporation in the cooling towers ranges from 4,500-gpm in winter to 6,000 gpm in summer for each of the two towers. Evaporation and other losses from the Circulating Water System (e.g., cooling tower blowdown) are replaced by makeup water withdrawn from the onshore Intake Structure by two 40,000 gpm dilution water pumps. Makeup water surplus is directed to the makeup basin where it combines with the Service Water System cooling water. Cooling water in the makeup basin that is not recirculated by the cooling tower pumps flows over weirs to the mixing basin for discharge to the lake. The discharge of some water from the Circulating Water System (cooling tower blowdown) and the addition of makeup water from the lake, maintains dissolved solids at an appropriate equilibrium in the system. The excess of cool lake water provided by the dilution water pumps also increases generation efficiency of the plant and reduces the temperature of the water discharged to the lake (NMC 2003, Section 10.2.4, Table 10-5).

Cooling water mixes with low-volume waste sources from plant operations in the mixing basin and flows through openings in the outer wall of the mixing basin to Lake Michigan via the shoreline Discharge Structure (NMC 2003, Figure 10-6; Crawford 2003, Exhibit 1-10). The Palisades Discharge Structure is a diverging pile structure extending from the mixing basin outfall at the lakeshore that widens from 37 feet wide at the mixing basin outlet wall to 100-feet wide at its terminus 108 feet from the outlet wall (AEC 1972, Section III.D.1.a; Figure 2.1-3). The discharge is monitored for both radiological and nonradiological parameters in accordance with Palisades' procedures. Monitoring requirements for nonradiological parameters are specified in accordance with provisions of the Palisades NPDES permit. Associated limits include a maximum allowable discharge flow of 135.2 million gallons per day, equivalent to a maximum daily average of 93,889 gpm, a daily maximum heat addition limit of $2.1x10^9$ British thermal units per hour (Btu/hr), and limits for release of total residual oxidants used for biofouling control (MDEQ 2004).

3.1.3.3 Biofouling Control

The Palisades Service Water System and Circulating Water System are vulnerable to fouling from microbiological organisms and a notable macrofouling organism that occurs in Lake Michigan at the site, the zebra mussel (*Dreissena polymorpha*). NMC uses approved biocides in these systems to control biofouling in accordance with all use and discharge requirements, including provisions of the plant's NPDES permit and special MDEQ approvals required for discharge of water treatment additives (MDEQ 2004, Part I, Section A). NMC currently is permitted by MDEQ to use chlorination, bromination, and application of a quaternary amine formulation for biofouling control (MDEQ 2004; Crawford 2003). Compliance with NPDES permit limits for discharge of these biocides and associated residuals is confirmed by monitoring.

3.1.3.4 Thermal Discharge Characteristics

Thermal characteristics of the cooling water discharged to Lake Michigan and the resulting thermal plume in the lake are well understood from seven field surveys conducted from August 2000 to June 2003 (Consumers 2003). The surveyors recorded seasonal temperature measurements while the plant was operating near maximum power levels at a discharge flow rate of 92,500 gpm. Results of the surveys indicate that the thermal plume is much smaller than existed in the initial period of plant operation with a once-through cooling system, and that the plume remains largely on the surface. The area of the plume (3°F isotherm) ranged seasonally from 40 to 286 acres at the lake surface and 0-19 acres at a depth of 3 feet. The 3°F isotherm was seldom noted to extend at or below a depth of 5 feet. Temperature of the plant cooling water discharge during the surveys ranged from 77°F to 98°F, corresponding to approximately 25-34°F above the ambient lake temperature in all seasons except winter. During the winter survey, conducted March 19, 2001, the ambient lake temperature was 34°F, the discharge temperature was approximately 78°F, or 44°F above ambient, and the plume area at the surface was approximately 76 acres (Consumers 2003). The Palisades NPDES permit requires that cessation of thermal inputs to the lake occur gradually to avoid fish mortality due to cold shock during the winter months (MDEQ 2004, Part I, Section A.5).

3.1.3.5 Municipal Water Supply and Sanitary Wastewater Treatment

Municipal water from the South Haven Municipal Water Authority supplies the station Domestic Water Distribution System. Average water use is approximately 12.5 gpm (0.018 million gallons per day) (Crawford 2003, Exhibit 1-10, Section 3, Part A). This system distributes water throughout the Palisades site for potable, sanitary, emergency showers, eyewash stations, and other uses. Most of this water is disposed of as sanitary wastewater, which is collected in the Palisades Septic System. This system collects the raw sanitary wastewater in holding tanks where solids settle out. Effluent from the tanks flows to three sanitary drain fields, one located between the north cooling tower and the power block, one located east at Warehouse #2, and one located north of the Outage Building (see Figure 2.1-3). Wastewater is treated and disposed of by infiltration at the drain fields; solids are periodically removed from the holding tanks and disposed of at a licensed wastewater treatment facility by a commercial vendor (Consumers 1998).

3.1.4 POWER TRANSMISSION SYSTEMS

Power output from the Palisades main generator is fed to the transmission grid via an overhead circuit between the main transformer at the south end of the Turbine Building and the Palisades switchyard (Palisades Substation), situated east of the power block area on the Palisades site (see Figure 2.1-3). Two other circuits between the plant and the substation supply offsite power to the plant’s electrical system, one overhead and one underground (NMC 2003, Section 8.1.2). The Palisades Substation is designed to be the interconnection point between the power plant and the power grid system, and provides a tie between the Michigan Power Pool and the American Electric Power Company's system grid. The Substation operates at 345 kV and is arranged to ensure maximum availability of the power system grid to Palisades when the plant is not operating (NMC 2003, Section 8.2).

A total of seven circuits, other than those connecting to the plant and described above, extend from the Palisades Substation on four double-circuit steel lattice towers transmission lines, all of which operate at 345 kV, as follows (NMC 2003, Section 8.2.3; Consumers 2001, Section 1.2):

- Palisades- Cook #1 & #2 (Circuits 310B & 310A)
- Palisades–Argenta #1 & #2 (Circuits 309A & 309B)
- Palisades-Vergennes & Roosevelt-Palisades (Circuits 306A & 306B)
- Palisades-Covert Plant (Circuit 306J)

These lines are shown on Figures 2.1-3 and 3.1-1 and described in detail in Table 3.1-1. The two Palisades-Cook circuits are connected to the American Electric Power (AEP) system. The Palisades-Argenta, Palisades-Vergennes, and Roosevelt-Palisades circuits are connected to the Michigan Electric Transmission Company, LLC (METC) system and the Michigan Power Pool. Each of these six circuits has sufficient capacity to carry the entire output of the Palisades main turbine generator (NMC 2003, Section 8.2.2). The Palisades-Covert Plant circuit was constructed in 2002 to connect the neighboring Covert Generating Plant to the transmission grid (Consumers 2001).

In March 2002, Consumers Energy Company sold its wholly owned subsidiary, the Michigan Electric Transmission Company, Inc., to an independent owner. The new company, METC, assumed ownership of these transmission lines, including those portions of the lines passing over the Palisades site and certain equipment in the Palisades Substation (NMC 2003, Section 8.2.4).

A review of the original FES for Palisades confirms that only two transmission lines were installed as a direct result of initial construction and operation of the plant. The Palisades-Argenta line was constructed as an addition to the 345-kV transmission system between major power plants of the Michigan Power Pool. The initial 0.6 mile segment of what is now the Palisades-Cook line, denoted in the FES as the Palisades-West Olive line, was constructed to provide a tie to existing Indiana and Michigan Electric Company facilities, part of the AEP system (AEC 1972, Section III.B).

The transmission corridors of concern for license renewal are those constructed for the specific purpose of connecting the plant to the transmission system [10 CFR 51.53(c)(3)(ii)(H)]. NRC further indicates in the *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (GEIS) and its guidance to applicants that the corridors to be addressed are those between the plant switchyard and their connection with the existing transmission system, and reviewed as part of the construction permit for the plant (NRC 1996, Section 4.5, pages 4-59; NRC 2000, Section 4.13). As indicated above, METC and Consumers consider the Palisades Substation to be the Palisades connection with the transmission system, a view supported by its choice as the grid connection for the recently constructed Covert Generating Plant, an independent power production facility. In addition, METC expects the Palisades Substation and connecting transmission lines would remain in service irrespective of continued operation of Palisades. Thus, the environmental effects related to these transmission lines would occur irrespective of license renewal, and therefore are not effects that should be considered causally related to license renewal. Nevertheless, in Chapter 4 of this ER, NMC presents environmental impacts assessments for those lines from the Palisades Substation that were originally built to connect the plant to the transmission system and addressed in the FES for Palisades (i.e., the initial 0.6-mile segment of the 345-kV Palisades-Cook line from the substation and the 345-kV Palisades-Argenta line).

METC has programs in place to ensure continued safe and reliable operation of its transmission lines, continued compatibility of land uses on the transmission rights-of-way (ROWs) for these lines, and environmentally sound maintenance of the ROWs. The following paragraphs provide a general description of program provisions applicable to the Palisades-Argenta 345-kV line and the 0.6 mile segment of the Palisades-Cook 345-kV line, which were addressed by the AEC in its FES for initial licensing of Palisades.

Consumers, under contract to METC, conducts semiannual visual helicopter patrols and biennial infrared inspections of these transmission lines. The semiannual visual helicopter patrols utilize a patrol crew consisting of a pilot and dedicated observer. The observer is a qualified lineman experienced in observing line anomalies from the helicopter. Anomalies observed include but are not limited to:

- frayed or damaged conductor, including broken or open conductor jumpers
- damaged or broken insulators
- damaged or broken tower and conductor hardware and attachments
- damaged, broken or missing tower steel or damaged steel towers
- unauthorized attachments to the towers, such as signs or deer hunting platforms
- ROW encroachments

ROW encroachments identified include any trees, buildings, or obstructions that, due to proximity to the energized transmission line, pose a threat to public safety or to the operating reliability of the transmission line. Infrared inspections, which are also performed from a helicopter, utilize a FLIR Model 2000 camera. This inspection is done, when practical, in conjunction with routine visual patrol and utilizes an experienced thermographer to record and analyze “hot spots” on the energized conductor and conductor connections. Visual and infrared anomalies are prioritized by the observer or thermographer, as applicable, and recorded in a maintenance management database. Repair orders are initiated from this database and referred via a separate METC Internet database to the METC Maintenance Manager for approval. Upon METC approval, the work is scheduled and completed by Consumers.

Consumers also currently implements METC’s program for maintaining vegetation on the associated transmission line ROWs addressed in this ER. Consumers (Forestry Operations) inspects the ROWs approximately every two years on foot to assess condition of trees and other vegetation. Contractors perform vegetation maintenance approximately every four years in accordance with METC-approved maintenance plans. Consumers Environmental and Laboratory Services identifies areas of specific consideration with respect to potential occurrence of threatened or endangered species on the ROWs for which maintenance activities are planned. Practices to mitigate potential harm to these species are reviewed and approved by METC.

METC employs the border zone, wire zone vegetation management protocol instituted by Consumers for its rural transmission lines in 2001, prior to the sale of transmission assets to METC. Under this protocol, the area beneath the conductors (i.e., “clear wire zone”) is managed to promote a diverse mix of herbaceous plant species that serves as food and bedding for wildlife and maintain the area free of woody plant species. The “border area” extending on both sides of the clear wire zone to the large tree edge, is managed to promote establishment of low-growing shrubs and other compatible vegetation. Low-growing trees and shrubs that do not interfere with transmission facilities are left undisturbed in the border zone, providing food and shelter for wildlife. Tree species having the potential to interfere with transmission facilities are removed from this zone. Vegetation beyond the border zone that is outside of the 150-foot ROW is managed to ensure trees cannot contact the line (danger tree removal). Maintenance involves selective cutting and selective herbicide application (i.e., to eliminate all woody species in wire zone and tree species in border zone). Only herbicides approved by the U.S. Environmental Protection Agency (EPA) are used, and are applied only by licensed contractors in accordance with use instructions.

3.2 REFURBISHMENT ACTIVITIES

NRC

"...The report must contain a description of...the applicant's plans to modify the facility or its administrative control procedures.... This report must describe in detail the modifications directly affecting the environment or affecting plant effluents that affect the environment…."
10 CFR 51.53(c)(2)

"...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: (1) SMITTR actions, most of which are repeated at regular intervals, and (2) major refurbishment or replacement actions, which usually occur fairly infrequently and possibly only once in the life of the plant for any given item…." (NRC 1996, Section 2.6.3.1, page 2-41.) ["SMITTR" is defined at GEIS Section 2.4, page 2-29, as surveillance, on-line monitoring, inspections, testing, trending, and recordkeeping.]

NRC identifies examples of major refurbishment activities that utilities might perform for license renewal in the GEIS (NRC 1996, Section 2.6, Table 2-7, and Appendix B, Table B.2). Such major activities involve substantial refurbishment or replacement of facility structures or components. The analysis presented in the GEIS assumed an applicant would begin any major refurbishment work shortly after NRC granted a renewed license and would complete the activities during five outages, including one major outage at the end of the 40th year of operation. NRC refers to this as the refurbishment period.

GEIS Table B.2 lists major license renewal refurbishment activities NRC anticipates utilities might undertake. In identifying these activities, NRC intended to encompass actions that typically take place only once in the life of a nuclear power plant, if at all. The analysis presented in the GEIS assumed that a utility would undertake these activities solely to extend plant operations beyond 40 years and would undertake them during the refurbishment period. NRC indicates in the GEIS that many licensees will have undertaken various major refurbishment activities at their facilities to support the current license period. However, NRC also indicates that some licensees might perform such tasks in support of extended plant operations through the license renewal process.

NMC has conducted an Integrated Plant Assessment (IPA) for Palisades. As a result of this assessment, NMC has identified no major refurbishment or replacement activities associated with license renewal. In addition, there are no planned facility modifications that would affect the environment or plant effluents. Therefore, detailed analysis for environmental issues related to refurbishment are not warranted for Palisades.

3.3 PROGRAMS AND ACTIVITIES FOR MANAGING THE EFFECTS OF AGING

NRC

"...The report must contain a description of...the applicant's plans to modify the facility or its administrative control procedures....This report must describe in detail the modifications directly affecting the environment or affecting plant effluents that affect the environment…."
10 CFR 51.53(c)(2)

"...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:
(1) SMITTR actions, most of which are repeated at regular intervals, and (2) major refurbishment or replacement actions, which usually occur fairly infrequently and possibly only once in the life of the plant for any given item…." (NRC 1996, Section 2.6.3.1, page 2-41.) ["SMITTR" is defined at GEIS Section 2.4, page 2-29, as surveillance, on-line monitoring, inspections, testing, trending, and recordkeeping.]

In accordance with NRC regulations at 10 CFR 54, NMC has performed an aging management review of Palisades and has included in the Palisades License Renewal Application the results of an IPA that identifies how NMC would manage the effects of aging on systems, structures, and components. In some cases, the results of the review show existing Palisades programs to adequately address aging effects with no license renewal modification. In other cases, NMC has identified necessary modifications or enhancements to existing programs, or has identified the need to develop and implement new programs.

Appendix B of the Palisades License Renewal Application describes the programs and activities used to manage the effects of aging during the extended period of operation. Appendix B describes existing programs, including planned enhancements where applicable, as well as proposed new programs and activities. Other than implementation of the programs and activities in Appendix B, there are no planned modifications of Palisades' administrative control procedures associated with license renewal.

3.4 EMPLOYMENT

3.4.1 CURRENT WORKFORCE

The normal operations workforce at the Palisades site consists of approximately 534 permanent employees and 110 contractors, a number that is within the range of 600 to 800 personnel per reactor unit NRC estimates in the GEIS (NRC 1996, Section 2.3.8.1). Approximately 56 percent of workers comprising the permanent workforce live in Van Buren County and approximately 21 percent live in Berrien County. The remaining employees live in various other locations, primarily in the vicinity of the city of Holland, located in Ottawa County.

NMC refuels Palisades at intervals of approximately 18 months (NMC 2003, Section 3.3.4.3). During refueling outages, site employment increases by approximately 384 workers for temporary (30 to 40 days) duty. NMC expects similar increases would occur for refueling outages during the license renewal term. This is within the range of 200 to 900 additional workers per reactor outage cited by NRC in the GEIS (NRC 1996, Section 2.3.8.1).

3.4.2 LICENSE RENEWAL INCREMENT

Performing the license renewal surveillance, on-line monitoring, inspections, testing, trending, and recordkeeping (SMITTR) activities would necessitate increasing Palisades' site staff workload by some increment, the size of which would be a function of the schedule within which NMC must accomplish the work and the amount of work involved.

NRC assumes in the GEIS that a renewed nuclear power plant operating license would be issued for a maximum of 20 years past the current license expiration date (NRC 1996, Section 2.6.2.7). The GEIS analysis further assumes the utility would initiate SMITTR activities when the renewed license is issued and would conduct license renewal SMITTR activities throughout the remaining life of the plant (NRC 1996, Section B.3.1.3). NRC assumed these activities would be performed at times during full-power operation, but mostly during normal refueling outages and 5-year and 10-year in-service inspection outages.

NMC has determined that the GEIS scheduling assumptions are reasonably representative of Palisades incremental license renewal workload scheduling. Many SMITTR activities would have to be performed during outages. Although some Palisades license renewal SMITTR activities would be one-time efforts, others would be recurring, periodic activities that would continue for the operating life of the plant.

NRC cites estimates in the GEIS that 20 to 60 additional personnel per reactor would be needed to perform additional inspection, surveillance testing, and maintenance tasks during the license renewal term. NRC uses the upper value of this range, 60 workers, as a conservative estimator of additional permanent workers needed per unit for license renewal SMITTR activities. GEIS Section C.3.1.2 was written using this approach in order to “...provide a realistic upper bound to potential population-driven impacts….”

NMC expects to be able to perform the increased SMITTR workload at the Palisades site with few, if any, additional staff. Nonetheless, for the purpose of analyses in this ER, NMC has adopted NRC’s GEIS approach as described, and assumes that Palisades would require 60 additional permanent workers to perform license renewal SMITTR activities.

Adding full-time employees to the plant workforce for operation during the license renewal period would have the indirect effect of creating additional jobs and related population growth in the community. Using the Regional Input-Output Modeling System (RIMS II), the U.S. Bureau of Economic Analysis calculated a regional employment multiplier appropriate for the electric services (utilities) sector for the Van Buren and Berrien County Area of southwestern Michigan (DOC 2004). NMC used this value (2.5257) to estimate the total increase in the number of direct and indirect jobs during the license renewal period for the analysis assumption discussed above. Applying the multiplier, a total of 152 (60 × 2.5257) new jobs would be created in the area. More specifically, NMC assumes that 60 additional permanent direct workers during the license renewal period would create an additional 92 indirect jobs in the community. These 152 new direct and indirect jobs represent less than one percent of the current labor force of the Van Buren and Berrien County combined-county area (117,025 workers) (see Section 2.6 of this ER).

Conservatively assuming that each direct and indirect job is filled by an in-migrating worker, these 152 new jobs (60 direct and 92 indirect) could result in a population increase of 389 persons in the area (152 jobs multiplied by 2.56, the average number of persons per household in the state of Michigan). This increase represents less than one percent of the Census Bureau’s estimated population in year 2000 (238,716 persons) for the combined area of Van Buren and Berrien Counties (Census 2004).

TABLE 3.1-1
TRANSMISSION LINES FROM PALISADES SUBSTATION

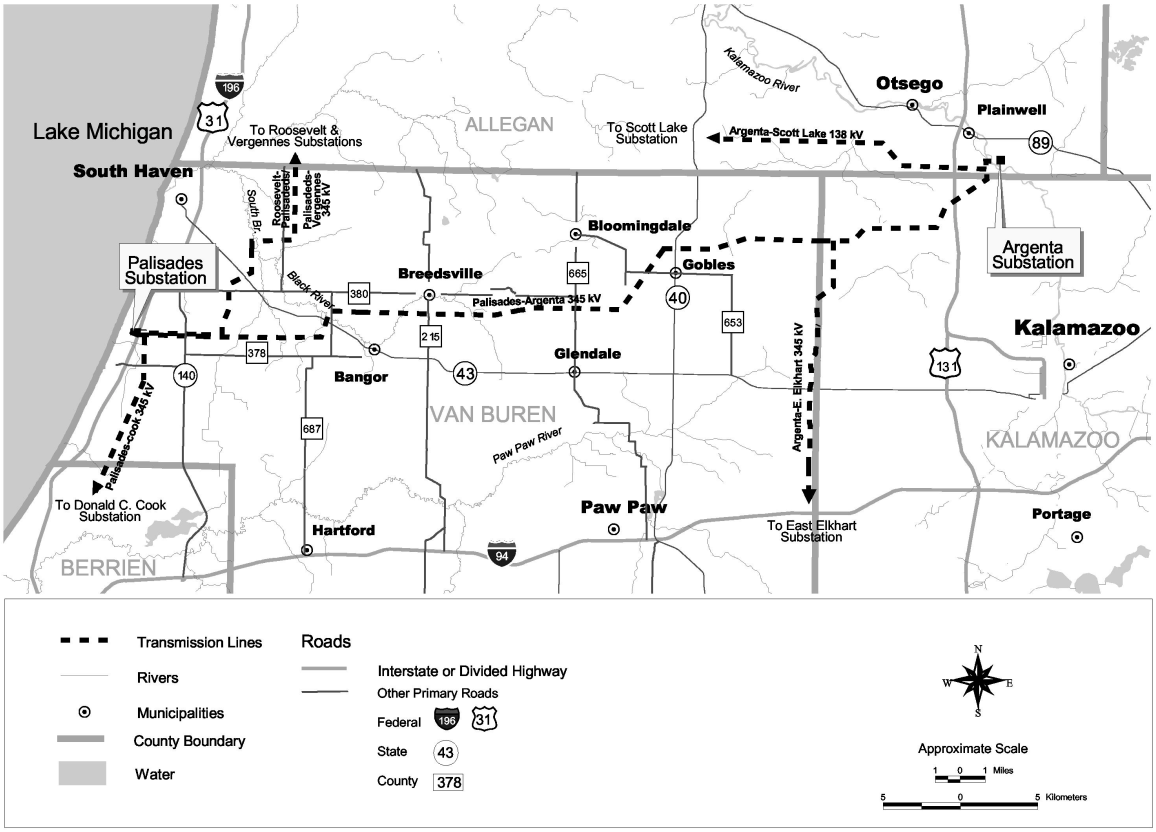
Palisades- Cook #1 & #2 (345 kV; METC Circuits 310B & 310A)
Extends 0.6 miles eastward from the substation on double-circuit steel lattice towers on a 1,312-foot wide ROW fee strip owned by Consumers. Much of the offsite portion of this line segment consists of highway crossings (see Figure 2.1-3). The centerline of the Palisades-Cook #1 and #2 line is 515 feet north of the southern border of the fee strip and 100 feet immediately south of the Palisades-Argenta line (see below). The line continues southward to complete a total run of approximately 31 miles to the D. C. Cook Substation, providing interconnection with the AEP system 9.2 miles south of the Palisades Substation (NMC 2003, Section 8.2.2 and Figure 2-2; IMPC 2003, Section 3.1.3; see Figure 2.1-3). The ROW also includes a 69-kV line 200 feet north of the Palisades-Cook line and a METC double-circuit 345-kV line (Roosevelt-Palisades/Palisades-Vergennes) 500 feet north of the Palisades-Cook line. The initial 0.6-mile segment extending from the Palisades Substation was constructed in 1969 to connect Palisades to the AEP transmission system, and was addressed by the AEC in the FES for Palisades as the Palisades-West Olive line (AEC 1972, Section III.B). Although the names of the Palisades-Cook circuits have changed, the 0.6-mile tie line has not undergone significant alterations since the FES was issued. METC has owned the portion of the line that connects to the AEP since March 2002 (NMC 2003, Section 8.2.4).
Palisades–Argenta #1 & #2 (345 kV; METC Circuits 309A & 309B)
Extends approximately 40 miles eastward from the Palisades Substation on double-circuit steel lattice towers to the Argenta Substation located approximately 1 mile west of Plainwell, Michigan, on ROW located on land (fee strips) owned by Consumers (see Figure 2.1-3; Figure 3.1-1). For the initial 0.6 miles out of the Palisades Substation, the ROW parallels the adjoining Palisades-Cook line 100 feet to the south, an AEP 69-kV line 100 feet to the north, and another METC-owned 345-kV line (Roosevelt-Palisades/Palisades-Vergennes) 400 feet to the north for 0.6 miles, at which point the Palisades-Cook line departs the ROW to the south. From 0.6 miles to approximately 1.0 miles from Palisades Substation the Palisades-Argenta line heads eastward within the fee strip 615 feet north of the southern border of the fee strip, and parallel to the AEP 69-kV wood-pole line that is 100 feet to the north of the Palisades-Argenta line. The Roosevelt-Palisades/Palisades-Vergennes double-circuit 345-kV line runs parallel as well, 400 feet to the north. The AEP line departs the fee strip approximately 1 mile east of the Palisades Substation. For the next 2.5 miles, the Palisades-Argenta line continues eastward 615 feet north of the southern border of the fee strip and 400 feet south of the double circuit METC line until it departs to the north. For the next 27 miles, the Palisades-Argenta line continues eastward as the sole occupant of the ROW, which varies in width from 1,320 feet to 350 feet. For the remaining distance, approximately 10 miles, a second 345-kV double-circuit line on steel lattice towers, the Argenta-East Elkhart line, parallels the Palisades-Argenta line 100 feet to its north/east into the Argenta Substation. The ROW is 450-610 feet wide in this run except for a 2,500-foot segment approximately 1 mile from the Argenta Substation, where METC's 138-kV Argenta-Scott Lake line, a singe circuit strung on steel lattice structures, and a Consumers 46-kV sub-transmission line on wood poles, parallel the Palisades-Argenta line 100 feet and 220 feet to the south/west, respectively. The ROW is 610 feet wide in this latter segment. The Palisades-Argenta line was constructed in 1969 to deliver the power from Palisades to the Consumers Power Company (Consumers progenitor) then-existing transmission system, and was evaluated in the AEC's FES for Palisades (AEC 1972, Section III.B). The line has not undergone significant alterations since that time. METC has owned the line since March 2002 (NMC 2003, Section 8.2.4).

TABLE 3.1-1 (CONTINUED)
TRANSMISSION LINES FROM PALISADES SUBSTATION

Palisades-Vergennes & Roosevelt-Palisades (345 kV; METC Circuits 306A & 306B)
Extends approximately 3.5 miles eastward on double-circuit steel lattice towers approximately 400 feet north of and parallel to the Palisades-Argenta line, then northward (see Figure 2.1-3). The circuits split near Zeeland, Michigan. One circuit extends to the Roosevelt Substation north of Zeeland, approximately 45 miles total line distance from Palisades. The other circuit extends to the Vergennes Substation east of Grand Rapids, approximately 85 miles line distance from Palisades (Consumers/METC 2003).
This line was originally constructed in 1973 as a double-circuit 345-kV line to the Tallmadge Substation west of Grand Rapids, Michigan, for purposes of expanding and interconnecting the grid. The line represented an expansion of the Consumers Power Company (Consumers progenitor) transmission system as it existed then. The original circuits to the Tallmadge Substation were subsequently re-routed to the Vergennes Substation and Roosevelt Substation. The environmental impact of constructing and operating this line was not acknowledged or evaluated in the AEC's FES for Palisades (AEC 1972, Section III.B). METC has owned the line since March 2002 (NMC 2003, Section 8.2.4).
Palisades-Covert Plant (345 kV; METC Circuit 306J)
A single-circuit line extending approximately 0.6 miles eastward from the Palisades Substation to the Covert Generating Plant on double-circuit steel lattice towers on a 150-foot wide ROW (Consumers 2001, Section 1.0; see Figure 2.1-3). Constructed and energized in 2002 to connect the newly constructed Covert Generating Plant, an independent power production facility developed by Pacific Gas and Electric Company, to the transmission grid.

AEC = U.S. Atomic Energy Commission
AEP = American Electric Company
FES = Final Environmental Statement
kV = kilovolt(s)
METC = Michigan Electric Transmission Company, LLC
Palisades = Palisades Nuclear Plant
ROW = right-of-way

FIGURE 3.1-1
TRANSMISSION LINES



3.5 REFERENCES

Note to reader: This list of references identifies web pages and associated URLs where reference data was obtained. Some of these web pages may likely no longer be available or their URL address may have changed. NMC has maintained hard copies of the information and data obtained from the referenced web pages.

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4.0 ENVIRONMENTAL CONSEQUENCES OF THE PROPOSED ACTION AND MITIGATING ACTIONS

NRC

The environmental report shall discuss the "…impact of the proposed action on the environment. Impacts shall be discussed in proportion to their significance…." [10 CFR 51.45(b)(1) as adopted by 51.53(c)(2)]

The report "...should not be confined to information supporting the proposed action but should also include adverse information." [10 CFR 51.45(e)]

4.1 INTRODUCTION

In Chapter 4, Nuclear Management Company, LLC (NMC) presents an assessment of the environmental consequences and potential mitigating actions associated with the renewal of the Palisades Nuclear Plant (Palisades) operating license. The U.S. Nuclear Regulatory Commission (NRC) has identified and analyzed 92 environmental issues considered to be associated with nuclear power plant license renewal and has designated the issues as Category 1, Category 2, or Not Applicable (NA). NRC designated issues Category 1 if, after analysis, the following criteria were met:

- The environmental impacts associated with the issue have been determined to apply either to all plants or, for some issues, to plants having a specific type of cooling system or other specified plant or site characteristic; and
- A single significance level (i.e., SMALL, MODERATE, or LARGE) has been assigned to the impacts (except for collective offsite radiological impacts from the fuel cycle and from high-level-radioactive waste and spent-fuel disposal); and
- Mitigation of adverse impacts associated with the issue has been considered in the analysis, and it has been determined that additional plant-specific mitigation measures are likely not to be sufficiently beneficial to warrant implementation.

If NRC analysis concluded that one or more of the Category 1 criteria could not be met, NRC designated the issue as a Category 2 issue, requiring plant-specific analyses. NRC designated two issues NA, signifying that the categorization and impact definitions do not apply to these issues. NRC rules do not require analyses of Category 1 issues that NRC has resolved using the generic findings (10 CFR 51, Subpart A, Appendix B, Table B-1) derived from its *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (GEIS) (NRC 1996). An applicant may reference the generic findings or GEIS analyses for Category 1 issues.

Attachment A of this report lists the 92 issues, their respective category, and the Environmental Report (ER) and GEIS sections that address each issue. For those issues not applicable to Palisades license renewal, a notation gives the basis for that designation. The issues are numbered in the same order in which they are listed in 10 CFR 51, Appendix B to Subpart A, Table B-1, for ease of reference.

4.1.1 CATEGORY 1 LICENSE RENEWAL ISSUES

NRC

"The environmental report for the operating license renewal stage is not required to contain analyses of the environmental impacts of the license renewal issues identified as Category 1 issues in appendix B to subpart A of this part." [10 CFR 51.53(c)(3)(i)]

"…absent new and significant information, the analysis for certain impacts codified by this rulemaking need only be incorporated by reference in an applicant's environmental report for license renewal…." (61 Federal Register, page 28483).

NMC has determined that of the 69 Category 1 issues, six do not apply to Palisades because they apply to design, operational, or location features that do not exist at the facility, such as use of once through cooling heat dissipation systems, cooling ponds or Ranney wells, and groundwater withdrawal (see Attachment A, Table A-1). In addition, NRC findings for seven Category 1 issues related to refurbishment do not apply to Palisades because NMC does not plan to undertake any major refurbishment activities (see Section 3.2; Attachment A, Table A-1). NMC has not identified or become aware of any new and significant information that would alter NRC conclusions on other Category 1 issues (see Section 5.0 of this ER). Therefore, NMC adopts by reference NRC findings for the 56 Category 1 issues that NMC determined to be applicable to Palisades license renewal.

4.1.2 CATEGORY 2 LICENSE RENEWAL ISSUES

NRC

"The environmental report must contain analyses of the environmental impacts of the proposed action, including the impacts of refurbishment activities, if any, associated with license renewal and the impacts of operation during the renewal term, for those issues identified as Category 2 issues in appendix B to subpart A of this part…." [10 CFR 51.53(c)(3)(ii)]

"The report must contain a consideration of alternatives for reducing adverse impacts, as required by § 51.45(c), for all Category 2 license renewal issues…." [10 CFR 51.53(c)(3)(iii)]

In the GEIS NRC designated 21 issues as Category 2 issues. NMC has determined that of these 21 issues, nine do not apply to Palisades license renewal due to facility design, operational, or location features (see Attachment A, Table A-1). These issues and the basis for exclusion are listed in Table 4.1-1.

Sections 4.2 through 4.12 of this ER address the 12 Category 2 issues applicable to continued operation of Palisades, including the issues that apply to refurbishment activities. Each section begins with a statement of the issue and explains why NRC was not able to generically resolve the issue. If an issue does not warrant detailed analysis, as is the case for the four issues relating to refurbishment, NMC explains the basis.

The sections present details resulting from NMC's analyses for the eight Category 2 issues determined to be applicable to Palisades license renewal and warranting detailed analysis (i.e., those not related to refurbishment). These analyses include conclusions regarding the significance of the impacts relative to renewal of the Palisades operating license and discuss potential mitigative alternatives, when applicable and to the extent required. NMC has identified the significance of the impacts associated with each issue as either SMALL, MODERATE, or LARGE, consistent with the following criteria NRC codified at 10 CFR 51, Subpart A, Appendix B, Table B-1, Footnote 3:

> SMALL - Environmental effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource. For the purposes of assessing radiological impacts, NRC has concluded that those impacts that do not exceed permissible levels in NRC's regulations are considered small.
>
> MODERATE - Environmental effects are sufficient to alter noticeably but not to destabilize any important attribute of the resource.
>
> LARGE - Environmental effects are clearly noticeable and are sufficient to destabilize any important attributes of the resource.

In accordance with National Environmental Policy Act (NEPA) practice, NMC considered ongoing and potential additional mitigation in proportion to the significance of the impact to be addressed (i.e., impacts that are small receive less mitigative consideration than impacts that are large).

4.1.3 "NA" LICENSE RENEWAL ISSUES

NRC determined that its categorization and impact finding definitions did not apply to two issues. Regarding chronic effects from electromagnetic fields (10 CFR 51, Subpart A, Appendix B, Table B-1, Footnote 5), NRC noted that applicants currently do not need to submit analysis for this issue because no consensus has been reached by appropriate federal health agencies regarding adverse health effects from electromagnetic fields. Likewise, applicants are not required to submit information regarding environmental justice because NRC will address the issue in a site-specific review (10 CFR 51, Subpart A, Appendix B, Table B-1, Footnote 6). However, NRC has indicated that applicants should include in the ER pertinent information to support an environmental justice review by NRC (NRC 2000, Section 4.22). Therefore, NMC has included supporting demographic information for an environmental justice analysis in Section 2.5.3 of this ER.

4.2 IMPACTS OF REFURBISHMENT ON TERRESTRIAL RESOURCES

NRC

The environmental report must contain an assessment of "…the impact of refurbishment and other license-renewal-related construction activities on important plant and animal habitats…." [10 CFR 51.53(c)(3)(ii)(E)]

"…Refurbishment impacts are insignificant if no loss of important plant and animal habitat occurs. However, it cannot be known whether important plant and animal communities may be affected until the specific proposal is presented with the license renewal application…." [10 CFR 51, Subpart A, Appendix B, Table B-1, Issue 40]

"…If no important resources would be affected, the impacts would be considered minor and of small significance. If important resources could be affected by refurbishment activities, the impacts would be potentially significant…." (NRC 1996, Section 3.6, page 3-6)

NRC designated impacts of refurbishment on terrestrial resources as a Category 2 issue because the significance of ecological impacts cannot be determined without considering site-specific and project-specific details (NRC 1996, Section 3.6). Aspects of the site and the project to be ascertained are (1) the identification of important ecological resources, (2) the nature of refurbishment activities, and (3) the extent of impacts to plant and animal habitats.

As discussed in Section 3.2 of this ER, NMC does not plan to undertake major refurbishment for Palisades license renewal. NMC concluded there would be no refurbishment-related impacts in terrestrial resources and no analysis is required.

4.3 THREATENED OR ENDANGERED SPECIES

NRC

"All license renewal applicants shall assess the impact of refurbishment and other license-renewal-related construction activities on important plant and animal habitats. Additionally, the applicant shall assess the impact of the proposed action on threatened and endangered species in accordance with the Endangered Species Act." [10 CFR 51.53(c)(3)(ii)(E)]

"Generally, plant refurbishment and continued operation are not expected to adversely affect threatened or endangered species. However, consultation with appropriate agencies would be needed at the time of license renewal to determine whether threatened or endangered species are present and whether they would be adversely affected." [10 CFR Part 51, Subpart A, Appendix B, Table B-1, Issue 49]

NRC designated impacts to threatened and endangered species as a Category 2 issue because the status of many species is being reviewed, and a site-specific assessment is required to determine whether any identified species could be affected by refurbishment activities or continued plant operations through the license renewal period. In addition, compliance with the Endangered Species Act requires consultation with the appropriate federal agency (NRC 1996, Sections 3.9 and 4.1). Information pertinent to this assessment includes: (a) actual or potential occurrence of threatened or endangered species on or in the vicinity of the Palisades site and associated transmission lines that NMC has chosen to address in this ER, (b) impact initiators presented by continued operation of Palisades and these transmission lines that could affect threatened or endangered species that do or may occur, (c) controls established for impact initiators, and (d) industry and plant experience related to potential impacts.

NMC does not plan to conduct major refurbishment or construction activities at Palisades to enable continued operations during the license renewal period (see Section 3.2 of this ER). NMC concludes there would be no refurbishment-related impacts to special-status species and no further analysis of refurbishment-related impacts is required. NMC's assessment presented in this section is therefore limited to potential impacts from operation during the license renewal period of Palisades and those transmission line segments NMC has chosen to address in this ER. These transmission lines, the 40-mile long Palisades-Argenta 345-kV transmission line and the initial 0.6 mile segment of the Palisades-Cook 345-kV extending from the Palisades Substation, which runs adjacent to the Palisades-Argenta line, are more fully described in Section 3.1.4 of this ER and are depicted in Figures 2.1-3 and 3.1-1. Section 3.1.4 also describes vegetation maintenance practices for the transmission rights-of-way (ROW). Land use and terrestrial habitats that occur along the line are described in Section 2.3.2 of this ER. Although NRC's license renewal regulations at 10 CFR 51.53(c)(3)(ii)(E) require only an assessment of impact on species protected under the federal Endangered Species Act, NMC also addresses in this assessment those species designated as endangered or threatened by the State of Michigan.

NMC presented in Section 2.3.3 of this ER a screening analysis to identify those threatened, endangered, and candidate species of potential concern to Palisades license renewal and the likelihood of their occurrence in Lake Michigan at Palisades, on the Palisades site, or on the Palisades-Argenta transmission line ROW (and, by inference, the Palisades-Cook line segment ROW). Other than transient bird species, those known or considered most likely to occur in these areas are the lake sturgeon (*Acipenser fulvescens*) and lake herring (*Coregonus artedii*), in Lake Michigan, and Pitcher's thistle (*Cirsium pitcheri*), known to occur on the Palisades site. NMC lists in Table 4.3-1 these and other species considered on the basis of the screening assessment to have relatively more likelihood to occur in these areas than other rare species recorded for the general area, exclusive of bird species likely to occur only as transients. In the remainder of this section, NMC presents an analysis of potential impacts of continued operation of Palisades and the transmission lines in consideration of potential impact initiators, controls established for these impact initiators, industry and plant experience related to potential impacts, information received from regulatory agencies, and other relevant factors. Although the analysis is focused on the species listed in Table 4.3-1, it is nonetheless generally applicable to other such protected species that may occur in these areas of concern.

4.3.1 LAKE MICHIGAN

Impact initiators pertaining to Lake Michigan species of concern, including lake sturgeon and lake herring, are associated with the plant's cooling water system. Specific impacts include impingement of fish on intake screens, entrainment of eggs and larvae through the cooling water system, and heat shock or cold shock of fish in the vicinity of the heated cooling water discharge. Discharge of biocides and other contaminants in cooling water and wastewater streams is another impact initiator of potential concern.

However, the use of a closed-cycle cooling water system (cooling towers) at Palisades, implemented in 1974, substantially reduces the associated potential for adverse impact associated with the cooling water system by minimizing cooling water flow and the resultant thermal plume, which is now small and largely confined to the lake surface. In the case of Palisades, conversion to closed-cycle cooling also reduced water intake velocities at the face of the intake crib from as high as 0.95 foot per second (fps) to about 0.1 fps (Consumers 1975, Consumers and NMC 2001). While the Michigan Department of Environmental Quality (MDEQ) has yet to formally determine conformance, it is NMC's view that closed-cycle cooling as implemented at Palisades represents the best available technology for minimizing the adverse impact of cooling water intake structures, as recently defined by performance standards issued by the U.S. Environmental Protection Agency (EPA 2004, Section V). The physical and chemical characteristics of Palisades cooling water and wastewater discharges to the lake, including heat addition and concentration of biocides and other relevant pollutants, are also regulated by provisions of the plant's National Pollutant Discharge Elimination System (NPDES) permit to ensure protection of lake biota. The permit also includes the requirement for gradual shutdown of the facility to minimize potential for cold shock of fish that may congregate in the thermal plume during periods when the ambient lake water is below their thermal preferenda (MDEQ 2004).

Potential for adverse impact on the lake sturgeon is further reduced, since this species spawns primarily in tributary streams, reducing the potential for entrainment of early life forms. As a benthivore, this species is also less likely to be exposed to or tend to aggregate in the thermal plume than more pelagic species, further reducing any potential for attendant adverse impact (see Section 2.3.1 and Table 2.3-5 of this ER). Lake herring prefer relatively cool water temperatures, reducing potential for cold shock, and are most abundant in northern parts of the lake, away from the Palisades site (AEC 1972). Finally, impingement and entrainment monitoring conducted at Palisades between 1999-2000 determined that few fish are impinged or entrained as a result of plant operation. No threatened or endangered species were noted in impingement and entrainment samples collected during that study (Consumers and NMC 2001).

4.3.2 PALISADES SITE

Impact initiators pertaining to Pitcher's thistle, known to occur on the site, and the prairie warbler (*Dendroica discolor*) and prairie vole (*Microtus ochrogaster*), determined to have some limited potential to occur, include direct destruction of habitat from land disturbing activities and routine vegetation maintenance practices. However, NMC has not identified any land disturbing activities that would be undertaken for license renewal. Further, because the site lies in an Environmentally Sensitive Area designated by Covert Township ordinance, any onsite activity potentially resulting in significant land disturbance during the license renewal term would necessitate an environmental assessment that includes an evaluation of potential impact to threatened or endangered species, and a permit from the township. Similarly, any such activity on areas of the site designated Michigan Critical Dunes (see Figure 2.1-3) would require a similar assessment and permit from the MDEQ (see Section 2.3.2.4 of this ER). NMC routinely conducts these assessments and obtains necessary permits before implementing any activities on the site that could potentially result in adverse impact to threatened or endangered species, and would continue to comply with all such applicable protective requirements in the license renewal term.

Vegetation maintenance practices used for the onsite power corridor and transmission ROW are consistent with those described in Section 3.1.4 of this ER, and are designed to maintain herbaceous (dune grass) and scrub-shrub habitat within these areas using selective removal of woody vegetation by manual cutting and selective application of

EPA-approved herbicides. If anything, these practices result in long-term persistence on the site of areas consistent with the habitat affinities of the three species addressed in this assessment.

Finally, NMC is not aware of any significant adverse impact that has resulted from operation of the plant on these three species, and notes that the security measures in place for the site afford a high degree of protection for all special-status species and habitats on the site by precluding uncontrolled access that could result in habitat disturbance or direct taking.

4.3.3 TRANSMISSION LINE

Impact initiators pertaining to threatened, endangered, or candidate species identified in Table 4.3-1 include ROW vegetation maintenance practices, which may include adverse alteration of community species composition or structure, destruction of habitat or individuals from maintenance vehicles, and chemical effects of herbicides. Collision with the transmission lines or conductors may also be a concern for transient bird species that occur in the area (e.g., osprey, bald eagle).

However, NMC observes that plant communities that are maintained on the ROW by these established management practices are highly consistent with those recommended for the conservation of the plants and terrestrial animals listed in Table 4.3-1. In particular, management recommendations for wetland species found in open habitats, inclusive of all plants on the table except sedge (*Carex seorosa*), consistently specify active measures to maintain open habitat (see Table 2.3-5). As would be expected, measures to conserve species adapted to forest habitats include efforts to preserve mature, intact forest, relevant to sedge, or preservation of maternal summer roosts for the Indiana bat (*Myotis sodalis*). This practice is observed to the maximum practical extent by established ROW management protocols (METC 2004U), which call for only selective removal of those trees beyond the border zone that could jeopardize reliability of the line. Preservation of an appropriate hydrologic regime, which is unaffected by these vegetation management practices, is obviously relevant to the conservation of any wetland species.

These same observations are relevant to conservation of the spotted turtle (*Clemmys guttata*) and eastern massasauga (*Sistrurus e. catenatus*), both inhabitants of open wetlands - the spotted turtle exclusively so. These species, in addition, are particularly subject to decimation by direct taking of individuals. These and other similar impacts (e.g., disturbance of protected species habitat by off-road maintenance vehicles, including siltation of streams potentially inhabited by the creek chubsucker (*Erimyzon oblongus*); appropriate selection and use of herbicides) are controlled by the use of appropriate vegetation management plans.

Further, NMC notes that these transmission ROWs have been subject to these or comparable vegetation management practices since the lines were constructed, indicating that threatened or endangered species that do occur there may well be so as a result of these practices rather than in spite of them. Finally, neither NMC nor Consumers is aware of any adverse impacts to threatened or endangered species that have resulted from operation of the transmission lines addressed in this ER, including collisions of threatened or endangered birds with the transmission towers or conductors (NMC 2005U).

4.3.4 CONCLUSION

NMC has considered initial input from the Michigan Department of Natural Resources (MDNR) in the above assessment of potential impacts of Palisades and transmission line operation in the license renewal period on threatened and endangered species. NMC has also solicited additional input from MDNR and the U.S. Fish and Wildlife Service (USFWS) on the assessment. Attachment B includes copies of relevant correspondence with these agencies.

Based on the assessment presented above, renewal of the Palisades operating license is not expected to result in the taking of any threatened or endangered species and is not likely to jeopardize the continued existence of any threatened or endangered species or result in the destruction or adverse modification of any critical habitat. NMC concludes that impact to threatened and endangered species from continued operation of Palisades and the transmission lines addressed in this ER in the license renewal period would be SMALL, and further mitigation would be unwarranted.

4.4 AIR QUALITY DURING REFURBISHMENT (NONATTAINMENT AREAS)

NRC

“If the applicant’s plant is located in or near a nonattainment or maintenance area, an assessment of vehicle exhaust emissions anticipated at the time of peak refurbishment workforce must be provided in accordance with the Clean Air Act as amended….” [10 CFR 51.53(c)(3)(ii)(F)]

“Air quality impacts from plant refurbishment associated with license renewal are expected to be small. However, vehicle exhaust emissions could be cause for concern at locations in or near nonattainment or maintenance areas. The significance of the potential impact cannot be determined without considering the compliance status of each site and the numbers of workers expected to be employed during the outage.” (10 CFR 51, Subpart A, Appendix B, Table B-1, Issue 50)

NRC designated impacts to air quality during refurbishment as a Category 2 issue because vehicle exhaust emissions could be cause for some concern, and a general conclusion about the significance of the potential impact could not be drawn without considering the compliance status of each site and the number of workers expected to be employed during the outage (NRC 1996, Section 3.3). Information needed would include (1) the attainment status of the plant-site area and (2) number of vehicles added as a result of refurbishment activities.

As noted in Section 2.4 of this ER, Palisades is located in a moderate non-attainment area for 8-hour ozone. However, as discussed in Section 3.2 of this ER, NMC does not plan to undertake major refurbishment for Palisades license renewal. NMC concludes there would be no refurbishment-related impacts to air quality, and no analysis is required.

4.5 ELECTROMAGNETIC FIELDS – ACUTE EFFECTS

NRC

"If the applicant's transmission lines that were constructed for the specific purpose of connecting the plant to the transmission system do not meet the recommendations of the National Electrical Safety Code for preventing electric shock from induced currents, an assessment of the impact of the proposed action on the potential shock hazard from the transmission lines must be provided." [10 CFR 51.53 (c)(3)(ii)(H)]

"Electrical shock resulting from direct access to energized conductors or from induced charges in metallic structures have not been found to be a problem at most operating plants and generally are not expected to be a problem during the license renewal term. However, site-specific review is required to determine the significance of the electric shock potential at the site." (10 CFR Part 51, Subpart A, Appendix B, Table B-1, Issue 59)

NRC designated the impact of electric shock from transmission lines as a Category 2 issue because conformance of the plant's transmission lines with the currently applicable National Electrical Safety Code® (NESC®) standard for electric shock potential could not be determined without site-specific review (NRC 1996, Section 4.5.4.1). NRC does not define the phrase "transmission line" in its regulations at 10 CFR 51.53(c)(3)(ii)(H), but does indicate in the GEIS that transmission lines use voltages of about 115/138 kilovolts (kV) and higher (NRC 1996, Section 4.5.1). As indicated in the regulation cited above, the transmission lines of concern to license renewal are those constructed for the specific purpose of connecting the plant to the transmission system. NRC further elaborates in the GEIS and its guidance that the transmission lines to be addressed for license renewal are those that were constructed to connect the plant switchyard to the existing transmission system and reviewed as part of the construction permit for the plant (NRC 1996, Section 4.5; NRC 2000, Section 4.13).

As discussed in Section 3.1.4 of this ER, Michigan Electric Transmission Company, LLC (METC), the owner of the transmission lines connecting to the Palisades Substation, and Consumers Energy Company (Consumers), the owner of Palisades, consider the Palisades Substation to be the Palisades connection with the transmission system. However, NMC nonetheless has chosen to present in this section a demonstration of conformance with the NESC® standard for electric shock potential for those lines from the Palisades Substation that were originally built to connect the plant to the transmission system and addressed in the Final Environmental Statement (FES) for Palisades: i.e., the initial 0.6-mile segment of the 345-kV Palisades-Cook line from the substation (Circuits 310 A/B) and the 40-mile long 345-kV Palisades-Argenta line (Circuits 309 A/B).

Information to be ascertained for the analysis with respect to these transmission facilities includes: (1) present conformance with the NESC® standard for electric shock hazard, (2) anticipated changes in transmission line operations or other parameters (e.g., land use) that would affect conformance with the NESC® standard, and (3) for any line segments for which nonconformance exists or is anticipated, a determination regarding the need for and nature of appropriate mitigation measures.

The NESC® standard applicable to this analysis specifies "electric lines operating at voltages exceeding 98 kV alternating current (AC) to ground must be designed with sufficient conductor clearance or other provisions as needed to limit the steady-state current[1] due to electrostatic effects to 5 milliamperes (mA) if the largest anticipated truck, vehicle, or other equipment under the line were short-circuited to ground." The rule further specifies that the determination of conductor clearance needed to meet the standard be performed under conditions of final unloaded conductor sag at 120°F (NESC® 2001, Rule 232.C.1.c).

No assessment of the anticipated electrostatic effects of the transmission lines of interest were presented by the Atomic Energy Commission (AEC) or NRC in the FES for Palisades or by NRC in the final addendum to the FES (AEC 1972; NRC 1978). Therefore, NMC conducted an independent analysis of the two lines of interest to determine conformance with the current NESC® standard (CNS 2004aU).

For the analysis, NMC used a process that generally involved the following three steps:

1. NMC determined conductor clearances and other relevant design and operating characteristics of the transmission lines of interest and other transmission lines close enough to the line of interest to influence the electric field. These other lines included the Roosevelt-Palisades (Palisades-Vergennes 345-kV line (Circuits 306 A/B) and Palisades-Covert 345-kV line (Circuit 306J) out of the Palisades Substation, and two other METC transmission lines: the Argenta-East Elkhart 345-kV line (Circuits 313 A/B), which shares the Palisades-Argenta corridor from near the Kalamazoo County line to the Argenta Substation, and the Scott Lake-Argenta 138-kV line, which lies on this same corridor for a short distance as it approaches the Argenta Substation (see Figures 2.1-3 and 3.1-1).

2. Using the relevant data from Step 1, NMC calculated the electric field strength profile, expressed as kilovolts per meter (kV/m), under the transmission lines at locations of minimum conductor clearance where electric field strength near ground level would be highest.

3. Using the calculated electric field strength profile in Step 2, NMC calculated the steady-state short-circuit current value through the largest anticipated vehicle.

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[1] The NESC® and the GEIS use the phrase "steady-state current," whereas 10 CFR 51.53(c)(3)(ii)(H) uses the phrase "induced current." The phrases have the same meaning here.

Plan and profile drawings of the transmission lines and other relevant documentation available from METC through Consumers constituted the primary source of information for Step 1 of the analysis. NMC performed Steps 2 and 3 of the analysis using a standard industry guide and computer program (ENVIRO), both developed and issued by the Electric Power Research Institute (EPRI) (EPRI 1987, EPRI 1995).

In Step 2, cross-sections were selected if they represent the highest potential to generate induced current to ground that exceeds the NESC® standard, generally corresponding to spans that exhibit the lowest conductor clearance relative to ground surface for a given conductor configuration. Some road crossings were excluded if a more limiting cross-section existed nearby on the line. For example, the crossing at Interstate 196 was not selected because there is a more limiting crossing one span to the west at Blue Star Memorial Highway, which exhibits a lower wire height and clearance to ground surface. A total of six cross-sections, listed and described in Table 4.5-1, were selected for subsequent detailed analysis.

For each of the selected cross-sections, conductor clearances and vertical spacing, voltage, current, and other relevant data for the lines of primary interest and those nearby lines that could influence the electric field were entered into the ENVIRO computer program. The results yielded by the program include the electric field strengths at 1 meter above the ground at appropriate horizontal intervals.

In Step 3, a 70-foot wide section of the profile exhibiting the highest maximum field strength in the cross-section was selected to bound the largest anticipated vehicle that could occur beneath the lines. NMC assumed for analysis purposes the largest vehicle to be a tractor-trailer 65 feet long, 8.0 feet wide, and 13.6 feet high, representative of the largest regularly allowed vehicle on Michigan roads with an assumed geometry that has high capacitance (MDOT 2002). For conservatism, the peak electric field strength in the interval was then used to calculate the resulting maximum expected steady-state (short-circuit) current.

Results of the analysis for all six cross-sections are shown in Table 4.5-1. As shown, the resulting short-circuit current for this hypothetical worst-case is 4.9 mA. Therefore, this conservative analysis demonstrates conformance with the NESC® 5 mA standard for all lines addressed in the analysis.

As discussed in Section 3.1.4 of this ER, Consumers, under contract to METC, performs periodic inspections and maintenance of the lines addressed in this analysis to determine the physical condition of towers, conductors, and other equipment; land use changes; and any encroachments on the corridors, which are generally owned or appropriately controlled (e.g., through easements) by Consumers. Appropriate practices in this regard would continue in the license renewal term, and neither METC nor Consumers currently expect changes in operating voltage or other parameters for these lines that would affect conformance status with respect to the NESC® 5 mA standard.

On the basis of these considerations, NMC concludes that the impact of electric shock is of SMALL significance for these transmission lines, and that further mitigation, such as the installation of warning signs at roadway crossings or increasing wire clearances, is not warranted.

4.6 HOUSING IMPACTS

NRC

The environmental report must contain " …[a]n assessment of the impact of the proposed action on housing availability…" [10 CFR 51.53(c)(3)(ii)(I)]

"…Housing impacts are expected to be of small significance at plants located in a medium or high population area and not in an area where growth control measures that limit housing development are in effect. Moderate or large housing impacts of the workforce associated with refurbishment may be associated with plants located in sparsely populated areas or areas with growth control measures that limit housing development…." (10 CFR Part 51, Subpart A, Appendix B, Table B-1, Issue 63)

"…small impacts result when no discernible change in housing availability occurs, changes in rental rates and housing values are similar to those occurring statewide, and no housing construction or conversion occurs." (NRC 1996, Section 4.7.1.1)

NRC designated housing impacts as a Category 2 issue because impact magnitude depends on local conditions NRC could not predict for all plants at the time of the GEIS publication (NRC 1996, Section 3.7.2). Local conditions that need to be ascertained are (1) population categorization as small, medium, or high and (2) applicability of growth control measures.

Refurbishment activities and continued operations could impact housing due to increased staffing. As described in Section 3.2 of this ER, NMC does not plan to undertake major refurbishment activities for Palisades license renewal. NMC concludes that there would be no refurbishment-related impacts to area housing and no analysis is required. Accordingly, the following discussion focuses on impacts of continued Palisades operations on local housing availability during the license renewal term.

As NMC discusses in Section 2.5 of this ER, the Palisades site is in an area ranked in the high population category according to NRC criteria. In addition, Van Buren and Berrien Counties and the municipalities within them have no county-imposed growth control measures that limit housing development (see Section 2.9 of this ER). In 10 CFR Part 51, Subpart A, Appendix B, Table B-1 (Issue 63), NRC concludes that impacts to housing are expected to be of small significance at plants in areas with a high population ranking where growth control measures are not in effect. Therefore, NMC expects related housing impacts to be SMALL.

A site-specific housing analysis supports this conclusion. The maximum impact to area housing is calculated using the following assumptions: (1) all direct and indirect jobs would be filled by immigrating residents; (2) the residential distribution of new residents would be similar to current worker distribution; and (3) each new job created (direct and indirect) represents one housing unit. As described in Section 3.4 of this ER, approximately 77 percent of the Palisades site workforce resides in Van Buren and

Berrien Counties. Therefore, the focus of the housing impact analysis is on these two counties. Also noted in Section 3.4 of this ER, NMC's conservative estimate of 60 additional permanent employees during the license renewal period could generate the demand for 152 new jobs (60 direct and 92 indirect jobs). If it is assumed that 77 percent of the 152 new workers would locate in the Van Buren and Berrien combined-county area, consistent with current employee trends, 117 housing units (new construction or resale/rental of vacant single-family dwellings or multiple family dwelling units) would be needed. In an area with a population of more than 238,716 and homeowner and rental vacancy rates of 2.1 and 8.0 percent (5,993 vacant housing units) for Van Buren County and 1.9 and 8.1 percent (9,876 vacant housing units) for Berrien County (Census 2000a, GCT-H5), this would not create a discernible change in housing availability, change rental rates and housing values, or spur housing construction or conversion. Given the magnitude of the impact on housing from continued operation of Palisades in the license renewal period, which is SMALL, mitigative measures would not be necessary.

4.7 PUBLIC UTILITIES: PUBLIC WATER SUPPLY AVAILABILITY

NRC

The environmental report must contain "…an assessment of the impact of population increases attributable to the proposed project on the public water supply." [10 CFR 51.53(c)(3)(ii)(I)]

"An increased problem with water shortages at some sites may lead to impacts of moderate significance on public water supply availability." (10 CFR Part 51, Subpart A, Appendix B, Table B-1, Issue 65)

"Impacts on public utility services are considered small if little or no change occurs in the ability to respond to the level of demand and thus there is no need to add capital facilities. Impacts are considered moderate if overtaxing of facilities during peak demand periods occurs. Impacts are considered large if existing service levels (such as quality of water and sewage treatment) are substantially degraded and additional capacity is needed to meet ongoing demands for services." (NRC 1996, Section 3.7.4.5)

NRC designated public utility impacts as a Category 2 issue because water shortages may occur in conjunction with plant demand and plant-related population growth (NRC 1996, Section 4.7.3.5). Local information needed would be a description of water shortages experienced in the area and an assessment of the public water supply system's available capacity.

NRC's analysis of impacts to the public water supply system considered both plant demand and plant-related population growth demands on local water resources. As discussed in Section 3.2 of this ER, NMC does not plan to undertake major refurbishment for Palisades license renewal. NMC concludes there would be no refurbishment-related impacts on the water supply system, and no analysis is required. Accordingly, the following discussion addressed impacts of continued Palisades operation on public water supply availability during the license renewal term.

The Palisades site acquires potable water through the South Haven Municipal Water Authority. Current average daily plant usage represents only 1.1 percent of the South Haven Municipal Water Authority's average daily demand and 0.45 percent of its permitted capacity (CNS 2004bU). NMC does not expect any significant change in this usage during the license renewal term. Considering the South Haven Water Authority's excess capacity of 0.77 million gallons per day (CNS 2004bU), NMC anticipates impacts resulting from Palisades site operations during the license renewal period would be SMALL, requiring no increase in allocations and warranting no mitigation.

The impact to the local water supply systems from plant-related population growth can be determined by calculating the amount of water potentially required by the additional individuals. As described in Section 3.4 of this ER, NMC's conservative estimate of 60 additional permanent employees during the license renewal period could generate a total of 152 new jobs in the area of interest. If it is assumed that 117 of the new workers would reside in the two-county area (152 multiplied by 77 percent), this could increase population in the area by 300 [117 jobs multiplied by 2.56 average number of persons per household in the State of Michigan (Census 2000b, DP-1)]. The average American uses between 50 and 80 gallons per day for personal use (Fetter 1980, page 2). Using this consumption rate, the plant-related population increase would require approximately 15,000 to 24,000 additional gallons per day. As NMC describes in Section 2.8.1 of this ER, the major water suppliers in both Van Buren and Berrien Counties all have excess capacity. This additional demand represents less than 1 percent of the collective excess capacities of the major municipal systems in Van Buren County (CNS 2004bU). As noted in Section 2.5.1 of this ER, population projections in Van Buren and Berrien County projections are declining. In addition, NMC did not identify any new large water users expected in the area as a result of its review efforts as described in Sections 2.8, 2.9, and Chapter 5 of this ER. Therefore, the impacts resulting from plant-related population growth to the public water supply from continued operation of Palisades in the license renewal period would be SMALL, and would not warrant mitigation.

4.8 EDUCATION IMPACTS FROM REFURBISHMENT

NRC

The environmental report must contain "An assessment of the impact of the proposed action on… public schools (impacts from refurbishment activities only) within the vicinity of the plant…." [10 CFR 51.53(c)(3)(ii)(I)]

"…Most sites would experience impacts of small significance but larger impacts are possible depending on site- and project-specific factors…." (10 CFR 51, Subpart A, Appendix B, Table B-1, Issue 66)

"…small impacts are associated with project-related enrollment increases of 3 percent or less. Impacts are considered small if there is no change in the school systems' abilities to provide educational services and if no additional teaching staff or classroom space is needed. Moderate impacts are associated with 4 to 8 percent increases in enrollment, and if a school system must increase its teaching staff or classroom space even slightly to preserve its pre-project level of service…. Large impacts are associated with enrollment increases greater than 8 percent…." (NRC 1996, Section 3.7.4.1)

NRC designated impacts to education as a Category 2 issue because site-specific and project-specific factors determine the significance of impacts (NRC 1996, Section 3.7.4.1). Local factors to be ascertained include (1) project-related enrollment increases and (2) status of the student/teacher ratio.

As discussed in Section 3.2 of this ER, NMC does not plan to undertake major refurbishment for Palisades license renewal. NMC concludes that there would be no refurbishment-related impacts to education, and no analysis is required.

4.9 OFFSITE LAND USE

4.9.1 REFURBISHMENT

NRC

The environmental report must contain "…an assessment of the impact of the proposed action on… land-use… within the vicinity of the plant…." [10 CFR 51.53(c)(3)(ii)(I)]

"…Impacts may be of moderate significance at plants in low population areas…." (10 CFR 51, Subpart A, Appendix B, Table B-1, Issue 68)

"…if plant-related population growth is less than 5 percent of the study area's total population, off-site land-use changes would be small, especially if the study area has established patterns of residential and commercial development, a population density of at least 60 persons per square mile, and at least one urban area with a population of 100,000 or more within 50 miles…." (NRC 1996, Section 3.7.5)

NRC designated impacts to offsite land use from refurbishment activities as a Category 2 issue because land-use changes could be considered beneficial by some community members and adverse by others. Local conditions to be ascertained include (1) plant-related population growth, (2) patterns of residential and commercial development, and (3) proximity to an urban area of at least 100,000 residents.

As discussed in Section 3.2 of this ER, NMC does not plan to undertake major refurbishment for Palisades license renewal. NMC concludes there would be no refurbishment-related impacts to offsite land use, and no analysis is required.

4.9.2 LICENSE RENEWAL TERM

> **NRC**
>
> **The environmental report must contain "…[a]n assessment of the impact of the proposed action on …land-use…within the vicinity of the plant…" [10 CFR 51.53(c)(3)(ii)(I)]**
>
> **"Significant changes in land use may be associated with population and tax revenue changes resulting from license renewal." (10 CFR Part 51, Subpart A, Appendix B, Table B-1, Issue 69)**
>
> **"…if plant-related population growth is less than five percent of the study area's total population, off-site land-use changes would be small…" (NRC 1996, Section 3.7.5)**
>
> **"If the plant's tax payments are projected to be small relative to the community's total revenue, new tax-driven land-use changes during the plant's license renewal term would be small, especially where the community has pre-established patterns of development and has provided adequate public services to support and guide development." (NRC 1996, Section 4.7.4.1)**

NRC designated impacts to offsite land use during the license renewal term as a Category 2 issue because land use changes may be perceived to be beneficial by some community members and adverse by others. Therefore, NRC could not assess the potential significance of site-specific offsite land-use impacts (NRC 1996, Section 4.7.4.1).

In the GEIS, NRC presents an analysis of population-driven and tax-driven impacts on offsite land use for the renewal term (NRC 1996, Section 4.7.4.1). Based on the case study analysis described in the GEIS, NRC concludes that all new population-driven land-use changes during the license renewal term at all nuclear power plants would be small because population growth caused by license renewal would represent a much smaller percentage of the local area's total population than has resulted from plant operation (NRC 1996, Section 4.7.4.2).

Section 4.7.4.1 of the GEIS states that the assessment of tax-driven land-use impacts during the license renewal term should consider (1) the size of the plant's payments relative to the community's total revenues, (2) the nature of the community's existing land-use pattern, and (3) the extent to which the community already has public services in place to support and guide development (NRC 1996). If the plant's tax payments are projected to be small relative to the community's total revenue, new tax-driven land-use changes by the plant during the plant's license renewal term would be SMALL, especially where the community has pre-established patterns of development and has provided adequate public services to support and guide development. If the plant's tax payments are projected to be medium-to-large relative to the community's total revenue, new tax-driven land-use changes will be MODERATE. This is most likely to be true where the community has no pre-established patterns of development (i.e., land-use plans or controls) or has not provided adequate public services to support and guide development in the past, especially infrastructure that would allow industrial development. If the plant's tax payments are projected to be a dominant source of the community's total revenue, new tax-driven land-use changes would be LARGE. This would be especially true where the community has no pre-established pattern of development or has not provided adequate public services to support and guide development in the past.

As noted in Section 3.2 of this ER, NMC does not plan to undertake major refurbishment activities for Palisades license renewal. Therefore, no new sources of plant-related tax payments attributable to refurbishment are expected that could significantly influence land use in Van Buren County, and no related analysis is required. However, new land-use impacts could result from the use by local governments of the property tax revenue NMC would continue to pay for the Palisades site during the license renewal term. This latter source of potential impact is discussed in the following paragraphs.

NMC's annual property tax payments to Van Buren County for the Palisades site represent less than 6.6 percent of the county's annual operating budget for the period 1994 through 2003 (see Table 2.7-1). During the same period, NMC property tax payments to Covert Township for the Palisades site represented an average of approximately 41 percent of the Township's annual operating budget, approximately 44 percent of the Covert School District's annual operating budget, 12 percent of the District Library annual operating budget, and less than 10 percent of the annual operating budgets of the Van Buren Intermediate School District and the South Haven Community Hospital District (CNS 2004bU). NMC assumes that these values are substantially representative of conditions that would exist in the Palisades license renewal term.

NRC has determined that the significance of tax payments is small if payments are less than 10 percent of a taxing jurisdiction's total revenue, moderate if payments are 10 to 20 percent, and large if payments are greater than 20 percent (NRC 1996, Section 4.7.2.1).

As noted in the introduction to this section, the potential for tax-driven impacts relates not only to those relative budget contributions, but also on existing land use patterns and controls. Van Buren County has not experienced any significant changes in land-use patterns due to the operation of Palisades. Current land use characteristics within Van Buren County, as described in Section 2.9 of this ER, are similar to those described in the FES related to operation of Palisades (AEC 1972; Section II.C). Development is encouraged in areas that can be served by existing infrastructure along the Lake Michigan shore and along the I-94 and M-43 corridors. Continued growth is expected in these same areas. Overall, total population within Van Buren County has increased in the past 20 years. From 1980 to 2000, total population in Van Buren County has increased by nearly 14 percent, and the Michigan Office of the State Demographer projects that populations in the county will continue to increase by approximately 1 percent annually, through the year 2020 (see Section 2.5 of this ER).

As described in Section 2.9 of this ER, an established pattern of development exists in Van Buren County and Covert Township. Van Buren County and of its municipalities have developed comprehensive planning documents. The Van Buren County Planning Commission supports the goal of guiding development in areas that can be served by existing infrastructure. Municipalities within Van Buren County, including Covert Township, administer land use regulations, such as zoning, designed to regulate and guide development.

Although the plant's contribution to Covert Township's annual operating budget is large, the plant's contribution to the Van Buren County operating budget is small. With the slowly increasing populations and the established pattern of growth that exists in Van Buren County, including Covert Township, NMC expects few, if any, land use changes during the renewal period due to new tax-driven impacts. NMC concludes that tax-driven land-use impacts would be SMALL and additional mitigation would not be warranted.

4.10 TRANSPORTATION

NRC
The environmental report must contain an assessment of "…the impact of the proposed project on local transportation during periods of license renewal refurbishment activities." [10 CFR 51.53(c)(3)(ii)(J)]   **"Transportation impacts are generally expected to be of small significance. However, the increase in traffic associated with the additional workers and local road and traffic control conditions may lead to impacts of moderate or large significance at some sites." (10 CFR Part 51, Subpart A, Appendix B, Table B-1, Issue 70)**   **Level of Service (LOS) "A and B are associated with small impacts because the operation of individual users is not substantially affected by the presence of other users." LOS A is characterized by "free flow at the traffic stream; users are unaffected by the presence of others." LOS B is characterized by "stable flow in which the freedom to maneuver is slightly diminished." (NRC 1996, Section 3.7.4.2)**

NRC designated impacts to transportation as a Category 2 issue because road conditions existing at the time of the project, which NRC could not forecast for all plants, primarily determine impact significance (NRC 1996, Section 3.7.4.2). Local road conditions to be ascertained are (1) highway capacity and traffic flow and (2) incremental increase in traffic associated with major refurbishment activities and additional permanent employees attributable to license renewal.

As described in Section 3.2 of this ER, NMC does not plan to undertake major refurbishment for Palisades license renewal. NMC concludes there would be no refurbishment-related impacts to local transportation and no analysis is required. Accordingly, the following discussion addresses potential impacts to transportation from Palisades operation in the license renewal term.

As NMC notes in Section 2.8.2 of this ER, access to the Palisades site is via the Blue Star Memorial Highway and the major commuting routes used by Palisades site employees are in mainly rural areas and have stable flows. The current Palisades workforce, including NMC employees and contractors is approximately 644 employees, including NMC employees and contractors (see Section 3.4 of this ER). Refueling outages, which are scheduled approximately every 18 months and last about 30 days, add as many as 384 temporary workers. NMC's conservative assumption of 60 additional employees associated with operating through the Palisades license renewal term represents a small (approximately 9 percent) increase in the current number of employees and an even smaller percentage of the employees on-site during outages (e.g., for periodic refueling), when Palisades traffic volume is heaviest. The Van Buren County Planning Department has not identified any of the major commuting routes to Palisades as deficient due to limited capacity or physical condition (see Section 2.8 of this ER). On this basis and the LOS designations for State trunklines and traffic counts for likely commuting routes to the Palisades site as described in Section 2.8 and Tables 2.8-2 and 2.8-3, NMC concludes that impacts to transportation from continued operation of Palisades in the license renewal period would be SMALL and mitigative measures would not be necessary.

4.11 HISTORIC AND ARCHAEOLOGICAL RESOURCES

NRC

The environmental report must contain an assessment of "…whether any historic or archaeological properties will be affected by the proposed project." [10 CFR 51.53(c)(3)(ii)(K)]

"Generally, plant refurbishment and continued operation are expected to have no more than small adverse impacts on historic and archaeological resources. However, the National Historic Preservation Act requires the Federal agency to consult with the State Historic Preservation Officer to determine whether there are properties present that require protection." (10 CFR 51, Subpart A, Appendix B, Table B-1, Issue 71)

"Sites are considered to have small impacts to historic and archaeological resources if (1) the State Historic Preservation Office (SHPO) identifies no significant resources on or near the site; or (2) the SHPO identifies (or has previously identified) significant historic resources but determines they would not be affected by plant refurbishment, transmission lines, and license-renewal term operations and there are no complaints from the affected public about the character; and (3) if the conditions associated with moderate impacts do not occur." (NRC 1996, Section 3.7.7)

NRC designated impacts to historic and archaeological resources as a Category 2 issue because determinations of impacts to historic and archaeological resources are site-specific in nature, and the National Historic Preservation Act mandates that determination of impacts must be made through consultation with the State Historic Preservation Officer (SHPO) (NRC 1996, Section 4.7.7.3).

As described in Section 3.2 of this ER, NMC does not plan to undertake major refurbishment activities for Palisades license renewal. NMC concludes that there would be no refurbishment-related impacts on historic and archaeological resources and no analysis is required. Accordingly, the following discussion addresses impacts of continued Palisades operation on historic and archaeological resources during the license renewal term.

As discussed in Section 2.10 of this ER, NMC reviewed the FES for Palisades and listings of the National Park Service (NPS) and the Michigan Historic Preservation Office for National and State Register of Historic Places listed and eligible properties. In addition, NMC has initiated contact with the Michigan Historic Preservation Officer regarding the potential impact of continued operation of Palisades and transmission lines addressed in this ER as part of its license renewal environmental review. Results of these activities indicate that there are no known National Register eligible or listed historic or archaeological properties on or near the Palisades site or the transmission line corridors (see Section 2.10 and Attachment C). NMC also foresees no significant land disturbing activities that would be associated with license renewal and notes that for this reason the transmission corridors are not considered part of the area of potential effects.

In view of these considerations, operation of Palisades and transmission lines addressed in this ER in the license renewal term would have no effect on significant historic and archaeological resources. NMC therefore concludes that impacts on historic and archaeological resources associated with license renewal would be SMALL, and mitigation would be unwarranted.

4.12 SEVERE ACCIDENT MITIGATION ALTERNATIVES

NRC

The environmental report must contain a consideration of alternatives to mitigate severe accidents "…if the staff has not previously considered severe accident mitigation alternatives for the applicant's plant in an environmental impact statement or related supplement or in an environment assessment..." 10 CFR 51.53(c)(3)(ii)(L)

"…The probability weighted consequences of atmospheric releases, fallout onto open bodies of water, releases to ground water, and societal and economic impacts from severe accidents are small for all plants. However, alternatives to mitigate severe accidents must be considered for all plants that have not considered such alternatives…." 10 CFR 51, Subpart A, Appendix B, Table B-1, Issue 76

The term "accident" refers to any unintentional event (i.e., outside the normal or expected plant operation envelope) that results in the release or a potential for release of radioactive material to the environment. NRC categorizes accidents as "design basis" or "severe." Design basis accidents are those for which the risk is great enough that NRC requires plant design and construction to prevent unacceptable accident consequences. Severe accidents are those that NRC considers too unlikely to warrant design controls.

Historically, NRC has not included in its environmental impact statements or environmental assessments any analysis of alternative ways to mitigate the environmental impacts of severe accidents. A 1989 court decision ruled that, in the absence of an NRC finding that severe accidents are remote and speculative, severe accident mitigation alternatives (SAMAs) should be considered in the NEPA analysis [Limerick Ecology Action v. NRC, 869 F.d 719 (3rd Cir. 1989)]. For most plants, including Palisades, license renewal is the first licensing action that would necessitate consideration of SAMAs.

NRC concluded in its license renewal rulemaking that the unmitigated environmental impacts from severe accidents met its Category 1 criteria. However, NRC made consideration of mitigation alternatives a Category 2 issue because not all plants had completed ongoing regulatory programs related to mitigation (e.g., individual plant examinations and severe accident management). Site-specific information to be presented in the license renewal environmental report includes: (1) potential SAMA candidates; (2) benefits, costs, and net value of implementing potential SAMA candidates; and (3) sensitivity of analysis to changes in key underlying assumptions.

Section 4.12 provides a brief synopsis of the methodology and results for the NMC SAMA analysis, and Attachment E provides additional detail on the characterization of plant risk, the process used to identify potential modifications, the cost-benefit methodology, and results.

NMC maintains a probabilistic safety assessment (PSA) model to use in evaluating the most significant risks of radiological release. The Palisades PSA model has two aspects. Level 1 determines core damage frequencies based on system analysis and human-factor evaluations, and Level 2 determines the physical and chemical phenomena that affect the performance of the containment and other radiological release mitigation features to quantify accident behavior and release of fission products to the environment. To support the SAMA analysis, NMC developed a Level 3 PSA model to characterize the hypothetical impacts from severe accidents on the surrounding environment and members of the public. The results of these models provide the primary input to the cost-benefit analysis.

4.12.1 METHODOLOGY OVERVIEW

The methodology used to perform the Palisades SAMA cost-benefit analysis was based on the handbook used by NRC to analyze benefits and costs of its regulatory activities (NUREG/BR-0184), subject to Palisades-specific considerations. The metrics used to represent plant risk include core damage frequency (CDF), dose risk, and economic cost risk. The following summarizes the approach NMC used in the SAMA analysis in Attachment E.

- <u>Palisades PSA Model</u> – Use the Palisades Internal and External Events PSA models to characterize plant risk (Section E.2).

- <u>Level 3 PSA Analysis</u> – Use Palisades Level 1 and 2 Internal Events PSA output and site-specific meteorology, demographic, land use, and emergency response data as input in performing a Level 3 PSA using the MELCOR Accident Consequences Code System Version 2 (MACCS2) (Section E.3).

- <u>Baseline Risk Monetization</u> – Use NRC regulatory analysis techniques to calculate the monetary value of the unmitigated Palisades severe accident risk. Assuming that all plant risk is eliminated, this value represents the maximum averted cost-risk (MACR) (Section E.4).

- <u>Phase I SAMA Analysis</u> – Identify potential SAMA candidates based on the Palisades PSA, coupled with documentation from the industry and NRC. Screen SAMA candidates that are not applicable to the Palisades design or are of low benefit in pressurized water reactors such as Palisades; have already been implemented at Palisades or whose benefits have been achieved using other means; or have estimated implementation costs that exceed the MACR (Section E.5).

- <u>Phase II SAMA Analysis</u> – Screen Phase II SAMA candidates using PSA insights. Calculate the risk reduction attributable to each remaining SAMA candidate, and perform a detailed cost-benefit analysis to identify the potential net benefit (Section E.6).

- Uncertainty Analysis – Evaluate how changes in certain assumptions used in the SAMA analysis might affect the results (Section E.7).

4.12.2 BASELINE RISK MONETIZATION

The purpose of establishing baseline cost risk is to provide a basis for determining the cost-risk reductions (benefits) that would be attributable to the implementation of potential SAMA(s). In accordance with NUREG/BR-0184, the present dollar value for severe accident risk is characterized as the sum of the offsite exposure costs, offsite economic costs, onsite exposure costs, and onsite economic costs including replacement power costs. The total baseline cost risk for Palisades is approximately $2,815,000 (based on on-line internal events contributions). The methodology for calculating each of the 5 factors is presented in Attachment E, Section E.4. As described in Section E.5.1.7, NMC modified this value by applying a factor of two to account for external events contributions. Assuming all risk is eliminated, this modified value ($5,630,000) represents the maximum averted cost-risk, and is used as in the Phase I screening process.

4.12.3 SAMA IDENTIFICATION AND SCREENING

NMC utilized industry, NRC, and Palisades -specific information to create a list of approximately 23 SAMA candidates for consideration. NMC analyzed this list and screened out those SAMAs already implemented at Palisades, those not applicable to Palisades design, or those achieving results already attained at Palisades by other means. NMC prepared preliminary cost estimates for the remaining SAMAs and used the baseline risk value to screen out SAMAs that would clearly not be cost-beneficial. Sixteen candidate SAMAs remained for further consideration.

For each SAMA candidate, NMC calculated the risk reduction that would be attributable to implementing the modification and re-quantified the risk value. The difference between the baseline risk value (MACR) and the SAMA-reduced risk value is the averted risk or the benefit of implementing the SAMA. NMC prepared more detailed cost estimates for implementing each SAMA and repeated the cost-benefit comparison.

4.12.4 COST-BENEFIT RESULTS

The benefits of revising the operational strategies in place at Palisades and/or implementing hardware modifications can be evaluated without the insight from a risk-based analysis. Use of the PSA in conjunction with cost-benefit analysis methodologies has, however, provided an enhanced understanding of the effects of the proposed changes relative to the cost of implementation and projected dose and economic impact. The results of this study indicate several potential improvements are cost beneficial based on the methodology applied in this analysis and warrant further review for potential implementation. These include:

SAMA 3: Direct drive diesel injection pump (reduces the risk of station blackout scenarios by providing an injection method to supplement the turbine-driven auxiliary feedwater pump)

SAMA 10: Power independent turbine driven Auxiliary Feedwater operation (modify the turbine-driven auxiliary feedwater train so that it can operate indefinitely without alternating current, direct current, or pneumatic support)

SAMA 13: Nitrogen station for automatic backup to CV-2010 air supply (provides a backup air supply that would automatically provide a backup air supply to CV-2010; thus reducing the importance of loss of instrument air to the valve)

SAMA 16: Insulate Emergency Diesel Generator exhaust ducts (reduces the heat load in the room and provides additional time to align alternate room cooling in the event that room cooling has failed)

SAMA 22: Replace the undervoltage relay for Buses 1C and 1D with a higher fragility model (provides a more durable relay that would reduce the contribution from loss of power to Bus 1D)

SAMA 23: Direct PCS cooldown on loss of PCP seal cooling (reduces the probability of seal failures related to long-term high temperature exposure or thermal shock after recovery of circulating cooling water)

Sensitivity cases were conducted to assess the impact on the results if a 3 percent discount rate were used, if the 95th percentile results were used for CDF, and if a different level of effectiveness of seal cooling were used. The base case calculation used a 7 percent discount rate and the mean CDF value. While the magnitude of the benefit changed for each of the remaining SAMAs, all of the remaining net values were negative.

NMC notes that this analysis should not necessarily be considered dispositive because other engineering reviews are necessary to determine ultimate implementation. NMC continues consideration and implementation of the 6 SAMAs (3, 10, 13, 16, 22, and 23) identified in this analysis through the appropriate Palisades design process.

TABLE 4.1-1
NRC CATEGORY 2 ISSUES NOT APPLICABLE TO PALISADES LICENSE RENEWAL

Issue	Basis for Exclusion
13. Water-use conflicts (plants with cooling ponds or cooling towers using makeup water from a small river with low flow)	Not applicable because Palisades withdraws makeup water from Lake Michigan.
25. Entrainment of fish and shellfish in early life stages for plants with once-through and cooling pond heat dissipation systems	Not applicable because Palisades uses closed-cycle cooling for heat dissipation (cooling towers).
26. Impingement of fish and shellfish for plants with once-through and cooling pond heat dissipation systems	Not applicable because Palisades uses closed-cycle cooling for heat dissipation (cooling towers).
27. Heat shock for plants with once-through and cooling pond heat dissipation systems	Not applicable because Palisades uses closed-cycle cooling for heat dissipation (cooling towers).
33. Groundwater use conflicts (potable, service, and dewatering; plants that use >100 gallons per minute)	Not applicable because groundwater use at Palisades is less than 100 gallons per minute.
34. Groundwater-use conflicts (plants with cooling ponds or cooling towers using makeup water from a small river)	Not applicable because Palisades withdraws makeup water from Lake Michigan.
35. Groundwater use conflicts (Ranney wells)	Not applicable because Palisades does not use Ranney wells.
39. Groundwater quality degradation (cooling ponds at inland sites)	Not applicable because Palisades is not equipped with cooling ponds.
57. Microbiological organisms (public health). (Plants using lakes or canals, or cooling towers or cooling ponds that discharge to a small river)	Not applicable because Palisades uses cooling towers that discharge to Lake Michigan.

TABLE 4.3-1
THREATENED, ENDANGERED, AND CANDIDATE SPECIES WITH OCCURRENCE POTENTIAL IN AREAS OF CONCERN TO PALISADES LICENSE RENEWAL[a]

Species	Status	Habitat
Lake Michigan		
Lake herring (*Coregonus artedii*)	ST	Nearshore areas of Lake Michigan
Lake sturgeon (*Acipenser fulvescens*)	ST	Nearshore areas of Lake Michigan
Palisades Site		
Pitcher's thistle (*Cirsium pitcheri*)	FT, ST	Open habitats on dunes
Prairie warbler (*Dendroica discolor*)	SE	Scrub-shrub
Prairie vole (*Microtus ochrogaster*)	SE	Open prairie and savannah
Palisades-Argenta Right-of-Way		
Bald-rush (*Psilocarya scirpoides*)	ST	Intermittent open wetlands
Carey's smartweed (*Polygonum careyi*)	ST	Sandy marshes, lakeshores, beaver ponds
Globe-fruited seedbox (*Ludwigia sphaerocarpa*)	ST	Moist muddy or sandy shores of streams, marshes, swamps
Netted nut-rush (*Scleria reticularis*)	ST	Seasonally flooded open wetlands
Scirpus-like rush (*Juncus scirpoides*)	ST	Intermittent open wetlands
Sedge (*Carex seorosa*)	ST	Forested wetlands
Creek chubsucker (*Erimyzon oblongus*)	SE	Kalamazoo River and tributaries
Eastern massasauga (*Sistrurus c. catenatus*)	FC	Wetlands and nearby uplands.
Spotted turtle (*Clemmys guttata*)	ST	Sphagnum seeps, grassy marshes with mud bottom, shallow clean water, clumps of sedge or marsh grass.
Indiana bat (*Myotis sodalis*)	FE, SE	Floodplain forest along larger streams (e.g., South Branch Black River, Kalamazoo River)

a. Source: Section 2.3.3 and Table 2.3-5. This list is exclusive of bird species likely to occur only as transients on the Palisades site or transmission line rights-of-way addressed in this Environmental Report.

FC = Federal Candidate
FE = Federal Endangered
FT = Federal Threatened
SE = State Endangered
ST = State Threatened

TABLE 4.5-1
CALCULATED SHORT-CIRCUIT CURRENTS AT CROSS-SECTIONS

Cross-Section No.	Location and Summary Description	Short-Circuit Current (mA)[a]
1	Located at the Palisades Site Access Road. This cross-section includes lines 310 A/B, 309 A/B, 306 A/B, and 306J.	4.3
2	Located at the New Blue Star Highway (US-31). This cross-section includes lines 310 A/B, 309 A/B, 306 A/B, and 306J.	3.4
3	Located 1-span east of 72nd Street in Van Buren County. This cross-section location has a low clearance adjacent to cultivated property, which would allow access of larger commercial vehicles. The cross-section includes lines 309 A/B and 306 A/B.	4.1
4	Located 2-spans east of 69th Street in Van Buren County at a low clearance point on line 309 A/B adjacent to cultivated property.	4.2
5	Located 1-span east of 2nd Street in Kalamazoo County. This cross-section location has a low clearance adjacent to cultivated property, which would allow access to larger commercial vehicles. The cross-section includes lines 309 A/B and 313 A/B.	4.9
6	Located 1-span west of Riverview Road in Kalamazoo County. This cross-section is adjacent to cultivated property and includes lines 309 A/B, 313 A/B, and the South Lake-Argenta 138 kV line.	1.6

4.13 REFERENCES

Note to reader: This list of references identifies web pages and associated URLs where reference data was obtained. Some of these web pages may likely no longer be available or their URL address may have changed. NMC has maintained hard copies of the information and data obtained from the referenced web pages.

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NRC (U.S. Nuclear Regulatory Commission). 1996. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants.* NUREG-1437. Office of Nuclear Regulatory Research. Washington, D.C. May.

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5.0 ASSESSMENT OF NEW AND SIGNIFICANT INFORMATION

NRC

"The environmental report must contain any new and significant information regarding the environmental impacts of license renewal of which the applicant is aware." 10 CFR 51.53(c)(3)(iv)

The U.S. Nuclear Regulatory Commission (NRC) licenses the operation of domestic nuclear power plants and provides for license renewal, requiring an applicant to submit with its application a separate Environmental Report (ER) (10 CFR 54.23). NRC regulations at 10 CFR 51 prescribe the ER content and identify the specific analyses the applicant must perform. In an effort to perform the environmental review efficiently and effectively, NRC has resolved most of the environmental issues generically (designated as Category 1 issues), but requires an applicant's analysis of all the remaining applicable issues (designated as Category 2 issues).

While NRC regulations do not require an applicant's ER to contain analyses of the impacts of the generically resolved environmental issues [10 CFR 51.53(c)(3)(i)], the regulations do require that an applicant identify any new and significant information of which the applicant is aware [10 CFR 51.53(c)(3)(iv)]. This requirement serves to alert NRC staff to such pertinent information so that the staff can determine whether to seek NRC's approval to waive or suspend application of the rule with respect to the affected generic analysis. NRC has explicitly indicated, however, that an applicant is not required to perform a site-specific validation of its conclusions in the *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (GEIS) (NRC 1996a; NRC 1996b, pages C9-13 and C9-14, Concern Number NEP 015).

Nuclear Management Company, LLC (NMC) assumes new and significant information to include the following:

- Information that identifies a significant environmental issue the GEIS does not cover and is not codified in the regulation, or

- Information not covered in the GEIS analyses that leads to an impact finding different from that codified in the regulation.

NRC does not define the term "significant." For the purpose of its review, NMC used guidance available in Council on Environmental Quality (CEQ) regulations. The National Environmental Policy Act (NEPA) authorizes the CEQ to establish implementing regulations for federal agency use. NRC requires license renewal applicants to provide NRC with input, in the form of an ER (10 CFR 51.10) that NRC will use to meet NEPA requirements as they apply to license renewal. CEQ guidance provides that federal agencies should prepare environmental impact statements for actions that would significantly affect the environment (40 CFR 1502.3), to focus on significant environmental issues (40 CFR 1502.1), and to eliminate from detailed study issues that are not significant [40 CFR 1501.7(a)(3)]. The CEQ guidance includes a lengthy definition of “significantly,” which requires consideration of the context of the action and the intensity or severity of the impact(s) (40 CFR 1508.27). NMC assumed that moderate or large impacts, as defined by NRC, would be “significant.” NMC presents NRC definitions of “moderate” and “large” impacts in Section 4.1.2 of this ER.

NMC prepared this *Palisades Nuclear Plant Environmental Report – Operating License Renewal Stage* in accordance with NRC regulations at 10 CFR 51.53(c). In response to 10 CFR 51.53(c)(3)(iv), NMC implemented a process for identifying new and significant information as part of its preparation of this ER for the license renewal of Palisades Nuclear Plant (Palisades). The process was directed by the License Renewal Environmental Lead and included the following actions:

1. Assembly of an investigative team comprised of key representatives of NMC, Consumers Energy (Consumers), and Constellation Nuclear Services, Inc., a subsidiary of Constellation Energy, to support preparation of the ER and to conduct the new and significant information review (NMC and Consumers representatives consisted of individuals specifically knowledgeable about plant systems, the site environment, and plant environmental issues);

2. Interviews with subject matter experts from NMC and Consumers related to the conclusions in the GEIS as they relate to Palisades;

3. Review of the environmental management programs, permits, procedures, and practices in place for Palisades to understand their scope and effectiveness for managing potential impacts of Palisades operations and/or as mechanisms for staff to become aware of new and significant information;

4. Review of internal and external documents and records related to environmental aspects of Palisades, its environs, and its associated transmission lines, including but not limited to, environmental assessments and monitoring reports, procedures, and other management controls, compliance history reports, and environmental resource plans and data;

5. Correspondence with state and federal regulatory agencies to determine agency environmental concerns related to Palisades operations;

6. Interface with nuclear power industry representatives to ensure current knowledge of events at other plants with potential to affect environmental issues;

7. Review of other license renewal application submittals for pertinent issues; and

8. Crediting the oversight provided by inspections of plant facilities by state and federal regulatory agencies.

Information obtained as a result of these activities was evaluated with respect to the criteria described above. As a result of this process, NMC is aware of no new and significant information regarding the environmental impacts of Palisades license renewal and continued operation.

5.1 REFERENCES

NRC (U.S. Nuclear Regulatory Commission). 1996a. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*. NUREG-1437. Office of Nuclear Regulatory Research. Washington, D.C. May.

NRC (U.S. Nuclear Regulatory Commission). 1996b. *Public Comments on the Proposed 10 CFR Part 51 Rule for Renewal of Nuclear Power Plant Operating Licenses and Supporting Documents: Review of Concerns and NRC Staff Response*. NUREG-1529. Office of Nuclear Regulatory Research. Washington, D.C. May.

6.0 SUMMARY OF LICENSE RENEWAL IMPACTS AND MITIGATING ACTIONS

6.1 LICENSE RENEWAL IMPACTS

Nuclear Management Company, LLC (NMC) has reviewed the environmental impacts associated with renewing the Palisades Nuclear Plant (Palisades) operating license and has concluded that all of the impacts would be SMALL and would not require mitigation. This Environmental Report (ER) documents NMC's basis for this conclusion. In Section 4.1 of this ER, NMC incorporates by reference the U.S. Nuclear Regulatory Commission's (NRC's) findings for the Category 1 issues applicable to Palisades, all of which have impacts that are SMALL (see Attachment A). Sections 4.2 through 4.12 of this ER present NMC's analysis of the 12 Category 2 issues applicable to the Palisades site. Results of these analyses indicate impacts would be SMALL for all applicable Category 2 issues. Table 6.1-1 summarizes impacts that Palisades license renewal would have on resources associated with all Category 2 issues.

6.2 MITIGATION

NRC
"The report must contain a consideration of alternatives for reducing adverse impacts...for all Category 2 license renewal issues..." [10 CFR 51.53(c)(3)(iii)]
"The environmental report shall include an analysis that considers and balances...alternatives available for reducing or avoiding adverse environmental effects...." [10 CFR 51.45(c) as incorporated by 10 CFR 51.53(c)(2)]

Based on NMC's analysis in Chapter 4 of this ER, all impacts of license renewal at Palisades have been determined to be SMALL and would not require additional mitigation. Current operations include environmental monitoring that would continue during the license renewal term. These activities include radiological environmental monitoring, National Pollutant Discharge Elimination System discharge monitoring, radiological emissions monitoring, and focused surveys for sensitive resources (e.g., threatened or endangered species) for onsite land-disturbing activities.

6.3 UNAVOIDABLE ADVERSE IMPACTS

NRC

The environmental report shall discuss any "…adverse environmental effects which cannot be avoided should the proposal be implemented…." [10 CFR 51.45(b)(2)] as adopted by 51.53(c)(2)]

The report "...should not be confined to information supporting the proposed action but should also include adverse information." [10 CFR 51.45(e)]

NMC adopts by reference for this ER NRC findings stated in the *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (GEIS) for applicable Category 1 issues (see Attachment A), including discussions of any unavoidable adverse impacts. In Chapter 4 of this ER, NMC examined the 21 Category 2 issues NRC identified in the GEIS and identified the following unavoidable adverse impacts of renewing the operating license for Palisades:

- NMC does not expect to add permanent employees for the license renewal period. However, for purpose of a bounding analysis, NMC assumed that license renewal would necessitate adding 60 permanent employees. The assumed addition of 60 direct workers and associated 92 indirect workers would result in only minor efforts on housing availability, public water supplies, offsite land use, and transportation infrastructure in areas where these additional workers are likely to reside (see Sections 4.6, 4.7, 4.9, and 4.10 of this ER).

Based on the discussion and analyses presented in Chapter 4 of this ER, NMC expects that all unavoidable adverse impacts resulting from renewal of the Palisades operating licenses would be SMALL.

6.4 IRREVERSIBLE OR IRRETRIEVABLE RESOURCE COMMITMENTS

NRC

The environmental report shall discuss any "...irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented…." [10 CFR 51.45(b)(5) as adopted by 51.53(c)(2)]

The continued operation of Palisades for the license renewal term would result in irreversible and irretrievable resource commitments including:

- Nuclear fuel, which is utilized in the reactor and converted to radioactive waste;
- Land required to permanently store or dispose of this spent nuclear fuel and low-level radioactive wastes generated from plant operations;
- Elemental materials that will become radioactive; and
- Materials used for the normal industrial operations of the plant that cannot be recovered or recycled or that are consumed or reduced to unrecoverable forms.

NMC has not identified any activities during the license renewal term that would irreversibly or irretrievably commit additional resources beyond those committed during the construction and operation of Palisades during the initial operating license term and the preemption of land and consumption of materials such as those discussed above.

6.5 SHORT-TERM USE VERSUS LONG-TERM PRODUCTIVITY OF THE ENVIRONMENT

NRC

The environmental report shall discuss the "...relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity…."
[10 CFR 51.45(b)(4) as adopted by 51.53(c)(2)]

The current balance between short-term use and long-term productivity of the environment at the Palisades site was set in 1972, when the plant began operating. The AEC (predecessor to NRC) documented its evaluations of this balance in its Final Environmental Statement (FES) for Palisades (AEC 1972, Section VIII). Of particular note in these evaluations was the conversion of approximately 32 acres of land to electric power generation facilities (AEC 1972, Section VII). The AEC noted that, upon decommissioning, much of the facility could be dismantled and the site restored to its original condition for the long term (AEC 1972, Section V).

As discussed in Section 2.1.2 of this ER, approximately 80 acres of the site are now developed or maintained. However, NMC notes that the current balance nonetheless is now well established and can be expected to remain essentially unchanged by renewal of the operating license and extended operation of the Palisades site. Extended operation of Palisades would postpone restoration of the site and its potential availability for other uses and would also result in other short-term impacts on the environment. However, all of these impacts have been determined to be SMALL on the basis of NRC's evaluation in the GEIS and NMC's evaluation in this ER. License renewal does not eliminate or preclude such restoration in the future.

TABLE 6.1-1
ENVIRONMENTAL IMPACTS RELATED TO LICENSE RENEWAL OF PALISADES (CATEGORY 2 ISSUES[a])

No.	Issue	Environmental Impact
	Surface Water Quality, Hydrology, and Use (for all plants)	
13	Water-use conflicts (plants using cooling ponds or cooling towers using makeup water from a small river with low flow)	NONE. This issue is not applicable because Palisades draws make-up water from Lake Michigan.
	Aquatic Ecology (for plants with once-through and cooling pond heat dissipation systems)	
25	Entrainment of fish and shellfish in early life stages	NONE. This issue is not applicable because Palisades uses a closed cycle cooling system (cooling towers).
26	Impingement of fish and shellfish	NONE. This issue is not applicable because Palisades uses a closed cycle cooling system (cooling towers).
27	Heat shock	NONE. This issue is not applicable because Palisades uses a closed cycle cooling system (cooling towers).
	Groundwater Use and Quality	
33	Groundwater use conflicts (potable and service water, and dewatering; plants that use more than 100 gpm)	NONE. The issue is not applicable because the Palisades site uses less than 100 gallons per minute of groundwater (no dewatering; potable and service water are from municipal supply).
34	Groundwater use conflicts (plants using cooling towers withdrawing makeup water from a small river)	NONE. This issue is not applicable because the Palisades site draws makeup water from Lake Michigan.
35	Groundwater use conflicts (Ranney wells)	NONE. The issue is not applicable because Palisades does not use Ranney wells.
39	Groundwater quality degradation (cooling ponds at inland sites)	NONE. The issue is not applicable because Palisades does not use cooling ponds.
	Terrestrial Resources	
40	Refurbishment impacts to terrestrial resources	NONE. NMC has no plans for major refurbishment at Palisades.

TABLE 6.1-1 (CONTINUED)
ENVIRONMENTAL IMPACTS RELATED TO LICENSE RENEWAL OF PALISADES (CATEGORY 2 ISSUES[a])

No.	Issue	Environmental Impact
		Threatened or Endangered Species
49	Threatened or endangered species	SMALL. Other than the federally-listed Pitcher's Thistle, known to occur on undeveloped regulatory protected dune areas of the Palisade site, species of concern are not known to occur and generally have a low potential for occurrence (other than as transient individuals) in areas likely to be affected by plant and transmission line operation associated maintenance: protective design, operation, and maintenance practices are employed; no significant land-disturbing activities are planned; and operational monitoring has not indicated significant adverse impacts on species of concern. When land disturbance at the site is anticipated or planned, the site is reviewed for the presence of protected species.
		Air Quality
50	Air quality during refurbishment (nonattainment and maintenance areas)	NONE. NMC has no plans for major refurbishment at Palisades.
		Human Health
57	Microbiological organisms (public health) (plants using lakes or canals, or cooling towers or cooling ponds that discharge to a small river)	NONE. Palisades uses cooling towers and discharges cooling waters to Lake Michigan, not to a small river.
59	Electromagnetic fields, acute effects (electric shock)	SMALL. All potentially applicable circuits meet National Electrical Safety Code® requirements for limiting induced shock.
		Socioeconomics
63	Housing impacts	SMALL. No impacts are anticipated because no additional employees are expected. A bounding analysis, which assumes 60 additional employees are required during the license renewal term, indicates the need for an additional 117 housing units in an area with a population greater than 238,716 and 15,869 vacant housing units.
65	Public services: public utilities	SMALL. No impacts are anticipated because no additional employees are expected. A bounding analysis assumes the license renewal term requires 60 additional employees indicating as many as 300 new residents could move to Van Buren and Berrien Counties. This would result in an estimated increased demand of approximately 15,000 - 24,000 gallons of water per day on water systems in the two counties. This amounts to less than 1 percent of the collective excess capacities of the major water supply systems of the Van Buren County.

TABLE 6.1-1 (CONTINUED)
ENVIRONMENTAL IMPACTS RELATED TO LICENSE RENEWAL OF PALISADES (CATEGORY 2 ISSUES[a])

No.	Issue	Environmental Impact
		Socioeconomics (continued)
66	Public services: education (refurbishment)	NONE. NMC has no plans for major refurbishment at Palisades.
68	Offsite land use (refurbishment)	NONE. NMC has no plans for major refurbishment at Palisades.
69	Offsite land use (license renewal term)	SMALL. NMC's annual property tax payments for Palisades averaged less than 6.6 percent of Van Buren County's operating budget for the period 1994 through 2003. Payments to Covert Township and Covert School District averaged 41 percent and 44 percent respectively of their operating budgets for that period. Given the area's established pattern of growth, license renewal tax-driven land-use changes would generate very little new development and minimal changes in the area's land-use patterns.
70	Public services: transportation	SMALL. No impacts are anticipated because no additional employees are expected. The addition of up to 60 employees, assumed for purposes of a bounding analysis, would be less than a typical refueling outage workforce (384). Access and commuting routes are adequate to handle outage traffic.
71	Historic and archaeological resources	SMALL. No impacts to historic or archaeological resources were identified.
76	Severe accidents	SMALL. NMC identified 6 potentially cost-beneficial modifications; however, none of these are related to plant aging effects. NMC will either implement these enhancements or evaluate them further through the appropriate Palisades design process.

a. NMC adopts by reference NRC's findings for applicable Category 1 issues, all of which have SMALL impacts. No impact analyses are presented for Issue 60, "Electromagnetic Field – Chronic Effects," which has been categorized "NA" by NRC and for which the applicant is not required to provide an analysis [10 CFR 51.53(c)(3); 10 CFR 51, Subpart A, Appendix B, Table B-1] and Issue 92, "Environmental Justice," which will be addressed by NRC in plant-specific reviews [10 CFR 51, Subpart A, Appendix B, Table B-1].

Palisades = Palisades Nuclear Plant

NMC = Nuclear Management Company, LLC

gpm = gallons per minute

No. = issue number

NRC = U.S. Nuclear Regulatory Commission

6.6 REFERENCES

AEC (U.S. Atomic Energy Commission). 1972. Final Environmental Statement related to the operation of Palisades Nuclear Generating Plant, Consumers Power Company. Docket No. 50-255. Directorate of Licensing. Washington, D.C. June.

7.0 ALTERNATIVES TO THE PROPOSED ACTION

NRC

The environmental report shall discuss "Alternatives to the proposed action.…"
10 CFR 51.45(b)(3), as adopted by reference at 10 CFR 51.53(c)(2).

"...The report is not required to include discussion of need for power or economic costs and benefits of ... alternatives to the proposed action except insofar as such costs and benefits are either essential for a determination regarding the inclusion of an alternative in the range of alternatives considered or relevant to mitigation...." 10 CFR 51.53(c)(2).

"While many methods are available for generating electricity, and a huge number of combinations or mixes can be assimilated to meet a defined generating requirement, such expansive consideration would be too unwieldy to perform given the purposes of this analysis. Therefore, NRC has determined that a reasonable set of alternatives should be limited to analysis of single, discrete electric generation sources and only electric generation sources that are technically feasible and commercially viable…." (NRC 1996a, Section 8.1).

"…The consideration of alternative energy sources in individual license renewal reviews will consider those alternatives that are reasonable for the region, including power purchases from outside the applicant's service area.…" (NRC 1996b, Section II.H, page 66541).

The U.S. Nuclear Regulatory Commission (NRC) considers the environmental impacts of the proposed action (i.e., license renewal) and alternatives to the proposed action in accordance with its National Environmental Policy Act (NEPA) implementing regulations when deciding whether to approve renewal of an applicant's operating license [10 CFR 51.95(c)]. In this chapter, Nuclear Management Company, LLC (NMC) identifies reasonable alternatives to renewal of the Palisades Nuclear Plant (Palisades) operating license and presents its evaluation of associated environmental impacts. This chapter also includes descriptions of alternatives NMC considered but determined to be unreasonable to consider in detail, and associated supporting rationale.

NMC divided its alternatives discussion into two categories, "no action" and "alternatives that meet system generating needs." In Section 7.1, NMC addresses the "no-action alternative" in terms of the potential environmental impacts of not renewing the Palisades operating license, independent of any actions taken to replace or compensate for the loss of generating capacity. In Section 7.2, NMC describes feasible alternative actions that could be taken, which NMC also considers to be elements of the no-action alternative, and presents other alternatives that NMC does not consider to be reasonable. Section 7.3 presents environmental impacts for the reasonable alternatives.

The environmental impact evaluations of alternatives presented in this chapter are not intended to be exhaustive. Rather, the level of detail and analysis rely on NRC's decision-making standard for license renewal, as follows:

> "…the NRC staff, adjudicatory officers, and Commission shall determine whether or not the adverse environmental impacts of license renewal are so great that preserving the option of license renewal for energy planning decision makers would be unreasonable" [10 CFR 51.95(c)(4)].

Therefore, NMC generally structured the analyses to provide enough information to support NRC decision-making by demonstrating whether an alternative would have a smaller, comparable, or greater environmental impact than the proposed action. Additional detail or analysis was not considered useful or necessary if it would identify only additional adverse impacts of license renewal alternatives. This approach is consistent with the Council on Environmental Quality regulations, which provide that the consideration of alternatives (including the proposed action) be adequately addressed so reviewers may evaluate their comparative merits [40 CFR 1502.14(b)].

NMC characterizes environmental impacts in this chapter using the same definitions of SMALL, MODERATE, and LARGE used in Chapter 4 of this environmental report (ER) and by NRC in its *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (GEIS) (NRC 1996a, pages 1-4, 1-5). In Chapter 8 of this ER, NMC presents a summary comparison of environmental impacts of the proposed action and alternatives.

7.1 NO-ACTION ALTERNATIVE

NMC considers the no-action alternative addressed in this ER to be a scenario in which NRC does not renew the current Palisades operating license, Palisades ceases operation and is decommissioned, and Consumers Energy Company (Consumers) or others take appropriate action to replace the resulting loss of generating capacity. Section 7.1.1 addresses potential environmental impacts of terminating operations and decommissioning, exclusive of actions to replace power from Palisades. NMC discusses impacts associated with replacement power in Section 7.2 of this ER.

7.1.1 TERMINATING OPERATIONS AND DECOMMISSIONING

In the event NRC does not renew the Palisades operating license, NMC assumes the unit would be operated until its current license expires in 2011 then would be decommissioned in accordance with NRC requirements. Decommissioning, defined by NRC at 10 CFR 50.2, denotes the safe removal from service of a nuclear generating facility and the reduction of residual radioactivity to a level that permits release of the property for unrestricted or restricted use, and termination of the license. The two decommissioning options typically selected for U.S. reactors (NRC 2002, Section 3.2) are:

- immediate decontamination and dismantlement (DECON); and
- safe storage of the stabilized and de-fueled facility for a period of time, followed by decontamination and dismantlement (SAFSTOR).

Regardless of the option chosen, decommissioning methods would be described in the post-shutdown decommissioning activities report, which must be submitted to NRC within two years following cessation of operations [10 CFR 50.82(a)(4)]. Decommissioning activities must be completed within 60 years after operations cease in accordance with 10 CFR 50.82(a)(3) [NRC 2002, Section 3.2; NRC 1996a, Section 7.2]. Related NRC requirements ensure decommissioning activities, when defined, would be subject to required environmental reviews in accordance with NEPA [10 CFR 50.82(a)(4)(i) and (a)(9)(ii)(G), 10 CFR 51.53(d)].

NRC provides a summary of decommissioning activities, generic environmental impacts of the decommissioning process, and an evaluation of potential changes in impact that could result from deferring decommissioning for up to 20 years in the GEIS (NRC 1996a, Chapter 7). This GEIS analysis is based on a 1988 generic environmental impact evaluation of decommissioning, NUREG-0586 (NRC 1988), which uses the 1,175-megawatt-electric (MWe) Trojan Nuclear Plant as representative of decommissioning activities for a pressurized water reactor, the reactor type found at Palisades (see Section 3.1.2). NRC concluded in the GEIS that decommissioning would have SMALL impacts with respect to radiation dose, waste management, air quality, water quality, socioeconomic impacts and ecological resources, and that impacts would not be significantly greater as a result of the proposed action (NRC 1996a, Section 7.4; 10 CFR 51, Subpart A, Appendix B, Table B-1).

Considering the information presented in Chapter 7 of the GEIS and the fact that Palisades is a smaller unit than the GEIS reference reactor, NMC considers NRC's generic evaluation and associated conclusions in the GEIS as bounding Palisades for purposes of this ER. NRC has updated the 1988 generic environmental impact evaluation of decommissioning on which the GEIS is based. This update, Supplement 1 to NUREG-0586, expanded the original analysis by addressing impacts of dismantling structures, systems, and components required to operate the reactor and also considered characteristics of plants currently operating in the U.S. (NRC 2002, Sections 1.1, 1.3, 3.1). Of the 23 environmental issues evaluated in this updated analysis, NRC concluded that the following were site-specific: impacts on land use from offsite activities; impacts on aquatic and terrestrial ecology and cultural and historic resources from activities beyond operational areas; impacts on threatened and endangered species; and environmental justice impacts. NRC concluded that all of the remaining issues were generic with SMALL impacts (NRC 2002, Table ES-1).

Based on its review of Supplement 1 to NUREG-0586, NMC considers these generic conclusions to be appropriate for Palisades for purposes of this ER. With respect to those environmental issues identified as site-specific:

- NMC has no reason at this time to believe Palisades decommissioning would involve significant land use disturbance off site or beyond current operational areas.
- Decommissioning activities would be subject to substantial environmental reviews as noted above.
- No significant historic or archaeological resources are known to occur on the site (see Section 2.10 of this ER).
- Potential for significant impacts to threatened or endangered species would be low considering their occurrence in the site area (see Section 2.3.3 of this ER). NMC assumes special precautions would be taken as needed to ensure protection of Pitcher's thistle, which occurs onsite (see Section 2.3.3.2 of this ER).

In consideration of the above, NMC concludes that impacts of Palisades decommissioning activities would be SMALL for all environmental issues evaluated in this ER.

NMC notes that decommissioning activities and their impacts, discussed above, are not discriminators between the proposed action and the no-action alternative. License renewal would only postpone decommissioning for 20 years, and NRC has established in the GEIS that the timing of decommissioning operations does not substantially influence the environmental impacts of decommissioning. NMC adopts by reference NRC findings that the impacts of delaying decommissioning until after the renewal term would be SMALL (10 CFR 51, Appendix B, Table B-1).

Environmental impacts that could result more directly from terminating plant operations, as opposed to impacts from the decommissioning process itself, (e.g., from cessation of thermal effluents, reduced property tax payments, workforce reductions) are not in the scope of the analyses presented in Chapter 7 of the GEIS or in Supplement 1 to NUREG-0586 (NRC 2002, 1996a). However, impacts of terminating plant operations are discussed in Section 8.4 of the GEIS and in Section 4.3.12 of Supplement 1 to NUREG-0586. With the potential exception of ecological resources and socioeconomics, NRC's generic evaluation of these issues indicates environmental impacts of terminating operations would be SMALL (NRC 1996a, Section 8.4). Based on its review of the discussion in these documents and information presented in this ER, NMC considers NRC's generic evaluation and conclusions in Section 8.4 of the GEIS to be appropriate for Palisades. With particular respect to ecological resources and socioeconomics impacts:

- NMC expects terminating Palisades operations would have little, if any, adverse effect on ecological resources, considering occurrence and habitat affinities of threatened or endangered species (see Section 2.3 of this ER), possible impact initiators (e.g., cessation of thermal discharge), small significance of operational impacts (see Chapter 4 of this ER), and the expectation that transmission lines from Palisades addressed in this ER would continue to be used (see Section 3.1.4 of this ER).

- NMC notes terminating Palisades operations would result in a decrease in tax revenues to local jurisdictions 20 years sooner than if the Palisades operating license were renewed. Property tax payments attributable to Palisades represents over 30 percent of total revenues and operating budgets for Covert Township and the Covert School District (see Section 2.7, Table 2.7-1 of this ER), and NRC criteria (NRC 2002, Section 4.3.12.3) indicate that losses over 20 percent are destabilizing. NMC notes also that areas comprising or within these jurisdictions qualify by NRC criteria as areas with low-income and minority populations (see Section 2.5.3; Figures 2.5-2, 2.5-6 of this ER).

In consideration of the above, NMC concludes terminating Palisades operations could result in LARGE impact with respect to socioeconomics from loss of tax revenues by Covert Township and the Covert School District 20 years earlier than would occur if the Palisades operating license is renewed. NMC further concludes terminating operations and decommissioning Palisades would result in SMALL impacts with respect to the remaining resource areas evaluated, providing little or no basis for discriminating between the proposed action and the no-action alternative. The environmental impacts of replacement options considered in Section 7.3 provide substantial additional information useful for evaluating the relative environmental merits of the proposed action versus the no-action alternative.

7.1.2 REPLACEMENT CAPACITY

Palisades has a net generating capability of approximately 786 MWe (see Section 3.1.2 of this ER). In 2003, Palisades generated approximately 6,200,000 megawatt-hours (MWh) of electricity, approximately 22 percent of Consumers' total electricity generation in that year (EIA 2004a). This power, equivalent to the annual electric power usage of approximately

775,000 of Consumers' Michigan residential customers, would be unavailable in the event the Palisades operating license is not renewed. Replacement options considered include building new generating facilities, delaying retirement of non-nuclear assets, and reducing power requirements through demand reduction, all discussed in Section 7.2.

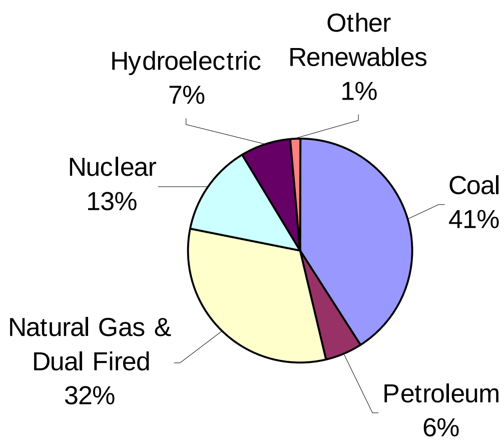
7.2 ALTERNATIVES THAT MEET SYSTEM GENERATING NEEDS

In Section 7.2.1, NMC provides background information pertinent to the identification and selection of alternatives available to replace Palisades generating capability. Alternatives NMC considers to be reasonable alternatives are described in Section 7.2.2. Section 7.2.3 describes other alternatives NMC evaluated and rationale for not considering them further in this ER.

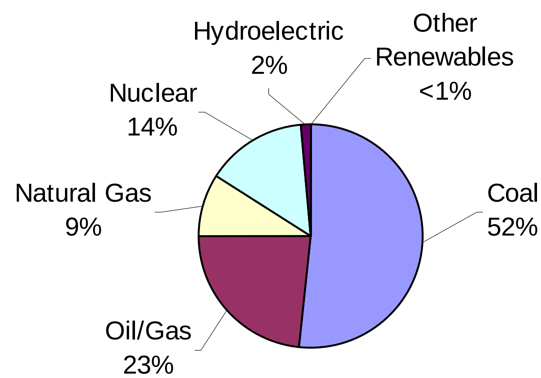
7.2.1 GENERAL CONSIDERATIONS

7.2.1.1 Current and Projected Generating Capability and Utilization

Current and anticipated future electric power generating capability and utilization are indicative of the technical and economic viability of technologies for generating electricity, and therefore are indicative of potentially reasonable alternatives to replace power produced by Palisades. As illustrated by the following graphs, the generating capacity of Michigan's electric utility industry as a whole and Consumers in particular consists mostly of coal, natural gas and dual-fired, and nuclear units. Renewables (i.e., conventional hydroelectric, wind, solar, biomass, other) and petroleum represent relatively small capacity shares.

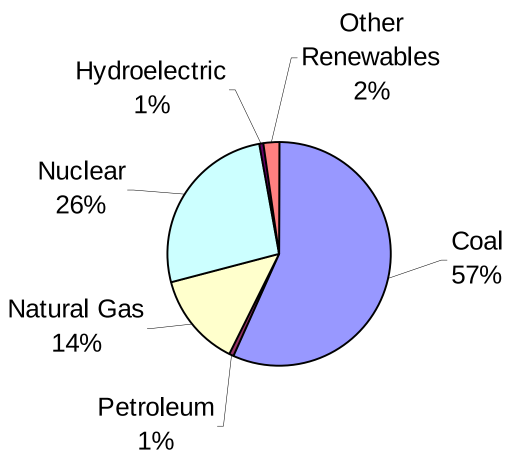


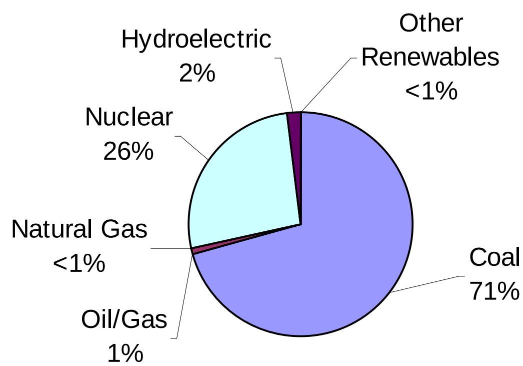
2002 Michigan Electric Industry Capacity (EIA 2004b)



2002 Consumers' Capacity

Comparison of generating capacity by type with actual utilization of this capacity as illustrated below indicates preferential use of coal-fired and nuclear plants to generate electricity in Michigan, and is reflective of relatively low operating cost and suitability of these technologies for continuous (base-loaded) operation. Coal-fired units, for example, represent 41 percent of the installed statewide capacity, but produced 57 percent of the electric power generated in Michigan in 2002. Similarly, nuclear units comprised only 13 percent of statewide generating capacity in 2002, but provided 26 percent of the power generated. Utilization of fossil-fueled generating capability other than coal (i.e., gas and oil) is relatively low, reflecting relatively high fuel costs for oil and natural gas and use of these fuels primarily as needed to meet peak loads. Specifically, natural gas and oil-fired facilities, which together account for approximately 38 percent of generating capacity in Michigan, produced only approximately 15 percent of state-





2002 Michigan Electric Industry Utilization (EIA 2004b)

2002 Consumers' Utilization

wide generation in 2002; this differential is even more pronounced for Consumers' generating assets.

Nonetheless, natural gas-fired capacity and utilization in Michigan has increased by an average annual rate of 15.1 percent and 5.2 percent, respectively, during 1993-2002 (EIA 2004b, Tables 4 and 5). Further, all merchant power plant capacity announced or under construction in the state as of August 2004 (totaling 11,795 MW, most of which has been delayed) consists of natural gas-fueled facilities (MPSC 2004a).

Further insight into Michigan's future generation portfolio can be gained by referencing U.S. Department of Energy (DOE) Energy Information Agency (EIA) projections for the nation and the East Central Area Reliability (ECAR) Coordination Agreement region, which includes the southern peninsula of Michigan (NERC 2004). Coal-fired generation is expected to remain the predominant source of electricity through 2025 and the relative amount of generation from natural gas and coal is expected to increase. Aggregate generation from nuclear plants is expected to remain near present levels, with no new facilities expected as a result of relatively favorable economics of competing technologies (EIA 2004c, page 6; EIA 2004d, Table 60). Generating capacity from combined-cycle units for the period 2004-2025 is projected to increase by 21,000 MW (162 percent) in the ECAR region (EIA 2004d, Table 60). Generation from renewable sources nationally is expected to exhibit relatively slow growth because of the relatively low costs of fossil-fired generation and because competitive electricity markets favor less capital-intensive technologies (EIA 2004c, page 6). The increase in generating capacity from renewable sources in the ECAR region is projected to total only 120 MW and 600 MW in the 2004-2011 and 2004-2025 time periods, respectively (EIA 2004d, Table 60). As a whole, projected increase in generating capacity in the ECAR region for the 2005-2013 period totals 8,702 MW, comprised of coal-fired steam units (2,505 MW), gas-fired combustion turbines (1,658 MW), and gas combined-cycle units (4,014 MW) (ECAR 2004, Table 1).

In conclusion, current and projected capacity and utilization data for Michigan and the ECAR region support the view that coal-fired and natural gas-fired combined-cycle generating units would be reasonable and feasible generating technology choices to replace Palisades capacity.

7.2.1.2 Electric Power Industry Regulation

The U.S. electric power industry began its transition from a regulated monopoly structure to a competitive retail market with the passage of the federal Energy Policy Act of 1992 and associated state initiatives. As summarized by the EIA, the Federal Energy Regulatory Commission (FERC) Order 888 requires that all public utilities provide open access to their transmission lines and functionally separate their wholesale power services and transmission services. This order also encourages the creation of independent system operators (ISOs) to ensure independence in transmission operations (EIA 2004e; FERC 2002). Order 889 prevents public utility power marketing organizations from having preferential access to transmission information, and requires that such information be equally shared with transmission customers. FERC Order 2000 encourages all transmission owners to voluntarily allow operation of their transmission assets by independent Regional Transmission Operators (RTOs) to improve market performance and equal access (FERC 2002).

In the wake of these federal initiatives, almost half the states, including Michigan, have passed major legislation and/or regulations to restructure their electric power industry (EIA 2004e). The process of restructuring Michigan's electric industry began with enactment of Public Acts (PA) 141 known as the "Customer Choice and Electricity Reliability Act." The Act, implemented under orders of the Michigan Public Service Commission, introduced electric competition by offering Michigan customers the opportunity to purchase their electric generation services from their choice of supplier at unregulated prices (MPSC 2004b). Full open access for customers of Michigan investor-owned utilities was initiated under PA 141 on January 1, 2002. PA 141 also required that all investor-owned electric utilities in Michigan join a FERC-approved RTO or divest transmission assets to an independent transmission owner (MPSC 2004b, pages 3 and 11).

The current status of electric generation and transmission in Michigan as described by the Michigan Public Service Commission (MPSC) reflects these initiatives. In 2003, electric generating capacity in Michigan totaled 30,643 MW, of which 80 percent was utility capacity; non-utility suppliers and cogeneration facilities accounted for 14 percent and 6 percent of the total capacity, respectively (MPSC 2004b, Table 3). All transmission assets formerly owned by CMS Energy (Consumers' parent company) are now part of the Midwest ISO (MISO), which operates transmission networks in Michigan and several other midwestern states (MPSC 2004b, Section 2; MISO 2004). These include the transmission lines that connect to the Palisades Substation, which are now owned by Michigan Electric Transmission Company, LLC (METC) (METC 2004; see Section 3.1.4 of this ER).

The MPSC, under provisions of the Michigan Compiled Laws 460.6, 460.502, and 460.565, and MPSC Rule R 460.868, exerts control over the development of major transmission lines, natural gas pipelines, and most public utility power plants (municipal plants, merchant plants, and certain renewable resource power production facilities with capacity less than 30 MWe excepted) by requiring a Certificate of Public Convenience and Necessity before construction and operation. Activities related to all such facilities would be subject to applicable federal, state and local environmental laws and regulations.

7.2.1.3 Mixtures

NRC indicated in the GEIS that, while many methods are available for generating electricity and a huge number of combinations or mixes can be assimilated to meet system needs, such expansive consideration would be too unwieldy given the purposes of the alternatives analysis. Therefore, NRC determined that a reasonable set of alternatives should be limited to analysis of single discrete electrical generation sources and only those electric generation technologies that are technically reasonable and commercially viable (NRC 1996a, page 8-1). Consistent with NRC determination, NMC has not evaluated mixes of generating sources; however, the impacts from all coal- or all gas-fired generation presented in this chapter are expected to bound impacts from any generation mixture of the two technologies.

7.2.2 FEASIBLE ALTERNATIVES

In view of the background information presented in Section 7.2.1 and additional information presented in this section, NMC considers that purchased power and new generating capacity represented by modern natural gas combined-cycle and pulverized coal-fired steam technologies are reasonable alternatives to replace Palisades generating capacity in the event its operating license is not renewed. NMC describes these alternatives in the following subsections as reasonable hypothetical scenarios for analysis without regard to whether they would be actually developed by Consumers or others.

7.2.2.1 Purchased Power

Michigan has undertaken electric industry restructuring initiatives promoting competition in retail energy markets by allowing participation of non-utility suppliers and providing retail customers the option to choose between Consumers and other state-qualified alternative energy suppliers (see Section 7.2.1.2). In addition, projections indicate that ECAR is demonstrating continued ability to maintain sufficient capacity reserves, as discussed below. Therefore, NMC assumes for the purposes of this ER that purchased power would be a reasonable alternative to replace power lost in the event the Palisades operating license is not renewed.

Because of the size of the block of base-load capacity supplied by Palisades, construction of additional generating capacity would likely be required even under the power purchase scenario, but such construction could occur within or outside of the ECAR region. The technologies that would be used to generate the purchased power are a matter of conjecture, but the most likely candidates would be coal-fired options during off-peak periods and gas-fired options during on-peak periods. NMC assumes the GEIS descriptions of generating technologies to be appropriately representative.

Consumers expects that the purchased power to replace Palisades would most likely be sourced somewhere south of Michigan and NMC assumes this scenario for the purchase power alternative. Due to the large transmission network of American Electric Power (AEP) and the configuration of the transmission systems south of Michigan, Consumers expects that most of this power would enter Michigan on the four 345 kV lines connecting METC's transmission system with AEP. At least one, possibly two, additional 345 kV lines connecting the METC system to a southern transmission system like AEP would be required to accommodate an additional 780 MW of power importation. A potentially viable alternative is to extend AEP's 765-kV system that terminates in southwestern Michigan, probably somewhere near Kalamazoo (see Figure 2.1-1). Some right-of-way (ROW) has been purchased in southwestern Michigan for future lines like these; however, the extent to which such land would be used for power importation in this case is conjectural.

In view of these considerations, NMC assumes 40 miles of new 345-kV transmission line on a previously undeveloped, undedicated 150-foot ROW would be required for this alternative. This development would be subject to substantial environmental review and approvals. In particular, utilities intending to construct a 345-kV line within Michigan 5 miles or more in length must obtain a Certificate of Public Convenience and Necessity from the MPSC under provisions of Michigan's Electric Transmission Line Certification Act (Act 30 of 1995), and the proposed line must comply with all applicable state and federal environmental standards, laws, and rules. Since Palisades is one of two large base-load 345-kV connected generators controlling voltage in western Michigan, METC also may have to install some form of a dynamic voltage control device (like a flexible AC transmission device) in western Michigan in the event Palisades ceases operation and replacement power is imported. However, considering the nature of these facilities and associated small land requirement and flexibility in location, NMC assumes that no significant environmental impacts would be associated with development or operation of such a facility.

7.2.2.2 Representative Natural Gas-fired Generation

For purposes of this analysis, NMC assumes development of a modern natural gas-fired combined-cycle plant similar to others being planned or developed in Michigan (e.g., the Covert Generating Plant; see Section 2.1.1) that could be readily configured as a baseload facility to replace power currently generated by Palisades. Basic design and operating assumptions are listed in Table 7.2-1. The assumed representative plant consists of two standard units, one of which is comprised of two 171 MW steam combustion turbines (CTs) with associated heat recovery steam generators (HRSGs) that supply steam to a 196 MW steam turbine generator, and the second comprised of a single 171 MW CT and associated HRSG that supplies steam to a 96 MW steam turbine. This configuration provides a combined gross generating capacity of 805 MWe and net generating capacity of 793 MWe, comparable to the Palisades net capacity.

NMC assumes for conservatism that the representative plant would use natural gas as its only fuel. However, the facility reasonably could be constructed with capability to fire oil as a backup fuel for use during high demand periods for natural gas, thus improving fuel supply capabilities and operating cost. Based on the information presented in Table 7.2-1, total annual heat input from natural gas would be approximately 38,960,000 million British thermal units (MMBtu) per year, corresponding to natural gas consumption of approximately 38.4 billion cubic feet per year.[1] The facility would be designed to meet applicable standards with respect to control of air and wastewater emissions. As a minimum, NMC assumes that the plant would feature water/steam injection to minimize formation of nitrogen oxides (NOx) during combustion, and selective catalytic reduction for post-combustion NOx control. NMC assumes emissions of particulate matter and carbon monoxide (CO) would be limited through proper combustion controls. Exhaust from the CTs would be dispersed through individual stacks for each of the three HRSGs, which NMC assumes would be approximately 160 feet high. For purposes of siting flexibility and simplicity in the analysis, NMC assumes that the plant would feature a closed-cycle cooling system that uses mechanical draft cooling towers. Cooling water intake, evaporative losses, and discharge flows for the plant would be substantially less than that of Palisades, primarily because only about one-third of its power is derived from a steam cycle.

For a greenfield location, NMC estimates that a minimum of approximately 30 acres would be required to accommodate the combined-cycle plant. Additional land for buffer would also likely be required. For example, NRC estimates that 110 acres would be required for a somewhat larger (1,000 MW) plant (NRC 1996a, Table 8.1).

NMC estimates the plant would be constructed in approximately 3 years with average and peak onsite workforces of approximately 240 and 420 workers, respectively. Operation of the completed plant is expected to require a permanent workforce of approximately 30 persons.

7.2.2.3 Representative Coal-fired Generation

The specific coal generating technologies that would represent viable alternatives in 2011, when the Palisades operating license expires, are less certain than for a natural gas-fired plant, particularly in view of potentially higher air emissions. Integrated gasification combined-cycle (IGCC) technology could prove to be technically feasible and commercially viable alternative to pulverized coal by 2011; coal gasification and combined-cycle technologies are each well demonstrated. However, Consumers considers IGCC, the combination of these technologies to produce electricity, to be not yet fully demonstrated, and also considers it unlikely that the long-

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1 Annual Natural Gas Requirement (Btu) = [Natural Gas Heat Input] x [Heating Value of Fuel] = [Total Gross Capability (805 MW) x Heat Rate (6,500 Btu/kW-hour) x 1,000 kW/MW x Capacity Factor (0.85) x 8,760 hr/yr] Therefore: Natural Gas Heat Input = 3.896×10^{13} Btu/yr, or 3.896×10^{7} MMBtu/yr. Volume of gas required per year = Annual Natural Gas Requirement (Btu) x [Heating Value of Fuel (1 scf/1,014 Btu)] = 3.842×10^{10} scf/yr, or 38.4 billion scf^3/yr. Table 7.2-1 lists all necessary parameters and values.

term reliability of IGCC will be known by the time a decision needs to be made regarding the replacement of Palisades capacity. Consumers recognizes proven, economically competitive, and commercially viable modern pulverized coal plants with advanced, clean-coal technology air emission controls in large-capacity unit sizes as an alternative that could effectively replace Palisades. Therefore, NMC uses a representative plant of this type for purposes of impact evaluation, noting that air emissions impacts of IGCC may be lower than modern pulverized coal, but likely would be comparable to or higher than the gas-fired combined-cycle alternative (DOE 1999, page 7).

Table 7.2-2 lists basic specifications for a representative coal-fired plant. The representative plant consists of two commercially available standard-sized units, each having a nominal net output of approximately 400 MW. The combined net capability of the units would be comparable to Palisades' net capacity. Consistent with the representative gas-fired plant alternative, NMC assumes the representative coal-fired plant would use closed-cycle cooling with cooling towers. Based on this information, annual coal consumption for the facility would be approximately 3.2 million tons.[2] The facility would be designed to meet applicable standards with respect to control of air and wastewater emissions. As a minimum, NMC assumes that the plant would feature low-NOx burners with overfire air to minimize formation of NOx, and selective catalytic reduction for post-combustion NOx control. NMC assumes emissions of particulate matter would be limited by use of a fabric filter (baghouse) and some sort of sorbent injection system, and SOx emissions would be controlled using a scrubber with limestone as the reagent. NMC estimates that approximately 46,000 tons of limestone would be needed annually for scrubber operation. Exhaust would be dispersed through stacks approximately 500 feet high, assuming application of good engineering practice on the basis of a boiler building height of approximately 200 feet [40 CFR 51.100(ii)].

NMC estimates that approximately 360 acres would be required to accommodate the generating plant and related onsite ancillary and support facilities and infrastructure (e.g., coal and limestone transport, storage, and handling facilities; switchyard and onsite transmission lines; storage tanks; cooling towers; technical and administration buildings; access roads; parking). Additional land would be required to dispose of solid waste from the plant's air emissions control systems (i.e., ash and flue gas desulfurization waste). Consumers estimates that, of this waste, approximately 85 percent of the ash could be marketed, and NMC assumes for this ER that the remainder of this air emission control waste would be landfilled onsite. Assuming an average fill depth of 30 feet, approximately 100 acres would be required over an assumed 40-year plant life. Therefore, the minimum total land requirement for the plant is assumed to be approximately 460 acres. Additional land could be necessary to allow for a peripheral buffer. For example, NRC estimates that a total of 1,700 acres could be required for a slightly larger (1,000 MW) plant (NRC 1996a, Table 8.1).

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2 Coal Combusted (tons/year) = Total Gross Capability (900 MW) x Heat Rate (9800 Btu/kilowatt-hour) x 1,000 kilowatt/MW x 1/Fuel Heat Value (10,359 Btu/lb) x 0.0005 (ton/lb) x Capacity Factor (0.85) x 8,760 hr/year = 3.2 million tons/yr. All necessary parameters and values are provided in Table 7.2-2.

NMC assumes the plant could be constructed in approximately 5 years with average and peak onsite workforces of approximately 600 and 1,500 workers, respectively. Depending on the level of automation, a permanent work force of 75-120 full-time employees would likely be required to operate the plant.

7.2.2.4 Siting Considerations

NMC does not consider the Palisades site to be a reasonable location for either the representative gas-fired or coal-fired plant because of topographic, regulatory, and land-use constraints. Undeveloped area on the site consists predominantly of very rugged topography (dunes) unsuited to practical development, most of which is afforded protection as designated Michigan Critical Dunes Areas (see Figure 2.1-3). The most suitable area for plant development from a topographic standpoint lies in the northeast quadrant of the site, consisting of a contiguous tract of approximately 30 acres and some additional relatively level land between that area and the Palisades Substation that could readily accommodate an onsite transmission corridor. This area would be only marginally sufficient for the gas-fired representative plant, which NMC estimates would require approximately 30 acres for plant facilities and onsite transmission corridor, and would be much too small to accommodate the coal-fired alternative plant.

Siting an alternative plant on the Palisades site is also unlikely considering the entire site is designated by Covert Township as an Environmentally Sensitive Area and limited buffer would be available between the operating facility and the adjacent Van Buren State Park (see Section 2.3.2.4 and Figure 2.1-3 of this ER). While neither the township ordinance nor the proximity to the park would necessarily preclude development of the representative gas-fired plant onsite, Consumers and NMC view this option as holding a higher potential for adverse impact than other potentially viable locations.

Given these considerations, NMC assumes as a primary alternative that the representative gas-fired or coal-fired plant alternative would be located elsewhere at a greenfield location. NMC has not identified a specific site that would be suitable for the representative plant alternatives. However, key considerations for a cost-competitive site include proximity to adequate natural gas supply for the natural gas-fired plant or rail for the coal-fired plant, transmission infrastructure, cooling water, and sufficient land suitable for development. Based on plans for or actual development of new power plants in southern-lower Michigan (MPSC 2004a), NMC assumes that a suitable location could be found in the region. NMC acknowledges as a secondary option that a plant potentially could be sited at an existing power plant site to maximize use of land and infrastructure already dedicated for power generation and thereby potentially minimize impact on land use and other resources.

Offsite infrastructure needed to locate either plant at a greenfield site is conjectural. NMC assumes that 5 miles of new natural gas supply pipeline would be needed to supply the gas-fired plant and 10 miles of new rail would be required for delivery of coal and limestone to the coal-fired plant. In addition, NMC assumes 5 miles of new 345-kV transmission line would be needed to connect either plant to the grid. NMC assumes that the pipeline or rail spur would require 50-foot wide ROWs and that the transmission line would occupy a 150 foot wide ROW. Offsite infrastructure for the representative plant located at an existing power plant site is also site dependent, but the potential need for offsite infrastructure is likely to be less than for a greenfield site, particularly if the representative plant represents an expansion of technology that already exists at the site.

As indicated by discussion elsewhere in this ER, the location and design of the alternative plant and offsite infrastructure would be subject to substantial environmental restrictions and review, particularly at the state and local level. Therefore, NMC assumes that the representative plant and associated offsite infrastructure would be sited, developed, and operated in accordance with all applicable environmental requirements and in a manner that ensures adverse environmental impacts would not be destabilizing with respect to resources of concern.

7.2.3 OTHER ALTERNATIVES CONSIDERED

In this section, NMC describes alternatives other than purchasing power and developing new coal- or natural gas-fired generation. The following discussion presents the reasons why NMC does not consider these alternatives to be reasonable or feasible for purposes of this evaluation.

7.2.3.1 Other Generation Alternatives

In addition to coal-fired and natural gas-fired generation, NRC evaluated several other generation technologies in the GEIS (NRC 1996a, Chapter 8.0). NMC has considered these options as potential alternatives to continued operation of Palisades and determined them to be unreasonable on the basis of economics, high land-use impacts, low capacity factors, geographic limitations, insufficiently developed technology, or other reasons. Table 7.2-3 summarizes the results of the review.

7.2.3.2 Delayed Retirement of Existing Non-nuclear Units

Extending the lives of existing non-nuclear generating plants beyond the time they were originally scheduled to be retired represents another potential alternative to license renewal (NRC 1996a, Section 8.3.13). However, delaying retirement in order to compensate for Palisades would be unreasonable without major construction to upgrade or replace plant components. This action does not represent a realistic option with respect to Consumers' generating assets. NMC expects that the environmental impacts of implementing such actions are reasonably bounded by assessments presented in this chapter for the gas-fired and coal-fired alternatives.

7.2.3.3 Demand-Side Management

There are a wide variety of conservation technologies (i.e., demand-side management, or DSM) that could be considered as potential alternatives to generating electricity at Palisades. Examples of these conservation options include:

- Conservation Programs – homeowner agreements to limit energy consumption; educational programs that encourage the wise use of electricity.
- Energy Efficiency Programs – discounted residential rates for homes that meet specific energy efficiency standards; programs providing residential energy audits and encouraging efficiency upgrades; incentive programs used to encourage customers to replace older inefficient appliances or equipment with newer, more efficient versions.
- Load Management Programs – programs that encourage customers to switch load to customer-owned standby generators during periods of peak demand; programs that encourage customers to allow a portion of their load to be interrupted during periods of peak demand.

Market conditions that provided the initial support for utility-sponsored conservation and load management efforts during the late 1970s and early 1980s can be broadly characterized by:

- increasing long-term marginal prices for capacity and energy production resources;
- forecasts projecting increasing demand for electricity across the nation;
- general agreement that conditions (1) and (2) would continue for the foreseeable future;
- limited competition in the generation of electricity;
- economies of scale in the generation of electricity, which supported the construction of large central power plants; and
- the use of average embedded cost as the basis for setting electricity prices within a regulated context.

However, market changes have significantly impacted the cost-effectiveness of utility-sponsored DSM. Among the factors most responsible are declining generation costs and national and state energy legislation encouraging wholesale and retail competition. Other significant changes include the adoption of increasingly stringent national appliance standards for most major energy-using equipment and the adoption of energy efficiency requirements in state building codes. Finally, energy services and products are increasingly being offered in competitive markets at prices that reflect their value to the customer. Market conditions can be expected to continue this shift among providers of cost effective load management.

In the past, Consumers had a variety of DSM programs offered to residential, commercial, and industrial customers. However, these programs were largely discontinued due to the implementation of deregulation. Consumers does maintain a peak load management program, but the intent of the program is to maintain system reliability during peak loads, not to encourage a decrease energy demand. Since DSM programs have been displaced by deregulation and competition, and in any event only mitigated load growth and did not eliminate the need for existing facilities, DSM is not considered a reasonable alternative for replacing the 786 MWe of net capacity from Palisades, beginning in 2011 and continuing another twenty years.

7.3 ENVIRONMENTAL IMPACTS OF ALTERNATIVES

NMC evaluations of environmental impacts for the feasible replacement power alternatives are presented in the following sections. Section 7.3.1 addresses impacts of the purchased power alternative. Sections 7.3.2 and 7.3.3 address impacts associated with the natural gas-fired and coal-fired representative alternatives, respectively. Chapter 8 presents a summary comparison of the environmental impacts of license renewal and the alternatives discussed in this section.

The evaluations presented below focus on the impacts specific to these alternatives. Impacts associated with terminating operations and decommissioning Palisades (i.e., base case, Section 7.1.1 of this ER) are expected to be of SMALL significance for all resource areas addressed except socioeconomics; therefore, these generally are not further discussed. However, conclusions expressed below regarding the significance of impact for each alternative denote the total expected impact for each resource area, inclusive of the base case. The influence of the base case on these conclusions is noted where appropriate.

The new generating plants addressed in Sections 7.3.2 and 7.3.3 would not be constructed only to operate for the period of extended operation of Palisades. Therefore, NMC assumes for this analysis a typical design life of 30 years for the combined-cycle natural gas-fired plant and 40 years for the coal-fired plant, and considers impacts associated with operation for the entire design life of the units in this analysis. As discussed in Section 7.2, NMC assumes that construction of these plants would be phased to provide replacement capacity in 2011 when the operating license for Palisades expires.

7.3.1 PURCHASED POWER

As noted in Section 7.2.2.1 of this ER, NMC assumes that the generating technology employed under the purchased power alternative would be one of those that NRC analyzed in the GEIS (NRC 1996a, Section 8.3). NMC is adopting by reference NRC analysis of the environmental impacts from those technologies. Therefore, under the purchased power alternative, environmental impacts associated with developing any new generation required would still occur, but would be located elsewhere in the region, the U.S., or Canada. For purposes of comparative analysis, NMC assumes these generation-associated adverse impacts would be no greater than are identified in this ER for the gas-fired and coal-fired representative plant.

NMC assumes that 40 miles of new 345-kV transmission on a previously undeveloped 150-foot wide ROW, potentially affecting approximately 730 acres, would be required to import purchased power. Considering the nature of transmission line development and mitigation available, impacts of greatest concern are those related to changes in land use, terrestrial ecological communities, and aesthetics.

Based on regional characteristics (see Sections 2.1.1, 2.3.3), NMC expects land use and habitats most affected by transmission line development would consist of agricultural land and early successional plant communities interspersed with forested tracts. Development of the transmission line would limit development of future incompatible land uses on the ROW, but agricultural practices, for the most part, could continue. Similarly, habitat values on agricultural land traversed by the line, though small, would be little affected. Some clearing of forest and shrubland, some of which may qualify as wetlands, would also likely be required; however, these habitats are regionally abundant (see Sections 2.1.1, 2.3.3). NMC expects that site location and routing of the linear facilities could be accomplished such that there would be little or no adverse impact on important habitats and associated important species. Maintenance of ROW areas as open (herbaceous and shrub) habitats can be advantageous to species with affinities for habitats in the early successional stage. In limited cases, naturally occurring herbaceous habitats (e.g., prairie habitats) may not be incompatible with transmission ROWs (see Section 2.3.3.2).

Some visual impairment of the rural landscape would result from development of the transmission line. However, the topography throughout most of the southern peninsula of Michigan is slightly rolling and forested tracts are common, both of which act to reduce the viewshed and limit potential for impairment of visual aesthetics. In addition, the presence of transmission lines is not out of character for the existing rural southern-lower Michigan landscape.

Finally, NMC assumes for this analysis that routing and design of the line would be subject to strict environmental scrutiny and would be established on the basis of empirical studies that ensure potential adverse impacts to land use, ecological resources, aesthetics, and other resources were appropriately considered. On the basis of these considerations, NMC concludes that the associated impacts of the transmission line would be SMALL to MODERATE with respect to land use, ecological resources, and aesthetics, and that impacts to remaining resources would be SMALL.

Considered together with impacts of the no action “base case” (terminating operations and decommissioning Palisades), the purchased power alternative could result in potentially LARGE adverse impacts to Covert Township and the Covert School District from the loss of tax revenues 20 year sooner than if the Palisades operating license were renewed (see Section 7.1.1 of this ER).

7.3.2 GAS-FIRED GENERATION

Potential moderate and large impacts associated with NMC’s natural gas-fired representative alternative are addressed in the following subsections by resource category, followed by a discussion of impacts for remaining resource categories.

Land Use

NMC assumes for this analysis that the representative gas-fired plant facilities would occupy approximately 30 acres of a 110-acre greenfield site in southern-lower Michigan. In addition to acres needed for plant facilities, approximately 120 additional acres would be potentially affected offsite from pipeline and transmission line development (see Sections 7.2.2.2, 7.2.2.4 of this ER). Although potential impacts on land use would be location specific and therefore conjectural for a greenfield site, NMC expects plant development would likely involve conversion of approximately 30 acres of rural agricultural land and/or natural plant communities abundant in the region to industrial use. NMC assumes current non-conflicting land uses on the balance of the plant site (e.g., agriculture) would remain unaffected and provide appropriate buffer with respect to any highly incompatible land uses (e.g., residential development). Development of offsite infrastructure (i.e., transmission line, gas pipeline) would similarly limit development of future incompatible land uses, but agricultural practices could, for the most part, continue on the associated ROWs. Considering also that land use impacts would be addressed in siting and designing these facilities, NMC concludes that land use impacts could range from SMALL to MODERATE, depending on site-specific factors.

Development of the representative plant at an existing power plant site would represent the expansion of existing land use, and associated land use impact likely would be SMALL. However, additional transmission lines or a natural gas supply pipeline could be required at some sites. Associated land use impacts would depend on numerous factors, including the extent to which existing ROWs could be used. Under the assumptions of this analysis, NMC concludes that associated land use impacts would be SMALL to MODERATE.

Air Quality

Potential for adverse impacts to air quality from a fossil-fueled power plant are substantially different from those of a nuclear power plant. The combustion process results in emissions of criteria pollutants including NOx, SO_2, CO, and particulates, as well as carbon dioxide (CO_2), an unregulated "greenhouse gas" implicated as a potential contributor to climate change. Natural gas contains very little sulfur and other contaminants present in coal and oil, and is inherently a relatively clean-burning fossil fuel (EPA 2000a, Sections 1.1 and 1.4).

Based on emission factors and estimated efficiencies for emission controls cited by the EPA (EPA 2000a) and assumed design parameters listed in Table 7.2-1, operation of

the plant would result in the following annual air emissions for criteria pollutants.[3] 190 tons of NOx, 12 tons of SO_2, 37 tons of particulates having a diameter of less than 10 microns (PM_{10}),

3 Annual emissions of regulated air pollutants calculated as follows from natural gas heat input and EPA estimates of uncontrolled air emissions and removal efficiencies: Annual Emissions (tons/yr) = Natural Gas Heat Input (3.896 × 107 MM Btu) × Uncontrolled Emissions (16/MM Btu) × 0.0005 (ton/lb × [100 – removal efficiency (%)]. Removal efficiencies for SO_x, CO, and PM_{10} are assumed to be zero.

and 292 tons of CO. These emission rates are relatively low. Nonetheless, emissions from the plant would result in some impairment of local air quality and would contribute to increased regional concentrations of other criteria pollutants listed above and CO_2. Considering that the plant would be subject to regulatory controls, NMC concludes that the overall impact on air quality from this alternative would be noticeable but not destabilizing, a characteristic of MODERATE impact, regardless of locations considered in this ER.

Ecological Resources

NMC expects that development of the representative plant at a greenfield site would likely result in the loss of 30 acres of terrestrial habitat for onsite plant facilities, and modification of 120 acres of ROW in existing offsite terrestrial habitat for a new natural gas supply pipeline and transmission line. NMC expects that terrestrial habitats most likely to be affected and impacts associated with construction and maintenance activities on the ROWs would be similar to those previously described for the purchased power alternative.

The most significant potential impacts to aquatic communities relate to operation of the cooling water system. However, the cooling system for the plant would be designed and operated in compliance with the Clean Water Act (CWA), including National Pollutant Discharge Elimination System (NPDES) limitations for physical and chemical parameters of potential concern and provisions of CWA Sections 316(a) and 316(b), which are respectively established to ensure appropriate protection of aquatic communities from thermal discharges and the location and operation of cooling water intakes. Moreover, the cooling water intake and discharge flows would be less than for Palisades, the impact from which is considered to be SMALL (see Sections 4.1.1 and 4.3 of this ER).

In view of these considerations and assumptions of this assessment, NMC expects that impacts on ecological resources would be apparent only locally, and would not significantly alter any important attribute of the resource, consistent with NRC's definition of SMALL impact significance. However, considering the uncertainties associated with greenfield development, NMC concludes that impacts on ecological resources could be of SMALL to MODERATE significance.

Impacts on ecological resources from development of the representative plant at an existing power plant site and associated offsite infrastructure would be similar in nature to that described for the greenfield site option. There is reasonable probability that plant facilities could be located on partly developed or highly disturbed areas with little habitat value. However, offsite infrastructure requirements with attendant potential for habitat alteration would be site-specific. Under the assumptions of this assessment, adverse impacts could range from SMALL to MODERATE, depending on site-specific factors.

Socioeconomics

Major sources of potential socioeconomic impacts from the representative gas-fired generation alternative include:

- temporary increases in jobs, economic activity, and demand for housing and public services in communities surrounding the site during the construction period, and
- net change in permanent jobs, tax revenues, and economic activity attributable to gas-fired plant operation and termination of Palisades operations.

Although southern-lower Michigan is predominantly rural, most areas are within commuting distance of relatively large population centers, including Muskegon, Grand Rapids, Kalamazoo, and Battle Creek, Michigan, and South Bend, Indiana in the west; Lansing and Jackson in the central part of the lower peninsula; and Detroit, Ann Arbor, Flint, and Saginaw, Michigan and Toledo, Ohio in the east (National Geographic 2001U). Considering the proximity of these sources of labor and services, NMC expects that most of the construction workforce would commute and relatively few would relocate to small communities near the plant such that significant demand for housing or public services would result. Associated socioeconomic impacts during construction are therefore expected to be SMALL, regardless of plant location. However, considered together with impacts of the no action “base case” (terminating operations and decommissioning Palisades), this alternative could result in potentially LARGE adverse impacts to Covert Township and the Covert School District from the loss of tax revenues 20 year sooner than if the Palisades operating license is renewed.

Aesthetics

Potential aesthetic impacts of construction and operation of a gas-fired plant include visual impairment resulting from the presence of a industrial facility and associated ROWs, including a building housing the CTs and HRSGs, a 160-foot high exhaust stack per unit, mechanical-draft cooling towers, with associated condensate plumes and transmission lines. These potential impacts would be limited by vegetation and topography as discussed in the purchased power alternative. Considering also that the location and design of the plant and associated offsite infrastructure would be decided with consideration of potential adverse aesthetic effects and would subject to review by local jurisdictions affected, NMC concludes that aesthetic impact could range from SMALL to MODERATE, depending on location.

A similar conclusion is appropriate for the representative plant located at an existing generating plant site, though NMC expects that aesthetic impacts associated with the generating facility itself, as an incremental addition to an existing facility, would most likely be SMALL, and overall impact significance would be more dependent on offsite transmission requirements.

Other Impacts

Cooling water intake and discharge flows for the representative gas-fired plant would be substantially lower than currently result from Palisades operation. Potable and service water use and other wastewater discharges would also be less and, like Palisades, cooling water and wastewater discharges would be regulated under the CWA and corresponding state programs by NPDES permit. Potential impacts on water quality during construction would also be subject to regulatory controls and the plant would be sited with appropriate consideration of water use and quality impacts.

Operation of the gas-fired alternative would generate small quantities of municipal and industrial waste, and could also include spent catalyst used for NOx control. The amount of these wastes would be less than is currently generated from Palisades operations, and would be disposed of in accordance with applicable regulations at a permitted offsite disposal facility, regardless of the plant's location.

In the GEIS, NRC cites risk of accidents to workers and public risks (e.g., cancer, emphysema) from the inhalation of toxics and particulates associated with air emissions as potential risks to human health associated with the gas-fired generation alternative (NRC 1996a, Tables 8.1 and 8.2). NMC assumes that regulatory requirements imposed on facility design and operations under the authority of the Occupational Safety and Health Act, Clean Air Act, and related statutes are designed to provide an appropriate level of protection to workers and the public with respect to these risks.

Under the assumptions of this analysis the representative gas-fired plant and associated gas supply pipeline and transmission line would be located with consideration for cultural resources, and NMC expects that appropriate measures would be taken to avoid, recover or provide other mitigation for loss of any resources discovered during onsite or offsite construction.

NMC concludes that the potential adverse impacts of this alternative on water quality and use, waste disposal, human health, and cultural resources would likely be SMALL.

7.3.3 COAL-FIRED GENERATION

In the following subsections, NMC presents its impact evaluations for the representative coal-fired generation alternative for resource categories potentially subject to moderate to large impacts, followed by a discussion of impacts for remaining resource categories.

Land Use

NMC assumes the plant is located at a hypothetical greenfield site in southern-lower Michigan and estimates development of the representative coal-fired plant would require approximately 460 acres for the plant and onsite infrastructure. The total site could consist of up to approximately 1,700 acres to provide flexibility in facilities arrangement and appropriate buffer from adjacent land uses. Offsite infrastructure is assumed for analysis to consist of 5 miles of 150-foot wide transmission ROW to connect the plant to the grid and 10 miles of new rail spur on a 50-foot wide ROW for delivery of coal and limestone, amounting to approximately 90 acres and 60 acres, respectively.

Potential impacts on land use would be location specific and therefore conjectural for a greenfield site. However, NMC expects development for plant facilities and the rail line would result in the conversion of 520 acres of rural agricultural land and/or natural plant communities abundant in the region to exclusive industrial use. NMC assumes that current non-conflicting land uses on the balance of the plant site (e.g., agriculture) would remain relatively unaffected and provide appropriate buffer with respect to any highly incompatible land uses (e.g., residential development). Similarly, development of the transmission line would limit future incompatible land uses on the ROW, but compatible land uses (e.g., most agricultural land) would remain largely unaffected.

These land use impacts would noticeably alter land use patterns, particularly in areas near the plant and rail line. However, NMC assumes that appropriate consideration of land use impacts in the siting process, state and local environmental reviews, and application of appropriate mitigation found to be needed as a result would ensure that impacts on land use would not be destabilizing. On this basis, NMC concludes that land use impacts would be MODERATE.

Development of the representative plant at an existing power plant site would represent the expansion of existing land use and, NMC assumes, avoid the need to develop offsite infrastructure for coal and limestone delivery. However, development of the plant at some sites could reduce or eliminate onsite buffer areas from neighboring incompatible land uses (e.g., residential areas) and additional transmission lines could be required at some sites. Associated land use impacts would depend on numerous factors, including the extent to which existing ROWs could be used. Under the assumptions of this analysis, NMC concludes that associated land use impacts would be SMALL to MODERATE for development of the representative plant at an existing plant site.

Air Quality

The principal air emissions from a coal-fired power plant are the same as those noted for the natural gas alternative, and include the criteria pollutants NOx, SO_2, CO, and particulates, as well as CO_2, which is currently unregulated. However, coal contains much higher concentrations of sulfur, and combustion is less efficient than for natural gas. As a result, even with application of appropriate control technologies, emission of these compounds from a coal-fired facility are typically higher than for a natural gas-fired facility of comparable size (EPA 2000a, Sections 1.1 and 1.4). In addition, coal contains other constituents (e.g., mercury, beryllium) that are potentially emitted as hazardous air pollutants (EPA 2000b, Table 1).

NMC has assumed a plant design that effectively minimizes emissions of criteria pollutants. Based on emission factors and estimated efficiencies for emission controls cited by the EPA and assumed design parameters listed in Table 7.2-2, operation of the

plant would result in the following annual air emissions for criteria pollutants.[4] 2,750 tons of SO_2, 690 tons of NOx, 800 tons of CO, 120 tons of total particulates (filterable); and 28 tons of PM_{10} (EPA 2000a, Tables 1.1-3 and 1.1-4).

Emissions from the plant would result in some impairment of local air quality and would contribute to increased regional concentrations of other criteria pollutants listed above, some hazardous air pollutants (e.g., mercury), and CO_2, a potential contributor to climate change. Considering that the plant would be subject to regulatory controls, NMC concludes that the overall impact on air quality from this alternative would be noticeable but not destabilizing, a characteristic of MODERATE impact, regardless of locations considered in this ER.

Waste Management

The representative coal-fired plant would annually consume approximately 3.2 million tons of coal having an ash and sulfur content of 7.66 percent and 0.47 percent, respectively. Assumed air emission controls would remove 99.9 percent of the ash and 90 percent of the sulfur (see Table 7.2-2 of this ER). Estimated annual waste generation amounts to approximately 243,000 tons of ash and approximately 76,000 tons of flue gas desulfurization waste on a dry basis. Consumers estimates that approximately 85 percent of the ash could be recycled; NMC assumes the remainder of these high-volume wastes would be disposed of in an onsite landfill occupying approximately 100 acres over an assumed plant operating life of 40 years (see Section 7.2.2.3 of this ER). The coal-fired alternative plant could also generate relatively small quantities of the spent catalyst used for NOx control at the plant. NMC assumes this waste would be disposed of in accordance with applicable regulations at a permitted offsite disposal facility.

The ash and flue gas desulfurization waste landfill would be designed and operated to maintain landfill integrity and minimize the potential for escape of leachate, which could result in some local degradation of groundwater quality. NMC assumes that groundwater quality would be appropriately managed to ensure an adequate level of protection. After closure and revegetation of the disposal facility, the land could be made available for other uses (e.g., recreation).

4 Annual emissions of regulated air pollutants calculated as follows from coal heat input and EPA estimates of uncontrolled air emissions and removal efficiencies: Annual Emissions (tons/yr) = Annual Coal Combusted (3.2 million tons/yr) $\times$ Uncontrolled Emissions (pounds/ton of coal combusted) $\times$ 0.0005 (ton/lb $\times$ [100 – removal efficiency (%)]. Removal efficiency for CO assumed to be zero.

Considering the large volumes of waste that would be generated and potential for noticeable localized impacts on land use and groundwater quality resulting from its disposal, NMC concludes that waste management impacts for the coal-fired generation alternative would be MODERATE, regardless of plant location.

Ecological Resources

NMC expects that development of the coal-fired representative plant at a greenfield site in southern-lower Michigan would likely result in the loss of approximately 520 acres of terrestrial habitat for onsite plant facilities and a 10-mile long rail spur, and modification of an additional 90 acres of terrestrial habitat for new transmission line development. NMC expects that construction activities for the transmission ROW would be similar to those described in both the purchased power and gas-fired alternatives. Impacts to terrestrial habitats from the development of a coal-fired facility and the associated transmission ROW would be similar in nature to those of both the purchased power and gas-fired alternatives.

The most significant potential impacts to aquatic communities relate to operation of the cooling water system. However, as for the gas-fired alternative, the plant is assumed to employ a closed-cycle cooling system with cooling towers, and substantial regulatory controls (e.g., CWA Sections 316a, 316b) would be applied. NMC concludes that related impacts would be SMALL.

In view of these considerations and assumptions of this assessment, NMC expects that impacts on ecological resources would be apparent, but would not significantly alter any important attribute of the resource in many locations, consistent with NRC's definition of SMALL impact significance. However, considering the uncertainties associated with greenfield development and the relatively large amount of habitat that could be lost to plant development, NMC concludes that impacts on ecological resources could be of MODERATE significance.

NMC expects that impacts on ecological resources from development of the representative plant at an existing power plant site to be similar in nature to that described for the greenfield site alternative. However, there is reasonable probability that a portion of the plant facilities could be located on partly developed or highly disturbed areas with little habitat value. However, as previously noted, offsite infrastructure requirements with attendant potential for habitat alteration would be site-specific. Under the assumptions of this assessment, adverse impacts could range from SMALL to MODERATE, depending on site-specific factors.

Socioeconomics

Major sources of potential socioeconomic impacts from the representative coal-fired generation alternative include:

- temporary increases in jobs, economic activity, and demand for housing and public services in communities surrounding the site during the construction period, and
- net change in permanent jobs, tax revenues, and economic activity attributable to coal-fired plant operation and termination of Palisades operations.

For the same reasons as discussed in Section 7.3.2 for the gas-fired alternative, NMC expects socioeconomic impacts from construction of the coal-fired alternative to be SMALL, regardless of plant location. However, considered together with impacts of the no action "base case" (terminating operations and decommissioning Palisades), this alternative could result in potentially LARGE adverse impacts to Covert Township and the Covert School District from the loss of tax revenues 20 years sooner than if the Palisades operating license is renewed.

Aesthetics

Potential aesthetic impacts of construction and operation of the representative coal-fired plant include visual impairment resulting from the presence of a large industrial facility, including buildings housing the boilers and turbine-generators; emission control equipment; 500-foot high stacks; fuel and limestone receiving, handling, and storage facilities; waste handling and disposal facilities; stormwater runoff control basins; mechanical-draft cooling towers with associated condensate plumes and transmission lines. These potential impacts likely would be limited by vegetation and topography as discussed for previous alternatives (see Sections 7.3.1 and 7.3.2 of this ER). Considering also that the location and design of the plant and associated offsite infrastructure would be decided with consideration of potential adverse aesthetic effects and would subject to review by local jurisdictions affected, NMC concludes that aesthetic impact could range from SMALL to MODERATE, depending on location and character of the site.

A similar conclusion is appropriate for the representative plant located at an existing generating plant site, though NMC expects that aesthetic impacts associated with the generating facility itself, as an incremental addition to an existing facility, could be small if adequate buffer to populated offsite locations is maintained. Overall impact significance also would be affected by the need for and flexibility available in routing offsite transmission lines.

Other Impacts

NMC assumes that the representative coal-fired plant would be designed with a closed-cycle cooling system (mechanical draft cooling towers). Considering the higher thermal efficiency of coal-fired units relative to nuclear units (NRC 1996a, Table 8.2), consumptive water use is likely to be less than that from Palisades operation. Like Palisades, cooling water and wastewater discharges would be regulated under the CWA and corresponding state programs by NPDES permit. Potential impacts on water quality during construction would also be subject to regulatory controls, and the plant would be sited with appropriate consideration of water use and quality impacts.

In the GEIS, NRC cites risk of accidents to workers and public risks (e.g., cancer, emphysema) from the inhalation of toxics and particulates associated with air emissions as potential risks to human health associated with the coal-fired generation alternative (NRC 1996a, Tables 8.1 and 8.2). NMC assumes that regulatory requirements imposed on facility design and operations under the authority of the Occupational Safety and Health Act, Clean Air Act, and related statutes are designed to provide an appropriate level of protection to workers and the public with respect to these risks.

Under the assumptions of this analysis the representative coal-fired plant and associated rail spur and transmission line would be located with consideration for cultural resources, and NMC expects that appropriate measures would be taken to avoid, recover or provide other mitigation for loss of any resources discovered during onsite or offsite construction.

NMC concludes that the potential adverse impacts of this alternative on water use and quality, human health, and cultural resources would likely be SMALL.

TABLE 7.2-1
REPRESENTATIVE NATURAL GAS-FIRED GENERATION ALTERNATIVE

Characteristic	Basis/Detail
No. of units, type and capability (gross): Unit 1 = 2 CTs x 171 MW + 1 ST x 196 MW. Unit 2 = 1 CT x 171 MW + 1 ST x 96 MW (Total = 805 MW).	*Approximately equivalent to Palisades total net capacity* (Industry data). Gross capability less net capability = energy consumed onsite.
No. of units, type and capability (net): Unit 1 = 530 MW; Unit 2 = 263 MW (Total = 793 MW)	*Standard size* (Industry data).
Capacity factor: 85%	Within range for base-load plants; results in annual generation reasonably comparable Palisades.
Fuel type = natural gas	Assumed.
Heat rate = 6,500 Btu/kWh	Estimate from Industry data.
Fuel heating value = 1,014 Btu/scf	Value for Michigan natural gas (EIA 2004f, Table 14).
Fuel S content: 0.2 grains/100 scf (0.00068 wt%)	Typical for pipeline quality natural gas (EPA 2000a, page 1.4-2).
SO_2 emissions: 0.00064 lb/MMBtu [= 0.94 x wt% S in fuel]	EPA estimate for natural gas-fired turbines (EPA 2000a, Table 3.1-2a).
NOx emissions (assuming dry-low-NOx combustors): 0.099 lb/MMBtu	EPA estimate for best available NOx combustion control (EPA 2000a, Table 3.1-1).
NOx post-combustion control: selective catalytic reduction (90 percent reduction)	EPA estimate for best available NOx post-combustion control (EPA 2000a, Section 3.1.4.3).
CO emissions (assuming dry low-NOx combustors): 0.015 lb/MMBtu	EPA estimate (EPA 2000a, Table 3.1-1).
PM emissions (all PM_{10}): 0.0019 lb/MMBtu	EPA estimate (EPA 2000a, Table 3.1-2a).
CO_2 emissions: 110 lb/MMBtu	EPA estimate (EPA 2000a, Table 3.1-2a).

% = percent
Btu = British thermal unit
CO = carbon monoxide
CO_2 = carbon dioxide
CT = combustion turbine
EPA = U.S. Environmental Protection Agency
kWh = kilowatt-hour
lb = pound
MMBtu = million Btu
MW = megawatts
NMC = Nuclear Management Company, LLC
NOx = nitrogen oxides
Palisades = Palisades Nuclear Plant
PM = filterable particulate matter
PM_{10} = filterable particulates with diameter less than 10 microns
Ref. = Reference
scf = standard cubic feet
SOx = sulfur oxides
ST = steam turbine
wt% = percent by weight

TABLE 7.2-2
REPRESENTATIVE COAL-FIRED GENERATION ALTERNATIVE

Characteristic	Basis/Detail
Number of units: 2 Unit size: 450 MW (gross); 400 MW (net)	Standard size; approximated net capacity comparable to Palisades (Consumers data).
Capacity factor: 85%	Within range for base-load plants; results in annual generation comparable to Palisades.
Firing mode: subcritical, tangential, dry-bottom pulverized coal	Widely demonstrated, reliable, economical; tangential firing minimizes NOx emissions (EPA 2000a, Table 1.1-3).
Fuel type: bituminous, sub-bituminous mix	Type used at Consumers Campbell Plant (EIA 2004f, Table 24).
Fuel heating value: 10,359 Btu/lb	Average for coal used at Consumers Campbell Plant (EIA 2004f, Table 24).
Heat rate: 9800 Btu/kWh	Consumers estimate.
Fuel ash content by weight: 7.66%	Average for coal used at Consumers Campbell Plant (EIA 2004f, Table 24).
Fuel sulfur content: 0.47 wt%; 0.46 lb/MMBtu	Average for coal used at Consumers Campbell Plant (EIA 2004f, Table 24).
Uncontrolled SOx emissions: 17.2 lb/ton coal	Average of EPA estimates for bituminous and sub-bituminous coal calculated as 36.5 x wt% sulfur in coal (EPA 2000a, Table 1.1-3).
Uncontrolled NOx emissions: 8.6 lb/ton coal	EPA estimate (EPA 2000a, Table 1.1-3).
Uncontrolled CO emissions: 0.5 lb/ton coal	EPA estimate (EPA 2000a, Table 1.1-3).
Uncontrolled PM emissions: 76.6 lb/ton coal	EPA estimate calculated as 10 x percent of ash in coal (EPA 2000a, Table 1.1-4).
Uncontrolled PM_{10} emissions: 17.6 lb/ton coal	EPA estimate calculated as 2.3 x percent of ash in coal (EPA 2000a, Table 1.1-4).
NOx control: low NOx burners, overfire air, selective catalytic reduction (95% reduction)	Best available for minimizing NOx emissions (EPA 2000a, Table 1.1-2).
Particulate control: fabric filter (99.9% removal)	Best available for minimizing particulate emissions (EPA 2000a, Section 1.1.4.1).
SOx control: Wet limestone flue gas desulfurization (90% removal)	Among best available for minimizing SOx emissions (EPA 2000a, Table 1.1-1). (Can be used on low sulfur coal with demonstrated 90% removal)

% = percent
Btu = British thermal unit
CO = carbon monoxide
EPA = U.S. Environmental Protection Agency
kWh = kilowatt-hour
lb = pound
MW = megawatts
MMBtu = million Btu
NOx = nitrogen oxides
Palisades = Palisades Nuclear Plant
PM = filterable particulate matter
PM10 = filterable particulates with diameter less than 10 microns
SOx = sulfur oxides
wt% = percent by weight

TABLE 7.2-3
OTHER GENERATION TECHNOLOGY OPTIONS CONSIDERED

Alternative	Considerations/Reasons for Not Evaluating Further[a]
Wind	Intermittency of adequate wind speed and expense of energy storage results in capacity factors too low for baseload generation, and land requirements are very large to account for 786 MW required to replace Palisades (NRC 1996a, Section 8.3.1). According to the *Wind Energy Resource Atlas of the United States* areas suitable for wind energy applications must be wind power Class 3 or higher. Exposed coastal and offshore areas of Lake Michigan offer the highest potential for wind development in Michigan, with estimated wind power ratings of Class 3 to Class 5. In the northern part of Michigan's lower peninsula, exposed sites on mountains, hilltops, and uplands are estimated to have Class 3 annual average wind power (NREL 1986). EIA projects that wind power generating capacity in ECAR will total 70 MW in 2004 and will increase by only 70 MW in the period 2004-2011 (EIA 2004d, Table 76). From a practical perspective, the scale of this technology is too small to directly replace a power generating plant the size of Palisades, and the functionality is not equivalent.
Solar Photovoltaic and Solar Central Receiver	EIA indicates there was no commercial solar thermal or solar photovoltaic generating capability in ECAR in 2001, and projects no additional capacity will be developed in the region by 2011 (EIA 2004d, Table 76). As NRC notes in the GEIS, low solar resource availability in the region (e.g., less than 3.3 kWh/m^2 per day in nearly all of Michigan, intermittency of this resource, and expense of energy storage results in capacity factors too low for practical baseline generation. Land requirements are very large. Based on estimates presented in the GEIS, approximately 11,000 and 28,000 acres, respectively, would be required for 786 MW of solar thermal or solar photovoltaic generating capability to replace Palisades, even in areas of high solar availability (NRC 1996a, Sections 8.3.2, 8.3.3). Because of the area's low rate of solar radiation and high technology costs, solar power in the region is limited to niche applications and is not a feasible base-load alternative to Palisades license renewal.
Hydroelectric	Undeveloped hydropower potential estimated to exist in Michigan amounts to only 389 MW, an aggregated total for 86 sites (DOE 1998). As noted in the GEIS, hydroelectric power's percentage of the country's generating capacity is expected to decline because of siting difficulties as a result of public concern over flooding, destruction of natural habitat, and alteration of natural river course and hydrology. This option has a large land-use requirement (e.g., inundation of approximately 786,000 acres for a hydroelectric plant large enough to replace Palisades) (NRC 1996a, Section 8.3.4), and ecological impacts during operation (e.g., fish impingement) are also a potential concern. In 2001, EIA indicates that 1,320 MW of conventional hydroelectric generating capacity had been developed in ECAR, but projects only 40 MW of additional capacity will be developed in ECAR through 2025 (EIA 2004d, Table 76).

TABLE 7.2-3 (CONTINUED)
OTHER GENERATION TECHNOLOGY OPTIONS CONSIDERED

Alternative	Considerations/Reasons for Not Evaluating Further[a]
Geothermal	As noted in the GEIS, hydrothermal reservoirs in the U.S. are most prevalent in contiguous U.S. western states, Alaska, and Hawaii, and are limited in the northeastern United States (NRC 1996a, Section 8.3.5). Currently, there is no geothermal generating capability in ECAR, nor does the DOE-EIA anticipate the development of any additional generating capability in the region in the foreseeable future. (EIA 2004d, Table 76).
Biomass	Biomass alternatives, including wood and crop-fired plants, have construction-related environmental impacts similar to a coal-fired plant, requiring large areas for fuel storage, processing, and waste disposal. As noted in the GEIS, a significant barrier to the use of wood waste to generate electricity is the high delivered-fuel cost and high construction cost per MW of generating capacity. The maximum practical capacity of biomass-fueled power plants is approximately 50 MW, and economic feasibility depends on a reliable supply of low-cost wood wastes and residues nearby. Additionally, large-scale timber cutting can result in significant ecological impacts (e.g., soil erosion and loss of wildlife habitat) (NRC 1996a, Sections 8.3.6 and 8.3.8). Other biomass alternatives, including burning crops, converting crops to a liquid fuel such as ethanol, and gasifying crops, have not progressed to the point of being competitive on a large scale or of being reliable enough to replace a baseload plant such as Palisades. The DOE estimates that potentially 17.7 billion kWh of electricity could be generated annually from biomass fuels in Michigan (DOE 2004). However, as pointed out above, the economic and achievable potential is almost certain to be substantially less than the technical potential. In 2001, ECAR had approximately 230 MW of biomass generating capacity; however, EIA projects that little or no additional generating capability will be developed in the region by 2011 (EIA 2004d, Table 76).
Municipal Solid Waste	Installed capital cost of a municipal solid-waste-fueled plant is higher than that of a wood-waste-fueled plant, and are required to operate with much stricter controls, which can result in higher operating costs. Use of this option is primarily a waste management decision. Tipping fees, availability of landfill space, and reduced heat content of the waste stream due to segregation and recycling of high-heat-content components (e.g., wood, paper, plastics) affect economic viability (NRC 1996a, Section 8.3.7). In 2001, only 160 MW of municipal solid waste generating capacity was available in ECAR, and only 20 MW of additional capacity is anticipated to be developed in the region through 2025 (EIA 2004d, Table 76).

TABLE 7.2-3 (CONTINUED)
OTHER GENERATION TECHNOLOGY OPTIONS CONSIDERED

Alternative	Considerations/Reasons for Not Evaluating Further[a]
Oil	Consumers has 2 oil/gas co-fired units; however, they produce only about 1 percent of Consumers' power generation. Fuel costs comprise most of the operating costs for fossil-fired generating plants, and oil is a much more expensive fuel than either coal or nuclear fuel on a cost per Btu basis. In addition, future increases in oil prices are expected to result in a decrease in oil-fired generation in the future (EIA 2004c, page 83). In 2001, only 1,910 billion kWh of electricity was generated from petroleum in ECAR, 0.11 percent of the total generation in the region; the percentage of total generation from oil in ECAR is projected to decrease to 0.03 percent by 2011 (EIA 2004d, Table 60).
Advanced Nuclear Reactor	Increased interest in the development of advanced reactor technology has been expressed publicly recently by members of both industry and government. However, the economics of new plants remain highly uncertain and, primarily because of the relatively favorable economics of competing technologies, no new nuclear facilities are expected to be built in the U.S. through 2025 (EIA 2004c, page 6). Moreover, NMC does not consider it reasonable to expect that a new nuclear facility could be licensed and constructed to replace Palisades by 2011, when its operating license expires. Operation of an advanced reactor would have environmental impacts similar to those of the continued operation of Palisades, and construction of a new nuclear power plant would entail further environmental impacts and incur capital costs not associated with license renewal of Palisades. For these reasons, Consumers does not consider development of a new nuclear plant to be economically reasonable or environmentally preferable alternative to Palisades license renewal.
Fuel Cells	Cost is the primary hurdle to fuel cell development as a major generating source. As of 2003, the most widely marketed fuel cells were commercially available at a cost of approximately $4,500 per kW of installed capacity; state-of-the-art fuel cells in testing at that time were projected to cost approximately $1,200 per kW (DOE 2003). NMC believes fuel cells are not currently economically or technologically competitive with other alternatives for baseload electricity generation.

a. Capacity data for ECAR cited in this table does not include small onsite sources of power, some of which may supply excess capacity to the grid (EIA 2004d, Table 76, Footnote 7). However, the amount of such capacity is very small for the entire period examined, and does not affect the rationale presented.

DOE = U.S. Department of Energy
ECAR = Mid-Continent Area Power Pool
EIA = U.S. Department of Energy, Energy Information Agency
GEIS = *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*
GWh = gigawatt hour(s)
kWh = kilowatt hour(s)
NMC = Nuclear Management Company, LLC
m^2 = square meter(s)
MW = megawatt(s)
Palisades = Palisades Nuclear Plant
NRC = U.S. Nuclear Regulatory Commission

7.4 REFERENCES

Note to reader: This list of references identifies web pages and associated URLs where reference data was obtained. Some of these web pages may likely no longer be available or their URL address may have changed. NMC has maintained hard copies of the information and data obtained from the referenced web pages.

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8.0 COMPARISON OF ENVIRONMENTAL IMPACTS OF LICENSE RENEWAL WITH THE ALTERNATIVES

NRC

"To the extent practicable, the environmental impacts of the proposal and the alternatives should be presented in comparative form.…" [10 CFR 51.45(b)(3) as adopted by 51.53(c)(2)]

Nuclear Management Company, LLC (NMC) presents its evaluations of the environmental impacts associated with Palisades Nuclear Plant (Palisades) operating license renewal (the proposed action) and those associated with selected alternatives in Chapter 4 and Chapter 7 of this ER, respectively. In this chapter, NMC provides a comparative summary of these impacts. The environmental impacts comparison addresses Category 2 issues associated with the proposed action and additional issues the U.S. Nuclear Regulatory Commission (NRC) identifies in the *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (GEIS) as major considerations in an alternatives analysis (NRC 1996, Section 8.1). For example, NRC concluded in the GEIS that air impacts from the proposed action would be SMALL (Category 1), but indicated a potential for major human health concerns associated with air emissions from fossil-fuel (coal, gas or both) generation alternatives (see Sections 7.3.2 and 7.3.3 of this ER). Inclusion of these additional issues therefore establishes a basis for comparison of relevant impacts among alternatives. NMC provides a comparative summary of its conclusions regarding these issues in Table 8.0-1, and a more detailed comparison in Table 8.0-2.

As indicated in Tables 8.0-1 and 8.0-2, environmental impacts of the proposed action (Palisades license renewal) are expected to be SMALL for all impact categories evaluated. In contrast, NMC expects that environmental impacts in some impact categories would be MODERATE or LARGE for the no-action alternative (NRC decision not to renew the Palisades operating license), considered with or without development of replacement generation facilities. Expected adverse environmental impacts include the loss of substantial tax revenues from termination of Palisades operations 20 years sooner than if its operating license is renewed. Notable adverse impacts in the areas of land use, air quality, ecological resources, socioeconomics, and aesthetics may result from replacement of Palisades generating capacity with an alternative generating source, depending on the alternative selected.

In summary, NMC's analysis indicates that renewal of the Palisades operating license is preferred from an environmental standpoint. With respect to NRC's decision-making standard at 10 CFR 51.95(c)(4), the analysis supports a conclusion that the option of renewing the Palisades operating license should be preserved.

TABLE 8.0-1
IMPACTS COMPARISON SUMMARY

Impact	Proposed Action (License Renewal)	No-Action Alternative[a]			
		Base (Terminate Operations & Decommission)	With Purchased Power[b]	With Gas-Fired Generation	With Coal-Fired Generation
Land Use	SMALL	SMALL	SMALL to MODERATE	SMALL to MODERATE	MODERATE
Water Use and Quality	SMALL	SMALL	SMALL	SMALL	SMALL
Air Quality	SMALL	SMALL	SMALL to MODERATE	MODERATE	MODERATE
Waste Management	SMALL	SMALL	SMALL to MODERATE	SMALL	MODERATE
Ecological Resourcesc	SMALL	SMALL	SMALL to MODERATE	SMALL to MODERATE	SMALL to MODERATE
Socioeconomics	SMALL	LARGE	LARGE	LARGE	LARGE
Human Health	SMALL	SMALL	SMALL	SMALL	SMALL
Aesthetics	SMALL	SMALL	SMALL to MODERATE	SMALL to MODERATE	SMALL to MODERATE
Cultural Resources	SMALL	SMALL	SMALL	SMALL	SMALL

a. Impact significance definitions (from 10 CFR 51, Subpart A, Appendix B, Table B-1, footnote 3):
SMALL - Environmental effects are not detectable or are so minor they will neither destabilize nor noticeably alter any important attribute of the resource.
MODERATE - Environmental effects are sufficient to alter noticeably but not to destabilize any important attribute of the resource.
LARGE – Environmental effects are clearly noticeable and are sufficient to destabilize important attributes of the resource.

b. Impacts include those from base case, generation, and development of new transmission. Impact from generation would depend on generation technologies used and location. NMC considers the technologies and associated impacts presented in Section 8.3 of the GEIS are representative but assumes for purposes of comparison that adverse impacts would not be of greater significance than those from coal-fired and gas-fired alternatives considered in this Environmental Report.

c. Impacts to threatened and endangered species are addressed within the Ecological Resources category.

TABLE 8.0-2
IMPACTS COMPARISON DETAIL

Proposed Action (License Renewal) [a]	No-Action Alternative: Base (Terminate Operations & Decommission) [a]	No-Action Alternative: With Purchased Power	No-Action Alternative: With Gas-Fired Generation	No-Action Alternative: With Coal-Fired Generation
Description				
Renew operating license for Palisades, extending operation of the unit 20 years beyond the expiration of its current operating license in 2011 (see Chapter 3).	Terminate operations and decommission Palisades following expiration of its current operating license in 2011. Adopting by reference NRC description of associated activities provided in the GEIS Chapter 7 and Section 8.4, and in Supplement 1 to NUREG-0586 as representative of corresponding Palisades activities (see Section 7.1.1).	Adopting by reference NRC description in the GEIS of alternate technologies. In addition, 40 miles of new 345-kV transmission line assumed to be required to import power (see Section 7.2.2.1).	New 793 MW (net) combined-cycle plant at greenfield site in southern lower Michigan with (see Section 7.2.2.2): • Closed-cycle cooling (mechanical-draft). • Offsite infrastructure: 5-mile gas pipeline; 5-mile transmission line. • Air emission controls: NOx: water/steam injection; selective catalytic reduction (90% removal). PM and CO emissions limited through proper combustion controls. • 160-foot-tall stack(s) • Estimated workforce: Construction: 240 average, 420 peak Operation: 30	New 800 MW (net) pulverized coal at greenfield site located in southern lower Michigan with (see Section 7.2.2.3): • Closed-cycle cooling (mechanical draft). • Offsite infrastructure: 10-mile rail spur and/or lake terminal; 5 mile transmission line. • Air emission controls: Particulates (fabric filter, 99.9% removal); SO_x (limestone scrubber, (90% removal); NO_x (low NO_x burners, overfire air, SCR; 95% removal). • 500-foot-tall stack(s). Estimated workforce: Construction: 600 average, 1,500 peak Operation: 75-120

TABLE 8.0-2 (CONTINUED)
IMPACTS COMPARISON DETAIL

	No-Action Alternative			
Proposed Action (License Renewal) [a]	**Base (Terminate Operations & Decommission)** [a]	**With Purchased Power**	**With Gas-Fired Generation**	**With Coal-Fired Generation**
		Land Use Impacts		
SMALL – Adopting by reference applicable NRC findings for GEIS Category 1 issues (see Section 4.1.1 and Attachment A, Issues 52, 53). Tax-driven and population-driven impacts on offsite land use are addressed below under Socioeconomic Impacts. No Category 2 issues.	SMALL – Adopting by reference applicable NRC impact conclusions in the GEIS Section 8.4 and Supplement 1 to NUREG-0586. Palisades decommissioning activities not expected to involve significant land-use disturbance offsite (see Section 7.1.1).	SMALL to MODERATE - Impact dependent on generation technology and location. Adopting by reference NRC description in the GEIS of land use impacts from alternate technologies (NRC 1996, Section 8.3) but assumed for comparison to be no more significant than that of gas-fired and coal-fired alternatives. Transmission lines would likely traverse rural agricultural land and areas of natural vegetation (woodland and shrubland) abundant in the region (see Section 7.3.1).	SMALL to MODERATE– Approximately 30 acres developed on 110-acre greenfield site. Assumed 5 miles each of 345-kV transmission line and natural-gas supply pipeline, together comprising 120 acres. Land uses displaced assumed to be rural agricultural land and areas of natural vegetation (woodland and shrubland) abundant in the region (see Section 7.3.2).	MODERATE– Approximately 460 acres developed on 1,700-acre greenfield site for plant facilities and waste disposal landfill. Assumed 5 miles of 345-kV transmission line and 10-miles of new rail required offsite, together comprising 150 acres. Land uses displaced assumed to be rural agricultural land and areas of natural vegetation (woodland and shrubland) abundant in the region (see Section 7.3.3).

TABLE 8.0-2 (CONTINUED)
IMPACTS COMPARISON DETAIL

	No-Action Alternative			
Proposed Action (License Renewal) [a]	**Base (Terminate Operations & Decommission)** [a]	**With Purchased Power**	**With Gas-Fired Generation**	**With Coal-Fired Generation**
Water Use and Quality Impacts				
SMALL – Adopting by reference applicable NRC findings for GEIS Category 1 issues (see Section 4.1.1 and Attachment A, Issues 3, 5-11, 32, 89). No applicable Category 2 issues.	SMALL – Adopting by reference applicable NRC impact conclusions in the GEIS Chapter 7 (as codified in 10 CFR 51, Subpart A, Appendix B, Table B-1) and Section 8.4, and in Supplement 1 to NUREG-0586 (see Section 7.1.1).	SMALL – Impact dependent on generation technology and location. Adopting by reference NRC description in the GEIS of water quality impacts from alternate technologies (NRC 1996, Section 8.3) but assumed for comparison to be no more significant than that of gas-fired and coal-fired alternatives (see Section 7.3.1).	SMALL – Construction impacts minimized by use of best management practices and regulatory controls. Cooling water and wastewater discharges lower than for Palisades and subject to regulatory controls (see Section 7.3.2).	SMALL – Construction impacts minimized by use of best management practices and regulatory controls. Operation-phase impacts similar to or less than those of Palisades; cooling water and wastewater discharges subject to regulatory controls (see Section 7.3.3).
Air Quality Impacts				
SMALL – Adopting by reference applicable NRC findings for GEIS Category 1 issue (see Section 4.1.1 and Attachment A, Issues 51, 88). No Category 2 issues.	SMALL – Adopting by reference applicable NRC impact conclusions in the GEIS Chapter 7 (as codified in 10 CFR 51, Subpart A, Appendix B, Table B-1) and Section 8.4, and in Supplement 1 to NUREG-0586 (see Section 7.1.1).	SMALL to MODERATE - Impact dependent on generation technology and location. Adopting by reference NRC description in the GEIS of air quality impacts from alternate technologies (NRC 1996, Section 8.3) but assumed for comparison to be no more significant than that of gas-fired and coal-fired alternatives (see Section 7.3.1).	MODERATE – Emissions: • 12 tons SO_2/yr • 190 tons NO_x/yr • 292 tons CO/yr • 37 tons PM_{10}/yr (see Section 7.3.2).	MODERATE – Emissions: • 2,750 tons SO_2/yr • 690 tons NO_x/yr • 800 tons CO/yr • 120 tons PM/yr • 28 tons PM_{10}/yr (see Section 7.3.3).

TABLE 8.0-2 (CONTINUED) IMPACTS COMPARISON DETAIL

	No-Action Alternative			
Proposed Action (License Renewal)[a]	**Base (Terminate Operations & Decommission)[a]**	**With Purchased Power**	**With Gas-Fired Generation**	**With Coal-Fired Generation**
Waste Management Impacts				
SMALL – Adopting by reference applicable NRC findings for GEIS Category 1 issues (see Section 4.1.1 and Attachment A, Issues 77-85, 87). No Category 2 issues.	SMALL – Adopting by reference applicable NRC impact conclusions in the GEIS Chapter 7 (as codified in 10 CFR 51, Subpart A, Appendix B, Table B-1) and Section 8.4, and in Supplement 1 to NUREG-0586 (see Section 7.1.1).	SMALL to MODERATE – Impact dependent on generation technology and location. Adopting by reference NRC description in the GEIS of waste management impacts from alternate technologies (NRC 1996, Section 8.3) but assumed for comparison to be no more significant than that of gas-fired and coal-fired alternatives (see Section 7.3.1).	SMALL –Relatively low waste generation (see Section 7.3.2).	MODERATE – Approximately 243,000 tons of ash and 76,000 tons of flue gas desulfurization waste generated annually over assumed 40-year plant life. Although 85 % of ash may be recycled, the remainder assumed to be disposed of in a 100-acre landfill designed to maintain integrity and minimize potential for escape of leachate (see Section 7.3.3).

TABLE 8.0-2 (CONTINUED)
IMPACTS COMPARISON DETAIL

Proposed Action (License Renewal) [a]	No-Action Alternative: Base (Terminate Operations & Decommission) [a]	No-Action Alternative: With Purchased Power	No-Action Alternative: With Gas-Fired Generation	No-Action Alternative: With Coal-Fired Generation
Ecological Resource Impacts				
SMALL – Adopting by reference applicable NRC findings for GEIS Category 1 issues (see Section 4.1.1 and Attachment A, Issues 15-24, 28-30, 41-43, 45-48, and 90). Category 2 Issue 49: Impacts to threatened and endangered species expected to be small due to one or more of the following: • low potential for occurrence in habitats affected by plant and transmission line operation and associated maintenance; • protective operation and maintenance practices; and • lack of observed impacts as documented by operational monitoring (see Section 4.3).	SMALL – Adopting by reference applicable NRC impact conclusions in the GEIS Chapter 7 (as codified in 10 CFR 51, Subpart A, Appendix B, Table B-1) and Section 8.4, and in Supplement 1 to NUREG-0586. Palisades decommissioning activities not expected to involve activities beyond operational areas that would result in significant impacts (see Section 7.1.1).	SMALL to MODERATE – Impact dependant on generation technology, location. Adopting by reference NRC's GEIS description of ecological resource impacts from alternate technologies (NRC 1996, Section 8.3), but assumed for comparison to be no more significant than that of gas-fired and coal-fired alternatives. Transmission facilities would likely traverse habitats agricultural land, woodlands, shrublands, (some of which may qualify as wetlands) abundant in the region; sensitive habitats would be avoided (see Section 7.3.1).	SMALL to MODERATE – Potential loss of 30 acres of habitat for plant facilities and modification of 120 acres of habitat for transmission line and pipeline, consisting of rural agricultural land and areas of natural vegetation (woodland and shrubland, some of which may qualify as wetlands) abundant in the region. Sensitive habitats would be avoided. Potential for impacts to aquatic resources from construction and operation (e.g., cooling water withdrawal and discharge) reduced by best management practices and regulatory controls (see Section 7.3.2).	SMALL to MODERATE- Potential loss of 520 acres of habitat for onsite facilities and rail spur and modification of 90 acres of habitat offsite for transmission line, consisting of rural agricultural land and areas of natural vegetation (woodland and shrubland, some of which may qualify as wetlands) abundant in the region. Sensitive habitats would be avoided. Potential for impacts to aquatic resources from construction and operation (e.g., cooling water withdrawal and discharge) reduced by best management practices and regulatory controls (see Section 7.3.3).

TABLE 8.0-2 (CONTINUED)
IMPACTS COMPARISON DETAIL

Proposed Action (License Renewal) [a]	No-Action Alternative: Base (Terminate Operations & Decommission) [a]	No-Action Alternative: With Purchased Power	No-Action Alternative: With Gas-Fired Generation	No-Action Alternative: With Coal-Fired Generation
Socioeconomic Impacts				
SMALL – Adopting by reference applicable NRC findings for GEIS Category 1 issues (see Section 4.1.1 and Attachment A, Issues 64, 67, and 91). Category 2 Issue 63: Location in area of high population with no growth control measures in effect minimizes potential for housing impacts (see Section 4.6). Category 2 Issue 69: Tax-driven land-use changes would be SMALL considering that property tax assessments for Palisades are expected to be similar to current levels, and Van Buren County and municipalities in the site vicinity (e.g., Covert Township) have established development patterns and guide growth with regulatory measures such as zoning and comprehensive planning (see Section 4.9.2).	LARGE – Adopting by reference applicable NRC impact conclusions in the GEIS Chapter 7 (as codified in 10 CFR 51, Subpart A, Appendix B, Table B-1) and Section 8.4, and in Supplement 1 to NUREG-0586. Decommissioning activities *per se* expected to result in SMALL impact. However, termination of operations could result in LARGE impacts from the loss of tax revenues that currently comprise over 30 percent of the total revenues and operating budgets for Covert Township and the Covert School District (see Sections 7.1.1 and 7.3.1).	LARGE – Impact dependent on generation technology and location. Adopting by reference NRC description in the GEIS of socioeconomic impacts from alternate technologies (NRC 1996, Section 8.3) but assumed to be no more significant than those associated with gas-fired and coal-fired alternatives evaluated in this analysis. However, LARGE impacts could result from the loss of tax revenues that currently comprise over 30 percent of the total revenues and operating budgets for Covert Township and the Covert School District (see Section 7.3.1).	LARGE - Impacts from construction considered SMALL because site would be within commuting distance of relatively large population centers (see Section 7.3.2). However, LARGE impacts could result from the loss of tax revenues that currently comprise over 30 percent of the total revenues and operating budgets for Covert Township and the Covert School District (see Section 7.3.1).	LARGE - Impacts from construction considered SMALL because site would be within commuting distance of relatively large population centers (see Section 7.3.3). However, LARGE impacts could result from the loss of tax revenues that currently comprise over 30 percent of the total revenues and operating budgets for Covert Township and the Covert School District (see Section 7.3.1).

TABLE 8.0-2 (CONTINUED)
IMPACTS COMPARISON DETAIL

Proposed Action (License Renewal) [a]	No-Action Alternative: Base (Terminate Operations & Decommission) [a]	No-Action Alternative: With Purchased Power	No-Action Alternative: With Gas-Fired Generation	No-Action Alternative: With Coal-Fired Generation
Socioeconomic Impacts (Continued)				
Category 2 Issue 65: Major water suppliers in Van Buren and Berrien Counties have potable water supplies with excess capacity (see Section 4.7). Category 2 Issue 70: Traffic volumes and capacities of major commuting routes minimize potential for transportation impacts (see Section 4.10).				
Human Health Impacts				
SMALL - Adopting by reference applicable NRC findings for GEIS Category 1 issues (see Section 4.1.1 and Attachment A, Issues 56-58, 61-62, 86). Category 2 Issue 59: Transmission line-induced currents conform to National Electric Safety Code® criteria (see Section 4.5).	SMALL – Adopting by reference applicable NRC impact conclusions in the GEIS Chapter 7 (as codified in 10 CFR 51, Subpart A, Appendix B, Table B-1) and Section 8.4, and in Supplement 1 to NUREG-0586 (see Section 7.1.1).	SMALL – Impact dependent on generation technology and location. Adopting by reference NRC description in the GEIS of human health impacts from alternate technologies (NRC 1996, Section 8.3) but assumed for comparison to be no more significant than that of gas-fired and coal-fired alternatives (see Section 7.3.1).	SMALL– Some risk of cancer and emphysema from air emissions and risk of accidents to workers, as NRC notes in the GEIS. Regulatory controls assumed to reduce risks to acceptable levels (see Section 7.3.2).	SMALL– Some risk of cancer and emphysema from air emissions and risk of accidents to workers, as NRC notes in the GEIS. Regulatory controls assumed to reduce risks to acceptable levels (see Section 7.3.3).

TABLE 8.0-2 (CONTINUED)
IMPACTS COMPARISON DETAIL

	No-Action Alternative			
Proposed Action (License Renewal) [a]	**Base (Terminate Operations & Decommission)** [a]	**With Purchased Power**	**With Gas-Fired Generation**	**With Coal-Fired Generation**
		Aesthetic Impacts		
SMALL – Adopting by reference applicable NRC findings for GEIS Category 1 issues (see Section 4.1.1 and Attachment A, Issues 73, 74). No Category 2 issues.	SMALL – Adopting by reference applicable NRC impact conclusions in the GEIS Section 8.4 and Supplement 1 to NUREG-0586 (see Section 7.1.1).	SMALL to MODERATE – Impact dependent on generation technology and location. Adopting by reference NRC description in the GEIS of aesthetic impacts from alternate technologies (NRC 1996, Section 8.3) but assumed for comparison to be no more significant than that of gas-fired and coal-fired alternatives (see Section 7.3.1).	SMALL to MODERATE – Stacks and cooling tower condensate plumes would be apparent offsite and transmission lines would be visible in rural landscape, but could be variously limited by vegetation and topography depending on location (see Section 7.3.2).	SMALL to MODERATE – Stacks and cooling tower condensate plumes would be apparent offsite and transmission lines and rail line would be visible in rural landscape, but could be variously limited by vegetation and topography depending on location (see Section 7.3.3).

TABLE 8.0-2 (CONTINUED)
IMPACTS COMPARISON DETAIL

	No-Action Alternative			
Proposed Action (License Renewal) [a]	**Base (Terminate Operations & Decommission)** [a]	**With Purchased Power**	**With Gas-Fired Generation**	**With Coal-Fired Generation**
Cultural Resource Impacts				
SMALL – No Category 1 issues. Category 2 Issue 71: No known archaeological or historic resources on site or transmission line corridor. There are no plans for land-disturbing activities (see Section 4.11).	SMALL – Adopting by reference applicable NRC impact conclusions in the GEIS Section 8.4 and Supplement 1 to NUREG-0586. Palisades decommissioning activities are not likely to involve significant activities beyond operational areas, and no National Register eligible historic or archaeological resources are known to exist on the Palisades site (see Section 7.1.1).	SMALL – Impact dependent on generation technology and location. Adopting by reference NRC description in the GEIS of cultural resource impacts from alternate technologies (NRC 1996, Section 8.3), but assumed for comparison to be no more significant than that of gas-fired and coal-fired alternatives (see Section 7.3.1).	SMALL – Siting of plant and offsite infrastructure (transmission line, natural gas pipeline) would be subject to regulatory review, and mitigation measures could be implemented (see Section 7.3.2).	SMALL – Siting of plant and offsite infrastructure (transmission line, natural gas pipeline) would be subject to regulatory review, and mitigation measures could be implemented (see Section 7.3.3).

TABLE 8.0-2 (CONTINUED)
IMPACTS COMPARISON DETAIL

	No-Action Alternative			
Proposed Action (License Renewal) [a]	**Base (Terminate Operations & Decommission)** [a]	**With Purchased Power**	**With Gas-Fired Generation**	**With Coal-Fired Generation**

a. See Attachment A, Table A-1, for a list of issues and applicability.
Impact significance definitions (from 10 CFR 51, Subpart A, Appendix B, Table B-1, footnote 3):
SMALL – Environmental effects are not detectable or are so minor they will neither destabilize nor noticeably alter any important attribute of the resource.
MODERATE – Environmental effects are sufficient to alter noticeably but not to destabilize any important attribute of the resource.
LARGE – Environmental effects are clearly noticeable and are sufficient to destabilize important attributes of the resource.

% = percent
CO = carbon monoxide
GEIS = *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (NRC 1996)
NO_X = nitrogen oxides
NRC = U.S. Nuclear Regulatory Commission
Palisades = Palisades Nuclear Plant
MW = megawatt(s)
PM = particulate matter
PM_{10} = filterable particulates having diameter less than 10 microns
ROW = right-of-way
SCR = selective catalytic reduction
SO_2 = sulfur dioxide
SO_x = sulfur oxides
yr = year

8.1 References

NRC (U.S. Nuclear Regulatory Commission). 1996. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*. NUREG-1437. Office of Nuclear Regulatory Research. Washington, D.C. May.

9.0 STATUS OF COMPLIANCE

9.1 PROPOSED ACTION

NRC

"The environmental report shall list all Federal permits, licenses, approvals and other entitlements which must be obtained in connection with the proposed action and shall describe the status of compliance with these requirements. The environmental report shall also include a discussion of the status of compliance with applicable environmental quality standards and requirements including, but not limited to, applicable zoning and land-use regulations, and thermal and other water pollution limitations or requirements which have been imposed by Federal, State, regional, and local agencies having responsibility for environmental protection." 10 CFR 51.45(d), as required by 10 CFR 51.53(c)(2)

9.1.1 GENERAL

Table 9.1-1 lists the Consumers Energy Company (Consumers) environmental authorizations for current Palisades Nuclear Plant (Palisades) operations. These "authorizations" include permits, licenses, approvals, and other entitlements required for plant operations and related activities. Nuclear Management Company, LLC (NMC) operates Palisades using an effective system of monitoring and management controls to ensure compliance with the provisions of these authorizations and applicable environmental standards and requirements. NMC also expects Consumers to continue renewing these authorizations as required during the current license period and through the license renewal period, and would continue to operate Palisades with the objective of ensuring compliance with the provisions of such authorizations, environmental standards, and requirements.

Table 9.1-2 lists additional environmental authorizations and consultations related to U.S. Nuclear Regulatory Commission (NRC) renewal of the Palisades operating license. As indicated, NMC anticipates needing relatively few such authorizations and consultations. Sections 9.1.2 through 9.1.5 of this ER discuss some of these items in more detail.

9.1.2 THREATENED OR ENDANGERED SPECIES

Section 7 of the Endangered Species Act requires federal agencies to ensure that an agency action is not likely to jeopardize any species that is listed or proposed for listing as endangered or threatened (16 USC 1531 *et seq*.). Depending on the action involved, the Act requires consultation with the U.S. Fish and Wildlife Service (USFWS) regarding effects on non-marine species, the National Marine Fisheries Service (NMFS) for marine species, or both. The USFWS and NMFS have issued joint procedural regulations that address consultation, at 50 CFR 402, Subpart B, and the USFWS maintains the joint list of threatened and endangered species at 50 CFR 17.

As discussed in Section 4.3 of this ER, NMC does not expect continued operation of Palisades to impact the population of any federal or state threatened or endangered species or plant communities in the vicinity of Palisades. Although neither federal law nor NRC regulation require it, NMC invited specific comment from the USFWS and the Michigan Department of Natural Resources (MDNR) regarding potential impacts that Palisades' license renewal might have on species of concern. NMC made the request to facilitate NRC's consultation process and to consider potential impacts to species having special status at both the federal and state level. Attachment B includes copies of relevant correspondence with these agencies. Based on the assessment presented in Section 4.3 of this ER, NMC concludes that Palisades' license renewal would not result in the taking of any threatened or endangered species, to jeopardize the existence of any threatened or endangered species, or result in the destruction or adverse modification of any critical habitat.

9.1.3 HISTORIC PRESERVATION

Section 106 of the National Historic Preservation Act (16 USC 470f) requires federal agencies having the authority to license any undertaking to take into account, prior to issuing the license, the effect of the undertaking on historic properties and to afford the Advisory Council on Historic Preservation an opportunity to comment on the undertaking. Council regulations provide for establishing an agreement with any State Historic Preservation Officer (SHPO) to substitute state review for Council review (36 CFR 800.2). Although not required by federal law or NRC regulation, NMC has chosen to invite comment by the Michigan SHPO. Attachment C includes copies of NMC correspondence with the SHPO. Based on the assessment presented in Section 4.11 of this ER**,** NMC concludes that Palisades license renewal would have no significant impact on historic or archaeological properties.

9.1.4 WATER QUALITY (401) CERTIFICATION

The Federal Clean Water Act, Section 401, requires an applicant for a federal license to conduct an activity that might result in a discharge into navigable waters to provide the licensing agency a certification from the state that the discharge will comply with applicable Clean Water Act requirements (33 USC 1341). NRC has indicated in its *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (GEIS) that issuance of a National Pollutant Discharge Elimination System (NPDES) permit implies certification by the state (NRC 1996, Section 4.2.1.1). The U.S. Environmental Protection Agency granted the State of Michigan authority to issue NPDES permits under its own program, and as indicated in Table 9.1-1, Palisades operates under the authority of an NPDES permit issued by the Michigan Department of Environmental Quality (MDEQ) (MDEQ 2004). MDEQ's issuance of the NPDES permit for Palisades reflects the State’s determination that discharges comply with the applicable standards and limitations established under the Clean Water Act.

9.1.5 COASTAL ZONE MANAGEMENT PROGRAM COMPLIANCE

The Federal Coastal Zone Management Act (16 USC 1451 *et seq*.) imposes requirements on applicants seeking a federal license to conduct an activity that could affect a state’s coastal zone (NRC 2004, page 7). The Act requires the applicant to certify to the licensing agency that the proposed activity would be consistent with the state’s federally-approved Coastal Zone Management Program [16 USC 1456(c)(3)(A)]. The National Oceanic and Atmospheric Administration (NOAA) has promulgated implementing regulations that indicate that the requirement is applicable to renewal of federal licenses for activities not previously reviewed by the state [15 CFR 930.51(b)(1)]. The regulation requires that the license applicant provide its certification to the federal licensing agency and a copy to the applicable state agency [15 CFR 930.57(a)]. Participation in the NOAA Coastal Zone Management Program is voluntary, but federal assistance is given to states willing to develop and implement a comprehensive Coastal Management Program and most states, including Michigan, have a program (DOE 2004). NMC’s Coastal Zone Management Program Consistency Certification for Palisades’ license renewal and a copy of the letter transmitting a copy of the certification to the MDEQ Federal Consistency Coordinator in fulfillment of the regulatory requirement is provided in Attachment D of this ER.

9.2 FEASIBLE ALTERNATIVES

NRC

"The discussion of alternatives in the report shall include a discussion of whether the alternatives will comply with such applicable environmental quality standards and requirements."
[10 CFR 45(d) as required by 10 CFR 51.53(c)(2)]

It is NMC's judgment that the representative coal- and gas-fired generation alternatives and the purchased power alternative, presented in Section 7.2 of this ER, could be developed or implemented, as appropriate, to comply with all applicable environmental quality standards and requirements. However, NMC notes that increasingly stringent air quality protection requirements could make development of a large fossil-fueled power plant infeasible in some locations.

TABLE 9.1-1
ENVIRONMENTAL AUTHORIZATIONS FOR CURRENT OPERATIONS

Agency	Authority	Authorization	Number	Issue Date	Expiration	Activity Covered
Federal Authorizations						
U.S. Nuclear Regulatory Commission	Atomic Energy Act [42 USC 2011 et seq.], 10 CFR 50.10	License to operate	DPR-20	3/24/71	3/24/11	Operation of Palisades Nuclear Plant.
State and Local Authorizations						
Michigan Department of Environmental Quality	Federal Clean Water Act, Section 402 (33 USC 1251 *et seq*.), Michigan Act 451, Public Acts of 1994 (as amended), Parts 31 and 41; Michigan Executive Orders 1991-31, 1995-4, and 1995-18.	NPDES Permit	MI0001457	9/23/04	10/1/08	Discharge of wastewater and stormwater to Lake Michigan.
Michigan Department of Environmental Quality	Clean Air Act, 42 USC 7401 *et seq*.; Michigan Act 451, Public Acts of 1994 (as amended), Part 55	Renewable Operating Permit (Air Quality)	200200005	2/4/03	2/4/08	Operation of Palisades air emission sources (evaporator heating boiler, plant heating boiler, feedwater purity boiler, emergency generators, cold cleaners).

TABLE 9.1-1 (CONTINUED)
ENVIRONMENTAL AUTHORIZATIONS FOR CURRENT OPERATIONS

Agency	Authority	Authorization	Number	Issue Date	Expiration	Activity Covered
State and Local Authorizations (Continued)						
Michigan Department of Environmental Quality	Michigan Act 207. Public Acts of 1941 (as amended), Section 5; Michigan Executive Order 1998-2	Aboveground Storage Tank Registration	Facility No. 91084220 (Diesel Tanks No. 1 and 2)	Annual	Annual	Storage of flammable or combustible liquid (diesel fuel) in aboveground storage tanks.
Michigan Department of Environmental Quality	Michigan Act 451. Public Acts of 1994 (as amended), Part 31	Wastewater Treatment Operator Certification	Various	Various	Various	Operation of treatment and control facilities for wastewater discharges to surface water and groundwater.
South Carolina Department of Environmental Quality	South Carolina Radioactive Waste Transportation and Disposal Act (Act No. 429 of 1980)	Radioactive Waste License for Delivery	0006-21-04	1/6/04	12/31/04 Renewed Annually	Shipment of radioactive material to a licensed disposal/processing facility within the State of South Carolina.
Tennessee Department of Environment and Conservation	Tennessee Code Annotated 68-202-206	Radioactive Waste License for Delivery	T-M 1003-L04	1/1/04	12/31/04 Renewed Annually	Shipment of radioactive material to a licensed disposal/processing facility within the State of Tennessee.

CFR = Code of Federal Regulations
MDEQ = Michigan Department of Environmental Quality
NPDES = National Pollutant Discharge Elimination System
USC = U.S. Code

TABLE 9.1-2
ENVIRONMENTAL AUTHORIZATIONS FOR LICENSE RENEWAL[a]

Agency	Authority	Requirement	Remarks
U.S. Nuclear Regulatory Commission	Atomic Energy Act (42 USC 2011 et seq.)	License renewal application	Environmental Report submitted in support of license renewal application.
U.S. Fish and Wildlife Service	Endangered Species Act Section 7 (16 USC 1536)	Consultation	Requires federal agency issuing a license to consult with USFWS and/or NMFS, as applicable (see Attachment B).
Michigan Department of Environmental Quality	Clean Water Act Section 401 (33 USC 1341)	Certification	Requires federal agency issuing a license to obtain certification from state authority that the action complies with state water quality standards. The NPDES permit evidences State determination of compliance with water quality standards.[b]
Michigan Department of Environmental Quality	Coastal Zone Management Act (16 USC 1451 *et seq*.)	Certification	Requires applicant to certify to federal agency issuing a license that proposed action would comply with the Act (see Attachment D)
Michigan State Historic Preservation Office	National Historic Preservation Act Section 106 (16 USC 470f)	Consultation	Requires federal agency issuing a license to consider cultural impacts and consult with the State Historic Preservation Officer (see Attachment C).

a. No license renewal-related requirements were identified for local or other agencies.

b. NRC 1996, Section 4.2.1.1.

USFWS = U.S. Fish and Wildlife Service

MDEQ = Michigan Department of Environmental Quality

NMFS = National Marine Fisheries Service

NPDES = National Pollutant Discharge Elimination System

USC = United States Code

9.3 REFERENCES

Note to reader: This list of references identifies web pages and associated URLs where reference data was obtained. Some of these web pages may likely no longer be available or their URL address may have changed. NMC has maintained hard copies of the information and data obtained from the referenced web pages.

DOE (U.S. Department of Energy). 2004. DOE Environmental Policy and Guidance – Coastal Zone Management Act. Accessed at http://tis-nt.eh.doe.gov/oepa/laws/czma.html.

MDEQ (Michigan Department of Environmental Quality). 2004. *Permit No. MI0001457 Michigan Department of Environmental Quality Authorization to Discharge Under the National Pollutant Discharge Elimination System.* Issued September 23.

NRC (U.S. Nuclear Regulatory Commission). 1996. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*. NUREG-1437. Office of Nuclear Regulatory Research. Washington, D.C. May.

NRC (U.S. Nuclear Regulatory Commission). 2004. "Procedural Guidance for Preparing Environmental Assessments and Considering Environmental Issues." NRR Office Instruction LIC-203, Rev. 1. Office of Nuclear Reactor Regulation. Washington, D.C. May 24.

ATTACHMENT A DISCUSSION OF NRC LICENSE RENEWAL NATIONAL ENVIRONMENTAL POLICY ACT ISSUES

Nuclear Management Company, LLC (NMC) has prepared this Environmental Report in accordance with U.S. Nuclear Regulatory Commission (NRC) requirements at 10 CFR 51.53. NRC included in the regulation a list of National Environmental Policy Act (NEPA) issues for license renewal of nuclear power plants. Table A-1 lists these 92 issues with their assigned classifications, i.e., categories, and identifies where NMC addresses each issue in this Environmental Report (ER). The table also provides a cross-reference to the section in the *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (GEIS) containing NRC's generic analysis (NRC 1996, 1999). For expediency, NMC has assigned a number to each issue and uses the issue numbers throughout the ER.

TABLE A-1
PALISADES NUCLEAR PLANT ENVIRONMENTAL REPORT
DISCUSSION OF LICENSE RENEWAL NEPA ISSUES

	Issue[a]	Category[a]	Section of this Environmental Report	GEIS Cross Reference[b] (Section)
1.	Impacts of refurbishment on surface water quality	1	NA[c]	
2.	Impacts of refurbishment on surface water use	1	NA[c]	
3.	Altered current patterns at intake and discharge structures	1	4.1	4.3.2.2
4.	Altered salinity gradients	1	NA[d]	
5.	Altered thermal stratification of lakes	1	4.1	4.3.2.2
6.	Temperature effects on sediment transport capacity	1	4.1	4.3.2.2
7.	Scouring caused by discharged cooling water	1	4.1	4.3.2.2
8.	Eutrophication	1	4.1	4.3.2.2
9.	Discharge of chlorine or other biocides	1	4.1	4.3.2.2
10.	Discharge of sanitary wastes and minor chemical spills	1	4.1	4.3.2.2
11.	Discharge of other metals in waste water	1	4.1	4.3.2.2
12.	Water use conflicts (plants with once-through cooling systems)	1	NA[e]	
13.	Water-use conflicts (plants with cooling ponds or cooling towers using makeup water from a small river with low flow)	2	NA[f]	
14.	Refurbishment impacts to aquatic resources	1	NA[c]	
15.	Accumulation of contaminants in sediments or biota	1	4.1	4.3.3
16.	Entrainment of phytoplankton and zooplankton	1	4.1	4.3.3
17.	Cold shock	1	4.1	4.3.3
18.	Thermal plume barrier to migrating fish	1	4.1	4.3.3
19.	Distribution of aquatic organisms	1	4.1	4.3.3

TABLE A-1 (CONTINUED)
PALISADES NUCLEAR PLANT ENVIRONMENTAL REPORT
DISCUSSION OF LICENSE RENEWAL NEPA ISSUES

	Issue[a]	Category[a]	Section of this Environmental Report	GEIS Cross Reference[b] (Section)
20.	Premature emergence of aquatic insects	1	4.1	4.3.3
21.	Gas supersaturation (gas bubble disease)	1	4.1	4.3.3
22.	Low dissolved oxygen in the discharge	1	4.1	4.3.3
23.	Losses from predation, parasitism, and disease among organisms exposed to sublethal stresses	1	4.1	4.3.3
24.	Stimulation of nuisance organisms (e.g., shipworms)	1	4.1	4.3.3
25.	Entrainment of fish and shellfish in early life stages for plants with once-through and cooling pond heat dissipation systems	2	NA[e]	
26.	Impingement of fish and shellfish for plants with once-through and cooling pond heat dissipation systems	2	NA[e]	
27.	Heat shock for plants with once-through and cooling pond heat dissipation systems	2	NA[e]	
28.	Entrainment of fish and shellfish in early life stages for plants with cooling tower-based heat dissipation systems	1	4.1	4.3.3
29.	Impingement of fish and shellfish for plants with cooling tower-based heat dissipation systems	1	4.1	4.3.3
30.	Heat shock for plants with cooling tower-based heat dissipation systems	1	4.1	4.3.3
31.	Impacts of refurbishment on groundwater use and quality	1	NA[c]	
32.	Groundwater use conflicts (potable and service water; plants that use < 100 gpm)	1	4.1	4.8.1.1

TABLE A-1 (CONTINUED)
PALISADES NUCLEAR PLANT ENVIRONMENTAL REPORT
DISCUSSION OF LICENSE RENEWAL NEPA ISSUES

	Issue[a]	Category[a]	Section of this Environmental Report	GEIS Cross Reference[b] (Section)
33.	Groundwater use conflicts (potable, service water, and dewatering; plants that use > 100 gpm)	2	NA[g]	
34.	Groundwater use conflicts (plants using cooling towers withdrawing makeup water from a small river)	2	NA[f]	
35.	Groundwater use conflicts (Ranney wells)	2	NA[h]	
36.	Groundwater quality degradation (Ranney wells)	1	NA[h]	
37.	Groundwater quality degradation (saltwater intrusion)	1	NA[d]	
38.	Groundwater quality degradation (cooling ponds in salt marshes)	1	NA[d,e]	
39.	Groundwater quality degradation (cooling ponds at inland sites)	2	NA[e]	
40.	Refurbishment impacts to terrestrial resources	2	4.2[i]	3.6[c]
41.	Cooling tower impacts on crops and ornamental vegetation	1	4.1	4.3.4
42.	Cooling tower impacts on native plants	1	4.1	4.3.5.1
43.	Bird collisions with cooling towers	1	4.1	4.3.5.2
44.	Cooling pond impacts on terrestrial resources	1	NA[e]	
45.	Power line right-of-way management (cutting and herbicide application)	1	4.1	4.5.6.1
46.	Bird collisions with power lines	1	4.1	4.5.6.2
47.	Impacts of electromagnetic fields on flora and fauna (plants, agricultural crops, honeybees, wildlife, livestock)	1	4.1	4.5.6.3
48.	Floodplains and wetlands on power line right-of-way	1	4.1	4.5.7
49.	Threatened or endangered species	2	4.3	3.9[c], 4.1

TABLE A-1 (CONTINUED)
PALISADES NUCLEAR PLANT ENVIRONMENTAL REPORT
DISCUSSION OF LICENSE RENEWAL NEPA ISSUES

Issue[a]	Category[a]	Section of this Environmental Report	GEIS Cross Reference[b] (Section/Page)
50. Air quality during refurbishment (nonattainment and maintenance areas)	2	4.4[i]	3.3[c]
51. Air quality effects of transmission lines	1	4.1	4.5.2
52. Onsite land use	1	4.1	3.2[c]
53. Power line right-of-way land-use impacts	1	4.1	4.5.3
54. Radiation exposures to the public during refurbishment	1	NA[c]	
55. Occupational radiation exposures during refurbishment	1	NA[c]	
56. Microbiological organisms (occupational health)	1	4.1	4.3.6
57. Microbiological organisms (public health) (Plants using lakes or canals, or cooling towers or cooling ponds that discharge to a small river)	2	NA[f]	
58. Noise	1	4.1	4.3.7
59. Electromagnetic fields, acute effects (electric shock)	2	4.5	4.5.4.1
60. Electromagnetic fields, chronic effects	NA[j]	4.1	4.5.4.2
61. Radiation exposures to public (license renewal term)	1	4.1	4.6.2
62. Occupational radiation exposures (license renewal term)	1	4.1	4.6.3
63. Housing impacts	2	4.6	3.7.2[c], 4.7.1
64. Public services: public safety, social services, and tourism and recreation	1	4.1	3.7.4[c], 4.7.3
65. Public services: public utilities	2	4.7	3.7.4.5[c], 4.7.3.5
66. Public services: education (refurbishment)	2	4.8[i]	3.7.4.1[c]
67. Public services: education (license renewal term)	1	4.1	4.7.3.1

TABLE A-1 (CONTINUED)
PALISADES NUCLEAR PLANT ENVIRONMENTAL REPORT
DISCUSSION OF LICENSE RENEWAL NEPA ISSUES

	Issue[a]	Category[a]	Section of this Environmental Report	GEIS Cross Reference[b] (Section)
68.	Offsite land use (refurbishment)	2	4.9[i]	3.7.5[c]
69.	Offsite land use (license renewal term)	2	4.9	4.7.4
70.	Public services: transportation	2	4.10	3.7.4.2[c], 4.7.3.2
71.	Historic and archaeological resources	2	4.11	3.7.7[c], 4.7.7
72.	Aesthetic impacts (refurbishment)	1	NA[c]	
73.	Aesthetic impacts (license renewal term)	1	4.1	4.7.6
74.	Aesthetic impacts of transmission lines (license renewal term)	1	4.1	4.5.8
75.	Design basis accidents	1	4.1	5.3.2, 5.5.1
76.	Severe accidents	2	4.12	5.3.3, 5.4, 5.5.2
77.	Offsite radiological impacts (individual effects from other than the disposal of spent fuel and high-level radioactive waste)	1	4.1	6.2.4, 6.6
78.	Offsite radiological impacts (collective effects)	1	4.1	6.2.4, 6.6
79.	Offsite radiological impacts (spent fuel and high-level radioactive waste disposal)	1	4.1	6.2.4, 6.6
80.	Nonradiological impacts of the uranium fuel cycle	1	4.1	6.2.2.6, 6.2.2.7, 6.2.2.8, 6.2.2.9, 6.6
81.	Low-level radioactive waste storage and disposal	1	4.1	6.4.2, 6.4.3, 6.4.4, 6.6
82.	Mixed waste storage and disposal	1	4.1	6.4.5, 6.6
83.	Onsite spent fuel	1	4.1	6.4.6, 6.6
84.	Nonradiological waste	1	4.1	6.5, 6.6
85.	Transportation	1	4.1	Addendum 1 (NRC 1999)
86.	Radiation doses (decommissioning)	1	4.1	7.3.1, 7.4
87.	Waste management (decommissioning)	1	4.1	7.3.2, 7.4
88.	Air quality (decommissioning)	1	4.1	7.3.3, 7.4

TABLE A-1 (CONTINUED)
PALISADES NUCLEAR PLANT ENVIRONMENTAL REPORT
DISCUSSION OF LICENSE RENEWAL NEPA ISSUES

Issue[a]	Category[a]	Section of this Environmental Report	GEIS Cross Reference[b] (Section)
89. Water quality (decommissioning)	1	4.1	7.3.4, 7.4
90. Ecological resources (decommissioning)	1	4.1	7.3.5, 7.4
91. Socioeconomic impacts (decommissioning)	1	4.1	7.3.7, 7.4
92. Environmental justice	NA[j]	2.5[k]	Not addressed in GEIS

a. Source: 10 CFR 51, Subpart A, Appendix B, Table B-1 (Issue numbers added by NMC to facilitate discussion).
b. Source: NRC 1996.
c. NRC findings in the GEIS related to refurbishment are not applicable to this issue because NMC has no plans for major refurbishment.
d. Not applicable because Palisades is not in a coastal area.
e. Not applicable because Palisades is not equipped with cooling ponds or once-through heat dissipation systems.
f. Not applicable because Palisades does not withdraw cooling water from or discharge to a small river.
g. Not applicable because Palisades groundwater use is < 100 gpm (no dewatering; potable water is from municipal supply).
h. Not applicable because Palisades does not use Ranney wells.
i. All Category 2 issues applicable to Palisades included in the report, though NMC plans no refurbishment activities.
j. Not applicable. NRC has not categorized this issue.
k. NMC provides demographic information to support an analysis by NRC, if an analysis is required.

GEIS = Generic Environmental Impact Statement for License Renewal of Nuclear Plants
gpm = gallons per minute
NA = Not Applicable
NEPA = National Environmental Policy Act
NMC = Nuclear Management Company, LLC
NRC = U.S. Nuclear Regulatory Commission

A.1 REFERENCES

NRC (U.S. Nuclear Regulatory Commission). 1996. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*. NUREG-1437. Office of Nuclear Regulatory Research. Washington, D.C. May.

NRC (U.S. Nuclear Regulatory Commission). 1999. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*. Main Report. Section 6.3 – "Transportation" and Table 9.1 "Summary of Findings on NEPA Issues for License Renewal of Nuclear Power Plants." NUREG-1437, Vol. 1, Addendum 1. Office of Nuclear Reactor Regulation. Washington, D.C. August.

ATTACHMENT B. THREATENED AND ENDANGERED SPECIES CORRESPONDENCE

Consumers Energy
Count on Us

NMC
Committed to Nuclear Excellence

February 4, 2005

Ms. Lori Sargent
Endangered Species Specialist
Wildlife Division, Natural Heritage Program
Michigan Department of Natural Resources
P.O. Box 30180
Lansing, MI 48909

SUBJECT: Palisades Nuclear Plant License Renewal Project
Draft Threatened and Endangered Species Impact Assessment

REFERENCE: (1) Letter D. Malone (NMC) and S.T. Wawro (Consumers Energy) to R.A. Humphries (MDNR), September 21, 2004
(2) Letter R.A. Humphries (MDNR) to D. Malone (NMC) and S.T. Wawro (Consumers Energy), November 1, 2004

Dear Ms. Sargent:

Nuclear Management Company, LLC (NMC) and Consumers Energy Company (Consumers) request that the Michigan Department of Natural Resources (MDNR) review the attached summary draft assessment of impact to threatened and endangered species from continued operation of Palisades Nuclear Plant (Palisades) with respect to those species under MDNR jurisdiction. The assessment is being developed as part of our license renewal application to the U.S. Nuclear Regulatory Commission (NRC), a process outlined in previous correspondence with your agency (Reference 1). As indicated in that correspondence, we expect that the MDNR's involvement at this stage will help ensure our application is complete and accurate. In addition, your early involvement will help facilitate future NRC consultations with the MDNR. We plan to include your agency's response to this request in our license renewal environmental report (ER), which will provide details of our final assessment for NRC consideration in their independent review.

Results of our draft assessment agree with the MDNR's initial conclusions that no negative impact to threatened or endangered species is anticipated as a result of license renewal (Reference 2). Nonetheless, we would value your agency's review of the attached summary of the assessment, which provides additional detail about Palisades design and operation, potentially affected resources, and other relevant information regarding impact to threatened and endangered species. Upon completion of your review, we request that your agency please provide to us any additional information the MDNR considers pertinent to the assessment and, as appropriate, its concurrence.

We would appreciate your expeditious review and written response. Please address any related questions or concerns to:

Mr. James Holthaus
Environmental Project Manager
Nuclear Management Company, LLC
27780 Blue Star Highway
Covert, Michigan 49043
1-800-701-4941 ext. 3380
James.Holthaus@nmcco.com

Thank you on behalf of NMC, Consumers and the Palisades License Renewal Environmental Review Team.

Sincerely,

Dan J. Malone
Site Vice President
Palisades Nuclear Plant
Nuclear Management Company

Stephen T. Wawro
Director of Nuclear Assets
Consumers Energy

Attachment

cc w/ attach: R. Humphries (MDNR-Lansing)
J. Allan (Consumers-Jackson)
E. Dehn (NMC-Palisades)

Consumers Energy
Count on Us

NMC
Committed to Nuclear Excellence

February 4, 2005

Mr. Craig Czarnecki
Field Supervisor
Ecological Services Field Office
U.S. Fish and Wildlife Service
2651 Coolidge Road
East Lansing, MI 48823

SUBJECT: Palisades Nuclear Plant License Renewal Project
Draft Threatened and Endangered Species Impact Assessment

REFERENCE: Letter D. Malone (NMC) and S.T. Wawro (Consumers Energy) to C. Czarnecki (USFWS), September 21, 2004

Dear Mr. Czarnecki:

Nuclear Management Company, LLC (NMC) and Consumers Energy Company (Consumers) request that the U.S. Fish and Wildlife Service (USFWS) review the attached summary draft assessment of impact to threatened and endangered species from continued operation of Palisades Nuclear Plant (Palisades) with respect to those species under USFWS jurisdiction. The assessment is being developed as part of our license renewal application to the U.S. Nuclear Regulatory Commission (NRC), an overview of which we provided in previous correspondence to you, referenced above.

As indicated in that correspondence, we expect that the USFWS's involvement at this stage will help ensure our application is complete and accurate. In addition, your agency's early involvement will help facilitate future NRC consultations with the USFWS. We plan to include your agency's response to this request in our license renewal environmental report (ER), which will provide details of our final assessment for NRC consideration in their independent review. Upon completion of your review, we request that your agency please provide to us any additional information the USFWS considers pertinent to the assessment and, as appropriate, its concurrence. We would appreciate your expeditious review and written response. Please address any related questions or concerns to:

Mr. James Holthaus
Environmental Project Manager
Nuclear Management Company, LLC
27780 Blue Star Highway
Covert, Michigan 49043
1-800-701-4941 ext. 3380
James.Holthaus@nmcco.com

Thank you on behalf of NMC, Consumers and the Palisades License Renewal Environmental Review Team.

Sincerely,

Dan J. Malone
Site Vice President
Palisades Nuclear Plant
Nuclear Management Company

Stephen T. Wawro
Director of Nuclear Assets
Consumers Energy

Attachment

cc w/ attach: R. Thorson (USFWS-Fort Snelling)
J. Brewer (USFWS–Lansing)
J. Allan (Consumers-Jackson)
E. Dehn (NMC-Palisades)

SUMMARY DRAFT IMPACT ASSESSMENT THREATENED AND ENDANGERED SPECIES PALISADES LICENSE RENEWAL ENVIRONMENTAL REVIEW

LOCATION AND ENVIRONMENTAL SETTING

Palisades Nuclear Plant (Palisades) is a single-unit, 786-megawatt nuclear-powered steam electric generating station located on the eastern shore of Lake Michigan in Covert Township, Van Buren County, Michigan (Figures 1 and 2). Consumers Energy Company (Consumers) owns the plant, while Nuclear Management Company, LLC (NMC) operates the facility. The Palisades site comprises 432-acres and, like contiguous lands to the north and south, consists primarily of sand dunes, mostly forested, which extend inland approximately 5,000 feet (Figure 3). No streams exist on the site; surface water and percolating runoff from the site drain directly to the lake. The lake bottom at Palisades consists of coarse to fine sands and slopes from the sand beach at the shoreline to a depth of approximately 10 feet within 500 feet of shore, then to a depth of approximately 50 feet 1 mile offshore.

Most of the Palisades site consists of natural plant communities, primarily deciduous hardwood forest (approximately 250 acres) with lesser amounts of pine forest, shrub-scrub and old-field communities, beach grass dunes and flats, sand dune blow-outs, and open sand. Wetland communities on the site are few, small, and scattered, totaling less than 10 acres. A portion of the deciduous forest along the southern boundary of the Palisades site is recognized as an "exemplary dune associated plant community" in the Michigan Department of Environmental Quality (MDEQ) *Atlas of Critical Dune Areas* and as an "exemplary mesic southern forest" by the Michigan Natural Features Inventory (MNFI). Ecological resources on the site and in nearby portions of Lake Michigan have been well studied and documented. Consumers-sponsored ecological surveys have documented the presence of 14 mammal species and seven amphibian or reptile species on the site, and approximately 113 bird species on or overhead the site or adjacent areas (e.g., lakeshore). Lake Michigan biotic communities were studied in pre- and post-operational studies, and additional fish impingement and entrainment monitoring has been conducted at Palisades in recent years.

Approximately 80 acres of the site are developed or maintained (Figure 3). These areas include power-generating and associated support facilities, including two mechanical draft cooling towers, two facilities for dry storage of spent nuclear fuel, radioactive waste storage buildings, other buildings, roads and parking lots. Developed or maintained site acreage also includes onsite power transmission facilities, including the Palisades Substation and transmission corridors.

A total of four transmission lines extend from the Palisades Substation, all 345-kilovolt lines on double-circuit steel lattice towers, which Consumers sold the lines and towers to the Michigan Electric Transmission Company in 2002 (METC) (Figure 3). Two of these lines are being addressed in the license renewal application for Palisades because they were installed as a direct result of initial construction and operation of the plant: the initial 0.6-mile segment of the Palisades-Cook line and the entire 40-mile length of the Palisades-Argenta line (Figures 3 and 4). Most of the former line segment consists of onsite land and highway crossings (Blue Star Memorial Highway and I-196); the latter line traverses exclusively rural landscape typical of southwestern lower Michigan. In particular, the Palisades-Argenta corridor lies on 2,200 acres of land owned by Consumers (i.e., fee strips) comprised primarily of active agricultural land, forest (mostly central hardwoods) and rangeland (mostly shrubland). Approximately 16 percent of the cleared right-of-way (ROW) length traverses wetlands, nearly all of which consist of seasonally or temporarily flooded palustrine emergent and, to a lesser extent, seasonally flooded palustrine scrub-shrub habitat. With exception of the southern mesic forest tract on the southern boundary of the Palisades site noted above and a similar forested tract located north of the site in South Haven Township, no MNFI-recognized exemplary communities lie within 1 mile of the transmission line.

THREATENED AND ENDANGERED SPECIES OCCURRENCE

NMC conducted a screening analysis to identify state-threatened (ST), state-endangered (SE), and federally threatened (FT), endangered (FE), and candidate (FC) species of potential concern to Palisades license renewal based on the likelihood of occurrence in Lake Michigan at Palisades, on the Palisades site, or on the Palisades-Argenta transmission line corridor (and, by inference, the corridor of the Palisades-Cook line segment of interest). Primary information sources for the screening included the following:

- occurrence records for both special-status species and habitats from the MNFI Biological and Conservation Database, for which Consumers has conditional access;
- Consumers-sponsored ecological surveys of the Palisades site and nearby parts of Lake Michigan;
- Consumers and NMC-sponsored impingement and entrainment monitoring study results; and
- additional information regarding occurrence, habitat affinities, and related topics (e.g., beneficial management practices) from the Michigan Department of Natural Resources (MDNR), MNFI, and others.

A total of 73 federal- or state-listed threatened or endangered species, inclusive of one species designated as a candidate for federal listing, were initially identified as potentially occurring in the general areas of concern. This initial group generally consists of species identified by MNFI as having records of occurrence in the counties (state-listed animals, federally listed species) or townships (state-listed plants) where the site and transmission lines of interest are located. Of the species in this initial group, seven are purely aquatic species, three of which - all fishes - have relatively greater likelihood of occurrence in the areas of interest (Table 1). They are the lake sturgeon (*Acipenser fulvescens*, ST) and lake herring (*Coregonus artedii*, ST), known from Lake Michigan in the general vicinity of Palisades, and the creek chubsucker (*Erimyzon oblongus*, SE), a siltation-intolerant fish species known to have occurred in the Kalamazoo River or its tributaries. Overexploitation and habitat destruction were largely responsible for decimation of the lake sturgeon population in Lake Michigan. The alewife invasion was instrumental in the decline of the lake herring population. Some recovery of these species may occur in the future (e.g., as a result of riverine spawning habitat restoration for the sturgeon). However, neither of these species nor any other threatened or endangered species were noted in recent impingement or entrainment monitoring at Palisades. The creek chubsucker is at the northern edge of its range in Michigan and populations were likely reduced by siltation (e.g., from agricultural practices). However, this species may have potential for occurrence in streams crossed by the Palisades-Argenta transmission line. None of these aquatic species have MNFI occurrence records within at least 1 mile of the Palisades site or transmission lines of interest.

Sixty-six of the 73 species initially identified occupy terrestrial or wetland habitats, inclusive of some plant species that may occur on stream or lake borders and animal species that rely on aquatic habitats for part of their life cycle. Several of these species have a high affinity for the Lake Michigan shoreline and open dunes habitat such as occurs on the Palisades site. These include two species indicated from MNFI records as occurring in the site vicinity: Pitcher's thistle (*Cirsium pitcheri,* FT, ST), known to occur on and near the Palisades site, and prairie warbler (*Dendroica discolor*, SE), which has not been documented on the site but is recorded by MNFI as recently nesting within 1 mile of the site.

Three additional species have been historically documented on or overhead the shoreline or open dune habitats on and near the plant site. These include the common tern (*Sterna hirundo*, ST) and the Caspian tern (*Sterna caspia*, ST), which were observed only as transients during Consumers-sponsored site surveys but not observed to nest there. The third species is the prairie vole (*Microtus ochrogaster*, SE), two individuals of which were collected on the site in 1978 only (follow-up collection efforts in 1979 were unsuccessful, suggesting that onsite habitat may be inadequate to sustain this species).

Two other bird species, the bald eagle (*Haliaeetus leucocephalus*, FT, ST), and osprey (*Pandion haliaetus*, ST) also have some affinity for the shoreline area in the site vicinity; however, nesting there is unlikely on the basis of occurrence records, absence of marsh habitat preferred by the osprey, and the observation that most bald eagle nesting in the area is north of Palisades. Our screening analysis indicates little or no likelihood of occurrence on the plant site for other threatened or endangered plant or animal species.

The screening study indicates that no threatened or endangered species are recorded by MNFI as occurring on the Palisades-Argenta transmission corridor. However, bald eagle, osprey, and red-shouldered hawk (*Buteo lineatus*, ST) have some potential to occur there, likely only as transients. MNFI records indicate recent osprey nesting in Gun Plain Township, Kalamazoo County, in which the Argenta Substation is located. However, there is no indication of nesting on or within one mile of the transmission corridor by any of these species on the basis of the screening analysis.

Nine additional species are considered on the basis of the screening analysis to have relatively higher occurrence potential on the transmission corridor than others among the 66 terrestrial species identified in the initial group, all of which have an affinity for wetlands or floodplains (see Table 1). These include three animal species, as follows:

- eastern massasauga rattlesnake (*Sistrurus catenatus catenatus*, FC), considered to be of special concern on the state level and recorded by MNFI as occurring in several townships along the transmission line, including locations within 1 mile of the line as recently as 1995;
- spotted turtle (*Clemmys guttata*, ST), noted in several townships along the line by MNFI, including a location within 1 mile of the line as recently as 2002; and
- the Indiana bat (*Myotis sodalis*, FE, SE) which is not recorded by MNFI as occurring in the area but potentially could utilize floodplain forest bordering the transmission corridor and occur on the corridor as a transient in summer.

The six plant species considered to have some likelihood of occurrence on or bordering the transmission corridor, all state-threatened (ST), are:

- globe-fruited seedbox (*Ludwigia sphaerocarpa*), scirpus-like rush (*Juncus scirpoides*), netted nut-rush (*Scleria reticularies*), and Carey's smartweed (*Polygonum careyi*), all noted by MNFI in Covert Township as recently as 1982-83;
- bald rush (*Psilocarya scirpoides*), noted in Covert Township in 1996; and
- sedge (*Carex seorsa*), noted by MNFI within 1 mile of the Palisades site in South Haven Township as recently as 1996.

Sedge is found in floodplain forest habitat, which may occur on the border of the transmission corridor. The remaining plant species have affinities for more open wetland types such as could exist and be maintained as such on the corridor (Table 1).

OPERATIONS AND RESOURCE PROTECTIONS

Relevant impact initiators pertaining to Lake Michigan species of concern are associated with cooling water system operation. However, design and operation of the cooling water system act to minimize potential for adverse impact to species of concern. Palisades withdraws approximately 98,000 gallons per minute (gpm) from Lake Michigan during normal full power operation for waste heat removal in the plant's circulating water system (a closed-cycle cooling system featuring two cooling towers) and the service water system. This water is withdrawn via pipeline from a submerged intake crib structure located 3,300 feet offshore at about the 35-foot water depth. The intake crib was designed and initially operated as part of a once-through cooling water system. However, conversion to a closed-cycle cooling system in 1974 has resulted in a substantial reduction of cooling water flow and very low approach velocities (approximately 0.1 foot per second) at the face of structure. Water from the intake crib flows via buried pipeline to the onshore intake structure where it passes through trash racks constructed of steeply sloped bars to prevent entry of coarse debris, then through vertical 0.375-inch mesh traveling screens for removal of finer debris. Monitoring studies conducted in 1999-2000 confirm that fish impingement and entrainment losses from plant operation are extremely low. No threatened or endangered species were found in these monitoring collections.

Cooling water not lost to evaporation in the cooling towers (approximately 86,000 gpm) mixes with low-volume wastewater from plant operations and flows to Lake Michigan via the shoreline Discharge Structure, a diverging pile structure (Figure 3), in accordance with provisions of a National Pollutant Discharge Elimination System (NPDES) permit issued by MDEQ for the plant. Results of recent surveys show that the resultant thermal plume is substantially smaller than occurred as a result of once-through operation. The plume remains largely on the surface of the lake, ranging seasonally in size (at the 3°F isotherm) from 40 to 286 acres at the surface and from 0 to19 acres at a depth of 3 feet. The Palisades NPDES permit requires that cessation of thermal discharge to the lake occur gradually to avoid fish mortality due to cold shock during the winter months.

Impact initiators pertaining to threatened or endangered species that may occur on the Palisades site (e.g., Pitcher's thistle, prairie warbler, prairie vole; see Table 1) include direct destruction of habitat from land disturbing activities, habitat disturbance or direct taking by the public, and routine vegetation maintenance practices. However, several factors act to ensure that such impacts do not occur, including the following:

- NMC and Consumers do not plan to conduct major refurbishment or construction activities (e.g., that may result in impacts from land-disturbance) to enable continued operation during the license renewal period, nor are there plans to significantly alter current Palisades operations for the license renewal period.

- Dunes along the entire length of shoreline in Covert Township, including those on the site, are classified and protected as Critical Dune Areas under Michigan's Natural Resources and Environmental Protection Act (NREPA, Part 353). The area west of I-196 in Covert Township, including the entire Palisades site, is designated by Covert Township as an Environmentally Sensitive Area (see Figure 3). Both of these regulatory controls impose land use prohibitions and requirements for permits and environmental reviews, including special-status species assessments, for new projects. In addition, Appendix B of the Palisades operating license requires an environmental evaluation before engaging in construction or operational activities that may affect the environment. NMC and Consumers have procedures in place to ensure compliance with these requirements.

- Security measures prevent public access to the site and associated potential for habitat disturbance and direct taking.

- Vegetation maintenance practices used for the onsite power and transmission line corridors are designed to maintain herbaceous (dune grass) and scrub-shrub habitat within these areas using selective removal of woody vegetation by manual cutting and selective application of EPA-approved herbicides. If anything, these practices result in long-term persistence on the site of habitats consistent with the affinities of the three species noted in Table 1 as having onsite occurrence potential on the site.

Impact initiators pertaining to species that may occur along the transmission line corridors include those associated with vegetation maintenance practices. Maintenance of transmission corridor vegetation involves selective cutting and selective application by licensed contractors of herbicides approved by the U.S. Environmental Protection Agency approximately every four years in accordance with use requirements and METC-approved maintenance plans. This maintenance is designed to promote a diverse mix of herbaceous plant species beneath the conductors (wire zone) and herbaceous and low-growing woody species (e.g, shrubs) beyond the wire zone to the large tree edge (border zone). Vegetation beyond the border zone is subject to limited management as needed to ensure trees cannot contact the conductors (danger tree removal). Consumers identifies areas of specific consideration with respect to potential occurrence of threatened or endangered species on the ROWs for which maintenance activities are planned. Practices to mitigate potential for harm to these species are reviewed and approved by METC. Consumers and NMC note that these maintenance activities do not affect hydrologic regime, which is important for the persistence of aquatic and wetland species, and are highly consistent with practices recommended for the conservation of plants and animals listed in Table 1 (e.g., maintenance of open wetland habitat). Collision with the transmission structures or conductors may also be a concern for transient bird species that may occur in the area. However, neither NMC nor

Consumers is aware of any adverse impacts to threatened or endangered species that have resulted from operation of transmission lines of interest, including such collisions.

CONCLUSION

Based on the considerations described above, renewal of the Palisades operating license is not expected to result in the taking of any threatened or endangered species, jeopardize the continued existence of such species, or result in the destruction or adverse modification of any critical habitat. These considerations include potential species occurrence in areas of interest, operations and resource protections in place, and the observation that no major refurbishment or construction activities are planned to enable continued operation during the license renewal period and no significant alterations in current Palisades operations are planned for the license renewal period.

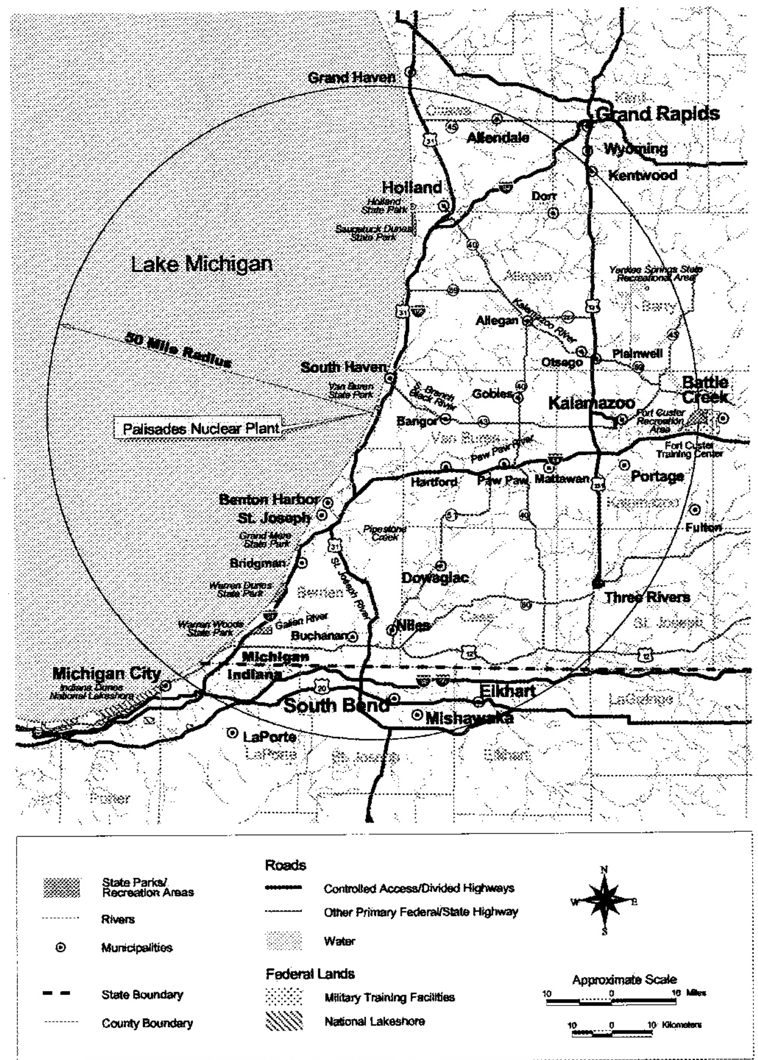
TABLE 1
THREATENED, ENDANGERED, AND CANDIDATE SPECIES WITH OCCURRENCE POTENTIAL IN AREAS OF CONCERN TO PALISADES LICENSE RENEWAL[a]

Species	Status	Habitat
Lake Michigan		
Lake herring (*Coregonus artedii*)	ST	Nearshore areas of Lake Michigan
Lake sturgeon (*Acipenser fulvescens*)	ST	Nearshore areas of Lake Michigan
Palisades Site		
Pitcher's Thistle (*Cirsium pitcheri*)	FT, ST	Open habitats on dunes
Prairie Warbler (*Dendroica discolor*)	SE	Scrub-shrub
Prairie vole (*Microtus ochrogaster*)	SE	Beach grass stabilized dunes and flats
Palisades-Argenta Right-of-Way		
Bald-rush (*Psilocarya scirpoides*)	ST	Intermittent open wetlands
Carey's smartweed (*Polygonum careyi*)	ST	Sandy marshes, lakeshores, beaver ponds
Globe-fruited seedbox (*Ludwigia sphaerocarpa*)	ST	Moist muddy or sandy shores of streams, marshes, swamps
Netted nut-rush (*Scleria reticularis*)	ST	Seasonally flooded open wetlands
Scirpus-like rush (*Juncus scirpoides*)	ST	Intermittent open wetlands
Sedge (*Carex seorosa*)	ST	Forested wetlands
Creek chubsucker (*Erimyzon oblongus*)	SE	Kalamazoo River and tributaries
Eastern massasauga (*Sistrurus c. catenatus*)[b]	FC	Wetlands and nearby uplands.
Spotted turtle (*Clemmys guttata*)	ST	Sphagnum seeps, grassy marshes with mud bottom, shallow clean water, clumps of sedge or marsh grass.
Indiana bat (*Myotis sodalis*)[c]	FE, SE	Floodplain forest along larger streams (e.g., South Branch Black River, Kalamazoo River)

a. Exclusive of bird species likely to occur on the Palisades site or transmission lines of interest only as transients, including bald eagle (*Haliaeetus leucocephalus*), osprey (*Pandion haliaetus*), red-shouldered hawk (*Buteo lineatus*), common tern (*Sterna hirundo*), and Caspian tern (*Sterna caspia*).
b. Michigan species of Special Concern.
c. Likely to occur on Palisades site or transmission line corridor only as a transient.

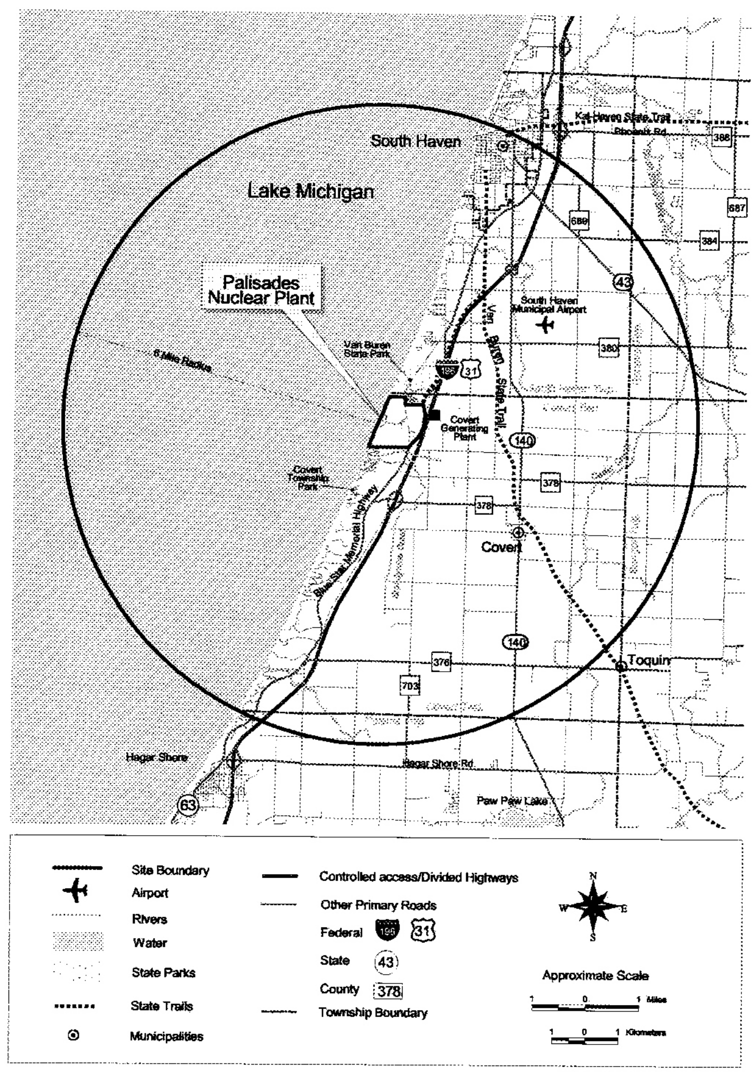
FC = Federal Candidate
FE = Federal Endangered
FT = Federal Threatened
SE = State Endangered
ST = State Threatened

FIGURE 1
50-MILE REGION



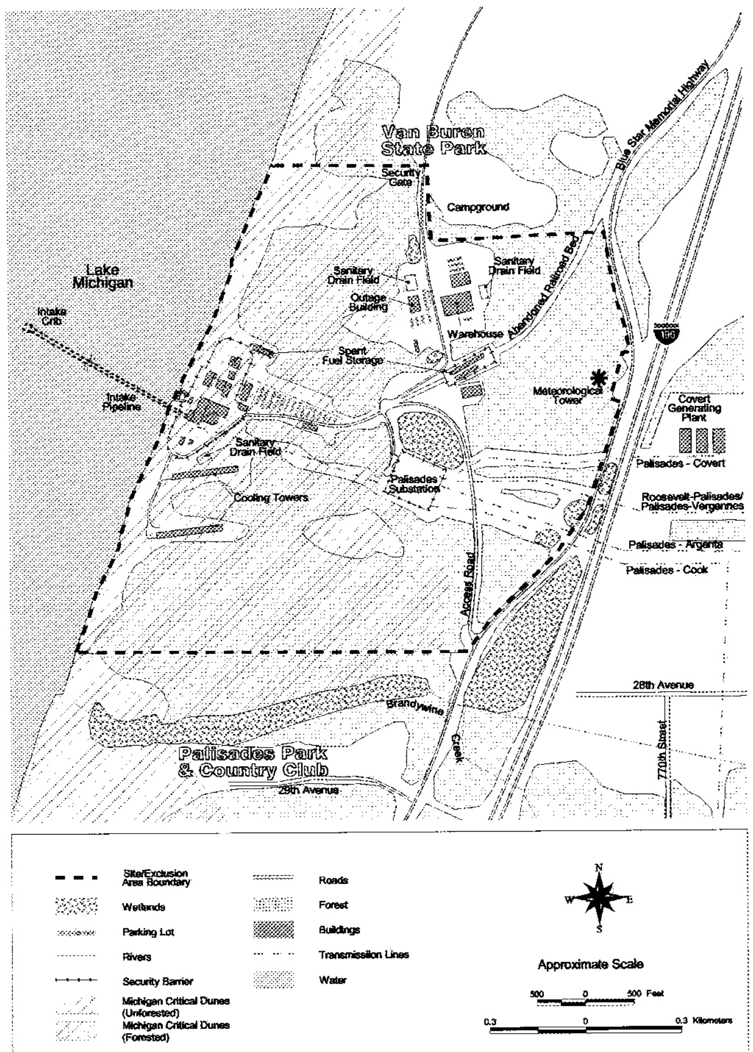
Summary of Draft Impact Assessment 9 2/04/05
T&E Species
Palisades License Renewal ER

FIGURE 2
6-MILE VICINITY



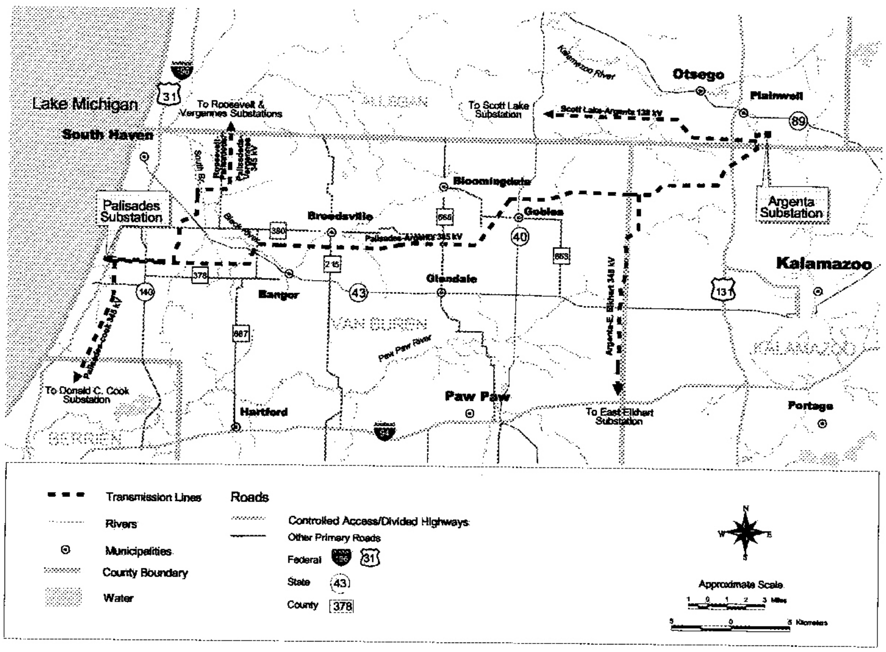
Summary of Draft Impact Assessment 10 2/04/05
T&E Species
Palisades License Renewal ER

FIGURE 3
SITE MAP



Summary of Draft Impact Assessment T&E Species Palisades License Renewal ER 11 2/04/05

FIGURE 4
TRANSMISSION LINES



Summary of Draft Impact Assessment 12 2/04/05
T&E Species
Palisades License Renewal ER

Consumers Energy Count on Us

NMC Committed to Nuclear Excellence

March 1, 2005

Mr. Craig Czarnecki
Field Supervisor
Ecological Services Field Office
U.S. Fish and Wildlife Service
2651 Coolidge Road
East Lansing, MI 48823

SUBJECT: Palisades Nuclear Plant License Renewal Project
Request for Threatened and Endangered Species Information

REFERENCE: Letter D.J. Malone (NMC) and S.T. Wawro (Consumers Energy) to C. Czarnecki (USFWS), February 4, 2005

Dear Mr. Czarnecki

As you know from previous correspondence, referenced above, Nuclear Management Company, LLC (NMC) and Consumers Energy Company (Consumers) are preparing an assessment of impact on threatened and endangered species from continued operation of Palisades Nuclear Plant (Palisades). The assessment will be included as part of our application to the U.S. Nuclear Regulatory Commission (NRC) for renewal of the Palisades operating license. Please consider this letter to be our formal request to the U.S. Fish and Wildlife Service (USFWS) for a listing of federally threatened, endangered, and candidate species and associated critical habitats that may occur on or near the Palisades site and associated transmission lines being considered in the license renewal application, and for any related information the USFWS considers relevant to our assessment.

Attached Figures 1 – 4 show the location of the Palisades site and the two transmission lines being addressed in the license renewal application: the initial 0.6-miles of the Palisades-Cook 345-kV line from the Palisades Substation and the entire 40-mile length of the Palisades-Argenta 345-kV line. We have listed the U.S. Geological Survey (USGS) 7-1/2 minute series quadrangles depicting these facilities on Attachment 1 to this letter for your further reference. A detailed description of these facilities, associated operations, and protections afforded threatened and endangered species (e.g., by plant design and operating features, regulatory restrictions, company policies and procedures) are included in the summary draft assessment we provided to you as an attachment to the above-referenced letter.

We would appreciate the USFWS' prompt response to this information request and to our February 4, 2005, request for input to our summary draft assessment, which will facilitate the NRC's independent review and consultations with USFWS on this matter.

Please address requested information, comments, questions or concerns to:

Mr. James Holthaus
Environmental Project Manager
Nuclear Management Company, LLC
27780 Blue Star Highway
Covert, Michigan 49043
1-800-701-4941 ext. 3380
James.Holthaus@nmcco.com

Thank you on behalf of NMC, Consumers Energy and the Palisades License Renewal Environmental Review Team.

Sincerely,

Daniel J. Malone
Site Vice President
Palisades Nuclear Plant
Nuclear Management Company

Stephen T. Wawro
Director of Nuclear Assets
Consumers Energy

Attachments

cc w/ attach: R. Thorson (USFWS-Fort Snelling)
J. Brewer (USFWS–Lansing)
J. Allan (Consumers-Jackson)
E. Dehn (NMC-Palisades)
J. Holthaus (NMC-Hudson)

FIGURE 1
PALISADES 50-MILE REGION

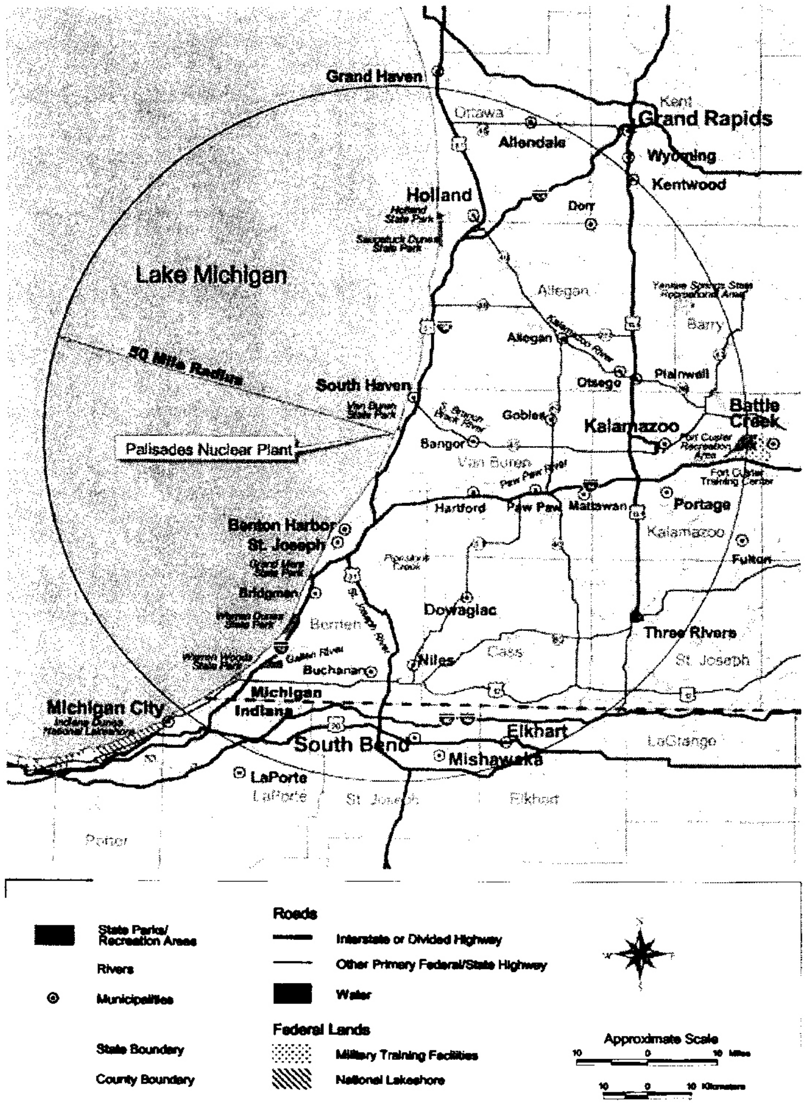


FIGURE 2
PALISADES 6-MILE VICINITY

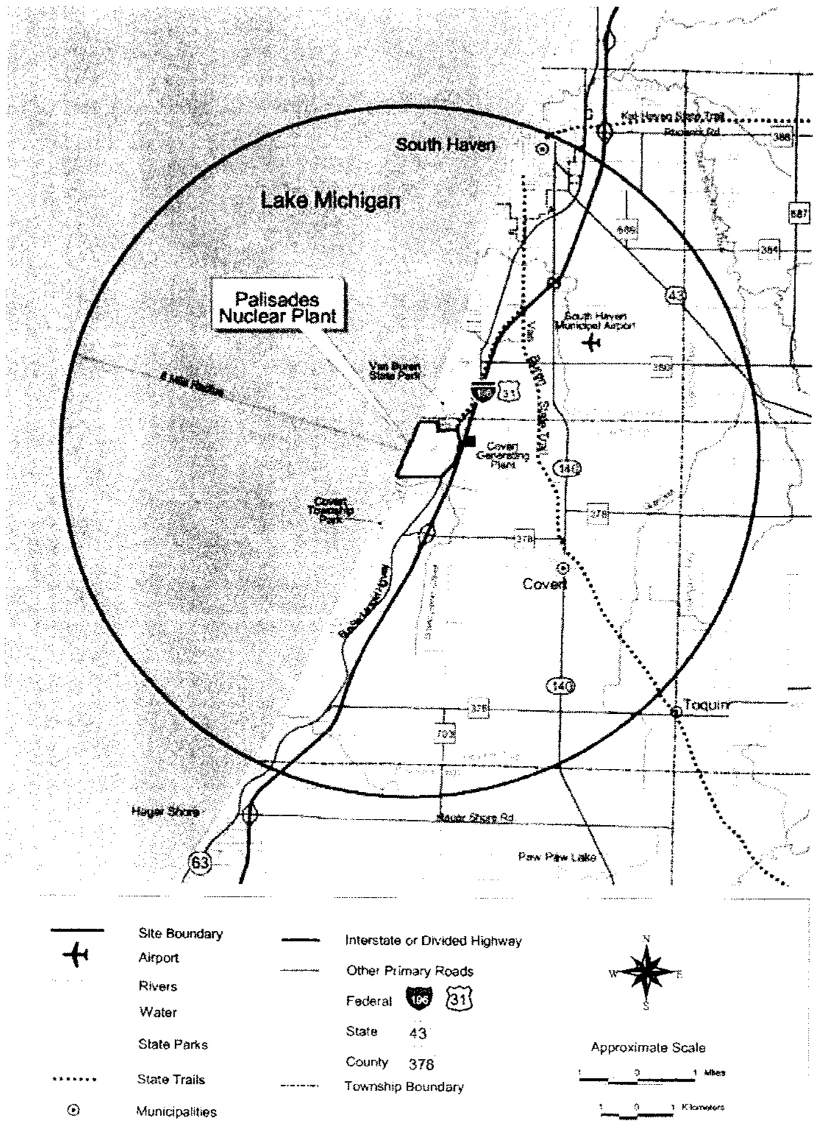


FIGURE 3
PALISADES SITE MAP

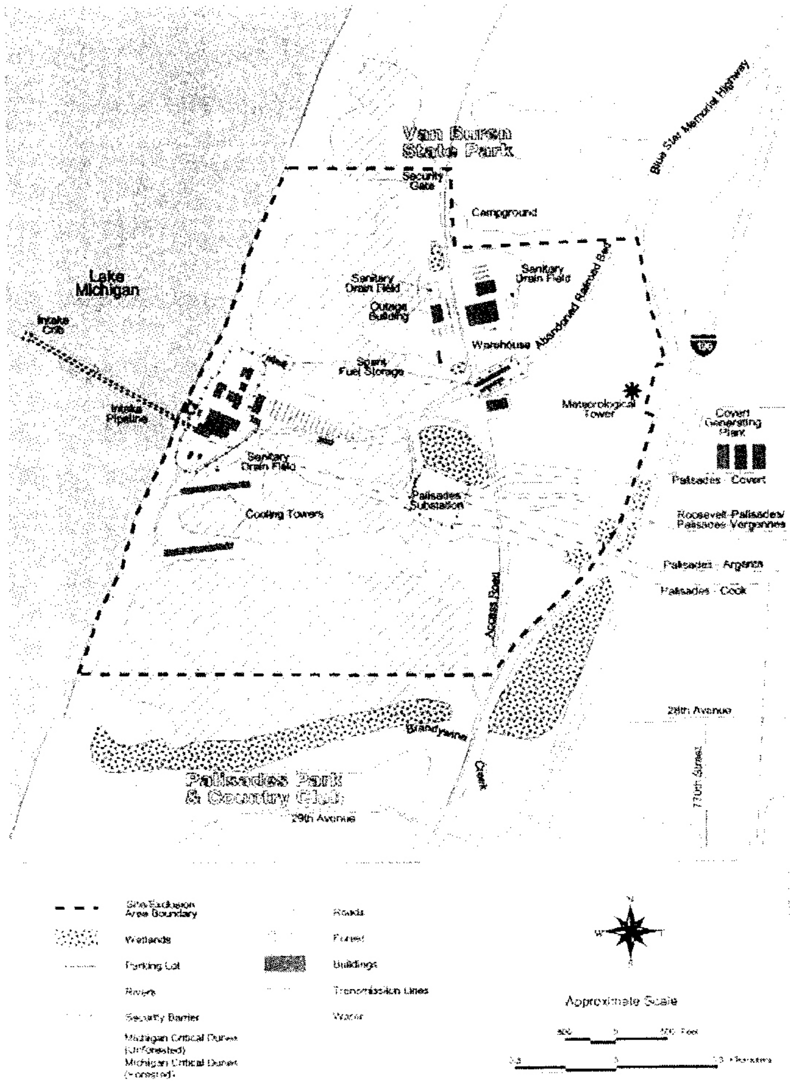


FIGURE 4
TRANSMISSION LINES

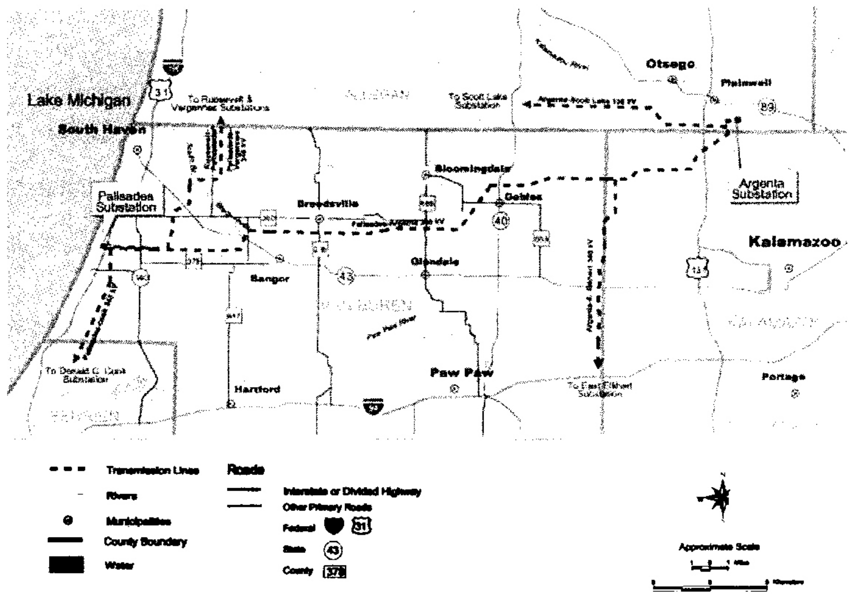


TABLE 1
USGS TOPOGRAPHIC MAPS (7-1/2 MINUTE SERIES)
SHOWING AREAS ON AND WITHIN 1 MILE OF
PALISADES SITE AND ASSOCIATED TRANSMISSION LINES
ADDRESSED IN LICENSE RENEWAL APPLICATION

Covert (1981)

Bangor (1980)

Gobles West (1981)

Bloomingdale (1981)

Merson (1981)

Gobles East (1981)

Otsego (1973)

Kalamazoo SW (1979)

Kalamazoo NE (1979)

ATTACHMENT C. CULTURAL RESOURCES CORRESPONDENCE

Consumers Energy
Count on Us

NMC
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February 11, 2005

Ms. Martha MacFarlane-Faes
Environmental Review Coordinator
Michigan State Historic Preservation Office
Michigan Historical Center
702 W. Kalamazoo St.
Lansing, MI 48909-8240

SUBJECT: Palisades Nuclear Plant— License Renewal Environmental Review

REFERENCE: Letter D. Malone (NMC) and S.T. Wawro (Consumers Energy) to B. Conway (SHPO) 9/21/2004

Dear Ms. MacFarlane-Faes:

Nuclear Management Company, LLC (NMC) and Consumers Energy Company (Consumers) thank the Michigan State Historic Preservation Office (SHPO) for their review of the letter regarding potential renewal of the Palisades Nuclear Plant (Palisades) operating license (referenced above). Consequent telephone correspondence on 10/02/2004 with James Holthaus, Environmental Project Manager, has revealed your agency's concern pertaining to possible unreported archaeological properties present on, or within the vicinity of, the Palisades site.

As there are no plans to significantly alter current operations or engage in any substantive land disturbing activities on the site or the associated transmission corridors as a part of the license renewal process, NMC, Consumers, and the Palisades Environmental Review Team conclude the operation of Palisades through the license renewal term will not have an adverse effect on any historic or cultural property in the region. Therefore, NMC and Consumers do not believe a survey of the project area is necessary, as Federal and state agencies have confirmed on multiple occasions that no historic properties, archeological or architectural, are known to exist on, or in the immediate vicinity of the Palisades site. Relevant correspondence to support this conclusion is summarized below, and is included for your records.

Prior to the issuance of Palisades' original operating license, DPR-20, the U.S. Atomic Energy Commission (AEC) conducted a site-specific analysis of Palisades to comply with the National Environmental Policy Act of 1969 (NEPA) (42 U.S.C. 4321-4347). The AEC is the predecessor of the United States Nuclear Regulatory Commission (NRC). AEC findings were published in the June 1972 *Final Environmental Statement related to operation of Palisades Nuclear Generating Plant* (FES) (Docket No. 50-255). The AEC considered the site in accordance with the requirements of the National Historic Preservation Act of 1966 (16 U.S.C. 470f) to determine whether any historic landmarks would be affected by the plant location. Findings determined that no landmark in the vicinity of the site was listed in the National Register of Historic Places, and that no Federal, state, or local historical landmark would be affected by plant operations. Consultations with Federal and state agencies were a crucial component of the AEC's analysis of Palisades' potential effect on natural and cultural resources on, or in the vicinity of, the Palisades site. Relevant correspondence related to AEC determinations is summarized below:

- An April 7, 1972 letter from the Deputy Assistant to the U.S. Secretary of the Department of Interior (DOI) to the AEC Director of Regulation established the DOI's opinion that Palisades' operation would not, "directly affect any existing or proposed unit of the National Park System, nor any site eligible for registration of as a national historic, natural, or environmental education landmark." The letter recommended confirmation of this fact be provided to the AEC by the appropriate State agency.

- A May 19, 1972 letter from the Michigan State Liaison Officer for Historic Protection to the AEC confirmed the DOI's determination and stated that Palisades would not, "adversely affect known historical or archaeological resources of the State of Michigan."

In addition, a 1979 Terrestrial Ecological Survey conducted for Consumers by an independent contractor found that no significant historical or archaeological resources were known to occur on the Palisades site. Study findings were confirmed by correspondence with Dr. Martha Bigelow, Director of the Michigan Department of State's Michigan History Division; the agency verified that no significant historical or archaeological sites had been found in the immediate area of Palisades.

When conducting the environmental review in support of license renewal, NMC drew upon the aforementioned documents to establish baseline information. As part of the license renewal process, the U.S. Nuclear Regulatory Commission (NRC) requires, in 10 CFR 51.53(c)(3)(ii)(K), that applicants assess, "whether any historic or archaeological properties will be affected by the proposed project." As of 2004, five properties in Van Buren County are listed on the National Park Service's National Register of Historic Places. Of these, two properties— the Liberty Hyde Bailey Birthplace and the Navigation Structures at South Haven Harbor— are within the six-mile radius of Palisades. In addition, NMC found one property— the James Noble Sherwood House in Plainwell, Allegan County— within one-half-mile of an associated transmission corridor. The status of the concerned sites will be discussed in Palisades' license renewal application to the NRC.

NMC and Consumers feel that adequate environmental controls are in place to ensure protection of cultural resources. In order to ensure compliance with applicable state and federal laws and company policies, a Consumers Environmental Review is required before employees conduct construction or modification activities/projects, or before any land transaction activities occur. Examples of activities requiring an Environmental Review include disturbance of 1 or more acres of previously undisturbed land, any earth change within 500 feet of water, wetland and waterway activities, and structural interference with landforms, lakes and streams, among others. The Environmental Review requires completion of an Environmental Permits Checklist to ensure environmental protection/permit compliance, identify land use constraints, and become aware of regulated resources, including cultural resources. These controls are applicable to projects, processes and activities on Consumers-owned or leased lands or on customer-owned lands on which Consumers performs an activity. In the event that potential items of significance were indeed discovered, NMC and Consumers would consult with your office on a case-by-case basis. In addition, any future release of land would be subject to full NEPA review and further agency consultations, including consultation with the Michigan SHPO.

Further, because the site lies in an Environmentally Sensitive Area designated by Covert Township ordinance, any onsite activity potentially resulting in significant land disturbance during the license renewal term would necessitate an environmental assessment that includes an evaluation of potential impacts and a permit from the township. Similarly, any such activity on areas of the site designated as Michigan Critical Dunes would require a similar assessment and permit from the Michigan Department of Environmental Quality.

NMC and Consumers hope this letter provides an adequate response to your agency's concerns. The NRC will request a consultation with your office in the future in accordance with Section 106 of the National Historic Preservation Act of 1966, as amended (16 USC 470) and the Federal Advisory Council on Historic Preservation regulations (36 CFR 800). After your review of this letter and its attachments, we request your written input regarding our conclusions. Please detail any additional concerns regarding historic or archaeological properties and confirm our conclusion that continued operation of Palisades would have no effect on any historic or archaeological properties in the area. Your expeditious response will facilitate future NRC correspondence with your agency. NMC will include a copy of this letter and your response in the Environmental Report submitted to the NRC as part of the Palisades license renewal application.

NMC and Consumers look forward to continued correspondence and cooperative efforts with the Michigan SHPO. If you have any questions, please contact:

James Holthaus
Environmental Project Manager
Palisades Nuclear Plant
27780 Blue Star Highway
Covert, Michigan 49043
1-800-701-4941 ext. 3360
James.Holthaus@nmcco.com

Sincerely,

Dan J. Malone
Site Vice President
Palisades Nuclear Plant
Nuclear Management Company, LLC

Stephen T. Wawro
Nuclear Assets Manager
Consumers Energy

Encl: -Letter from Deputy Assistant to the Secretary of Interior (DOI) to Mr. L. Manning Muntzing (AEC), April 7, 1972
-Letter from S. Milstein (DNR-Liaison Officer for Historic Preservation) to Dr. M.J. Oestmann (AEC), May 19, 1972

Cc: Brian Conway, SHPO
Jon Allan, Consumers

United States Department of the Interior

OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20240

APR 7 1972

RECEIVED APR 11 1972

Dear Mr. Muntzing:

This is in response to Mr. Rogers' letter of March 3, 1972, requesting our comments on the Atomic Energy Commission's draft detailed statement, dated February 29, 1972, on environmental considerations for Palisades Nuclear Generating Plant, Van Buren County, Michigan.

General

Our concerns for the adverse environmental impacts of this plant have been greatly reduced as a result of several major modifications in gaseous and liquid radwaste systems, and the decision to install cooling towers.

It appears that the AEC has expended considerable effort to assess the adequacy of the applicant's studies and to point out the inadequacies in the draft environmental statement. Inadequacies in assessing environmental impacts were acknowledged throughout the statement, but were critically evaluated beginning on page 131. We assume that inadequacies pointed out in the statement by AEC will also become AEC's requirements; therefore, we have generally not commented on them.

Site Selection

The various site selection studies described in this section are based primarily on economic considerations. We are cognizant of the greater emphasis now being placed on non-economic factors than at the time these studies were made. However, the assessment of environmental considerations is conspicuously absent from any of the studies described in this section.

Historic Significance

It does not appear that the existing plant should directly affect any existing or proposed unit of the National Park System, nor any site eligible for registration as a national historic, natural or environmental education

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landmark; however, the final statement should contain evidence of consultation with the State Historic Preservation Officer concerning the effects of the power station on places on or being considered for nomination to the National Register of Historic Places. He is the Director, Department of Natural Resources, Stevens T. Mason Building, Lansing, Michigan 48926.

Transmission Lines

We think that the applicant should conduct normal inspection of the right-of-way for the transmission line by plane, helicopter or on foot, thus eliminating the need to keep the entire right-of-way cut back in wooded areas. Clearing should be limited to only permit access of maintenance vehicles, and to keep the line free from intrusion of timber which would interfere with the safe operation of the line.

Effluent Systems

According to the report, debris and small fish removed from the trash racks and traveling screens in the water intake system will be disposed of as solid waste. However, the method of solid waste disposal is not explained, nor is an estimate of the quantity of solid waste involved given for other than radioactive wastes. We think these data should be included in the final environmental statement.

Radioactive Waste

According to the statement, all solid radioactive waste will be packaged and shipped to a licensed burial ground in accordance with AEC and DOT regulations. We think the location of burial site and the agency licensing it should be included in the final environmental statement.

Controls to Reduce or Limit Environmental Impacts

We suggest that the applicant consult with State and local authorities on constructing nature trails, landscaping and replanting dune grasses where necessary to restore the site, and disposing of solid waste collected on the water intake screens. It appears that the applicant is taking

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appropriate action in regard to most of these items; however, we think consultation with appropriate entities would assure adequate protection and utilization of the environment at minimum cost.

Biological Impacts

The term "sterile zone" used on page 108 is misleading since it includes a zone extending approximately one mile offshore. Figures V-4 and V-5 show that there is some benthic productivity in this wave-washed zone. Various studies also indicate that this zone is highly important to certain fish and other aquatic life during some portion of their life cycle. We suggest the term "less productive" be substituted for "sterile".

We remain concerned that the project may have significant adverse effects on aquatic life in Lake Michigan. Significant numbers of important sport and commercial fishes may become entrapped by the cooling system during the 42-month period prior to construction of cooling towers. Preoperational studies, with sampling done in May, June, August, and October revealed that the intake is located at a depth used extensively by many fishes. The area within the zone influenced by the thermal plume will act as an attractant for certain fish species, resulting in possible entrapment of considerable numbers in front of the screens. Although the intake velocity is about 0.5 or 0.8 feet per second, operating experience may show that additional screens around the intake are necessary for adequate protection of the fishery.

Accidents

The section on Environmental Impact of Postulated Plant Accidents gives an adequate evaluation of impacts resulting from postulated accidents through Class 8 for air borne emissions. However, the environmental effects of releases to water are lacking. Many of these accidents described in tables V-6, V-7, and V-8 could result in releases to the water and should be evaluated in detail.

We also think that Class 9 accidents resulting in both water and air releases should be described and the impact on human life and the remaining environment discussed as

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long as there is any possibility of occurrence. The consequences of an accident of this severity could have far-reaching effects on land and possibly throughout the entire Great Lakes and could persist for centuries.

Transportation of Nuclear Fuel and Solid Radioactive Waste

According to information given on page 166, about 9 truck-loads or 1 to 3 rail car loads of packaged solid radioactive wastes will be shipped from the plant site each year. Later subsections treat the probability of recurrence and the impact of accidents. We suggest that details concerning the procedures to be used when a spilled shipment occurs should also be given in this section.

Adverse Environmental Effects Which Cannot be Avoided

The statement is made on page 183 that no consumptive use of the lake water will result from once-through cooling. Although consumptive use of the cooling water is not apparent at the plant, a substantial amount of induced evaporation is involved and water is evaporated as a direct result of the plant. It is estimated that about 50 - 75% of the waste heat discharged in the cooling water is dissipated from the lake water surface through the evaporative process. Furthermore, table IX-2 shows that the consumptive use of water from the once-through operation is about 80% of that for the cooling tower systems; however, this estimate appears to be high.

Cost-Benefit Analysis

We continue to believe that environmental costs and benefits should be expressed in non-dollar quantitative terms. A table similar to IX-2 but with emphasis on environmental impacts is suggested for the final statement.

Recommendations

Since fish are expected to be attracted to the warm water plume, a shutdown, especially during the winter, would probably cause significant mortality during the period when the once-through method of cooling is used. Consequently, we recommend that all maintenance requiring shutdown be scheduled during times other than winter.

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We hope these comments will be helpful as you prepare the final environmental statement.

Sincerely yours,

Deputy Assistant Secretary of the Interior

Mr. L. Manning Muntzing
Director of Regulation
U. S. Atomic Energy Commission
Washington, D. C. 20545

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ATTACHMENT D. COASTAL ZONE MANAGEMENT ACT CONSISTENCY DETERMINATION

COASTAL ZONE MANAGEMENT CONSISTENCY CERTIFICATION
PALISADES NUCLEAR PLANT
OPERATING LICENSE RENEWAL

This certification documents a determination by Nuclear Management Company, LLC (NMC) that continued operation of the Palisades Nuclear Plant (Palisades), as would be authorized by U.S. Nuclear Regulatory Commission (NRC) renewal of its operating license, complies with the enforceable policies of the federally approved Coastal Management Program of the State of Michigan and will be conducted in a manner consistent with such program.

Background

The NRC licenses the operation of domestic nuclear power plants in accordance with the Atomic Energy Act of 1954, as amended, and NRC implementing regulations set forth in Title 10, Code of Federal Regulations, Part 51 (10 CFR 51)[1]. Palisades, a nuclear-powered steam electric generating station, operates under authority of NRC Operating License DPR-20. NMC is applying to the NRC for renewal of this license, which expires March 24, 2011. License renewal would provide the opportunity to operate the plant for an additional 20 years beyond the current license term; i.e., until March 24, 2031.

Maximum authorized power level of the Palisades reactor is 2,565.4 megawatts–thermal (MWt), corresponding to a current net summer electrical generating capacity of approximately 786 MW-electrical (MWe). Palisades is owned by Consumers Energy Company (Consumers), a subsidiary of CMS Energy Corporation. NMC operates Palisades on behalf of Consumers. With respect to the Palisades operating license, Consumers is the owner licensee and NMC is the licensed operator of the facility.

The NRC requires that applicants prepare an environmental report (ER) to address the environmental impacts of license renewal and describe the status of compliance with

[1] NRC regulations in 10 CFR 51 are accessible online at http://www.access.gpo.gov/nara/cfr/waisidx_04/10cfr51_04.html

respect to applicable federal environmental quality requirements [10 CFR 51.45, 10 CFR 51.53(c)]. Among those requirements is the federal Coastal Zone Management Act of 1972 (CZMA; 16 USC 1451 et seq.). The CZMA requires that applicants for a federal license or other form of permission for an activity which may affect any land or water use or natural resource of the coastal zone, as defined in the statute, certify in the application to the approving federal agency that the proposed activity complies with the enforceable policies of affected states' approved management program and will be conducted in a manner consistent with such program [see 16 USC 1456(c)(3)(A) and 15 CFR 930.57(b)]. National Oceanic and Atmospheric Administration (NOAA) regulations indicate that this requirement is applicable to renewal of federal licenses for activities not previously reviewed by the state [see 15 CFR 930.51(b)(1)]. NMC has prepared this certification in view of Palisades' location on the Lake Michigan shoreline and the observation that the State of Michigan has not previously reviewed Palisades' consistency with the Michigan Coastal Management Program (Antieau 2004). Specifically, the entire Palisades site and portions of transmission lines emanating from the Palisades Substation addressed in the Palisades license renewal application are located within the state's designated Coastal Zone Management Area (see MDEQ 2004a and Figures 1 through 4 of this certification). In addition, the initial operating license for Palisades was issued March 24, 1971, before Michigan's Coastal Management Program received federal approval in 1978 (NOAA 2003, MDEQ 2004b).

In accordance with NOAA regulations at 15 CFR 930.58 and NRC guidance (NRC 2004), NMC includes in the remainder of this document information necessary to support its CZMA consistency determination. This supporting information includes a description of Palisades facilities and operations, potentially affected environmental resources, enforceable provisions of the Michigan Coastal Management Program and compliance status with respect to these provisions, and a summary of NMC's environmental impact evaluations and associated findings.

Proposed Activity

NMC expects that Palisades operations during the license renewal term would be a continuation of current plant operations, and provides in this section information about facilities, operations, and environmental features relevant to this certification.

Palisades is located on the eastern shore of Lake Michigan in Covert Township, Van Buren County, Michigan (parts of Sections 4 and 5, T2S, R17W). Major features within 50 miles and 6 miles of the plant are illustrated in Figures 1 and 2, respectively. Features on the Palisades site and along the routes of associated transmission lines being addressed in the Palisades license renewal application are shown in Figures 3 and 4, respectively.

The Palisades site comprises 432 acres. Like contiguous lands to the north and south, the site consists primarily of sand dunes, mostly forested, which extend inland approximately 5,000 feet. As a result of this local topography, site drainage is independent of Brandywine Creek, a nearby Lake Michigan tributary that drains areas immediately east and south of the plant site. Surface water and percolating runoff from the site drain directly to the lake. Site studies indicate that dune sand varies in thickness from about 10 feet near the Palisades Substation to well over 100 feet near the lake. Depth to groundwater during those studies was found to vary from approximately 10-15 feet near the eastern end of the site to approximately lake level near the shoreline. Bathymetry and bottom sediment studies indicate that the lake bottom at Palisades slopes from the sand beach at the shoreline to a depth of approximately 10 feet within 500 feet of shore, then to a depth of approximately 50 feet 1 mile offshore. Bottom sediments consist of coarse to fine sands. Approximately 80 acres of the Palisades site are developed or maintained. The remainder consists primarily of natural plant communities, mostly deciduous hardwood forest (approximately 250 acres), with lesser amounts of pine forest, shrub-scrub and old-field communities, beach grass dunes and flats, sand dune blow-outs, and open sand. Wetland communities on the site are few, small, and scattered, totaling less than 10 acres. An ecological survey of the site documented the presence of 14 mammal species and seven amphibian or reptile species on the site, and approximately 113 bird species on or overhead the site or adjacent areas (e.g., lakeshore). A portion of the deciduous forest along the southern boundary of the Palisades site is recognized as an "exemplary dune associated plant community" in the Michigan Department of Environmental Quality (MDEQ) Atlas of Critical Dune Areas and as an "exemplary mesic southern forest" by the Michigan Natural Features Inventory (MNFI).

The natural resources on the site are protected by security measures that prevent public access to the site, regulatory restrictions, and site implementing procedures. For example, dunes along the entire length of shoreline in Covert Township, including those on the site, are classified and protected as Critical Dune Areas under Michigan's Natural Resources and Environmental Protection Act (NREPA, Part 353; see Figure 3). In addition, the area west of I-196 in Covert Township, including the entire Palisades site, is designated as an Environmentally Sensitive Area by Covert Township. This area is subject to specific land use prohibitions, and new projects require permits and environmental impact statements, which include special status species assessments.

Developed and maintained portions of the site (Figure 3) include the power block area, where the following key plant facilities are located: Reactor Containment Building, Turbine Building, Auxiliary Building and Auxiliary Building Addition (Radioactive Waste Building), Condensate and Makeup Demineralizer Building, the Intake Structure, and the Cooling Tower Pump House. Major facilities outside of the power block include two mechanical draft cooling towers, two facilities for dry storage of spent nuclear fuel, radioactive waste storage building, a mausoleum for storage of spent steam generators that were replaced in the early 1990s, a warehouse, the outage/training facility, and the spent fuel services building. Power transmission facilities on the site include the Palisades Substation and transmission lines and corridors that extend eastward from the power block to the eastern site boundary at the Blue Star Memorial Highway. The transmission lines connecting to the Palisades Substation, all of which operate at 345 kilovolts (kV), and certain equipment in the substation are owned by the Michigan Electric Transmission Company (METC). Consumers owns the site and onsite transmission corridors.

Water used for Palisades plant operation consists of raw water from Lake Michigan and potable water from the South Haven Municipal Water Authority. Water withdrawn from Lake Michigan, amounting to approximately 98,000 gallons per minute (gpm) during normal full power operation, is used primarily for waste heat removal in the plant's Circulating Water System (a closed-cycle system featuring two cooling towers; see Figure 3) and the Service Water System. This water is withdrawn from Lake Michigan via pipeline from a submerged intake crib structure located 3,300 feet offshore at about the 35-foot water depth. Water enters the crib on each of its four sides, which are constructed of 2-inch vertical steel bars spaced at 10-inch intervals. The intake crib was designed and initially operated as part of a once-through cooling water system. However, conversion to a closed-cycle cooling system in 1974 has resulted in a substantial reduction of cooling water flow and very low approach velocities (approximately 0.1 foot per second) at the face of structure. Water from the intake crib flows through an 11-foot diameter pipe to the onshore Intake Structure where it passes through trash racks constructed of steeply sloped bars to prevent entry of coarse debris, then through vertical 0.375-inch mesh traveling screens for removal of finer debris. Debris accumulated on the trash racks is removed and disposed of in accordance with provisions of the Palisades National Pollutant Discharge Elimination System (NPDES) permit issued by the MDEQ. Recent monitoring studies confirm that fish impingement and entrainment losses from plant operation are extremely low.

Consumptive losses due to evaporation from the two cooling towers is estimated to range as high as approximately 12,000 gpm in summer. The remainder of the cooling water, approximately 86,000 gpm, mixes with low-volume wastewater from plant operations and flows to Lake Michigan via the shoreline Discharge Structure, a diverging pile structure (Figure 3). The discharge is monitored for both radiological and nonradiological parameters. Monitoring requirements for nonradiological parameters are specified in accordance with provisions of the Palisades NPDES permit, which include limits for maximum allowable discharge flow, daily maximum heat addition, and release of total residual oxidants used for biofouling control in the cooling water systems. Results of recent surveys show that the thermal plume remains largely on the surface of the lake, and ranges seasonally in size (at the 3°F isotherm) from 40 to

286 acres at the lake surface and 0 to19 acres at a depth of 3 feet. The Palisades NPDES permit requires that cessation of thermal inputs to the lake occur gradually to avoid fish mortality due to cold shock during the winter months.

Water obtained from the South Haven Municipal Water Authority for domestic use averages approximately 12.5 gpm, most of which is ultimately disposed of onsite to sanitary drain fields. Onsite groundwater use is limited to potential withdrawals for grounds maintenance or other miscellaneous uses from three small production wells having a combined production capacity of 24 gpm.

Palisades is located in an area designated by the U.S. Environmental Protection Agency (EPA) as marginal non-attainment for 8-hour ozone. Surrounding counties are also designated as marginal non-attainment for ozone, with the exception of Cass County, which is designated as moderate non-attainment. NMC holds a permit from MDEQ for Palisades emission sources, which include an evaporator heating boiler, plant heating boiler, feedwater purity boiler, emergency generators, and cold cleaners.

The normal operations workforce at Palisades consists of approximately 534 permanent employees and 110 contractors. Approximately 56 percent of workers comprising the permanent workforce live in Van Buren County and approximately 21 percent live in Berrien County. The remaining employees live in various other locations, primarily in the vicinity of the city of Holland, Ottawa County. During refueling outages, which occur at intervals of approximately 18 months, site employment increases by approximately 384 workers for temporary (30 to 40 days) duty. NMC expects that few, if any, additional staff will be needed for either routine operations or refueling outages during the license renewal term.

A total of seven METC 345-kV circuits extend from the Palisades Substation on double-circuit steel lattice towers as four transmission lines (see Figure 3). Two of these lines are being addressed in the license renewal application for Palisades because they were installed as a direct result of initial construction and operation of the plant: the initial 0.6-mile segment of the Palisades- Cook line and the entire 40-mile length of the Palisades-Argenta line (see Figures 3 and 4). The 0.6-mile Palisades-Cook line segment and the portion of the Palisades-Argenta line extending east to state highway M-140, a distance of approximately 2 miles, lie within the Coastal Zone Management Boundary (see Figure 4, MDEQ 2004a). Most of the former line segment consists of onsite land and highway crossings (Blue Star Memorial Highway and I-196); the latter line traverses exclusively rural landscape typical of southwestern lower Michigan. In particular, the Palisades-Argenta right-of-way (ROW) lies on 2,200 acres of land owned by Consumers (i.e., fee strips) comprised primarily of active agricultural land, forest (mostly central hardwoods) and rangeland (mostly shrubland). Approximately 16 percent of the cleared ROW length traverses wetlands, nearly all of which consist of seasonally or temporarily flooded palustrine emergent and, to a lesser extent, seasonally flooded palustrine scrub-shrub habitat.

Consumers implements METC's program for maintaining vegetation on the transmission ROWs. This maintenance involves selective cutting and selective application by licensed contractors of EPA-approved herbicides approximately every four years in accordance with METC-approved maintenance plans. These activities are undertaken to promote a diverse mix of herbaceous plant species beneath the conductors (wire zone) and low-growing woody species (e.g, shrubs) beyond that zone to the large tree edge (border zone). Vegetation beyond the border zone is managed to ensure trees cannot contact the conductors (danger tree removal). Consumers identifies areas of specific consideration with respect to potential occurrence of threatened or endangered species on the ROWs for which maintenance is planned. Practices to mitigate potential harm to such species are reviewed and approved by METC.

Michigan Coastal Management Program Enforceable Provisions

Michigan's Coastal Management Program is based on several different state authorities rather than a single law and set of regulations. The MDEQ implements the program and maintains a website that includes a program description (MDEQ 2004b). Table 1 lists enforceable provisions of the program and NMC's basis for certifying compliance. Table 2 lists environmental authorizations for current Palisades operations. The following sections provide additional information regarding probable environmental impacts of license renewal and NMC's findings with respect to this certification.

Probable Effects

The NRC has prepared a *Generic Environmental Impact Statement* (GEIS) (NRC 1996, 1999) that examines environmental impacts nuclear power plant operations could have on the environment. NRC findings are codified in 10 CFR 51, Subpart A, Appendix B, Table B-1[2]. A total of 92 potential environmental issues are identified in the codification, 69 of which the NRC termed "Category 1 issues". All of these Category 1 issues were determined by NRC to have small environmental impacts on a generic basis (i.e., for all nuclear power plants). The NRC defines "small" as:

> SMALL – For the issue, environmental effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource. For the purpose of assessing radiological impacts, the Commission has concluded that those impacts that do not exceed permissible levels in the Commission's regulations are considered small as the term is used in this table (10 CFR 51, Subpart A, Appendix B, Table B-1).

The NRC discusses the following types of Category 1 environmental issues in its codification and the GEIS:

- Surface water quality, hydrology, and use
- Aquatic ecology
- Groundwater use and quality
- Terrestrial resources
- Air quality

[2] The GEIS is accessible online at http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1437/. NRC conclusions in 10 CFR 51, Subpart A, Appendix B, Table B-1 are accessible online at http://www.access.gpo.gov/nara/cfr/waisidx_04/10cfr51_04.html (link to 51.125, pages 4-12).

- Land use
- Human health
- Postulated accidents
- Socioeconomics
- Uranium fuel cycle and waste management
- Decommissioning

Absent new and significant information to the contrary, the NRC relies on its codified findings and supporting information in the GEIS for its assessment of Category 1 environmental issues for plant-specific license renewal applications [10 CFR 51.95(c)(4)]. For plants such as Palisades that are located in a coastal zone, many of these issues involve impacts to the coastal zone. NMC has adopted by reference in its license renewal ER the NRC findings and GEIS analyses for all 56 Category 1 issues applicable to Palisades[3].

The NRC identified 21 of the 92 environmental issues as "Category 2" in 10 CFR 51, Subpart A, Appendix B, Table B-1. The NRC could not resolve these issues on a generic basis; therefore, license renewal applicants are required to submit additional site-specific information for applicable issues in their ERs.[4] Of these 21 issues, nine do not apply to Palisades license renewal due to facility design, operation or location features. NMC summarizes impact conclusions for the remaining 12 Category 2 issues in the following paragraphs:

[3] The remaining 13 Category 1 issues do not apply to Palisades. Six of these apply to design, operational, or location features that do not exist at the facility, such as use of once through cooling heat dissipation systems, cooling ponds or Ranney wells, and groundwater withdrawal. The remaining seven issues relate to plant refurbishment, which do not apply because NMC does not plan to undertake any major refurbishment activities.

[4] The NRC also identifies in 10 CFR 51, Subpart A, Appendix B, Table B-1 two issues as "NA" for which NRC could not come to a conclusion regarding categorization. NMC believes that these issues, chronic effects of electromagnetic fields and environmental justice, do not affect "coastal zone" as that phrase is defined by the CZMA [16 USC 1453(1)].

- Terrestrial Resources: Refurbishment impacts – NMC has no plans to perform major refurbishment activities as a result of license renewal; therefore, no impacts to terrestrial resources from refurbishment are expected.

- Threatened or Endangered Species – This issue concerns potential impacts of refurbishing the plant and potential impacts of operating the plant and transmission lines considered in the license renewal application during the Palisades license renewal term on species that are listed under federal law as threatened (FT) or endangered (FE) or candidates for such listing (FC). NMC also considered potential impact on species listed as threatened (ST) or endangered (SE) by the State of Michigan. NMC has no plans to perform major refurbishment activities as a result of license renewal; therefore, no impact to threatened or endangered species from refurbishment is expected. NMC conducted a screening analysis to identify those threatened, endangered, and candidate species of potential concern to Palisades license renewal and the likelihood of their occurrence in Lake Michigan at Palisades, on the Palisades site, or on the Palisades-Argenta transmission line ROW (and, by inference, the Palisades-Cook line segment of interest). Other than transient bird species, the only species known or considered most likely to occur in these areas are the state-threatened lake herring and lake sturgeon, in Lake Michigan, and the federally threatened Pitcher's thistle (*Cirsium pitcheri*), known to occur on the Palisades site. Threatened, endangered, and candidate species considered on the basis of the screening assessment to have relatively more likelihood than others to occur in areas of concern, exclusive of bird species likely to occur only as transients, are:

Lake Michigan

Lake herring (*Coregonus artedii*)	ST
Lake sturgeon (*Acipenser fulvescens*)	ST

Palisades Site

Pitcher's thistle (*Cirsium pitcheri*)	FT, ST
Prairie warbler (*Dendroica discolor*)	SE
Prairie vole (*Microtus ochrogaster*)	SE

Palisades-Argenta Right-of-Way

Bald-rush (*Psilocarya scirpoides*)	ST
Carey's smartweed (*Polygonum careyi*)	ST
Globe-fruited seedbox (*Ludwigia sphaerocarpa*)	ST
Netted nut-rush (*Scleria reticularis*)	ST
Scirpus-like rush (*Juncus scirpoides*)	ST
Sedge (*Carex seorosa*)	ST
Creek chubsucker (*Erimyzon oblongus*)	SE
Eastern massasauga (*Sistrurus c. catenatus*)	FC
Spotted turtle (*Clemmys guttata*)	ST
Indiana bat (*Myotis sodalis*)	FE, SE

Relevant impact initiators pertaining to Lake Michigan species of concern are associated with the plant's cooling water system. However, the use of a closed-cycle cooling water system (cooling towers) at Palisades tends to minimize cooling water flow and the resultant thermal plume, which is small and largely confined to the lake surface. Recent studies show that fish impingement and entrainment losses at Palisades are very small; no threatened or endangered species were noted in impingement and entrainment samples collected during these studies. The Palisades NPDES permit limits potential discharge of pollutants and includes the requirement for gradual shutdown of the facility to minimize potential for cold shock of fish.

Impact initiators pertaining to Pitcher's thistle, known to occur on the site, and the prairie warbler and prairie vole, determined to have some limited potential to occur on the site, include direct destruction of habitat from land disturbing activities and routine vegetation maintenance practices. However, NMC has not identified any land disturbing activities that would be undertaken for license renewal. Further, because the site lies in an Environmentally Sensitive Area designated by Covert Township ordinance, onsite activity potentially resulting in significant land disturbance during the license renewal term would necessitate an environmental assessment that includes an evaluation of potential impact to threatened or endangered species, and a permit from the township. Similarly, any such activity on areas of the site designated as Michigan Critical Dunes (Figure 3) would require an assessment and permit from the MDEQ.

Vegetation maintenance practices for the onsite power line corridor from the plant to the Palisades Substation and onsite transmission line ROWs from the substation are designed to maintain herbaceous (dune grass) and scrub-shrub habitat within these areas using selective removal of woody vegetation by manual cutting and selective application of EPA-approved herbicides. These practices result in long-term persistence on the site of habitats consistent with the affinities of Pitcher's thistle, prairie vole and prairie warbler. In addition, security measures in place for the site afford a high degree of protection for all special-status species and habitats on the site by precluding uncontrolled access that could result in habitat disturbance or direct taking.

Impact initiators pertaining to species that may occur along offsite transmission line ROWs include previously described ROW vegetation maintenance practices. However, as noted above, this maintenance is conducted in accordance with METC-approved plans and includes consideration of threatened and endangered species protection prior to implementation. NMC's analysis indicates that plant communities maintained on the ROW by these established management practices are highly consistent with those recommended for the conservation of special-status terrestrial species listed above as having potential for occurrence.

Finally, neither NMC nor Consumers is aware of any adverse impacts to threatened or endangered species that have resulted from operation of Palisades or transmission lines addressed in its license renewal application. Based on its analysis, which includes consideration of the above factors and input from the Michigan Department of Natural Resources (MDNR), renewal of the Palisades operating license is not expected to result in the taking of any threatened or endangered species, jeopardize the continued existence of such species, or result in the destruction or adverse modification of any critical habitat. NMC concludes that impact to threatened and endangered species from continued operation in the license renewal period of Palisades and associated transmission lines addressed in its license renewal application would be SMALL.

- Air Quality: refurbishment impacts – NMC has no plans to perform major refurbishment activities as a result of license renewal; therefore, no impacts on air quality due to refurbishment are expected.

- Human Health: Electromagnetic fields, acute effects (electric shock) – This issue concerns the potential for shock from induced currents, similar to static electricity effects, in the vicinity of transmission lines. Because this strictly human-health issue does not directly or indirectly affect natural resources of concern within the Coastal Zone Management Act definition of "coastal zone" [16 USC 1453(1)], NMC concludes that the issue is not subject to the Coastal Management Program certification requirement.

- Socioeconomics: Housing impacts – This issue concerns impacts that additional employees required to support Palisades license renewal (i.e., for refurbishment and for operation in the license renewal term) could have on local housing availability. NMC has no plans to perform major refurbishment activities as a result of license renewal; therefore, no impacts to housing availability due to refurbishment are expected. The NRC concluded in the GEIS, and NMC concurs, that impacts would be small for plants located in high population areas with no growth control measures. Using the NRC definitions and categorization methodology, NMC determined that Palisades is located in a high population area. NMC also determined that locations where additional employees, if any, would probably live do not have growth control measures. NMC concludes that impacts during the Palisades license renewal term would be SMALL.

- Socioeconomics: Public services; public utilities (water supply availability) – This issue concerns impacts that adding license renewal workers for refurbishment or during the license renewal term could have on public water supply systems. NMC has no plans to perform major refurbishment activities as a result of license renewal; therefore, no impacts to housing availability due to refurbishment are expected. NMC's analysis of this issue, which conservatively assumed 60 additional license renewal personnel during the license renewal term, indicates that public water suppliers in Van Buren and Berrien County, Michigan have excess capacity and that new permanent employees relocating into the area would not affect the ability of the public water suppliers to provide service. NMC concludes that impacts during the Palisades license renewal term would be SMALL.

- Socioeconomics: Public services; education (refurbishment) – NMC has no plans to perform major refurbishment activities as a result of license renewal; therefore, no impacts to public education systems due to refurbishment are expected.

- Socioeconomics: Offsite land use (refurbishment) – NMC has no plans to perform major refurbishment activities as a result of license renewal; therefore, no impacts to offsite land use due to refurbishment are expected.

- Socioeconomics: Offsite land use (license renewal term) – This issue concerns impacts that local government spending of plant property tax revenue can have on land use patterns. NMC's annual property tax payments attributable to Palisades represent approximately 41 percent and 44 percent, respectively of the Covert Township and Covert School District annual operating budgets; approximately 12 percent of the District Library annual operating budget; and less than 10 percent of the annual operating budgets of the Van Buren

Intermediate School District, South Haven Community Hospital District, and Van Buren County. NMC assumes that these values are substantially representative of conditions that would exist in the Palisades license renewal term. The NRC concluded in the GEIS, and NMC concurs, that impacts to offsite land use would be small if tax payments are less than 10 percent of total revenue. Based on this standard, NMC concludes that the continued operation of Palisades throughout the license renewal period would have no impact on county land use. Property tax payments attributable to Palisades are of large significance to Covert Township. However, potential for tax-driven land use impacts also depends on existing land use patterns and controls. NMC's review indicates that Van Buren County has not experienced any significant changes in land-use patterns due to the operation of Palisades, and that an established pattern of development exists in both the county and in Covert Township. Development is encouraged in areas that can be served by existing infrastructure, and population growth in the area is expected to continue irrespective of Palisades. In addition, Van Buren County and its municipalities have developed comprehensive planning documents, the Van Buren County Planning Commission supports the goal of guiding development in areas that can be served by existing infrastructure, and Van Buren County municipalities, including Covert Township, administer land use controls to regulate and guide development. NMC concludes that offsite land use impacts attributable to the continued operation of Palisades during the license renewal term would be SMALL.

- Socioeconomics: Public services; transportation – This issue concerns potential impacts on local traffic patterns from addition of license renewal workers for refurbishment or for operation during the license renewal term. NMC has no plans to perform major refurbishment activities as a result of license renewal; therefore, no impacts on local traffic patterns due to refurbishment are expected. Major commuting routes used by Palisades site employees are in rural and uncongested areas and the Van Buren County Planning Department has not identified any of the major commuting routes to Palisades as deficient due to limited capacity or physical condition. Considering also the level of service (LOS) designations for the state trunklines and traffic counts for the likely commuting routes and little or no anticipated increase in workforce (which NMC assumed to be 60 employees as a conservative upper bound), NMC concludes that impacts to transportation from continued operation of Palisades in the license renewal period would be SMALL.

- Socioeconomics: Historic and archaeological resources – This issue concerns potential impacts license renewal activities (refurbishment and license renewal term) could have on resources of historic or archaeological significance. NMC has no plans to perform major refurbishment activities as a result of license renewal; therefore, no impacts to historic or archaeological resources due to refurbishment are expected. Based on NMC's review, there are no known National Register eligible or listed historic or archaeological properties on or near the Palisades site or the transmission line corridors. NMC also foresees no significant land disturbing activities that would be associated with license renewal. NMC concludes that impact to historic and archaeological resources due to Palisades operation in the license renewal term would be SMALL.

- Postulated accidents: Severe accidents – The NRC determined that the license renewal impacts from severe accidents would be small, but that applicants should perform site-specific analyses of ways to further mitigate potential impacts. NMC's Severe Accident Mitigation Alternatives (SAMA) analysis concluded that there are six potentially cost-beneficial mitigation alternatives that would reduce the impacts of a severe accident; however, none of these are related to plant aging effects and therefore will be addressed as part of normal plant activities and are not related to license renewal. NMC will either implement these enhancements or evaluate them further through the Palisades Corrective Action Process.

Findings

1. The NRC has found that the environmental impacts of Category 1 issues are SMALL. NMC has adopted by reference the NRC findings for Category 1 issues applicable to Palisades.
2. For Category 2 issues applicable to Palisades, NMC has determined that the environmental impacts are SMALL.
3. To the best of NMC's knowledge, Palisades is in compliance with Michigan licensing and permitting requirements and is in compliance with its state-issued licenses and permits.
4. Palisades license renewal and continued operation of Palisades would be consistent with the enforceable provisions of the Michigan Coastal Management Program.

State Notification

By this certification that activities authorized by NRC's renewal of the Palisades operating license are consistent with the Michigan Coastal Management Program, the State of Michigan is notified that, pursuant to 15 CFR 930.62(a), it has six months from the receipt of this certification and accompanying information to concur or object. However, pursuant to 15 CFR 930.62(b), if the State of Michigan has not issued a decision within three months following commencement of State agency review, it shall notify the contacts listed below of the status of the matter and the basis for further delay. The State's concurrence, objections, or notification of review status should be sent to the following contacts:

Original:

Mr. James Holthaus
Environmental Lead
Nuclear Management Company, LLC
Palisades Nuclear Plant, DFS Building

27780 Blue Star Highway
Covert, Michigan 49043
Telephone: 1-800-701-4941 ext. 3380
Email: James.Holthaus@nmcco.com

Copy:

Mr. Michael Morgan
Project Manager (License Renewal)
Office of Nuclear Reactor Regulation
Mail Stop: O-11f1
Washington, DC 20555-0001
Telephone: 301-415-2232
E-mail: mjm2@nrc.gov

TABLE 1

COMPLIANCE WITH MICHIGAN COASTAL MANAGEMENT PROGRAM

Law and Topic[a]	Compliance Status
Natural Resources and Environmental Protection Act, Public Act 451 of 1994:	See entries for individual Parts below.
Part 31 Water Resources Protection (MCL Section 324.3101 – 324.3133)	See determinations below for separate provisions.
- Permit to Discharge Provisions	In compliance – Wastewater and stormwater discharges from Palisades to Lake Michigan are permitted under Part 31 (NPDES Permit MI0001457; see Table 2). No discharges are associated with transmission line segments addressed in the Palisades license renewal application.
- Floodplain Regulatory Provisions	In compliance - Transmission line segments addressed in the Palisades license renewal application cross at least one stream within the Coastal Zone Management Boundary that may have a drainage area of 2 square miles and thus be subject to these permitting requirements (MDEQ 2004a, MDEQ 2004c, HUD 1978; see also Figures 3 and 4). However, there are no plans to undertake any activities that would affect floodplains for purposes of Palisades license renewal and METC has programs in place to ensure environmentally sound maintenance of transmission ROWs. The Palisades site is not within a floodplain except that of Lake Michigan, which is exempt from permitting requirements under this statute (HUD 1978, MDEQ 2004c).
Part 33 Aquatic Nuisance Control (MCL Sections 324.3301 – 324.3313)	Not applicable – Palisades' aquatic nuisance control activities (biocide application to cooling water) are authorized by NPDES permit issued pursuant to NREPA Part 31, and are therefore exempt from requirements of this statute. Transmission line ROW maintenance does not involve aquatic nuisance control activities.
Part 91 Soil Erosion and Sedimentation Control (MCL Sections 324.9101 – 324.9123a)	In compliance – This statute applies to land-disturbing activities, none of which are planned for purposes of Palisades license renewal. Procedures are in place to ensure that soil erosion and sedimentation control permits are obtained for any future land disturbing activities related to Palisades operation. In addition, METC has programs in place to ensure environmentally sound maintenance of transmission ROW segments within the Coastal Zone Management Boundary.

TABLE 1 (CONTINUED)
COMPLIANCE WITH MICHIGAN COASTAL MANAGEMENT PROGRAM

Law and Topic[a]	Compliance Status
Part 301 Inland Lakes and Streams (MCL Sections 324.30101 – 324.30113)	In compliance –Transmission line segments addressed in the Palisades license renewal application cross at least one inland stream within the Coastal Zone Management Boundary (Figures 3 and 4). However, there are no plans to undertake any activities that would affect inland lakes or streams for purposes of Palisades license renewal and METC has programs in place to ensure environmentally sound maintenance of transmission ROWs. No inland lakes or streams exist on the Palisades site (Figure 3).
Part 303 Wetlands Protection (MCL Sections 324.30301 – 30323)	In compliance –Wetlands exist on the Palisades site (Figure 3). However, there are no plans to undertake any activities that would affect wetlands for purposes of Palisades license renewal. Procedures are in place to ensure that a wetland protection permit is obtained for any future activities related to Palisades operation. Transmission line maintenance, repair and operation are conditionally exempt from Part 303 permit requirements.
Part 307 Inland Lake Levels (MCL Sections 324.30701 – 324.30723)	Not applicable – No inland lakes exist on the Palisades site or transmission line segments within the Coastal Zone Management Boundary addressed in the Palisades license renewal application (Figures 3 and 4). This statute applies to land-disturbing activities, none of which are planned for purposes of Palisades license renewal.
Part 315 Dam Safety (MCL Sections 324.31501 – 324.31529)	Not applicable – No dams are located on the Palisades site or transmission line segments within the Coastal Zone Management Boundary addressed in the Palisades license renewal application.
Part 323 Shoreland Protection and Management (MCL Sections 324.32301 – 324.32315)	See determinations below for separate provisions.
- Environmental Area and Flood Risk Area Provisions	Not applicable – The Palisades site and transmission line segments within the Coastal Zone Management Boundary addressed in the Palisades license renewal application are not located in an Environmental Area or Flood Risk Areas designated under this statute (MDEQ 2004d, ORR 2002).
- High-risk Erosion Area Provisions	In compliance – Part of the Palisades site is in a designated High-risk Erosion Area (Holt 2004), but there are no plans to undertake activities for purposes of license renewal that would require permits under this statute (ORR 2002, MDEQ 2004e). Procedures are in place to ensure that a permit is obtained for any such future activities related to Palisades operation. Transmission line segments within the Coastal Zone Management Boundary addressed in the Palisades license renewal application are not located in High Risk Erosion Areas.

TABLE 1 (CONTINUED)
COMPLIANCE WITH MICHIGAN COASTAL MANAGEMENT PROGRAM

Law and Topic[a]	Compliance Status
Part 325 Great Lakes Submerged Lands (MCL Sections 324.32501 – 324.32516)	In compliance – Palisades includes structures (e.g., cooling water intake crib and pipeline) in Lake Michigan. However, there are no plans to undertake activities subject to this statute (e.g., maintenance dredging) for purposes of Palisades license renewal. Procedures are in place to ensure that a permit is obtained for any such future activities related to Palisades operation. Transmission line segments within the Coastal Zone Management Boundary addressed in the Palisades license renewal application are not located in submerged lands designated under this statute (Figures 3 and 4)
Part 353 Sand Dunes Protection and Management (MCL Sections 324.35301 – 324.35326)	In compliance – Part of the Palisades site consists of dunes designated under this statute (Figure 3), though use of such areas as needed to obtain or maintain Palisades' operating license is not precluded [MCL 324.35306(3)]. There are no plans to undertake land-disturbing activities for purposes of Palisades license renewal. Procedures are in place to ensure that a critical dunes permit is obtained for any future land disturbing activities related to Palisades operation. Transmission line segments addressed in the Palisades license renewal application are not located on dunes designated under this statute (Figure 3)
Part 365 Endangered Species Protection (MCL Sections 324.36501-324.36507)	In compliance – NMC's environmental assessment for license renewal indicates that operation of Palisades and transmission lines addressed in the Palisades license renewal application is not expected to result in the taking of species protected under this statute, jeopardize their continued existence, or adversely modify associated critical habitat. There are no plans to undertake land-disturbing activities for license renewal. Procedures are in place to ensure that operational changes or future land-disturbing activities related to Palisades operations would ensure continued protection of such species. In addition, METC has programs in place to ensure environmentally sound maintenance of transmission ROW segments within the Coastal Zone Management Boundary.

TABLE 1 (CONTINUED)
COMPLIANCE WITH MICHIGAN COASTAL MANAGEMENT PROGRAM

Law and Topic[a]	Compliance Status
Clean Water Act of 1972, Section 404 (33 USC 1344)	In compliance – Palisades includes structures in Lake Michigan (e.g., cooling water intake crib and pipeline). However, there are no plans to undertake activities (e.g., discharge of dredged or fill material) subject to this statute for purposes of Palisades license renewal. Procedures are in place to ensure that a Section 404 permit is obtained for any such future activities related to Palisades operation. Transmission line operation and routine maintenance do not involve activities requiring a Section 404 permit and METC has programs in place to ensure environmentally sound maintenance of transmission ROW segments within the Coastal Zone Management Boundary.

a. Source: Antieau 2004.
MCL = Michigan Code of Laws
MDEQ = Michigan Department of Environmental Quality
METC = Michigan Electric Transmission Company
NPDES = National Pollutant Discharge Elimination System
NREPA = Natural Resources and Environmental Protection Act
ROW = right-of-way
USC = United States Code

TABLE 2
ENVIRONMENTAL AUTHORIZATIONS FOR CURRENT OPERATIONS

Agency	Authority	Authorization	Number	Issue Date	Expiration	Activity Covered
Federal Authorizations						
U.S. Nuclear Regulatory Commission	Atomic Energy Act [42 USC 2011 et seq.], 10 CFR 50.10	License to operate	DPR-20	3/24/71	3/24/11	Operation of Palisades Nuclear Plant.
State and Local Authorizations						
Michigan Department of Environmental Quality	Federal Clean Water Act, Section 402 (33 USC 1251 *et seq.*), Michigan Act 451, Public Acts of 1994 (as amended), Parts 31 and 41; Michigan Executive Orders 1991-31, 1995-4, and 1995-18.	NPDES Permit	MI0001457	9/23/04	10/1/08	Discharge of wastewater and stormwater to Lake Michigan.
Michigan Department of Environmental Quality	Clean Air Act, 42 USC 7401 *et seq.*; Michigan Act 451, Public Acts of 1994 (as amended), Part 55	Renewable Operating Permit (Air Quality)	200200005	2/4/03	2/4/08	Operation of Palisades air emission sources (evaporator heating boiler, plant heating boiler, feedwater purity boiler, emergency generators, cold cleaners).

TABLE 2 (CONTINUED)
ENVIRONMENTAL AUTHORIZATIONS FOR CURRENT OPERATIONS

Agency	Authority	Authorization	Number	Issue Date	Expiration	Activity Covered
State and Local Authorizations (Continued)						
Michigan Department of Environmental Quality	Michigan Act 207. Public Acts of 1941 (as amended), Section 5; Michigan Executive Order 1998-2	Aboveground Storage Tank Registration	Facility No. 91084220 (Diesel Tanks No. 1 and 2)	Annual	Annual	Storage of flammable or combustible liquid (diesel fuel) in aboveground storage tanks.
Michigan Department of Environmental Quality	Michigan Act 451. Public Acts of 1994 (as amended), Part 31	Wastewater Treatment Operator Certification	Various	Various	Various	Operation of treatment and control facilities for wastewater discharges to surface water and groundwater.
South Carolina Department of Environmental Quality	South Carolina Radioactive Waste Transportation and Disposal Act (Act No. 429 of 1980)	Radioactive Waste License for Delivery	0006-21-04	01/16/04	12/31/04 renewed annually	Shipment of radioactive material to a licensed disposal/processing facility within the State of South Carolina.
Tennessee Department of Environment and Conservation	Tennessee Code Annotated 68-202-206	Radioactive Waste License for Delivery	T-M 1003-L04	01/01/04	12/31/04 renewed annually	Shipment of radioactive material to a licensed disposal/processing facility within the State of Tennessee.

CFR = Code of Federal Regulations
MDEQ = Michigan Department of Environmental Quality
NPDES = National Pollutant Discharge Elimination System
USC = U.S. Code

FIGURE 1
PALISADES 50-MILE REGION

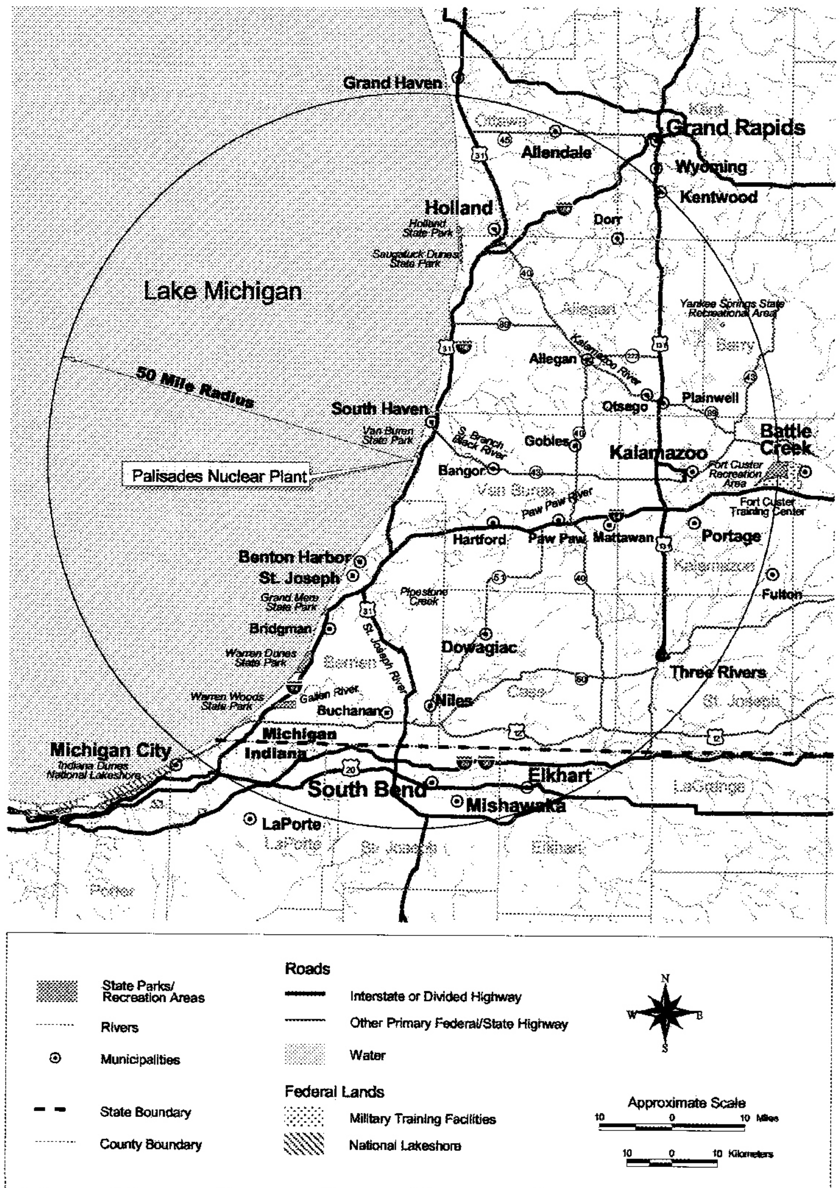

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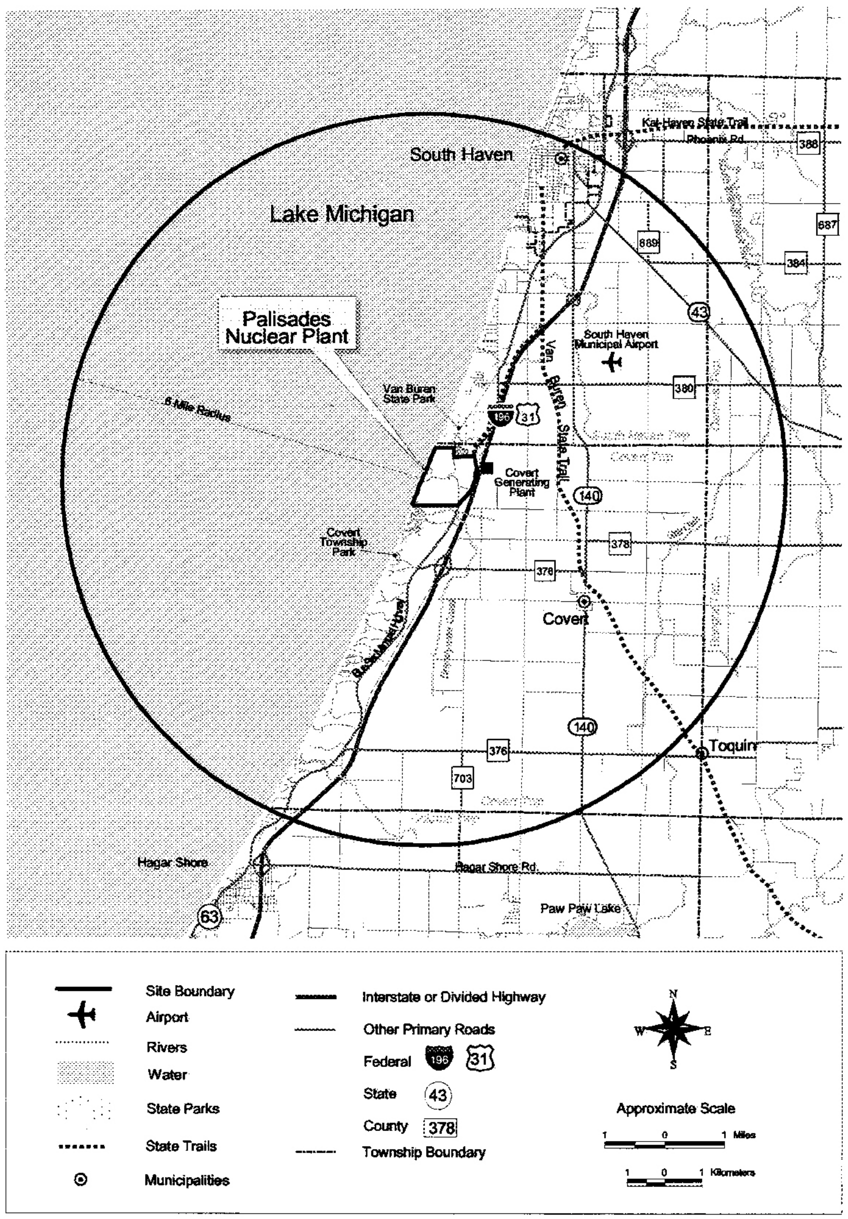
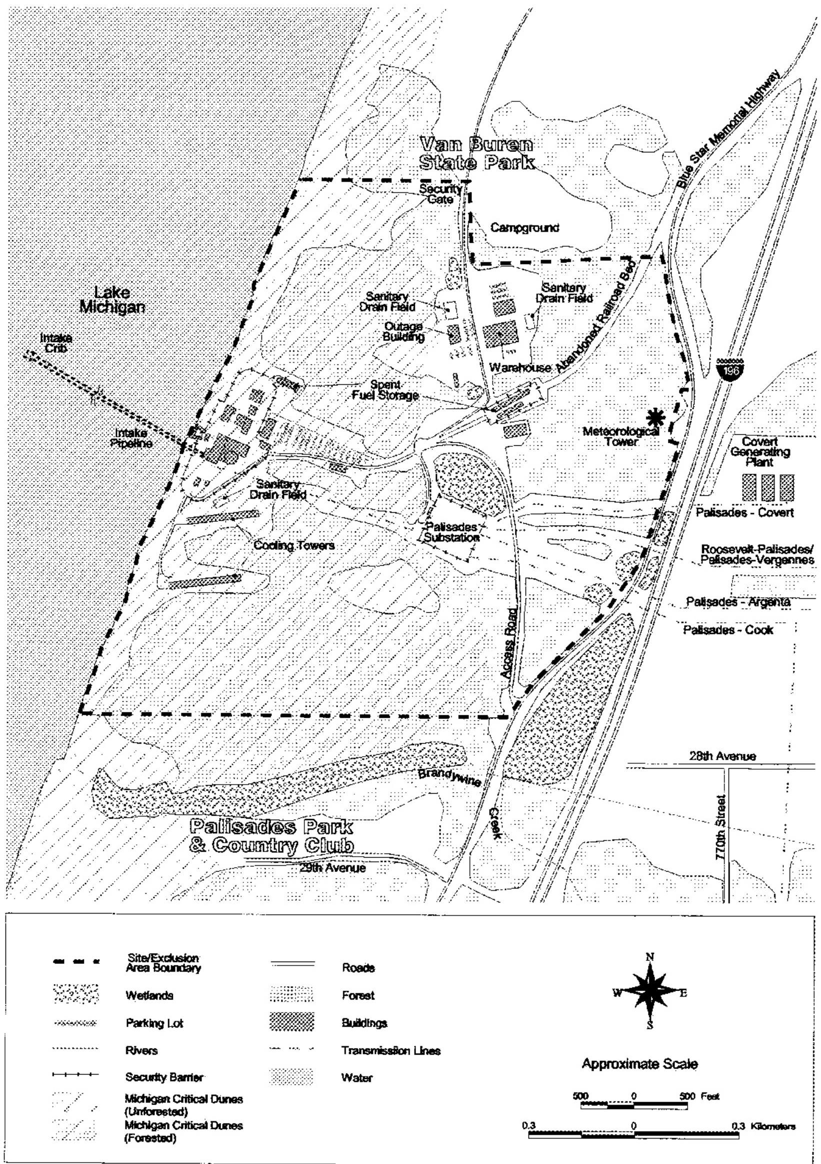
FIGURE 2
PALISADES 6-MILE VICINITY

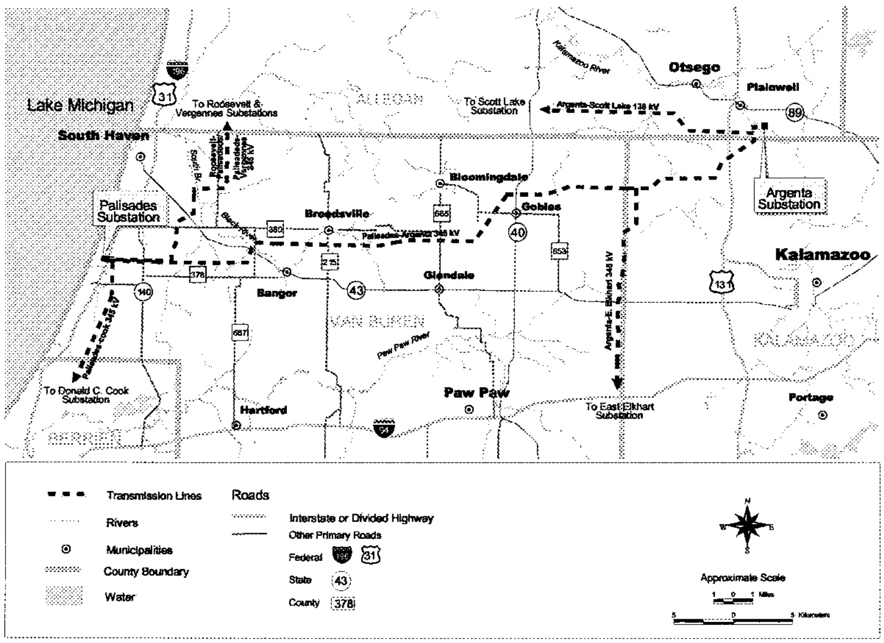


1 **FIGURE 3**
2 **PALISADES SITE MAP**



3

FIGURE 4
TRANSMISSION LINES



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Consumers Energy
Count on Us

NMC
Committed to Nuclear Excellence

March 9, 2005

Mr. Christopher Antieau
Federal Consistency Coordinator
Coastal Program Unit, Land and Water Management Division
Michigan Department of Environmental Quality
P.O. Box 30458
525 W. Allegan
Lansing, MI 48909

SUBJECT: Palisades Nuclear Plant License Renewal Project
Federal Coastal Zone Management Act Consistency Certification

Dear Mr. Antieau:

Nuclear Management Company, LLC (NMC) and Consumers Energy (Consumers) request your concurrence with the subject consistency determination, enclosed, which we are submitting to the U.S. Nuclear Regulatory Commission (NRC) in accordance with provisions of the federal Coastal Zone Management Act of 1972 at 16 USC 1456(c)(3)(a) and implementing regulations at 15 CFR 930.57(a). The certification documents our determination that continued operation of the Palisades Nuclear Plant (Palisades), as would be authorized by NRC renewal of the plant's operating license, complies with the enforceable policies of the federally approved Coastal Management Program of the State of Michigan and will be conducted in a manner consistent with such program.

NMC will submit this certification to the NRC with our application to renew the Palisades operating license, which expires March 24, 2011. License renewal would provide the opportunity to operate the plant for an additional 20 years beyond the current license term; i.e., until March 24, 2031. Palisades is located on the eastern shore of Lake Michigan in Covert Township, Van Buren County. The enclosed certification describes the plant and its operation, probable environmental impacts of continued operation, and conformance with the state Coastal Management Program. NMC and Consumers have no plans to alter current operations for the license renewal period and expect no change from current environmental impacts.

NMC is planning to submit the Palisades license renewal application (LRA) to the NRC at the end of March 2005. After LRA submittal, NMC will provide to you an electronic copy (compact disc) of LRA Appendix E, *Environmental Report,* for your reference in completing the certification review. We would appreciate your expeditious review of the enclosed certification and receipt of a letter from the Michigan Department of Environmental Quality documenting its concurrence with the certification. Please address any related questions or concerns to:

Mr. James Holthaus
Environmental Project Manager
Nuclear Management Company, LLC
27780 Blue Star Highway
Covert, Michigan 49043
1-800-701-4941 ext. 3380
James.Holthaus@nmcco.com

Thank you on behalf of NMC, Consumers Energy and the Palisades License Renewal Environmental Review Team.

Sincerely,

Daniel J. Malone
Site Vice President
Palisades Nuclear Plant
Nuclear Management Company

Stephen T. Wawro
Director of Nuclear Assets
Consumers Energy

Enclosures: - Coastal Zone Management Consistency Certification, Palisades Nuclear Plant, Operating License Renewal

cc: Jon Allan- Consumers
Eric Dehn-NMC Palisades

ATTACHMENT E

SEVERE ACCIDENT MITIGATION ALTERNATIVES

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List of Tables

Acronyms Used in Attachment E

ADV	atmospheric dump valve
AFW	auxiliary feedwater
ATWS	anticipated transient without scram
BWR	boiling water reactor
CCF	common cause failure
CDF	core damage frequency
CET	containment event tree
CEOG	Combustion Engineering Owners Group
CFS	cavity flooding system
CHP	containment high pressure
CPMAAP	Consumers Power MAAP
CR	control room
Cs	cesium
CS	containment spray
CsI	cesium iodine
CST	condensate storage tank
DCH	direct containment heating
DDDIP	direct drive diesel injection pump
DG	diesel generator
ECCS	emergency core cooling system
EDG	emergency diesel generator
EOPs	emergency operating procedures
EPRI	Electric Power Research Institute
EPZ	emergency planning zone
ESF	engineered safeguard feature
FPS	fire protection system
FW	feedwater
HELB	high energy line break
HEP	human error probability
HPCI	high-pressure coolant injection
HPI	high-pressure injection
HPME	high-pressure melt ejection
HPSI	high-pressure safety injection
HVAC	heating, ventilation and air-conditioning system
INEEL	Idaho National Engineering and Environmental Laboratory
IE	initiating event
IPE	Individual Plant Examination
IPEEE	Individual Plant Examination – External Events
ISLOCA	interfacing system LOCA
LOCA	loss-of-coolant accident
LOOP	loss of off-site power
LPSI	low-pressure safety injection
MAAP	Modular Accident Analysis Program

Acronyms Used in Attachment E

MACCS2	Melcor Accident Consequences Code System, Version 2
MACR	maximum averted cost-risk
MCC	motor control center
MCR	main control room
MGL	multiple Greek letter
MSIV	main steam isolation valve
MSLB	main steam line break
NPSH	net positive suction head
NRC	U.S. Nuclear Regulatory Commission
OECR	off-site economic cost risk
OSP	off-site power
OTC	once through cooling
PCP	primary coolant pump
PCS	Primary Coolant System
PMP	probable maximum precipitation
PRA	probabilistic risk analysis
PSA	probabilistic safety assessment
psia	pounds per square inch absolute
psid	pounds per square inch differential
psig	pounds per square inch guage
PTS	pressurized thermal shock
PORV	pressure operated relief valve
PWR	pressurized water reactor
RAS	recirculation acutation signal
RCIC	reactor core isolation cooling
RDR	real discount rate
RHR	residual heat removal
RHRSW	residual heat removal service water
RPV	reactor pressure vessel
RRW	risk reduction worth
SAMA	severe accident mitigation alternative
SBO	station blackout
SEP	systemic evaluation program
SIRWT	safety injection and refueling water tank
SRV	safety relief valve
SW	service water
SWS	Service Water System
Te	tellurium

Attachment E
Severe Accident Mitigation Alternatives

The severe accident mitigation alternative (SAMA) analysis for Palisades Nuclear Plant (Palisades) discussed in Section 4.12 of the Environmental Report is presented below.

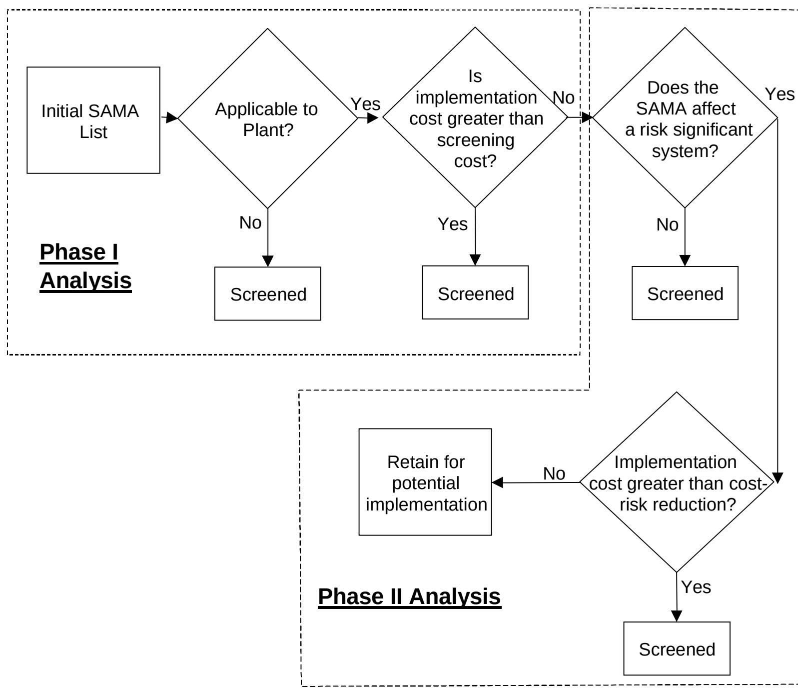
E.1 METHODOLOGY

The methodology selected for this analysis involves identifying SAMA candidates that have the highest potential for reducing plant risk and determining whether or not the implementation of those candidates is beneficial on a cost-risk reduction basis. The metrics chosen to represent plant risk include the core damage frequency (CDF), the dose-risk, and the economic cost-risk. These values provide a measure of both the likelihood and consequences of a core damage event. The SAMA process consists of the following steps:

- **Palisades Probabilistic Safety Assessment (PSA) Model** – Use the Palisades Internal Events PSA model as the basis for the analysis (Section E.2). Incorporate external events contributions as described in Section E.5.1.7.
- **Level 3 PSA Analysis** – Use Palisades Level 1 and 2 Internal Events PSA output and site-specific meteorology, demographic, land use, and emergency response data as input in performing a Level 3 PSA using the MELCOR Accident Consequences Code System Version 2 (MACCS2) (Section E.3).
- **Baseline Risk Monetization** – Use U.S. Nuclear Regulatory Commission (NRC) regulatory analysis techniques to calculate the monetary value of the unmitigated Palisades severe accident risk. This becomes the maximum averted cost-risk (MACR) that is possible (Section E.4).
- **Phase I SAMA Analysis** – Identify potential SAMA candidates based on the Palisades PSA, Individual Plant Examination – External Events (IPEEE), and documentation from the industry and NRC. Screen out Phase I SAMA candidates that are not applicable to the Palisades design or are of low benefit in pressurized water reactors (PWRs) such as Palisades, candidates that have already been implemented at Palisades or whose benefits have been achieved at Palisades using other means, and candidates whose estimated cost exceeds the possible MACR (Section E.5).
- **Phase II SAMA Analysis** – Calculate the risk reduction attributable to each remaining SAMA candidate and compare to a more detailed cost analysis to identify the net cost benefit. PSA insights are also used to screen SAMA candidates in this phase (Section E.6).

- **Uncertainty Analysis** – Evaluate how changes in the SAMA analysis assumptions might affect the cost-benefit evaluation (Section E.7).
- **Conclusions** – Summarize results and identify conclusions (Section E.8).

The steps outlined above are described in more detail in the subsections of this attachment. The graphic below summarizes the high-level steps of the SAMA process.



E.2 PALISADES PSA MODEL

The SAMA analysis is based on version PSAR1c of the Palisades PSA model for internal events. The following subsections provide more detailed information related to the evolution of the Palisades internal events PSA model and the current results.

The Palisades IPEEE represents the latest external events analyses performed for the plant (CP 1995). This reference is considered to document the external events models and results.

E.2.1 1982 PSA MODEL DEVELOPMENT

Palisades began development of detailed probabilistic risk analyses(PRA) models in 1982. This effort was in support of addressing the risk associated with failing to satisfy single failure design criteria with respect to the main steam isolation valves (MSIVs), specifically systemic evaluation program (SEP) Topic XV-2.

As part of SEP Topic XV-2 “Spectrum of Steam System Piping Failures Inside and Outside Containment,” a previously unanalyzed transient was identified for Palisades assumed a rupture of one of the two main steam lines inside containment with a concurrent single-failure of the MSIV in the other main steam line.

As a resolution to the deficiencies identified in this SEP Topic, Consumers Power committed to back fit the plant eliminating single-failure design issues. Consequently, a PSA review of this issue began in 1982 evaluating the risks/benefits associated with alternate modifications. To disposition this issue, a detailed analysis employing probabilistic risk assessment (PRA) modeling began in 1982, which addressed the following:

- reevaluated the assumptions made in concluding the need for the back fit,
- examined the plant deterministic response to this transient initiator,
- included the creation and quantification of event and fault tree logic (including front-line, support system, instrumentation and control logic modeling etc.) incorporating common cause modeling, as well as the development of plant-specific component failure rates/probabilities,
- included the development of dose consequence methods and techniques,
- included an assessment of the uncertainties, and
- included a cost analysis of the MSIV backfit along with several alternatives using PRA techniques.

In 1986, NRC issued a safety evaluation concerning the risks associated with steam line breaks at Palisades. The safety evaluation concluded that extensive backfitting of the main steam (and main feedwater lines) at Palisades was not necessary and that the existing configuration of the plant was acceptable. These conclusions were drawn from the plant-specific PRA analyses.

In addition to addressing the single failure design issue, the product of this initiative resulted in Palisades developing detailed risk models (e.g., initiators, fault trees, event trees, deterministic capabilities, etc.) some 6 years prior to NRC issuing Generic Letter 88-20 (CP 1993).

E.2.2 1993 LEVEL 2 PSA MODEL DEVELOPMENT

Palisades has several atypical design features that can affect accident progression. As a result, instead of relying on the results of previous PSA's, plant-specific, detailed, deterministic evaluations were performed in support of the 1993 submittal for the key severe accident phenomena. These evaluations included a review of all available experimental data, as well as creating a plant-specific version of the Modular Accident Analysis Program (MAAP). The more important of these assessments included:

- Containment Structural Evaluation
- Reactor Cavity Structural Evaluation
- Thermal Creep Induced Rupture of the primary coolant system (PCS) Pressure Boundary Analyses
- Cavity Pressurization During Debris Dispersal
- Direct Containment Heating (DCH)
- Cooling of Core Debris in the Lower Reactor Vessel Head
- Molten Debris Behavior and the Potential to Quench and Retain
- Core Debris in the Reactor Cavity and engineered safeguard feature (ESF) Sump
- Performance of PCS Insulation at High Containment Temperature
- Potential for Flammable Gas Detonations and Deflagration-Detonation-Transition

These detailed plant-specific analyses were performed in a manner to avoid introducing intentional bias (conservatism) when evaluating severe accident phenomena. Rather, the analyses endeavored to provide as an accurate assessment of risk.

For example, in high-pressure accident sequences at Palisades, debris is dispersed upwards out of the reactor cavity, past the reactor pressure vessel (RPV) flange and into the volume bounded by the refueling pool walls. Since the ESF sump is located underneath the cavity, undispersed debris remaining in the cavity can potentially drain into the sump through the cavity drains, flow into the Auxiliary Building through the recirculation piping, or melt through the piping and bypassing the containment. Thus, it is not obvious whether high-pressure accident sequences with debris dispersal to the upper containment result in a larger potential for off-site health effects than low-pressure accident sequences without debris dispersal. Most PSA's assume that accident sequences with debris dispersal pose a higher risk of prompt containment failure than those without. Rather than make such an assumption, the approach taken was to perform as accurate an assessment as possible of the likelihood and consequences of either dispersing the debris or having it remain in the cavity.

Therefore to ensure an adequate representation of the various phenomenological issues, a detailed containment event tree (CET) was developed to represent the dependencies between phenomenological assumptions. The CET was then quantified by a relatively detailed process involving the development of probability distributions for a number of the key phenomena, along with point estimates for some other issues. Again, a detailed approach was judged necessary to avoid biasing the results in either direction.

As mentioned above, Palisades-specific version of the MAAP 3.0B code, called CPMAAP, was developed to allow the evaluation of the integrated effect of the plant-specific features on overall containment performance and fission product release. The most important of the enhancements made to MAAP was to model the transport of core debris to the Auxiliary Building for the accident sequences where this was being postulated.

E.2.2.1 DETAILED EVALUATION OF KEY SEVERE ACCIDENT PHENOMENA

A brief discussion of some of the key plant characteristics addressed in the Individual Plant Examination for Severe Accident Vulnerabilities (IPE) submittal (CP 1993), the associated accident phenomena, and the potential impact on accident progression is provided below.

In support of the SAMA analysis, as assessment of accident phenomena and progression was conducted to review the methods used to quantify the CET given the state of knowledge in a few areas of severe accident phenomenology has improved. Select phenomena of interest to the SAMA analysis are discussed further in this section.

E.2.2.1.1 Reactor Cavity Description

The Palisades in-core instrumentation enters the reactor vessel through the upper head, which is typical of most early Combustion Engineering-designed plants. Access to the lower reactor cavity is gained through a 30-inch diameter access tube. The access tube connects the bottom of the reactor cavity to the containment 590-foot elevation through the reactor cavity wall. The containment end of the access tube is closed with a strong-back reinforced blind flange bolted to a reinforced weld neck flange, and is sealed with a flexitallic gasket. This closure arrangement is designed to withstand very high differential pressures (>300 psid). A standpipe of the same diameter as the access tube branches vertically from the access tube, ending in the steam generator compartment, with the entire length of the access tube and standpipe imbedded in the reactor cavity wall. The standpipe is sealed during normal operation with a 4-psid plastic rupture disk.

The hot and cold leg loop piping penetrations through the cavity wall are filled with individually formed concrete shield blocks. The shield blocks are held in place during normal operation by a restraint system designed to allow the shield blocks to be ejected at a pressure differential between the reactor cavity and the containment of 75 psid. There is a gap of approximately 1 inch between the shield blocks and the piping insulation.

The reactor cavity is connected to the upper containment through the gap between the reactor vessel flange and the refueling pool floor. Except for a 1-inch annular gap, the space between the vessel flange and the floor is closed off by the refueling pool seal support plate. Following refueling operations, the refueling pool seal which spans the 1-inch gap is removed. To ensure that no leakage occurs during refueling operations, the refueling pool seal support plate is permanently welded to the refueling pool floor around its outer circumference only. Since it is only welded to the refueling pool floor (it is not welded to the support brackets), the seal support plate will blow out at a differential pressure of approximately 12 psid.

To prevent the accumulation of water in the reactor cavity during normal operation and refueling, there are two drains in the reactor cavity floor. These two, 1-inch diameter drains directly connect the reactor cavity to the ESF Sump, which is directly below the floor. As described in Section E.2.3.7, these lines have been filled with ceramic beads to address accident progression issues.

Potential Impact on Accident Progression

The reactor cavity phenomena described above is called high-pressure melt ejection (HPME), and the interaction between the dispersed debris and the containment is termed DCH. A substantial effort was made in the IPE to calculate the implications of this feature of Palisades, which had not previously been studied to any significant degree in plants of this type.

If the RPV head fails due to contact with molten core debris, a relatively large failure area could develop since the head contains no in-core instrumentation penetrations. The small reactor cavity volume, the close proximity of the reactor vessel to the cavity floor, the limited area for gas flow in the annulus between the RPV and the biological shield, and the expected larger size of the breach in the RPV head made the cavity response following vessel failure at high pressure significantly different from other PWRs previously evaluated.

The larger RPV breach area combined with the smaller gas flow area out of the cavity results in substantially higher gas velocities in the cavity; this will make debris dispersal occur at lower PCS pressures than for plants with an instrument tunnel. The higher gas velocity, along with the proximity of the breach in the vessel to the cavity floor is also expected to result in the fragmentation of a larger fraction of the available debris, which results in an increased potential for containment loads caused by DCH.

The ratio of the cavity to RPV breach flow areas and the expected high degree of debris fragmentation also has the potential to substantially increase the peak reactor cavity pressure following vessel failure. The 1993 IPE parametric analyses of the peak cavity pressure as a function of PCS pressure, vessel failure size and debris dispersal flow regime indicated that pressures in excess of the cavity failure pressure could occur in some cases. If the cavity was to be over-pressurized and a failure resulted, the subsequent movement of the reactor vessel and the PCS has the potential to fail the containment liner by pulling out a piping penetration.

Due to the uncertainty in reactor cavity fluid dynamics following vessel failure, Palisades joined with the other Combustion Engineering plants with similar reactor cavity geometry to sponsor scale model experiments of debris dispersal. The intent of these experiments was to reduce the uncertainty related to the evaluation of potential containment failure due to cavity pressurization and DCH pressure loads for this type of cavity. Results of these experiments, as well as their impact on the Palisades SAMA CET quantification are presented below.

State of Knowledge Improvement

Since the completion of the IPE, NRC has addressed this issue in plants similar to Palisades by performing a series of experiments and detailed code calculations. This work, documented in NUREG/CR-6469 and NUREG/CR-6475 led NRC to close out the DCH issue for Palisades (NRC 1997a; NRC 1998a). The information in these reports allowed a reassessment of the HPME and DCH major assumptions used in the original IPE, as described below.

- In all likelihood, debris will be removed from a Palisades-type reactor cavity as relatively fine particles and not as a continuous film (as seen in earlier experiments involving similar cavities). Both these possibilities were considered in the IPE, with the former believed to lead to more severe consequences.

- The subsequent experiments have demonstrated the "non-coherence" of the time scales required for debris removal and primary system blowdown in Palisades. That is, the time of the blowdown is much longer than the time period over which the debris is removed from the cavity. This significantly mitigates the increase in containment pressure during DCH by reducing the amount of energy that can be removed from the debris while it is transported. While this non-coherence was predicted in the IPE, scale-up of the subsequent experimental results leads to the conclusion that the time frame for debris dispersal will be on the order of 1 second in the plant. For the medium pressure range of greatest interest (since cases initially at high pressure usually undergo hot leg rupture), calculations performed for the IPE predicted a debris dispersal time of approximately 0.4 seconds for similar assumptions on vessel failure size. However, the IPE assumed that the complete core mass was available to be dispersed, whereas more recent analyses summarized below indicate that the dispersed mass will be significantly smaller. Thus, the dispersal rates calculated in the 1993 IPE were roughly five times smaller than the conclusions of the NRC study. This difference results from the fact that the analyses performed for the IPE conservatively assumed virtually instantaneous particulation of the debris in the cavity, absent any experimental data on entrainment rates. As noted below, the vessel failure areas assumed in the IPE were also conservatively large, leading to a faster blowdown. The non-coherence limits the containment pressure rise due to DCH, and the longer debris entrainment times greatly reduce peak cavity pressures during HPME.

- At the time of the IPE, core melt progression models were quite simplified. Detailed calculations were subsequently performed with the SCDAP/RELAP5 code as it became available (NRC 1998e). The results of these calculations have three implications for DCH.

    - First, NUREG/CR-6475 concluded that the gasses that cause debris dispersal are more likely to be steam-rich rather than hydrogen-rich. This is primarily because the metal content of the debris is predicted to be much smaller than assumed in the IPE. This conclusion also reflects the fact that hydrogen produced in-vessel would most likely have been discharged prior to vessel failure through openings in the PCS (it is now considered very unlikely that the PCS would remain completely bottled up by the time of a vessel failure). The overall effect is to greatly reduce expected pressure loads from zirconium oxidation and hydrogen combustion during DCH.

- The second implication of the detailed core melt progression calculations would be that the mass of debris that is expected to be present at the time of a vessel failure is about half the full core mass conservatively assumed in the deterministic studies performed for the IPE. This is because much of the core mass would not yet have relocated to the lower plenum, in part because of cooling from steam generated in the lower plenum. However, as discussed in the IPE, the quantification of the DCH pressures used the expert elicitation results from NUREG-4551, which are roughly consistent with the new results, so the overall impact of this consideration is modest.

- The third implication of the detailed core melt progression models is that the ablated radius of the postulated opening in the lower head of the reactor vessel would be expected to be no larger than approximately 0.2 meters, the low end of the failure size distribution assumed in the IPE. Recent large-scale vessel failure experiments conducted in reactor vessels without lower head penetrations have not revealed any tendency for very large openings to form, as once feared. The NRC reports also agree with the assumption in the IPE that the maximum failure area could be further limited in Palisades by the sagging of the vessel head to the cavity floor prior to a failure of the head.

• Due to improved understanding of the processes involved in induced hot leg rupture, the likelihood of vessel failure occurring at high pressure is considered very small. While this was also the case in the IPE, induced rupture is considered more likely by NRC than was the case previously. In fact, still later work by the industry has revealed that the creep rupture resistance of the hot leg steel used in CE plants like Palisades is lower than that of the more extensively studied Westinghouse plants (EPRI 2002). This makes it even more likely that creep rupture will occur in all but relatively low-pressure accident sequences. The focus in the recent NRC-sponsored studies was, therefore, on intermediate pressure sequences and on recovery sequences in which operator actions led to high PCS pressure with a water-filled (and cool) reactor vessel, rather than transients such as station blackout (SBO). Recovery sequences played little role in the IPE, due to the large uncertainties associated with degraded core coolability, and neither the IPE nor NRC-sponsored studies have addressed recovery sequences in any detail. However, for plants of the Palisades design, it is considered that the operators are very unlikely to maintain a very high PCS pressure following successful recovery.

• The IPE proposed a primary system pressure criterion of 2 megapascal (MPa) to define accident sequences that will result in HPME. Interestingly, this is the same criterion recommended in the later NRC studies. Absent operator-induced repressurization and cooling caused by recovery actions, there is thus a relatively narrow window in which the pressure is low enough to avoid induced hot leg rupture but high enough to lead to HPME. The effect of this in mitigating DCH is particularly pronounced in Palisades for three reasons. First, as noted above, the low molybdenum carbon steel used in the Palisades hot leg has a relatively high susceptibility to hot leg rupture. Second, the time required for the lower head to fail is relatively long because of the absence of lower head penetrations. This would allow the primary system time to depressurize through any openings in the reactor coolant system. Finally, the low accumulator pressure setpoint of 1.5 MPa makes it unlikely that steaming caused by accumulator discharge would lead to repressurization above the threshold for HPME.

- As noted in the IPE, subsequent research has confirmed that the most probable reactor failure would occur near the upper surface of the debris pool, where the heat flux is maximized. Scoping calculations reported in NRC studies indicate that this would lead to 25–50 percent of the molten debris in the lower head being retained within the vessel. Taken together with the relatively small mass that would drop into the head (as revealed by the SCDAP/RELAP5 calculations); this would further reduce the amount of debris available for HPME and DCH.

- Experiments conducted by Sandia in a scaled version of the Calvert Cliffs containment showed virtually no retention of upwardly expelled debris by the missile shield (NRC 1997a). This contradicts the view espoused in the IPE that a maximum of 25 percent of the expelled debris would bypass the missile shield. However, the missile shield in Calvert Cliffs, unlike Palisades, is supported above the operating floor, so that debris can be transported past the missile shield through gaps on all four of its sides. In Palisades, the missile shield is located flush with the top of the operating floor, so that debris can bypass the missile shield on only two sides. Experimental evidence cited in NUREG/CR-6469 confirms the assumption in the IPE that debris will not readily follow sudden changes in gas trajectory. Thus, it is still considered reasonable to expect the debris to impact the missile shield and the sides of the refueling pool, and then re-entrain only along the open edges. For this reason, the missile shield should be at least moderately effective in mitigating the pressure rise during DCH, even though the Calvert Cliffs experiments cannot be used to directly support this conclusion.

- The Sandia experiments have confirmed the assumption in the CPMAAP code used in the quantification of the IPE that debris bypassing the missile shield will interact efficiently with the upper containment region but not with gasses below the operating deck. The resulting stratification of the containment atmosphere reduces the pressure rise during DCH compared to early analyses (not used in the IPE) that assumed that the entire containment would interact homogeneously.

- Concern was expressed in the IPE that hydrogen released from the reactor vessel along with that produced during HPME would contribute strongly to the pressure rise during DCH. One specific concern was that the usual steam-inerting phenomena might not remain effective at the high temperatures reached during the event. However, the later NRC-sponsored work concluded that containment loading would not increase substantially due to hydrogen combustion, due to the low metal content of the dispersed debris noted above and effective inerting by steam even at high containment temperatures.

E.2.2.1.2 ESF Sump Description

The ESF sump is located directly below the reactor cavity floor (the floor of the reactor cavity is the ceiling of the sump). The sump ceiling is an 18-inch thick, steel reinforced concrete slab, with a ¼-inch carbon steel liner on the sump side. The ceiling of the sump is supported by twelve floor-to-ceiling structural steel columns arranged in two rings. The floor to ceiling height is approximately 3 feet 6 inches.

Water from the containment basement enters the sump through five downcomer pipes. The downcomers angle down and in toward the sump from the containment basement floor and are completely imbedded in the reactor cavity wall. There are two 4-inch vent pipes leading from the top inside of the sump to the containment to allow the sump to vent and fill completely with water. There are two 1-inch drains, which connect the sump to the reactor cavity through the ceiling of the sump. As described in Section E.2.3.7, these drains have been filled with ceramic beads to address accident progression issues.

The sump is connected to the ESF systems by two 24-inch recirculation suction pipes. The bottom of these pipes connects to the sump liner approximately 4.75 inches above the sump floor, with the openings protected by debris screens located in the sump. The recirculation piping is imbedded in the containment basemat at an angle of approximately 2 degrees, entering the Engineered Safeguards rooms in the Auxiliary Building approximately 13 feet above the floor. A 4-inch drain in the sump floor is provided to allow periodic draining of water that accumulates during normal operation. The normal drain enters the Auxiliary Building at approximately the same elevation as the recirculation piping.

Potential Impact on Accident Progression

If a molten core debris pool forms in the reactor cavity following vessel failure, it can flow through the two drains in the reactor cavity floor into the ESF sump. If sufficient debris enters the sump and it remains molten for a long enough period of time, the debris will overflow into the 24-inch recirculation piping. Any significant amount of molten debris in the recirculation piping is not expected to be coolable, even in the presence of water. Thermal attack of the recirculation piping where it exits the containment wall is expected, which would soon result in recirculation pipe failure, containment failure, and debris flow into the Auxiliary Building.

Although the drains from the reactor cavity to the sump are small, calculations performed as part of the IPE indicated that the likelihood of the debris forming a plug in the drains as a result of heat transfer to the concrete floor is very unlikely unless the amount of superheat in the debris is only a few degrees. This is not considered likely given the expected prolonged time to vessel failure (caused by the absence of penetrations in the lower RPV head), so relatively quick debris relocation to the sump is considered very likely if the reactor cavity is dry at the time of vessel failure.

If the reactor cavity is flooded at the time of vessel failure, high rates of heat transfer to the water (either explosive or non-explosive) can be expected during the period in which the debris is being expelled into the water. It is expected that the interaction of the debris with the water will fragment and cool a substantial fraction of the debris mass, so that the potential for immediate debris flow through the drains and into the sump is much reduced compared to the dry case. Therefore, accident sequences with the reactor cavity flooded are much less likely to result in early core debris relocation to the Auxiliary Building than if the reactor cavity is dry.

Energetic debris/water interactions are also expected to occur in the sump as the debris drains from the reactor cavity. The potential for debris to enter the sump is the largest for the case of a dry reactor cavity, but the uncertainty in the debris-quenching rate in the cavity does not exclude the potential for debris to flow into the sump for cases with a flooded reactor cavity. Due to the confined geometry of the sump and the relatively small total flow area of the pipes, which connect the sump to the containment floor, it is expected that water will be expelled from the sump as the debris enters and will have difficulty flowing back into the sump. For this reason, it is judged less likely that a large molten debris mass could be quenched and cooled in the sump quickly enough to prevent thermal attack of the recirculation piping.

An additional effect of the high heat transfer rates from the debris to the water in the immediate post-vessel failure period is that much of the debris will be fragmented. In the long-term, the fragmentation of the debris, whether in the cavity or in the sump, will make it more likely that the final debris configuration will be coolable.

State of Knowledge Improvement

As described above, two small drains couple the reactor cavity to the sump. In the IPE, these drains were predicted to allow rapid transport of debris from the cavity to the sump in low-pressure accident sequences. This in turn usually led to overflow of the debris into the ESF suction lines, causing their failure.

Based on this finding, a plant modification (described in Section E.2.3.7) was subsequently made to effectively plug the drains with high melting temperature ceramic beads. The modification was designed to promote freezing of a small mass of the debris, effectively plugging the drainpipes. This should prevent immediate debris transport to the sump. If the debris cannot be cooled within the confines of the cavity, it may later melt through the cavity floor, but the delay will greatly extend the time available for evacuation and other mitigation measures.

In order to credit this modification for the SAMA analysis, the Palisades CET event "CAVSMPDRNS" should be set to zero. This assignment effectively prevents immediate debris transport to the Auxiliary Building, but subsequent transport due to long-term attack of the cavity floor is still being considered in the CET.

E.2.2.1.3 Integral Lower Reactor Vessel Head

As mentioned above, the Palisades in-core instrumentation enters the reactor vessel through the upper head. Therefore, there are no penetrations in the lower reactor vessel head. The lower head is approximately 4.5 inches thick, including the ¼-inch stainless steel cladding on the inside surface.

The lower reactor vessel head itself is not insulated; instead insulation is attached to the lower reactor cavity wall and the reactor cavity floor. At an elevation of approximately ten feet from the cavity floor, the insulation crosses over from the cavity wall to the reactor vessel wall. This horizontal piece of insulation is called the convective barrier, and it isolates the lower reactor cavity from the upper reactor cavity during normal operation. The convective barrier is designed to blow out at a differential pressure of 11 psid.

Potential Impact on Accident Progression

In most PSAs, it is assumed likely that the PWR lower reactor vessel head will fail due to thermal attack of the partial thickness welds, which hold the bottom head instrument tubes in place. The lack of instrument tube penetrations in the Palisades lower reactor head means that there is no identifiable local weak spot in the lower head. If the lower head does not fail due to ablation caused by the debris flowing from the core region, then it is judged likely that the time required for lower head failure to occur will be long compared to the case of reactors with lower head penetrations.

If the outside of the lower head is submerged in water and the primary system pressure is sufficiently low, calculations performed for the Palisades PSA indicate that sufficient heat can be removed through the lower head wall to prevent vessel failure under most circumstances. Since the Palisades lower reactor vessel head is not insulated, the ability of the water in the reactor cavity to cool the outside of the lower reactor vessel head is assured. The absence of lower head penetrations also implies that short-term head failures are quite unlikely, allowing time for a coolable debris configuration to be established.

The 1993 IPE calculations indicated that a somewhat lowered PCS pressure is necessary to prevent vessel failure under these circumstances, mainly because the strength of the alloy steel, which comprises the head, is much reduced at elevated temperatures. In fact, a reduction in wall thickness of approximately 33 percent was calculated to occur before sufficient heat could be transferred through the wall to prevent further thinning.

State of Knowledge Improvement

A very unusual aspect of Palisades is a set of features that increase the likelihood that debris can be cooled in the lower head:

- The lack of instrument penetrations in the lower head of the reactor vessel.
- The absence of insulation attached to the lower head.
- A dedicated cavity flooding system (CFS) that ensures the reactor head is covered by water whenever the containment spray (CS) system is in operation.

In this regard, the Palisades design was ahead of its time in that it incorporated characteristics that are only now included in advanced reactor designs. A relatively detailed analysis was performed for the Palisades IPE to evaluate the conditions under which the debris could be cooled in the lower head. The conditions for coolability were considered in detail in the CET review. It was concluded that the debris should be coolable if cooling water is supplied to the cavity and the reactor coolant system pressure is below about 11 MPa.

Considerable work was performed subsequent to the completion of the Palisades IPE to assess coolability of debris in the lower head (OECD 1994; OECD 1999). This work appears to confirm the basic heat transfer assumptions used in the IPE. For example, one area of particular concern in the IPE was whether critical heat flux (CHF) limits would be exceeded. CHF measurements on simulated reactor vessel lower heads show large margins to the estimated peak heat flux in Palisades of 500 kW/m^2 at the equator.

As a result, no major changes to the associated basic event probabilities were recommended. Event “VSSLTHXFER”, which accounts for residual uncertainties in the modeling of lower head coolability, can be reduced somewhat in view of the additional data; a value of 0.05 is considered appropriate.

E.2.2.1.4 Cavity Flooding System

The original plant design includes a CFS. The CFS functions only if a CS pump is in operation and is aligned to one of the CS headers. The CFS collects all the containment floor drain water and directs it into four drain downcomers. At the end of each drain downcomer is a plate with an orifice sized to allow normal drain water to flow out freely without backing up in the drain downcomer. When the flow rate into the floor drain system exceeds the combined capacity of the four orifices (as it will when a CS pump is in operation), the water will back up in the drain downcomers, and spill into the reactor cavity.

The CFS includes backwater float-type valves at each floor drain on the intermediate levels of the containment to prevent back flow. Proper operation of the CFS will flood the reactor cavity to the PCS loop piping cutouts in the reactor cavity wall. Should a backwater float valve fail on the lowest level, the minimum expected reactor cavity water level would be 15 feet.

Potential Impact on Accident Progression

If a CS pump is operating, the CFS will cause the complete flooding of the reactor cavity. The presence of this deep water pool in the reactor cavity, in combination with the integral, uninsulated lower reactor vessel head greatly enhances the potential for cooling the core debris in the lower head and preventing reactor vessel failure.

E.2.2.1.5 PCS Insulation

The reflective insulation still in use on the Palisades PCS loop piping, pressurizer and reactor vessel consists of nine crumpled sheets of aluminum contained in stainless steel enclosures. Following the replacement of the Palisades steam generators in 1990; some loop piping insulation within six feet of the steam generators was replaced with fiberglass type insulation. Other small portions of the PCS [i.e., parts of the primary coolant pumps (PCPs)] have also had fiberglass insulation installed.

Potential Impact on Accident Progression

As a PCS pressure boundary component (e.g. a hot leg) heats, temperatures sufficient to begin melting the insulation plates may be reached. If this occurs, the PCS will be able to reject more heat to the containment atmosphere, which may retard continued heatup of the component. This has two major implications for severe accident progression.

First, enhanced cooling of the hot leg may in principle prevent thermally induced (creep) failures from occurring. This would substantially affect the subsequent behavior of the plant by preventing depressurization of high-pressure sequences.

Second, the PCS is heated by volatile fission products (e.g. iodine), which settle on heat sinks in the PCS prior to reactor vessel failure. Melting of the insulation may delay or prevent temperatures from being reached which would cause long-term revaporization of volatile fission products.

E.2.2.1.6 Carbon Steel PCS LOOP Piping

The Palisades PCS loop piping is carbon steel with all interior surfaces clad with ¼-inch stainless steel. The Palisades reactor vessel and pressurizer were fabricated from the same type of carbon steel and are also clad with 1/4-inch stainless steel. The pressurizer surge line is stainless steel, as are all other pipes connected to the PCS or pressurizer.

Potential Impact on Accident Progression

For some postulated transient-initiated accident progressions, the PCS pressure boundary may be intact at the time of core overheating, melting and relocation to the lower reactor vessel head. Accident progressions with high PCS pressure at vessel failure require consideration of the effects of cavity pressurization and debris dispersal, including DCH.

Based on the work of Larson and Miller, carbon steel is more susceptible to thermal creep rupture than stainless steel (CP 1993). For this reason, it is concluded that the Palisades carbon steel hot legs are more likely to fail by creep rupture during high-pressure core damage accident progressions than similar plants, which have stainless steel hot legs. Therefore, creep induced failure of the PCS pressure boundary for high-pressure accident progressions is judged to be more likely for Palisades than for plants with stainless steel PCS loop piping. As a result MAAP was modified to evaluate the response of the hot legs, surge line, and steam generator tubes to creep induced failure.

State of Knowledge Improvement

As suggested above, if core overheating and melting occur at high PCS pressure (greater than approximately 14.5 MPa, 2100 psia), natural circulation of gas between the core, upper plenum, hot legs, and steam generators is promoted. The circulation of steam and hydrogen transfers heat from the reactor core to other PCS components. Sufficient heat transfer can be developed such that the PCS pressure boundary can be threatened by the combination of high temperature and high differential pressure.

Temperature induced creep failures of the PCS that occur prior to the failure of the lower reactor vessel head can depressurize the PCS sufficiently to prevent the containment challenges associated with high pressure at vessel failure. On the other hand, the avoidance of debris dispersal can allow core debris to flow to the Auxiliary

Building after vessel failure. For these reasons, a rather careful treatment of creep rupture was undertaken in the 1993 IPE. The 1993 submittal considered the following events to have the potential to depressurize the PCS prior to vessel failure:

a. Primary coolant pump (PCP) shaft seal failure(s).

b. Control Rod Drive Mechanism seal failure(s).

c. Operator action to open a pressurizer pressure operated relief valve (PORV).

d. Stuck open pressurizer code safety relief valve(s).

e. Thermal creep failure of a hot leg.

f. Thermal creep failure of the surge line.

g. Thermal creep failure of a steam generator tube(s).

Several of these events, specifically items d, e, f and g, were re-evaluated given the knowledge advancement. These phenomena were assembled in a creep rupture event tree. The creep rupture event tree together with the aforementioned CPMAAP/3.0B hard coded Larsen and Miller deterministic models provided the basis for the CET developed creep-rupture probabilities.

The top logic of the IPE developed creep rupture event tree included an additional heading to represent the timing of the pressurizer safety relief valve (SRV) failure, should it occur. The assessment of PCS creep rupture assumed that the hierarchy of PCS component failure is: hot leg, surge line, steam generator tubes. This conclusion follows from the fact that the hot leg is closest to the core, the surge line next closest and the steam generator tubes farthest. In addition, the surge line tends to see relatively small flow rates of hot gasses after the core has become hot due to low steam generation rates (corresponding to low core water levels) existent at that time. The steam generator tubes are cooled by circulation of gasses on the secondary side of the unit, which thermally couples the tubes to the shell and retards their heat-up. For all these reasons, failure is judged to be most likely for the hot legs, and this conclusion is confirmed by inspection of the results of CPMAAP hard coded creep rupture calculations.

The hard coded equation model solution integrated the fractional time to creep rupture over every CPMAAP time step. This resulted in an estimate of the time to creep rupture for the modeled components given a variety of transient initiators. A sample of these re-evaluated hard coded constants (such as PSRV, ERLY, SEAL etc.,), as well as several key creep rupture event tree nodes are discussed in more detail below.

- Steam Generator Tubes- The Palisades steam generator inspection program, like that of other nuclear power plants, implicitly accounts for the possible presence of relatively deep, but short cracks. When exposed to high differential pressures (due to depressurization of a steam generator) or high temperatures (due to a severe accident), the thin remaining tube ligament can fail, causing a "pop-through" of the crack. This is only of concern from the standpoint of mitigating design basis accidents or significantly affecting source term during a severe accident if the crack then opens to a large "fishmouth" rupture.

  Since the inspection program does not prevent pop-throughs from occurring during design basis accidents, it must be recognized that they may also occur during severe accidents. For this reason, the assessment of steam generator tube integrity during severe accidents should focus not on creep rupture of the remaining ligament, as in most previous severe accident analyses, but rather on the potential for fishmouth ruptures to develop given a through-wall pop-through defect.

- Effect of Stuck Open Pressurizer SRV - If a pressurizer code SRV were failed open, the PCS thermal-hydraulic response would greatly differ from the response of an intact PCS. The open valve would quickly depressurize the PCS to pressures below which creep rupture would not be a concern. If the SRV fails open before the core becomes uncovered, the PCS will be at relatively low pressure at the time of vessel failure. If the SRV fails later (at or after the time of core uncovering), substantial surge line heating by the hot gases from the core would be expected. This heating has been shown to likely cause surge line failure.

  PSRV: Pressurizer SRV fails open (previous value 0.5, recommended value 0.5).

  The available evidence cited in Electric Power Research Institute (EPRI) TR-107623 Volume 1 suggests that a pressurizer SRV is likely to stick open due to the severe challenges associated with the passage of water through the valves (EPRI 2002). However, there is no conclusive evidence on failure mode (i.e., what flow area will exist after the valve sticks). For this reason, it is recommended not to change this value. This event is defined as the probability that a SRV sticks open sufficiently wide to prevent tube rupture, given that the failure occurs well before core uncovering.

  ERLY: Pressurizer SRV failure is early (previous value 0.9, recommended value 0.9).

  The pressurizer PORV or safety valve challenges from the passage of one- and two-phase water occur well before core uncovering as the primary system empties. The previous value is still judged reasonable.

- Status of Primary System Loop Seals - SEAL: Loop seals clear (previous value 0.1, recommended value 0.1)
  For high-pressure core melt accident sequences, counter-current natural circulation of steam and hydrogen is promoted through the hot legs. This flow pattern would tend to heat the hot legs and the surge line faster and to higher temperatures than the steam generator tubes, since the thermal inertia of the steam generator shell indirectly cools the tubes. If two or more of the loop seals clear, counter-current hot leg flow would be suppressed. Instead, unidirectional loop flow will occur which will tend to result in relatively uniform PCS component temperatures.
  In detailed calculations performed with the SCDAP/RELAP5 code, loop seal clearing is generally associated with large reactor coolant pump seal loss-of-coolant accidents (LOCAs). While loop seals are relatively shallow in CE plants such as Palisades, the absence or low likelihood of a seal LOCA in the reactor coolant pumps prevents loop seal clearing. Also, for loop seal clearing to result in unidirectional flow through one of the coolant loops, in general a clear loop seal as well as a core water level below the base of the core barrel is required. For these reasons, no change is recommended. If the loop seals do clear it is now conservatively considered that tube failure would be likely (this is a change from previous treatment of the IPE submittal creep rupture event tree end state 4).

- Effect of Stuck Open Steam Generator Atmospheric Dump Valve or SRV - As discussed in the IPE submittal, a depressurized secondary side will nearly double the hoop stress in the steam generator tubes. This increased stress level would make tube failure more likely. It would also increase the tube temperature, since when the secondary system is at high pressure natural convection on the secondary side will transfer heat from the tubes to the steam generator shell. When the secondary system is depressurized this natural convection heat transfer is much reduced resulting in higher tube temperatures.

  SSRV: At least 1 secondary atmospheric dump valve (ADV)/SRV fails open (previous value 0.67, recommended value 0.08)

  Recent EPRI work indicates that the failure probability of a secondary safety or relief valve is dominated by maintenance failures that manifest themselves on the first lift. Limited vendor data indicates that many subsequent lifts can occur without failure or evidence of wear. The recommended numerical value is calculated using the methods provided by Fuller et al. (EPRI 2002), assuming 100 lifts on each of two steam generators as documented in the IPE submittal.

- Effect of Steam Generator Tube Wastage - Steam generator tube wastage will increase the hoop stress in the tube making creep rupture more likely. As discussed in the IPE, 50 percent wastage is considered an appropriate value of wastage to model all potential tube defects.

WAST: One or more tube(s) are badly degraded (previous value 0.05, recommended value 0.05).

In accordance with the fishmouth rupture analysis presented above, this event is slightly reinterpreted as follows. Success of this event implies that at least one of the tubes carrying “out” flow away from the inlet plenum (about 50 percent of all the tubes) has damage characterized by a stress multiplier “m” greater than 2 at the time of the severe accident. As discussed above, the Palisades steam operator inspection program is designed to prevent any tube from having an “m” value greater than about 2.2 by the time it is inspected, so such severe tube damage is considered unlikely.

HL: Hot leg fails before tubes, given a depressurized steam generator (previous values are 0.675 if one or more tubes wasted, 0.9 otherwise; recommended values are 0.1 if one or more tubes tube wasted, 0.9 otherwise)

The logic for this was discussed previously. This event applies to end states 5 through 9.

HL: Hot leg fails before reactor vessel head with steam generators pressurized (previous value 0.9; recommended value 0.99). Hot leg failure prior to reactor vessel head failure is considered extremely likely in this case since there is no implied race with tube rupture (steam generators are pressurized, making tube rupture very unlikely). This applies to the IPE creep rupture event tree end states 10 and 11.

SRG: Surge line or hot leg fails given an open pressurizer SRV (previous value 0.5, recommended value 0.5). Surge line rupture is not currently modeled in MAAP4. The recommended value is considered conservative based on previous work for cases where a pressurizer SRV is open, drawing hot gas into the surge line.

SGT: Badly degraded tube fails given secondary depressurized, PCS pressurized (previous value 0.9, recommended value 1.0). In accordance with the previous discussion, tube failure is considered virtually guaranteed in this case. This top event could be eliminated if desired.

E.2.2.2 PALISADES CREATED MAAP/3.0B (CPMAAP) VERSION

As described above, a number of Palisades-specific design features were identified which could affect the progression of severe accidents. In order to perform integrated containment performance and fission product release evaluations for the dominant Palisades accident sequences, modifications were made to the EPRI developed version of PWR MAAP/3.0B (hereafter referred to as MAAP). The enhanced, Palisades-specific version of MAAP was named CPMAAP in accordance with EPRI policy. All severe accident calculations performed in support of the Palisades Level 2 IPE submittal were performed using CPMAAP. Note that in some instances, MAAP4.0 was used to augment the 'state of knowledge review'.

The significant modifications and enhancements added to IPE developed CPMAAP code are discussed below.

- Elevation Head in Accumulator Discharge Model - The Palisades safety injection tanks are located in the upper containment approximately 100 feet above the centerline of the PCS loop piping. The hydrostatic head caused by this elevation difference is not modeled by MAAP, and is important since the accumulator pressure is relatively low (200 psi). For these reasons, the hydrostatic head was added to the accumulator discharge model in CPMAAP.

- Tellurium (Te) Release During Direct Containment Heating Model - The best estimate assumption for tellurium release during fuel overheating implemented in MAAP and CPMAAP is that the tellurium reacts with available zirconium to form zirconium telluride. If the core debris is subsequently dispersed in a fragmented form (i.e. if a High-Pressure Melt and DCH occur), MAAP assumes that the zirconium in the dispersed debris is oxidized by steam that is present in the containment atmosphere. MAAP does not model the release of the tellurium that was bound to the oxidized zirconium. In CPMAAP, the tellurium that is bound to the zirconium prior to dispersal is released as a fission product aerosol to the containment atmosphere during DCH in the same proportion as the amount of zirconium that is assumed oxidized.

- Non-Cladding Hydrogen Source Model - One of the consequences of the aluminum reflective PCS insulation is that it can be oxidized by the highly borated water in containment, resulting in an additional source of hydrogen in containment. Oxidation of organic coatings and radiolytic decomposition of water will also be an additional source of hydrogen during a severe accident. A simple model was added to allow the addition of hydrogen to the containment at a user specified rate. If the rate is set to a negative value, the model will act as a simple recombiner. In any event, the ability to supply an arbitrary source of hydrogen was used in the IPE in sensitivity studies of the containment response unrelated to the aluminum insulation.

- Steam Generator Level Correction at Full Power - To better model steam generator water level during full power operation, the increase in the downcomer water level caused by the pressure drop through the tube bundle was modeled.

- Improved Numeric/Logic for Modeling Solid Steam Generator - For many steam generator tube rupture-initiated accident sequences, the secondary side of the steam generator with the ruptured tube goes solid. The MAAP modeling to treat a solid steam generator was found to be inadequate, so it was modified to properly treat this type of accident progression.

- Deadband Model for Secondary Relief Valves - MAAP did not include a deadband in its model for secondary side code safety relief and atmospheric steam dump valves. A simple deadband model was added to CPMAAP.

- PCS Insulation Melting Model - The original Palisades PCS and reactor cavity insulation was metallic reflective insulation made of aluminum sheets encased in steel enclosures. Following the steam generator replacement project, the insulation on the steam generators, reactor vessel head, and pressurizer was replaced with fiberglass insulation, except for approximately six feet of PCS loop piping nearest the steam generators, which still has the original aluminum reflective insulation. Since some accident sequences are predicted to heat parts of the PCS pressure boundary to temperatures in excess of the melting temperature of aluminum, a model to individually melt the aluminum reflective insulation plates was added to CPMAAP.

- PCS Pressure Boundary Creep Rupture Model - A thermal creep rupture model based on the correlation of Larson and Miller was added to CPMAAP to evaluate the response of the hot legs, surge line, and steam generator tubes. The model integrates the fractional time to creep rupture over every CPMAAP time step.

- Hydrogen Detonation Cell Width Model - In response to a perceived sensitivity to hydrogen-related phenomena, a simple model that estimates the detonation cell width in the four containment compartments was implemented in CPMAAP. The model computes the detonation cell width as a function of pressure, temperature, and steam mole fraction. The results of the calculations give a gross indication of the potential for global hydrogen detonation for sensitivity cases in which it is assumed that deflagrations do not occur at the expected concentrations of flammable gas.

- Core Debris Flow to the Auxiliary Building Model - Due to the location of the ESF sump and the associated potential for core debris to enter the recirculation piping, it was judged desirable to add to CPMAAP the capability to model debris flow from the reactor cavity to the sump, and subsequently to the Auxiliary Building. The implementation of this model used all of the standard MAAP phenomenological models for debris behavior. Two debris/gas/water flow paths were added from the reactor cavity to the Auxiliary Building. The cavity and sump geometry were represented including curb heights, flow areas, etc. The models necessary to represent core debris in Auxiliary Building nodes were also added.

- Palisades Specific ESF Modeling - Four Palisades-specific ESF models were added to CPMAAP. The containment air cooler flow direction can either be from the lower containment to the upper containment or the reverse. The capability to line-up the discharge of the CS pump to the suction of a high-pressure safety injection (HPSI) pump(s) was added, as was the automatic trip of low-pressure safety injection (LPSI) at the switchover to recirculation mode. A model for auxiliary pressurizer spray was also added to improve the modeling of certain steam generator tube rupture sequences where this system is important.

- Separate Containment Leakage/Failure and ISLOCA Flow Junctions - In MAAP, the flow junction used to specify an interfacing system loss of coolant accident (ISLOCA) into the Auxiliary Building is the same junction used to model containment leakage and failure. This was found too restrictive, so separate flow junctions that can have different downstream nodes in the Auxiliary Building for an ISLOCA and containment leakage are provided in CPMAAP.

E.2.3 UPDATES SINCE THE 1993 IPE SUBMITTAL

The Palisades IPE was submitted in January 1993. Subsequent PSA updates have involved the examination of plant operating logs, corrective action documents, out of service time histories for selected components, industry data, implemented plant modifications, model review comments and suggested peer review changes. The following table lists each of the model updates.

Palisades Model (date)	Truncation (per yr)	CDF (per yr)
IPE (1993)	1.0E-9	5.07E-05
PSAR1 (1999)	1.0E-9	5.95E-05a
PSAR1a (2000)	1.0E-9	5.47E-05 a
PSAR1b (2000)	1.0E-9	6.18E-05 a
PSAR1b-Modified (2001)	1.0E-9	6.16E-05 a
PSAR1b-Modified w/HELB (2002)	1.0E-9	6.24E-05b
PSAR1c (SAMA; 2004)	1.0E-9	4.05E-05b

a. Subsumed cutset solution.
b. Non-subsumed cutset solution.

As a result of these examinations, the following examples of PRA model updates since the IPE submittal include:

- Initiating Events
- Event Trees
- Fault Trees
- Human Reliability Analysis
- Component Performance Data
- Common Cause Modeling
- Containment Sump Modification
- Software Changes

E.2.3.1 INITIATING EVENTS

The Palisades initiating event frequencies have been updated based on evolving industry data, as well as state of knowledge advances regarding specific issues. For example, the PSAR1c (SAMA) analysis has included the lessons learned from the Pressurized Thermal Shock (PTS) Rule [10CFR50.61] ongoing revaluation that has included Palisades as one of the analyzed plants, as well as insights characterized by the Westinghouse Owners Group regarding the August 14, 2003 loss of offsite power (LOOP) event.

E.2.3.1.1 LOCA's

During the Palisades SAMA analysis, a separate effort was underway at NRC to review and revise the LOCA frequencies from NUREG/CR-5750 for use particularly in work associated with 10CFR50.46 (Acceptance Criteria for Emerency Core Cooling Systems), but with applicability for other risk-informed applications such as the PTS project. There was a concern that the LOCA frequencies in NUREG/CR-5750 did not account for age-related factors important to deriving the frequencies, and an expert elicitation effort at NRC was conducted to account for these adjustments (NRC 2004).

The results from that elicitation were not appropriate for use in the Palisades PTS study because the elicitation structure and results involved both piping and non-piping causes for the various size breaches. To fit the Palisades-specific application, just the piping contribution was required. Since the elicitation had not been formatted in a way to separate the two parts, it was not possible to directly discern the appropriate frequencies to use in this evaluation. Hence discussions were held with the elicitation subject matter experts. It was concluded that the Palisades plant-specific initiating event frequencies were nearly the same as that developed in the elicitation effort. Therefore, no change was made to the Palisades values.

E.2.3.1.2 Loss of Offsite Power

As was the case above for LOCAs, other Palisades initiating events were updated periodically as industry information became available. For example, the SAMA PSAR1c LOOP initiating event frequency was last updated in 2003. In developing the prior distributions for the Palisades-specific update, the plant-to-plant variability in the industry data was assessed by using the typical 'Two Stage Bayes' Updating process. The industry LOOP statistics included data from 72 sites and about 100 reactor units. Some of these units and sites have experienced multiple LOOP events, others have experienced a single LOOP event, and a sizable fraction had never experienced a LOOP event.

Subsequent to this update, the lessons learned from the draft assessment of the 2003 Loss of Off-Site Power Event were examined with respect to the SAMA PSAR1c Level 1 model. As a result of this investigation, the PSAR1c initiating event value was increased to account for the likelihood of a site LOOP event given that other plants had tripped in the East Central Area Reliability region of which Palisades is a member. It was concluded from this approximated sensitivity assessment that the SAMA conclusions were not affected.

E.2.3.2 EVENT TREES

A review of the Palisades event trees was performed in support of the PSAR1c model update. As an example of some of these updates, changes were made to the LOOP event tree that included:

- Diesel generator (DG) repair had been included in Palisades' model via two event tree 'heading' developed events: DG-REC-2HR and DG-REC-4HR. These events recovered one of the two DGs to enable once through cooling (OTC) (2 hours) or to enable continued auxiliary feedwater (AFW) flow (4 hours – instrument indication is maintained by recovering the DGs). To ensure that these recovery terms are only applied to the diesel engine, they were removed from the tree and applied to the appropriate cutset results.

- The LOOP event tree top 2400VAC was created to segregate bus 1C and bus 1D failures because of design asymmetries and as a result of using the SETS code. Given the various Systems Analysis Programs for Hands-on Integrated Reliability

Evalutions (SAPHIRE) (the present Palisades PSA computer code of choice) solution options, this heading was been removed to simplify the structure.

- Per completion of the Combustion Engineering Owners Group (CEOG) assessment of failure of the PCP seals given loss of seal cooling, PCP seal modeling was added to not only the LOOP, but to the loss of component cooling water and service water (SW) event trees, as well.

Updates also included adding event trees. For example, the CEOG peer review questioned the Palisades PSA in that inadvertent pressurizer safety valve or PORV opening was not addressed in the analysis. The Palisades PORVs are normally blocked during power operation. Although Palisades has not experienced pressurizer safety valve setup or setpoint drift problems or has identified safety valve challenges as a result of deterministic analysis, industry experience has shown that such events are plausible (note that Palisades operates at about 100 psia less than other CE designed PWRs). As a result, a new event tree model was created that analyzes a transient demand on the pressurizer SRV(s) that results in a premature opening of the valve(s) and subsequent closure. Failure of the pressurizer safeties to close was subsequently modeled by transferring to the small break LOCA event tree.

E.2.3.3 FAULT TREES

Many changes made to the main steam line break (MSLB) Submittal fault trees culminated in the IPE fault trees. The promulgation of the 1986 MSLB Submittal fault trees to the 1993 IPE fault trees was a directly related to the evolution of PRA research. This progression will not be presented here; however, examples of subsequent changes to the IPE fault trees to the present model are noted below:

- Permanent removal of steam supply from the alternate steam supply valve CV-0522A to turbine-drive AFW pump P-8B.

- The power sources on C-6A and C-6B were swapped MCC-8 to C-6A and MCC-7 to C-6B. Additional direct current (DC) bus faults were added and certain DC demand failure modes were included as well.

- Failure of the flow path through shutdown cooling (SDC) heat exchanger E-60B was conservatively modeled as failing subcooling paths for both high-pressure injection (HPI) pumps P-66A & P-66B, as well as flow through both CS headers. This was changed so that failure of the E-60B flow path would only fail flow through the "B" CS header (via CV-3001) and the P-66B subcooling flow path (via CV-3070).

- Evaluation of the impact of a High Energy Line Break in CCW Room with either Door 167 to 590 Corridor Auxiliary Building or 167B to the West Engineered Safeguards Room Open.

- PCP seal modeling has been included.

- Deficiencies associated with the load shed logic developed under logic gates PLSRE11 and PLSRE21 were identified. The load shed circuitry utilizes four relays on each channel to implement the breaker opening operations to load shed components from the safety buses. The PSA model had included a basic event for one relay on each channel. The other three relays were added to the model.

- A plant modification in 2001 eliminated the need for the operator to open sub-cooling valves to the suction of the HPSI pumps after the recirculation actuation signal (RAS) to ensure adequate PCS sub-cooling. The modification included:

  - the installation of key-locked switches for bypassing the containment high pressure (CHP) open signal to CS Header Isolation valves CV-3001 and CV-3002,

  - the installation of wiring that with HPSI pump P-66A motor breaker 152-207 closed, the initiation of RAS will open CV-3071 HPSI sub-cooling valve,

  - the installation of wiring and relays for the automatic opening of CV-3070 HPSI sub-cooling valve when valve CV-3030 Containment Sump Isolation valve is fully open and HPSI pump P-66B motor breaker 152-113 is closed, and

  - the installation of wiring and relays for the automatic closure of CS Header Isolation valve CV-3001, if Containment Sump Isolation valve CV-3030 fails to fully open following the initiation of a RAS signal.

- Fire protection system (FPS) makeup to motor-drive AFW pump P-8C was modified to include failure of condensate storage tank (CST) T-2.

- FPS logic was modified to include reliance on the traveling screens.

- The auto MSIV close logic 'CHP' and 'low Steam Generator (SG) pressure' were modified to correctly account for steam line break and LOCA initiators.

- The condensate pump logic was modified to include both gland seal condenser and air ejector after condenser ruptures.

- CCW pumps P-52A, P-52B and P-52C logic were modified to include failures as a result of steam line breaks outside of containment (Environmential Qualification limits).

- Flow control valves for AFW Pump C (motor) are supplied by non-safety-grade instrument air. These valves do not have nitrogen back-up. The failure of air to these valves will result in the valves failing to the full open state causing the potential overfilling and/or overcooling of the SGs. This issue was addressed as discussed above, by inclusion of an operator action to address overfilling the steam generators assuming the AFW flow control valves had failed open upon a loss of instrument air.

- MOD-2003-17 replaced half-capacity instrument air compressors C-2A and C-2C with individual full capacity air-cooled compressors.

E.2.3.4 HUMAN RELIABILITY ANALYSIS

Several enhancements to the Palisades Human Reliability Analysis (HRA) analyses have been performed since the IPE Submittal.

The first such enhancement was the re-analysis of the IPE-developed Human Error Probability (HEP) models using the “Accident Sequence Evaluation Program (ASEP) HRA Procedure,” methodology. This analysis technique which yields sufficiently accurate HEPs for actions taken during normal operating and post-accident operating conditions are generally more conservative than the IPE developed THERP events due to the greater uncertainties of predicting human behavior.

The next update occurred as a result of the CEOG PSA Peer review. To address an issue regarding dependent operator actions, this analysis evaluated behavioral dependencies between the multiple operator actions that could occur in the accident sequences. Post-initiator operator actions that were considered to have obvious dependencies were already assigned the same basic event name in the model, thus implicitly assuming a complete reliance between the actions. This evaluation, however, addressed the remaining operator action dependencies that were not obvious. Although the original IPE results were not much affected, the evaluation defined dependent terms that were subsequently included in the linked fault tree models employed in PSAR1c.

Subsequent enhancements have also included development of new HEP models in order to address other peer review issues. For example, these post-initiator actions have included an operator action to address overfilling the steam generators assuming the AFW flow control valves had failed open upon a loss of instrument air and the re-assessment of applied stress factors for several HEP models.

E.2.3.5 COMPONENT PERFORMANCE DATA

Plant component performance data were updated in 1999 including valves (check, control, motor operated etc.), pumps, fans, heat exchangers etc. The following table lists the various analyses.

Description
• Gather demand, standby failure and run data from industry or generic sources for components used in the Palisades PSA model.
• Calculate the availability factor of the Palisades reactor from 1/1/94 through 12/31/98.
• Determine the detection interval and mission time for the time dependent basic events in the Palisades PSA model.
• Determine the number and type of shutdowns since 01/01/94.
• Gather demand and run time success data from surveillance procedures on the components modeled in the Palisades PSA for power operation.
• Document equipment failures of PSA related equipment at Palisades from 1994 to the present.
• Perform a Bayesian update of the plant-specific data.
• Determine the amount of time different equipment has been out of service since 1/1/94.
• Determine the out of service probability for components in the PSA model based on the out of service data collected between August 21, 1995 and August 21, 2002 (7 years)

E.2.3.6 COMMON CAUSE MODELING

The Palisades common cause modeling was updated employing the methodology described in NUREG/CR-6268 (NRC 1998b) and the industry events taken from the associated NRC/Idaho National Engineering and Environmental Laboratory (INEEL) Common Cause software. Calculations of multiple Greek letter (MGL) parameters were based on the ERIN Common Cause analyses for the plant not the INEEL software. MGL parameters were created for those components for which events were found in the INEEL database. In addition, MGL parameters were created for other component types and failure modes commonly modeled but absent from this database. For these later component types and failure modes, generic MGL values were used. The generic distributions are taken from NUREG/CR-5485 (NRC 1998c).

Screening of events for applicability to Palisades was done for selected components and failure modes. Only those components and failure modes for which there were ten or more common cause events in the database were screened. Where possible and appropriate, the INEEL Common Cause software was used to help generate the MGL factors in support of the update.

The MGL parameters presented in the INEEL software are based on the impact vectors from the screened events, the number of independent failures, and an independent event-scaling factor. As a result, there is no option to choose or supply a generic prior distribution and perform a Bayesian update. Consequently, these latter steps were performed in order to develop plant-specific MGL factors for Palisades. As mentioned above, the event applicability evaluation, vector mapping, and MGL factor calculation were performed outside the INEEL software in the ERIN specifically tailored Palisades analysis. This step was required, as the INEEL software does not provide the flexibility to change common cause group size or component degradation impacts. Interim common cause failure data were employed in the PSAR1c model. The final set of common cause values were subsequently evaluated and found to result in a slight reduction in the baseline PSAR1c CDF of about 2 percent. This is considered not to impact the SAMA baseline model conclusions.

E.2.3.7 1995 CONTAINMENT SUMP MODIFICATION

The Palisades IPE identified two significant insights. The first was the impact of an installed cavity flooding system that increased the time to vessel failure in severe accidents, as well as providing for ex-vessel cooling when CS System is functioning.

The second insight was a “significant containment performance” issue for severe accidents. Due to the location of the Engineered Safeguard sump in the containment, core melt accidents that are not recovered prior to vessel failure (melt-through) can result in core debris flow out of the containment and into the Auxiliary Building. The Engineered Safeguards sump is located directly below the reactor cavity. The reactor cavity floor has two one-inch drain lines that allow water to flow from the reactor cavity to the sump. The IPE discerned that molten core debris could quickly ablate the drain lines and allow significant amounts of core debris to relocate to the sump and ultimately to the Engineered Safeguards equipment rooms in the Auxiliary Building.

As a result of this discovery, several alternatives were evaluated to reduce or eliminate the consequence of this design configuration. The option to modify the reactor cavity drain lines was chosen as the best opportunity to forestall sump failure based on both risk and normal operating design requirements. Normal operation requires the ability to collect any water accumulating in the reactor cavity in the containment sump in order to calculate PCS leak rates. From a risk perspective, analyses determined that this alternative would delay relocation of core debris from the reactor cavity to the sump by six to twelve hours.

As a result, the modification consisted of installing a removable cartridge containing ceramic beads. This design provided the capability of meeting normal operating requirements by allowing a minimum of 1 gallon per minute of flow. In addition, the cartridge provides enough density under severe accident conditions to reduce the ablation rate resulting from the core-concrete interaction. The drain plugs were made removable from the bottom side of the reactor cavity floor to allow removal for inspection and replacement.

E.2.3.8 SOFTWARE CHANGES

This model update involved moving the logic models and data from the SET Equation Transformation System (SETS) code to the INEEL developed SAPHIRE code. The primary objective was to improve the quantification speed of the model and take advantage of the many SAPHIRE features ranging from basic event distribution assignments (in order to support uncertainty analyses) to multiple event tree linking capability.

E.2.4 CURRENT LEVEL 1 PALISADES PSA MODEL

The SAMA analysis is based on the Palisades PSA model for internal events (PSAR1c). The PSAR1c baseline CDF is 4.05E-5 per reactor year. The results are summarized below. The following table lists the Palisades CDF initiating event contributions that are greater than 1 percent.

Initiating Event	CDF (reactor year)	Percent CDF
Loss of OSP (including SBO)	1.24E-05	31
Small Break LOCA	1.02E-05	26
Steam Generator Tube Rupture	6.06E-06	15
General Transient w/Main Condenser Available	2.94E-06	7
Loss of Instrument Air	2.41E-06	6
Loss of Service Water	1.84E-06	5
Loss of Main Feedwater	9.07E-07	2
Loss of the Main Condenser	6.46E-07	2
Pressurizer Safety Valve Spurious Opening	4.08E-07	1

It has been observed in past PSAs that the calculation of radionuclide releases are strongly linked to the results of the Level 1 accident sequences. More specifically, there is a high correlation between the types of accident sequences (e.g., Level 1 end states or Plant Damage States or Accident Classes) and the determination of the radionuclide release categories. This observation can be explained because the severe accident progression is strongly influenced by the systems available and the accident sequence timing as determined in Level 1. These features are directly correlated to the Plant Damage States or Accident Classes.

Table E.2-1 is a summary of the Palisades Level 1 accident classes. Table E.2-1 also summarizes the CDF determined from the analysis. In addition, the Level 2 CETs are quantified using the aggregated plant damage state frequencies from the Containment Bridge Tree (CBT). The CBT categorizes the status of water available to the containment, PCS heat removal, the availability of sprays etc. for defining the containment event tree input.

E.2.5 CURRENT LEVEL 2 PALISADES PSA MODEL

The results of the Palisades Level 2 analysis are summarized in the following subsections.

E.2.5.1 OVERVIEW OF POTENTIAL RELEASE CHARACTERIZATION

This subsection provides the following information regarding the characterization of the Level 2 CET end states:

- Brief overview of radionuclide removal processes and the concept of binning
- Summary of key features governing radionuclide release
- Radionuclide release category parameters
- Identification of radionuclide release categories or bins
- Deterministic calculations to support CET End States definition

Radionuclide release processes are initiated when the core overheats and melts. These release processes involve transport from the fuel, from the primary system, and from primary and secondary containment. These release processes when categorized into end states can indicate the amounts and types of radionuclide material that could potentially be released to the environment. It should be noted that, depending on the kind of accident in progress, there are inherent removal mechanisms that can occur to remove and retain these fission products. These deposition mechanisms include plateout and retention on the vessel surfaces (at least as long as primary system temperatures remain relatively low).

Once the fission products are airborne in the containment, there are removal mechanisms that reduce the magnitude of the source terms that are available for leakage to the environment. These removal mechanisms include plateout and settling in containment. The degree of attenuation is determined to a large extent by the time available for these processes to occur. The time between fission product release from the fuel until containment failure determines the residence time of the radionuclides within containment. The containment failure modes and failure location also contribute to determining the radionuclide removal mechanisms that are operating along the exit path to the environment.

Each CET end state can be associated with a radionuclide source term bin, which covers a spectrum of similar potential scenarios and timing.

E.2.5.2 SUMMARY OF IMPORTANT FEATURES GOVERNING RADIONUCLIDE RELEASE

There are a number of plant features or accident progression features that can substantially increase or decrease the ability to retain fission products or mitigate their release. This subsection reviews some of the more important of these features including:

- Removal processes
- Containment failure modes
- Phenomenology
- Timing

Of course, the accident sequence definition also is a major factor in the assessment of the radionuclide releases. Therefore, a number of sequence variations have been included to assess these impacts.

E.2.5.2.1 Removal Processes in Containment

Given that radionuclides are released from the fuel, the removal of fission products from any leakage pathway varies with the kind of accident sequence in progress, the containment failure mode, and the type of fission product. These removal mechanisms may be classified as follows:

- <u>Natural removal</u> – Radionuclides may be removed by natural deposition (i.e., plateout) or settling mechanisms.
- <u>Active Safety System</u> – The actuation of CSs can reduce the concentration of radionuclides suspended in the containment atmosphere by wash-out removal mechanisms.
- <u>Passive Safety System</u> – Water pools can provide a "passive" removal mechanism for aerosol and non-noble gas vapors when it is in the release pathway during a core melt progression accident. The effectiveness of pool decontamination depends on the characteristic of the aerosol source (e.g., particle size distribution), the temperature of the water, and whether pool bypass pathways exist.

E.2.5.2.2 Containment Failure Modes

For each of the accident sequence classes, there is a set of containment failure modes and release pathways that affect the magnitude of the radionuclide releases. Briefly, the location of a particular containment failure may allow for additional scrubbing of radionuclides if the break location is into adjacent plant buildings. In addition, breaks that occur in interfacing system piping may allow for a direct release that bypasses the containment.

To determine the adequacy of the requirements that define containment performance with respect to radionuclide release, a systematic review of the containment challenges associated with a spectrum of severe accident types has been performed. Radionuclide releases are associated with a containment failure and accident sequence. Plant-specific MAAP evaluations can be used to determine the release characterizations (i.e., magnitude and timing) associated with the various release categories associated with the spectrum of accident scenarios postulated in the PSA.

E.2.5.2.3 Phenomenology

The CET includes an assessment of the probability of occurrence of energetic phenomenological effects that can result in containment failure and add energy to the radionuclide release. Examples of such phenomena include the following:

- Steam explosions
- Hydrogen detonation
- Direct Containment Heating
- Induced Steam Generator Tube Rupture
- Excessive blowdown pressure

Such phenomena, while of low probability (even given a severe accident), may have a substantial influence on the containment integrity, radionuclide removal processes, and the radionuclide releases. Therefore, the end states of the Level 2 PSA are also influenced directly by the occurrence of these phenomena.

There are also other core melt progression phenomena such as in-vessel and ex-vessel debris coolability that are included in the evaluation through the use of the MAAP deterministic evaluation code.

E.2.5.2.4 Timing

Radionuclide releases are calculated to be strongly affected by the time of initial release (e.g., containment failure) and the duration of the accident.

The length of time over which the accident progresses can influence the degree of retention and the pathway through which the release propagates. The initial release is always characterized by a MAAP evaluation or typical plant severe accident evaluation. In fact, it is taken to be so important as to be part of the radionuclide release bin characterization. This is found to be conservative in that it overestimates the release characterization in many sequences. Thus, only the duration remains to be specified.

The assessment of radionuclide release duration for the purposes of calculating release magnitudes and the assignment of accident sequences to release categories includes two considerations:

- The compensatory measures that can be taken to significantly reduce or prevent dose to the public.
- The characteristics of radionuclide release.

E.2.5.3 RADIONUCLIDE RELEASE CATEGORIES CHARACTERIZATION (CET END STATES)

The continuous spectrum of possible radionuclide release scenarios is represented by a discrete set of release categories or bins. The end states of the containment and phenomenological event sequences may be characterized according to certain key quantitative attributes that affect off-site consequences. These attributes include two important factors:

- Timing (e.g., early or late releases); and
- Total quantity of fission products released.

Therefore, the CET end states are meant to represent the source term magnitude and relative timing of the radionuclide release.

The description of the source term, the release timing, and the implications of each are determined using the results of the IPE CPMAAP calculations. The event sequences contributing to a radionuclide release are ranked on the basis of the product of the relative consequences [based on estimated radionuclide release fractions of noble gases, cesium iodine (CsI), and tellurium (Te)] and their respective conditional probabilities, so that potentially risk-dominant scenarios are identified and adequately represented. Those scenarios that exhibit similar release characteristics in timing and radionuclide fractions are sorted and combined into groups of release categories to reduce the number of sequences required to calculate the risk profile.

E.2.5.4 IDENTIFICATION OF RADIONUCLIDE RELEASE CATEGORIES OR BINS

The release categories are defined based on two parameters: timing and severity. Timing of the release for each sequence is based on CPMAAP calculations of the sequence chronology.

E.2.5.4.1 Timing Bins

Three timing classifications are used, as follows:

- Early (E) – Releases occur less than 4 hours from declaration of a General Emergency. This is the time frame in which minimal off-site protective measures can be taken.
- Intermediate (I) – Releases occur greater than or equal to 4 hours, but less than 24 hours. This is the time frame in which much of the off-site nuclear plant protective measures can be assured to be accomplished.
- Late (L) - Releases occur at 24 hours or after. This is the time at which the off-site measures can be assumed to be fully effective.

E.2.5.4.2 Release Magnitude Bins

The five severity classifications associated with volatile or particulate releases[1] are defined as follows:

- High (H) – A radionuclide release of sufficient magnitude to have the potential to cause early fatalities.
- Moderate (M) – A radionuclide release of sufficient magnitude to cause near term health effects.[2]
- Low (L) – A radionuclide release with the potential for latent health effects.[2]
- Low-Low (LL) – A radionuclide release with undetectable or minor health effects.[2]

[1] The effects of noble gases may be quite dramatic, causing substantial early health effects if released early in an accident and if the associated plume is directed at an occupied location. The noble gases themselves may result in early injuries or fatalities. In the definition of the above timing categories, early health effects due to noble gases are not addressed, rather the focus is on the dominant term in cost-benefit evaluations from past assessments, i.e., the latent health effects for which the above formulation adequately encompasses the effects of noble gases on the release.

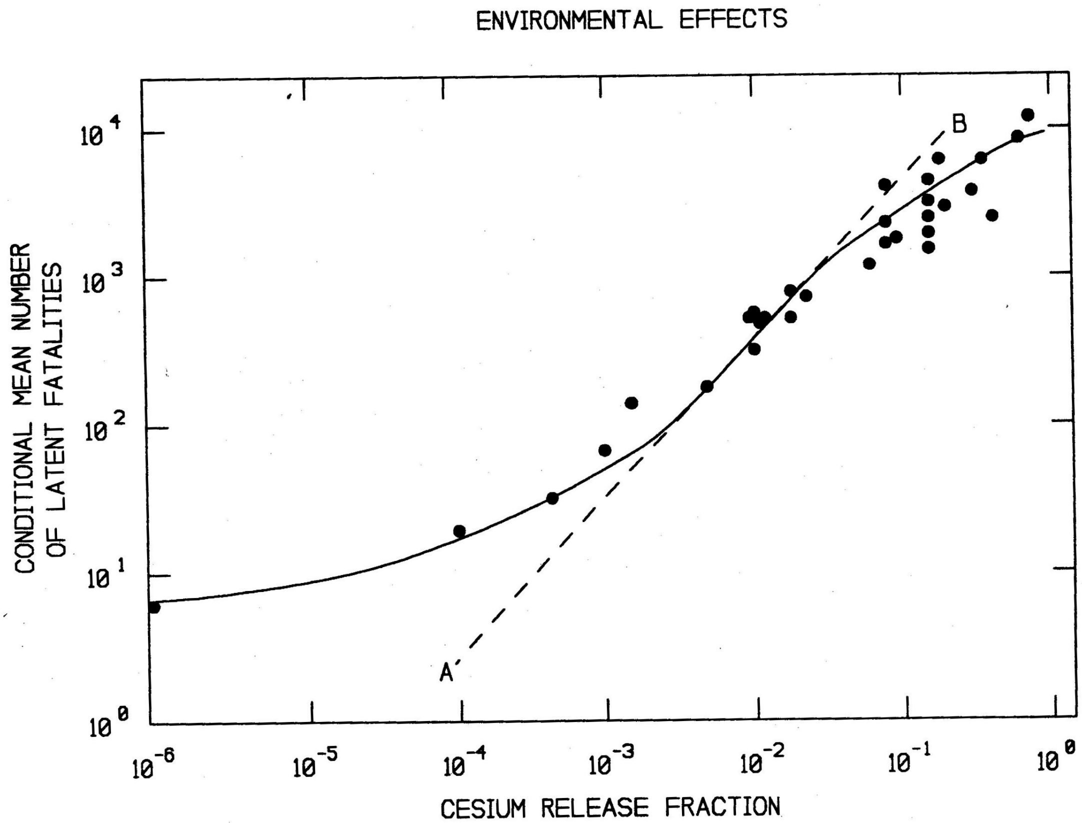
[2] Combined into non-large early release frequency (LERF) category for the current Level 2/LERF assessment

- Negligible (OK) – A radionuclide release that is less than or equal to the containment design base leakage.[2]

The quantification of the source terms associated with each of these release severity categories was accomplished through the review of existing consequence analyses performed in previous Industry Degraded Core Rule Making Program (IDCOR) studies, PRAs, and NRC studies containing detailed consequence modeling. To date, no single consequence analysis has evaluated all of the release paths identified in this study. Therefore, it was necessary to identify a common factor that could be used to allow the results of consequence analyses from different studies to be used in this study. The review of previous studies revealed an assumption that could be made relating release characteristics based on CsI release fraction to off-site consequences. That is, an approximate relationship exists between the fraction of iodine released and the whole-body population dose. The following figure shows the conditional mean number of latent cancer fatalities projected by the studies as a function of the cesium release fraction. Cesium (Cs) is chosen as a measure of the source term magnitude because it delivers a substantial fraction of the total whole body population dose. A significant feature of this figure is that a reduction in the source term magnitude by a given factor does not lead to a reduction in the number of latent cancer fatalities by the same factor.

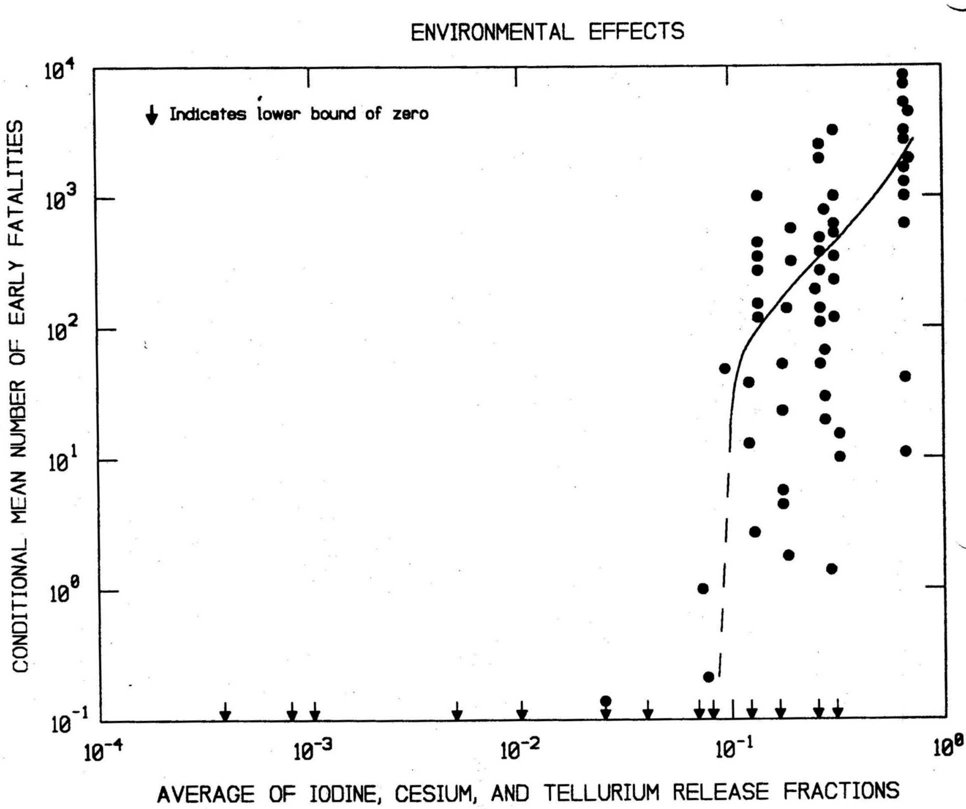
For low source terms, the population dose tends to be dominated by the noble gases because, for the source terms considered here, the noble gas release fraction remains equal to unity even when the cesium release fraction becomes very small. This explains why the curve shown tends to flatten out at the left-hand end.

Therefore, for Cs release fractions of 1.0E-03 to 1.0E-04, the number of latent fatalities is projected to be less than 1 percent of the latent fatalities for the highest release. In addition, the latent fatalities are dominated by the noble gas release. This grouping of releases is referred to in this analysis as the LL grouping (NS 1986).



The next figure summarizes the impacts of release magnitude on another health effects measure, i.e., the early fatalities. The line drawn through the results is a representation of where the base case results of a typical PSA might lie given "reasonable" assumptions about evacuation, the availability of medical treatment, and so forth.

The wide range of uncertainties shown in the figure is such that drawing conclusions about the effect of variations in the source term magnitude on public risk is not always obvious. However, the most significant feature of this figure is that, once the average CsI release fraction falls below approximately 0.1, the conditional mean number of early fatalities is very small or zero except for a few outliers that correspond to some pessimistic assumptions concerning meteorology and public evacuation.



Once the source term to the environment climbs above 0.1 CsI, however, the mean increases very rapidly because the source terms are large enough to project that doses above the postulated early fatality threshold can sometimes occur within a population center a few miles (kilometers) from the site. Therefore, CsI fractions above 0.1 are included as the high (H) release category.

Moderate and low release categories are simple interpolations between H and LL using the approximate 1 to 1 relationship in latent health effects over this range of CsI release (Kaiser 1986).

Based on these insights, a relationship was developed to correlate CsI release fractions with the five release severity categories. The results of this partitioning are as follows:

Release Severity	CsI Release Fraction (%)
High	Greater than 10
Moderate	1 to 10
Low	0.1 to 1.0
Low-Low	less than 0.1
Negligible	much less than 0.1

This relationship allows the use of results from many consequence analyses to assess the impact of source terms associated with the breadth of release end states analyzed in this study. Understanding the plant-specific influences on each sequence source term, as affected by the various release paths, allows the assignment of release severity to each of the sequences.

Because timing can be an important parameter in assessing accident management and emergency response actions, the timing of the radionuclide release is carried along with the end state definition. The release timing is a surrogate for the containment failure timing and is judged to be a more useful parameter. Therefore, the CET end states are characterized using a two-term matrix (i.e., time, severity) as shown in the following table:

Release Severity Source Term Release Fraction		Release Timing	
Classification Category	Percent CsI in Release	Classification Category	Time of Release (noble gases or CsI)
High (H)	greater than 10	Late (L)	Greater than 24 hours
Moderate (M)	1 to 10	Intermediate (I)	4 to 24 hours
Low (L)	0.1 to 1	Early (E)	less than 4 hours
Low-low (LL)	less than 0.1		
No iodine (OK)	0		

E.2.5.5 DETERMINISTIC CALCULATIONS TO SUPPORT CET END STATES DEFINITION

CPMAAP3.0B calculations were used to define the timing and release history for each of the release categories defined in the previous section. Information contained in the Palisades IPE was utilized to define the source term release characteristics for each release category. The following describes each of the release categories represented in the Palisades Level 2 PRA and provides the critical parameters used for the offsite consequence evaluation.

E.2.5.5.1 Release Category Early-High (E-H) – Case 433

This release category is represented by IPE Case 433. This scenario is typical of a break outside of containment (ISLOCA). Radionuclides are assumed to be released from the primary system directly to the environment. Onset of release is taken when the core is assumed to uncover at 1.3 hours, since the containment is already bypassed at that time. All of the safety injection is assumed to fail when the safety injection and refueling water tank (SIRWT) is depleted at 0.44 hrs. The critical parameters used for the off-site consequence evaluation are summarized below.

Noble Gas	I	Cs	Te	Sr	Mo	La	Ce	Ba	Release Time	Warning Time	Release Duration	Frequency (per reactor year)
1.0	9.2E-1	9.2E-1	1.E-3	1.E-2	2.2E-1	2.0E-3	1.0E-2	7.0E-2	1.3 hr	0.9 hr	2.0 hr	3.55E-7

E.2.5.5.2 Release Category Early-Moderate (E-M) – Case 485

This release category is represented by IPE Case 485. This scenario is typical of a transient accident with induced steam generator tube rupture. The critical parameters used for the off-site consequence evaluation are summarized below.

Noble Gas	I	Cs	Te	Sr	Mo	La	Ce	Ba	Release Time	Warning Time	Release Duration	Frequency (per reactor year)
9.0E-1	3.0E-2	3.0E-2	1.0E-5	9.0E-5	3.0E-3	1.0E-5	1.0E-5	1.0E-3	3.4 hr	2.1 hr	1.0 hr	3.59E-6

E.2.5.5.3 Release Category Intermediate-High (I-H) – Case 460

This release category is represented by IPE Case 460. This scenario is typical of a steam generator tube rupture with a stuck open relief valve on the faulted steam generator. The critical parameters used for the off-site consequence evaluation are summarized below.

Noble Gas	I	Cs	Te	Sr	Mo	La	Ce	Ba	Release Time	Warning Time	Release Duration	Frequency (per reactor year)
9.7E-1	3.0E-1	2.9E-1	1.0E-3	1.0E-3	4.0E-2	3.0E-5	6.0E-5	1.0E-2	27 hr	5.7 hr	2.0 hr	2.60E-6

E.2.5.5.4 Release Category Intermediate-Moderate (I-M) – Case 613

This release category is represented by IPE Case 613. This scenario represents accident progressions with vessel failure at low pressure, no upward debris dispersal and debris relocation to the Auxiliary Building. Prior to modification of the containment sump, this would have represented an early release. Given that the sump modification results in a delayed failure of containment, the timing is shifted to intermediate. The critical parameters used for the off-site consequence evaluation are summarized below. Note that due to the accident progression, the release is represented in two phases.

Noble Gas	I	Cs	Te	Sr	Mo	La	Ce	Ba	Release Time	Warning Time	Release Duration	Frequency (per reactor year)
8.5E-1	7.0E-2	6.0E-2	1.0E-2	5.0E-3	5.0E-2	2.0E-3	4.0E-2	4.0E-2	16.9 hr	5.5 hr	1.0 hr	1.66E-5
5.0E-2	8.0E-2	7.0E-2	6.5E-1	9.0E-2	1.0E-5	2.0E-2	9.0E-2	3.0E-2	32. hr	5.5 hr	3.0 hr	

E.2.5.5.5 Release Category Low-Low (L-L) – Case 419

This release category is represented by IPE Case 419. This scenario is represented by accident progression with vessel failure at high pressure, upward debris dispersal, late containment failure and no core-concrete interaction due to debris cooling. The critical parameters used for the off-site consequence evaluation are summarized below.

Noble Gas	I	Cs	Te	Sr	Mo	La	Ce	Ba	Release Time	Warning Time	Release Duration	Frequency (per reactor year)
1.0	1.0E-3	1.0E-3	1.0E-3	1.0E-5	1.0E-5	1.0E-5	1.0E-5	1.0E-5	41 hr	40 hr	2.0 hr	4.37E-8

E.2.5.5.6 Release Category Late-Low Low (L-LL) – Case 621

This release category is represented by IPE Case 621. This scenario is similar to case 419 described above except that a late revaporization release from the primary system does not occur. The critical parameters used for the off-site consequence evaluation are summarized below.

Noble Gas	I	Cs	Te	Sr	Mo	La	Ce	Ba	Release Time	Warning Time	Release Duration	Frequency (per reactor year)
1.0	2.0E-4	4.0E-4	7.0E-3	1.0E-5	2.0E-5	1.0E-5	1.0E-5	1.0E-5	65 hr	63 hr	6.0 hr	1.33E-5

E.2.6 PALISADES PSA REVIEW SUMMARY

The CEOG Peer review of the Palisades PSA resulted in 9 Level A and 50 Level B comments. All Level A comments have been addressed and when appropriate were included in the SAMA PSAR1c model. Forty two of the 50 level B comments have been addressed. The remaining 8 Level B comments either address documentation issues or have been closed out through other peer review comment dispositions and only the paperwork remains to be finalized. These 8 Level B comments do not affect the SAMA results.

E.3 LEVEL 3 PSA ANALYSIS

E.3.1 ANALYSIS

The MACCS2 code (NRC 1998d) was used to perform the Level 3 PRA for Palisades. The input parameters given with the MACCS2 "Sample Problem A," which included the NUREG-1150 food model (USDA 1998), formed the basis for the present analysis. These generic values were supplemented with parameters specific to Palisades and the surrounding area. Site-specific data included population distribution, economic parameters, and agricultural production. Plant-specific release data included the timed-nuclide distribution of releases and release frequencies. The behavior of the population during a release (evacuation parameters) was based on plant and site-specific set points (i.e., declaration of a General Emergency) and the emergency planning zone (EPZ) evacuation study (NMC 2005). These data were used in combination with site-specific meteorology to simulate the probability distribution of impact risks (exposure and economic) to the surrounding population (within 50 miles) from Palisade's accident release sequences.

E.3.2 POPULATION

The population surrounding the Palisades site was estimated for the year 2031. Population projections within 50 miles of Palisades were determined using SECPOP2000 (NRC 2003), a geographic information system (GIS), U.S Census block-group level population data allocated to each sector based on the area fraction of the census block-groups in each sector, and population growth rate estimates. U.S. Census data from 1990 and 2000 were used to determine a total annual average population growth estimate (1.1 percent per year). The annual population growth estimate was applied uniformly to all sectors to calculate the year 2031 population distribution. The distribution was given in terms of population at ten distances (one-mile interals out to 5 miles, 10 miles, and 10-mile intervals out to 50 miles) from the plant and in the direction of each of the 16 compass points (i.e., N, NNE, NE……NNW). The total year 2031 population for the 160 sectors (10 distances × 16 directions) was estimated as 1,739,624; the distribution of which is given in Tables E.3-1 and E.3-2.

A population sensitivity case was also performed in which the sector populations were uniformly increased by 30 percent. This was selected based on engineering judgement to investigate a possible upper bound limit. The results are discussed in Section E.3.8

E.3.3 ECONOMY

MACCS2 requires the spatial distribution of certain economic data (fraction of land devoted to farming, annual farm sales, fraction of farm sales resulting from dairy production, and property value of farm and non-farm land) in the same manner as the population. This was done by using the SECPOP2000 code (NRC 2003) for each of the counties surrounding the plant to a distance of 50 miles. SECPOP2000 utilizes economic data from the U.S. Department of Agriculture, “1997 Census of Agriculture” (USDA 1998) and from other 1998 and 1999 data sources. Economic values for 97 economic zones were calculated and allocated to each of the 160 sectors.

In addition, generic economic data that are applied to the region as a whole were revised from the MACCS2 sample problem input when better information was available. These revised parameters include per diem living expenses (applied to owners of interdicted properties and relocated populations), relocation costs (for owners of interdicted properties), and value of farm and non-farm wealth.

E.3.4 AGRICULTURE

Agricultural production information was taken from the 1997 Agricultural Census (USDA 1998). Production within 50 miles of the site was estimated based on those counties within this radius. Agriculture cropland includes food crops and pastures. The largest harvested food crops are comprised of fruits, grains, legumes, and stored forage.

The lengths of the growing seasons for the primary crops of grains, legumes, and stored forage were obtained from the Usual Planting and Harvesting Dates for U.S. Field Crops (USDA 1997). The duration of the growing season for the remaining crop categories (pasture, green leafy vegetables, roots/tubers and other food crops) were based on reasonable estimates.

E.3.5 NUCLIDE RELEASE

The core inventory at the time of a postulated accident is based on recent plant-specific ORIGEN2.1 calculation. The core inventory corresponds to the best estimate end-of-cycle values for the current Palisades core.

Palisades nuclide release categories were related to MACCS2 categories as shown in Table E.3-3. All releases were modeled as occurring at 18.6 meters. The thermal content of each of the releases (i.e., buoyant plume rise) varied from 9.3E+05 to 1.1E+07 watts based on Palisades CPMAAP IPE results (CP 1993).

E.3.6 EVACUATION

Reactor scram begins each evaluated accident sequence. A General Emergency is declared when plant conditions degrade to the point where it is judged that there is a credible risk to the public. Therefore, the timing of the General Emergency declaration is sequence specific and ranges from 54 minutes to 63 hours for the release sequences evaluated (see Table E.3-5).

Consistent with the MACCS2 User's Guide, input parameters include 95 percent of the population within 10 miles of the plant's EPZ evacuating and 5 percent not evacuating were employed. These values have been used in similar studies [e.g., Hatch (SNOC 2000), Calvert Cliffs (BGE 1998)] and are conservative relative to the NUREG-1150 study, which assumed 99.5 percent of the population evacuates within the EPZ (NRC 1989). The evacuees are assumed to begin evacuating in 15 to 30 minutes after a General Emergency has been declared and are evacuated at an average radial speed of 1.8 miles per hour (0.81 meters per second) (NMC 2005). This speed is a time weighted value accounting for season, day of the week, time of day, weather conditions, and special festival events. The evacuation time weighted average of 361 minutes is for the full 0-10 mile EPZ and includes an assumed 15 minute notification time and 15 minutes for evacuation preparation (NMC 2005).

Two evacuation sensitivity cases were also performed to determine the impact of evacuation assumptions. One sensitivity reduced the evacuation speed by a factor of two (0.41 meters per second). The second sensitivity assumed a 90 minute delay (in lieu of 30 minute delay) prior to the start of physical evacuation movement. The results are discussed in Section E.3.8.

E.3.7 METEOROLOGY

Annual Palisades meteorology data from the site tower for year 2000 was used in MACCS2 for the base case results. Year 2000 data was nearly 100 percent complete, missing only 4 scattered hours of data for the year. The Palisades site does not collect hourly precipitation data; therefore, data from the nearby Benton Harbor Ross Field National Weather Station was utilized. Atmospheric mixing heights were specified for AM and PM hours based on previous Palisades meteorological studies from 1982-1991. These values were consistent with those of EPA report "Mixing Heights, Wind Speeds, and Potential for Urban Air Pollution throughout the Contiguous United Stats" (EPA 1972).

Site meteorological data for years 2001, 2002, and 2003 were also evaluated as sensitivity cases to ensure that year 2000 data was a representative data set. The results are discussed in Section E.3.8.

Meteorological data was prepared for MACCS2 input as follows:

- Wind speed and direction from the 10-meter sensor of the site tower were used. If the lower wind direction was unavailable, the 60-meter sensor direction was used to estimate the lower wind direction. If the lower wind speed was unavailable, other means of estimate were used (i.e., the 60-meter values were not used).

- If a brief period (i.e., few hours) of missing data existed, interpolation was used between hours.
- Atmospheric stability was calculated according to the vertical temperature gradient of the tower temperature data.

E.3.8 MACCS2 RESULTS

Table E.3-4 shows the mean off-site doses and economic impacts to the 50-mile region for each of six release categories calculated using MACCS2. These impacts are multiplied by the annual frequency for each release category and then summed to obtain the risk-weighted mean doses and economic costs. Table E.3-5 provides a summary of the Palisades Level 2 PRA results.

Table E.3-6 provides summary results of the MACCS sensitivity cases evaluated. As expected, population and evacuation assumptions have a moderate impact on population dose results. Evacuation assumptions do not impact MACCS cost estimates since MACCS calculated costs are based on land contamination levels and the number of people evacuating (not the dose received by those individuals). Based on the meteorological sensitivity cases, year 2000 meteorological data was found to result in the highest population dose and cost and was, therefore, chosen for the base case.

E.4 BASELINE RISK MONETIZATION

This section explains how NMC calculated the monetized value of the status quo (i.e., accident consequences without SAMA implementation). NMC also used this analysis to establish the maximum benefit that could be achieved if all risk for reactor operation were eliminated.

E.4.1 OFF-SITE EXPOSURE COST

The baseline annual off-site exposure risk was converted to dollars using NRC's conversion factor of $2,000 per person-rem, and discounted to present value using NRC standard formula (NRC 1997b):

$$W_{pha} = C \times Z_{pha}$$

Where:

W_{pha}	=	monetary value of public health risk after discounting
C	=	$[1-\exp(-rt_f)]/r$
t_f	=	years remaining until end of facility life (20 years)
r	=	real discount rate (RDR) (as fraction; 0.07 per year)
Z_{pha}	=	monetary value of public health (accident) risk per year before discounting ($ per year)

The Level 3 analysis showed an annual off-site population dose risk of approximately 31.9 person-rem. The calculated value for C using 20 years and a 7 percent discount rate is approximately 10.7. Therefore, calculating the discounted monetary equivalent of accident dose-risk involves multiplying the dose (person-rem per year) by $2,000 and by the C value (10.7). The calculated off-site exposure cost is estimated to be $687,566.

E.4.2 OFF-SITE ECONOMIC COST RISK

The Level 3 analysis showed an annual off-site economic risk of about $124,974. Calculated values for off-site economic costs caused by severe accidents must be discounted to present value as well. This is performed in the same manner as for public health risks and uses the same C value. The resulting value is approximately $1,345,082.

E.4.3 ON-SITE EXPOSURE COST RISK

Occupational health was evaluated using NRC methodology that involves separately evaluating immediate and long-term doses (NRC 1997b).

For immediate dose, NRC recommends using the following equation:

Equation 1:

$$W_{IO} = R\{(FD_{IO})_S - (FD_{IO})_A\}\{[1 - \exp(-rt_f)]/r\}$$

Where:

W_{IO} = monetary value of accident risk avoided due to immediate doses, after discounting

R = monetary equivalent of unit dose ($2,000 per person-rem)

F = accident frequency (4.05E-05 events per year)

D_{IO} = immediate occupational dose [3,300 person-rem per accident (NRC estimate)]

$_S$ = subscript denoting status quo (current conditions)

$_A$ = subscript denoting after implementation of proposed action

r = RDR (0.07 per year)

t_f = years remaining until end of facility life (20 years).

Assuming F_A is zero, the best estimate of the immediate dose cost is:

$$W_{IO} = R\,(FD_{IO})_S\{[1 - \exp(-rt_f)]/r\}$$

$$= 2{,}000*4.05E\text{-}05*3{,}300*\{[1 - \exp(-0.07*20)]/0.07\}$$

$$= \$2{,}877$$

For long-term dose, NRC recommends using the following equation:

Equation 2:

$$W_{LTO} = R\{(FD_{LTO})_S - (FD_{LTO})_A\}\{[1 - \exp(-rt_f)]/r\}\{[1 - \exp(-rm)]/rm\}$$

Where:

W_{LTO} = monetary value of accident risk avoided long-term doses, after discounting, $

D_{LTO} = long-term dose [20,000 person-rem per accident (NRC estimate)]

m = years over which long-term doses accrue (as long as 10 years)

Using values defined for immediate dose and assuming F_A is zero, the best estimate of the long-term dose is:

W_{LTO} = R $(FD_{LTO})_S$ {[1 - exp(-rt_f)]/r} {[1 - exp(-rm)]/rm}

= 2,000∗4.05E-05 ∗20,000∗{ [1 - exp(-0.07∗20)]/0.07} {[1 -exp(-0.07∗10)]/0.07∗10}

= $12,539

The total occupational exposure is then calculated by combining Equations 1 and 2 above. The total accident related on-site (occupational) exposure risk (W_O) is:

$$W_O = W_{IO} + W_{LTO} = (\$2,877 + \$12,539) = \$15,416$$

E.4.4 ON-SITE CLEANUP AND DECONTAMINATION COST

The net present value that NRC provides for cleanup and decontamination for a single event is $1.1 billion, discounted over a 10-year cleanup period (NRC 1997b). NRC uses the following equation to integrate the net present value over the average number of remaining service years:

$$U_{CD} = [PV_{CD}/r][1-\exp(-rt_f)]$$

Where:

PV_{CD} = net present value of a single event (1.1E+09)

r = RDR (0.07)

t_f = 20 years (license renewal period)

The resulting net present value of cleanup integrated over the license renewal term, $1.18E+10, must be multiplied by the total CDF (4.05E-05) to determine the expected value of cleanup and decontamination costs. The resulting monetary equivalent is $479,487.

E.4.5 REPLACEMENT POWER COST

Long-term replacement power costs were determined following NRC methodology in NUREG/BR-0184 (NRC 1997b). The net present value of replacement power for a single event, PV_{RP}, was determined using the following equation:

$$PV_{RP} = [\$1.2\times10^8/r] * [1 - \exp(-rt_f)]^2$$

Where:

PV_{RP} = net present value of replacement power for a single event, ($)

r = RDR (0.07)

t_f = 20 years (license renewal period)

To attain a summation of the single-event costs over the entire license renewal period, the following equation is used:

$$U_{RP} = [PV_{RP} /r] * [1 - \exp(-rt_f)]^2$$

Where:

U_{RP} = net present value of replacement power over life of facility ($-year)

After applying a correction factor to account for Palisades size relative to the generic reactor described in NUREG/BR-0184 (i.e., 816 megawatt electric/910 megawatt electric), the replacement power costs are determined to be 7.08E+09 ($-year). Multiplying this value by the CDF (4.05E-05) results in a replacement power cost of $286,549.

E.4.6 TOTAL COST RISK

The sum of the baseline costs is as follows:

Off-site exposure cost	=	$687,566
Off-site economic cost	=	$1,345,083
On-site exposure cost	=	$15,416
On-site cleanup cost	=	$479,487
Replacement Power cost	=	$286,549
Total cost	=	$2,814,100

The total cost risk represents the maximum averted cost risk if all risk were eliminated. The MACR based on on-line internal events contributions, which is rounded to next highest thousand ($2,815,000) for SAMA calculations.

As described in Section E.5.1.7, the internal events MACR is doubled to account for external events contributions. The resulting modified MACR is $5,630,000 and was used in the Phase I screening process.

E.5 PHASE I SAMA ANALYSIS

The Phase I SAMA analysis, as discussed in Section E.1, includes the development of the initial SAMA list and a coarse screening process. This screening process eliminated those candidates that are not applicable to the plant's design or are too expensive to be cost beneficial even if the risk of on-line operations were completely eliminated. The following subsections provide additional details of the Phase I process.

E.5.1 SAMA IDENTIFICATION

The initial list of SAMA candidates for Palisades was developed from a combination of resources including:

- Palisades PSA results
- Industry Phase II SAMAs
- Palisades IPE (CP 1993)
- Palisades IPEEE (CP 1995)

These resources are judged to provide a list of potential plant changes that are most likely to reduce risk in a cost-effective manner for Palisades.

In order to provide consistency with previous industry SAMA analyses and to provide a recognized source for potential SAMAs, a generic SAMA list developed from several industry SAMA analyses was used to help identify potential enhancements for selected functions at Palisades. This list is provided for reference purposes in Addendum 1.

E.5.1.1 LEVEL 1 PALISADES IMPORTANCE LIST REVIEW

The Palisades PSA was used to generate a list of events sorted according to their risk reduction worth (RRW) values. The top events in this list are those events that would provide the greatest reduction in the Palisades CDF if the failure probability were set to zero. The events were reviewed down to the 1.01 level, which corresponds to a 1.0 percent change in the CDF given 100 percent reliability of the event. If the dose-risk and off-site economic cost-risk were also assumed to be reduced by 1.0 percent, the corresponding averted cost-risk would be approximately $27,862. Applying a factor of 2 to estimate the potential impact of external events (refer to Section E.5.1.7), the result is about $55,725. This is considered to be the threshold for implementation costs of potential plant changes, especially given that this estimate is based on complete reliability of the proposed change. No further review of the importance listing was performed below the 1.01 level. Table E.5-1 documents the disposition of each event in the Level 1 Palisades RRW list.

E.5.1.2 LEVEL 2 PALISADES IMPORTANCE LIST REVIEW

A similar review was performed on the importance listings from the Level 2 results. In this case, a composite file based on the top 97 percent of all dose-risk was used to identify potential SAMAs. The composite file was composed of the following release category results: Early High, Early Moderate, Intermediate High, and Intermediate Moderate. This method was chosen to prevent high frequency-low consequence events from dominating the importance listing.

The Level 2 RRW values were reviewed down to the 1.01 level. As described for the Level 1 RRW list, events below the 1.01 threshold value are estimated to yield an averted cost-risk less than $55,725 and are not considered to be likely candidates for identifying cost effective SAMAs. As such, the events with RRW values below 1.01 were not reviewed. Table E.5-2 documents the disposition of each event in the Level 2 Palisades RRW list.

E.5.1.3 INDUSTRY SAMA ANALYSIS REVIEW

The SAMA identification process for Palisades is primarily based on the PSA importance listings, the IPE, and the IPEEE. In addition to these plant-specific sources, selected industry SAMA analyses were reviewed to identify any Phase II SAMAs that were determined to be potentially cost beneficial at other plants. These SAMAs were further analyzed and included in the Palisades SAMA list if they were considered to be potentially cost beneficial for Palisades.

While many of these SAMAs are ultimately shown not to be cost beneficial, some are close contenders and a small number have been estimated to be cost beneficial at other plants. Use of the Palisades importance ranking should identify the types of changes that would most likely be cost beneficial for Palisades, but review of selected industry Phase II SAMAs may capture potentially important changes not identified for Palisades due to PSA modeling differences. Given this potential, it was considered prudent to include a review of selected industry Phase II SAMAs in the Palisades SAMA identification process.

Phase II SAMAs from the following U.S. nuclear power sites have been reviewed:

- Calvert Cliffs (BGE 1998)
- H.B. Robinson (CPL 2002)
- Edwin I. Hatch (SNOC 2000)
- Peach Bottom (Exelon 2001)

- Dresden (Exelon 2003a)
- Quad Cities (Exelon 2003b)

Two PWR and four boiling water reactor (BWR) sites were chosen from available documentation to serve as the Phase II SAMA sources. Not all of the Phase II SAMAs from these sources were included in the initial Palisades SAMA list. Many of the industry Phase II SAMAs were already represented by other SAMAs in the Palisades list or it was judged that they would not be close contenders for Palisades. These SAMAs were not considered further. Based on engineering judgment, the SAMAs considered to be potentially cost beneficial for Palisades were retained and included in the initial Palisades SAMA list. As a result, only one potential SAMA was identified:

- Proceduralize PCS Cooldown on Loss of CCW (SAMA Number 23)

The installation of improved PCP seals was also initially identified as a potential improvement; however, Palisades recently completed the replacement of its PCP seals with improved N-9000 seals. This change is considered to address the requirements of the SAMA.

Another SAMA that was considered for inclusion was the use of a low-pressure, diesel driven pump that would provide long-term RPV injection while taking suction from the suppression pool. While this was originally designed for a BWR, the concept was reviewed for applicability for a PWR. It was determined that the primary benefit of the original SAMA would be to maintain core cooling/inventory control after battery depletion in an SBO. The Palisades SAMA list includes several SAMAs that already address this issue, including: a) a Direct Drive Diesel Injection Pump to supplement the AFW system, b) Use of a portable generator to provide turbine-driven AFW valve and instrumentation power after battery depletion in an SBO, and c) Procedure updates to govern local, manual operation of the turbine-driven AFW pump after battery depletion. As these SAMAs address the same issues, it was not considered necessary to include the low-pressure diesel injection pump on the Palisades list.

E.5.1.4 PALISADES IPE

The Palisades IPE generated a list of risk-based insights and potential plant improvements. Typically, changes identified in the IPE process are implemented and closed out; however, there are some items that are not completed within the industry due to high projected costs or other criteria. Because the criteria for implementation of a SAMA may be different than what was used in the post-IPE decision-making process, these recommended improvements are re-examined in this analysis. For Palisades, only one item that was proposed in the IPE as a potential change was not completed.

This change was the installation of a means of providing emergency makeup to the SIRWT. This enhancement has been added to the SAMA list (SAMA Number 5).

E.5.1.5 PALISADES IPEEE

Similar to the IPE, there may be a number of proposed plant changes in the IPEEE that were not implemented based on other criteria that should be re-examined using SAMA methodology. In addition, there may be issues that are in the process of being resolved, which may be important to the disposition of some SAMAs. The IPEEE was used to identify these items.

An effort was also made to use the IPEEE to develop new SAMAs based on a review of the original results. However, the Palisades IPEEE was not maintained as a “living” analysis. This limits the capability of the models that make up the IPEEE as they do not include the latest PSA practices nor do they necessarily represent the current plant configuration or operating characteristics. The fact that the models are not currently in a quantifiable state presents further difficulty because the results are limited to what has been retained from the original analysis. These factors limit the qualitative insights and quantitative estimates that can be made with regard to external events contributors.

On a larger scale, given that the industry has generally not pursued external events modeling at a level consistent with internal events models, the technology for external events analysis is not as robust or refined. The result is that the CDF values yielded by the internal and external events models are not necessarily comparable. External events models are considered to be useful tools for identifying important accident sequences and mitigative equipment, but the quantitative results should not be directly combined with those from the internal events models. In this analysis, external events contributions are estimated for the reasons described above.

E.5.1.6 USE OF EXTERNAL EVENTS IN THE PALISADES SAMA ANALYSIS

The IPEEE was used in the Palisades SAMA analysis primarily to identify the highest risk accident sequences and the potential means of reducing the risk posed by those sequences. Some of the events addressed in the IPEEE were not considered further based on inapplicability to the plant, low frequency of occurrence, or because the events or consequences of the events are already addressed by the PRA. These events include:

- Severe temperature transients (extreme heat, extreme cold)
- Severe storm (ice, hail, snow, dust, and sand storms)
- Lightning

- External Fires
- Extraterrestrial Activity (meteor strikes, satellite falls)
- Volcanic activity
- Earth movement (avalanche, landslide)

After the elimination of the preceding events, the events requiring further investigation at Palisades were limited to:

- Internal Fires (Section E.5.1.6.1)
- Seismic Events (Section E.5.1.6.2)
- High Wind Events (Section E.5.1.6.3)
- External Flooding and Probable Maximu Precipitation (Section E.5.1.6.4)
- Transportation and Nearby Facility Accidents (Section E.5.1.6.5)

The type of information available for these initiators varied due to the manner in which they were addressed in the IPEEE. For instance, the fire analysis used an approach that combined the deterministic evaluation techniques from the EPRI Fire Induced Vulnerability Evaluation (FIVE) methodology with classical PRA techniques. The Palisades seismic analysis utilized the existing plant PRA with event trees specifically developed to evaluate seismic scenarios. Due to limitations of the Fire and Seismic modeling processes, however, the results of these kinds of analyses are not necessarily compatible with those of the internal events analysis. As a result, each of the external event contributors must be considered in a manner suiting the type of analysis performed. A summary of the review process used to identify SAMAs is provided for each of the external event types listed above followed by a description of the method used to quantitatively incorporate external events contributions into the SAMA analysis.

E.5.1.6.1 Internal Fires

As discussed above, the techniques used to model external events vary according to the type of initiator being analyzed. The Palisades Fire Model shares many of the same characteristics as the internal events model, but limitations on the state of technology produce results that are more conservative than the internal events model. The following summarizes the fire PRA topics where quantification of the CDF may introduce different levels of modeling uncertainty than the internal events PRA.

In general, fire PRAs are useful tools to identify design or procedural items that could be clear areas of focus for improving the safety of the plant. Fire PRAs use a structure and quantification technique similar to that used in the internal events PRA. Since less attention historically has been paid to fire PRAs, conservative modeling is common in a number of areas of the fire analysis to provide a "bounding" methodology for fires. This concept is contrary to the base internal events PRA, which has had more analytical development and is judged to be closer to a realistic assessment (i.e., best estimate) of the plant. There are a number of fire PRA topics involving technical inputs, data, and modeling that prevent the effective comparison of the CDF between the internal events PRA and the fire PRA. These areas are identified as follows:

PSA Topic	Comment
Initiating Events:	The frequency of fires and their severity are generally conservatively overestimated. A revised NRC fire events database indicates the trend toward lower frequency and less severe fires. This trend reflects the improved housekeeping, reduction in transient fire hazards, and other improved fire protection steps at plants.
System Response:	FPS measures such as sprinklers, CO_2, and fire brigades may be given minimal (conservative) credit in their ability to limit the spread of a fire.
Sequences:	Sequences may subsume a number of fire scenarios to reduce the analytic burden. The subsuming of initiators and sequences is done to envelope those sequences included. This results in additional conservatism.
Fire Modeling:	Fire damage and fire spread are conservatively characterized. Fire modeling presents bounding approaches regarding the immediate effects of a fire (e.g., for a cable tray fire, all cables in a tray always fail) and fire propagation.
HRA:	There is little industry experience with crew actions under conditions of the types of fires modeled in fire PRAs. This has led to conservative characterization of crew actions in fire PRAs. Because the CDF is strongly correlated with crew actions, this conservatism has a profound effect on the calculated fire PRA results.
Level of Detail:	The fire PRAs may have reduced level of detail in the mitigation of the initiating event and consequential system damage.
Quality of Model:	The peer review process for fire PRAs is not as developed as internal events PRAs. For example, no industry standard, such as NEI 00-02, exists for the structured peer review of a fire PRA. This may lead to less assurance of the realism of the model.

The results of the Palisades Fire IPEEE accident sequence quantification were derived from a methodology that includes a number of conservative assumptions. Examples include:

- Fires were assumed to increase until they completely engulfed the area where they were located and fail all equipment in the area if not suppressed,

- With the exception of the main control room (MCR), cable spreading room and the Class 1E switchgear rooms, the effects of suppression were not credited,
- Even when suppression was credited, the AFW system was assumed to fail due to the fire,
- No credit was given for continued operation of the plant (all fires evaluated were assumed to result in a plant trip),
- No credit was given for low-pressure feed (condensate pumps) for any fire area.

In addition to modeling limitations, the fire PRA may be subject to more modeling uncertainty than the internal events PRA evaluations. While the fire PRA is generally self-consistent within its calculational framework, the fire PRA does not compare well with internal events PRAs because of the number of conservative assumptions that have been included in the fire PRA process. Therefore, the use of the fire PRA results as a reflection of CDF may be inappropriate. Any use of fire PRA results and insights should consider areas where the “state of the art” in fire PRAs is less evolved than other PRA topics.

While the ability to directly compare the results of the internal events and fire models is limited, information is available that may be used to identify the most important contributors for Palisades. The Revision 1 of the IPEEE Fire document provides a summary of the most important contributors to each of the accident classes, which has been used to identify potential SAMAs and is summarized below.

Accident Class	Description
Class IA	59.4 percent of Fire CDF
Class IB	39.6 percent of Fire CDF
Class II	1.0 percent of fire CDF
Class IIIA	No fire initiator was identified that could credibly lead to a loss of coolant accident.
Class IIIB	No fire initiator was identified that could credibly lead to a loss of coolant accident.
Class IIIC	No fire initiator was identified that could credibly lead to a loss of coolant accident.
Class IIID	No fire initiator was identified that could credibly lead to a loss of coolant accident.
Class IV	No fire initiator was identified that could credibly lead to a failure of the reactor protection system. The simultaneous failure of the reactor protection system and control rod insertion is probabilistically insignificant.
Class VB	No fire initiator was identified that could credibly lead to a steam generator tube rupture event.

The event rankings within these classes are used to identify the largest contributors to fire risk at Palisades. SAMAs are suggested to prevent or mitigate the loss of the functions represented by the events.

Accident Class IA

The important operator actions for this accident class include:

- Failure to initiate OTC
- Failure to control the AFW steam supply or injection valves [from the alternate shutdown panel (ASDP) or locally]

Failure to initiate OTC occurs following a successfully suppressed exposure fire (which fails the AFW system except for local controls) in the main Control Room (CR), cable spreading room, and both switchgear rooms. The contributions of the sequences including this failure could be reduced if an additional means of secondary side heat removal was available to preclude the need to initiate OTC. The installation of a direct drive diesel injection pump (DDDIP) is a potential means of achieving this goal (SAMA 3).

Failure to control the AFW steam supply or injection valves could be mitigated by enhancing primary side cooling. The addition of another HPI pump or the conversion of AFW pump P-8C back to a HPSI pump has been suggested (SAMA 4).

Important hardware failures and/or sequences for the Class IA include:

- Failure of P-8B (steam-driven AFW pump)
- SBO sequences (less than 1 percent of this accident class)

Failure of AFW pump P-8B could be mitigated by providing an alternate means of secondary side heat removal. Installation of a DDDIP to back up AFW is considered to meet this need (SAMA 3).

SBO sequences have also been identified as important contributors in the Level 1 model. For the Fire analysis, a potential SAMA is to proceduralize the use of the steam driven AFW pump to operate without support systems (SAMA 10). The DDDIP is another alternate means of providing long-term steam generator makeup in an SBO assuming that a portable generator is included in the SAMA to provide power for instruments and valve control (SAMA 3).

Accident Class IB

The important operator actions for this accident class include:

- Failure to initiate HPSI pump subcooling upon successful transfer of HPSI suction from the SIRWT to the containment sump.

- Failure to repair random failures in the AFW system prior to recirculation.

In the Palisades IPEEE fire analysis, the operator was required to manually open the sub-cooling valves to the suction of the HPSI pumps after the RAS to ensure adequate HPSI net positive suction head (NPSH). RAS is initiated when the inventory in the SIRWT reaches 2 percent. At this time, the HPSI and CS suction from the SIRWT is automatically switched over to the containment sump. To ensure adequate HPSI pump suction pressure, the operator was instructed by procedure to open sub-cooling valves CV-3070 and CV-3071 from the CS pumps at the outlet of the shutdown heat exchangers. The HPSI pumps "piggyback" on CS pumps, thus ensuring adequate NPSH at the pump suction.

In 2002, a design deficiency was identified for a large break LOCA with loss of the 1-1 emergency diesel generator (EDG). Given RAS signal with only one CS pump available, both spray header valves opened, a CHP present and supplying subcooling to a HPSI pump, the operating spray pump could be in runout condition. One of the spray header valves must be closed to prevent the runout condition on the operating CS pump. As a result, an automatic close signal is generated to close one spray valve if only one CS pump is operating. Subsequently, the alignment of the subcooling valves was automated by providing an opening signal upon receipt of a RAS signal. Automating the alignment of the subcooling valves CV-3070 and CV-3071 increases the reliability of the function and provides greater assurance that adequate NPSH is maintained for the HPSI P-66A/B pumps post RAS. Therefore, the 2002 hardware modification already addresses the importance of the action to align subcooling, and no additional SAMAs are suggested.

The impact of random failures of the AFW system could be reduced through the addition of a DDDIP for steam generator makeup (SAMA 3).

Important hardware failures for the Class IB sequences include:

- Random failures of the AFW system
- SBO sequences

Random AFW System failures and SBO contributors could both be mitigated with the DDDIP (SAMA 3). An alternate means of steam generator makeup would reduce failure probability for secondary side heat removal and provide an additional source of steam generator makeup that could be functional in an SBO (assuming that a portable generator is included in the SAMA to provide long-term DC power).

Accident Class II

Class II fire sequences comprise only 1 percent of the Fire CDF. This is a small component of the external events contributions and the information can be used to demonstrate that the potential benefits associated with reducing the risk associated with Class II fire sequences is also small.

While use of the absolute frequency used in the external events models is not considered to be appropriate for direct use in the SAMA analysis, a relative comparison is useful. Given the assumption that the external events contributions are approximately equal to the internal events contributions and assuming that the external events CDFs can be compared with one another, the cost-risks associated with each external event type can be estimated. Assuming that the only contributors to the external events CDF are Fire and Seismic, the percent contribution of Fire initiators can be calculated:

Accident Initiator Type	CDF (per year)	Percent Contribution
Fire	3.31E-05	77
Seismic	8.88E-06	21
Other	1.00E-06	2
Total	4.20E-05	100

As documented in Section E.4, the external events contribution to the modified MACR is $2,815,000, which corresponds to a Fire cost-risk of $2,167,550 ($2,815,000 x 0.77 = $2,167,550). As the Class II Fire sequences are only one percent of the Fire contributions, the cost-risk associated with those sequences is only $21,676 ($2,167,550 x 0.01 = $21,676). No SAMAs are expected to be found that could be implemented for this amount of money. As a result, no additional effort has been made to identify SAMAs to reduce the risk of Class II Fires.

Fire SAMA Identification Summary

Based on the review of the Palisades fire area and accident class results, several SAMAs were identified as potential means of reducing fire risk:

- Direct Drive Diesel Injection Pump (SAMA 3)
- Enhanced HPI capability (SAMA 4)
- Power Independent Turbine Driven AFW Operation (SAMA 10)

While each of these SAMAs is considered to provide a means of reducing the risk associated with fire related events, none of these SAMAs are unique to the fire analysis.

Review of the Level 1 PSA importance rankings has also identified these potential plant enhancements.

E.5.1.6.2 Seismic Events

NRC has set an industry goal to develop aggregate risk models that consider both internal and external events together; however, the current state of technology is not considered to be adequate to support this goal for the SAMA analysis. While Palisades performed a relatively robust seismic analysis as part of the IPEEE, the seismic model is considered to introduce a level of conservative bias that is greater than what is present in the current internal events PRA. As a result, considering the internal events and seismic CDFs together may result in masking the most relevant potential plant enhancements in the SAMA analysis (CP 1995).

No definitive study has been performed to define the differences in the quantitative capabilities of the internal events and seismic models. Given that, several key seismic modeling areas have been identified as potential contributors to a conservative bias in the seismic model:

- Hazard curve
- Fragility curves
- Correlation of seismic failures
- Treatment of Off-Site Power and balance of plant equipment
- Modeling simplifications
- Non-living model

While none of these items preclude the use of the seismic model as a tool for identifying potential seismic vulnerabilities, which was the intent of the IPEEE, it is not clear that the fidelity of the elements lend themselves to more precise applications. For instance, no reliable and/or efficient means have been identified to develop realistic Hazard and Fragility curves. The results are believed to overestimate the frequencies and consequences of seismic events. The consequences of seismic events are also further conservatively estimated through the correlation of seismic failures. This method imposes an assumption of failure when failure is not assured and bypasses the effectiveness of the redundancy in plant design. Off-site power (OSP) and balance of plant equipment is often considered to be failed without detailed analyses of equipment response due to resource limitations. In addition, the variability in consequences of other types of failures is so large that conservative simplifications are made to bind the results. For example, Palisades assumes that structural failure of the Auxiliary Building leads directly to core damage. There are a number of ways in which the structure could fail and not lead to core damage, but these cases are not analyzed. Finally, the IPEEE was developed with the methods and data that were available at the time of the analysis, which has since been refined and improved in many cases. Use of a model that employs an outdated PRA does not take advantage of the insights that have been developed in the last decade.

For these reasons, additive treatment of the internal events CDF and the seismic CDF is not recommended for the SAMA analysis. Section E.5.1.7 provides a discussion related to the quantitative treatment of the seismic contributors in the cost-benefit analysis.

Not withstanding the limits of the seismic analysis, it was possible to use the results to identify the largest contributors to seismic risk. While the Seismic analysis did not identify any significant seismic concerns, several insights were gained about the most important equipment failures during and after seismic events. These insights are summarized below along with the SAMA candidates that are proposed to reduce the risk of the most important equipment failures.

Accident Class IA

The principal contributors to Accident Class IA are associated with the failure to provide makeup to the CST. Normal makeup sources to the CST at Palisades rely on off-site power for operation, which is typically one of the systems most likely to be damaged by a seismic event. Therefore, the CST makeup systems supported by emergency power or those that are power independent are important to accident mitigation. These systems include the FPS and service water system (SWS) at Palisades.

While no significant seismic vulnerabilities of the SWS have been identified, there are several potential seismically induced failures that would lead to loss of the FPS. These include: loss of the diesel fuel oil day tanks, failure of the FPS control cabinet (EC-137), and failure of transformer EX-13. With loss of the FPS, the ability to directly supply AFW pumps 8A and 8B with an alternate suction source is lost along with the ability to make up to the CST. The SWS is available to supply AFW pump 8C, but a random failure of that pump results in loss of all AFW after CST depletion.

While it is possible to cross-tie the SWS to the FPS, no credit was taken for this alignment in the IPEEE. Procedural guidance for this action is available in Section 7.5 of SOP-21, and it is considered to be a valid basis for crediting the cross-tie action. Given that approximately 6 hours of CST injection are available before the action is required to be complete, crediting this action would greatly reduce the contributions of the relevant seismic sequences. No plant changes are considered to be required to address alternate AFW suction sources.

Accident Class IB

Similar to Accident Class IA, the dominant failures leading to damage in this accident class are a result of loss of equipment used for CST makeup. The same insights from Class IA are applicable and no additional SAMAs are suggested.

Accident Class II

Given stabilization of inventory control, long-term containment heat removal must then be established for success. Systems supporting containment heat removal include CS, Containment Air Coolers, Component Cooling Water, and SW. It has been determined that all of these systems have relatively high seismic fragilities; therefore, no specific seismic vulnerability has been identified. No seismic related SAMAs are suggested based on the Class II results.

Accident Class III

Failure of PCS makeup during the injection or recirculation phase (Classes IIIA and IIIB, respectively) did not contribute to the CDF or plant level fragility for Palisades. The seismically induced LOCA requires HPSI injection and recirculation, which have limited vulnerability to seismic failures as discussed for Accident Classes IA and IB. No seismic related SAMAs are suggested based on the Class III results.

Accident Class IV

Accident Class IV sequences did not contribute to the Palisades CDF or plant level fragility. No seismic related SAMAs are suggested based on the Class IV results.

Important Seismically Induced Equipment Failures

In addition to providing Accident Class based results, the IPEEE identified four groups of equipment that contributed to most of the Seismic PRA CDF. These groups included: the FPS, MSIVs, EDG fuel oil supply, and the bus under-voltage relay for safety bus 1D. The results sections for each of these groups were reviewed in order to identify potential SAMAs, as discussed below.

The FPS failures were already identified as important contributors to the Class IA and IB sequences. As FPS failures have already been addressed, no additional SAMAs are suggested here.

The MSIVs are assumed to interact with components located near the valves during significant ground motion. The Seismic PRA models the result of this interaction as failure of the MSIVs to close and isolate the steam generators. This is important only if an ADV randomly fails to close. The model assumes that the stuck open ADV and MSIV pair results in a dual steam generator blowdown, which is an excessive steam demand requiring termination of AFW flow to one of the steam generators. However, the importance of the event is inflated due to a conservative modeling approach. The logic in the PRA model, representing all of the possible excessive steam demand events results in both steam generators being considered unavailable under these conditions. Realistically, the operators would continue to provide AFW flow to the lesser impacted steam generator and secondary side cooling would not be lost. If the model more closely represented actual operation, MSIV seismic interactions would not be risk significant. No SAMAs are suggested for this failure group.

The EDG fuel oil supply tank (T-10) may fail during a seismic event. During the performance of the IPEEE, this was considered to result in a loss of the EDGs after about 18 hours and subsequent battery depletion in an additional 6 hours. However, diverse methods exist to refill the EDG day tanks and subsequent analysis has shown that the inventory in the EDG bed tanks and day tanks is sufficient to provide alternating current (AC) power for the 24 hour mission time applied in the PSA, as described below.

There are five methods that can be used to refill the day tank:

- Transfer fuel from T-10A (fuel oil underground storage tanks) to T-25A(B) (auxiliary day tanks) via P-18A or P-18B (the normal method)
- Transfer fuel from T-926 (feed water purity fuel oil tank) to T-25A(B) via pump P-965
- Transfer fuel from T-926 to T-25A(B) using a pre-staged air pump and hoses
- Transfer fuel from T-10A to T-25A(B) using an pre-staged air pump and hoses (if P-18A and P-18B are unavailable)
- Transfer fuel from a tank truck to T-25A(B)

Prior to the Palisades PSAR1c model development (used in the SAMA analysis), the Palisades internal events PSA only credited the refueling path from P-18A. Tanks T-25A(B) and T-10A were required for the successful 24 hour mission time considered in that analysis.

P-18A is powered from MCC-8 and requires an operator action to close a breaker during a LOOP event. This action can be performed in the main CR. This operator action was represented in the earlier PSA models. All the other options (including start of P-18B) require local actions and were not included in these earlier analyses.

If recovery of OSP within 18 hours fails (this was the previously assumed inventory capacity), then fuel oil makeup was required. However, since the IPEEE analysis, updated fuel oil inventory capacities were calculated and shown to have a supply in excess of 24 hours (as shown below).

Fuel Oil Tanks Available	EDG 1-1 Operating Time (hours)
EDG1-1	
Bedplate day (belly tank)	3.52
Auxiliary day tank, T-25A	20.6
Fuel oil storage tank, T-10A	78.5
EDG1-2	
Bedplate day (belly tank)	3.68
Auxiliary day tank, T-25B	24.2
Fuel oil storage tank, T-10B	78.5

From the above, the bedplate and auxiliary day tanks can provide over 24 hours of fuel (24.1 hours for EDG 1-1 and 27.9 hours for EDG 1-2). Since T-10A is not necessary to support the 24-hour mission duration considered in the present PSA analysis, there is no measurable benefit from a modification to strengthen or replace Tank T-10. No SAMAs are suggested based on the potential for seismically induced failure of tank T-10.

Finally, failure of the under-voltage relay for bus 1D is important because it starts the EDG that powers AFW pump P-8C, which is the only AFW pump with a seismically sound water source. The importance of the relay failure includes credit that is taken for the local start of the EDG. While local start of the EDG is considered to be a viable option, the contribution of this failure mode could be further reduced if this relay were to be replaced with one that is less susceptible to seismic activity (SAMA 22). This change has been added to the SAMA list.

Important Random Failures

The important random failures that have been identified for the Palisades seismic analysis include:

- Failure of EDG 1-2
- Failure of AFW pump 8C
- Failure of the ADVs to close

Failure of EDG 1-2 is primarily important to the Seismic analysis because it provides power to AFW pump 8C, which is the only pump with a seismically durable water source. Providing an AC cross-tie would limit the impact of this failure (SAMA 9). This change is included on the SAMA list

Finally, the failure of the ADVs has been identified as important; however, the importance of these valves has been overestimated by conservative modeling. The explanation of this overestimation is provided in the discussion of the importance of seismically induced failures of the MSIVs. No SAMAs are suggested related to ADV failures.

Potentially Unresolved Seismic Enhancements from the IPEEE

The Palisades IPEEE concluded that there were no significant seismic concerns at Palisades, and no plant enhancements were suggested to reduce the seismic CDF. While some relays were found to be vulnerable to seismic activity and some equipment anchorage updates were required, these were addressed as part of closing out USI A-46. All activities with respect to USI-A-46 have been completed. NRC issued a Safety Evaluation Report (SER) on September 25, 1998 (NRC 1998e). The SER indicated that the plant actions provided sufficient basis to close the USI A-46 review at Palisades. Several items were identified that required resolution. Completion of the last item requiring resolution was documented in a letter to NRC in June 2003 (NMC 2003).

The SAMA identification process includes a step to review the plant changes that were suggested in the IPEEE to determine if these enhancements were completed. In this case, no enhancements were suggested and this step is not required.

Seismic Summary

Based on the review of the Palisades seismic analysis, two SAMAs were suggested to address the largest contributors to seismic risk.

- AC Cross-tie (SAMA 9)
- Replace the Undervoltage Relay for Bus 1D with a Seismically Qualified Model (SAMA 22)

These two SAMAs are included in the Palisades SAMA list. SAMA 22 is an insight unique to the seismic PRA results and was not identified through the Level 1 Internal Events results review.

E.5.1.6.3 High Wind Events

NRC's SEP included an assessment of the capability of Palisades Design Class 1 structures to resist the effects of tornado and wind loads. The results of this analysis were used in the IPEEE as part of the high wind evaluation. In addition, several issues not previously evaluated by the SEP were examined in the IPEEE to identify other potential high wind vulnerabilities at the site. The non-SEP areas of investigation were included in the IPEEE analysis based on the conclusions of walkdowns, recent plant modifications, and reclassification of safety systems. Evaluation of the SEP and non-SEP areas was considered to address the potential high wind vulnerabilities at Palisades. It should be noted that because the winds expected from a tornado are much higher than those classified as “high winds”, it was assumed that plant structures that satisfied the design criteria for tornados would also satisfy those for high winds. As a result, the information available for the SAMA evaluation is focused on tornado effects.

SEP Evaluation, Tornado Loads

The SEP concluded that the Palisades Design Class 1 structures were designed for tornado loads and that no vulnerabilities existed with the exception of the following:

- Condensate Storage Tank (CST)
- Intake and exhaust vents for the electric diesel generators
- The Safety Injection & Refueling Water Tank (SIRWT)
- Steel framed enclosure over the spent fuel pool

Revisions to the plant emergency operating procedures (EOPs) were subsequently made to provide alternative water sources for safe shutdown should the SIRWT or the CST fail due to tornado wind and pressure loading.

Further review of the EDG intake and exhaust system resulted in the conclusion that the intake/exhaust structure was able to withstand tornado loadings on three of its four sides and that the remaining side was protected by other structures such that loss of the intake/exhaust lines to both EDGs was unlikely.

Based on the procedural changes that were made to address the need for alternate water sources and the durability of the EDG intake/exhaust structure, no additional SAMAs have been proposed to address tornado wind loads.

SEP Evaluation, Tornado Missiles

Tornado missiles were also identified as potential threats. The SEP included a review of the nine Palisades Design Class 1 systems and concluded that the following equipment was potentially vulnerable to tornado missiles:

- Condensate Storage Tank
- Intake and exhaust vents for the EDGs
- The Safety Injection & Refueling Water Tank

- Atmospheric relief stacks of steam relief valves

- The compressed air system

With the exception of the atmospheric relief stacks of the steam relief valves, the equipment identified above was not judged to require backfit to remove tornado vulnerabilities. This was considered to be true based on the same reasons cited in the tornado loading discussion. While it was noted that this argument addressed the CST, the EDG intake and exhaust vents, and the SIRWT, it does not appear to address the compressed air vulnerability.

Based on the limited impact of high winds events on other equipment at Palisades, the importance of the compressed air system was considered to be similar to a LOOP event for the internal events model. Given that LOOP events were significant contributors to the internal events CDF and that the compressed air system did not appear on the importance list, any potential compressed air vulnerabilities are believed to be unlikely to yield cost beneficial SAMAs. As a result, no further investigation into the impact of tornado missiles on the compressed air system was considered necessary.

The relief valve stacks of the steam relief valves were also not considered to require backfit to remove tornado missile vulnerabilities. The reasons provided were:

- To achieve safe shutdown, one relief valve has sufficient capacity to remove all decay heat from the core,

- The 12 relief valves and dump valve stacks extend approximately 6 to 8 feet above the Auxiliary Building roof and are distributed over approximately 300 square feet,

- The relevant section of the Auxiliary Building roof is below that of the surrounding structures and is well protected from all sides, except from above.

The first two items above dismiss the importance of the vulnerabilities based on a low probability of failure resulting from the diversity of the system. This should not be used to screen the equipment from review for SAMA as the probability criteria applied in the IPEEE may be different from what could be considered important in the SAMA analysis. In this case, a quantitative assessment of importance of the failures is not readily available because no probability models were developed for high winds. However, the last item above indicates that the structures surrounding the Auxiliary Building would preclude the building from being exposed to tornado missiles (other than from directly above). This is considered to be acceptable, and no further examination of the effects of tornado missile damage to the vent stacks was considered necessary.

Non-SEP Evaluation

As part of the IPEEE high wind assessment, several issues not previously considered by SEP were evaluated. These issues were included in the assessment based on the results of walkdowns, recent plant modifications, and reclassification of safety related systems. The issues that were identified for review included:

- The EDG fuel oil supply
- Hydrogen tanks
- EDG Room Heating, Ventilation and Air-Conditioning System (HVAC)
- 1984 Auxiliary Building addition

Examination of the EDG fuel oil supply system revealed that it did not meet General Design Criterion 2, “Design Basis for Protection Against Natural Phenomenon”. While requirements specify that the tank must be completely buried and covered with a concrete slab, tank T-10 was only partially buried and covered with sand. The tank was subsequently updated to meet the design requirements.

The hydrogen tanks were reviewed, and it was determined that their loss would not impact the safe shutdown functions of the plant. No further review is considered necessary.

The EDG HVAC system was found to be susceptible to damage from the effects of tornado wind loading; however, the potential failure mode was determined not to cause failure of the system. The HVAC inlet plenum was also found to be exposed to potential tornado missiles, but the surrounding structures provide a good degree of shielding. In addition, given that the inlet plenum is a concrete box from which both HVAC trains take suction, it was considered unlikely that a tornado missile would incapacitate the HVAC for both EDG rooms. While it is not considered necessary to develop SAMAs for EDG HVAC failures due to tornado missiles, it should be noted that the SAMA list includes the modification to the AFW pump to allow its operation without support systems. This would be an effective means of reducing the risk posed from loss of the EDGs.

The 1984 Auxiliary Building addition was also evaluated to identify how tornado winds and missiles could impact the systems housed in the building. It was shown that the design criteria for the building meet those set in the Standard Review Plan and that no changes were required to improve high wind survivability. Tornado missiles impact on the Auxiliary Building was screened from the Palisades IPEEE based on low frequency of occurrence (less than 1E-06 per year). While use of the absolute frequency used in the External Events models is not considered to be appropriate for direct use in the SAMA analysis, a relative comparison is useful. Given the assumption that the external events contributions are approximately equal to the internal events contributions, the potential benefit of those events that were screened from the IPEEE based on the fact that they their frequencies were below 1E-06 per year may be estimated. Assuming that the only contributors to the external events CDF are Fire and Seismic, the percent contribution of an accident with an upper bound frequency of 1E-06 per year can be calculated:

Accident Initiator Type	CDF (per year)	Percent Contribution
Fire	3.31E-05	77
Seismic	8.88E-06	20.7
Upper bound for tornado missile impact on the Auxiliary Building	1.00E-06	2.3
Total	4.3E-05	100

As the external events contribution to the modified MACR is $2,815,000, the averted cost-risk associated with removing all accidents related to tornado missile strikes on the Auxiliary Building would be less than $64,745 ($2,815,000 x 0.023 = $64,745). No SAMAs are expected to be found that could be implemented for this amount of money. As a result, no additional effort has been made to identify SAMAs to reduce the risk of tornado missile strikes on the Auxiliary Building.

High Wind Summary

Given the low potential for identifying cost-beneficial SAMAs to mitigate risk posed by high winds, no further efforts were made in the SAMA analysis to develop high wind related SAMAs.

E.5.1.6.4 External Flooding and Probable Maximum Precipitation

The Palisades external flooding analysis assessed the potential for flood damage to the plant. As the SEP also included an assessment of floods at Palisades, the IPEEE used the existing analysis to help evaluate the flooding threats at the site. As was the case for the high winds analysis, it was necessary to consider the plant changes that had occurred between the time of the SEP and the IPEEE.

The results of the SEP indicated that the potential flooding scenarios at Palisades were not a threat to the equipment required for safe shutdown and that the existing flooding procedures were adequate. At the time the IPEEE was performed, the definition of the Probable Maximum Precipitation (PMP) for the plant had changed since it was used in the SEP. It was judged that the flooding resulting from the updated PMP was bounded by the surge/seiche flooding event, which was shown not to be a threat. As a result, no further investigation of flooding events was performed for structures and equipment included in the SEP.

As indicated in the high wind analysis review, the EDG Fuel Oil system was re-classified as a safety related system. Examination of the system reveals that the design of the T-10 fuel supply tank did not meet design criteria for withstanding a design basis flood.

Subsequently, a seiche protection barrier around the fuel oil transfer pumps was built to limit the impact of flood events. No other changes are considered to be warranted for the fuel oil system.

Roof ponding resulting from the PMP was also examined at the site to determine if there were any structures that were susceptible to collapse from the weight of the collected water. Even when the updated PMP was used, no structures were found to be in danger of collapsing. No SAMAs are suggested to address external flooding events.

E.5.1.6.5 Transportation and Nearby Facility Accidents

Transportation and nearby facility accidents were included in the Palisades IPEEE to account for human errors or equipment failures that may occur in events not directly related to the power generation process at the plant. The types of hazards identified for analysis included:

- Transportation accidents
    - Aircraft Activity
    - Roads/Highways
    - Railroad
    - Great Lakes Shipping
    - Pipelines
    - Aviation
- Nearby Industrial Facilities
- Nearby Military Facilities
- Hazardous Material Releases from Onsite Storage
- Other Onsite Hazards

As was the case with the high winds and external flooding analyses, the SEP was used to help evaluate the threats from these events.

At the time the IPEEE was performed, available information related to military, commercial, and general aviation traffic was used to estimate the frequency of a release of radionuclides caused by aircraft impact. Given the information and conditions present at the time of the analysis, the frequency was determined to be less than 1E-06 per year, and further analysis was not considered warranted.

It is recognized that the types of credible threats to nuclear facilities by aircraft have changed since the time the IPEEE was published. While this is true, efforts are underway within the industry to address this issue in conjunction with other forms of sabotage. Based on the fact that this topic is currently being analyzed in another forum and due to the complexity of the issue, aircraft impact events are considered to be out of the scope of the SAMA analysis.

Transportation and nearby facility related events listed above were reviewed, and it was determined that they did not pose a credible threat to the plant. No effort was expended to identify SAMAs related to these events due to the fact that even if the events were likely to occur, they would not impact the operation of plant systems.

E.5.1.7 QUANTITATIVE STRATEGY FOR EXTERNAL EVENTS

The quantitative methods available to evaluate external events risk at Palisades are limited, as discussed above. In order to account for the external events contributions in the SAMA analysis, a multi-staged process has been implemented to provide gross estimates of the averted cost-risk based on external events accidents.

The first part of this process is used in the Phase I analysis and is based on the assumption that the risk posed by external and internal events is approximately equal. For Palisades, the external events analysis, which has been identified as a conservative analysis, yielded a CDF of only 4.3E-05 per year for the quantified event types (Fire and Seismic). As this is comparable to the internal events CDF of 4.05E-05 per year, the assumption that the external events contributions are not more than the internal events contributions is considered to be well founded.

Given that the risk is assumed to be equal, the MACR calculated for the internal events model has been doubled to account for external events contributions. This total is referred to as the modified MACR. The modified MACR is used in the Phase I screening process to represent the maximum achievable benefit if all risk related to on-line power operations was eliminated. Therefore, those SAMAs with costs of implementation greater than the modified MACR were eliminated from further review.

The second stage of this strategy is to also apply the doubling factor to the Phase II analysis. Any averted cost-risk calculated for a SAMA was multiplied by two to account for the corresponding reduction in external events risk.

The final stage of the process is used for SAMAs that were identified based on IPEEE insights. For these cases, IPEEE insights and the Internal Events PSA are used, as appropriate, to develop an averted cost-risk for the SAMA that accounts for the external and internal events risk reductions. For instance, the IPEEE typically provides information that can be used to estimate bounding changes in risk that would be realized if the SAMAs were implemented. These risk changes are used to approximate averted cost-risks based on external events contributions. Then, if it can be determined that the SAMA would impact the internal events model, the PSA is used to quantify the averted cost-risk based on its internal events contributions. The cost-risks from the external and internal events results are then added to yield the total for the SAMA. In some cases, the SAMAs do not impact the internal events models and the calculations do not require the use of the PSA model.

E.5.2 PHASE I SCREENING

The initial list of SAMA candidates and the Phase I results are presented in Table E.5-3. This list was developed as described in Section E.5.1, and is used as the starting point for the Palisades SAMA review.

The purpose of the Phase I analysis is to use high-level knowledge of the plant and SAMAs to preclude the need to perform detailed cost-benefit analyses. The following criteria are used in the Phase I analysis to eliminate SAMAs from further consideration:

- <u>Applicability to the Plant</u>: If a proposed SAMA does not apply to the Palisades design, it is screened from further analysis.
- <u>Excessive Implementation Cost</u>: If a SAMA requires extensive changes that are known to exceed any possible benefit, they are screened without developing an estimated cost of implementation. For example, the cost of installing an additional buried OSP source over a path of fifty miles is known to exceed any potential benefit and would be screened.
- <u>Implementation Cost Greater than Screening Cost</u>: If the estimated cost of implementation is greater than the modified MACR, the SAMA cannot be cost beneficial and is screened from further analysis.

The potential for screening SAMA candidates using the first of these criteria is limited as the Palisades list was developed from plant-specific insights and other industry SAMAs that were judged to be potentially cost beneficial at Palisades. The second and third criteria are also limited in their use as the Palisades modified MACR is relatively high at greater than $5.6 million. However, these criteria were applied to the initial SAMA list in order to identify the list of SAMAs for evaluation in Phase II.

E.6 PHASE II SAMA ANALYSIS

Phase II involves additional screening and detailed cost-benefit analysis. Some of the remaining SAMA candidates were screened from further analysis based on plant-specific insights regarding the risk significance of the systems that would be affected by the proposed SAMA. The SAMAs related to non-risk significant systems were screened from a detailed cost-benefit analysis as any change in the reliability of these systems is known to have a negligible impact on the PSA evaluation. In addition, those SAMAs that can be shown to have a small averted cost-risk based on relevant importance rankings are excluded from further review. The disposition of these SAMAs is provided in Table E.5-4.

For each of the remaining SAMA candidates, a more detailed conceptual design was prepared. This information was then used to evaluate the effect of the candidates' changes upon the plant safety model.

The final cost-risk based screening method is defined by the following equation:

> Net Value = [baseline cost-risk of site operation (modified MACR) – cost-risk of site operation with SAMA implemented] – cost of implementation

If the net value of the SAMA is negative, the cost of implementation is larger than the benefit associated with the SAMA and the SAMA is not considered beneficial. The baseline cost-risk of plant operation was derived using the methodology presented in Section E.4. The cost-risk of plant operation with the SAMA implemented is determined in the same manner with the exception that the revised PSA results reflect implementation of the SAMA.

Sections E.6.1 – E.6.8 describe the detailed cost-benefit analysis that was used for each of the remaining candidates.

E.6.1 SAMA NUMBER 3: DIRECT DRIVE DIESEL INJECTION PUMP

This SAMA represents the use of a diesel-driven pump to provide makeup to the steam generators. The DDDIP has the potential of reducing the risk of SBO scenarios by providing an injection method to supplement the turbine-driven AFW pump. For long-term SBO benefit, this SAMA should include the use of a portable generator to provide steam generator instrumentation capability and a hard pipe connection to the FPS for suction in order to bypass the dependence on the CST. Improving the reliability of secondary side heat removal is also a means of reducing the dependence on primary side cooling in non-SBO conditions. In cases where the existing AFW system fails, the DDDIP would preclude the need to initiate OTC.

In order to represent this SAMA, the model was modified by reducing the existing pump failure probabilities to simulate the addition of the DDDIP (assuming that the failure rate for the DDDIP is comparable to the existing pumps). In addition, the pump common cause failure (CCF) terms and random system failures were removed to represent the independence of the pump.

The cost of implementation for this SAMA was estimated to be $1,100,000 based on plant-specific cost estimate.

Results

The results from this case indicate a 15.1 percent reduction in CDF (CDF_{new}=3.44E-05 per year), a 13.8 percent reduction in dose-risk ($Dose\text{-}Risk_{new}$=27.5 person-rem per year), and a 13.7 percent reduction in offsite economic cost risk (OECR) ($OECR_{new}$ = $107,893 per year). A further breakdown of this information is provided below according to release category.

Release Category	E-H	E-M	I-H	I-M	L-L	L-LL	Total
Baseline Freq.	3.55E-07	3.59E-06	2.60E-06	1.66E-05	4.37E-06	1.33E-05	4.08E-05
SAMA Freq.	3.22E-07	2.38E-06	2.31E-06	1.45E-05	3.88E-06	1.12E-05	3.45E-05
$Dose\text{-}Risk_{NEW}$	2.0	1.4	4.3	19.2	0.3	0.5	27.5
$OECR_{NEW}$	$3,993	$4,618	$20,018	$78,915	$194	$155	$107,893

This information was used as input to the cost-benefit calculation. The results of this calculation are provided in the following table.

SAMA Number 3 Net Value

Base Case Cost-Risk	Revised Cost-Risk	Averted Cost-Risk	Cost of Implementation	Net Value
$5,630,000	$4,837,137	$792,863	$1,100,000	-$307,137

Given that the cost of implementation is greater than the averted cost-risk for this SAMA, the net value is negative.

E.6.2 SAMA NUMBER 4: ENHANCE HPSI CAPABILITY

An additional HPSI pump would increase HPSI redundancy and reduce the probability of requiring RPV depressurization early in an accident. Given that Palisades converted an original HPSI pump to an AFW pump, the power and piping tie-ins to add the additional pump are available; however, the converted pump was not moved. The modification would require the replacement of the converted pump with a new AFW pump and conversion of the third AFW pump (P-8C) back to a HPSI pump. This creates a space related issue that would increase the cost of this SAMA.

In order to represent this SAMA, the model was modified by reducing the “A” train pump and valve failure rates to reflect the installation of an additional pump. The power dependencies are shared with the “A” train, as was true for the original third HPSI pump.

The cost of implementation for this SAMA was estimated to be $1,620,000 based on plant-specific cost estimate.

Results

The results from this case indicate a 3.0 percent reduction in CDF (CDF_{new}=3.93E-05 per year), a 1.1 percent reduction in dose-risk ($Dose\text{-}Risk_{new}$=31.6 person-rem per year), and a 0.9 percent reduction in OECR ($OECR_{new}$ = $123,844 per year). A further breakdown of this information is provided below according to release category.

Release Category	E-H	E-M	I-H	I-M	L-L	L-LL	Total
Baseline Freq.	3.55E-07	3.59E-06	2.60E-06	1.66E-05	4.37E-06	1.33E-05	4.08E-05
SAMA Freq.	3.47E-07	3.54E-06	2.60E-06	1.64E-05	4.38E-06	1.23E-05	3.96E-05
$Dose\text{-}Risk_{NEW}$	2.1	2.0	4.8	21.9	0.3	0.5	31.6
$OECR_{NEW}$	$4,299	$6,870	$22,549	$89,735	$219	$171	$123,844

This information was used as input to the cost-benefit calculation. The results of this calculation are provided in the following table.

SAMA Number 4 Net Value

Base Case Cost-Risk	Revised Cost-Risk	Averted Cost-Risk	Cost of Implementation	Net Value
$5,630,000	$5,544,634	$85,366	$1,620,000	-$1,534,634

Given that the cost of implementation is greater than the averted cost-risk for this SAMA, the net value is negative.

E.6.3 SAMA NUMBER 10: POWER INDEPENDENT TURBINE-DRIVEN AFW OPERATION

The Palisades turbine-driven AFW pump is capable of operating with only DC power such that it can provide makeup to the steam generators in an SBO when AC powered sources are unavailable. However, when the station batteries deplete, the instrumentation and control power for the system is lost, and it is assumed that the injection system would fail due to overfill or dryout of the steam generators.

Changes at Palisades have made it possible to manually operate the turbine-driven AFW pump after battery depletion. While no changes have been made that would provide instrumentation power, the pump flow could be matched to the decay heat curve such that the required makeup could be maintained without instrumentation. This change would require only engineering analysis and procedure updates for implementation.

In order to represent this SAMA, the model was modified by setting the AC power recovery failures to zero. The current model assumed that the station batteries deplete at 4 hours and that if AC power was not recovered at that time, core damage ensued. Removing the AC power recovery failures simulates the indefinite operation of the turbine -driven AFW pump.

The cost of implementation for this SAMA was estimated to be $200,000 based on the required procedure changes and engineering analysis to develop the flow curves for the AFW pumps. For this SAMA, a range of $50,000 to $100,000 is considered to be a reasonable estimate for the cost of procedure changes based on those included in the Brunswick Application for License Renewal (CPL 2004). The upper end of this range is used to reflect the need to update the EOPs, which is more resource intensive than isolated system operating procedures. This cost has been doubled to address the development of flow curves and valve throttling correlations for matching boiloff in the steam generators as reactor decay heat decreases over time. The cost of implementation for this SAMA is, therefore, $200,000.

Results

The results from this case indicate a 26.9 percent reduction in CDF (CDF_{new}=2.96E-05 per year), a 32.5 percent reduction in dose-risk (Dose-Risk_{new}=21.6 person-rem per year), and a 32.8 percent reduction in OECR ($OECR_{new}$ = $83,930 per year). A further breakdown of this information is provided below according to release category.

Release Category	E-H	E-M	I-H	I-M	L-L	L-LL	Total
Baseline Freq.	3.55E-07	3.59E-06	2.60E-06	1.66E-05	4.37E-06	1.33E-05	4.08E-05
SAMA Freq.	2.98E-07	3.43E-06	2.57E-06	9.35E-06	8.90E-07	1.32E-05	2.97E-05
Dose-Risk_{NEW}	1.8	1.9	4.8	12.4	0.1	0.5	21.6
$OECR_{NEW}$	$3,695	$6,659	$22,299	$51,049	$44	$183	$83,930

This information was used as input to the cost-benefit calculation. The results of this calculation are provided in the following table.

SAMA Number 10 Net Value

Base Case Cost-Risk	Revised Cost-Risk	Averted Cost-Risk	Cost of Implementation	Net Value
$5,630,000	$3,879,255	$1,750,745	$200,000	$1,550,745

Given that the cost of implementation is less than the averted cost-risk for this SAMA, the net value is positive.

E.6.4 SAMA NUMBER 13: NITROGEN STATION FOR AUTOMATIC BACKUP TO CV-2010 AIR SUPPLY

Loss of Instrument Air is the primary contributor to the failure of CST makeup. Procedures exist to cross-tie the Feedwater Purity Air system to IA to mitigate its failure and preclude the operator action to manually operate the CST makeup valves. No credit is currently taken for this action. While a relatively high dependence likely exists between the action to manually open the CST makeup valves from the FPS and the action to open the Feedwater Purity cross-tie, the cross-tie is a viable option. Any other manual action to mitigate the failure of CST makeup would have a similar dependence and would not have a large impact on the CDF.

A potential means of removing the operator dependence on CST makeup is the installation of a nitrogen station to automatically supply air to the CV-2010 valve on loss of the normal air supply. This SAMA would preclude the need to use the Feedwater Purity cross-tie and eliminates the dependent operator action for accident mitigation.

In order to represent this SAMA, the model was modified by combining an undeveloped event with the air supply to CV-2010 to represent the operation of the nitrogen station. The undeveloped event is assumed to have a failure probability of 1E-02.

The cost of implementation of this SAMA is $220,000 based on plant-specific cost estimate.

Results

The results from this case indicate a 5.2 percent reduction in CDF (CDF_{new}=3.84E-05 per year), a 4.4 percent reduction in dose-risk ($Dose\text{-}Risk_{new}$=30.5 person-rem per year), and a 4.5 percent reduction in OECR ($OECR_{new}$ = $119,355 per year). A further breakdown of this information is provided below according to release category.

Release Category	E-H	E-M	I-H	I-M	L-L	L-LL	Total
Baseline Freq.	3.55E-07	3.59E-06	2.60E-06	1.66E-05	4.37E-06	1.33E-05	4.08E-05
SAMA Freq.	3.48E-07	3.42E-06	2.50E-06	1.58E-05	5.39E-06	1.13E-05	3.88E-05
Dose-Risk$_{NEW}$	2.1	1.9	4.6	21.0	0.4	0.5	30.5
OECR$_{NEW}$	$4,320	$6,640	$21,712	$86,256	$269	$158	$119,355

This information was used as input to the cost-benefit calculation. The results of this calculation are provided in the following table.

SAMA Number 13 Net Value

Base Case Cost-Risk	Revised Cost-Risk	Averted Cost-Risk	Cost of Implementation	Net Value
$5,630,000	$5,367,788	$262,212	$220,000	$42,212

Given that the cost of implementation is less than the averted cost-risk for this SAMA, the net value is positive.

E.6.5 SAMA NUMBER 14: ENHANCE THE MCR TO INCLUDE CONTROLS FOR THE CROSS-TIE BETWEEN SW AND THE FPS

In the event that the SWS fails, providing a means to align the FPS to the SWS in the MCR will reduce the time required to perform the action and improve the man-machine interface of the manipulation. This action is necessary to allow FPS to provide cooling of the CCW heat exchanger (source of cooling to the PCP seals). Given that a reliable backup cooling water source exists to fulfill the cooling requirements for the seals, no SAMAs are suggested to provide alternate system connection. In addition, no automatic alignments are suggested for the existing connection to the FPS based on the desire to prevent inadvertent pressurization of the RCP seal cooling header with low quality water or diversion of fire protection flow to the SWS during a fire related demand. It should be noted that a local, manual cross-tie is currently available at Palisades, but no credit is taken for it because the estimated implementation time is greater than the time that is believed to be available to perform the action.

In order to represent this SAMA, the model was modified by setting the consequential seal LOCAs that would occur on loss of seal cooling to zero. This method is considered to be conservative given that 55 percent of the seal failure probability is associated with the operator action to trip the PCPs. As the action to trip the PCPs and alignment of alternate cooling to the seals share the same goal, dependence issues will limit the potential to reduce risk through implementation of this SAMA. This is discussed further in Section E.7.3.

Palisades has estimated the cost of this enhancement to be $2,900,000.

Results

The results from this case indicate a 4.7 percent reduction in CDF (CDF_{new}=3.86E-05 per year), a 6.6 percent reduction in dose-risk ($Dose\text{-}Risk_{new}$=29.8 person-rem per year), and a 6.7 percent reduction in OECR ($OECR_{new}$ = $116,631 per year). A further breakdown of this information is provided below according to release category.

Release Category	E-H	E-M	I-H	I-M	L-L	L-LL	Total
Baseline Freq.	3.55E-07	3.59E-06	2.60E-06	1.66E-05	4.37E-06	1.33E-05	4.08E-05
SAMA Freq.	3.32E-07	3.58E-06	2.60E-06	1.51E-05	4.36E-06	1.29E-05	3.89E-05
$Dose\text{-}Risk_{NEW}$	2.0	2.0	4.8	20.1	0.3	0.5	29.8
$OECR_{NEW}$	$4,119	$6,936	$22,587	$82,592	$218	$179	$116,631

This information was used as input to the cost-benefit calculation. The results of this calculation are provided in the following table.

SAMA Number 14 Net Value

Base Case Cost-Risk	Revised Cost-Risk	Averted Cost-Risk	Cost of Implementation	Net Value
$5,630,000	$5,285,782	$344,218	$2,900,000	-$2,555,782

Given that the cost of implementation is greater than the averted cost-risk for this SAMA, the net value is negative.

E.6.6 SAMA NUMBER 16: INSULATED EDG EXHAUST DUCTS

Action to check that SW is aligned to the EDGs after a start is already taken based on previous plant experience, but the action is not proceduralized. Steps are taken immediately to prevent overheating the EDGs engines and could include credit for opening the EDG room doors to also address loss of room cooling, if procedures were provided. However, because the time available is short, the error rate for the action would be high. Insulating the EDG exhaust ducts will reduce the heat load in the room and provide additional time to align alternate room cooling in the event that room cooling has failed.

In order to represent this SAMA, the model was modified by setting the room cooling recovery event to zero.

The cost of this SAMA includes the procedural changes to align alternate room cooling early and the cost of insulating the EDG exhaust ducts. The cost for implementation is estimated to be $160,000.

Results

The results from this case indicate a 3.7 percent reduction in CDF (CDF_{new}=3.90E-05 per year), a 4.4 percent reduction in dose-risk ($Dose\text{-}Risk_{new}$=30.5 person-rem per year), and a 4.4 percent reduction in OECR ($OECR_{new}$ = $119,468 per year). A further breakdown of this information is provided below according to release category.

Release Category	E-H	E-M	I-H	I-M	L-L	L-LL	Total
Baseline Freq.	3.55E-07	3.59E-06	2.60E-06	1.66E-05	4.37E-06	1.33E-05	4.08E-05
SAMA Freq.	3.46E-07	3.56E-06	2.60E-06	1.56E-05	3.87E-06	1.32E-05	3.92E-05
$Dose\text{-}Risk_{NEW}$	2.1	2.0	4.8	20.8	0.3	0.5	30.5
$OECR_{NEW}$	$4,295	$6,905	$22,551	$85,341	$193	$183	$119,468

This information was used as input to the cost-benefit calculation. The results of this calculation are provided in the following table.

SAMA Number 16 Net Value

Base Case Cost-Risk	Revised Cost-Risk	Averted Cost-Risk	Cost of Implementation	Net Value
$5,630,000	$5,393,266	$236,734	$160,000	$76,734

Given that the cost of implementation is less than the averted cost-risk for this SAMA, the net value is positive.

E.6.7 SAMA NUMBER 22: REPLACE THE UNDERVOLTAGE RELAY FOR BUSES 1C AND 1D WITH A HIGHER FRAGILITY MODEL

Failure of the under-voltage relay for bus 1D is important because it starts the EDG that powers AFW pump P-8C and two SW pumps. The SWS is the most likely of the water sources to the AFW pump suctions to survive a seismic event. However, SW as a suction source is only directly available to pump P-8C. The importance of the relay failure currently includes credit of a local start of the EDG. While local start of the EDG is considered to be a viable option, the contribution of this failure mode could be further reduced if this relay were to be replaced with one that is less susceptible to seismic activity. Failure of the undervoltage relay has been identified as important to the Class IA and IB accidents.

The IPEEE did not credit the cross-tie between the SWS and the FPS, which is currently proceduralized. This cross-tie would allow the SWS to pressurize the suction of the AFW P-8A and P-8B pumps, which would eliminate most of the asymmetry between the EDGs. The overall importance of the undervoltage relays is still important to the seismic results, but the importance is actually more evenly distributed between the EDGs than the IPEEE concluded. As a result, this SAMA recommends replacing the undervoltage relays for both the 1-1 and 1-2 EDGs.

This SAMA assumes that if the undervoltage relays for EDGs 1-1 and 1-2 are replaced, the risk of Class IA and IB seismic accidents could be eliminated. This is based on the IPEEE documentation that identifies the undervoltage relay as a major contributor to the Class IA and IB accident classes. Further refinement of this assumption is difficult as the available information does not provide details related to the specific importance of the major contributors to each accident class.

The impact of this change is estimated using available information from the seismic IPEEE documentation and engineering judgment. No model quantification was performed for this evaluation.

It is assumed that if the portion of the Palisades CDF related to seismically induced Class IA and IB accidents can be identified, then an averted cost-risk can be calculated for this SAMA. The steps used to perform this calculation include:

- Determine the percentage of the overall modified MACR attributable to external events,
- Determine the percentage of the external events modified MACR contribution attributable to seismic events,
- Determine the percentage of the seismic component of the modified MACR classified as Class IA and IB accidents.

The baseline assumption for external events contributions in the Palisades SAMA is that they are approximately equal to the internal events contributions. Given that the internal events MACR is $2,815,000, the same value is assigned to external events.

The relative contribution of seismic events to the total external events CDF is difficult to determine due to the fact that the seismic analysis and other external events analyses are not necessarily comparable in methodology. However, for the purposes of this calculation, it is assumed that the Fire and Seismic CDFs can be used to determine their relative contributions to the external events CDF. No other external event type is assumed to contribute to the total external events CDF for this calculation. Given that this relay failure mode is unique to the seismic analysis, this assumption is conservative in that the relative contribution of the seismic CDF to the external events CDF will be greater and yield and larger potential averted cost-risk. This results in a higher likelihood that SAMAs will be retained. The following table summarizes the most recent Seismic and Fire model results and identifies their percent contributions to the total external event CDF:

Accident Initiator Type	CDF per year	Percent Contribution
Fire	3.31E-05	78.8
Seismic	8.88E-06	21.2
Total	4.20E-05	100

Given that 21.2 percent of the external events contributions can be attributed to Seismic accidents, the associated averted cost risk is $596,780 ($2,815,000 x 0.212 = $596,780).

Based on the Palisades IPEEE, Class IA and IB events comprise 69.4 percent of the seismic risk. This corresponds to a cost-risk of $414,165 ($596,780 x 0.694 = $414,165). Given that it was assumed that implementation of this SAMA could eliminate all of this risk, the averted cost-risk for this SAMA is also $414,165.

The cost of replacing a single undervoltage relay is estimated to be $55,000. Replacing both relays is assumed to be $110,000.

This information was used as input to the cost-benefit calculation. The results of this calculation are provided in the following table.

SAMA Number 26 Net Value

Base Case Cost-Risk	Revised Cost-Risk	Averted Cost-Risk	Cost of Implementation	Net Value
$5,630,000	$5,215,835	$414,165	$110,000	$304,165

Given that the cost of implementation is less than the averted cost-risk for this SAMA, the net value is positive.

E.6.8 SAMA NUMBER 23: DIRECT PCS COOLDOWN ON LOSS OF PCP SEAL COOLING

While Palisades has upgraded the plant's PCPs with new seals, the cooldown process may further reduce the probability of seal failures related to long-term high temperature exposure or thermal shock after recovery of CCW.

In order to represent this SAMA, the same changes used to model the implementation of SAMA 14 would be performed. This includes setting the consequential seal LOCAs that would occur on loss of seal cooling to zero. While it is likely that both this SAMA and SAMA 14 would not completely eliminate the consequential seal LOCAs, information related to the quantitative effectiveness of either change is not readily available. Elimination of all risk provides a bounding estimate based on the existing PSA model.

This method is considered to be conservative given that 55 percent of the seal failure probability is associated with the operator action to trip the PCPs. As the action to trip the PCPs and alignment of alternate cooling to the seals share the same goal, dependence issues will limit the potential to reduce risk through implementation of this SAMA. This is discussed further in Section E.7.3.

The cost of implementation for this SAMA was estimated to be $100,000 based on the required procedure changes to direct RCS cooldown on loss of seal cooling. For this SAMA, a range of $50,000 to $100,000 is considered to be a reasonable estimate for the cost of procedure changes based on those included in the Brunswick Application for License Renewal (CPL 2004). The upper end of this range is used to reflect the potential need to update the EOPs and operator training, which is more resource intensive than isolated system operating procedures.

Results

The results from this case indicate a 4.7 percent reduction in CDF (CDF_{new}=3.86E-05 per year), a 6.6 percent reduction in dose-risk ($Dose\text{-}Risk_{new}$=29.8 person-rem per year), and a 6.7 percent reduction in OECR ($OECR_{new}$ = $116,631 per year). A further breakdown of this information is provided below according to release category.

Release Category	E-H	E-M	I-H	I-M	L-L	L-LL	Total
Baseline Freq.	3.55E-07	3.59E-06	2.60E-06	1.66E-05	4.37E-06	1.33E-05	4.08E-05
SAMA Freq.	3.32E-07	3.58E-06	2.60E-06	1.51E-05	4.36E-06	1.29E-05	3.89E-05
$Dose\text{-}Risk_{NEW}$	2.0	2.0	4.8	20.1	0.3	0.5	29.8
$OECR_{NEW}$	$4,119	$6,936	$22,587	$82,592	$218	$179	$116,631

This information was used as input to the cost-benefit calculation. The results of this calculation are provided in the following table.

SAMA Number 23 Net Value

Base Case Cost-Risk	Revised Cost-Risk	Averted Cost-Risk	Cost of Implementation	Net Value
$5,630,000	$5,285,782	$344,218	$100,000	$244,218

Given that the cost of implementation is less than the averted cost-risk for this SAMA, the net value is positive.

E.6.9 EFFECTS OF IMPLEMENTATION OF SAMA 10 ON REMAINING PALISADES SAMAS

Implementation of the SAMA 10 changes the Palisades risk profile. If it is assumed that SAMA 10 is implemented, the cost-benefit analysis changes for the remaining Phase 2 SAMAs. For Palisades, it reduces the potential averted cost-risk for some of those plant changes and increases it for others. The following table identifies the averted cost risks and net values for these SAMAs with and without implementation of SAMA 10.

SAMA ID	Cost of Implementation	Averted Cost-Risk (Base)	Net Value (Base)	Averted Cost- Risk (With SAMA 10)	Net Value (With SAMA 10)	Change in Cost Effectiveness?
3	$1,100,000	$792,863	-$307,137	$798,534	-$301,466	No
4	$1,620,000	$85,366	-$1,534,634	$92,645	-$1,527,355	No
13	$220,000	$262,212	$42,212	$209,216	-$10,784	Yes
14	$2,900,000	$344,218	-$2,555,782	$349,041	-$2,550,959	No
16	$160,000	$236,734	$76,734	$1,406	-$158,594	Yes
22	$110,000	$414,165	$304,165	$285,281[a]	$175,281	No
23	$100,000	$344,218	$244,218	$349,041	$249,041	No

a. This estimate is derived by preserving the assumption that external risk is comparable to the internal events risk. Thus if the internal events risk is reduced, the external events risk is reduced as well.

Implementation of SAMA 10 reduces the averted cost-risk for SAMAs 13 and 16 by a large enough margin to change the net values from positive to negative.

SAMA 13 is a borderline case with or without the implementation of SAMA 10. Reasonable changes in assumptions can change the results of the cost-benefit analysis for this SAMA.

The impact on SAMA 16 is much more dramatic than based on the results of the cost-benefit analysis alone; it would appear that SAMA 16 should not be considered for implementation if SAMA 10 is implemented. However, implementation of SAMA 16 will help normal, emergency systems remain in service while SAMA 10 provides for the operations of AFW under extreme conditions. Implementation of SAMA 16 would preclude the need for SAMA 10 in some cases, and it would provide a more desirable success path. While the cost-benefit analysis shows that SAMA 16 is not cost beneficial after implementation of SAMA 10, other reasons exist not to exclude SAMA 16 from consideration even if SAMA 10 is implemented.

The external events based calculation (SAMA 22) has a greatly reduced averted cost-risk after implementation of SAMA 10 using the assumptions adopted in this analysis; however, an accurate assessment of the benefit for this SAMA is difficult to perform with the information that is available.

E.6.10 PHASE II SAMA ANALYSIS SUMMARY

The SAMA candidates that could not be eliminated from consideration by the baseline screening process or other PSA insights required the performance of a detailed cost-benefit analysis. SAMA candidates are potentially justified only if the averted cost-risk resulting from the modification is greater than the cost of implementing the SAMA. Several of the SAMAs analyzed were found to be cost-beneficial as defined by the methodology used in this study, as shown in the following table.

Summary of the Detailed SAMA Analyses

Phase II SAMA ID	Averted Cost- Risk	Cost of Implementation	Net Value	Cost Beneficial?
3	$792,863	$1,100,000	-$307,137	No
4	$85,366	$1,620,000	-$1,534,634	No
10	$1,750,745	$200,000	$1,550,745	Yes
13	$262,212	$220,000	$42,212	Yes
14	$344,218	$2,900,000	-$2,555,782	No
16	$236,734	$160,000	$76,734	Yes
22	$414,165	$110,000	$304,165	Yes
23	$344,218	$100,000	$244,218	Yes

However, these results only account for the baseline assumptions used to quantify the net value of the SAMAs. The final disposition of the SAMA candidates, which reflects the results of the sensitivity analyses and other modeling insights, is presented in Section E.8.

E.7 UNCERTAINTY ANALYSIS

Sensitivity cases were run for the following three conditions to assess the impact on the overall SAMA evaluation:

- Use of a 3 percent discount rate, instead of 7 percent used in the original base case analysis.
- Use of the 95th percentile PSA results in place of the mean PSA results used in the base case analysis.
- Impact of assumed effectiveness of seal cooling on cost benefit.

E.7.1 REAL DISCOUNT RATE

A sensitivity case has been performed in order to identify how the conclusions of the SAMA analysis might change based on the value assigned to the RDR. The original RDR of 7 percent has been changed to 3 percent and the modified MACR was re-calculated using the methodology outlined in Section E.4.

Implementation of the 3 percent RDR increased the modified MACR by 32.8 percent. This relates to an increase in the modified MACR from $5,630,000 to $7,474,000. The Phase I SAMA list was reviewed to determine if such an increase in the modified MACR would impact the disposition of any SAMAs. Of the SAMAs screened on high cost, none would be retained for Phase II analysis.

The Phase II SAMAs are initially dispositioned based on PSA insights or detailed analysis. Use of the 3 percent RDR did not affect the PSA insights used to screen the SAMAs. Therefore, the SAMA candidates screened based on these insights are considered to be addressed and are not investigated further.

The remaining Phase II SAMAs were dispositioned based on the results of a SAMA specific cost-benefit analysis. This step has been re-performed using the 3 percent RDR to calculate the net values for the SAMAs. As shown below, the determination of cost effectiveness did not change for any Phase II SAMAs when the 3 percent RDR was used.

Results Summary Using a 3 Percent RDR

SAMA ID	Cost of Implementation	Averted Cost-Risk (7% RDR)	Net Value (7% RDR)	Averted Cost- Risk (3% RDR)	Net Value (3% RDR)	Change in Cost Effectiveness
3	$1,100,000	$792,863	-$307,137	$1,048,805	-$51,195	No
4	$1,620,000	$85,366	-$1,534,634	$107,658	-$1,512,342	No
10	$270,000	$1,750,745	$1,550,745	$2,340,797	$2,140,797	No
13	$220,000	$262,212	$42,212	$346,055	$126,055	No
14	$2,900,000	$344,218	-$2,555,782	$462,585	-$2,437,415	No
16	$160,000	$236,734	$76,734	$316,268	$156,268	No
22	$110,000	$414,165	$304,165	$549,817	$439,817	No
23	$100,000	$344,218	$244,218	$462,585	$362,585	No

E.7.2 95TH PERCENTILE PSA RESULTS

The results of the SAMA analysis can be impacted by implementing conservative values from the PRA's uncertainty distribution. If the best estimate failure probability values were consistently lower than the "actual" failure probabilities, the PRA model would underestimate plant risk and yield lower than "actual" averted cost-risk values for potential SAMAs. Re-assessing the cost-benefit calculations using the high end of the failure probability distributions is a means of identifying the impact of having consistently underestimated failure probabilities for plant equipment and operator actions included in the PRA model. This sensitivity uses the 95th percentile results to examine the impact of uncertainty in the PRA model.

For Palisades, the SAPHIRE software code was used to perform the Level 1 internal events model uncertainty analysis. The results of the calculation are provided below:

PARAMETER	CDF
Mean	4.46E-05
5 percent	1.84 E-05
Median	3.55 E-05
95 percent	9.23 E-05
Standard Deviation	4.91 E-05

The PRA uncertainty calculation identifies the 95th percentile CDF as 9.23E-05 per year. This is a factor of 2.3 greater than the CDF point estimate produced by the Palisades PRA.

E.7.2.1 PHASE I IMPACT

For Phase I screening, use of the 95th percentile PRA results will increase the modified MACR and may prevent the screening of some of the higher cost modifications. However, the impact on the overall SAMA results due to the retention of the higher cost SAMAs for Phase II analysis is small. This is due to the fact that the benefit gleaned from the implementation of those SAMAs must be extremely large in order to be cost beneficial.

The impact of uncertainty in the PRA results on the Phase I SAMA analysis has been examined. The modified MACR is the primary Phase I criteria affected by PRA uncertainty. Thus, this portion of this sensitivity is focused on recalculating the modified MACR using the 95th percentile PRA results and re-performing the Phase I screening process.

The uncertainty analyses that are currently available for some industry Level 1 models are not available for Level 2 and 3 PSA models. The dose-risk and off-site economic cost risk were increased by a factor of 2.3 to simulate the increase in the CDF resulting from the use of the 95th percentile CDF. The corresponding 95th percentile dose-risk and economic cost risk modified MACR is $12,949,000.

The initial SAMA list has been re-examined using the revised modified MACR to identify SAMAs that would be retained for the Phase II analysis. Those SAMAs that were previously screened due to costs of implementation that exceeded $5.6 million are now retained if the costs of implementation are less than $13 million. The additional SAMA candidates that would be retained for Phase II analysis are SAMAs 11, 15, 18, and 21.

The cost of implementation for SAMA 11 is over 81 percent of the 95th percentile modified MACR. The anticipated transient without scram (ATWS) sequences, which are the accident sequences addressed by this SAMA, are responsible for only a small portion of the risk profile. This SAMA is not expected to be cost beneficial even if it was 100 percent reliable.

The CDF based RRWs for the valves on which SAMA 15 is based are only 1.04. Small break LOCA sequences, which are the primary contributing sequences that include these events, have Level 2 based RRWs of about 1.1. Neither the random failure of the valves nor the small LOCAs are important external events contributors. Given 100 percent reliability of this SAMA, the averted cost-risk is expected to be less than 10 percent of the total. Given that the cost of implementation for SAMA 15 is about 50 percent of the 95th percentile modified MACR, this SAMA would not be cost beneficial.

SAMA 18 is based on events representing loss of the SWS supply path to the EDGs for cooling. While the Level 1 internal events importance list identified the event failures, the RRW values are only 1.011, which is near the threshold value for event review (1.01). These events are not contributors to the Level 2 importance list, which was also reviewed down to the 1.01 RRW value. No contribution to the external events results has been identified. The potential averted cost-risk for this SAMA is likely no more than a couple percent of the modified MACR. Given that the cost of implementation for this SAMA is about 50 percent of the 95th percentile modified MARC, it could not be cost beneficial even if it was 100 percent reliable.

SAMA 21 is considered in more detail in Section E.7.2.2.

E.7.2.2 PHASE II IMPACT

As mentioned above, it was necessary to make an assumption about the 95th percentile PSA results for the Level 2 and 3 analyses. The assumption that has been made is that the 95th percentile results have been represented by increasing the base dose-risk and economic cost risk in proportion to the Level 1 results. The factor of 2.3 is also assumed to propagate through the results for the model runs performed for the Phase II detailed calculations. This means that the averted cost-risks for each case will be increased by the same factor.

The following table provides a summary of the impact of using the 95th percentile PSA results in the detailed cost-benefit calculations that have been performed.

Results Summary for the 95th Percentile PSA Results

SAMA ID	Cost of Implementation	Averted Cost- Risk (Base)	Net Value (Base)	Averted Cost- Risk (95th Percentile)	Net Value (95th Percentile)	Change in Cost Effectiveness
3	$1,100,000	$792,863	-$307,137	$1,823,584	$723,584	Yes
4	$1,620,000	$85,366	-$1,534,634	$196,341	-$1,423,659	No
10	$200,000	$1,750,745	$1,550,745	$4,026,714	$3,826,714	No
13	$220,000	$262,212	$42,212	$603,089	$383,089	No
14	$2,900,000	$344,218	-$2,555,782	$791,702	-$2,108,298	No
16	$160,000	$236,734	$76,734	$544,489	$384,489	No
22	$110,000	$414,165	$304,165	$952,580	$842,580	No
23	$100,000	$344,218	$244,218	$791,702	$691,702	No

Of the SAMAs initially evaluated in the Phase II analysis, only SAMA 3 was found to be cost beneficial after having been classified as not cost-beneficial in the baseline results.

Due to SAMA 21's complex contribution to the Level 2 results, a detailed analysis was required to estimate the impact of the use of the 95th percentile PRA results on its disposition. The process used to analyze SAMA 21 is the same as the process used for the Phase II SAMAs. The details of the analysis are provided below.

E.7.2.2.1 SAMA Number 21: FPS Backup for Containment Spray

In the event that the core has already melted and cooling the vessel exterior is the primary concern, the cavity could be flooded to provide this cooling by using the FPS to pressurize the CS header. The CS System is also important for scrubbing releases after vessel failure and for cooling core debris once it has exited the vessel. While it is possible to use other systems to supplement the CS System, use of the FPS as the pumping source provides an added benefit over a pump that is dependent on AC power because two diesel fire pumps will be available during a SBO. Given that SBO is Palisades largest contributor to CS failure, use of the FPS for the cross-tie would maximize the benefit of the SAMA.

In order to represent this SAMA, the Level 2 model was modified by setting the events related to CS recovery to “TRUE”. The Level 1 model is not modified for this SAMA as the CS System has a minimal impact on CDF.

The cost of this enhancement has been estimated to be $7,000,000.

The results from this case indicate no reduction in CDF (CDF_{new}=4.05E-05 per year), a 36.6 percent reduction in dose-risk ($Dose\text{-}Risk_{new}$=20.3 person-rem per year), and a 39.0 percent reduction in OECR ($OECR_{new}$ = $76,260 per year). A further breakdown of this information is provided below according to release category.

Release Category	E-H	E-M	I-H	I-M	L-L	L-LL	Total
Baseline Freq.	3.55E-07	3.59E-06	2.60E-06	1.66E-05	4.37E-06	1.33E-05	4.08E-05
SAMA Freq.	3.08E-07	3.34E-06	2.40E-06	8.19E-06	2.49E-06	2.41E-05	4.08E-05
$Dose\text{-}Risk_{NEW}$	1.9	1.9	4.4	10.9	0.2	1.0	20.3
$OECR_{NEW}$	$3,817	$6,478	$20,814	$44,693	$124	$335	$76,260

This information was used as input to the cost-benefit calculation. The results of this calculation are provided in the following table.

SAMA Number 21 Net Value

Base Case Cost-Risk	Revised Cost-Risk	Averted Cost-Risk	Cost of Implementation	Net Value
$5,630,000	$4,078,596	$1,551,404	$7,000,000	-$5,448,596

The baseline averted cost-risk for this SAMA is $1,551,404, which yields a net value of -$5,448,596 given the $7,000,000 cost of implementation. The 95th percentile averted cost-risk is estimated by applying the factor of 2.3 to the baseline cases, which yields an averted cost-risk of $3,568,230. Given the net value is still negative (-$3,431,770), the conclusions related to this SAMA are not impacted by the use of the 95th percentile results.

E.7.3 IMPACT OF ASSUMED EFFECTIVENESS OF SEAL COOLING ON COST BENEFIT

A sensitivity study has been performed in order to identify how assumptions made about seal cooling effectiveness impact the results. It was assumed that implementation of SAMAs 14 and 23 will remove all risk related to consequential PCP LOCAs. This assumption was made due to the difficulty in assessing the true impact of the mitigative actions represented by the SAMAs.

The PCP seal failure event is a module – 55 percent is due to an operator action to trip the PCPs within 20 minutes, and 44 percent is related to successful PCP trip and isolation of controlled bleed-off with subsequent random failures. Crediting a new, aggressive cooldown strategy would require the development of a new operator action and the performance of a dependency analysis to prevent over estimating the impact of the SAMA. The same is true for aligning the FPS to SW as a backup cooling strategy. This sensitivity approximates the effects of operator dependence and provides what is considered to be a more realistic assessment of the results than the baseline analysis.

The alternate PCP seal cooling action shares many important qualities with the actions to trip the PCPs, including:

- Symptoms or action cues.
- Procedures: The same step in the procedure would likely direct both actions.
- Timing: The actions will be performed simultaneously or be performed in rapid succession.
- Goals: The actions are taken for the same reason.

Due to these shared qualities, the actions are considered to be completely dependent. No reduction is considered to be possible for the 55 percent of the PCP seal failure that is due to operator error. Success of the action is considered to eliminate the remaining contribution to seal failure. Changes to the applicable basic events indicate a 2.2 percent reduction in CDF (CDF_{new}=3.96E-05 per year), a 3.0 percent reduction in dose-risk ($Dose\text{-}Risk_{new}$=31.0 person-rem per year), and a 3.1 percent reduction in OECR ($OECR_{new}$ = $121,155 per year). A further breakdown of this information is provided below according to release category (as the model changes are equivalent for both SAMAs, the model results apply to both SAMAs).

Release Category	E-H	E-M	I-H	I-M	L-L	L-LL	Total
Baseline Freq.	3.55E-07	3.59E-06	2.60E-06	1.66E-05	4.37E-06	1.33E-05	4.08E-05
SAMA Freq.	3.44E-07	3.59E-06	2.60E-06	1.59E-05	4.36E-06	1.31E-05	3.90E-05
Dose-Risk$_{NEW}$	2.1	2.0	4.8	21.2	0.3	0.5	31.0
OECR$_{NEW}$	$4,266	$6,941	$22,535	$87,013	$218	$182	$121,155

This information was used as input to the cost-benefit calculations. The results of this calculation are provided in the following tables.

SAMA Number 14 Net Value

Base Case Cost-Risk	Revised Cost-Risk	Averted Cost-Risk	Cost of Implementation	Net Value
$5,630,000	$5,471,161	$158,839	$2,900,000	-$2,741,161

SAMA Number 23 Net Value

Base Case Cost-Risk	Revised Cost-Risk	Averted Cost-Risk	Cost of Implementation	Net Value
$5,630,000	$5,471,161	$158,839	$100,000	$58,839

Given that the baseline averted cost risk for SAMA 23 was estimated to be $344,218 each, the reduction in averted cost-risk to $158,839 corresponds to a change of 53.8 percent. This change would not alter the conclusions of the analysis assuming the cost of implementation of $100,000 is valid and that no credit is available from the FPS/SWS cross-tie.

The dominant sequence addressed by these SAMAs is successful secondary side cooling, successful HPSI and recirculation, and containment heat removal failure (SW failure). As discussed for SAMA 14, alternate seal cooling could be provided by aligning the FPS to the SWS. While SAMA 14 proposes enhancing the main CR to reduce the time required, it is likely that the local, manual actions to align FPS to SWS could be performed with a failure probability that is less than 1.0. This would further reduce the averted cost risk for SAMAs 14 and 23 below $158,839.

In addition, the Palisades cooldown limits are very restrictive and must satisfy 10CFR61 criteria. The Office of Nuclear Regulatory Research has undertaken a project aimed at developing the technical basis to support a fundamental revision of the pressurized thermal shock (PTS) rule and the associated PTS risk and criteria. This effort has been going on for many years and successful promulgation will not likely be achieved before

2006. Any changes to the PCS curves will not occur before the aforementioned PTS rule change.

E.8 CONCLUSIONS

The benefits of revising the operational strategies in place at Palisades and/or implementing hardware modifications can be evaluated without the insight from a risk-based analysis. Use of the PSA in conjunction with cost-benefit analysis methodologies has, however, provided an enhanced understanding of the effects of the proposed changes relative to the cost of implementation and projected impact on a offsite dose and economic impacts. The results of this study indicate that of the identified potential improvements that can be made at Palisades, several are cost beneficial based on the methodology applied in this analysis and warrant further review for potential implementation.

The baseline Phase II analysis indicates that the following SAMAs have positive net values:

- SAMA 10: Power independent turbine-driven AFW operation
- SAMA 13: Nitrogen station for automatic backup to CV-2010 air supply
- SAMA 16: Insulate EDG exhaust Ducts
- SAMA 22: Replace the Undervoltage Relay for Buses 1C and 1D with a higher fragility model
- SAMA 23: Direct PCS cooldown on loss of PCP seal cooling

SAMA 10 is a highly cost beneficial plant enhancement with a net value of nearly $1.5 million. It is recommended that this SAMA be considered for implementation at Palisades.

SAMA 13 has a positive net value, but it is only about 16 percent of the averted cost-risk associated with the SAMA. This implies that the margin by which it has been shown to be cost beneficial is small. In addition, the total averted cost risk is only about 4.7 percent of the modified MACR and indicates the risk reduction for this SAMA is small compared with the total plant risk. Use of the 3 percent real discount rate and the 95th percentile PSA results increase the margin by which SAMA 13 is cost beneficial.

SAMA 16 has a positive net value, which is about 32.4 percent of the averted cost-risk associated with the SAMA. While the margin by which it has been shown to be cost beneficial is larger than for SAMA 13, the overall risk decrease for SAMA 16 is smaller (about 4.2 percent of the modified MACR). As documented in Sections E.7.1 and E.7.2, use of the 3 percent real discount rate and the 95th percentile PSA results increase the margin by which SAMA 16 is cost beneficial. However, if SAMA 10 is implemented, the net value of SAMA 16 becomes negative, as shown in Section E.6.9. While the reduction in net value is believed to accurately reflect the reduced importance of this SAMA, it does not capture the desirability of maintaining the EDGs operable over use of local, and/or manual, operation of the turbine drive AFW pump.

SAMA 22 has been analyzed using the information available in the IPEEE. Given the lack of detail, conservative assumptions have been used to calculate the averted cost-risk for the SAMA, including:

- The SAMA is 100 percent reliable,
- The SAMA removes all seismic risk associated with the accident classes for which it has been identified as an important contributor (Classes IA and IB).

This SAMA could be considered for implementation; however, the potential conservatisms of the cost-benefit calculations should be weighed during the review process.

SAMA 23 also provides a relatively small averted cost risk, which is only about 6 percent of the modified MACR. While the net value is over 70 percent of its averted cost-risk, which implies it is cost beneficial by a considerable margin, there are other considerations that impact this SAMA. As discussed in Section E.7.3, the Office of Nuclear Regulatory Research is working to develop a technical basis to support a fundamental revision to the PTS rule. No changes are suggested to the cooldown rate until after the PTS rule change is complete.

Of the SAMAs evaluated in Phase II, SAMAs 3, 4, and 14 were found not to be cost beneficial in the baseline Phase II analysis. SAMAs 4 and 14 were shown to have negative net values even when the 95^{th} percentile PSA results were used in the cost-benefit calculations, as shown in Section E.7.2. These SAMAs are screened from further review. The net value for SAMA 3 changed from negative to positive when the 95^{th} percentile PSA results were applied, which implies that a conservative use of the PSA would identify SAMA 3 as cost effective. However, as there are several SAMAs that are shown to be cost beneficial using best estimate results, the priority of investigating this SAMA should be placed below them.

In summary, SAMAs 10, 13, and 16 show the largest potential for delivering a cost beneficial risk reduction at Palisades. While these results are believed to accurately reflect potential areas for improvement at the plant, NMC notes that this analysis should not necessarily be considered formally dispositioned as other engineering reviews are necessary to determine ultimate implementation. NMC will implement or continue to consider the 6 SAMAs (3, 10, 13, 16, 22, and 23) identified in the analysis through the appropriate Palisades design process.

TABLE E.2-1
PALISADES ACCIDENT CLASSES

Accident Class	Description
Class IA	Sequences that progress to core damage due to failure of secondary heat removal and OTC during the injection phase.
Class IB	Sequences that progress to core damage due to failure of secondary heat removal and OTC during the recirculation phase.
Class II	Sequences involving the loss of containment heat removal leading to containment failure and the subsequent loss of coolant inventory makeup.
Class IIIA	Sequences initiated by Small Break Loss of Coolant Accident (SBLOCA) with loss of primary coolant makeup during the injection phase. This class leads to core damage due to the inability to maintain sufficient PCS inventory during the injection phase of HPSI.
Class IIIB	Sequences initiated by SBLOCA with loss of primary coolant makeup during the recirculation phase. This class leads to core damage due to the inability to maintain sufficient PCS inventory during the recirculation phase of HPSI.
Class IIIC	Sequences initiated by a medium or large break loss of coolant accident with loss of primary coolant makeup during the injection phase. This class leads to core damage due to the inability to maintain sufficient PCS inventory during the injection phase of all engineered safeguards pumps.
Class IIID	Sequences initiated by a medium or large break loss of coolant accident with loss of primary coolant makeup during the recirculation phase. This class leads to core damage due to the inability to maintain sufficient PCS inventory during the recirculation phase of all engineered safeguards pumps.
Class IV	Sequences leading to core damage due to the failure of reactivity control. No fire initiator was identified that could credibly lead to a failure of the reactor protection system.
Class VA	Sequences involving interfacing system loss of coolant outside of containment with loss of effective coolant inventory makeup. Since the LOCA occurs outside of containment, the coolant lost from the PCS will not accumulate in the containment sump and, therefore, it is not available as a recirculation source. Thus, this class leads to core damage due to the inability to maintain sufficient PCS inventory after the SIRWT has been depleted.
Class VB	Sequences initiated by steam generator tube rupture with loss of effective coolant inventory makeup. This class contains those steam generator tube rupture initiated events that do not lead to core damage due to failure of decay heat removal, but rather due to the inability to maintain sufficient PCS inventory.

HPSI = high-pressure safety injection
OTC = once through cooling
PCS = Primary Coolant System
SBLOCA = small break loss of coolant accident
SIRWT = safety injection and refueling water tank

TABLE E.3-1
ESTIMATED POPULATION DISTRIBUTION WITHIN A 10-MILE RADIUS OF PALISADES, YEAR 2031

Sector	Distance from Palisades (miles)						
	0-1	1-2	2-3	3-4	4-5	5-10	Total
N	0	0	0	0	0	0	0
NNE	0	116	308	440	584	8,684	10,132
NE	0	110	269	520	498	3,499	4,896
ENE	0	103	173	263	205	1,631	2,375
E	4	78	129	210	212	1,361	1,994
ESE	0	87	191	461	206	1,208	2,153
SE	0	41	261	425	111	1,740	2,578
SSE	8	66	78	130	118	7,413	7,813
S	7	98	0	169	59	6,862	7,195
SSW	20	23	11	54	138	3,225	3,471
SW	0	0	0	0	0	0	0
WSW	0	0	0	0	0	0	0
W	0	0	0	0	0	0	0
WNW	0	0	0	0	0	0	0
NW	0	0	0	0	0	0	0
NNW	0	0	0	0	0	0	0
Total	39	722	1,420	2,672	2,131	35,623	42,607

TABLE E.3-2
ESTIMATED POPULATION DISTRIBUTION WITHIN A 50-MILE RADIUS OF PALISADES, YEAR 2031

Sector	Distance from Palisades (miles)					
	0-10	10-20	20-30	30-40	40-50	Total
N	0	0	16	12,102	20,302	32,420
NNE	10,132	4,868	18,761	125,935	98,104	257,800
NE	4,896	7,139	8,318	14,528	124,014	158,895
ENE	2,375	6,131	18,168	29,005	24,299	79,978
E	1,994	7,664	14,689	196,180	51,391	271,918
ESE	2,153	5,579	27,099	49,847	28,487	113,165
SE	2,578	8,271	9,866	11,233	32,725	64,673
SSE	7,813	8,330	16,965	22,925	179,110	235,143
S	7,195	7,646	22,748	66,187	271,821	375,597
SSW	3,471	60,698	37,387	15,494	28,222	145,272
SW	0	0	0	0	4,763	4,763
WSW	0	0	0	0	0	0
W	0	0	0	0	0	0
WNW	0	0	0	0	0	0
NW	0	0	0	0	0	0
NNW	0	0	0	0	0	0
Total	42,607	116,326	174,017	543,436	863,238	1,739,624

TABLE E.3-3
MACCS RELEASE CATEGORIES VS. PALISADES RELEASE CATGEGORIES

MACCS Release Groups	Palisades Release Categories
Xe/Kr	noble gases
I	CsI
Cs	CsOH
Sb/Te	Sb
Sr	SrO
Mo/Ru	MoO_2
La	$La2O_3$
Ce	CeO_2
Ba	BaO
Pu/Np	UO_2+NPO_2+PUO_2

TABLE E.3-4
MACCS BASE CASE RESULTS

MAAP Case	Release Category	Pop. Dose (Sv)	Costs ($)	Frequency (per yr)	Dose Risk (p-rem/yr)	Cost Risk ($/yr)
433	Early-High (E-H)	6.15E+04	1.24E+10	3.55E-07	2.18E+00	4.40E+03
485	Early-Moderate (E-M)	5.68E+03	1.94E+09	3.59E-06	2.04E+00	6.96E+03
460	Intermediate-High (I-H)	1.85E+04	8.68E+09	2.60E-06	4.81E+00	2.26E+04
613	Intermediate-Moderate (I-M)	1.33E+04	5.46E+09	1.66E-05	2.21E+01	9.06E+04
419	Late-Low (L-L)	6.54E+02	5.00E+07	4.37E-08	2.86E-01	2.19E+02
621	Late-Low Low (L-LL)	4.10E+02	1.39E+07	1.33E-05	5.45E-01	1.85E+02
Frequency Weighted Totals					3.19E+01	1.25E+05

TABLE E.3-5
ACCIDENT SEQUENCE TIMINGS AS A FUNCTION OF CONSEQUENCE CATEGORY – BASE CASE

Dominant Release Category	MAAP Case CET End State	General Emergency Declaration (hr)	Time of Initial Release (hr)	Plume Duration (hr)	Release Frequency (Per Reactor Yr)
E-H	433	0.9	1.3	2.0	3.55E-07
E-M	485	2.1	3.4	1.0	3.59E-06
I-H	460	5.7	27	2.0	2.60E-06
I-M	613	5.5	16.9	1.0	1.66E-05
			32	3.0	
L-L	419	40	41	2.0	4.37E-08
L-LL	621	63	65	6.0	1.33E-05

TABLE E.3-6
MACCS SENSITIVITY CASES RESULTS

Description	Population Dose Risk (Per-rem/yr)	Percent Change	Cost Risk ($/yr)	Percent Change
Base Case (Year 2000 Meteorological data; 1.8 mph evacation speed; evacauation 30 minutes after general declaration)	3.19E+1	--	1.07E+5	--
Year 2031 population values increased uniformly 30% over base case.	3.88E+1	22	1.61E+5	51
Evacuation speed decreased 50% to 0.9 mph, 0.41 m/sec (Base Case is 1.8 mph).	3.77E+1	18	1.25E+5	17
Evacuation begins 90 minutes after declaration of General Emergency (Base Case is 30 minutes).	3.57E+1	12	1.25E+5	17
Year 2001 Meteorological data	3.14E+1	-2	1.07E+5	--
Year 2002 Meteorological data	2.95E+1	-8	1.15E+5	7
Year 2003 Meteorological data	2.97E+1	-7	1.13E+5	6

mph = miles per hour
m/sec = meters per second

TABLE E.5-1
LEVEL 1 IMPORTANCE LIST REVIEW

Event Name	Probability	RRW	Description	Potential SAMAs
IE_LOOP	1.00E-02	1.459	Loss of off-site power	The presence of this initiating event indicates that it is important for Palisades; however, this event alone is too general to provide specific insights about the potential means of reducing plant risk. The ability to reduce the LOOP frequency is limited. High cost changes such as burying OSP lines or providing an independent off-site source have been shown in other SAMA submittals to not be cost effective. Switchyard work is already monitored to prevent activities that could result in a LOOP. In addition, the Safeguards transformer was added to preclude the need to transfer on a plant trip, which is a factor that will reduce the LOOP frequency for Palisades. An additional DG would help mitigate a LOOP event; however, this is addressed in the EDG failure events. No SAMAs suggested.
REC-30MIN	7.33E-01	1.458	Failure to recover OSP in 30 minutes	Add an additional EDG (SAMA 1). Add a DDDIP for SG make-up (SAMA 3).
REC-4HR	4.67E-01	1.367	Failure to recover OSP in 4 hours	Add an additional EDG (SAMA 1). Add a DDDIP for SG make-up (SAMA 3). The timing for this event is based on the conservative assumption that if power is not recovered by 4 hours that the batteries deplete and core damage ensues. No credit is given for AC power recovery in the time that is available prior to core damage related to steam generator dryout and boiloff of the RPV inventory
IE_SBLOCA	2.26E-03	1.352	Small break LOCA	The importance of this general initiating event category suggests that mitigating enhancements would include additional HPI capability and enhanced depressurization ability. Potential SAMAs related to this event include: 1) installation of an additional HPI pump (SAMA 4), or 2) installation of a new high pressure (HP) system (typically cost prohibitive and not included on the SAMA list). Improvement to the depressurization capability is also a change that would typically be associated with mitigating SBLOCA sequences; however, Palisades has already replaced the PORVs with upgraded models. A single PORV is now capable of accommodating the entire Feed and Bleed flow alone and can also depressurize the PCS in time to allow LPI before core damage give loss of SSHR. No depressurization SAMAs have been suggested.

Table E.5-1
Level 1 Importance List Review (Continued)

Event Name	Probability	RRW	Description	Potential SAMAs
IE_SGTR	3.01E-03	1.182	Steam generator tube rupture	The importance of this general initiating event category suggests that mitigating enhancements would include improved detection and isolation capabilities, enhancing makeup capabilities to the RPV, providing makeup to the SIRWT, greater primary side depressurization reliability, and means of reducing the initiating event frequency. Such enhancements might include: - additional instrumentation in the SG to measure radioactivity (SAMA 6), - additional HPI capability (SAMA 4), - make-up to the SIRWT (SAMA 5) - additional SGTR training (SAMA 7), - SG tube inspection/replacement (SAMA 8)
E-DG-ENGINE-REC-4HR	4.30E-01	1.109	EDG engine recovery in 4 hours	Add an additional EDG (SAMA 1). Add a DDDIP for SG make-up (SAMA 3).
P-LOOP-REC-CORR-4HR	3.27E-01	1.099	OSP correction factor for EDG 24-hour run time-4 hours	This is used for long-term LOOP cases. No action required.
E-DGMG-K-6B	5.00E-02	1.094	DG 1-2 fails to run	Add an additional EDG (SAMA 1). Add timely AC cross tie capability for accident response (SAMA 9). Proceduralize TD AFW pump manual throttling during a SBO. (SAMA 10). A portable generator could also be used to provide power to the battery chargers for long-term DC support (SAMA 2).
IE_TRANS-WC	2.00E+00	1.081	Transient with main condenser available	This event is important due to its contribution to ATWS sequences. It should be noted that the most recent available data suggests that the frequency of this initiating event is overestimated by a factor of two, which would reduce the importance of this event. Further, the failure probabilities of mechanical and electrical RPS subsystems are also overestimated. Quantitative assessments of the cost-benefit of ATWS related SAMAs should address these data issues. Given this, potential means of reducing risk could include installing a new, unique system to inject borated water in an ATWS (SAMA 11). Alternatively, logic could be installed for auto boron injection with the CVCS pumps given a scram condition with high reactor power (SAMA 12).

Table E.5-1
Level 1 Importance List Review (Continued)

Event Name	Probability	RRW	Description	Potential SAMAs
RXC-MECH-FAULTS	1.00E-05	1.081	RPS mechanical failure - CRDS	This event is important due to its contribution to ATWS sequences. However, the failure probabilities of the mechanical and electrical RPS subsystems are overestimated. The frequency of the most common ATWS initiating event is also considered to be overestimated by a factor of 2. Quantitative assessments of the cost-benefit of ATWS related SAMAs should address these data issues. Given this, potential means of reducing risk could include installing a new, unique system to inject borated water in an ATWS (SAMA 11). Alternatively, logic could be installed for auto boron injection with the CVCS pumps given a scram condition with high reactor power (SAMA 12).
E-DGMG-K-6A	5.00E-02	1.08	DG 1-1 fails to run	Add an additional EDG (SAMA 1). Add timely AC cross tie capability for accident response (SAMA 9). Proceduralize the use of the TD AFW pump so that it can be used after battery depletion during a SBO event (SAMA 10). A portable generator could also be used to provide power to the battery chargers for long-term DC support (SAMA 2).
E-DGOO-K-6B	1.82E-02	1.069	DG 1-2 out of service	Add an additional EDG (SAMA 1). Add timely AC cross tie capability for accident response (SAMA 9). Proceduralize the use of the TD AFW pump so that it can be used after battery depletion during a SBO event (SAMA 10). A portable generator could also be used to provide power to the battery chargers for long-term DC support (SAMA 2).
IE_LOIA	1.13E-01	1.065	Loss of instrument air	This initiating event is often paired with the operator action to open valve CV-2010 (A-AVOA-CV-2010), which is required on failure of instrument air. This importance of the Loss of Instrument Air initiating event could be reduced if a Nitrogen Station were installed to automatically back up the air supply to valve CV-2010 (SAMA 13). This change has been added to the SAMA list.
G-PMOE-P-55ABC	5.64E-02	1.06	Operator fails to initiate charging flow	Over 99.9 percent of the contributors for this event are related to ATWS scenarios. While the charging pumps are equipped with auto initiation logic, it is not designed to function for ATWS conditions; thus, the operator action is required. SAMAs 11 and 12 address ATWS scenario risk reduction.

Table E.5-1
Level 1 Importance List Review (Continued)

Event Name	Probability	RRW	Description	Potential SAMAs
H-ZZOA-OTC-CDTNL-HEP-2	3.66E-01	1.057	Operator fails to adjust AFW flow given flow instrument	This event is a conditional HEP that addresses the potential dependence between AFW control and establishing OTC. While some degree of dependence may be justified, the operators will perform OTC based on a different set of cues and use different procedures. The value of 3.7E-01 that is currently used for this action is considered to be high. Use of low dependence would reduce the RRW of this event to about 1.007, which is below the review cutoff for SAMA. Other systems or function initiated by operator action would likely be assumed to carry the same level of dependence as the initiation of OTC; therefore, no large reductions could be claimed through manual recovery actions. Automatic controls are a potential change, but the existing AFW controls are unreliable and are not used. Auto OTC is not considered viable by plant personnel. No SAMAs suggested.
B-XVOB-ADVS-MAN	4.03E-02	1.056	Operator fails to close manual valves to close ADV	This event is important due to its impact on providing steam flow to the turbin-driven AFW pump and for its role in modeling two steam generator blowdown. The two steam generator blowdown model is recognized to be overly conservative in that it assumes all AFW is terminated and isolated when an ADV is stuck open. In actuality, the lesser impacted steam generator is maintained in operation and used to mitigate the accident. No SAMAs are considered to be required to address the effects of two steam generator blowdown. The DDDIP (SAMA 3) addresses the loss of steam flow to the TD AFW pump. No additional SAMAs are suggested.
A-AVOA-AFWFLADJ	1.45E-03	1.052	Operator fails to adjust AFW flow given failure of one HDR	An automatic system was purchased to control AFW flow; however, it was found to be unreliable and is not used at Palisades. Operator intervention is considered to be the best means of controlling the AFW system, and no additional auto AFW controls are suggested for Palisades. In the event that AFW fails, improved primary side heat removal reliability would be beneficial. Several SAMAs are already included to address this issue including the installation of a new HPI pump (SAMA 4) and proceduralizing the removal of plugged air filters to allow RAS (SAMA 17). No additional SAMAs are suggested based on this event.

Table E.5-1
Level 1 Importance List Review (Continued)

Event Name	Probability	RRW	Description	Potential SAMAs
A-AVOA-CV-2010	2.59E-03	1.049	Operator fails to open CV-2010 for T-939 makeup to CST	Procedures currently exist that direct the cross-tie of Feedwater Purity Air to the Instrument Air system to provide a backup source of air; however, this action is not credited. Including this credit would likely provide only a small benefit as the dependence between the cross-tie operator action and the action to open the valve manually would likely be assessed as "high". Other operator actions to recover secondary side heat removal after loss of CST makeup would be assessed in a similar manner, which indicates that an automatic function or primary side actions would be required to mitigate the failure represented by this event. A Nitrogen Station could be installed to provide automatic backup to the air supply to valve CV-2010 (SAMA 13).
A-OOOT-CSTMK-CDTNL-HEP-1	4.99E-01	1.049	Operator fails to make up to CST given failure of A-AVOA-CV-2010	Procedures currently exist that direct the cross-tie of Feedwater Purity Air to the Instrument Air system to provide a backup source of air; however, this action is not credited. Including this credit would likely provide only a small benefit as the dependence between the cross-tie operator action and the action to open the valve manually would likely be assessed as "high". Other operator actions to recover secondary side heat removal after loss of CST makeup would be assessed in a similar manner, which indicates that an automatic function or primary side actions would be required to mitigate the failure represented by this event. A Nitrogen Station could be installed to provide automatic backup to the air supply to valve CV-2010 (SAMA 13).
IE_LOSWS	7.31E-04	1.049	Loss of SWS	Over 97 percent of the risk from loss of SW is based on RCP seal failures after loss of SW support for seal cooling. A potential mitigating enhancement is to modify the MCR to include controls for the FPS to SW cross-tie (SAMA 14). Currently, the cross-tie requires local manipulation and the time assumed to be required to perform the cross-tie is longer than the time that is estimated to be available. Having the cross-tie controls in the MCR would reduce the manipulation time to the extent that credit could be taken for alternate seal cooling.
PP-PMMT-CCW-MBLOCA	2.35E-03	1.049	PCP seal failure given a SBO and consequential medium break LOCA	A potential mitigating enhancement is to modify the MCR to include controls for the FPS to SW cross-tie (SAMA 14). Currently, the cross-tie requires local manipulation and the time assumed to be required to perform the cross-tie is longer than the time that is estimated to be available. Having the cross-tie controls in the MCR would reduce the manipulation time to the extent that credit could be taken for alternate seal cooling.

Table E.5-1
Level 1 Importance List Review (Continued)

Event Name	Probability	RRW	Description	Potential SAMAs
SGTRA	5.00E-01	1.049	Steam generator tube rupture on SG A	These are fractions used to symmetrically allocate the initiating event between the SGs. No SAMA required.
SGTRB	5.00E-01	1.049	Steam generator tube rupture on SG B	These are fractions used to symmetrically allocate the initiating event between the SGs. No SAMA required.
E-DGOO-K-6A	1.91E-02	1.048	DG 1-1 out of service	Add an additional EDG (SAMA 1). Add timely AC cross tie capability for accident response (SAMA 9). Proceduralize the use of the TD AFW pump so that it can be used after battery depletion during a SBO event (SAMA 10). A portable generator could also be used to provide power to the battery chargers for long-term DC support (SAMA 2).
W-AVOA-PZR-SPRAY	1.30E-03	1.044	Operator fails to depressurize PCS with PZR spray/aux spray	This action is important for SGTR only. Removing the need for an operator action could theoretically be addressed by installing an automatic depressurization system. It would have to be capable of maintaining an appropriate pressure differential between the PCS and the secondary side during a tube rupture event. A more cost beneficial means of improving the pressure control function is considered to be the installation of a DDDIP to supplement the current AFW system (SAMA 3).
Y-AVMD-CV-3027	4.44E-04	1.04	Air operated valve CV-3027 fails to remain open	The primary contributor to the importance of this event is its failure after a small LOCA. Installing a bypass line to prevent pump dead head with an MOV controllable from the MCR is a change that could reduce the impact of this failure (SAMA 15).
Y-AVMD-CV-3056	4.44E-04	1.04	Air operated valve CV-3056 fails to remain open	The primary contributor to the importance of this event is its failure after a small LOCA. Installing a bypass line to prevent pump dead head with an MOV controllable from the MCR is a change that could reduce the impact of this failure (SAMA 15).
RXC-ELEC-FAULTS	2.00E-06	1.039	RPS electrical failure	This event is important due to its contribution to ATWS sequences. However, the failure probabilities of the mechanical and electrical RPS subsystems are overestimated. The frequency of the most common ATWS initiating event is also considered to be overestimated by a factor of 2. Quantitative assessments of the cost-benefit of ATWS related SAMAs should address these data issues. Given this, potential means of reducing risk could include installing a new, unique system to inject borated water in an ATWS (SAMA 11). Alternatively, logic could be installed for auto boron injection with the CVCS pumps given a scram condition with high reactor power (SAMA 12).

Table E.5-1
Level 1 Importance List Review (Continued)

Event Name	Probability	RRW	Description	Potential SAMAs
REC-HVAC	9.40E-02	1.034	Operator fails to recover DG room HVAC	Portable cooling fans are in place near the EDG rooms to provide alternate cooling; however, low credit is taken for alignment of alternate cooling due to the short amount of time available before room heat up. Installing insulation on the EDG exhaust ducts would increase the time available to align recovery by reducing the heat radiated to the room from the ducts (SAMA 16).
P-CBCC-SG-MA	3.50E-04	1.033	Common cause failure of a BRKR to open on each load shed channel	Actions to manually close these breakers are currently available, but not credited. In addition, the diesels are capable of operating without the load shed and it is not required for success. No SAMAs suggested.
MTC-NOTTRIP	1.60E-01	1.028	Negative moderator temperature coefficient - no turbine trip	No suggestions are made for changing the probability of having an unfavorable moderator temperature coefficient in an ATWS.
IE_LOMF	6.00E-01	1.024	Loss of main feedwater	Installation of a direct drive AFW pump would help mitigate loss of feedwater scenarios (SAMA 3). A potential means of reducing spurious Feedwater trips is through the installation of digital feedwater controls, but Palisades has already performed this update and no additional benefit is considered attainable through control refinement. No measurable reductions in the feedwater initiating event frequency are assumed to be possible by enhancing the existing Palisades training program. No new SAMAs suggested.
Y-AVCC-3027-56MB	3.09E-04	1.022	Both SIRWT recirc valves CV-3027 & CV-3056 common cause FTC	The primary contributor to the importance of this event is its failure after a small LOCA. Installing a bypass line with an MOV controllable from the MCR is a change that could reduce the impact of this failure (SAMA 15).
H-ZZOA-OTC-INIT	2.90E-03	1.021	Operator fails to initiate OTC	Improvements could be made to improve the SSHR reliability to prevent the need to use OTC for the cases in which there is no leak in the primary loop. These types of enhancements include installation of a DDDIP (SAMA 3). It should also be noted that the current model does not credit the Feedwater Purity Air to IA Cross-tie to allow makeup to the CST. While operator action dependence issues will limit the benefit of modeling this action, it will show an improvement in the SSHR function.

Table E.5-1
Level 1 Importance List Review (Continued)

Event Name	Probability	RRW	Description	Potential SAMAs
U-PMOO-P-7B	5.39E-03	1.021	P-7B out of service for maintenance	The Palisades model includes a simplification that results in only crediting the "B" SW train for EDG B cooling. This simplification artificially increases the importance of the "B" pump (any SW pump can supply any EDG). There is no actual weakness in the plant design and no SAMAs are suggested. In addition, the definition used for maintenance "unavailability" to develop the number used in the model does not reflect the PRA definition of unavailability. The unavailability suggested by the data is higher than appropriate, which artificially inflates the importance of the SWS.
A-OOOT-CSTMK-CDTNL-HEP-2	1.43E-01	1.02	Operator fails to make up to CST given failure to initiate SDC	Installation of a Nitrogen Station for automatic backup of the CV-2010 valve has been included on the SAMA list (SAMA 13). This SAMA would reduce the requirements for manual CST makeup action. Due to operator dependence issues, further changes would also have to include automatic equipment in order to reduce the risk related to sequences including this action. Given the low importance of the action, these types of changes are not likely to be cost beneficial.
L-ZZOA-SDC-INIT	1.55E-02	1.02	Operator fails to initiate SDC	The most important sequences that include SDC initiation failure are the Loss of Instrument Air sequences. In these cases, crediting the Feedwater Purity Air cross-tie to the Instrument Air system will reduce the importance of SDC initiation failure by some degree. This is because the sequences which include SDC failures also question operation of long-term secondary side cooling as potential success path. In turn, long-term secondary side cooling depends on CST makeup, which is partially dependent on the IA system. Crediting the feedwater purity cross-tie will show an improvement in the reliability of long-term secondary side cooling, which will reduce the failure probability of the relevant sequences. A SAMA for providing a Nitrogen Station for automatic backup of the CV-2010 air supply has also been added to the SAMA list (SAMA 13). The DDDIP AFW (SAMA 3) enhancement will also improve these sequences given that this SAMA assumes the pump will have an independent suction source.
X-HSE-SGA-BLDN	1.00E+00	1.019	Set to 'T' - ESDE on SG E-50A	These events are labels for SG blowdown combinations that lead to AFW failure. The direct drive AFW pump would reduce the impact of SG blowdown (SAMA 3).

Table E.5-1
Level 1 Importance List Review (Continued)

Event Name	Probability	RRW	Description	Potential SAMAs
Y-AVOB-RAS-VLVS	2.60E-04	1.018	Operator fails to enable ESS recirc valves to close on RAS	A potential SAMA would be to change the existing logic so that the recirc and CS header valves will automatically close on RAS regardless of valve control position. An inhibit switch could be provided to prevent this actuation for the conditions in which it is not desirable. However, the current PRA conservatively models the impact of this function's failure. Failing to close one of the CS headers does result in inadequate NPSH for the HPSI pumps, but only during a LOCA with an EDG failure such that only one CS pump is available. Given that it is only a small fraction of the sequences requiring RAS, no true benefit is considered to be attainable through pursuit of the potential changes identified above. No SAMAs are suggested.
IE_LOMC	4.13E-01	1.017	Loss of main condenser vacuum	No measurable reduction in the initiating event frequency is assumed to be possible for this initiator through training improvements. Improving mitigation is judged to be the only practical means of reducing the risk of accident sequences resulting from this initiator. The installation of a DDDIP is an enhancement that would reduce the risk posed by this initiator (SAMA 3).
X-HSE-SGB-BLDN	1.00E+00	1.017	Set to 'T' - ESDE on SG E-50B	These events are labels for SG blowdown combinations that lead to AFW failure. The direct drive AFW pump would reduce the impact of SG blowdown (SAMA 3).
I-FLMK-F-321	5.31E-03	1.016	Air filter F-321 plugged	Proceduralize pulling the plugged filters out of the air path for emergency operation (SAMA 17).
MTC-TTRIP	2.00E-02	1.016	Negative moderator temperature coefficient - turbine trip	No suggestions are made for changing the probability of having an unfavorable moderator temperature coefficient in an ATWS.
I-FLMK-F-319	5.31E-03	1.015	Air filter F-319 plugged	Proceduralize pulling the plugged filters out of the air path for emergency operation (SAMA 17).
L-ZZOA-SDC-CDTNL-HEP	1.53E-01	1.015	Operator fails to initiate SDC given failure to depressurize	A potential change would be to install auto cooldown logic to reduce the operator dependence; however, improving the secondary side heat removal capabilities is a more desirable approach. Installation of the direct drive diesel AFW pump is considered to address this event (SAMA 3).
Y-AVCC-SUMP-MA	2.09E-04	1.015	CCF of CV-3029 & CV-3030 to open	Install a makeup system for the SIRWT (SAMA 5).
B-HCMA-HIC-0780A	1.14E-02	1.014	SDCR controller HIC-0780A fails to de-energize	This is addressed by the discussion for event “B-XVOB-ADVS-MAN”.

Table E.5-1
Level 1 Importance List Review (Continued)

Event Name	Probability	RRW	Description	Potential SAMAs
E-AVCC-0884-85MA	1.60E-04	1.014	Common cause of the SWS supply to DGS CV-0884 & CV-0885	Provide a dedicated pump and line for EDG cooling (SAMA 18).
E-AVMA-CV-0885	2.28E-03	1.011	SWS supply to DG 1-2 CV-0885 FTO	Provide a dedicated pump and line for EDG cooling (SAMA 18).
H-KVMB-SV-3071	3.93E-03	1.011	P-66A subcooling solenoid valve SV-3071 FTE	Provide a cross-tie between the high-pressure pump suction lines to provide access to the opposite train of cooled water (SAMA 19). While this is an option, it has been shown that Palisades does not require the sub-cooling connection to provide adequate NPSH for RAS.
U-FLCC-TRAV-SCRN	8.19E-06	1.011	CCF of traveling screens	Improve traveling screen performance (SAMA 20).
Z-KVMB-SV-3029A	3.93E-03	1.011	Sump to east ESS air supply SV-3029A FTE	This valve controls operating air flow to CV-3029 (SAMA 5). Installing a makeup system for the SIRWT would preclude the need to take suction from the sump.
Z-KVMB-SV-3029B	3.93E-03	1.011	Sump to east ESS air supply SV-3029B FTE	This valve controls operating air flow to CV-3029 (SAMA 5). Installing a makeup system for the SIRWT would preclude the need to take suction from the sump.
Z-LSOH-SIRW-HI	1.30E-04	1.011	SIRWT level switches miscalibrated high	This miscalibration term is related to the conductivity probes used to measure the tank level. The probe conductors are cut to a specified length such that when the water drops below that point, there is no means to complete the circuit and the open circuit is interpreted as a low water level. The potential problem is related to cutting the probes short. In this case, the water level would drop below the conductors and result in a "low water" signal and an early RAS initiation. A potential problem with early RAS for Palisades is inadequate NPSH due to low pump head. However, the miscalibration event has been described as a small miscalibration in the probes, which is not considered to result in loss of NPSH when containment backpressure is considered. No SAMAs suggested.
H-AVCC-HPISUBCLG	1.48E-04	1.01	Common cause opening failure for subcooled suction valves	This event is driven by LOCA events, for which subcooling in not an issue. The model conservatively includes this event in those sequences thereby artificially increasing the importance of the subcooling valves. No SAMAs are required or suggested based on this event.

Table E.5-1
Level 1 Importance List Review (Continued)

Event Name	Probability	RRW	Description	Potential SAMAs
H-KVMB-SV-3070	3.93E-03	1.01	P-66B subcooling solenoid valve SV-3070 FTE	Provide a cross-tie between the high-pressure pump suction lines to provide access to the opposite train of cooled water (SAMA 19). While this is an option, it has been shown that Palisades does not require the sub-cooling connection to provide adequate NPSH for RAS.
IE_LOCA-PZRSRV	1.38E-02	1.01	PZR stuck open safety valve - small break LOCA	Add motor operated isolation valves to the relief lines that can be closed in the event that a relief valve sticks open. This enhancement would mitigate the event; however, it is noted that regulations do not allow for such a valve to be included on a relief line and addition of the MOV is not suggested as a SAMA. This event is considered to be addressed by enhanced HPI capability (SAMA 4).
Z-KVMB-SV-3030A	3.93E-03	1.01	Sump to west ESS air supply SV-3030a FTE	This valve controls operating air flow to CV-3030. Installing a makeup system for the SIRWT would preclude the need to take suction from the sump (SAMA 5).
Z-KVMB-SV-3030B	3.93E-03	1.01	Sump to west ESS air supply SV-3030b FTE	This valve controls operating air flow to CV-3030. Installing a makeup system for the SIRWT would preclude the need to take suction from the sump (SAMA 5).
R-REMD-TVX-4	6.52E-03	1.01	Relay TVX-4 fails to remain de-energized	Further investigation of the testing procedures for the TX-4 and TVX-4 relays indicated that the current test interval is shorter than what is assumed in the PSA model. If the failure probabilities for these relays are updated to match plant practices, their RRWs decrease to 1.001, which is below the RRW SAMA screening cutoff of 1.01. As a result, no SAMAs are required to address failures of the TX-4 or TVX-4 relays for Palisades. This issue has been screened from further review.
R-REMD-TX-4	6.52E-03	1.01	Relay TX-4 fails to remain de-energized	Further investigation of the testing procedures for the TX-4 and TVX-4 relays indicated that the current test interval is shorter than what is assumed in the PSA model. If the failure probabilities for these relays are updated to match plant practices, their RRWs decrease to 1.001, which is below the RRW SAMA screening cutoff of 1.01. As a result, no SAMAs are required to address failures of the TX-4 or TVX-4 relays for Palisades. This issue has been screened from further review.

Table E.5-1
Level 1 Importance List Review (Continued)

Event Name	Probability	RRW	Description	Potential SAMAs
P-CBMA-152-211	2.00E-03	1.01	Breaker 152-211 fails to open	Add an additional logic loop such as the opening of 1 of 2 breakers will satisfy the signal requirements. The Palisades model does not credit the existing procedures to manually recover from failure of these breakers. If this credit was included in the model, the importance of these events would fall below the screening criteria for the SAMA analysis. No SAMAs are suggested.
P-CBMA-52-1201	2.00E-03	1.01	Breaker 52-1201 fails to open	Add an additional logic loop such as the opening of 1 of 2 breakers will satisfy the signal requirements. The Palisades model does not credit the existing procedures to manually recover from failure of these breakers. If this credit was included in the model, the importance of these events would fall below the screening criteria for the SAMA analysis. No SAMAs are suggested.
H-C2CC-HPSIPP-MB	1.13E-04	1.01	Both HPSI pump BKRS 152-113 & 152-207 common cause FTC	The pump failure rates already include the breaker failures and the use of separate events is considered to be conservative. No SAMAs are suggested based on these events.

AC = alternating current
ADV = atmospheric dump valve
AFW = Auxiliary Feedwater
ATWS = anticipated transient without scram
CCF = common cause failure
CRDS = Control Rod Drive System
CST = condensate storage tank
CVCS = Chemical Volume Control System
DC = direct current
DDDIP = direct drive diesel injection pump
DG = Diesel generator
EDG = emergency diesel generator
ESDE = excessive steam demand event
ESS = engineered safeguard system
FPS = Fire Protection System
FTC = failure to close
FTE = failure to energize
FTO = failure to open
HDR = header
HEP = human error probability
HPI = high-pressure injection
HPSI = high-pressure safety injection
IA = instrument air
LOCA = loss of coolant accident
LOOP = loss of offsite power
LPI = low-pressure injection
MCR = Main Control Room
MOV = motor-operated valve
NPSH = net positive suction head
OSP = offsite power
OTC = once through cooling
PCP= primary coolant pump
PCS = Primary Coolant System
PORV = pressure operated relief valve
PRA = probabilistic risk assessment
PZR = pressurizer
RAS = recirculation actuation signal
RCP = reactor coolant pump
RPS = Reactor Protection System
RPV = reactor pressure vessel
RRW = risk reduction worth
SAMA = severe accident mitigation alternative
SBLOCA = small break loss of coolant accident
SBO = station blackout
SDC = shutdown cooling
SDCR = steam dump controller
SG = steam generator
SGTR = steam generator tube rupture
SIRWT = safety injection and refueling water tank
SSHR = safe shutdown heat removal
SWS = service water system
TD = turbine driven

TABLE E.5-2
LEVEL 2 IMPORTANCE LIST REVIEW (BASED ON LERF)

Basic Event	Probability	RRW	Description	Potential SAMAs
CE-TW-TRANSIENT	1.00E+00	1.720	Turbine trip initiator	This event is completely tied to CET_TEJW. No additional SAMAs required.
CET_TEJW	1.29E-05	1.720	PDS FREQ | TRANSIENT | NO CACS + NO SPRAYS + NO SIRWT + NO SG COOLING [Important contributors include: REC-30MIN, IE_LOOP, E-DGMG-K-6B, E-DGMG-K-6A]	The important contributors are addressed in the Level 1 RRW list or subsumed by a similar event.
CE-TW-CSP	1.00E+00	1.719	CS failed early	CS reliability could be improved through providing additional pumping capability with the FPS (SAMA 21).
CE-TW-REVAPTMNG	1.00E+00	1.298	Revaporization occurs after containment failure	Revaporization could be prevented by successful operation of CS. CS reliability could be improved through providing additional pumping capability with the FPS (SAMA 21).
CE-TW-SECONDCOOL	1.00E+00	1.298	All SG secondary cooling failed	Addressed in the Level 1 RRW list or subsumed by a similar event.
CE-TW-DRYOUTTMNG	1.00E+00	1.226	Pool dryout occurs after containment failure	Improving the reliability of CS is an effective means of reducing the likelihood of pool dryout. CS reliability could be improved through providing additional pumping capability with the FPS (SAMA 21).

Table E.5-2
Level 2 Importance List Review (Based on LERF) (continued)

Basic Event	Probability	RRW	Description	Potential SAMAs
CE-TW-CRDBAFTBD	5.00E-01	1.190	Most of the core debris exits the vessel after blowdown	Ensuring that the containment has water on the floor will help limit the damage that core relocation may cause. Enhancing CS is a means of increasing the probability that the cavity can be flooded. Using the FPS to backup CS is a method to achieve this (SAMA 21).
CET_DEJP	3.98E-06	1.158	PDS FREQ | SGTR | SPRAYS + CACS + NO SG COOLING [Important contributors include: B-XVOB-ADVS-MAN, A-AVOA-AFWFLADJ, IE_SGTR, H-ZZOA-OTC-CDTNL-HEP-2, W-AVOA-PZR-SPRAY]	The important contributors are addressed in the Level 1 RRW list or subsumed by a similar event.
CE-DP-SGTR	1.00E+00	1.158	Steam generator tube rupture initiator	Addressed in the Level 1 RRW list or subsumed by a similar event.
CE-TW-VFTIMELONG	5.60E-01	1.136	Time to vessel failure after core relocation very long	The probability that the time to vessel failure after core re-location is long may be improved by ensuring that the cavity is flooded. A potential means of providing water to the cavity would be to pressurize the CS header with the FPS (SAMA 21).
CE-TW-PZSRVFTC	4.75E-01	1.127	PZR code safety fails open	Addressed in the Level 1 RRW list or subsumed by a similar event.
CE-TW-HOTLEGFAIL	4.41E-01	1.122	Heating induces hot leg failure	This event represents creep rupture of the hot leg of the RCS during and/or after a core damage event. For Palisades, hot leg failure is preferable to creep rupture in the steam generator tubes, which is a competing failure mode (SGTR leads to an early release). Preventing core damage is the best approach to reduce the importance of these events, which are related to turbine trip initiators. The DDDIP will address this issue (SAMA 3). No additional SAMAs are suggested.

Table E.5-2
Level 2 Importance List Review (Based on LERF) (continued)

Basic Event	Probability	RRW	Description	Potential SAMAs
CET_DEJS	2.80E-06	1.113	PDS FREQ | SGTR | CACS + NO SIRWT + NO SG COOLING [Important contributors include: IE_SGTR, W-AVOA-PZR-SPRAY]	The important contributors are addressed in the Level 1 RRW list or subsumed by a similar event.
CE-DS-SGTR	1.00E+00	1.113	Steam generator tube rupture initiator	Addressed in the Level 1 RRW list or subsumed by a similar event.
CET_BEGR	4.06E-06	1.110	PDS FREQ | SMALL LOCA | CACS+SIRWT + SG COOLING [Important contributors include: IE_SBLOCA. Y-AVCC-3027-56MB is the second highest contributor and is added for completeness even though the RRW for this event is below 2.0]	Addressed in the Level 1 RRW list or subsumed by a similar event.
CE-BR-SBLOCA	1.00E+00	1.110	SBLOCA initiator	Addressed in the Level 1 RRW list or subsumed by a similar event.
CE-BR-CSP	1.00E+00	1.107	CS failed early	CS reliability could be improved through providing additional pumping capability with the FPS. This has been included on the SAMA list.
CE-DS-CSP	1.00E+00	1.107	CS failed early	CS reliability could be improved through providing additional pumping capability with the FPS (SAMA 21).
CE-2R-MBLOCA	1.00E+00	1.062	Medium break LOCA initiator	This event is completely tied to CET_A2EGR. No additional SAMAs required.
CET_A2EGR	1.84E-06	1.062	PDS FREQ | MLARGE LOCA | CACS+SIRWT + SG COOLING [Important contributors include: PP-PMMT-CCW-MBLOCA and IE_LOSW]	The important contributors are addressed in the Level 1 RRW list or subsumed by a similar event.
CE-2R-CSP	1.00E+00	1.062	CS failed early	CS reliability could be improved through providing additional pumping capability with the FPS (SAMA 21).

Table E.5-2
Level 2 Importance List Review (Based on LERF) (continued)

Basic Event	Probability	RRW	Description	Potential SAMAs
CE-2R-DRYOUTTMNG	1.00E+00	1.061	Pool dryout occurs after containment failure	Improving the reliability of CS is an effective means of reducing the likelihood of pool dryout. CS reliability could be improved through providing additional pumping capability with the FPS (SAMA 21).
CET_ZEGP	4.42E-06	1.059	PDS FREQ | ATWS | SPRAYS + CACS + SG COOLING [Important contributors include: RXC-MECH-FAULTS, IE_TRANS-WC, G-PMOE-P-55ABC]	Addressed in the Level 1 RRW list or subsumed by a similar event.
CE-ZP-TRANSIENT	1.00E+00	1.059	Turbine trip initiator	This initiator is linked to ATWS events, which are addressed in the Level 1 RRW list.
CE-BR-DRYOUTTMNG	1.00E+00	1.051	Pool dryout occurs after containment failure	Improving the reliability of CS is an effective means of reducing the likelihood of pool dryout. CS reliability could be improved through providing additional pumping capability with the FPS (SAMA 21).
CE-ZP-NCCVDBCNFG	7.50E-01	1.046	Debris config in cavity non-coolable	The ability to cool a debris pool is enhanced if the debris pool forms in an existing water pool rather than on a dry cavity floor that is later covered with water. Enhancing CS is a means of increasing the probability that the cavity can be flooded. Using the FPS to backup CS is a method to achieve this (SAMA 21).
CE-BP-SBLOCA	1.00E+00	1.043	SBLOCA initiator	Addressed in the Level 1 RRW list or subsumed by a similar event.
CET_BEGP	6.26E-06	1.043	PDS FREQ | SMALL LOCA | SPRAYS + CACS + SG COOLING [Important contributors include: IE_SBLOCA, Y-AVMDCV-3056, Y-AVMDCV-3027, Y-AVCC-3027-56MB, Y-AVOB-RAS-VLVS]	Addressed in the Level 1 RRW list or subsumed by a similar event.

Table E.5-2
Level 2 Importance List Review (Based on LERF) (continued)

Basic Event	Probability	RRW	Description	Potential SAMAs
CET_TEJP	2.50E-06	1.040	PDS FREQ | TRANSIENT | SPRAYS + CACS + NO SG COOLING. [Important contributors include: IE_LOOP, REC-4HR, REC-30MIN, IE_LOIA, A-OOOT-CSTMK-CDTNL-HEP1, A-AVOA-CV-2010]	Addressed in the Level 1 RRW list or subsumed by a similar event.
CE-TP-TRANSIENT	1.00E+00	1.040	Turbine trip initiator	This event is completely tied to CET_TEJP. No additional SAMAs required.
CE-BR-NCCVDBCNFG	7.50E-01	1.038	Debris config in cavity non-coolable	The ability to cool a debris pool is enhanced if the debris pool forms in an existing water pool rather than on a dry cavity floor that is later covered with water. Enhancing CS is a means of increasing the probability that the cavity can be flooded. Using the FPS to backup CS is a method to achieve this (SAMA 21).
CE-BR-CRDBAFTBD	5.00E-01	1.033	Most of the core debris exits the vessel after blowdown	Ensuring that the containment has water on the floor will help limit the damage that core relocation may cause. Enhancing CS is a means of increasing the probability that the cavity can be flooded. Using the FPS to backup CS is a method to achieve this (SAMA 21).
CE-BR-VFTIMELONG	5.00E-01	1.033	Time to vessel failure after core relocation very long	The probability that the time to vessel failure after core re-location is long may be improved by ensuring that the cavity is flooded. A potential means of providing water to the cavity would be to pressurize the CS header with the FPS (SAMA 21).

Table E.5-2
Level 2 Importance List Review (Based on LERF) (continued)

Basic Event	Probability	RRW	Description	Potential SAMAs
CE-BP-NCCVDBCNFG	7.50E-01	1.033	Debris config in cavity non-coolable	The probability that the debris will be non-coolable is directly related to the presence of water on the containment floor. Core debris entering a water pool has a greater chance of remaining coolable. Thus, enhancing CS reliability or providing an alternate method of flooding the cavity would increase the probability of successfully mitigating the consequences of a core melt. Using the FPS to pressurize the CS header is a potential means of increasing the cavity flooding reliability (SAMA 21).
CE-TP-NCCVDBCNFG	7.50E-01	1.030	Debris config in cavity non-coolable	The probability that the debris will be non-coolable is directly related to the presence of water on the containment floor. Core debris entering a water pool has a greater chance of remaining coolable. Thus, enhancing CS reliability or providing an alternate method of flooding the cavity would increase the probability of successfully mitigating the consequences of a core melt. Using the FPS to pressurize the CS header is a potential means of increasing the cavity flooding reliability (SAMA 21).
CE-2R-VFTIMELONG	9.50E-01	1.028	Time to vessel failure after core relocation very long	The probability that the time to vessel failure after core re-location is long may be improved by ensuring that the cavity is flooded. A potential means of providing water to the cavity would be to pressurize the CS header with the FPS (SAMA 21).
CE-ZP-CRDBAFTBD	5.00E-01	1.025	Most of the core debris exits the vessel after blowdown	Ensuring that the containment has water on the floor will help limit the damage that core relocation may cause. Enhancing CS is a means of increasing the probability that the cavity can be flooded. Using the FPS to backup CS is a method to achieve this (SAMA 21).

Table E.5-2
Level 2 Importance List Review (Based on LERF) (continued)

Basic Event	Probability	RRW	Description	Potential SAMAs
CE-DS-CNCATKTMG1	1.00E+00	1.025	Concrete attack in upper containment begins after early containment failure	This phenomenon can be mitigated with CS, but the important part of the CS function is that the spray headers operate successfully. Having cooling water in the upper part of the containment area is the important issue for this event rather than ensuring that the containment floor is flooded (SAMA 21).
CE-2R-NCCVDBCNFG	7.50E-01	1.022	Debris config in cavity non-coolable	The probability that the debris will be non-coolable is directly related to the presence of water on the containment floor. Core debris entering a water pool has a greater chance of remaining coolable. Thus, enhancing CS reliability or providing an alternate method of flooding the cavity would increase the probability of successfully mitigating the consequences of a core melt. Using the FPS to pressurize the CS header is a potential means of increasing the cavity flooding reliability (SAMA 21).
CE-TP-CRDBAFTBD	5.00E-01	1.019	Most of the core debris exits the vessel after blowdown	Ensuring that the containment has water on the floor will help limit the damage that core relocation may cause. Enhancing CS is a means of increasing the probability that the cavity can be flooded. Using the FPS to backup CS is a method to achieve this (SAMA 21).
CE-BP-VFTIMELONG	9.50E-01	1.018	Time to vessel failure after core relocation very long	The probability that the time to vessel failure after core re-location is long may be improved by ensuring that the cavity is flooded. A potential means of providing water to the cavity would be to pressurize the CS header with the FPS (SAMA 21).
CE-ZP-PCSRETEN	5.50E-01	1.018	Significant retention of PCS fission products	In the event that the fission products are not retained early or if revaporization occurs late, use of CS will limit the release of the fission products to the environment. A potential means of improving CS is to provide a means for the FPS pumps to pressurize the CS header (SAMA 21).

Table E.5-2
Level 2 Importance List Review (Based on LERF) (continued)

Basic Event	Probability	RRW	Description	Potential SAMAs
CET_TEJS	5.36E-07	1.017	PDS FREQ | TRANSIENT | CACS + NO SIRWT + NO SG COOLING [Important contributors include: IE_LO-ALL4PREFAC, X-HSE-SGA-BLDN, X-HSE-SGB-BLDN, B-RVMB-SRV-SGA, B-RVMB-SRV-SGB]	Events X-HSE-SGA-BLDN and X-HSE-SGB-BLDN are addressed in the Level 1 importance list, but IE_LO-ALL4PREFAC is not explicitly included. Loss of the preferred instrument buses result in AFW failures due to spurious low suction pressure trips, HPSI fails on spurious RAS, and main Feedwater system is failed due to excessive steam demands that are present in a majority of the cutsets linked to this event. The DDDIP can be used to mitigate this situation assuming that the pump does not include low suction pressure trips and that it can feed either steam generator (to address excessive steam demand events) (SAMA 3). No additional SAMAs have been suggested based on this event.
CE-TS-TRANSIENT	1.00E+00	1.017	Turbine trip initiator	This event is completely tied to CET_TEJS. No additional SAMAs required.
CE-TS-CSP	1.00E+00	1.017	CS failed early	CS reliability could be improved through providing additional pumping capability with the FPS. This has been included on the SAMA list (SAMA 21).
CE-TS-NCCVDBCNFG	9.90E-01	1.015	Debris config in cavity non-coolable	The probability that the debris will be non-coolable is directly related to the presence of water on the containment floor. Core debris entering a water pool has a greater chance of remaining coolable. Thus, enhancing CS reliability or providing an alternate method of flooding the cavity would increase the probability of successfully mitigating the consequences of a core melt. Using the FPS to pressurize the CS header is a potential means of increasing the cavity flooding reliability (SAMA 21).
CE-ZP-VFTIMELONG	9.50E-01	1.012	Time to vessel failure after core relocation very long	The probability that the time to vessel failure after core re-location is long may be improved by ensuring that the cavity is flooded. A potential means of providing water to the cavity would be to pressurize the CS header with the FPS (SAMA 21).

Table E.5-2
Level 2 Importance List Review (Based on LERF) (continued)

Basic Event	Probability	RRW	Description	Potential SAMAs
CET_BEGS	4.43E-07	1.012	PDS FREQ | SMALL LOCA | CACS + NO SIRWT + SG COOLING [Important contributors include: IE_SBLOCA and Z-LSOH-SIRW-HI]	The important contributors are addressed in the Level 1 RRW list or subsumed by a similar event.
CE-BS-SBLOCA	1.00E+00	1.012	SBLOCA initiator	This event is completely tied to CET_BEGS. No additional SAMAs required.
CE-BP-PCSRETEN	5.00E-01	1.012	Significant retention of PCS fission products	In the event that the fission products are not retained early or if revaporization occurs late, use of CS will limit the release of the fission products to the environment. A potential means of improving CS is to provide a means for the FPS pumps to pressurize the CS header (SAMA 21).
CE-BS-CSP	1.00E+00	1.012	CS failed early	CS reliability could be improved through providing additional pumping capability with the FPS (SAMA 21).
CET_TEJR	3.76E-07	1.011	PDS FREQ | TRANSIENT | CACS+SIRWT + NO SG COOLING [Important events include: IE_LOIA, A-AVOA-CV-2010, A-OOOT-CSTMK-CDTNL-HEP-1]	The important contributors are addressed in the Level 1 RRW list or subsumed by a similar event.
CE-TR-TRANSIENT	1.00E+00	1.011	Turbine trip initiator	This event is completely tied to CET_TEJR. No additional SAMAs required.
CE-TR-CSP	1.00E+00	1.011	CS failed early	CS reliability could be improved through providing additional pumping capability with the FPS (SAMA 21).
CE-BP-CSPFAILRIV	5.00E-02	1.011	Accident progression fails CS	Given that several different CS system failure modes related to the effects of accident progression have been identified, preventing a core melt is considered to be more effective than mitigating the effects of the melt to prevent CS system failure. This event is linked with the initiator group CET_BEGP, which is already addressed. No additional SAMAs suggested.

Table E.5-2
Level 2 Importance List Review (Based on LERF) (continued)

Basic Event	Probability	RRW	Description	Potential SAMAs
CE-BS-NCCVDBCNFG	9.90E-01	1.011	Debris config in cavity non-coolable	The probability that the debris will be non-coolable is directly related to the presence of water on the containment floor. Core debris entering a water pool has a greater chance of remaining coolable. Thus, enhancing CS reliability or providing an alternate method of flooding the cavity would increase the probability of successfully mitigating the consequences of a core melt. Using the FPS to pressurize the CS header is a potential means of increasing the cavity flooding reliability (SAMA 21).
CE-TS-SECONDCOOL	1.00E+00	1.010	All SG secondary cooling failed	The Direct Drive Diesel Injection AFW pump addresses the importance of this event (SAMA 3).
CE-TS-REVAPTMNG	1.00E+00	1.010	Revaporization occurs after containment failure	Revaporization could be prevented by successful operation of CS. CS reliability could be improved through providing additional pumping capability with the FPS (SAMA 21).

AFW = Auxiliary Feedwater
CS = Containment Spray
ATWS = anticipated transient without scram
DDDIP = direct drive diesel injection pump
FPS = Fire Protection System
HPSI = high-pressure safety injection
LERF = large early release frequency
PCS = Primary Coolant System
PZR = pressurizer
RAS = recirculation actuation system
RCS = reactor coolant system
RRW = risk reduction worth
SAMA = severe accident mitigation alternative
SBLOCA = small break loss of coolant accident
SG = steam generator
SGTR = steam generator tube rupture
SIRWT = safety injection and refueling water tank

TABLE E.5-3
PHASE I SAMA

SAMA ID	SAMA TITLE	SAMA DESCRIPTION	SOURCE	PHASE 1 DISPOSITION	RETAINED FOR PHASE II ANALYSIS?
1	Additional EDG	This SAMA would help mitigate LOOP events and would reduce the risk of on-line EDG maintenance. Benefit would be increased if the additional DG could 1) be substituted for any current diesel that is in maintenance, and 2) if the diesel was of a diverse design such that CCF dependence was minimized.	Palisades Level 1 Importance List	The cost of installing an additional EDG has been estimated to be greater than $20 million in the Calvert Cliffs Application for License Renewal (BGE 1998). As this is greater than the Palisades modified MACR, it has been screened from further analysis.	No
2	Portable Generator for DC Support	This SAMA would allow the continued operation of AFW after battery depletion in SBO scenarios by supplying power to instrumentation necessary to monitor pump operation, flow, and steam generator level.	Palisades Level 1 Importance List	This enhancement addresses the same sequences addressed by SAMA 10. Given that SAMA 10 does not require the interface of non-Class 1E equipment with Class 1E equipment and because no hardware changes are required for SAMA 10, it is considered to be the more desirable of the two approaches. This SAMA is an alternate approach to SAMA 10 of operating P-8B during a SBO scenario. In addition the cost of this enhancement is $310,000, which is greater than the $270,000 for proceduralizing the use of the turbine drive AFW pump after battery depletion.	No

Table E.5-3
Phase I SAMA (Continued)

SAMA ID NUMBER	SAMA TITLE	SAMA DESCRIPTION	SOURCE	PHASE 1 DISPOSITION	RETAINED FOR PHASE II ANALYSIS?
3	Direct Drive Diesel Injection Pump	A DDDIP could be used to supplement AFW. This SAMA primarily has the potential of reducing the risk of SBO scenarios by providing an injection method to supplement the turbine-driven AFW pump. For long-term SBO benefit, this SAMA should include the use of a portable generator to provide instrumentation and valve power as well as a hard pipe connection to the FPS for suction.	Palisades Level 1 and Level 2 Importance List, IPEEE (Fire)	Palisades has estimated the cost of installing a DDDIP to be $1,100,000. As this estimate is less than the Palisades modified MACR, this SAMA has been retained for Phase II analysis.	Yes

Table E.5-3
Phase I SAMA (Continued)

SAMA ID NUMBER	SAMA TITLE	SAMA DESCRIPTION	SOURCE	PHASE 1 DISPOSITION	RETAINED FOR PHASE II ANALYSIS?
4	Enhanced HPI Capability	An additional HPI pump would increase HPI redundancy and reduce the probability of requiring RPV depressurization early in an accident. Given that Palisades converted an original HPSI pump (located in the West Engineered Safeguards Room) to an AFW pump (P-8C), the power and piping tie ins to add the additional pump are available. The P-8C conversion back to a HPSI pump would include reconstructing existing connections and restoring instrumentation and controls. However, installation of a new AFW pump to replace the restored P-8C as a HPSI pump would be required. Installation of a new pump would be difficult due to the present AFW space limitations. Besides locating a new AFW pump, new piping runs would be required to connect to the present P-8C feedwater connections.	Palisades Level 1 Importance List	Palisades has estimated the cost of this SAMA to be $1,620,000. As this estimate is less than the Palisades modified MACR, this SAMA has been retained for Phase II analysis.	Yes

Table E.5-3
Phase I SAMA (Continued)

SAMA ID NUMBER	SAMA TITLE	SAMA DESCRIPTION	SOURCE	PHASE 1 DISPOSITION	RETAINED FOR PHASE II ANALYSIS?
5	Emergency Make-up to the SIRWT	For SGTR or ISLOCA accidents in which inventory is not available for recirculation from the sump, the ability to provide make-up to the SIRWT will prolong the availability of injection. For cases where inventory is not being transferred outside of containment, SIRWT make-up would also provide for increased time to repair other cooling options. However, as described under the Phase 1 Disposition column, many issues would arise by increasing the amount of water in containment.	Palisades Level 1 Importance List, IPE	Prolonging the injection phase will result in raising the containment water level for breaks within containment. Such an increase would require raising the location of numerous transmitters, valves, and the containment air coolers. Additional tri-sodium phosphate would be required in order to maintain the containment pool pH above 7 in order to preclude iodine re-evolution. A variety of engineering design calculations would require re-analysis including seismic, the containment response analysisetc. Based on the fact that the containment is of finite size, the injection phase cannot continue indefinitely and it does not place the reactor in a stable state, which is not necessarily a success path. Finally, any measurable benefit resulting from implementation of this SAMA would be generated from increasing the repair/recovery probability for heat removal equipment, which is difficult to justify. Based on these insights, this SAMA would not be recommended for implementation and is screened from further review.	No

Table E.5-3
Phase I SAMA (Continued)

SAMA ID NUMBER	SAMA TITLE	SAMA DESCRIPTION	SOURCE	PHASE 1 DISPOSITION	RETAINED FOR PHASE II ANALYSIS?
6	Additional Instrumentation in the SG to Measure Radioactivity	Early detection of a SGTR may increase the probability of successful isolation and mitigation.	Palisades Level 1 Importance List	The Palisades model includes the failure to identify an SGTR event as part of an HEP. The instrumentation currently available to the Palisades operators is sufficient to allow them to make the determination that an SGTR has occurred and the human reliability analysis credits the cues from this instrumentation. More instrumentation will not lower the probability of failure to respond to the cue. As a result, there would be no measurable change in the ability of the operators to diagnose a steam generator tube rupture event. Screened from further review.	No
7	Additional Training on SGTR Accidents	Enhanced training on detection and mitigation of SGTR scenarios may improve operator response.	Palisades Level 1 Importance List	Accident training is recognized as an important component of plant safety and effort has been made at Palisades to use PSA insights to influence training topics. Recent training cycles, such as the 04A 2004 SGTR simulator scenarios, demonstrate that SGTR is recognized as an important initiator. Simulator training scenarios include: - SGTR with Faulted SG Cooldown - SGTR with ADV release - SGTR and ESDE - SGTR with Loss of IA No additions to the current training regime have been identified that would measurably improve operator response to SGTR events. Screened from further review.	No

Table E.5-3
Phase I SAMA (Continued)

SAMA ID NUMBER	SAMA TITLE	SAMA DESCRIPTION	SOURCE	PHASE 1 DISPOSITION	RETAINED FOR PHASE II ANALYSIS?
8	SG Tube Inspection, Replacement	Improved maintenance on the SG tubes may reduce the frequency of tube ruptures.	Palisades Level 1 Importance List	Palisades has already performed a steam generator replacement. In addition, an analysis has been performed that indicates the current Palisades inspection program adequately monitors the steam generator tubes for integrity. Screened from further review.	No
9	AC Cross-Tie	Provide capability to cross-tie 2.4kV AC buses from the MCR and update procedures to direct their use in emergency conditions. The implementation of the cross-ties is proceduralized only at the 480v level. SOP-30, Station Power, Rev 41, section 7.3 provides direction for: - supplying bus 11 from bus 12 - supplying bus 12 from bus 11 - supplying bus 13 from xfrmr 14 - supplying bus 14 from xfrmr 13, etc.	Palisades Level 1 Importance List	Hardware connections do not currently exist at Palisades to allow an AC cross-tie at the 2.4kV level. Palisades has estimated the cost of this enhancement to be $6,000,000, which is greater than the modified MACR. While the Palisades importance list did not indicate that the 480v AC cross-tie capability should be examined, it was investigated as part of this SAMA. The existing 480v AC cross-ties would impact low importance scenarios as the 480v AC components have RRW values that are below 1.01. A 2.4kV bus cross-tie would require installing a third independent Class 1E train. A third train would require a separate room/building, the installation of a third diesel, separate cable runs from the switchyard etc. Screened from further review.	No

Table E.5-3
Phase I SAMA (Continued)

SAMA ID NUMBER	SAMA TITLE	SAMA DESCRIPTION	SOURCE	PHASE 1 DISPOSITION	RETAINED FOR PHASE II ANALYSIS?
10	Power Independent Turbine Driven AFW Operation	Proceduralize P-8B operation so that it can operate indefinitely given no ac, dc or control air support. Provisions could be made to adjust AFW flow based on decay heat level so that SG level can be maintained without overfilling the steam generators when instrumentation fails on dc power depletion in a SBO event. This SAMA would also impact the fire initiated SBO sequences.	Palisades Level 1 and Level 2 Importance List, IPEEE (Fire)	Changes to AFW pump P-8B have removed support system dependencies such that pump P-8B could operate after battery depletion. Given that the hardware changes are already in place for this SAMA, only procedure changes and analysis are required for implementation (note that acoustic monitoring may be considered to augment the procedure changes as well). Palisades has estimated the cost of this enhancement to be $270,000. As this is less than the Palisades modified MACR, it has been retained for Phase II analysis.	Yes
11	Additional Boron Injection System	An additional high-pressure boron injection system would increase the means of injecting boron into the PCS in an ATWS. Diversity from the existing CVCS system would maximize the benefit.	Palisades Level 1 Importance List	The Palisades ATWS CDF contribution has been over-predicted by 75% because of the conservative RPS data employed. Moreover, an additional high-pressure boron injection train would require the construction of a new building, new piping layouts, new PCS connections, new power cabling, I&C cubicles, instrumentation, main CR modifications etc. Finally, the cost of this SAMA has been estimated to be $10,700,000, which is greater than the Palisades modified MACR. This SAMA is screened from further review.	No

Table E.5-3
Phase I SAMA (Continued)

SAMA ID NUMBER	SAMA TITLE	SAMA DESCRIPTION	SOURCE	PHASE 1 DISPOSITION	RETAINED FOR PHASE II ANALYSIS?
12	Automate Boron Injection for ATWS Conditions	Modify the CVCS so that injection from the BASTs will automatically occur in an ATWS. This system could operate in a manner similar to the SLC system in a BWR.	Palisades Level 1 Importance List	The Palisades ATWS CDF contribution has been over-predicted by 75% because of the conservative RPS data employed. A BWR Standby Liquid Control (SLC) system does not functionally translate into an equivalent PWR design. For example; - BWRs operate at much lower PCS conditions. - BWR SLC systems operate in a less severe environment when considering the electrical environmental qualification requirements when considering steam line break loads. This is a concern when including high-energy explosive valves in the design. Adding ATWS BWR mitigation features to a PWR system is not design feasible. This SAMA is screened from further review.	No
13	Nitrogen Station for Automatic Backup to CV-2010 Air Supply	Loss of Instrument Air is the primary contributor to the failure of CST makeup. Providing a Nitrogen Station that would automatically provide a backup air supply to CV-2010 would reduce the importance of the Loss of IA to the valve.	Palisades Level 1 Importance List	The cost of this SAMA is estimated at $220,000. This includes installation of a new bottled gas nitrogen station for auto-backup of air supply to valve CV2010, including piping, valves, instrumentation and procedure changes.	Yes

Table E.5-3
Phase I SAMA (Continued)

SAMA ID NUMBER	SAMA TITLE	SAMA DESCRIPTION	SOURCE	PHASE 1 DISPOSITION	RETAINED FOR PHASE II ANALYSIS?
14	Enhance the MCR to Include Controls for the Cross-tie Between SW and the FPS	In the event that the SWS fails, providing a means to align the Fire Water system to the SWS in the MCR will reduce the time required to perform the action. This action is necessary to allow FPS to provide cooling of the CCW Heat exchanger, which is critical for providing cooling water to the RCP seals.	Palisades Level 1 Importance List	Palisades has estimated the cost of this enhancement to be $2,900,000. As this is less than the modified MACR, it has been retained for further analysis.	Yes

Table E.5-3
Phase I SAMA (Continued)

SAMA ID NUMBER	SAMA TITLE	SAMA DESCRIPTION	SOURCE	PHASE 1 DISPOSITION	RETAINED FOR PHASE II ANALYSIS?
15	Bypass Around SIRWT Return Valves	Failure of the SIRWT return valves to open results in failure of the injection pumps. A bypass line around these valves would provide an alternate means of ensuring that the pumps do not overheat.	Palisades Level 1 Importance List	Adding a bypass around the SIRWT return lines could potentially prevent damage to the emergency core cooling system (ECCS) pumps. However, this pathway would increase the number of potential leakage paths for contaminated containment sump water back to the SIRWT during the re-circ phase of a DBA. An increased number of leakage paths would result in an increase in the rate and total amount of leakage to the SIRWT. Due to the low pH of the SIRWT water (pH ~4.5 - 5.5), any iodine in this back-leakage would undergo significant re-volatilization. Due to the proximity of the SIRWT vent to the main CR HVAC normal intakes (the normal intakes are also the assumed intake path for unfiltered main CR in leakage during emergency main CR HVAC operation), the main CR design basis dose consequences would be affected, as the dose is extremely sensitive to releases from the SIRWT. Therefore, this SAMA would increase the DBA dose consequences significantly and would require plant modifications to the main CR HVAC system and/or the SIRWT exhaust in addition to the postulated supplemental suction lines. Palisades has estimated the cost of implementing this SAMA to be $6,550,000, which is greater than the modified MACR. This SAMA is screened from further review.	No

Table E.5-3
Phase I SAMA (Continued)

SAMA ID NUMBER	SAMA TITLE	SAMA DESCRIPTION	SOURCE	PHASE 1 DISPOSITION	RETAINED FOR PHASE II ANALYSIS?
16	Insulate EDG Exhaust Ducts	Action to check that SW is aligned to the EDGs after a start is already taken based on previous plant experience, but the action is not proceduralized. The steps are taken immediately to prevent overheating the EDGs engines and could include credit for opening the EDG room doors for alternate room cooling if procedures were provided. However, because the time available is short, the error rate for the action would be high. Insulating the EDG exhaust ducts will reduce the heat load in the room and provide additional time to align alternate room cooling in the event that room cooling has failed.	Palisades Level 1 Importance List	Palisades has estimated the cost of implementing this SAMA to be $160,000 which is less than the modified MACR. Retained for Phase II analysis.	Yes
17	Proceduralize Air Filter Removal for Emergency Operation	Filters F-321 and F-319 are located in the air pathways that provide motive power to valves CV-3071 and CV-3070. In the event that the filters plug, the valves will be inoperable and failure of RAS is assumed. Procedures could be developed or new PPACs created to either direct the removal of the plugged filters to allow operation of the valves or increase the inspection frequency.	Palisades Level 1 Importance List	The cost of procedure change is on the order of $50,000 to $100,000 (CPL 2004), which is less than the modified MACR. Retained for Phase II analysis.	Yes

Table E.5-3
Phase I SAMA (Continued)

SAMA ID NUMBER	SAMA TITLE	SAMA DESCRIPTION	SOURCE	PHASE 1 DISPOSITION	RETAINED FOR PHASE II ANALYSIS?
18	Provide a Dedicated Pump and Line for EDG Cooling	While SW cooling is backed by the FPS system, line failures can cause loss of cooling to the EDGs that would not be mitigated by the existing FPS connection. A dedicated pump and line to the EDGs to serve as the primary cooling source would reduce the system dependencies.	Palisades Level 1 Importance List	Palisades has estimated the cost of implementing this SAMA to be $6,500,000, which is greater than the Palisades modified MACR. This SAMA is screened from further review.	No
19	Provide HPI Suction Crosstie to the Opposite Heat Exchanger	This cross-tie is an enhancement to specifically address failures of the HPSI pump suction sub-cooling (CV-3070 & CV-3071) valves between the heat exchangers and the HPI pumps.	Palisades Level 1 Importance List	The SAMA has been screened from further review. Refer to SAMA 17.	No

Table E.5-3
Phase I SAMA (Continued)

SAMA ID NUMBER	SAMA TITLE	SAMA DESCRIPTION	SOURCE	PHASE 1 DISPOSITION	RETAINED FOR PHASE II ANALYSIS?
20	Traveling Screens Improved Performance	Palisades has addressed traveling screen summer and winter issues with training and procedures.	Palisades Level 1 Importance List	The traveling screens contribution to the list of candidate events for SAMA is due only to the common cause event for failure of both screens. The contribution from this common cause term is low (RRW = 1.011). The current model takes no credit for operator actions to mitigate the consequences of loss of or degraded flow through the traveling screens. Palisades operating experience with degraded flow through the screens has been related to frazzle ice conditions and blockage of the screens during the fall when there is an increase in debris in the lake. Off-Normal Procedure ONP 6.01 (Loss of SW) provides specific guidance related to responding to indications of degraded flow. The guidance includes actions to take in response to high dp on the screens and low level in the SW bay. The specified actions include; - Trip an operating Dilution Water pump. - If the problem persists trip the second operating Dilution Water pump. - Ensure screens are backwashing. - Align P-5 (Warm Water Recirculation pump) for siphon operation. - Use P-5 to supply water to the intake structure. These actions are consistent with the types of SAMAs that would be developed to address the common cause failure of the traveling screens and no additional enhancements are suggested. This SAMA is screened from further review.	No

Table E.5-3
Phase I SAMA (Continued)

SAMA ID NUMBER	SAMA TITLE	SAMA DESCRIPTION	SOURCE	PHASE 1 DISPOSITION	RETAINED FOR PHASE II ANALYSIS?
21	FPS Backup for CS	In the event that the core has already melted and cooling the vessel exterior is the primary concern, the cavity could be flooded using the diesel-driven fire pumps.	Palisades Level 2 Importance List	This SAMA would require a separate piping layout configuration that would allow firewater to be directly sprayed into the annular region around the lower head in the reactor cavity. A new containment penetration with isolation valves would be required. The cost of routing new piping through a new containment penetration, around equipment at the 590 foot elevation and through the bioshield has been estimated to be $7,000,000. As this cost is greater than the modified MACR, this SAMA is screened from further review.	No
22	Replace the Undervoltage Relays for Buses 1C and 1D with a Seismically Qualified Model	Failure of the undervoltage relay results in failure of the automatic start of EDG 1-2, which provides power to the AFW pump (pump 8C) with a water source more likely to survive a seismic event (SW). This EDG also supplies two SW pumps versus one pump on bus 1C. A more durable relay would reduce the contributions from loss of power to bus 1D. Credit of the SW/FPA cross-tie would remove the model asymmetry and this SAMA would apply to both divisions.	Palisades IPEEE (Seismic)	Palisades has established the cost of this SAMA to be $55,000. Multiplying this estimate by 2 is considered to address both divisions. As this cost is less than the Palisades modified MACR, this SAMA has been retained for Phase II analysis.	Yes

Table E.5-3
Phase I SAMA (Continued)

SAMA ID NUMBER	SAMA TITLE	SAMA DESCRIPTION	SOURCE	PHASE 1 DISPOSITION	RETAINED FOR PHASE II ANALYSIS?
23	Direct PCS Cooldown on Loss of RCP Seal Cooling	While Palisades has upgraded the plant's reactor coolant pumps with new N-9000 seals, the cooldown process may further reduce the probability of seal failures related to long-term high temperature exposure or thermal shock after recovery of CCW.	Dresden Application for License Renewal (Exelon 2003a)	The cost of procedure changes can vary depending of the specific application. For this SAMA, a range of $50,000 to $100,000 is considered to be reasonable based on the procedure change estimates developed by CPL (CPL 2004). The upper bound of $100,000 is used for this case as the EOPs and training programs would have to be updated. As this is less than the Palisades modified MACR, it has been retained for Phase II analysis.	Yes

AC = alternating current
ADV = atmospheric dump valve
AFW = Auxiliary Feedwater
ATWS = anticipated transient without scram
BAST = Boric Acid Storage Tank
BWR = boiling water reactor
CCF = common cause failure
CCW = circulating cooling water
CDF = core damage frequency
CPL = Carolina Power and Light
CR = Control Room
CST = condensate storage tank
CVCS = chemical volume control system
DBA = Design Basis Accident
DC = direct current
DDDIP = direct drive diesel injection pump
DG = diesel generator
ECCS = Emergency Core Cooling System
EDG = emergency diesel generator
EOP = Emergency Operating Procedure
ESDE = excessive steam demand event
FPS = Fire Protection System
HEP = Human error probability
HPI = high-pressure injection
HPSI = high-pressure safety injection
HVAC = Heating, Ventilation, and Air Conditioning
I&C = Instrumentation and Controls
IA = instrument air
IPE = Independent plant evaluation
IPEEE = Independent Plant Evaluation for External Events
ISLOCA = interfacing system loss of coolant accident
kV = kilovolt
LOOP = loss of off-site power
MACR = maximum attainable cost risk
MCR = Main Control Room
ONP = Off Normal Procedure
PCS = Primary Coolant System
PPAC = Periodic and predetermined activity control
PSA = probabilistic safety analysis
PWR = pressurized water reactor
RAS = recirculation actuation signal
RCP = reactor coolant pump
RPS = reactor protection system
RPV = reactor pressure vessel
RRW = risk reduction worth
SAMA = severe accident mitigation alternative
SBO = station blackout
SGTR = steam generator tube rupture
SIRWT = safety injection and refueling water tank
SLC = standby liquid control
SOP = Standard Operating Procedure
SW = service water
SWS = Service Water System

TABLE E.5-4
PHASE II SAMA

SAMA ID NO.	SAMA TITLE	SAMA DESCRIPTION	ESTIMATED COST	COMMENT	BASELINE PHASE II DISPOSITION
3	Direct Drive Diesel Injection Pump	A DDDIP could be used to supplement AFW. This SAMA primarily has the potential of reducing the risk of SBO scenarios by providing an injection method to supplement the turbine-driven AFW pump. For long-term SBO benefit, this SAMA should include the use of a portable generator to provide instrumentation and valve power as well as a permanent connection to the FPS for suction.	The cost of installing a new non-safety related DDDIP was estimated to be $1,100,000 including permanent suction connection from the FPS, permanent discharge connection to the AFW header, associated check valves, isolation valves, fuel supply system, exhaust system, room HVAC modifications, piping and instrumentation; as well as a new portable generator to provide power for instrumentation and valves for long-term SBO benefit.	The averted cost-risk associated with installing a direct drive diesel driven AFW pump is $792,863. As this is less than the estimated cost of implementation, the SAMA is not cost beneficial.	Not cost beneficial. Refer to Section E.6.1 for additional details.
4	Enhanced HPI Capability	An additional HPI pump would increase HPI diversity and reduce the probability of requiring RPV depressurization early in an accident. Given that Palisades converted an original HPSI pump P-8C to an AFW pump and that the converted pump was not moved; pump P-8C can be converted back to its original use as a HPSI pump. However, a new AFW pump would have to be installed as part of this configuration change which involves space related issues, all of which would increase the cost of this SAMA.	The cost of restoring P-8C as a HPSI pump was estimated to be $1,620,000 and includes converting P-8C from its current use as an AFW pump back to its original use as a HPSI pump and installing a new AFW pump, including valves, piping and instrumentation. Due to space limitations for the new AFW pump, significant study and conceptual design is required, and significant piping runs may be required.	The averted cost-risk associated with installing an additional HPI pump is $85,366. As this is less than the estimated cost of implementation, the SAMA is not cost beneficial.	Not cost beneficial. Refer to Section E.6.2 for additional details.

TABLE E.5-4
PHASE II SAMA

SAMA ID NO.	SAMA TITLE	SAMA DESCRIPTION	ESTIMATED COST	COMMENT	PHASE II DISPOSITION
10	Power Independent Turbine Driven AFW	Modify the TD AFW train so that it can operate indefinitely without AC, DC, or pneumatic support. Provisions could be made to direct AFW flow adjustments based on decay heat level so that SG level can be maintained when instrumentation fails on DC power depletion. This SAMA would also impact the seismic sequences in which failure of EDG fuel oil tank T-10 results in loss of long-term AC and DC power.	Changes to the AFW pump P-8B have removed support system dependencies such that pump P-8B could operate after battery depletion. Given that the hardware changes are already in place for this SAMA, only procedure changes and analysis are required for implementation (note that acoustic monitoring may be considered to augment procedure changes, as well). Palisades has estimated the cost of this enhancement to be $270,000.	The averted cost-risk associated with this SAMA is $1,750,745. As this is larger than the estimated cost of implementation, this SAMA is cost-beneficial.	Cost beneficial. Refer to Section E.6.3 for additional details.
13	Nitrogen Station for Automatic Backup to CV-2010 Air Supply	Loss of Instrument Air is the primary contributor to the failure of CST makeup. Providing a Nitrogen Station that would automatically provide a backup air supply to CV-2010 would reduce the importance of the Loss of IA to the valve.	The cost of this SAMA is estimated at $220,000. This includes installation of a new bottled gas nitrogen station for auto-backup of air supply to valve CV2010, including piping, valves, instrumentation and procedure changes.	The averted cost-risk associated with this SAMA is $262,212. As this is larger than the estimated cost of implementation, the SAMA is cost beneficial.	Cost beneficial. Refer to Section E.6.4 for additional details.

TABLE E.5-4
PHASE II SAMA

SAMA ID NO.	SAMA TITLE	SAMA DESCRIPTION	ESTIMATED COST	COMMENT	PHASE II DISPOSITION
14	Enhance the MCR to Include Controls for the Cross-tie Between SW and the FPS	In the event that the SWS fails, providing a means to align the Fire Water system to the SWS in the MCR will reduce the time required to perform the action. This action is necessary to allow FPS to provide cooling of the CCW heat exchanger, which is critical for providing cooling water to the RCP seals.	Palisades has estimated the cost of this enhancement to be $2,900,000.	The averted cost-risk associated with this SAMA is $344,218. As this is less than the estimated cost of implementation, this SAMA is not cost beneficial.	Not cost beneficial. Refer to Section E.6.5 for additional details.
16	Insulate EDG Exhaust Ducts	Action to check that SW is aligned to the EDGs after a start is already taken based on previous plant experience, but the action is not proceduralized. The steps are taken immediately to prevent overheating the EDGs engines and could include credit for opening the EDG room doors for alternate room cooling if procedures were provided. However, because the time available is short, the error rate for the action would be high. Insulating the EDG exhaust ducts will reduce the heat load in the room and provide additional time to align alternate room cooling in the event that room cooling has failed.	The changes required for this action are estimated to cost $160,000. This includes installation of new insulation and lagging on the EDG exhaust ducts inside the EDG Rooms; and procedure changes to: 1. Check that SW is aligned to EDGs after an EDG start; 2. Optimize alignment of alternate room cooling such as opening the EDG room doors.	The averted cost-risk associated with this SAMA is $236,734. As this is greater than the estimated cost of implementation, the SAMA is cost beneficial.	Cost beneficial. Refer to Section E.6.6 for additional details

TABLE E.5-4
PHASE II SAMA

SAMA ID NO.	SAMA TITLE	SAMA DESCRIPTION	ESTIMATED COST	COMMENT	PHASE II DISPOSITION
17	Proceduralize Air Filter Removal for Emergency Operation	Filters F-321 and F-319 are located in the air pathways that provide motive power to valves CV-3071 and CV-3070. In the event that the filters plug, the valves will be inoperable and failure of RAS is assumed. Procedures could be developed or new PPACs created to either direct the removal of the plugged filters to allow operation of the valves or increase the inspection frequency.	The cost of procedure changes can vary depending on the specific application. For this SAMA, a range of $50,000 to $100,000 is considered to be reasonable based on the procedure change estimates developed by CPL (CPL 2004).	The present PSA model conservatively requires CV-3070 and CV-3071 operability to ensure adequate HPSI NPSH during an accident. However, if containment integrity is preserved adequate NPSH is available regardless of the state of valves CV-3070 and CV-3071. Given that the conditional likelihood of containment failure from either a phenomenological or an isolation perspective is about 1E-02, the importance of these failures is actually much less than the current model results indicate. The low conditional containment failure probability implies that the subcooling valves would not be risk significant given that their importance is driven by the NPSH issues. This SAMA is screened from further review.	Screened from further review based on PSA insights.

TABLE E.5-4
PHASE II SAMA

SAMA ID NO.	SAMA TITLE	SAMA DESCRIPTION	ESTIMATED COST	COMMENT	PHASE II DISPOSITION
22	Replace the Undervoltage Relays for Buses 1C and 1D with a Seismically Qualified Model	Failure of the undervoltage relay results in failure of the automatic start of EDG 1-2, which provides power to the AFW pump (pump 8C) with a water source more likely to survive a seismic event (SW). This EDG also supplies two SW pumps versus one pump on bus 1C. A more durable relay would reduce the contributions from loss of power to bus 1D. Credit of the SW/FPS cross-tie would remove the model asymmetry and this SAMA would apply to both divisions.	Palisades has established the cost of this SAMA to be $55,000. Multiplying this estimate by 2 is considered to address both divisions.	The averted cost risk for this SAMA has been estimated to be $414,165. As this is greater than the cost of implementation, this SAMA is considered to be cost beneficial.	Cost beneficial. Refer to Section E.6.7 for additional details.
23	Direct PCS Cooldown on Loss of RCP Seal Cooling	While Palisades has upgraded the plant's reactor coolant pumps with new N-9000 seals, the cooldown process may further reduce the probability of seal failures related to long-term high temperature exposure or thermal shock after recovery of CCW.	The cost of procedure changes can vary depending of the specific application. For this SAMA, a range of $50,000 to $100,000 is considered to be reasonable based on the procedure change estimates developed by CPL (CPL 2004). The upper bound of $100,000 is used for this case as the EOPs and training programs would have to be updated.	The averted cost-risk for this SAMA is $344,218. As this is greater than the cost of implementation, this SAMA is considered to be cost beneficial. Section E.7.3 includes an assessment of the impact of the main assumption used to calculate the averted cost-risk for this SAMA.	Cost beneficial. Refer to Section E.6.8 for additional details.

TABLE E.5-4
PHASE II SAMA

SAMA ID NO.	SAMA TITLE	SAMA DESCRIPTION	ESTIMATED COST	COMMENT	PHASE II DISPOSITION

AC = alternating current
AFW = Auxiliary Feedwater
CPL = Carolina Power and Light
CST = Condensate Storage Tank
DC = direct current
DDDIP = direct drive diesel injection pump
EDG = emergency diesel generator
EOP = Emergency Operating Procedure
FPS = Fire Protection System
HPI = high-pressure injection
HPSI = high-pressure safety injection
HVAC = Heating, Ventilation, and Air Conditioning
IA = instrument air
MCR = Main Control Room
NPSH = net positive suction head
PCS = Primary Coolant System
PPAC = Periodic and Predetermined Activity Control
PSA = probabilistic safety analysis
RCP = Reactor Coolant Pump
RPV = Reactor Pressure Vessel
SAMA = severe accident mitigation alternative
SBO = station blackout
SWS = Service Water System
TD = turbine driven

E.9 REFERENCES

Note to reader: This list of references identifies web pages and associated URLs where reference data was obtained. Some of these web pages may likely no longer be available or their URL address may have changed. NMC has maintained hard copies of the information and data obtained from the referenced web pages.

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ADDENDUM 1 TO ATTACHMENT E
SELECTED PREVIOUS INDUSTRY SAMAS

TABLE A-1
SELECTED PREVIOUS INDUSTRY SAMAs

SAMA ID Number	SAMA Title	Result of Potential Enhancement
Improvements Related to RCP Seal LOCAs (Loss of CC or SW)		
1	Cap downstream piping of normally closed component cooling water drain and vent valves.	SAMA would reduce the frequency of a loss of component cooling event, a large portion of which was derived from catastrophic failure of one of the many single isolation valves.
2	Enhance loss of component cooling procedure to facilitate stopping reactor coolant pumps.	SAMA would reduce the potential for reactor coolant pump (RCP) seal damage due to pump bearing failure.
3	Enhance loss of component cooling procedure to present desirability of cooling down reactor coolant system (RCS) prior to seal LOCA.	SAMA would reduce the potential for RCP seal failure.
4	Provide additional training on the loss of component cooling.	SAMA would potentially improve the success rate of operator actions after a loss of component cooling (to restore RCP seal damage).
5	Provide hardware connections to allow another essential raw cooling water system to cool charging pump seals.	SAMA would reduce effect of loss of component cooling by providing a means to maintain the centrifugal charging pump seal injection after a loss of component cooling.
6	Procedure changes to allow cross connection of motor cooling for residual heat removal service water (RHRSW) pumps.	SAMA would allow continued operation of both RHRSW pumps on a failure of one train of PSW.
7	Proceduralize shedding component cooling water loads to extend component cooling heatup on loss of essential raw cooling water.	SAMA would increase time before the loss of component cooling (and reactor coolant pump seal failure) in the loss of essential raw cooling water sequences.
8	Increase charging pump lube oil capacity.	SAMA would lengthen the time before centrifugal charging pump failure due to lube oil overheating in loss of CC sequences.
9	Eliminate the RCP thermal barrier dependence on component cooling such that loss of component cooling does not result directly in core damage.	SAMA would prevent the loss of recirculation pump seal integrity after a loss of component cooling. Watts Bar Nuclear Plant IPE said that they could do this with essential raw cooling water connection to RCP seals.
10	Add redundant DC control power for PSW pumps C & D.	SAMA would increase reliability of PSW and decrease CDF due to a loss of SW.
11	Create an independent RCP seal injection system, with a dedicated diesel.	SAMA would add redundancy to RCP seal cooling alternatives, reducing CDF from loss of component cooling or SW or from a SBO event.

TABLE A-1
SELECTED PREVIOUS INDUSTRY SAMAs (Continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
12	Use existing hydro-test pump for RCP seal injection.	SAMA would provide an independent seal injection source, without the cost of a new system.
13	Replace ECCS pump motor with air-cooled motors.	SAMA would eliminate ECCS dependency on component cooling system (but not on room cooling).
14	Install improved RCS pumps seals.	SAMA would reduce probability of RCP seal LOCA by installing RCP seal O-ring constructed of improved materials
15	Install additional component cooling water pump.	SAMA would reduce probability of loss of component cooling leading to RCP seal LOCA.
16	Prevent centrifugal charging pump flow diversion from the relief valves.	SAMA modification would reduce the frequency of the loss of RCP seal cooling if relief valve opening causes a flow diversion large enough to prevent RCP seal injection.
17	Change procedures to isolate RCP seal letdown flow on loss of component cooling, and guidance on loss of injection during seal LOCA.	SAMA would reduce CDF from loss of seal cooling.
18	Implement procedures to stagger high-pressure safety injection (HPSI) pump use after a loss of SW.	SAMA would allow HPSI to be extended after a loss of SW.
19	Use FPS pumps as a backup seal injection and high-pressure makeup.	SAMA would reduce the frequency of the RCP seal LOCA and the SBO CDF.
20	Enhance procedural guidance for use of cross-tied component cooling or SW pumps.	SAMA would reduce the frequency of the loss of component cooling water and SW.
21	Procedure enhancements and operator training in support system failure sequences, with emphasis on anticipating problems and coping.	SAMA would potentially improve the success rate of operator actions subsequent to support system failures.
22	Improved ability to cool the residual heat removal (RHR) heat exchangers.	SAMA would reduce the probability of a loss of decay heat removal by implementing procedure and hardware modifications to allow manual alignment of the FPS or by installing a component cooling water cross-tie.
23	8.a. Additional SW Pump	SAMA would conceivably reduce common cause dependencies from SW system and thus reduce plant risk through system reliability improvement.

TABLE A-1
SELECTED PREVIOUS INDUSTRY SAMAs (Continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
24	Create an independent RCP seal injection system, without dedicated diesel	This SAMA would add redundancy to RCP seal cooling alternatives, reducing the CDF from loss of CC or SW, but not SBO.
Improvements Related to Heating, Ventilation, and Air Conditioning		
25	Provide reliable power to control building fans.	SAMA would increase availability of CR ventilation on a loss of power.
26	Provide a redundant train of ventilation.	SAMA would increase the availability of components dependent on room cooling.
27	Procedures for actions on loss of HVAC.	SAMA would provide for improved credit to be taken for loss of HVAC sequences (improved affected electrical equipment reliability upon a loss of control building HVAC).
28	Add a diesel building switchgear room high temperature alarm.	SAMA would improve diagnosis of a loss of switchgear room HVAC. Option 1: Install high temp alarm. Option 2: Redundant louver and thermostat
29	Create ability to switch fan power supply to DC in an SBO event.	SAMA would allow continued operation in an SBO event. This SAMA was created for reactor core isolation cooling (RCIC) system room at Fitzpatrick Nuclear Power Plant.
30	Enhance procedure to instruct operators to trip unneeded RHR/CS pumps on loss of room ventilation.	SAMA increases availability of required RHR/CS pumps. Reduction in room heat load allows continued operation of required RHR/CS pumps, when room cooling is lost.
31	Stage backup fans in switchgear (SWGR) rooms	This SAMA would provide alternate ventilation in the event of a loss of SWGR Room ventilation
Improvements Related to Ex-Vessel Accident Mitigation/Containment Phenomena		
32	Delay CS actuation after large LOCA.	SAMA would lengthen time of refueling water storage tank (RWST) availability.
33	Install CS pump header automatic throttle valves.	SAMA would extend the time over which water remains in the RWST, when full CS flow is not needed
34	Install an independent method of suppression pool cooling.	SAMA would decrease the probability of loss of containment heat removal. For PWRs, a potential similar enhancement would be to install an independent cooling system for sump water.

TABLE A-1
SELECTED PREVIOUS INDUSTRY SAMAs (Continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
35	Develop an enhanced drywell spray system.	SAMA would provide a redundant source of water to the containment to control containment pressure, when used in conjunction with containment heat removal.
36	Provide dedicated existing drywell spray system.	SAMA would provide a source of water to the containment to control containment pressure, when used in conjunction with containment heat removal. This would use an existing spray loop instead of developing a new spray system.
37	Install an unfiltered hardened containment vent.	SAMA would provide an alternate decay heat removal method for non-ATWS events, with the released fission products not being scrubbed.
38	Install a filtered containment vent to remove decay heat.	SAMA would provide an alternate decay heat removal method for non-ATWS events, with the released fission products being scrubbed. Option 1: Gravel Bed Filter Option 2: Multiple Venturi Scrubber
39	Install a containment vent large enough to remove ATWS decay heat.	Assuming that injection is available, this SAMA would provide alternate decay heat removal in an ATWS event.
40	Create/enhance hydrogen recombiners with independent power supply.	SAMA would reduce hydrogen detonation at lower cost, Use either 1) a new independent power supply 2) a nonsafety-grade portable generator 3) existing station batteries 4) existing AC/DC independent power supplies.
41	Install hydrogen recombiners.	SAMA would provide a means to reduce the chance of hydrogen detonation.
42	Create a passive design hydrogen ignition system.	SAMA would reduce hydrogen denotation system without requiring electric power.
43	Create a large concrete crucible with heat removal potential under the basemat to contain molten core debris.	SAMA would ensure that molten core debris escaping from the vessel would be contained within the crucible. The water cooling mechanism would cool the molten core, preventing a melt-through of the basemat.
44	Create a water-cooled rubble bed on the pedestal.	SAMA would contain molten core debris dropping on to the pedestal and would allow the debris to be cooled.
45	Provide modification for flooding the drywell head.	SAMA would help mitigate accidents that result in the leakage through the drywell head seal.

TABLE A-1
SELECTED PREVIOUS INDUSTRY SAMAs (Continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
46	Enhance FPS and/or standby gas treatment system hardware and procedures.	SAMA would improve fission product scrubbing in severe accidents.
47	Create a reactor CFS.	SAMA would enhance debris coolability, reduce core concrete interaction, and provide fission product scrubbing.
48	Create other options for reactor cavity flooding.	SAMA would enhance debris coolability, reduce core concrete interaction, and provide fission product scrubbing.
49	Enhance air return fans (ice condenser plants).	SAMA would provide an independent power supply for the air return fans, reducing containment failure in SBO sequences.
50	Create a core melt source reduction system.	SAMA would provide cooling and containment of molten core debris. Refractory material would be placed underneath the reactor vessel such that a molten core falling on the material would melt and combine with the material. Subsequent spreading and heat removal form the vitrified compound would be facilitated, and concrete attack would not occur
51	Provide a containment inerting capability.	SAMA would prevent combustion of hydrogen and carbon monoxide gases.
52	Use the FPS as a backup source for the CS system.	SAMA would provide redundant CS function without the cost of installing a new system.
53	Install a secondary containment filtered vent.	SAMA would filter fission products released from primary containment.
54	Install a passive CS system.	SAMA would provide redundant CS method without high cost.
55	Strengthen primary/secondary containment.	SAMA would reduce the probability of containment overpressurization to failure.
56	Increase the depth of the concrete basemat or use an alternative concrete material to ensure melt-through does not occur.	SAMA would prevent basemat melt-through.
57	Provide a reactor vessel exterior cooling system.	SAMA would provide the potential to cool a molten core before it causes vessel failure, if the lower head could be submerged in water.
58	Construct a building to be connected to primary/secondary containment that is maintained at a vacuum.	SAMA would provide a method to depressurize containment and reduce fission product release.

TABLE A-1
SELECTED PREVIOUS INDUSTRY SAMAs (Continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
59	Refill CST	SAMA would reduce the risk of core damage during events such as extended SBOs or LOCAs which render the suppression pool unavailable as an injection source due to heat up.
60	Maintain ECCS suction on CST	SAMA would maintain suction on the CST as long as possible to avoid pump failure as a result of high suppression pool temperature
61	Modify containment flooding procedure to restrict flooding to below TAF	SAMA would avoid forcing containment venting
62	Enhance containment venting procedures with respect to timing, path selection and technique.	SAMA would improve likelihood of successful venting strategies.
63	1.a. Severe Accident EPGs/AMGs	SAMA would lead to improved arrest of core melt progress and prevention of containment failure
64	1.h. Simulator Training for Severe Accident	SAMA would lead to improved arrest of core melt progress and prevention of containment failure
65	2.g. Dedicated Suppression Pool Cooling	SAMA would decrease the probability of loss of containment heat removal. While PWRs do not have suppression pools, a similar modification may be applied to the sump. Installation of a dedicated sump cooling system would provide an alternate method of cooling injection water.
66	3.a. Larger Volume Containment	SAMA increases time before containment failure and increases time for recovery
67	3.b. Increased Containment Pressure Capability (sufficient pressure to withstand severe accidents)	SAMA minimizes likelihood of large releases
68	3.c. Improved Vacuum Breakers (redundant valves in each line)	SAMA reduces the probability of a stuck open vacuum breaker.
69	3.d. Increased Temperature Margin for Seals	This SAMA would reduce containment failure due to drywell head seal failure caused by elevated temperature and pressure.
70	3.e. Improved Leak Detection	This SAMA would help prevent LOCA events by identifying pipes which have begun to leak. These pipes can be replaced before they break.
71	3.f. Suppression Pool Scrubbing	Directing releases through the suppression pool will reduce the radionuclides allowed to escape to the environment.

TABLE A-1
SELECTED PREVIOUS INDUSTRY SAMAs (Continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
72	3.g. Improved Bottom Penetration Design	SAMA reduces failure likelihood of RPV bottom head penetrations
73	4.a. Larger Volume Suppression Pool (double effective liquid volume)	SAMA would increase the size of the suppression pool so that heatup rate is reduced, allowing more time for recovery of a heat removal system
74	5.a/d. Unfiltered Vent	SAMA would provide an alternate decay heat removal method with the released fission products not being scrubbed.
75	5.b/c. Filtered Vent	SAMA would provide an alternate decay heat removal method with the released fission products being scrubbed.
76	6.a. Post Accident Inerting System	SAMA would reduce likelihood of gas combustion inside containment
77	6.b. Hydrogen Control by Venting	Prevents hydrogen detonation by venting the containment before combustible levels are reached.
78	6.c. Pre-inerting	SAMA would reduce likelihood of gas combustion inside containment
79	6.d. Ignition Systems	Burning combustible gases before they reach a level which could cause a harmful detonation is a method of preventing containment failure.
80	6.e. Fire Suppression System Inerting	Use of the FPS as a back up containment inerting system would reduce the probability of combustible gas accumulation. This would reduce the containment failure probability for small containments (e.g. BWR MKI).
81	7.a. Drywell Head Flooding	SAMA would provide intentional flooding of the upper drywell head such that if high drywell temperatures occurred, the drywell head seal would not fail.
82	7.b. CS Augmentation	This SAMA would provide additional means of providing flow to the CS system.
83	12.b. Integral Basemat	This SAMA would improve containment and system survivability for seismic events.
84	13.a. Reactor Building Sprays	This SAMA provides the capability to use firewater sprays in the reactor building to mitigate release of fission products into the Rx Bldg following an accident.
85	14.a. Flooded Rubble Bed	SAMA would contain molten core debris dropping on to the pedestal and would allow the debris to be cooled.

TABLE A-1
SELECTED PREVIOUS INDUSTRY SAMAs (Continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
86	14.b. Reactor Cavity Flooder	SAMA would enhance debris coolability, reduce core concrete interaction, and provide fission product scrubbing.
87	14.c. Basaltic Cements	SAMA minimizes carbon dioxide production during core concrete interaction.
88	Provide a core debris control system	(Intended for ice condenser plants): This SAMA would prevent the direct core debris attack of the primary containment steel shell by erecting a barrier between the seal table and the containment shell.
89	Add ribbing to the containment shell	This SAMA would reduce the risk of buckling of containment under reverse pressure loading.
Improvements Related to Enhanced AC/DC Reliability/Availability		
90	Proceduralize alignment of spare diesel to shutdown board after LOOP and failure of the diesel normally supplying it.	SAMA would reduce the SBO frequency.
91	Provide an additional DG.	SAMA would increase the reliability and availability of onsite emergency AC power sources.
92	Provide additional DC battery capacity.	SAMA would ensure longer battery capability during an SBO, reducing the frequency of long-term SBO sequences.
93	Use fuel cells instead of lead-acid batteries.	SAMA would extend DC power availability in an SBO.
94	Procedure to cross-tie high-pressure core spray diesel.	SAMA would improve core injection availability by providing a more reliable power supply for the high-pressure core spray pumps.
95	Improve 4.16-kV bus cross-tie ability.	SAMA would improve AC power reliability.
96	Incorporate an alternate battery charging capability.	SAMA would improve DC power reliability by either cross-tying the AC busses, or installing a portable diesel-driven battery charger.
97	Increase/improve DC bus load shedding.	SAMA would extend battery life in an SBO event.
98	Replace existing batteries with more reliable ones.	SAMA would improve DC power reliability and thus increase available SBO recovery time.

TABLE A-1
SELECTED PREVIOUS INDUSTRY SAMAs (Continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
99	Mod for DC Bus A reliability.	SAMA would increase the reliability of AC power and injection capability. Loss of DC Bus A causes a loss of main condenser, prevents transfer from the main transformer to OSP, and defeats one half of the low vessel pressure permissive for low-pressure coolant injection (LPCI)/CS injection valves.
100	Create AC power cross-tie capability with other unit.	SAMA would improve AC power reliability.
101	Create a cross-tie for diesel fuel oil.	SAMA would increase diesel fuel oil supply and thus DG, reliability.
102	Develop procedures to repair or replace failed 4-kV breakers.	SAMA would offer a recovery path from a failure of the breakers that perform transfer of 4.16-kV non-emergency busses from unit station service transformers, leading to loss of emergency AC power.
103	Emphasize steps in recovery of OSP after an SBO.	SAMA would reduce HEP during OSP recovery.
104	Develop a severe weather conditions procedure.	For plants that do not already have one, this SAMA would reduce the CDF for external weather-related events.
105	Develop procedures for replenishing diesel fuel oil.	SAMA would allow for long-term diesel operation.
106	Install gas turbine generator.	SAMA would improve onsite AC power reliability by providing a redundant and diverse emergency power system.
107	Create a backup source for diesel cooling. (Not from existing system)	This SAMA would provide a redundant and diverse source of cooling for the DGs, which would contribute to enhanced diesel reliability.
108	Use FPS as a backup source for diesel cooling.	This SAMA would provide a redundant and diverse source of cooling for the DGs, which would contribute to enhanced diesel reliability.
109	Provide a connection to an alternate source of OSP.	SAMA would reduce the probability of a LOOP event.
110	Bury OSP lines.	SAMA could improve OSP reliability, particularly during severe weather.
111	Replace anchor bolts on DG oil cooler.	Millstone Nuclear Power Station found a high seismic SBO risk due to failure of the diesel oil cooler anchor bolts. For plants with a similar problem, this would reduce seismic risk. Note that these were Fairbanks Morse DGs.
112	Change undervoltage (UV), AFW actuation signal (AFAS) block and high pressurizer pressure actuation signals to 3-out-of-4, instead of 2-out-of-4 logic.	SAMA would reduce risk of 2/4 inverter failure.

TABLE A-1
SELECTED PREVIOUS INDUSTRY SAMAs (Continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
113	Provide DC power to the 120/240-V vital AC system from the Class 1E station service battery system instead of its own battery.	SAMA would increase the reliability of the 120-VAC Bus.
114	Bypass DG Trips	SAMA would allow D/Gs to operate for longer.
115	2.i. 16 hour SBO Injection	SAMA includes improved capability to cope with longer SBO scenarios.
116	9.a. Steam Driven Turbine Generator	This SAMA would provide a steam driven turbine generator which uses reactor steam and exhausts to the suppression pool. If large enough, it could provide power to additional equipment.
117	9.b. Alternate Pump Power Source	This SAMA would provide a small dedicated power source such as a dedicated diesel or gas turbine for the feedwater or condensate pumps, so that they do not rely on OSP.
118	9.d. Additional DG	SAMA would reduce the SBO frequency.
119	9.e. Increased Electrical Divisions	SAMA would provide increased reliability of AC power system to reduce core damage and release frequencies.
120	9.f. Improved Uninterruptible Power Supplies	SAMA would provide increased reliability of power supplies supporting front-line equipment, thus reducing core damage and release frequencies.
121	9.g. AC Bus Cross-Ties	SAMA would provide increased reliability of AC power system to reduce core damage and release frequencies.
122	9.h. Gas Turbine	SAMA would improve onsite AC power reliability by providing a redundant and diverse emergency power system.
123	9.i. Dedicated RHR (bunkered) Power Supply	SAMA would provide RHR with more reliable AC power.
124	10.a. Dedicated DC Power Supply	This SAMA addresses the use of a diverse DC power system such as an additional battery or fuel cell for the purpose of providing motive power to certain components (e.g., RCIC).
125	10.b. Additional Batteries/Divisions	This SAMA addresses the use of a diverse DC power system such as an additional battery or fuel cell for the purpose of providing motive power to certain components (e.g., RCIC).
126	10.c. Fuel Cells	SAMA would extend DC power availability in an SBO.

TABLE A-1
SELECTED PREVIOUS INDUSTRY SAMAs (Continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
127	10.d. DC Cross-ties	This SAMA would improve DC power reliability.
128	10.e. Extended SBO Provisions	SAMA would provide reduction in SBO sequence frequencies.
129	Add an automatic bus transfer feature to allow the automatic transfer of the 120V vital AC bus from the on-line unit to the standby unit	Plants are typically sensitive to the loss of one or more 120V vital AC buses. Manual transfers to alternate power supplies could be enhanced to transfer automatically.
Improvements in Identifying and Mitigating Containment Bypass		
130	Install a redundant spray system to depressurize the primary system during a steam generator tube rupture (SGTR).	SAMA would enhance depressurization during a SGTR.
131	Improve SGTR coping abilities.	SAMA would improve instrumentation to detect SGTR, or additional system to scrub fission product releases.
132	Add other SGTR coping abilities.	SAMA would decrease the consequences of an SGTR.
133	Increase secondary side pressure capacity such that an SGTR would not cause the relief valves to lift.	SAMA would eliminate direct release pathway for SGTR sequences.
134	Replace steam generators (SG) with a new design.	SAMA would lower the frequency of an SGTR.
135	Revise emergency operating procedures to direct that a faulted SG be isolated.	SAMA would reduce the consequences of an SGTR.
136	Direct SG flooding after a SGTR, prior to core damage.	SAMA would provide for improved scrubbing of SGTR releases.
137	Implement a maintenance practice that inspects 100% of the tubes in a SG.	SAMA would reduce the potential for an SGTR.
138	Locate RHR inside of containment.	SAMA would prevent intersystem LOCA (ISLOCA) out the RHR pathway.
139	Install additional instrumentation for ISLOCAs.	SAMA would decrease ISLOCA frequency by installing pressure of leak monitoring instruments in between the first two pressure isolation valves on low-pressure inject lines, RHR suction lines, and HPSI lines.
140	Increase frequency for valve leak testing.	SAMA could reduce ISLOCA frequency.
141	Improve operator training on ISLOCA coping.	SAMA would decrease ISLOCA effects.
142	Install relief valves in the CC System.	SAMA would relieve pressure buildup from an RCP thermal barrier tube rupture, preventing an ISLOCA.

TABLE A-1
SELECTED PREVIOUS INDUSTRY SAMAs (Continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
143	Provide leak testing of valves in ISLOCA paths.	SAMA would help reduce ISLOCA frequency. At Kewaunee Nuclear Power Plant, four MOVs isolating RHR from the RCS were not leak tested.
144	Revise EOPs to improve ISLOCA identification.	SAMA would ensure LOCA outside containment could be identified as such. Salem Nuclear Power Plant had a scenario where an RHR ISLOCA could direct initial leakage back to the pressurizer relief tank, giving indication that the LOCA was inside containment.
145	Ensure all ISLOCA releases are scrubbed.	SAMA would scrub all ISLOCA releases. One example is to plug drains in the break area so that the break point would be covered with water.
146	Add redundant and diverse limit switches to each containment isolation valve.	SAMA could reduce the frequency of containment isolation failure and ISLOCAs through enhanced isolation valve position indication.
147	Early detection and mitigation of ISLOCA	SAMA would limit the effects of ISLOCA accidents by early detection and isolation
148	8.e. Improved MSIV Design	This SAMA would improve isolation reliability and reduce spurious actuations that could be initiating events.
149	Proceduralize use of pressurizer vent valves during steam generator tube rupture (SGTR) sequences	Some plants may have procedures to direct the use of pressurizer sprays to reduce RCS pressure after an SGTR. Use of the vent valves would provide a back-up method.
150	Implement a maintenance practice that inspects 100% of the tubes in an SG	This SAMA would reduce the potential for a tube rupture.
151	Locate RHR inside of containment	This SAMA would prevent ISLOCA out the RHR pathway.
152	Install self-actuating containment isolation valves	For plants that do not have this, it would reduce the frequency of isolation failure.
Improvements in Reducing Internal Flooding Frequency		
153	Modify swing direction of doors separating turbine building basement from areas containing safeguards equipment.	SAMA would prevent flood propagation, for a plant where internal flooding from turbine building to safeguards areas is a concern.
154	Improve inspection of rubber expansion joints on main condenser.	SAMA would reduce the frequency of internal flooding, for a plant where internal flooding due to a failure of circulating water system expansion joints is a concern.

TABLE A-1
SELECTED PREVIOUS INDUSTRY SAMAs (Continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
155	Implement internal flood prevention and mitigation enhancements.	This SAMA would reduce the consequences of internal flooding.
156	Implement internal flooding improvements such as those implemented at Fort Calhoun.	This SAMA would reduce flooding risk by preventing or mitigating rupture in the RCP seal cooler of the component cooling system an ISLOCA in a shutdown cooling line, an AFW flood involving the need to remove a watertight door.
157	Shield electrical equipment from potential water spray	SAMA would decrease risk associated with seismically induced internal flooding
158	13.c. Reduction in Reactor Building Flooding	This SAMA reduces the Reactor Building Flood Scenarios contribution to core damage and release.
Improvements Related to Feedwater/Feed and Bleed Reliability/Availability		
159	Install a digital feedwater upgrade.	This SAMA would reduce the chance of a loss of main feedwater following a plant trip.
160	Perform surveillances on manual valves used for backup AFW pump suction.	This SAMA would improve success probability for providing alternative water supply to the AFW pumps.
161	Install manual isolation valves around AFW turbine-driven steam admission valves.	This SAMA would reduce the dual turbine-driven AFW pump maintenance unavailability.
162	Install accumulators for turbine-driven AFW pump flow control valves (CVs).	This SAMA would provide control air accumulators for the turbine-driven AFW flow CVs, the motor-driven AFW pressure CVs and SG power-operated relief valves (PORVs). This would eliminate the need for local manual action to align nitrogen bottles for control air during a LOOP.
163	Install separate accumulators for the AFW cross-connect and block valves	This SAMA would enhance the operator's ability to operate the AFW cross-connect and block valves following loss of air support.
164	Install a new CST	Either replace the existing tank with a larger one, or install a back-up tank.
165	Provide cooling of the steam-driven AFW pump in an SBO event	This SAMA would improve success probability in an SBO by: (1) using the FPS to cool the pump, or (2) making the pump self cooled.
166	Proceduralize local manual operation of AFW when control power is lost.	This SAMA would lengthen AFW availability in an SBO. Also provides a success path should AFW control power be lost in non-SBO sequences.

TABLE A-1
SELECTED PREVIOUS INDUSTRY SAMAs (Continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
167	Provide portable generators to be hooked into the turbine driven AFW, after battery depletion.	This SAMA would extend AFW availability in an SBO (assuming the turbine driven AFW requires DC power)
168	Add a motor train of AFW to the Steam trains	For PWRs that do not have any motor trains of AFW, this would increase reliability in non-SBO sequences.
169	Create ability for emergency connections of existing or alternate water sources to feedwater/condensate	This SAMA would be a back-up water supply for the feedwater/condensate systems.
170	Use FPS as a back-up for SG inventory	This SAMA would create a back-up to main and AFW for SG water supply.
171	Procure a portable diesel pump for isolation condenser make-up	This SAMA would provide a back-up to the city water supply and diesel FPS pump for isolation condenser make-up.
172	Install an independent DG for the CST make-up pumps	This SAMA would allow continued inventory make-up to the CST during an SBO.
173	Change failure position of condenser make-up valve	This SAMA would allow greater inventory for the AFW pumps by preventing CST flow diversion to the condenser if the condenser make-up valve fails open on loss of air or power.
174	Create passive secondary side coolers.	This SAMA would reduce CDF from the loss of Feedwater by providing a passive heat removal loop with a condenser and heat sink.
175	Replace current PORVs with larger ones such that only one is required for successful feed and bleed.	This SAMA would reduce the dependencies required for successful feed and bleed.
176	Install motor-driven feedwater pump.	SAMA would increase the availability of injection subsequent to MSIV closure.
177	Use Main feedwater pumps for a Loss of Heat Sink Event	This SAMA involves a procedural change that would allow for a faster response to loss of the secondary heat sink. Use of only the feedwater booster pumps for injection to the SGs requires depressurization to about 350 psig; before the time this pressure is reached, conditions would be met for initiating feed and bleed. Using the available turbine driven feedwater pumps to inject water into the SGs at a high pressure rather than using the feedwater booster alone allows injection without the time consuming depressurization.
Improvements in Core Cooling Systems		

TABLE A-1
SELECTED PREVIOUS INDUSTRY SAMAs (Continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
178	Provide the capability for diesel driven, low-pressure vessel make-up	This SAMA would provide an extra water source in sequences in which the reactor is depressurized and all other injection is unavailable (e.g., FPS)
179	Provide an additional HPSI pump with an independent diesel	This SAMA would reduce the frequency of core melt from small LOCA and SBO sequences
180	Install an independent AC HPSI system	This SAMA would allow make-up and feed and bleed capabilities during an SBO.
181	Create the ability to manually align ECCS recirculation	This SAMA would provide a back-up should automatic or remote operation fail.
182	Implement an RWT make-up procedure	This SAMA would decrease CDF from ISLOCA scenarios, some smaller break LOCA scenarios, and SGTR.
183	Stop LPSI pumps earlier in medium or large LOCAs.	This SAMA would provide more time to perform recirculation swap over.
184	Emphasize timely swap over in operator training.	This SAMA would reduce HEP of recirculation failure.
185	Upgrade Chemical and Volume Control System to mitigate small LOCAs.	For a plant like the AP600 where the Chemical and Volume Control System cannot mitigate a Small LOCA, an upgrade would decrease the Small LOCA CDF contribution.
186	Install an active HPSI system.	For a plant like the AP600 where an active HPSI system does not exist, this SAMA would add redundancy in HPSI.
187	Change "in-containment" RWT suction from 4 check valves to 2 check and 2 air operated valves.	This SAMA would remove common mode failure of all four injection paths.
188	Replace 2 of the 4 safety injection (SI) pumps with diesel-powered pumps.	This SAMA would reduce the SI system CCF probability. This SAMA was intended for the System 80+, which has four trains of SI.
189	Align low-pressure core injection or core spray to the CST on loss of suppression pool cooling.	This SAMA would help to ensure low-pressure ECCS can be maintained in loss of suppression pool cooling scenarios.
190	Raise high-pressure core injection/RCIC backpressure trip setpoints	This SAMA would ensure high-pressure core injection/RCIC availability when high suppression pool temperatures exist.
191	Improve the reliability of the secondary side heat removal.	This SAMA would reduce the frequency of high-pressure core damage sequences.

TABLE A-1
SELECTED PREVIOUS INDUSTRY SAMAs (Continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
192	Disallow automatic vessel depressurization in non-ATWS scenarios	This SAMA would improve operator control of the plant.
193	Create automatic swap over to recirculation on RWT depletion	This SAMA would reduce the human error contribution from recirculation failure.
194	Proceduralize intermittent operation of high-pressure coolant injection (HPCI).	SAMA would allow for extended duration of HPCI availability.
195	Increase available NPSH for injection pumps.	SAMA increases the probability that these pumps will be available to inject coolant into the vessel by increasing the available NPSH for the injection pumps.
196	Modify Reactor Water Cleanup (RWCU) for use as a decay heat removal system and proceduralize use.	SAMA would provide an additional source of decay heat removal.
197	Control Rod Drive (CRD) Injection	SAMA would supply an additional method of level restoration by using a non-safety system.
198	Condensate Pumps for Injection	SAMA to provide an additional option for coolant injection when other systems are unavailable or inadequate
199	Align EDG to CRD for Injection	SAMA to provide power to an additional injection source during loss of power events
200	Re-open MSIVs	SAMA to regain the main condenser as a heat sink by re-opening the MSIVs.
201	Bypass RCIC Turbine Exhaust Pressure Trip	SAMA would allow RCIC to operate longer.
202	2.a. Passive High-Pressure System	SAMA will improve prevention of core melt sequences by providing additional high pressure capability to remove decay heat through an isolation condenser type system
203	2.c. Suppression Pool Jockey Pump	SAMA will improve prevention of core melt sequences by providing a small makeup pump to provide low-pressure decay heat removal from the RPV using the suppression pool as a source of water.
204	2.d. Improved High-Pressure Systems	SAMA will improve prevention of core melt sequences by improving reliability of high pressure capability to remove decay heat.

TABLE A-1
SELECTED PREVIOUS INDUSTRY SAMAs (Continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
205	2.e. Additional Active High-Pressure System	SAMA will improve reliability of high-pressure decay heat removal by adding an additional system.
206	2.f. Improved Low-Pressure System (Firepump)	SAMA would provide FPS pump(s) for use in low-pressure scenarios.
207	4.b. CUW Decay Heat Removal	This SAMA provides a means for Alternate Decay Heat Removal.
208	4.c. High Flow Suppression Pool Cooling	SAMA would improve suppression pool cooling.
209	8.c. Diverse Injection System	SAMA will improve prevention of core melt sequences by providing additional injection capabilities.
210	Alternate Charging Pump Cooling	This SAMA will improve the high-pressure core flooding capabilities by providing the SI pumps with alternate gear and oil cooling sources. Given a total loss of Chilled Water, abnormal operating procedures would direct alignment of preferred Demineralized Water or the Fire System to the Chilled Water System to provide cooling to the SI pumps' gear and oil box (and the other normal loads).
Instrument Air/Gas Improvements		
211	Modify EOPs for ability to align diesel power to more air compressors.	For plants that do not have diesel power to all normal and back-up air compressors, this change would increase the reliability of IA after a LOOP.
212	Replace old air compressors with more reliable ones	This SAMA would improve reliability and increase availability of the IA compressors.
213	Install nitrogen bottles as a back-up gas supply for SRVs.	This SAMA would extend operation of SRVs during an SBO and loss of air events (BWRs).
214	Allow cross connection of uninterruptible compressed air supply to opposite unit.	SAMA would increase the ability to vent containment using the hardened vent.
ATWS Mitigation		
215	Install MG set trip breakers in the main CR	This SAMA would provide trip breakers for the MG sets in the main CR. In some plants, MG set breaker trip requires action to be taken outside of the main CR. Adding control capability to the main CR would reduce the trip failure probability in sequences where immediate action is required (e.g., ATWS).

TABLE A-1
SELECTED PREVIOUS INDUSTRY SAMAs (Continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
216	Add capability to remove power from the bus powering the control rods	This SAMA would decrease the time to insert the control rods if the reactor trip breakers fail (during a loss of feedwater ATWS which has a rapid pressure excursion)
217	Create cross-connect ability for standby liquid control trains	This SAMA would improve reliability for boron injection during an ATWS event.
218	Create an alternate boron injection capability (back-up to standby liquid control)	This SAMA would improve reliability for boron injection during an ATWS event.
219	Remove or allow override of low-pressure core injection during an ATWS	On failure on high-pressure core injection and condensate, some plants direct reactor depressurization followed by 5 minutes of low-pressure core injection. This SAMA would allow control of low-pressure core injection immediately.
220	Install a system of relief valves that prevents any equipment damage from a pressure spike during an ATWS	This SAMA would improve equipment availability after an ATWS.
221	Create a boron injection system to back up the mechanical control rods.	This SAMA would provide a redundant means to shut down the reactor.
222	Provide an additional instrument system for ATWS mitigation (e.g., ATWS mitigation scram actuation circuitry).	This SAMA would improve instrument and control redundancy and reduce the ATWS frequency.
223	Increase the SRV reseat reliability.	SAMA addresses the risk associated with dilution of boron caused by the failure of the SRVs to reseat after standby liquid control (SLC) injection.
224	Use CRD for alternate boron injection.	SAMA provides an additional system to address ATWS with SLC failure or unavailability.
225	Bypass MSIV isolation in Turbine Trip ATWS scenarios	SAMA will afford operators more time to perform actions. The discharge of a substantial fraction of steam to the main condenser (i.e., as opposed to into the primary containment) affords the operator more time to perform actions (e.g., SLC injection, lower water level, depressurize RPV) than if the main condenser was unavailable, resulting in lower human error probabilities
226	Enhance operator actions during ATWS	SAMA will reduce human error probabilities during ATWS
227	Guard against SLC dilution	SAMA to control vessel injection to prevent boron loss or dilution following SLC injection.

TABLE A-1
SELECTED PREVIOUS INDUSTRY SAMAs (Continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
228	11.a. ATWS Sized Vent	This SAMA would provide the ability to remove reactor heat from ATWS events.
229	11.b. Improved ATWS Capability	This SAMA includes items which reduce the contribution of ATWS to core damage and release frequencies.
Other Improvements		
230	Provide capability for remote operation of secondary side relief valves in an SBO	Manual operation of these valves is required in an SBO scenario. High area temperatures may be encountered in this case (no ventilation to main steam areas), and remote operation could improve success probability.
231	Create/enhance RCS depressurization ability	With either a new depressurization system, or with existing PORVs, head vents, and secondary side valve, RCS depressurization would allow earlier low-pressure ECCS injection. Even if core damage occurs, low RCS pressure would alleviate some concerns about HPME.
232	Make procedural changes only for the RCS depressurization option	This SAMA would reduce RCS pressure without the cost of a new system
233	Defeat 100% load rejection capability.	This SAMA would eliminate the possibility of a stuck open PORV after a LOOP, since PORV opening would not be needed.
234	Change CRD flow CV failure position	Change failure position to the "fail-safest" position.
235	Install secondary side guard pipes up to the MSIVs	This SAMA would prevent secondary side depressurization should a steam line break occur upstream of the MSIVs. This SAMA would also guard against or prevent consequential multiple SGTR following a Main Steam Line Break event.
236	Install digital large break LOCA protection	Upgrade plant instrumentation and logic to improve the capability to identify symptoms/precursors of a large break LOCA (leak before break).
237	Increase seismic capacity of the plant to a high confidence, low-pressure failure of twice the Safe Shutdown Earthquake.	This SAMA would reduce seismically -induced CDF.
238	Enhance the reliability of the demineralized water (DW) make-up system through the addition of diesel-backed power to one or both of the DW make-up pumps.	Inventory loss due to normal leakage can result in the failure of the CC and the SRW systems. Loss of CC could challenge the RCP seals. Loss of SRW results in the loss of three EDGs and the containment air coolers (CACs).

TABLE A-1
SELECTED PREVIOUS INDUSTRY SAMAs (Continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
239	Increase the reliability of SRVs by adding signals to open them automatically.	SAMA reduces the probability of a certain type of medium break LOCA. Hatch evaluated medium LOCA initiated by an MSIV closure transient with a failure of SRVs to open. Reducing the likelihood of the failure for SRVs to open, subsequently reduces the occurrence of this medium LOCA.
240	Reduce DC dependency between high-pressure injection system and secondary side heat removal.	SAMA would ensure containment depressurization and high-pressure injection upon a DC failure.
241	Increase seismic ruggedness of plant components.	SAMA would increase the availability of necessary plant equipment during and after seismic events.
242	Enhance RPV depressurization capability	SAMA would decrease the likelihood of core damage in loss of HPCI scenarios
243	Enhance RPV depressurization procedures	SAMA would decrease the likelihood of core damage in loss of HPCI scenarios
244	Replace mercury switches on FPSs	SAMA would decrease probability of spurious fire suppression system actuation given a seismic event
245	Provide additional restraints for CO_2 tanks	SAMA would increase availability of FPS given a seismic event.
246	Enhance control of transient combustibles	SAMA would minimize risk associated with important fire areas.
247	Enhance fire brigade awareness	SAMA would minimize risk associated with important fire areas.
248	Upgrade fire compartment barriers	SAMA would minimize risk associated with important fire areas.
249	Enhance procedures to allow specific operator actions	SAMA would minimize risk associated with important fire areas.
250	Develop procedures for transportation and nearby facility accidents	SAMA would minimize risk associated with transportation and nearby facility accidents.
251	Enhance procedures to mitigate Large LOCA	SAMA would minimize risk associated with Large LOCA
252	1.b. Computer Aided Instrumentation	SAMA will improve prevention of core melt sequences by making operator actions more reliable.
253	1.c/d. Improved Maintenance Procedures/Manuals	SAMA will improve prevention of core melt sequences by increasing reliability of important equipment
254	1.e. Improved Accident Management Instrumentation	SAMA will improve prevention of core melt sequences by making operator actions more reliable.

TABLE A-1
SELECTED PREVIOUS INDUSTRY SAMAs (Continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
255	1.f. Remote Shutdown Station	This SAMA would provide the capability to control the reactor in the event that evacuation of the MCR is required.
256	1.g. Security System	Improvements in the site's security system would decrease the potential for successful sabotage.
257	2.b. Improved Depressurization	SAMA will improve depressurization system to allow more reliable access to low-pressure systems.
258	2.h. Safety Related CST	SAMA will improve availability of CST following a Seismic event
259	4.d. Passive Overpressure Relief	This SAMA would prevent vessel overpressurization.
260	8.b. Improved Operating Response	Improved operator reliability would improve accident mitigation and prevention.
261	8.d. Operation Experience Feedback	This SAMA would identify areas requiring increased attention in plant operation through review of equipment performance.
262	8.e. Improved SRV Design	This SAMA would improve SRV reliability, thus increasing the likelihood that sequences could be mitigated using low-pressure heat removal.
263	12.a. Increased Seismic Margins	This SAMA would reduce the risk of core damage and release during seismic events.
264	13.b. System Simplification	This SAMA is intended to address system simplification by the elimination of unnecessary interlocks, automatic initiation of manual actions or redundancy as a means to reduce overall plant risk.
265	Train operations crew for response to inadvertent actuation signals	This SAMA would improve chances of a successful response to the loss of two 120V AC buses, which may cause inadvertent signal generation.
266	Install tornado protection on gas turbine generators	This SAMA would improve onsite AC power reliability.