Appendix D

Cultural Resources Correspondence

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AEP
AMERICAN ELECTRIC POWER

Mr. Brian Conway
Michigan State Historic Preservation Office
Michigan Historical Center
Box 30740
717 W. Allegan Street
Lansing, Michigan 48909-8240

March 17, 2003

Subject: Donald C. Cook Nuclear Plant
License Renewal Request for Information on Historic/
Archaeological Resources

Dear Mr. Conway

American Electric Power (AEP) is preparing an application to the U.S. Regulatory Commission (NRC) to renew the operating licenses for the D. C. Cook Nuclear Plant (CNP), which will expire in 2014 and 2017. AEP intends to submit this application for license renewal in November, 2003. As part of the license renewal process, the NRC requires license applicants to "assess whether any historic or archaeological properties will be affected by the proposed project." The NRC may also request an informal consultation with your office at a later date under 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). By contacting you early in the application process, we hope to identify any issues that need to be addressed or any information your office may need to expedite the NRC consultation.

CNP is located in Lake Charter Township, Berrien County, Michigan, on the eastern shoreline of Lake Michigan. This location is approximately 55 miles east of downtown Chicago, 55 miles southwest of Kalamazoo, Michigan, and 11 miles south-southwest of the twin cities of St. Joseph and Benton Harbor, Michigan (Figure 2-1). The nearest town is Bridgman, which is approximately two miles south of CNP (Figure 2-2).

The CNP property is approximately 650 acres owned by AEP (Figure 2-3) and includes 4,350 feet of lake frontage. The site extends approximately one and one quarter miles eastward from Lake Michigan. The local terrain consists of a gentle upward sloping beach that rises sharply into the dunes after about 200 feet. The area around CNP is largely rural, characterized by agriculture and heavily wooded rugged sand dunes along the lakeshore. In addition to the two reactor containment buildings, turbine building, auxiliary building, and service buildings, the site includes a fuel handling facility, and two switchyards.

AEP: America's Energy Partner℠

D. C. Cook Nuclear Plant License Renewal
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March 17, 2003

AEP's transmission system includes approximately 230 miles of corridor (right-of-way) that occupy approximately 4,600 acres (Figure 3-2). The transmission corridors pass through land that is primarily agricultural and forest land. The areas are mostly remote, with low population densities. The longer lines cross numerous state and U.S. highways; all cross I-94 immediately after leaving the switchyard. Corridors that pass through farmlands generally continue to be used as farmland. The six 345-kilivolt lines connect from the CNP Unit 1 switchyard; the single 765-kilovolt line connects from the Unit 2 switchyard.

As of 2002, the National Register of Historic Places lists 18 locations in Berrien County, Michigan (U.S. Department of the Interior 2002). Of these 18 locations, 3 fall within a 6-mile radius of CNP (Figure 2-2). There are several additional sites (within a 6-mile radius) that are of historical significance, but do not qualify for the National Register of Historic Places. They are the Mielke House, the Tyron School, and Bethany Beach. The attached table lists the three National Register of Historic Places sites within the 6-mile radius of CNP.

AEP has no plans to alter current operations over the license renewal period. No major expansion of existing facilities is planned, and no major structural modifications have been identified for the purposes of supporting license renewal. No additional land disturbance is anticipated.

We would appreciate your sending us a letter by April 15 detailing any concerns you may have about historic/archaeological resources in the area and/or a concluding statement that the operation of the D. C. Cook Nuclear Plant over the license renewal term would have no effect on any historic or archeological properties. This will enable us to meet our application preparation schedule. AEP will include a copy of this letter and your response in the license renewal application that we submit to the NRC. Please contact me at (269)465-5901 extension 1153 if you have questions or require any additional information to review the proposed action.

Sincerely,

John P. Carlson
Environmental Manager

Attachments: Table 1
Figure 2-1
Figure 2-2
Figure 2-3
Figure 3

Correspondence Control No. 2003-327

Table 1. Sites Listed in the National Register of Historic Places That Fall within a 6-mile Radius of CNP

Site Name	Location
Avery Road - Galien River Bridge	Avery Road over Galien River, New Troy
Sandburg House	Address Restricted
Snow Flake Motel	3822 Red Arrow Highway, Lincoln Township

a. Source: U. S. Department of the Interior 2002.

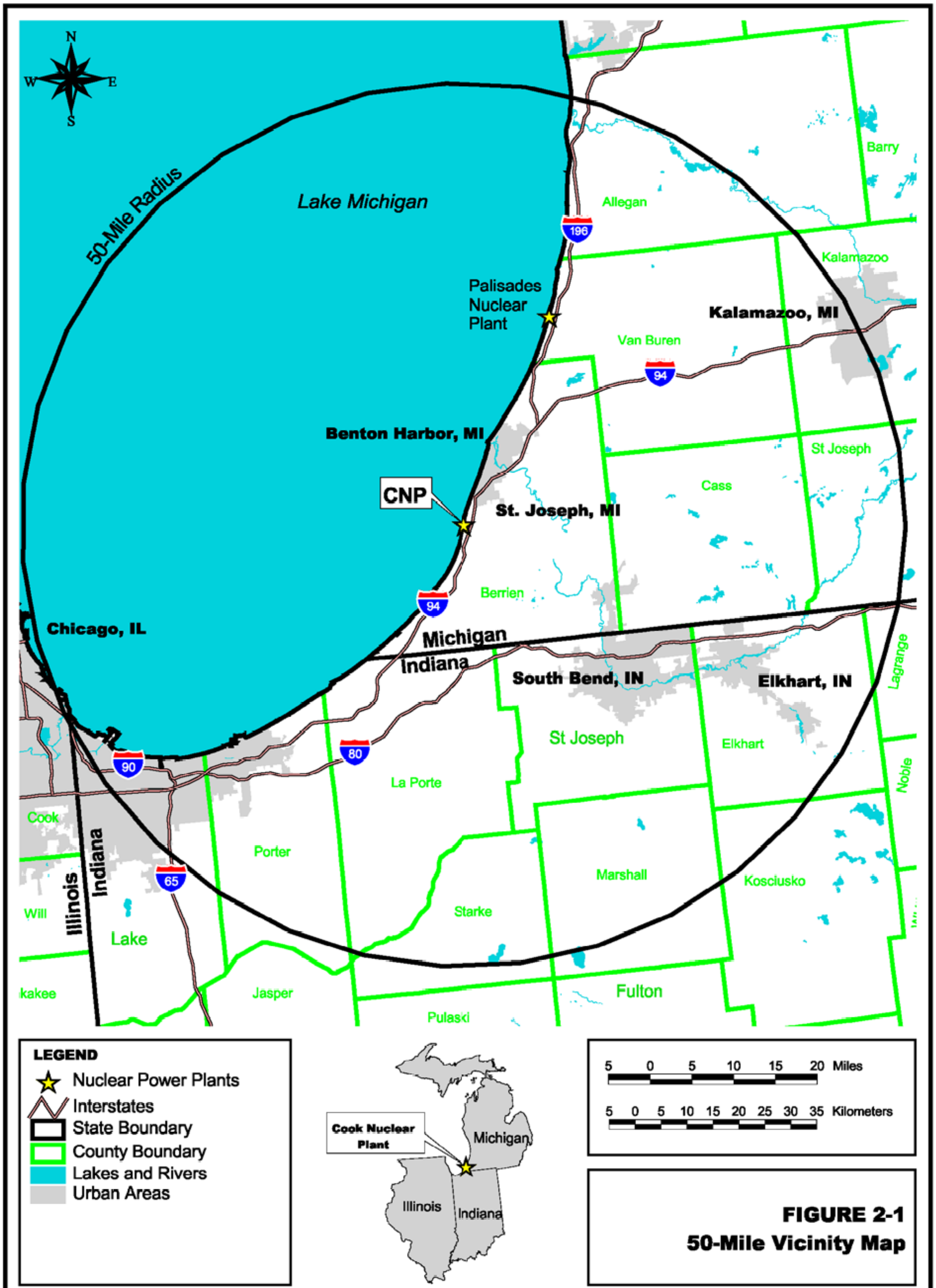

FIGURE 2-1
50-Mile Vicinity Map

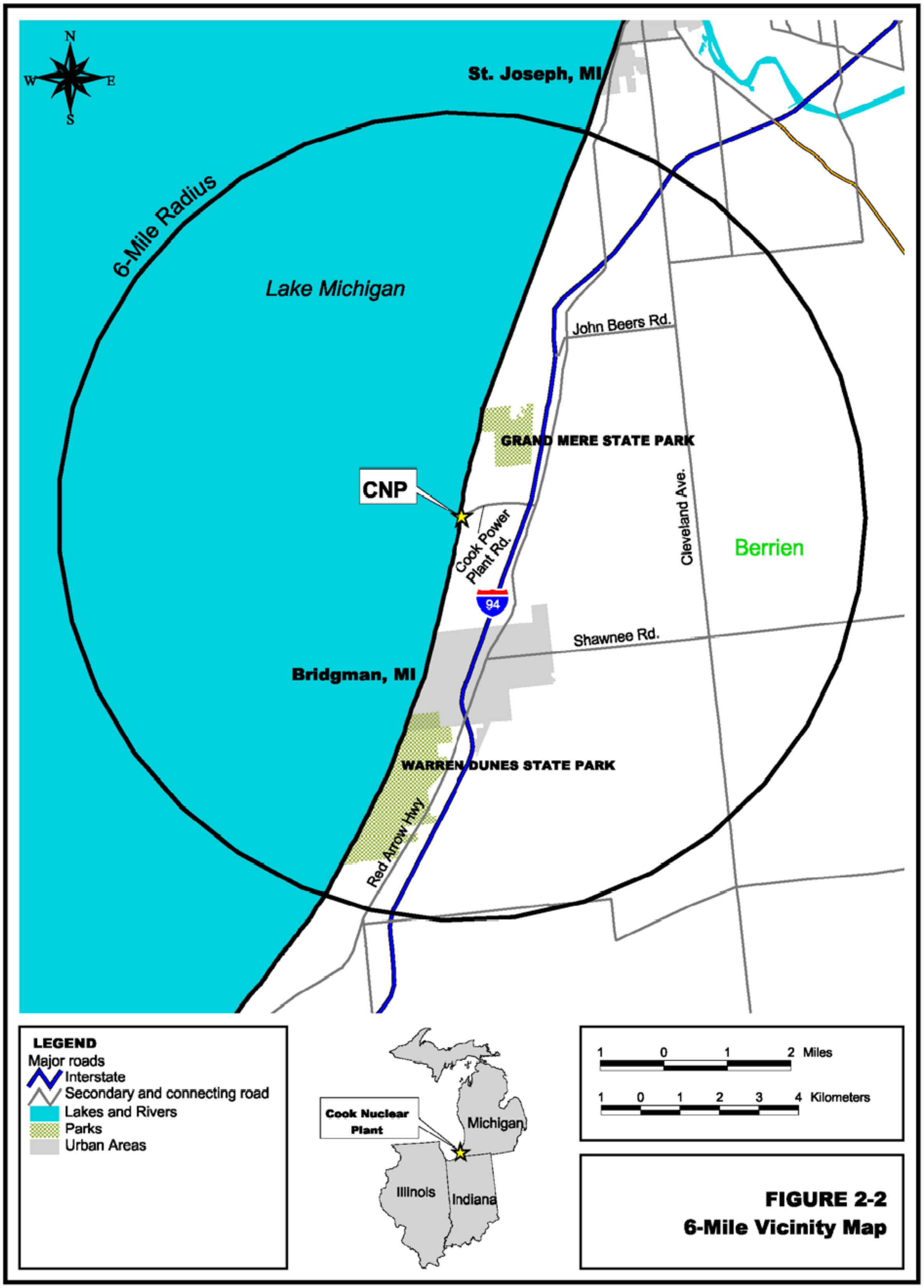

FIGURE 2-2
6-Mile Vicinity Map

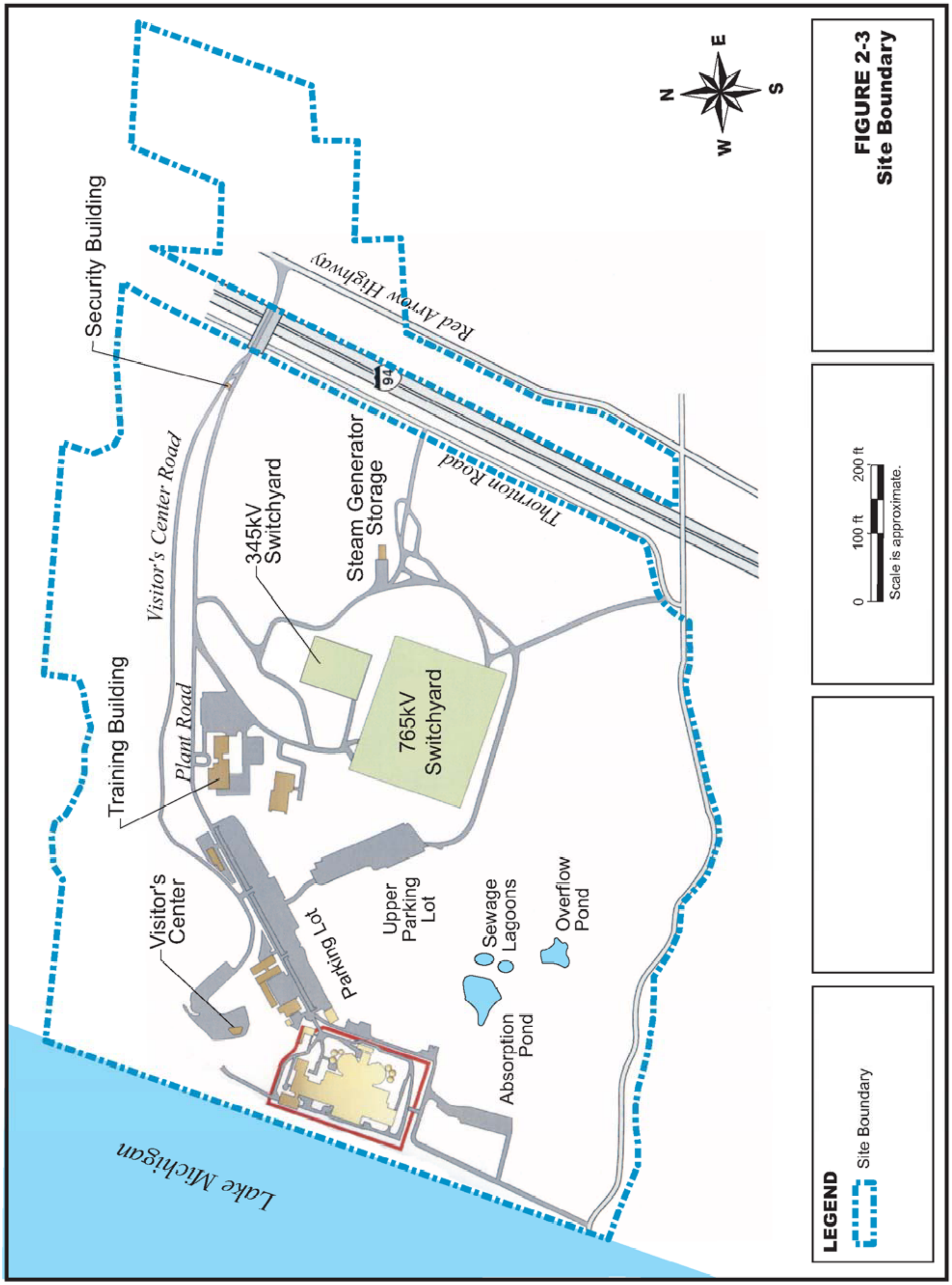

FIGURE 2-3
Site Boundary

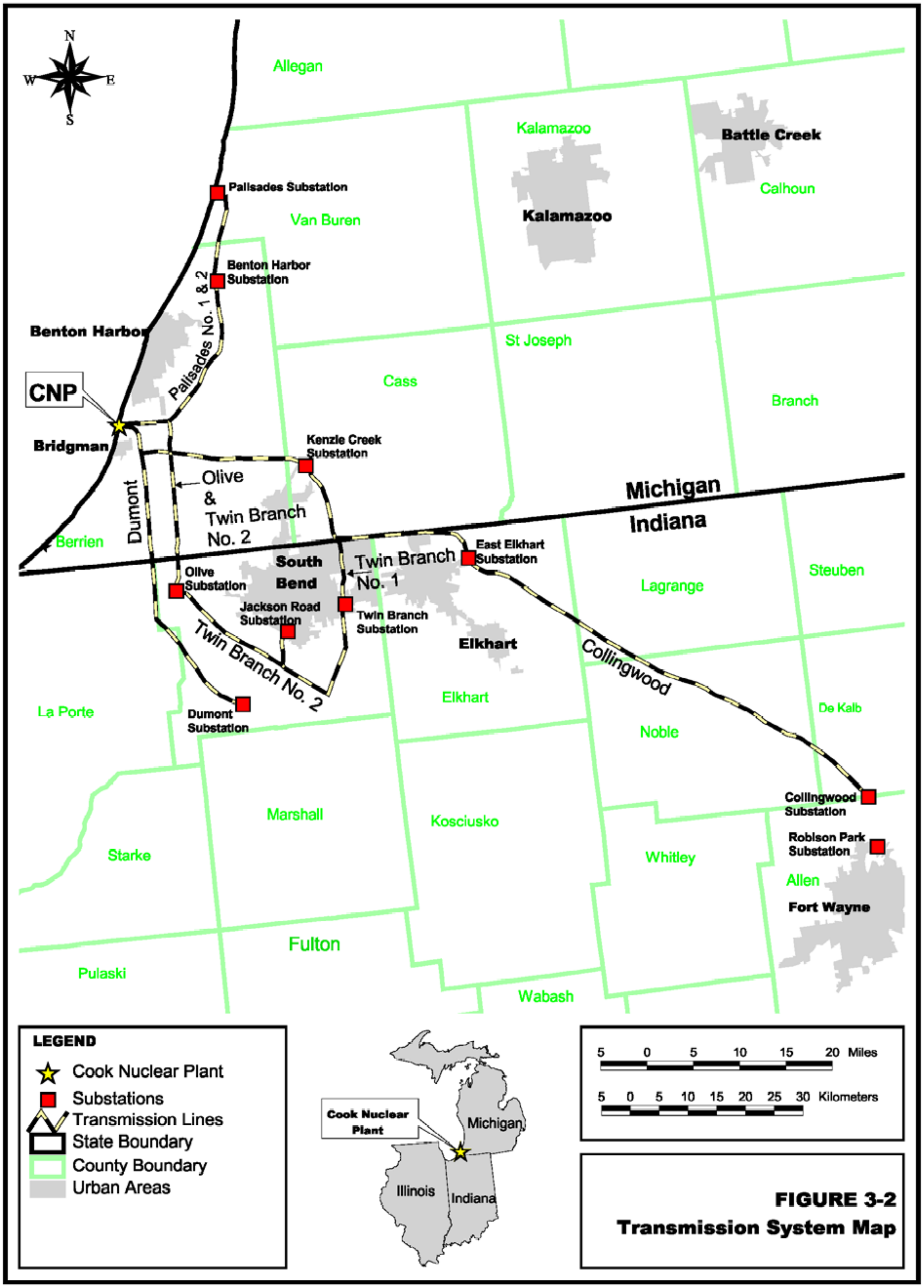

FIGURE 3-2
Transmission System Map

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Appendix E

Federal Coastal Management Program Consistency Certification

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AMERICAN ELECTRIC POWER

Mr. Christopher Anteau
Federal Consistency Coordinator
Coastal Program Unit, Land and Water Management Division
Department of Environmental Quality
PO Box 30458
Lansing, Michigan 48909

September 15, 2003

Subject: Donald C. Cook Nuclear Plant License Renewal Project
Federal Coastal Management Program Consistency Certification

Dear Mr. Anteau:

American Electric Power Company (AEP) is requesting concurrence with the enclosed draft Federal Coastal Management Program Consistency Certification. This certification presents AEP's position that continued operation of the Donald C. Cook Nuclear Plant (CNP) would be in compliance with the Michigan Coastal Management Program.

AEP is preparing an application to the U.S. Nuclear Regulatory Commission (NRC) to renew the operating licenses for CNP and, in accordance with NRC requirements, must ensure compliance with the Federal Coastal Zone Management Act. CNP is located in Lake Charter Township, Berrien County, on the eastern shoreline of Lake Michigan. The attached certification describes the plant and its operation, probable environmental impacts of continued operation, and conformance with the state coastal management program. AEP has no plans to alter current operations for the license renewal period and expects no change from current impacts.

After your review of the consistency certification, we would appreciate receiving a letter concurring with the attached Coastal Zone Management Program Consistency Certification. We will provide a copy of your response in our application to NRC, scheduled for this Fall.

If you have any questions or comments, please call me at 269-465 5901, extension 1153.

Sincerely,

John P. Carlson
Environmental Manager

Attachment: Federal Coastal Management Program Consistency Certification

Correspondence Control# 2003-1293

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FEDERAL COASTAL MANAGEMENT PROGRAM CONSISTENCY CERTIFICATION

Donald C. Cook Nuclear Plant License Renewal

This certification documents the Indiana Michigan Power Company determination that U.S. Nuclear Regulatory Commission (NRC) renewal of the Donald C. Cook Nuclear Plant operating licenses would be consistent with enforceable policies of the approved state Coastal Management Program.

Background

The NRC requires nuclear plant license renewal applicants to describe the status of compliance with federal environmental protection requirements.[1] Among those requirements is the federal Coastal Zone Management Act (CZMA),[2] which imposes requirements on applicants for a federal license to conduct an activity that could affect a state's coastal zone. The Act requires the applicant to certify to the licensing agency that the proposed activity would be consistent with enforceable policies of the state's federally-approved Coastal Zone Management Plan.[3] 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]).

Michigan has an approved Coastal Zone Management Program documented by NOAA (NRC 2001). Indiana Michigan Power Company (I&M) operates the Donald C. Cook Nuclear Plant (CNP), located in Berrien County, Michigan, and is applying to the NRC for renewal of the CNP operating licenses. Michigan has not previously reviewed NRC licensing of CNP for federal Coastal Management Program consistency; the NRC issued the current CNP licenses in 1974 and 1977, and NOAA approved the Michigan Coastal Management Program in 1978.

Proposed Activity

CNP is a nuclear-powered steam electric generating facility that began full-power operation on August 23, 1975, for Unit 1 and July 1, 1978, for Unit 2. I&M operates CNP Units 1 and 2 pursuant to NRC Operating Licenses DPR-58 (Docket No. 50-315) and DPR-74 (Docket No. 50-316), respectively. The Unit 1 license expires October 25, 2014, and the Unit 2 license expires December 23, 2017. License renewal, and conformance with license conditions, would permit operation for another 20 years (i.e., until 2034 for Unit 1 and 2037 for Unit 2).

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[1] Title 10, Code of Federal Regulations, Part 51, Section 51.45(d) [10 CFR 51.45(d)], as required by 10 CFR 51.53(c)(2). Available online at http://www.access.gpo.gov/nara/cfr/index.html.

[2] Title 16, United States Code, Part 1451 et seq. (16 USC 1451 et seq.) Available online at http://www4.law.cornell.edu/uscode/index.html.

[3] Ibid, Section 1456[c][3][A])

CNP is located in Lake Charter Township, Berrien County, Michigan, on the eastern shore of Lake Michigan. This location is approximately 55 miles east of downtown Chicago, Illinois; 55 miles southwest of Kalamazoo, Michigan; and 11 miles south-southwest of the twin cities of St. Joseph and Benton Harbor, Michigan (Figure 2-1). The nearest town is Bridgman, which is approximately two miles south of CNP (Figure 2-2).

The CNP property comprises approximately 650 acres and includes 4,350 feet of lake frontage. The site extends approximately one and one quarter miles inland from Lake Michigan (Figure 2-3). The local terrain consists of a gentle upward sloping beach that rises sharply into the dunes after about 200 feet. The major terrestrial coastal features at the CNP site are beaches and freshwater dune formations. The dunes, some of which are over 290 feet high, are part of the highest series of forested dunes along eastern Lake Michigan. Conifers, hardwoods, or shrubs and herbaceous species dominate the plant communities on the dunes. A variety of small mammals occur in the natural habitats at the site.

CNP withdraws water from, and discharges water to, Lake Michigan in accordance with a state-issued discharge permit. The once-through circulating water system removes heat rejected from the main condenser. Total circulating plant water flow when both plants are at full power is approximately 1.6 million gallons per minute. The Michigan Department of Environmental Quality has authorized CNP to discharge up to 17.3×10^9 British thermal units per hour for the total plant discharge. This limit is a variance from the state water quality standards, which are a 3-degree Fahrenheit limit above seasonally dependent maxima. The discharge permit also encompasses stormwater runoff.

In addition to water from Lake Michigan, numerous groundwater-monitoring wells are located onsite. These wells are used for compliance monitoring for the CNP state groundwater permit and NRC-required Radiological Environmental Monitoring Program. The groundwater permit allows discharges to onsite ponds that vent to Lake Michigan. The total pumping rate for all the groundwater wells is less than 100 gallons per minute.

CNP is located in the South Bend (Indiana) – Benton Harbor (Michigan) Interstate Air Quality Control Region. All counties in the region are designated as unclassifiable or in attainment for all criteria pollutants. I&M maintains a permit for CNP air emissions from the plant heating boiler and emergency diesel generators, and claims Michigan Department of Environmental Quality Rule 208a status (renewed annually) for those and other small air emissions units on site.

I&M employs a workforce of approximately 1,200 permanent employees at CNP. Approximately 88 percent live in Berrien County, Michigan, or St. Joseph County, Indiana. The CNP reactors are on 18-month refueling cycles. During refueling outages, site employment increases by as many as 700 workers for temporary duty (30 to 40 days).

CNP is connected to the regional electrical transmission system by approximately 230 miles of transmission line corridors (Figure 3-2). The corridors pass through primarily agricultural and forest land and occupy approximately 4,600 acres. I&M maintains the corridors by trimming and removing undesirable vegetation from the floor and sides of the corridors, and by use of herbicides. I&M patrols the corridors annually by helicopter in August and September. Unless otherwise needed, the maintenance schedule follows a three-year cycle. Herbicide application includes broadcast foliar applications and stump treatments, and is accomplished by certified applicators according to label specifications.

I&M has determined that no more than one or two additional permanent employees would be necessary during the license renewal term. I&M has no plans to alter current CNP operations during the license renewal term.

State Program – Michigan

Michigan has a networked Coastal Management Program, which means the program is based on several different state authorities rather than a single law and set of regulations. The Michigan Department of Environmental Quality implements the state Coastal Management Program and maintains a website that describes the program (DEQ 2002a). Table E-1 identifies enforceable provisions of the program and the I&M basis for certifying compliance. Table E-2 provides a list of all certifications, permits and authorizations for current operation of CNP.

State Program – Indiana

The Indiana Lake Michigan Coastal Program (LMCP) is also a networked program that is implemented by various state and local entities. The Indiana Department of Natural Resources maintains a website that summarizes the LMCP (DNR 2003).

The CNP Dumont transmission line traverses the easternmost portion of the coastal area in La Porte County (Figure 3-2). The corridor is approximately 15 miles from Lake Michigan and outside Indiana watersheds that drain to Lake Michigan (NOAA 2003). Based on the corridor's location relative to the coastal zone and the small impacts associated with corridor maintenance, I&M has determined that CNP license renewal would be consistent with the Indiana LMCP, and a detailed review of I&M's basis for certifying compliance with the program is not warranted.

Probable Effects

The NRC has prepared a *Generic Environmental Impact Statement* (GEIS) (NRC 1996) on impacts that nuclear power plant operations could have on the environment and has codified its findings (10 CFR 51, Subpart A, Appendix B, Table B-1). The codification identified 92 potential environmental issues, 69 of which the NRC identified as having small impacts and termed "Category 1 issues." 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 codification and the GEIS discuss the following types of Category 1 environmental issues:

- Surface water quality, hydrology, and use
- Aquatic ecology
- Groundwater use and quality
- Terrestrial resources
- Air quality
- Land use
- Human health
- Postulated accidents
- Socioeconomics
- Uranium fuel cycle and waste management
- Decommissioning

In its decision-making for plant-specific license renewal applications, absent new and significant information to the contrary, the NRC relies on its codified findings, as amplified by supporting information in the GEIS, for assessment of environmental impacts from Category 1 issues (10 CFR 51.95[c][4]). For plants such as CNP that are located in a coastal zone, many of these issues involve impacts to the coastal zone. I&M has adopted by reference the NRC findings and GEIS analyses for all 50[4] applicable Category 1 issues.

The NRC regulation identified 21 issues as "Category 2," for which license renewal applicants must submit additional site-specific information.[5] Of these, 11 apply to CNP[6]; and like the Category 1 issues, could involve impacts to the coastal zone. The

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[4] The remaining Category 1 issues do not apply to CNP because they are associated with either design or operational features that CNP does not have (e.g., cooling towers) or an activity (refurbishment) that I&M will not undertake.

[5] 10 CFR 51, Subpart A, Appendix B, Table B-1 also identifies two issues as "NA" for which NRC could not come to a conclusion regarding categorization. I&M believes that these issues, chronic effects of electromagnetic fields and environmental justice, do not affect "coastal zone" as that phrase is defined by the Coastal Zone Management Act [16 USC 1453(1)].

[6] The remaining Category 2 issues do not apply to CNP because they are associated with either design or operational features that CNP does not have (e.g., cooling towers) or an activity (refurbishment) that I&M will not undertake.

applicable issues and I&M's impact conclusions are discussed in the six groupings below.

- Aquatic ecology:

  - Entrainment of fish and shellfish in early life stages – This issue addresses mortality of organisms small enough to pass through the plant's circulating cooling water system. By issuing the plant an NPDES permit, the Michigan Department of Natural Resources acknowledges that the plant maintains the best available technology to minimize entrainment. I&M concludes that these impacts are SMALL during current operations and has no plans that would change this conclusion for the license renewal term.

  - Impingement of fish and shellfish – This issue addresses mortality of organisms large enough to be caught by intake screens before passing through the plant's circulating cooling water system. The NPDES permit also addresses impingement. I&M concludes that these impacts are SMALL during current operations and has no plans that would change this conclusion for the license renewal term.

  - Heat shock – This issue addresses mortality of aquatic organisms by exposure to heated plant effluent. I&M has conducted studies of this issue and, in issuing the plant's discharge permit, the Michigan Department of Environmental Quality determined that more stringent limits on the heated effluent are not necessary to protect the aquatic environment. I&M concludes that these impacts are SMALL during current operations and has no plans that would change this conclusion for the license renewal term.

- Threatened or endangered species – This issue address effects that CNP operations could have on species that are listed under federal law as threatened or endangered. In analyzing this issue, I&M has also considered species that are listed under Indiana and Michigan laws. Eleven plant species and three animal species listed as endangered, threatened, or extirpated are known to occur on the CNP site or along the transmission corridors in Indiana and Michigan. These species consist of the following:

  - The Caspian tern (*Sterna caspia*), listed as threatened;

  - The loggerhead shrike (*Lanius ludovicianus*), listed as endangered;

  - The golden-winged warbler (*Vermivora chrysoptera*), listed as endangered;

  - Prairie trillium (*Trillium recurvaturm*), listed as endangered;

  - Water-meal (*Wolffia papulifera*), listed as threatened;

  - Scirpus-like rush (*Juncus scirpoides*), listed as threatened;

- Rose-pink (*Sabatia anagularis*), listed as threatened;
- Straw sedge (*Carex straminea*), listed as endangered;
- Red mulberry (*Morus rubra*), listed as threatened;
- Purple coneflower (*Echinacea purpurea*), listed as extirpated;
- Carey's smartweed (*Polygonum Careyi*), listed as threatened;
- Southern dewberry (*Rubus enslenii*) listed as endangered;
- Drummond's rockcress (*Arabis drummondii*), listed as endangered; and
- Swamp smartweed (*Polygonum hydropiperoides setaceum*), listed as endangered.

The bald eagle (*Haliaeetus leucocephalus*), which is federally-listed and state-listed in Michigan as threatened, and state-listed in Indiana as endangered, and the osprey (*Pandion haliaetus*) and common tern (*Sterna hirundo*), which are state-listed in Michigan as threatened, are occasionally observed along the shoreline at the CNP site. However, no bald eagle, osprey, or common tern nests are known to occur at CNP.

No other protected species are known from the CNP site or associated transmission corridors.

I&M has identified no adverse impacts to such species and consultation with cognizant federal and state (Michigan and Indiana) agencies has identified no impacts of concern. I&M concludes that CNP impacts to these species are SMALL during current operations and has no plans that would change this conclusion for the license renewal term.

- Human health: Electromagnetic fields, acute effects (electric shock) – This issue addresses 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]), I&M concludes that the issue is not subject to the Coastal Management Program certification requirement.

- Socioeconomics: As a result of its studies on managing the effects of aging on the CNP facility, I&M expects to perform license renewal activities with no more than one or two additional staff. I&M assumes that these employees would find housing in the same locales where current employees reside.
  - Housing – This issue addresses impacts that additional CNP employees required to support license renewal could have on local housing availability. The NRC concluded in the GEIS, and I&M 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, CNP is located in a high population area and locations where additional employees would probably live do not have growth control measures. I&M concludes that impacts during the CNP license renewal term would be SMALL.
  - Public services; public utilities – This issue addresses impacts that adding license renewal workers could have on public water supply systems. I&M has analyzed the availability of public water supplies in candidate locales. Both Berrien County, Michigan, and St. Joseph County, Indiana, have excess capacity. Much of St. Joseph County relies on groundwater. The addition of one or two new permanent employees at CNP relocating into the area would not affect the ability of the public water supply to provide service. Therefore, I&M has concluded that impacts during the CNP license renewal term would be SMALL.
  - Offsite land use – This issue addresses impacts that local government spending of plant property tax dollars can have on land use patterns. CNP property taxes comprise 50 to 52 percent of Lake Charter Township property tax revenue and 2 to 3 percent of the Berrien County revenue. I&M expects this to remain generally unchanged during the license renewal term. The NRC concluded in the GEIS, and I&M 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, I&M concludes that the continued operation of CNP throughout the license renewal period will have no impact on county land use. CNP tax payments are of large significance to the Township; however, I&M expects annual taxes to remain relatively constant throughout the license renewal term, and therefore concludes that tax-increase-driven changes to offsite land-use or development patterns would be SMALL. I&M concludes that offsite land use impacts attributable to the continued operation of CNP during the license renewal term would be SMALL.
  - Public services; transportation – This issue addresses impacts that adding license renewal workers could have on local traffic patterns. I&M concludes that the impact of increasing the permanent workforce by 0.2 percent would be SMALL.

- Historic and archaeological resources – This issue address impacts that license renewal activities could have on resources of historic or archaeological significance. Although three National Register of Historic Places sites are within six miles of CNP, I&M is not aware of any adverse or detrimental impacts to these sites from current operations and has no plans for license renewal activities that would disturb these resources. I&M identified no issues of concern pertaining to the issue of historic and archaeological resources.

- Postulated 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 impacts. I&M's Severe Accident Mitigation Alternatives analysis concluded that there are no cost-beneficial mitigation alternatives related to license renewal.

Findings

1. The NRC has found that the environmental impacts of Category 1 issues are SMALL. I&M has adopted by reference the NRC findings for Category 1 issues applicable to CNP.

2. For Category 2 issues applicable to CNP, I&M has determined that the environmental impacts are SMALL.

3. To the best of I&M's knowledge, CNP is in compliance with Michigan licensing and permitting requirements and is in compliance with its state-issued licenses and permits.

4. I&M's license renewal and continued operation of CNP would be consistent with the enforceable provisions of the Michigan Coastal Management Program and the Indiana Lake Michigan Coastal Program.

State Notification

By this certification that CNP license renewal is consistent with the Michigan Coastal Zone Management Program, the State of Michigan is notified that, pursuant to 15 CFR 930.63(a), it has six months from the receipt of this letter and accompanying information in which to concur or object to the I&M certification. However, pursuant to 15 CFR 930.63(b), if 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 shall be sent to the following contacts:

Pao-Tsin Kuo
Program Director, License Renewal and Environmental Impacts
Division of Regulatory Improvement Programs
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
One White Flint North

11555 Rockville Pike
Rockville, Maryland 20555
(301) 415-1183

John Carlson
Environmental Manager
American Electric Power
Nuclear Generation Group
One Cook Place
Bridgman, MI 49106
(269) 465-5901, ext 1153

Table E-1. Compliance with Michigan Coastal Management Program.

Law and Topic	Compliance Status
Natural Resources and Environmental Protection Act, Public Act 451 of 1994	
Part 31 Water Resources Protection (Floodplain Regulatory Authority) (MCL Section 3101 – 324.3133)	Not applicable – CNP is not located within a floodplain and I&M has no plans for which a flood plain permit would be required.
Part 91 Soil Erosion and Sedimentation Control (MCL Sections 324.9101 – 324.9123a)	Not applicable – This applies to land-disturbing activities that I&M has no plans to undertake at CNP for the purpose of license renewal. If I&M identified any refurbishment or construction activities, procedures would require obtaining a soil erosion and sedimentation control permit.
Part 301 Inland Lakes and Streams (MCL Sections 324.30101 – 324.30113)	Not applicable – CNP is not located on an inland lake or stream.
Part 303 Wetlands Protection (MCL Sections 324.30301 – 30323)	In compliance – I&M has no plans for license renewal that would affect wetlands.
Part 307 Inland Lake Levels (MCL Sections 324.30701 – 324.30723)	Not applicable – CNP is not located on an inland lake.
Part 315 Dam Safety (MCL Sections 324.31501 – 324.31529)	Not applicable – There is no dam located on the CNP site.
Part 353 Sand Dunes Protection and Management (MCL Sections 324.35301 – 324.35326)	Not applicable – This applies to land-disturbing activities that I&M has no plans to undertake at CNP for the purpose of license renewal. If I&M identified any refurbishment or construction activities, procedures would require obtaining a critical dunes permit.
Land Division Act, Public Act 288 of 1967 (Subdivision Control) (MCL Sections 560.101 – 560.293)	Not applicable – CNP license renewal does not involve land subdivision.
Public Health Code, Public Act 368 of 1978 (Aquatic Nuisance Control) (MCL Sections 333.1101 – 333.25211)	Not applicable – I&M does not conduct applicable aquatic nuisance control at CNP.
Clean Water Act of 1972, Section 404 (33 USC 1344)	In compliance – I&M holds a permit for CNP maintenance dredging (see Table E-2).

Source: Modified from DEQ 2002b.
MCL = Michigan Code of Laws
USC = United States Code

Table E-2. Environmental Authorizations for Current Operations.

Agency	Authority	Requirement	Number	Issue or Expiration Date	Activity Covered
U.S. Nuclear Regulatory Commission	Atomic Energy Act (42 USC 2011, et seq.), 10 CFR 50.10	License to operate	DPR – 58 - Unit 1 DPR – 74 - Unit 2	Issued 10/25/74 Expires 10/25/14 Issued 12/23/77 Expires 12/23/17	Operation of Units 1 and 2
U. S. Department of Transportation	49 USC 5108	Registration	052703 013 027L	Issued 05/28/03 Expires 06/30/04	Hazardous materials shipments
Michigan Department of Environmental Quality	Clean Water Act (33 USC Section 1251 et seq.), Michigan Act 451. Public Acts of 1994, as amended, Parts 31 and 41, et. al.	NPDES permit (surface water)	MI0005827	Issued 09/21/00 Expires 10/01/03*	Plant discharges to Lake Michigan
Michigan Department of Environmental Quality	Federal Water Pollution Act (33 USC Section 1251 et seq.), Michigan Act 451. Public Acts of 1994, as amended, Parts 31, et. al.	NPDES permit (stormwater)	Part I.A.10 and 11 of NPDES permit	Issued 09/21/00 Expires 10/01/03*	Plant discharges to Lake Michigan
Michigan Department of Environmental Quality	Michigan Act 451. Public Acts of 1994, as amended, Parts 31 and 41, et. al.	Groundwater discharge permit	M 00988	Issued 09/29/00 Expires 09/01/05	Plant discharges to the State of Michigan groundwater and Lake Michigan
Michigan Department of Environmental Quality	Federal Clean Air Act (42 USC 7661, et seq.), IRS Ch.111-1/2, Sec.1039	Exemption to the federally-enforceable state operating permit	AQD ID B4252	Renewed annually via Rule 208a annual renewal registration submittal.	Exemption of air emissions from paint shop, boilers, and emergency generators
Michigan Department of Environmental Quality	Michigan Act 451. Public Acts of 1994, as amended, Part 325	Dredging permit	98-12-0414	Issued 9/30/98 Expires 12/31/03	Dredging near water intake

* Renewed application submitted to Michigan Department of Environmental Quality (MDEQ) on March 17, 2003 (I&M 2003); current NPDES permit is valid until a new permit is issued by MDEQ.

Table E-2. Environmental Authorizations for Current Operations. (Continued)

Agency	Authority	Requirement	Number	Issue or Expiration Date	Activity Covered
Michigan Department of Environmental Quality	Michigan Act 368. Public Acts of 1978, as amended, Part 135	Registration and inspection of radioactive materials	Not applicable	Not applicable	Radioactive materials handling
MDEQ – Geological and Land Management Division	Michigan Act 451. Public Acts of 1994, as amended, Parts 353 and 325	Critical dunes permit	02-11-0045-P	Expires 04/23/04	Security upgrades near critical dunes
MDEQ – Geological and Land Management Division	Michigan Act 451. Public Acts of 1994, as amended, Parts 353 and 325	Critical dunes permit	02-11-0111-P	Expires 12/31/04	North security fence upgrade near critical dunes
MDEQ – Geological and Land Management Division	Michigan Act 451. Public Acts of 1994, as amended, Part 325	Critical dunes permit	01-11-0069-P	Expires 12/31/03	Beach nourishment near critical dunes
MDEQ – Geological and Land Management Division	Michigan Act 451. Public Acts of 1994, as amended, Part 325	Submerged land permit	98-12-0414-P	Expires 12/31/03	Beach nourishment in submerged lands
MDEQ – Geological and Land Management Division	Michigan Act 451. Public Acts of 1994, as amended, Part 353	Critical dunes permit	94-BR-0321-C	Not applicable	Vegetation control near critical dunes
MDEQ – Geological and Land Management Division	Michigan Act 451. Public Acts of 1994, as amended, Part 353	Critical dunes permit	03-11-0096-P	Expires 05/08/04	Installation of fish avoidance system
Berrien County	Part 91 NREPA - Soil Erosion and Sedimentation Control of Natural Resources and Environmental Protection Act	Soil and erosion permit	3535R	Expires 04/16/04	Security upgrades
Berrien County	Part 91 NREPA - Soil Erosion and Sedimentation Control of Natural Resources and Environmental Protection Act	Soil and erosion permit	3448R	Expires 10/10/03	North security fence upgrades

Table E-2. Environmental Authorizations for Current Operations. (Continued)

Agency	Authority	Requirement	Number	Issue or Expiration Date	Activity Covered
Berrien County	Part 91 NREPA - Soil Erosion and Sedimentation Control of Natural Resources and Environmental Protection Act	Soil and erosion permit	3449R	Expires 10/10/03	Construction of beach ramp
Berrien County	Part 91 NREPA - Soil Erosion and Sedimentation Control of Natural Resources and Environmental Protection Act	Soil and erosion permit	3690	Expires 08/05/04	Installation of fish avoidance system
Berrien County	Part 91 NREPA - Soil Erosion and Sedimentation Control of Natural Resources and Environmental Protection Act	Soil and erosion permit	3585	Expires 09/29/03	Concrete removal in vicinity of dunes
U. S. Army Corps of Engineers	Section 10 of the Rivers and Harbors Act of 1899 (33 USC 403) Section 404 of the Clean Water Act (33 USC 1344) Section 103 of the Marine Protection, Research and Sanctuaries Act of 1972 (33 USC 1413)	U. S. Army Corps of Engineers permit	69-056-004-7	Expires 12/31/09	Beach nourishment

Table E-2. Environmental Authorizations for Current Operations. (Continued)

Agency	Authority	Requirement	Number	Issue or Expiration Date	Activity Covered
U. S. Army Corps of Engineers	Section 10 of the Rivers and Harbors Act of 1899 (33 USC 403) Section 404 of the Clean Water Act (33 USC 1344) Section 103 of the Marine Protection, Research and Sanctuaries Act of 1972 (33 USC 1413)	U. S. Army Corps of Engineers permit	03-056-043-1	Expires 08/06/04	Installation of fish avoidance system
South Carolina Department of Health and Environmental Control	South Carolina Radioactive Waste Transportation and Disposal Act (S.C. Code of Laws 13-7-110 et seq.)	Radioactive waste transport permit	0055-21-03X	Issued 01/01/03 Expires 12/31/03	Transportation of radioactive waste in South Carolina
Tennessee Department of Environment and Conservation	Tennessee Code Annotated 68-202-206	License to ship radioactive material	T-MI001-L03	Issued 12/23/02 Expires 12/31/03	Shipments of radioactive material to processing facility in Tennessee

CFR - Code of Federal Regulations
MDEQ - Michigan Department of Environmental Quality
NPDES - National Pollutant Discharge Elimination System
USC - United States Code

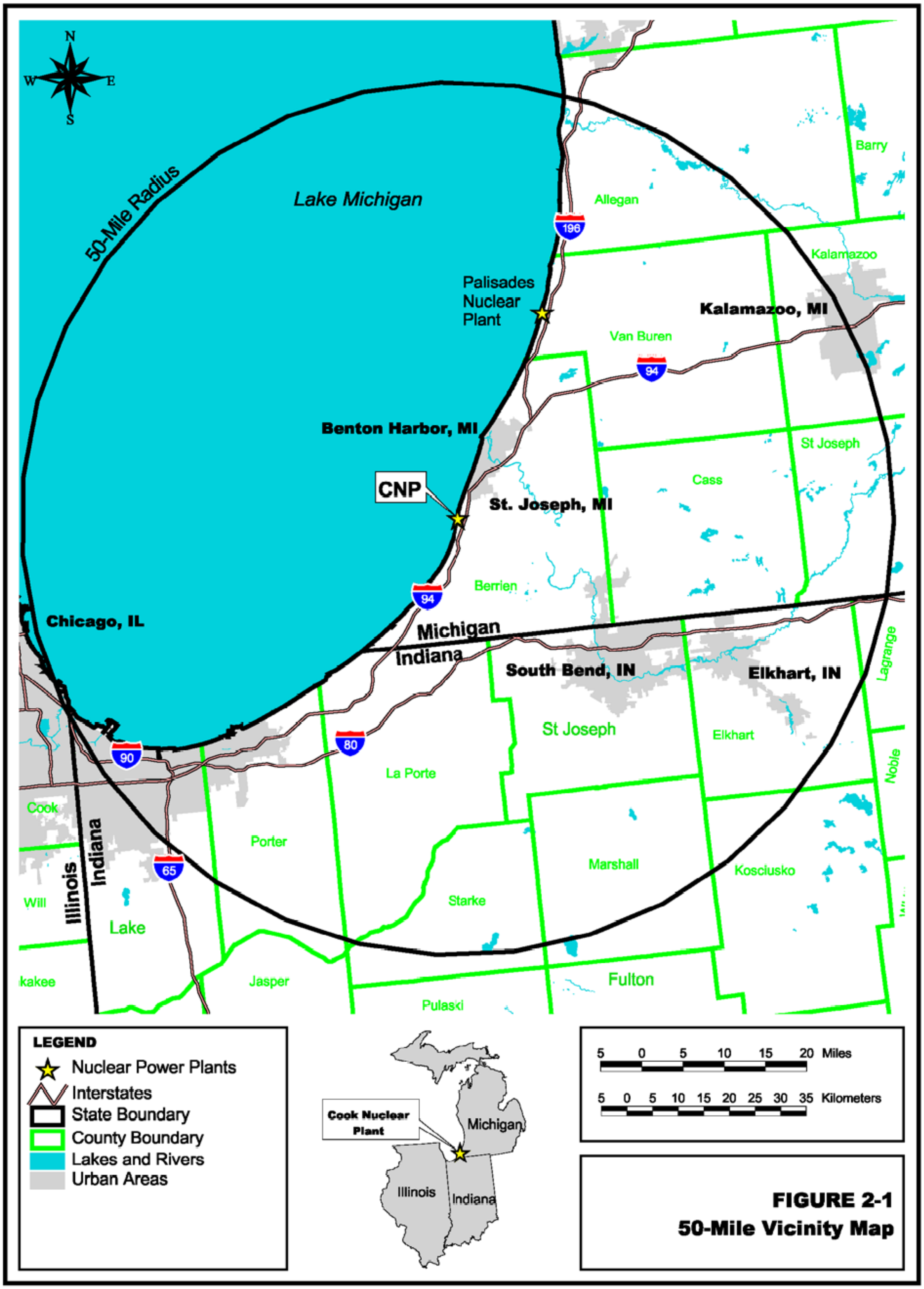

FIGURE 2-1
50-Mile Vicinity Map

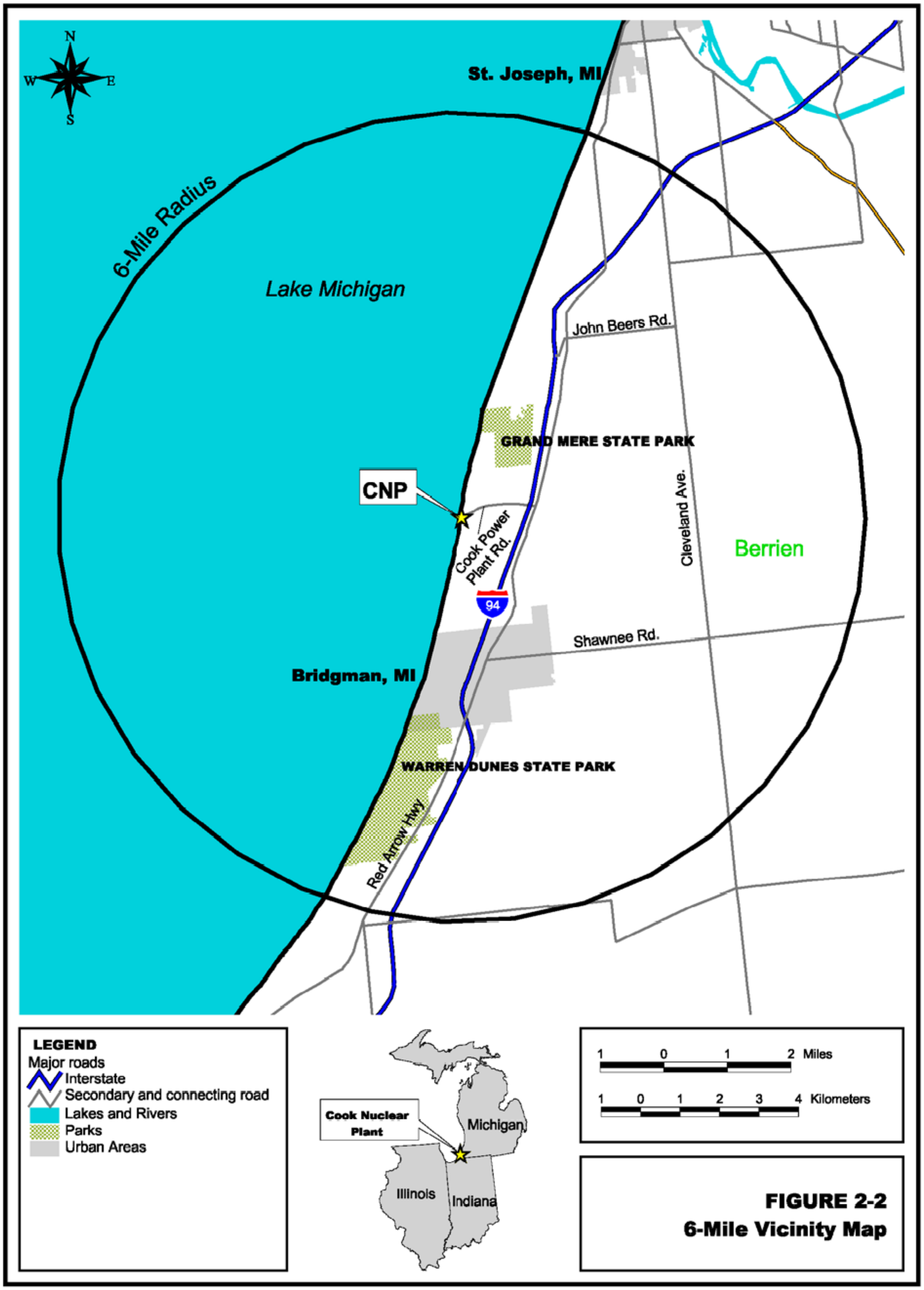

FIGURE 2-2
6-Mile Vicinity Map

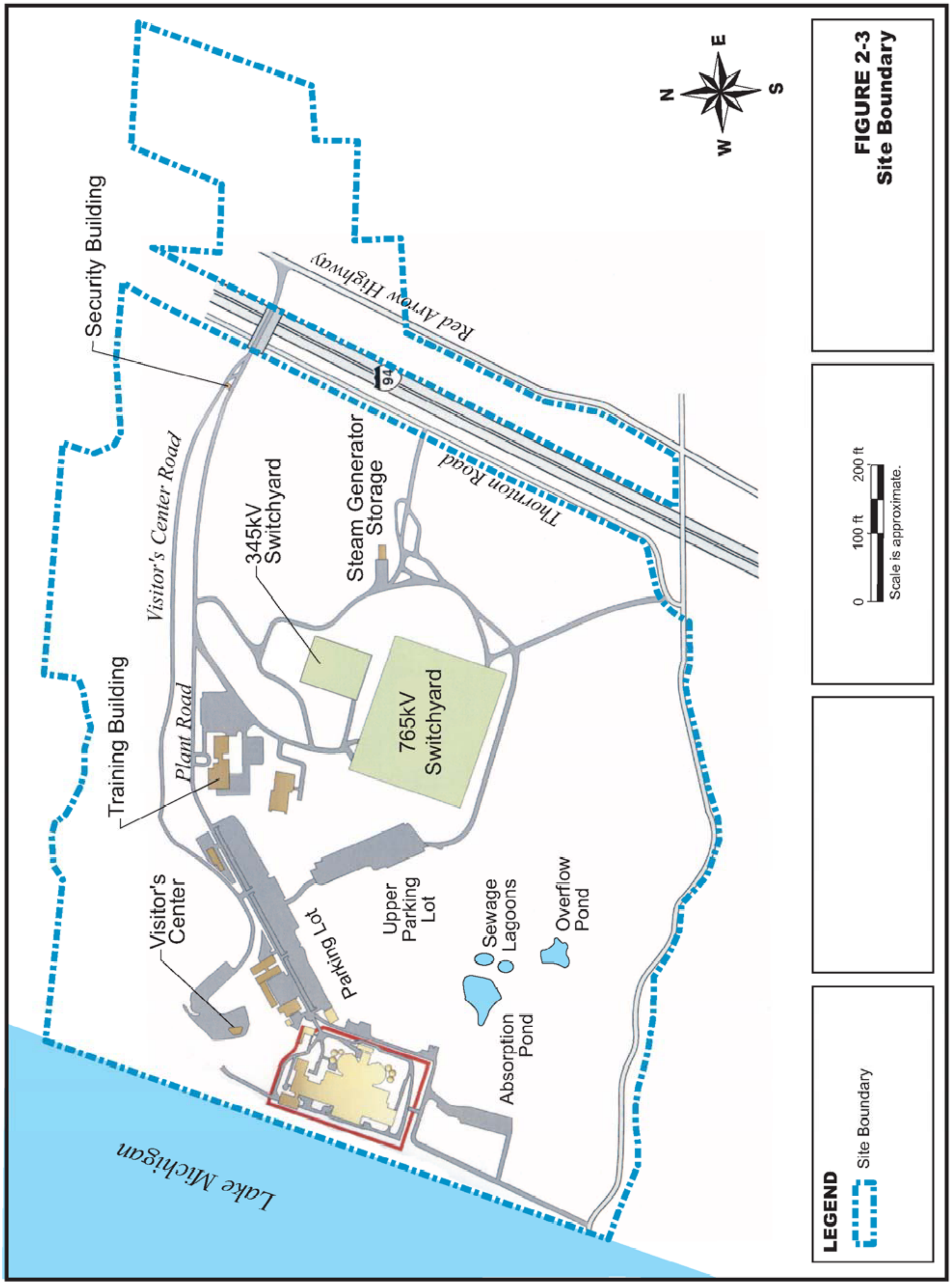

FIGURE 2-3
Site Boundary

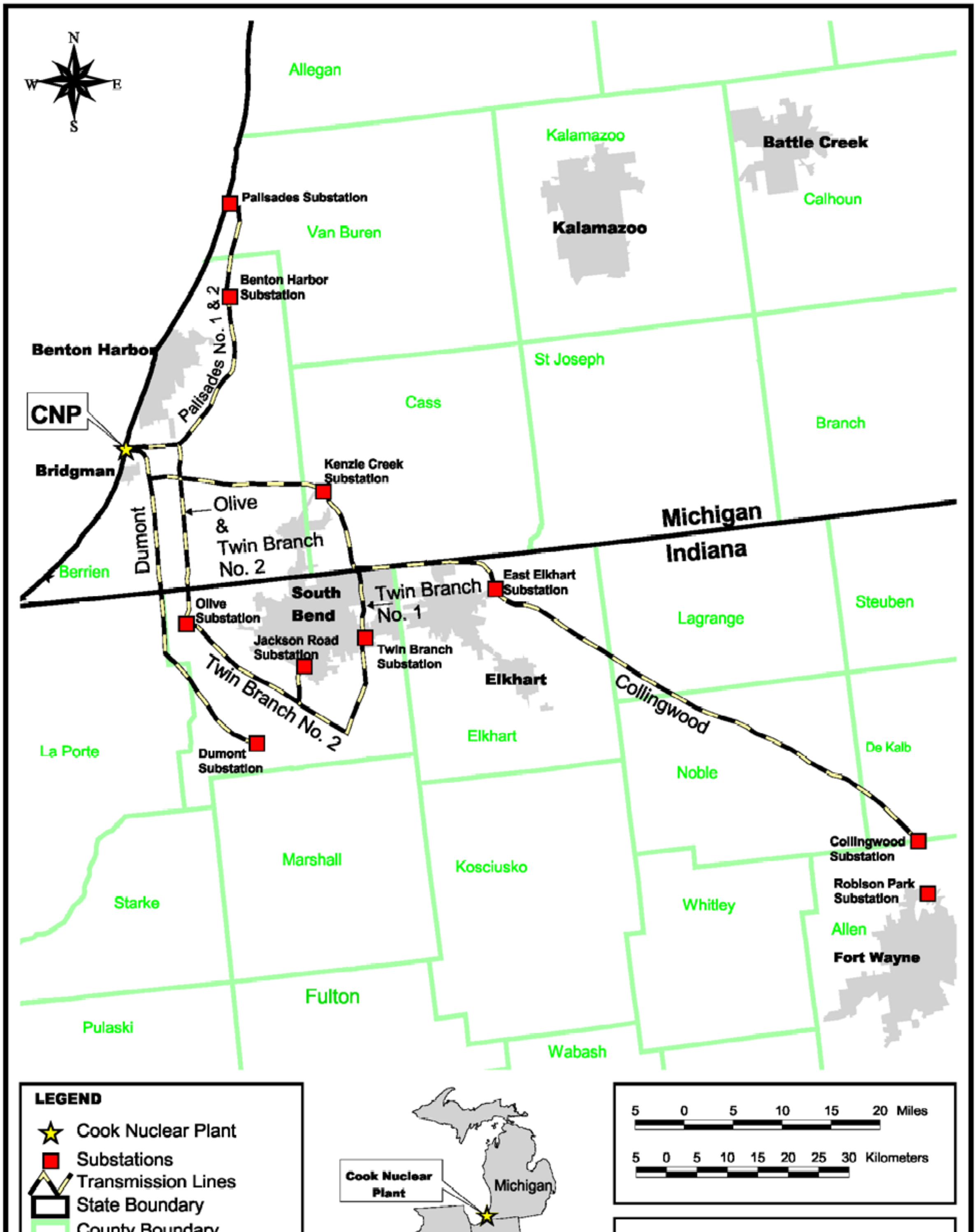

FIGURE 3-2
Transmission System Map

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Appendix F

Severe Accident Mitigation Alternatives Analysis

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Table of Contents

List of Tables

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List of Acronyms

AC	Alternating Current
AFW	Auxiliary Feedwater
AFWST	Auxiliary Feedwater Storage Tank
AMSAC	ATWS Mitigating System Actuation Circuitry
AOP	Abnormal Operating Procedure
ATWS	Anticipated Transient Without Scram
BOP	Balance of Plant
BWR	Boiling Water Reactor
CCW	Component Cooling Water
CDF	Core Damage Frequency
CET	Containment Event Tree
CIV	Containment Isolation Valve
CNP	Donald C. Cook Nuclear Plant
COMSORS	Core Melt Source Reduction System
CRD	Control Rod Drive
CRID	Control Room Instrument Distribution
CTS	Containment Spray
CST	Condensate Storage Tank
CVCS	Chemical and Volume Control System
DC	Direct Current
EDG	Emergency Diesel Generator
ECCS	Emergency Core Cooling System
EOP	Emergency Operating Procedure
EPZ	Emergency Planning Zone
ERCW	Emergency Raw Cooling Water
ESW	Essential Service Water
FW	Feedwater
GDC	General Design Criterion
GIS	Geographical Information System
HCLPF	High Confidence of Low Probability of Failure
HPCI	High Pressure Coolant Injection
HPCS	High Pressure Core Spray
HPSI	High Pressure Safety Injection
HRA	Human Reliability Analysis
HVAC	Heating, Ventilation and Air Conditioning
IC	Isolation Condenser
ICONE	International Conference on Nuclear Engineering
ICW	Intermediate Cooling Water
I&M	Indiana Michigan Power Company
IPE	Individual Plant Examination
IPEEE	Individual Plant Examination for External Events

List of Acronyms (Continued)

ISLOCA	Interfacing System LOCA
KV	Kilovolts
LERF	Large Early Release Frequency
LOCA	Loss of Coolant Accident
LOSP	Loss of Offsite Power
LPCI	Low Pressure Coolant Injection
MAAP	Modular Accident Analysis Program
MACCS2	MELCOR Accident Consequences Code System
MG	Motor-Generator
MOV	Motor-Operated Valve
MWe	Megawatts-Electrical
MWt	Megawatts-Thermal
NRC	Nuclear Regulatory Commission
PORV	Power-Operated Relief Valve
PRA	Probabilistic Risk Assessment
PWR	Pressurized Water Reactor
RCIC	Reactor Core Isolation Cooling
RCP	Reactor Coolant Pump
RCS	Reactor Coolant System
RHR	Residual Heat Removal
RRW	Risk Reduction Worth
RWST	Refueling Water Storage Tank
SAMA	Severe Accident Mitigation Alternative
SAMDA	Severe Accident Mitigation Design Alternative
SBO	Station Blackout
SER	Staff Evaluation Report
SG	Steam Generator
SGTR	Steam Generator Tube Rupture
SI	Safety Injection
SLC	Standby Liquid Control
SRP	Standard Review Plan
SRV	Safety Relief Valve
SSE	Safe Shutdown Earthquake
SSF	Safe Shutdown Feature
STC	Source Term Category
SW	Service Water
TVA	Tennessee Valley Authority
V	Volts
WOG	Westinghouse Owner’s Group

F.1 Methodology Overview

The methodology used to perform the CNP SAMA analysis was based on the handbook used by the NRC to analyze benefits and costs of its regulatory activities, NUREG/BR-0184 (Reference F.1-1), subject to CNP-specific considerations.

Environmental impact statements and environmental reports are prepared using a sliding scale in which impacts of greater concern and mitigative measures of greater potential value receive more detailed analysis than impacts of lesser concern and mitigative measures of lesser potential value. Accordingly, I&M used less detailed feasibility investigative and cost estimation techniques for SAMA candidates having disproportionately high costs and low benefits and more detailed evaluations for the most viable candidates.

Initial input for the CNP SAMA benefits analysis included the August 2001 Level 1 PRA model for internal events, which is an updated version of the IPE, and the October 2003 Level 2 PRA update (Reference F.1-2).

CNP is a two-unit plant. This SAMA analysis was performed based on the Unit 1 August 2001 Level 1 PRA model for internal events. The results produced by the Unit 1 Level 1 PRA model are nearly identical to the results that would be produced by the Unit 2 Level 1 PRA model. Any minor differences relate to slight differences in power supplies to components and slight changes to pressure relief requirements during ATWS events. Evaluation of offsite consequences used the higher rated thermal power for Unit 2, which was uprated to 3,468 MWt in June 2003. The radionuclide inventory used for this analysis was obtained by adjusting the end-of-cycle values for a 3,412 MWt PWR by a linear scaling factor of 1.0164.

The following is a brief outline of the approach taken in the SAMA analysis.

Step 1 – Establish the base case.

- Offsite exposure cost – Monetary value of consequences (dose) to offsite population.

  The August 2001 Level 1 PRA model was used to determine total accident frequency (CDF); the October 2003 Level 2 PRA model and MAAP Version 4.0.5 were used to determine radiological release source term fractions and plume duration; MACCS2 (as endorsed by NUREG/BR-0184) was used to convert radiological release data to public dose; and NUREG/BR-0184 methodology was used to convert dose to present worth dollars (based on valuation of $2,000 per person-rem and a present worth discount factor of 7 percent).

- Offsite economic cost – Monetary value of damage to offsite property.

  The August 2001 Level 1 PRA model was used to determine total accident frequency (CDF); the October 2003 Level 2 PRA model and MAAP Version 4.0.5 were used to determine radiological release source term fractions and plume duration; MACCS2 (as endorsed by NUREG/BR-0184) was used to convert radiological release data to offsite property damage; and NUREG/BR-0184 methodology was used to convert offsite property damage to present worth dollars.

- Onsite exposure cost – Monetary value of dose to workers.

  The August 2001 Level 1 PRA model was used to determine total CDF; the NUREG/BR-0184 best-estimate occupational dose values for immediate and long-term dose were determined; and NUREG/BR-0184 methodology was used to convert dose to present worth dollars (based on valuation of $2,000 per person-rem and a present worth discount factor of 7 percent).

- Onsite economic cost – Monetary value of damage to onsite property.

  The August 2001 Level 1 PRA model was used to determine total CDF; the NUREG/BR-0184 best-estimate cleanup and decontamination costs were determined; and NUREG/BR-0184 methodology was used to convert onsite property damage estimate to present worth dollars. It was assumed that, subsequent to a severe accident, the plant would not be restored to operation. Therefore, replacement/refurbishment costs are not included in onsite costs. Replacement power costs are included directly in this analysis.

Step 2 – Identify potential SAMA candidates using:

- Documented insights from review of the CNP PRA models;
- Ongoing CNP equipment reliability initiatives;
- NRC and industry documentation discussing potential plant improvements; and
- SAMDA analyses submitted in support of original licensing activities for other operating nuclear power plants and advanced light water reactor plants.

Step 3 – Perform preliminary screening of potential SAMA candidates and eliminate as non-viable, SAMA candidates:

- That modify features not applicable to CNP;
- That have already been implemented at CNP; or
- That would require extensive plant design and construction activities at a cost exceeding the maximum benefit for the base case evaluation.

Step 4 – Perform final evaluation of remaining SAMA candidates by using cost-benefit analysis, screening out SAMA candidates that are not cost-beneficial by:

- Calculating impacts (i.e., changes to onsite/offsite dose and damages) of implementing each SAMA individually by modifying existing Level 1 or Level 2 PRA models as appropriate to simulate revised plant risk following implementation of each individual SAMA;

- Calculating benefits for each SAMA in terms of averted consequences (the arithmetic differences between the calculated impact for the base case and revised impact following implementation of each individual SAMA);

- Estimating the cost of implementing each evaluated SAMA The detail of the cost estimate should be commensurate with the benefit. If the benefit is very low, it is not necessary to perform a detailed cost estimate to determine that a SAMA is not cost-beneficial and expert judgement may be applied; and

- Comparing the cost of implementing each evaluated SAMA to the calculated benefit, using twice the benefit amount as the screening limit, to determine if a SAMA is potentially cost-beneficial.

Step 5 – Perform sensitivity analysis to determine the effect that changing certain inputs, including discount rate, would have on the cost-benefit calculation.

Step 6 – Summarize results and conclusions, identifying SAMA candidates that are potentially cost-beneficial.

Step 7 – Determine if potentially cost-beneficial SAMA candidates are necessary to effectively manage the effects of aging, identifying whether implementation of these SAMA candidates would be required pursuant to 10 CFR 54.

The following sections describe and provide the results of the CNP SAMA analysis as outlined above, derived from the detailed CNP SAMA analysis performed by I&M (Reference F.1-3).

F.2 Establishing the Base Case

The purpose of establishing the base case is to provide the baseline for determining the risk reductions that would be attributable to the implementation of potential SAMA candidates. The August 2001 Level 1 and October 2003 Level 2 PRA models, and the MACCS2 Level 3 PRA model (Reference F.2-1), were used to calculate severe accident risk.

F.2.1 Overview of CNP PRA Models

The primary sources of data relating to the base case are the CNP PRA models. The results of the CNP PRA models can be used to:

- Develop an understanding of severe accident behavior;
- Understand the most likely severe accident consequences;
- Gain a quantitative understanding of the overall probabilities of core damage and fission product releases; and
- Evaluate potential hardware and procedure changes to determine the resulting changes in the overall probabilities of core damage and fission product releases.

The CNP PRA includes Level 1, Level 2, and Level 3 PRA models for internal events. The current Level 1 PRA model provides results for CDF, LERF, and individual accident sequence frequencies. Systems such as containment spray and distributed ignition that could have a significant impact on containment performance are included in the Level 1 PRA model. The Level 2 PRA model 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. The Level 2 PRA model makes use of the accident sequence results from the Level 1 PRA model. The Level 3 PRA model evaluates the offsite consequences that result from severe accidents and containment radiological releases. The Level 3 PRA model uses the source term characteristics generated by the Level 2 PRA model.

Original CNP IPE Model Description

Detailed Level 1, Level 2, and Level 3 PRA evaluations were performed in accordance with the methodology described in NUREG/CR-2300 (Reference F.2-2). The CNP IPE model was developed using small event trees (primarily systemic) and large fault trees. The CNP IPE model represents accident and transient initiating events starting from power operation and continuing for a 24-hour mission time. The IPE and IPEEE were submitted to the NRC on May 1, 1992 (Reference F.2-3). This submittal and supporting documentation were reviewed by NRC PRA, systems experts, and operations experts, and by independent industry PRA specialists. The NRC issued a SER on the CNP IPE on September 6, 1996 (Reference F.2-4) and an SER on the CNP IPEEE on August 5, 1998 (Reference F.2-5).

During development of the Level 1 CNP IPE model, I&M created a Level 2 PRA model. Containment response and radioactive source terms for the plant damage states for this model were determined with MAAP Version 3.0B (PWR Version 19) for a 48-hour mission time. Certain phenomenological issues were addressed using CNP-specific position papers. A best-estimate containment failure pressure-fragility curve was calculated for CNP.

CETs were used to characterize the containment response to core melt sequences, including uncertainties, using plant damage states quantified with the Level 1 CNP IPE model. CETs consider the possibilities of

- Containment being successful in isolating and preventing the release of radiological materials to the environment; or
- The possibilities of containment bypass occurring, containment isolation being impaired, or the containment building structurally failing during a severe accident sequence resulting in a quantifiable release of radiological materials to the environment.

August 2001 Level 1 PRA Model Update

The current Level 1 PRA model includes internal events (e.g., loss of FW event, LOCA, etc.) and is more advanced than the IPE. The Level 1 PRA model was updated in August 2001 to address four main areas:

- Support for Configuration Risk Management – Changes to support development of Configuration Risk Management tools were incorporated.
- Modeling Changes – The latest state of knowledge regarding PRA methods was incorporated.
- Plant Configuration Changes – Changes to the plant and procedures were incorporated.
- Equipment Performance – Based on data collection, new values of estimated failure rates and system unavailability were incorporated.

Specifically, initiating event frequencies, event trees, failure data, and system models were updated, and a partial update of the HRA was performed.

WOG Peer Review

The August 2001 Level 1 PRA model was reviewed by the WOG PRA Peer Review Team. All elements of the PRA Peer Review received a grade of contingent 3. This signified that, in the opinion of the reviewers, the August 2001 Level 1 PRA model could be used in licensing submittals to the NRC to support positions concerning absolute levels of safety significance, if supported by deterministic evaluations. The summary of strengths and areas for improvement is extracted from the final report and is provided below.

Strengths:

- PRA Notebooks are well constructed and useful.
- There is good interaction with plant personnel/functions, and good input into the HRA and the Risk Informed Steering Committee.
- The PRA is broad in scope and provides information tools for evaluation.
- There is strong attention to detail in the modeling and quantification process and documentation.
- There is a highly sophisticated single fault tree model able to be used for PRA or Configuration Risk Management quantification.

Areas for Improvement:

- Better estimates in success criteria could be used in analyses to remove conservatism.
- Some of the analytical bases for IPE success criteria should be re-created to confirm original conclusions.
- The internal flooding analysis should be updated.
- Common cause process could be improved; plant-specific common cause screening should be considered.
- The highly sophisticated single fault tree model used for PRA or Configuration Risk Management quantification requires a high degree of attention to quantification process.
- Some improvement in documentation could provide better support for future PRA applications.

October 2003 Level 2 PRA Model Update

The Level 2 PRA model was updated in October 2003. The Level 2 PRA model was updated to include more quantitative details for phenomenological factors that impact containment performance. Containment response and radioactive source terms for the plant damage states for this model update were determined in October 2003 using MAAP Version 4.0.5.

The internal flooding analysis CNP PRA model has not been updated since the original IPE submittal. The seismic and fire analyses were updated once since the original IPEEE submittal, and were approved by the NRC in the SER issued on August 5, 1998.

Summary of August 2001 Level 1 PRA Model Results

For this analysis, total CDF is quantified as the sum of STC frequencies and results in a CDF that is slightly higher than that of the PRA quantification, which calculates CDF as the sum of frequencies of minimal cutsets. This higher value is expected for two reasons.

- The first and most significant reason is that the cutsets generated for each event tree sequence can contain cutsets that are non-minimal to the cutsets of another sequence. The non-minimal cutsets appear because success term approximation is used to limit quantification time and output file size to manageable levels.

- The second reason is rounding that occurs in the Level 2 PRA model quantification process. Using the August 2001 Level 1 PRA model, the CDF calculated from the sum of minimal cutsets for Unit 1 is 4.858E-05 per year. Using the October 2003 Level 2 PRA model, the CDF calculated from the sum of STC frequencies for Unit 1 is 4.986E-05 per year, or approximately 3 percent higher. Using the August 2001 Level 1 PRA model, the CDF calculated for the sum of non-minimal cutsets for Unit 1 is 4.986E-05 per year, which to three decimal places compares exactly to CDF calculated as the sum of STC frequencies.

The major contributors to the CNP CDF and the relative percentage contribution of each to total CDF are shown in Table F.2-1 (by initiating event) and Table F.2-2 (by event type). As shown in Table F.2-1, two of the top five initiating event contributors to CDF are LOSP initiated sequences. In Table F.2-2, those LOSP sequences that lead to SBO events are the source of this significant contribution. The SBO contribution is approximately 36 percent of the total CDF for both single unit and dual unit initiated events. As shown in Table F.2-2, sequences that involve a loss of all ESW are the largest contributors to CDF, comprising approximately 24 percent of the total. The most significant contributors are loss of ESW either as the initiator or following a normal transient initiator with subsequent loss of ESW and combined with failure to recover ESW. Both tables show that a small LOCA is also an important contributor (approximately 17 percent of the total) to CDF.

The August 2001 Level 1 PRA update determined relative public risk by calculating LERF. The value obtained for LERF for each unit was calculated to be approximately 5.62E-06/year for Unit 1 and 5.63E-06 for Unit 2. The major contributors to the CNP LERF and the relative percentage contribution of each to total LERF are shown in Table F.2-3 (by initiating event) and Table F.2-4 (by event type). As shown in Table F.2-3 and Table F.2-4, the dominant contributors to LERF are LOSP initiated sequences that comprise approximately 50 percent of the total. SGTR, loss of ESW, and small LOCA events contribute approximately 34 percent of the total LERF.

Based on the IPEEE model, seismic events contribute a CDF of 3.2E-06/year and internal fires a CDF of 3.8E-06/year to the CNP risk profile. Other external events were found to add a probabilistically insignificant risk to the plant.

F.2.2 MACCS2 Modeling

Using the results of the October 2003 Level 2 PRA model analysis, the next step was to perform a Level 3 PRA, which calculates the hypothetical impacts of severe accidents on the surrounding environment and members of the public. MACCS2 (Reference F.2-6) was used for determining the offsite impacts for the Level 3 PRA. The principal phenomena analyzed are atmospheric transport of radionuclides; mitigative actions (i.e., evacuation, condemnation of contaminated crops and milk) based on dose projection; dose accumulation by a number of pathways, including food and water ingestion; and economic costs. Input for the Level 3 PRA includes the Unit 2 uprated thermal power core radionuclide inventory, source terms based on the October 2003 Level 2 PRA model, site meteorological data, projected population distribution (within 50-mile radius) for the year 2038, emergency response evacuation modeling, and economic data.

The Level 3 PRA looks at the source term for each of eight different source term categories, or STCs, associated with end states of the CET. Because the analysis is based on probabilistic risk input, the analytical results relate the frequency of an impact to the magnitude of the impact (i.e., frequency versus risk). In general, severe accidents having the greater predicted impact have the lower predicted probability of occurrence.

The following subsections describe the assumptions made and the results of modeling performed to assess the risks and consequences of severe accidents (NRC Class 9) at CNP.

F.2.2.1 Input

The input data required by MACCS2 are outlined below.

Core Inventory

The base core inventory in MACCS2 is for a reference PWR producing 3,412 MWt (Reference F.2-6). CNP is a two-unit PWR plant that produces a power level of 3,304 MWt for Unit 1 and 3,468 MWt for Unit 2. To bound the results of this analysis, the core inventory for CNP was obtained using the higher Unit 2 power level by adjusting the end-of-cycle values for a 3,412 MWt PWR (Table F.2-5) by a linear scaling factor of 1.0164.

Source Terms

The source term input data to MACCS2 were the severe accident source terms developed from the October 2003 Level 2 PRA model. Radiological releases were defined in terms of eight STCs and their associated annual frequencies. STCs include the following:

- STC-1 – Containment bypassed with noble gases plus up to 1 percent of the volatiles released.
- STC-2 – Containment bypassed with noble gases and more than 10 percent of the volatiles released.
- STC-3 – Containment failure prior to vessel failure with noble gases and less than 1/10 percent of the volatiles released (containment isolation impaired).
- STC-4 – Containment failure prior to vessel failure with noble gases and up to 10 percent of the volatiles released (containment isolation impaired).
- STC-5 – Containment failure prior to vessel failure with the noble gases and more than 10 percent of the volatile fission products released (containment isolation impaired).
- STC-6 – Early containment failure with noble gases and up to 10 percent of the volatiles released (containment failure within six hours of vessel failure; containment not bypassed; isolation successful).
- STC-7 – Late containment failure with noble gases and up to 10 percent of the volatiles released (containment failure greater than six hours after vessel failure; containment not bypassed; isolation successful).
- STC-8 – No containment failure (leakage only, successful maintenance of containment integrity; containment not bypassed; isolation successful).

The release fraction of each type of radionuclide was assigned to one of nine MACCS2 radionuclide groups, as shown in Table F.2-6. A release height of 100 feet above ground level was assumed for STC-1 and STC-2, and a release height of 80 feet above ground level was assumed for STC-3 through STC-7. STC-8 represents a case where containment failure does not occur. The amounts (becquerels) of each radionuclide released to the atmosphere for each STC are obtained from the analysis performed using MAAP Version 4.0.5.

The offsite consequences for each of the STC cases is weighted by the annual frequency of the STCs and the results summed to obtain the total annual accident risk for the base case and for each of the SAMA concepts evaluated. This summation calculation is performed outside of the MACCS2 code as part of the SAMA cost-benefit analyses.

Meteorological Data

The MACCS2 input uses a full year of consecutive hourly values of wind speed, wind direction, stability class, and precipitation. Data collected in 1997 were used in constructing the meteorological data file. Wind speed, direction, and stability data were compiled from the 10-meter and 60-meter levels. The 1997 data were compared with a three-year period used in previous calculations and found to be within expected results. A continuous complete site-specific set is not available. The only significant block of missing data was about a month (September 24, 1997 through October 20, 1997) of missing 60-meter wind speed. This data was extrapolated using the 10-meter wind speed and adjusting the data to the 60-meter level using the power law. The only other notable data feature was the heavy precipitation totals. About 57 inches of combined rain and snow fell during 1997 at the CNP meteorological tower. The site data were compared with local National Weather Service sites, particularly during periods of heavy precipitation, and found to agree well. Also, calibration records for 1996 and 1997 were checked and the rain gage was found to be functioning well within allowable tolerances.

The final data items required for the meteorological input file, the morning and afternoon mixing heights, were estimated from U. S. isopleth maps of mean annual mixing heights (Reference F.2-7). For CNP, the mean annual morning and afternoon mixing heights were estimated to be 510 meters and 1,200 meters, respectively.

MACCS2 calculations examine a representative subset of the 8,760 hourly observations contained in one year's data set (typically about 150 sequences). The representative subset is selected by sampling the weather sequences after sorting them into weather bins defined by wind speed, atmospheric stability, and rain conditions at various distances from the site.

Population Distribution

The predicted permanent resident population around the site for the year 2038 was distributed by location in a grid consisting of sixteen directional sectors, the first of which is centered on due north, the second on 22.5 degrees east of north, etc. A summary of the population distribution is shown in Table F.2-7. The direction sectors are divided into 10 radial intervals extending out to 50 miles, resulting in 160 population sectors. The habitable land fraction for each grid element was calculated from land fraction data within a 50-mile radius of the plant.

A GIS program was configured to import the year 2000 block-group population data from the U. S. Census Bureau into each of the 160 sectors. The year 2000 population based on these census data was allocated based on the area each block group occupied within each sector and the population density of that block group.

The fractional area of each county in each of the MACCS2 rosette sectors was also estimated using the GIS program. The population estimates and projections described below were then produced on a sector-wise/county area-weighted basis.

The state projections for the year 2020 county populations (Reference F.2-8, Reference F.2-9, and Reference F.2-10) were compared to the actual (not projected) year 2000 populations from the U. S. Census Bureau (Reference F.2-11). The growth rates between the year 2000 population and the year 2020 population projections were calculated for each county and were assumed to remain constant through the year 2038. Not all of the 16 counties within a 50-mile radius of the plant are projected to have a positive growth rate. In fact, the two counties closest to the plant (Berrien and Cass) are projected to lose population from 2000 to 2020, and this loss was assumed to continue at the same rate through 2038. These countywide growth rates were modified for each MACCS2 rosette sector, weighted by the fraction of county area(s) contained within each sector.

The aggregate population for the fifty-mile radius region was 1,288,306 in 2000 and is projected to grow to 1,469,288 in year 2038 (14 percent increase), despite the population losses projected for Berrien and Cass counties.

Emergency Response

As have other U. S. utilities that operate nuclear reactors, I&M has developed a plan for the evacuation of the population within the plume exposure EPZ. This EPZ is approximately a 10-mile radius centered on the CNP site. A site-specific evacuation study has been carried out by HMM Associates (Reference F.2-12), and the evacuation modeling employed for the severe accident analysis was based primarily on this study.

Scram for each sequence was taken as time zero relative to the core-containment response times. 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, at which time the public is instructed to proceed with the evacuation.

The MACCS2 User's Guide input parameters of 95 percent of the population within 10 miles of the plant EPZ evacuating and 5 percent not evacuating were employed. These values have been used in similar studies, including Edwin I. Hatch Nuclear Plant (Reference F.2-13) and Calvert Cliffs Nuclear Power Plant (Reference F.2-14), and are conservative relative to the NUREG-1150 study, which assumed evacuation of 99.5 percent of the population within the EPZ (Reference F.2-15). The evacuees are assumed to begin evacuation 30 minutes (15-minute initial notification plus 15-minute preparation/mobilization time) after a General Emergency has been declared and are evacuated at an average radial speed of 1.76 miles per hour (0.789 meters per second). This speed is calculated based on the maximum estimated evacuation time of 370 minutes (including the 30 minutes to notify and mobilize the population) from the full 0-10 mile EPZ, assuming a winter weeknight evacuation under adverse weather conditions. The minimum evacuation time from the 10-mile EPZ is estimated to be 210 minutes assuming winter weeknights under fair weather conditions.

For this analysis, it was conservatively assumed that people beyond 10 miles would continue their normal activities unless the following predicted radiation dose levels are exceeded. At locations for which 50 rem whole body effective dose equivalent in 1 week is predicted, it was assumed that relocation would take place after half a day. If 25 rem whole body dose equivalent in 1 week is predicted, relocation of individuals in those sectors was assumed to take place after 1 day.

Mainly the long-term effects govern exposure and accident mitigation costs over the whole 50-mile zone; therefore, the net changes would be small. For the same reasons, no significant dependencies on evacuation speed, warning time, and release delay times would be expected. Other recent SAMA analyses have shown that year-to-year weather variation for various locations in the eastern United States do not lead to very significant sensitivities in the results.

The long-term phase is assumed to begin after one week and extend for five years. Long-term relocation is assumed to be triggered by a four rem whole body effective dose equivalent. Long-term protective measures were assumed to be based on generic protective action guideline levels for actions such as decontamination, temporary relocation, contaminated crops and milk condemnation, and farmland production prohibition.

Economic and Agricultural Data

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 updating the database in the SECPOP90 code (Reference F.2-16) for each of the 16 counties surrounding the plant to a distance of 50 miles, using the methodology in Reference F.2-15 and data from Reference F.2-10, Reference F.2-17, Reference F.2-18, Reference F.2-19, and Reference F.2-20. The values for up to 97 economic zones allocated to each of the 160 sectors were then calculated using the SECPOP90 code with the updated economic and agricultural database.

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), value of farm and non-farm wealth, and fraction of farm wealth from improvements (e.g., buildings, equipment).

Land use statistics including farmland values, farm product values, dairy production, and growing season information were provided on a countywide basis within 50 miles. Agricultural production information was taken from the 1997 Agricultural Census (Reference F.2-20). Production within 50 miles of the site was estimated based on those counties within this radius. Production in those counties, which lie partially outside of this area, was multiplied by the fraction of the county within the area of interest. Of the food crops, grain (50 percent of the total cropland, made up of corn and wheat), and legumes (31 percent of the total cropland, made up of soybeans) were harvested from the largest areas. Pasture (7 percent) and stored forage (7 percent of total cropland, consisting of hay) made up most of the remaining harvested cropland.

The lengths of the growing seasons for grains and legumes were obtained from Reference F.2-21. The duration of the growing season for the remaining crop categories (pasture, stored forage, green leafy vegetables, roots/tubers and other food crops) was based on reasonable estimates. The uncertainty in these estimates does not have a significant impact due to the much smaller fraction of land dedicated to these crops.

Economic consequences were estimated using the MACCS2 code by summing:

- Costs of evacuation;
- Costs for temporary relocation (food, lodging, lost income);
- Costs of decontaminating land and buildings;
- Lost return-on-investments from properties that are temporarily interdicted to allow contamination to be decreased by decay of nuclides;
- Costs of repairing temporarily interdicted property;
- Value of crops destroyed or not grown because they were contaminated by direct deposition or would be contaminated by root uptake; and
- Value of farmland and of individual, public, and nonfarm commercial property that is condemned.

Costs associated with damage to the reactor, the purchase of replacement power, medical care, life-shortening, and litigation are not calculated by MACCS2.

F.2.2.2 Results

Based on the preceding input data, MACCS2 was used to estimate:

- The downwind transport, dispersion, and deposition of the radioactive materials released to the atmosphere from the failed reactor containment;
- The short-term and long-term radiation doses received by exposed populations via direct (cloudshine, plume inhalation, groundshine, and resuspension inhalation) and indirect (ingestion) pathways;
- The mitigation of those doses by protective actions (evacuation, sheltering, and post-accident relocation of people; disposal of milk, meat, and crops; and decontamination, temporary interdiction, or condemnation of land and buildings);
- The early fatalities and injuries expected to occur within 1 year of the accident (early health effects) and the delayed (latent) cancer fatalities and injuries expected to occur over the lifetime of the exposed individuals; and

- The offsite costs of short-term emergency response actions (evacuation, sheltering, and relocation), of crop and milk disposal, and of the decontamination, temporary interdiction, or condemnation of land and buildings.

The consequences calculated with the MACCS2 model in terms of the population dose and offsite economic costs are shown in Table F.2-8.

F.2.3 Determination of Present Value for the Base Case

This section explains how I&M calculated the monetized value of the status quo (i.e., accident consequences without SAMA implementation). I&M also used this analysis to establish the maximum benefit that a SAMA could achieve if it eliminated all CNP risk.

F.2.3.1 Offsite Exposure Cost

The baseline annual offsite exposure risk was converted to dollars using the NRC conversion factor of $2,000 per person-rem, and discounting to present value using the NRC standard formula (Reference F.2-22):

$W_{pha} = C*Z_{pha}$

Where:

W_{pha} = monetary value of public health risk after discounting;
C = $[1\text{-}exp(-r*T_f)]/r$;
r = real discount rate (as fraction) = 0.07/year;
T_f = years remaining until end of facility life = 20 years; and
Z_{pha} = monetary value of public health (accident) risk per year before discounting ($/year).

The Level 3 PRA analysis showed an annual offsite population dose risk of 42.53 person-rem. The calculated value for C using 20 years and a 7 percent discount rate is approximately 10.763. Therefore, calculating the discounted monetary equivalent of accident risk involves multiplying the dose (person-rem per year) by $2,000 and by the C value (10.763). The calculated offsite exposure cost is $915,492.

F.2.3.2 Offsite Economic Cost

The Level 3 PRA analysis showed an annual offsite economic risk of $64,582 (Reference F.1-3). Calculated values for offsite economic cost 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 $695,090.

F.2.3.3 Onsite Exposure Cost

The NRC evaluates occupational health using the methodology in Reference F.2-22, which involves separately evaluating immediate and long-term doses.

Immediate Dose

For the case where the plant is in operation, the equation that the NRC recommends using (Reference F.2-22) is the following:

Equation 1:

$$W_{IO} = R*\{(F*D_{IO})_S-(F*D_{IO})_A\}*\{[1-\exp(-r*T_f)]/r\}$$

Where:

- W_{IO} = monetary value of accident risk avoided due to immediate doses, after discounting;
- R = monetary equivalent of unit dose ($/person-rem);
- F = accident frequency (events/yr);
- D_{IO} = immediate occupational dose (person-rem/event);
- $_S$ = subscript denoting status quo (current conditions);
- $_A$ = subscript denoting after implementation of proposed action;
- r = real discount rate; and
- T_f = years remaining until end of facility life.

The values used in the CNP analysis are:

- R = $2,000/person-rem;
- F = $4.986x10^{-5}$ (total CDF for Unit 1, assumed to be the same for Unit 2);
- D_{IO} = 3,300 person-rem/accident (best estimate);
- r = 0.07; and
- T_f = 20 years (license extension period).

For the basis discount rate, assuming F_A is zero, the best estimate of the immediate dose cost is:

$$\begin{aligned} W_{IO} &= R*(F*D_{IO})_S*\{[1-\exp(-r*T_f)]/r\} \\ &= 2{,}000*(4.986\text{x}10^{-5}*3{,}300)*\{[1-\exp(-0.07*20)]/0.07\} \\ &= \$3{,}542 \end{aligned}$$

Long-Term Dose

For the case where the plant is in operation, the NRC equation (Reference F.2-22) is:

Equation 2:

$$W_{LTO} = R*\{(F*D_{LTO})_S-(F*D_{LTO})_A\}*\{[1-\exp(-r*T_f)]/r\}\{[1-\exp(-r*m)]/(r*m)\}$$

Where:

W_{LTO} = monetary value of accident risk avoided long-term doses, after discounting;
R = monetary equivalent of unit dose ($/person-rem);
F = accident frequency (events/yr);
D_{LTO} = long-term occupational dose (person-rem/event);
$_S$ = subscript denoting status quo (current conditions);
$_A$ = subscript denoting after implementation of proposed action;
r = real discount rate;
T_f = years remaining until end of facility life; and
m = years over which long-term doses accrue.

The values used in the CNP analysis are:

R = $2,000/person-rem;
F = 4.986×10^{-5} (total CDF)
D_{LTO} = 20,000 person-rem/accident (best estimate);
r = 0.07;
T_f = 20 years (license extension period); and
m = "as long as 10 years."

For the basis discount rate, assuming F_A is zero, the best estimate of the long-term dose is:

$$W_{LTO} = R*(F*D_{LTO})_S*\{[1-\exp(-r*T_f)]/r\}\{[1-\exp(-r*m)]/(r*m)\}$$
$$= 2{,}000*(4.986\times10^{-5}*20{,}000)*\{[1-\exp(-0.07*20)]/0.07\}\{[1-\exp(-0.07*10)]/(0.07*10)\}$$
$$= \$15{,}437$$

Total Occupational Exposure

Combining Equations 1 and 2 above and using the above numerical values, the total accident related onsite (occupational) exposure avoided (W_O) is:

$$W_O = W_{IO} + W_{LTO} = \$3{,}542 + \$15{,}437 = \$18{,}979$$

F.2.3.4 Onsite Economic Cost

The net present value that the NRC provides for cleanup and decontamination for a single event is $1.1 billion discounted over a 10-year cleanup period (Reference F.2-22). The NRC uses the following equation in integrating the net present value over the average number of remaining service years:

$U_{CD} = [PV_{CD}/r][1\text{-}exp(-r*T_f)]$

Where:

PV_{CD} = Net present value of a single event;
r = real discount rate; and
T_f = years remaining until end of facility life.

The values used in the CNP analysis are:

PV_{CD} = $\$1.0787x10^9$;
r = 0.07; and
T_f = 20.

The resulting net present value of cleanup integrated over the license renewal term, $\$1.161x10^{10}$, must be multiplied by the total CDF of $4.986x10^{-5}$ to determine the expected value of cleanup and decontamination cost. The resulting monetary equivalent is $578,896.

Long-term replacement power cost was determined following the NRC methodology in Reference F.2-22. The net present value of replacement power for a single event, PV_{RP}, was determined using the following equation:

$PV_{RP} = [\$1.2x10^8/r]*[1\text{-}exp(-r*T_f)]^2$

Where:

PV_{RP} = net present value of replacement power for a single event;
r = 0.07; and
T_f = 20 years (license renewal period).

To attain a summation of the single-event cost over the entire license renewal period, the following equation is used:

$U_{RP} = [PV_{RP}/r]*[1\text{-}exp(-r*T_f)]^2$

Where:

U_{RP} = net present value of replacement power over life of facility ($-year).

After applying a correction factor to account for CNP's size relative to the "generic" reactor described in NUREG/BR-0184 (i.e., 1117 MWe/910 MWe), the replacement power cost is determined to be 9.685×10^9 \$-year. Multiplying this value by the CDF (4.986×10^{-5}) results in a replacement power cost of $482,902.

The total onsite economic cost avoided is the sum of cleanup and decontamination cost and long-term replacement cost, or $1,061,798.

F.2.3.5 Baseline Screening

The sum of the baseline costs is as follows:

Offsite exposure cost	=	$915,492
Offsite economic cost	=	$695,090
Onsite exposure cost	=	$18,979
Onsite economic cost	=	$1,061,798
Total cost	=	$2,691,359

I&M rounded this value to $2,700,000 to use in screening out SAMA candidates as economically infeasible. If the estimated cost of implementing a SAMA exceeded $2,700,000, I&M discarded it from further analysis. Exceeding this threshold would mean that a SAMA could not have a positive net value even if it could eliminate all severe accident costs.

F.2.3.6 Sensitivity Analysis

A sensitivity analysis was performed by changing the real discount rate from seven to three percent. This had the effect of increasing the baseline cost-risk to $4,201,969.

F.3 Identification of SAMA Candidates

I&M generated a list of SAMA candidates by considering plant-specific enhancements and reviewing industry documents.

The CNP IPE, IPEEE, and subsequent updates to the CNP PRA, including the basic events having the greatest potential for risk reduction, were examined (Reference F.3-1), and CNP equipment reliability issues were reviewed, to determine whether any plant-specific improvements were identified. Thirty-two CNP-specific SAMA candidates were identified, including SAMA Numbers 2, 6, 8, 24, 28, 41, 73, 79, 101, 117, 126, 141, 142, 172 through 176, and 181 through 194 (see Table F.4-1).

In addition to the identified CNP-specific SAMA candidates, industry documents were reviewed to identify additional SAMA candidates including the following:

- Watts Bar Nuclear Plant Unit 1 IPE Submittal (Reference F.3-2);
- Limerick Generating Station SAMDA Cost Estimate Report (Reference F.3-3);
- NUREG-1437, Listing of SAMDAs Considered for the Limerick Generating Station (Reference F.3-4);
- NUREG-1437, Listing of SAMDAs Considered for the Comanche Peak Steam Electric Station (Reference F.3-5);
- Watts Bar Nuclear Plant SAMDA Submittal (Reference F.3-6);
- TVA Response to Request for Additional Information from the NRC on the Watts Bar Nuclear Plant SAMDA Submittal (Reference F.3-7);
- Westinghouse AP600 SAMDA Submittal (Reference F.3-8);
- Presentation on Insights from PSAs for European Nuclear Power Plants at the NRC - IPE Workshop Held April 7-9, 1997 (Reference F.3-9);
- NRC Presentation on Draft NUREG-1560 at the NRC - IPE Workshop Held April 7-9, 1997 (Reference F.3-10);
- NUREG-0498, Supplement 1, Final Environmental Statement for Watts Bar Nuclear Plant (Reference F.3-11);
- NUREG/CR-5567, PWR Dry Containment Issue Characterization (Reference F.3-12);
- NUREG-1560, Volume 2, IPE Program: NRC Perspectives on Reactor Safety and Plant Performance (Reference F.3-13);
- NUREG/CR-5630, PWR Dry Containment Parametric Studies (Reference F.3-14);

- NUREG/CR-5575, Quantitative Analysis of Potential Performance Improvements for the Dry PWR Containment (Reference F.3-15);
- CE System 80+ CESSAR Design Certification Submittal (Reference F.3-16);
- NUREG-1462, Final Safety Evaluation Report for the System 80+ Design (Reference F.3-17);
- ICONE Paper by C. W. Forsberg, et. al, on a COMSORS (Reference F.3-18); and
- Previously submitted SAMA analyses from peer nuclear power plants, including initial license renewal applications, NRC requests for additional information, licensee responses to NRC requests for additional information, and issued supplements to NUREG-1437, Generic Environmental Impact Statement for License Renewal of Nuclear Plants.

F.4 Preliminary Screening

The initial list of 194 potential SAMA candidates is presented in Table F.4-1. Table F.4-1 also presents a qualitative screening of the initial list. Items were eliminated from further evaluation based on one of the following criteria:

- Criterion A - Not Applicable: The SAMA is not applicable at CNP. For example, the SAMA may be determined to only apply for BWRs or the Westinghouse AP600 design, or the SAMA is a plant-specific enhancement that does not apply because of unique CNP design features or procedures.
- Criterion B - Implemented or Intent Met: The SAMA has already been implemented at CNP or the CNP design meets the intent of the SAMA.
- Criterion C - Too Costly: Either too costly or only feasible for a plant in the design phase.

Based on preliminary screening, 122 improvements were eliminated, leaving 72 subject to the final evaluation process (Criterion N - Not Initially Screened). These 72 improvements are listed in Table F.4-2.

F.5 Final Evaluation

I&M estimated the costs of implementing each SAMA during the final cost-benefit analysis through the application of engineering judgement, estimates from other licensee's submittals, and site-specific cost estimates. Evaluation was performed based on a single nuclear unit implementation basis. The cost estimates did not include the cost of replacement power during extended outages required to implement the modifications, nor did they include contingency costs associated with unforeseen implementation obstacles. Estimates based on modifications that were implemented or estimated in the past were presented in terms of dollar values at the time of implementation (or estimation), and were not adjusted to present-day dollars. Therefore, the cost estimates were conservative.

The methodology for determining if a SAMA is potentially cost-beneficial consists of determining whether the benefit provided by implementation of the SAMA exceeds the estimated cost of implementation. Since CNP does not have an external events PRA model, and to account for other risk contributions not specifically quantified by the CNP PRA models, SAMA candidates were considered potentially cost-beneficial in the final evaluation if the cost of implementation was estimated to be less than two times the calculated benefit. The benefit is defined as the present worth of the reduction in the sum of the dollar equivalents over the license renewal period for each severe accident impact (offsite exposure, offsite economic costs, occupational exposure, and onsite economic costs) resulting from the implementation of the SAMA.

The result of implementation of each SAMA would be a change in the CNP severe accident risk (i.e., a change in frequency or consequence of severe accidents). The methodology for calculating the magnitude of these changes is straightforward. First, the CNP severe accident risk after implementation of each SAMA is calculated using the same methodology as for the base case. The results of the Level 2 PRA model were combined with the Level 3 PRA model to calculate these post-SAMA risks. Next, the difference between the monetized value of the risk of the base case (before implementation of the SAMA) and the value of the risk after implementation of the SAMA was calculated. This represents the benefit of a specific SAMA.

The SAMA evaluations were, in general, performed in a bounding fashion to address the generic nature of the initial SAMA concepts. Such bounding calculations overestimate the benefit and thus are conservative calculations. SAMA candidates were evaluated by making relatively simple changes to the CNP PRA models and then quantifying the models to obtain a new set of STC frequencies. These STC frequencies were then analyzed to determine the impact on public risk. For example, one SAMA deals with providing an additional CCW pump to reduce the contribution to CDF from loss of CCW (alternatively, this could be interpreted as increasing the reliability of the existing CCW pumps). The bounding calculation to estimate the benefit of this improvement was to determine the impact of perfectly reliable CCW pumps. Such a calculation obviously overestimates the benefit, but if the inflated benefit indicates that the SAMA is not cost-beneficial then the purpose of the analysis is satisfied.

As described in Section F.2.3, values for avoided public and occupational health risk were converted to a monetary equivalent (dollars) using the NRC conversion factor of $2,000 per person-rem and discounted to present value for the license renewal period as described in NUREG/BR-0184 (Reference F.4-1). Values for avoided offsite economic costs over the license renewal period were also discounted to present value. The formula for calculating net present value for each SAMA is as follows:

Net value = ($APE + $AOC + $AOE + $AOSC) - COE

Where:

$APE	=	monetized value of averted public exposure ($);
$AOC	=	monetized value of averted offsite costs ($);
$AOE	=	monetized value of averted occupational exposure ($);
$AOSC	=	monetized value of averted onsite costs ($); and
COE	=	cost of enhancement ($).

If the net present value of a SAMA is negative, the cost of the enhancement is greater than the potential benefit, and the SAMA is not cost-beneficial. Because the total value for potential risk reduction at CNP is based upon internal, at-power risk, I&M took the approach of comparing the expected cost of the SAMA candidates with the benefit evaluated using the reduction of risk from internal events. As explained above, SAMA candidates were considered potentially cost-beneficial in the final evaluation if the cost of implementation was estimated to be less than two times the calculated benefit.

The estimated cost of implementation for each SAMA (COE) was determined by either utilizing applicable cost estimates published in NRC submittals from other licensees or by expert judgement by knowledgeable CNP staff. Estimates were performed only to the extent necessary to determine if a specific SAMA candidate was cost-beneficial. Detailed cost estimates were not necessary to disposition the final list of unscreened SAMA candidates. In many cases, the cost of implementation was largely underestimated whenever the calculated benefit was low or negligible, since further cost estimating was not necessary to screen the SAMA candidate from further consideration.

The cost-benefit analysis for the final list of unscreened SAMA candidates is presented in Table F.4-2.

F.6 Sensitivity Analyses

NUREG/BR-0184 recommends using a 7 percent real (i.e., inflation-adjusted) discount rate for value-impact analysis and notes that a 3 percent discount rate should be used for sensitivity analysis to indicate the sensitivity of the results to the choice of discount rate. This reduced discount rate takes into account the additional uncertainties (i.e., interest rate fluctuations) in predicting costs for activities that would take place several years in the future. Analyses performed by I&M used the 7 percent discount rate in calculating benefits of all the unscreened SAMA candidates. I&M also performed a sensitivity analysis by substituting the lower discount rate and recalculating the benefit of the SAMA candidates.

The sensitivity analysis performed produced an additional benefit result for each of the SAMA candidates analyzed in the cost-benefit analysis. However, the conclusions of the original cost-benefit analysis were not affected by any of the new calculated benefits using the more conservative 3 percent discount rate. Using the 3 percent discount rate, the maximum benefit that could be achieved if all risk was eliminated would be $4,201,969. Using this value does not result in any of the SAMA candidates that were screened out in the preliminary screening as meeting Criterion C (either too costly or only feasible for a plant in the design phase) becoming cost-beneficial. Furthermore, using a 3 percent discount rate does not result in any of the SAMA candidates that were screened out in the final evaluation becoming cost-beneficial. Although there are several cases where using the 3 percent discount rate would indicate that a SAMA candidate would be marginally cost-beneficial, the estimated cost of implementation for each of these SAMA candidates was grossly underestimated. These SAMA candidates affected include SAMA Numbers 127 and 172 (Items 3, 4, 7, 8, 9, 13, 14, 15, 21, 24, 25, and 26). I&M concludes that more detailed cost analyses would result in the cost of implementation for these SAMA candidates exceeding the calculated benefits using the 3 percent discount rate by a large margin.

The benefits calculated using the 3 percent discount rate are presented in Table F.6-1.

F.7 Conclusions

I&M analyzed 194 conceptual alternatives for mitigating CNP severe accident impacts. Preliminary screening eliminated 122 SAMA candidates from further consideration, based on inapplicability to CNP site-specific design features, design features that have already been incorporated into the current CNP site-specific design, procedures and programs that already implement the intent of the SAMA candidates, or extremely high cost of the alternatives considered. During the final disposition, 56 remaining SAMA candidates were eliminated because the cost was expected to exceed their benefit. The remaining 16 SAMA candidates can be grouped together into 5 potential areas for risk improvement.

Minimize Consequences of RCP Seal LOCAs

SAMA Numbers 5, 9, 10, 12, 13, 160, and 184 are related to improvements that would reduce the probability of a RCP seal LOCA following a loss of seal cooling. A loss of RCP seal cooling could be caused either by a loss of cooling water or by a loss of all AC power to systems needed to ensure RCP seal cooling. SAMA Number 184 was identified from the recent CNP PRA model update, and is a more general case that could be implemented by any of the other SAMA candidates.

The goal of SAMA Numbers 5 and 9 is to remove or minimize the dependence of charging pump operation on CCW. SAMA Number 5 would provide a hardware connection to another plant water system so that the other system could cool the charging pump seals. SAMA Number 9 would increase the charging pump lube oil sump capacity increasing the time from a loss of cooling to the oil coolers until failure of the pumps on high lube oil temperature.

The goal of SAMA Number 10 is to remove or minimize the dependence of RCP thermal barrier cooling on CCW. The goal of this SAMA is similar to the goal of SAMA Numbers 5 and 9. However, there are some significant differences. First, this SAMA would prevent RCP seal failure by providing cooling to the thermal barrier heat exchanger, but leakage from the RCP seals would still occur. As a result, long-term RCS inventory control would be a concern. SAMA Numbers 5 and 9 would maintain RCS inventory as well as RCP seal cooling on a loss of CCW since the charging pumps would continue to operate. Second, this SAMA has the potential to provide RCP seal cooling on a loss of all AC power if AC-independent water sources were aligned to cool the RCP thermal barrier heat exchangers. SAMA Numbers 5 and 9 would provide no benefit for seal cooling during a SBO, since the charging pumps require AC power for operation.

The goal of SAMA Number 12 is to remove the dependence of RCP seal injection on CCW and AC power. By providing an independent and diverse seal injection system with a dedicated and independent diesel-backed power supply, the chances of RCP seal failure, given a loss of cooling, would be substantially reduced, even under SBO conditions.

The goal of SAMA Number 13 is to minimize the dependence of RCP seal injection on CCW. By providing an independent and diverse seal injection system, the chances of RCP seal failure, given a loss of cooling, would be substantially reduced. However, because it is postulated that no backup power supply is provided, the system would provide no benefit under SBO conditions. This SAMA is similar to the case analyzed for SAMA Number 12, except that no benefit would be provided for SBO conditions.

The goal of SAMA Number 160 is to remove or minimize the dependence of ECCS pump operation on CCW. This SAMA is similar to SAMA Numbers 5 and 9. However, this case would eliminate all ECCS pump dependence on CCW whereas SAMA Numbers 5 and 9 limited their scope to just the charging pumps.

Based on review of the details of these SAMA candidates, it is concluded that none relate to adequately managing the effects of aging. Therefore, implementation of these SAMA candidates would not be required pursuant to 10 CFR 54.

Minimize Consequences of Loss of HVAC

SAMA Numbers 25, 26, 27, and 28 are related to improvements that would provide alternate ventilation to various risk-significant equipment. SAMA Number 27, which involves enhancing procedural guidelines for providing alternative ventilation, is included as a bounding case for the other SAMA candidates. These improvements would prevent or reduce the probability of the affected equipment failing.

The goal of SAMA Numbers 25 and 26 is to provide a backup means to cool the electrical switchgear rooms so that failure of room ventilation does not cause a direct failure of the electrical switchgear. SAMA Number 25 would stage backup, temporary ventilation equipment for the rooms. SAMA Number 26 would permanently install a backup train of ventilation.

The goal of SAMA Number 28 is to provide a backup means to ventilate the EDG rooms so that failure of room ventilation does not cause a direct failure of the EDG. This SAMA would stage backup, temporary ventilation equipment for the rooms. The equipment would either be permanently installed or a temporary alternative with equipment staged for use and procedures in place.

Based on review of the details of these SAMA candidates, it is concluded that none relate to adequately managing the effects of aging. Therefore, implementation of these SAMA candidates would not be required pursuant to 10 CFR 54.

Remove Dependence of Distributed Ignition System on AC Power

SAMA Numbers 39 and 40 are related to improvements that would remove AC power as a support system for the distributed ignition system. Implementation of these alternatives would reduce the likelihood that containment would be challenged by hydrogen combustion, particularly after a SBO.

The goal of SAMA Number 39 is to ensure that the hydrogen igniters inside containment would be provided power during SBO conditions.

The goal of SAMA Number 40 is to implement hydrogen control using a passive hydrogen control system for long-term, post-accident concerns.

Based on review of the details of these SAMA candidates, it is concluded that none relate to adequately managing the effects of aging. Therefore, implementation of these SAMA candidates would not be required pursuant to 10 CFR 54.

Minimize Consequences of AC Bus Failures

SAMA Number 67 is related to improvements that would provide the capability to cross-tie AC emergency power buses between the units. This improvement would increase overall reliability and availability of AC emergency power sources.

The goal of SAMA Number 67 is to provide a means to supply power from one emergency bus to another emergency bus within a unit. The cross-tie capability would either be permanently installed or a temporary alternative with equipment staged for use and procedures in place. When equipment on one bus is failed because of a loss of power, the ability to cross-tie power would allow recovery of that equipment if power were available on an opposite bus. The opposite bus would be powered from offsite power or from the associated EDG. Should the bus that is to supply power to the cross-tie be powered from the EDG, care would be required to avoid overloading the EDG.

Based on review of the details of this SAMA candidate, it is concluded that it does not relate to adequately managing the effects of aging. Therefore, implementation of this SAMA candidate would not be required pursuant to 10 CFR 54.

Improve Recovery from ISLOCA

SAMA Number 101 is related to improvements that would revise the procedures used to respond to ISLOCA events to specifically address the ISLOCA sequence with the frequency that was dominant in the CNP PRA. This improvement would reduce CDF from ISLOCA sequences. Improving successful isolation of this ISLOCA sequence was also identified by the cutset importance analysis for SAMA Number 172, item 27.

The goal of SAMA Number 101 is to improve the chance that the operators will successfully isolate an ISLOCA that occurs in the RHR cooldown suction line. Specifically, should failure of the cooldown isolation valves occur, it may be necessary to close motor-operated valves IMO-310 and IMO-320 to stop leakage from failed RHR pump seals. This SAMA would add to the applicable EOP a step to close IMO-310 and IMO-320, improving the chance that the operators would close the valves to terminate an ISLOCA.

Based on review of the details of this SAMA candidate, it is concluded that it does not relate to adequately managing the effects of aging. Therefore, implementation of this SAMA candidate would not be required pursuant to 10 CFR 54.

Summary

Using the 7 percent real discount rate recommended by NUREG/BR-0184, 56 SAMA candidates that were evaluated were determined not to be cost-beneficial. The sensitivities performed for each of these SAMA candidates indicated that the results of the analysis are significantly impacted by the discount rate that is assumed. A very conservative discount rate (3 percent) results in a large increase in the calculated benefit of these SAMA candidates. However, no additional cost-beneficial SAMA candidates are identified when comparing estimated cost of implementation with the more conservative benefits calculated using the 3 percent discount rate.

In summary, I&M discovered 5 categories of improvements that are potentially cost-beneficial, implemented by 16 SAMA candidates. This is based on conservative treatment of costs and benefits. This conclusion is consistent with the low residual level of risk indicated in the CNP PRA and the fact that CNP has already implemented many plant improvements identified from the IPE and IPEEE process. However, these SAMA candidates do not relate to adequately managing the effects of aging during the requested period of extended operation. Therefore, they need not be implemented as part of license renewal pursuant to 10 CFR 54. I&M is further evaluating these SAMA candidates and has not made any decision to implement them.

SAMA Number 39 is related to hydrogen control in SBO sequences (to ensure that the hydrogen igniters inside containment would be provided power during SBO conditions), and is cost-beneficial under certain assumptions. This SAMA candidate is currently being examined by the NRC Staff in connection with resolution of NRC Generic Safety Issue GSI-189. I&M anticipates that the need for plant design and procedural changes will be resolved as part of GSI-189 and addressed for CNP and all other ice condenser plants as a current operating license issue.

Table F.2-1. Contributions to CDF by Initiating Event.

Initiating Event	Percentage Contribution to Total CDF	
	Unit 1	Unit 2
Single Unit LOSP (LSP)	23.2	23.8
Small LOCA (SLO)	17.1	17.0
Dual Units LOSP (DLSP)	14.3	14.2
Transient with Power Conversion System Available (TRA)	13.3	13.0
Loss of All ESW to Both Units (ESW4)	12.9	12.8
Loss of ESW to Unit (ESW2)	5.0	4.9
Loss of CCW (CCW)	4.6	4.6
Steamline Break Outside MSIV (SLB-5)	1.3	1.3
SGTR in Loop 1 (SGR-1)	1.0	1.0
SGTR in Loop 2 (SGR-2)	1.0	1.0
SGTR in Loop 3 (SGR-3)	1.0	1.0
SGTR in Loop 4 (SGR-4)	1.0	1.0
Breaks Beyond ECCS Capability (VEF)	0.6	0.6
ISLOCA (ISL)	0.6	0.6
Steamline Break in Loop 1 (SLB-1)	0.6	0.6
Steamline Break in Loop 2 (SLB-2)	0.6	0.6
Steamline Break in Loop 3 (SLB-3)	0.6	0.6
Steamline Break in Loop 4 (SLB-4)	0.6	0.6
Transient without Power Conversion System Available (TRS)	0.4	0.4
Others, Individually	<0.1	<0.1

Table F.2-2. Contributions to CDF by Event Type.

Event Type (Event Tree)	Percentage Contribution to Total CDF	
	Unit 1	Unit 2
Loss of All ESW to Both Units (ESW4)	24.3	24.2
SBO from Single Unit LOSP (SBO)	22.8	23.3
Small LOCA (SLO)	17.1	17.1
SBO from Dual Unit LOSP (DSBO)	13.8	13.8
Loss of ESW to Unit (ESW2)	5.0	4.9
Loss of CCW (CCW)	4.6	4.6
SGTR (SGR-1, SGR-2, SGR-3, and SGR-4 Total)	4.0	4.0
Steamline Break (SLB-1, SLB-2, SLB-3, and SLB-4 Total)	3.5	3.5
ATWS	1.4	1.2
Others, Individually	<1	<1

Table F.2-3. Contributions to LERF by Initiating Event.

Initiating Event	Percentage Contribution to Total LERF	
	Unit 1	Unit 2
Single Unit LOSP (LSP)	30.3	30.5
Dual Units LOSP (DLSP)	21.9	22.0
Small LOCA (SLO)	7.7	7.7
Transient with Power Conversion System Available (TRA)	7.1	7.0
Loss of All ESW to Both Units (ESW4)	4.9	4.9
ISLOCA (ISL)	4.6	4.6
SGTR in Loop 1 (SGR-1)	4.0	4.0
SGTR in Loop 2 (SGR-2)	4.0	4.0
SGTR in Loop 3 (SGR-3)	4.0	4.0
SGTR in Loop 4 (SGR-4)	4.0	4.0
Loss of ESW to Unit (ESW2)	1.5	1.5
Loss of CCW (CCW)	1.4	1.4
Steamline Break Outside MSIV (SLB-5)	1.3	1.3
Steamline Break in Loop 1 (SLB-1)	0.6	0.6
Steamline Break in Loop 2 (SLB-2)	0.6	0.6
Steamline Break in Loop 3 (SLB-3)	0.6	0.6
Steamline Break in Loop 4 (SLB-4)	0.6	0.6
Breaks Beyond ECCS Capability (VEF)	0.5	0.5
Transient without Power Conversion System Available (TRS)	0.2	0.2
Others, Individually	<0.1	<0.1

Table F.2-4. Contributions to LERF by Event Type.

Event Type (Event Tree)	Percentage Contribution to Total LERF	
	Unit 1	Unit 2
SBO from Single Unit LOSP (SBO)	29.8	29.9
SBO from Dual Unit LOSP (DSBO)	21.3	21.3
SGTR (SGR-1, SGR-2, SGR-3, and SGR-4 Total)	16.1	15.9
Loss of All ESW to Both Units (ESW4)	10.5	10.5
Small LOCA (SLO)	7.7	7.7
ISLOCA (ISL)	4.6	4.6
Steamline Break (SLB-1, SLB-2, SLB-3, and SLB-4 Total)	3.7	3.7
Loss of ESW to Unit (ESW2)	1.5	1.5
Loss of CCW (CCW)	1.4	1.4
Others, Individually	<1	<1

Table F.2-5. MACCS2 Reference PWR Core Inventory.

	Core inventory (becquerels)		Core inventory (becquerels)
Nuclide	**MACCS2 Reference**	**Nuclide**	**MACCS2 Reference**
Cobalt-58	3.276E+16	Tellurium-131M	4.757E+17
Cobalt-60	2.505E+16	Tellurium-132	4.734E+18
Krypton-85	2.516E+16	Iodine-131	3.259E+18
Krypton-85M	1.178E+18	Iodine-132	4.803E+18
Krypton-87	2.153E+18	Iodine-133	6.890E+18
Krypton-88	2.911E+18	Iodine-134	7.562E+18
Rubidium-86	1.919E+15	Iodine-135	6.497E+18
Strontium-89	3.649E+18	Xenon-133	6.893E+18
Strontium-90	1.970E+17	Xenon-135	1.294E+18
Strontium-91	4.692E+18	Cesium-134	4.395E+17
Strontium-92	4.882E+18	Cesium-136	1.338E+17
Yttrium-90	2.113E+17	Cesium-137	2.457E+17
Yttrium-91	4.446E+18	Barium-139	6.385E+18
Yttrium-92	4.900E+18	Barium-140	6.318E+18
Yttrium-93	5.544E+18	Lanthanum-140	6.456E+18
Zirconium-95	5.617E+18	Lanthanum-141	5.922E+18
Zirconium-97	5.854E+18	Lanthanum-142	5.708E+18
Niobium-95	5.310E+18	Cerium-141	5.744E+18
Molybdenum-99	6.198E+18	Cerium-143	5.584E+18
Technetium-99M	5.349E+18	Cerium-144	3.461E+18
Ruthenium-103	4.617E+18	Praseodymium-143	5.484E+18
Ruthenium-105	3.002E+18	Neodymium-147	2.452E+18
Ruthenium-106	1.049E+18	Neptunium-239	6.570E+19
Rhodium-105	2.080E+18	Plutonium-238	3.724E+15
Antimony-127	2.833E+17	Plutonium-239	8.399E+14
Antimony-129	1.003E+17	Plutonium-240	1.059E+15
Tellurium-127	2.736E+17	Plutonium-241	1.784E+17
Tellurium-127M	3.622E+16	Americium-241	1.178E+14
Tellurium-129	9.419E+17	Curium-242	4.509E+16
Tellurium-129M	2.483E+17	Curium-244	2.639E+15

Source: Reference F.2-1.

Table F.2-6. MACCS2 Release Categories vs. CNP Release Categories.

MACCS2 Release Categories	CNP Release Categories
Xe/Kr	1 - noble gases
I	2 - CsI
Cs	6 - CsOH
Te	10 - Sb (TeO_2 & Te_2 fractions are smaller)
Sr	4 - SrO
Ru	5 - MoO_2 (Mo is in Ru MACCS2 category)
La	8 - La_2O_3
Ce	9 - CeO_2 (included UO_2 in this category)
Ba	7 - BaO

Table F.2-7. CNP Regional Population Distribution Projected to 2038.

	Radial Ring Distance, Miles									
Sector	**0-1**	**1-2**	**2-3**	**3-4**	**4-5**	**5-10**	**10-20**	**20-30**	**30-40**	**40-50**
N	0	0	0	0	0	0	0	0	0	0
NNE	37	140	183	213	243	8,156	2,554	2,922	9,738	10,632
NE	40	273	580	1,109	2,394	19,572	22,204	20,580	20,280	22,646
ENE	23	281	607	747	853	2,884	6,272	12,605	30,467	104,386
E	23	192	332	373	362	1,674	8,397	11,454	9,805	25,026
ESE	23	204	325	395	315	1,691	11,101	13,752	31,503	29,874
SE	23	201	337	320	171	999	23,767	161,091	96,629	58,194
SSE	23	151	297	376	440	850	4,819	67,222	13,845	26,071
S	23	77	224	370	481	1,111	6,895	7,163	11,570	21,218
SSW	11	35	63	108	213	2,495	5,701	33,820	11,794	11,225
SW	0	0	0	0	0	100	6,336	46,219	84,246	137,607
WSW	0	0	0	0	0	0	0	0	3,593	170,320
W	0	0	0	0	0	0	0	0	0	0
WNW	0	0	0	0	0	0	0	0	0	0
NW	0	0	0	0	0	0	0	0	0	0
NNW	0	0	0	0	0	0	0	0	0	0

Table F.2-8. Summary of Off-Site Consequence Results for Each Release Mode.

Source Term Category (STC)	Frequency (per year)	Offsite Dose (Person-rem)	Probabilistic Collective Offsite Dose (Rem)	Offsite Economic Cost ($)	Probabilistic Collective Offsite Economic Costs ($)
STC-1, Containment bypassed with noble gases plus up to 1 percent of the volatiles released	1.781E-06	3.71E+05	6.608E-01	2.97E+08	5.29E+02
STC-2, Containment bypassed with noble gases and more than 10 percent of the volatiles released	1.294E-06	9.67E+06	1.251E+01	1.33E+10	1.72E+04
STC-3, Containment failure prior to vessel failure with noble gases and less than 1/10 percent of the volatiles released (containment isolation impaired)	5.795E-09	1.94E+04	1.124E-04	4.42E+06	2.56E-02
STC-4, Containment failure prior to vessel failure with noble gases and up to 10 percent of the volatiles released (containment isolation impaired)	6.858E-09	8.39E+05	5.754E-03	9.04E+08	6.20E+00
STC-5, Containment failure prior to vessel failure with the noble gases and more than 10 percent of the volatile fission products released (containment isolation impaired)	1.150E-09	1.74E+06	2.001E-03	2.72E+09	3.13E+00
STC-6, Early containment failure with noble gases and up to 10 percent of the volatiles released (containment failure within six hours of vessel failure; containment not bypassed; isolation successful)	4.446E-06	2.16E+06	9.603E+00	3.73E+09	1.66E+04
STC-7, Late containment failure with noble gases and up to 10 percent of the volatiles released (containment failure greater than six hours after vessel failure; containment not bypassed; isolation successful)	1.250E-05	1.58E+06	1.975E+01	2.42E+09	3.03E+04
STC-8, No containment failure (leakage only, successful maintenance of containment integrity; containment not bypassed; isolation successful)	2.982E-05	Negligible	Negligible	Negligible	Negligible
Total Collective Offsite Dose (Rem)			42.53		
Total Collective Offsite Economic Costs ($)					64,582
Total CDF	4.986E-05				
Total Containment Failure Frequency	2.003E-05				

Table F.4-1. Initial List of Candidate Improvements for the CNP SAMA Analysis.

SAMA Number	Potential Improvement	Discussion	Source	Qualitative Screening
1	Cap downstream piping of normally closed CCW drain and vent valves.	Reduces the frequency of loss of CCW initiating event. Basis for Screening: To minimize the possibility of leakage from piping, valves, and equipment, welded construction is used wherever possible. Except for the normally closed makeup line and equipment vent and drain lines, there are no direct connections between the CCW system and other systems. The equipment vent and drain lines outside the containment have manual valves which are normally closed unless the equipment is being vented or drained for maintenance or repair operations. Failure of the socket welds attaching vent and drain lines to the CCW system process piping is not likely, but is more likely than failure of manual drain and vent valves to stay closed. Therefore, additional capping of the drain and vent lines provides very little additional assurance against leakage from the CCW system that may result in a total loss of CCW, and the intent of this SAMA is met with the current design.	(12)	B
2	Enhance loss of CCW (or loss of SW) procedure to facilitate stopping RCPs.	Reduces potential for RCP seal damage due to pump bearing failure. Basis for Screening: AOPs require tripping the RCPs immediately as a first step upon loss of CCW. Therefore, the intent of this SAMA is met with the current procedures.	(1), (9), (12), (22)	B
3	Enhance loss of CCW procedure to present desirability of cooling down RCS prior to RCP seal LOCA.	Potentially reduces the probability of RCP seal failure. Also consider adding emphasis on RCP seal temperatures in the EOPs to detect and potentially prevent RCP seal failure. Basis for Screening: Upon receipt of any RCP seal no. 1 outlet temperature high alarm, AOPs require an immediate and rapid RCS cooldown after isolation of the CCW path to the RCP thermal barrier and isolation of RCP seal injection. This order of actions is deemed appropriate for overall plant stabilization following a loss of CCW. Therefore, the intent of this SAMA is met with the current procedures.	(1)	B
4	Provide additional training on loss of CCW events.	Potentially improves success rate of operator actions after a loss of CCW. Basis for Screening: AOPs exist for a loss of CCW, and are used extensively in license operator initial training and license operator continuing training programs. Therefore, the intent of this SAMA is met with the current procedures and the associated operator training.	(1)	B
5	Provide hardware connections to allow ESW (SW) to cool charging pump seals.	Reduces effect of loss of CCW by providing a means to maintain the charging pump seal injection after a loss of CCW. Note, at Watts Bar Nuclear Plant, this capability was already there for one charging pump at one unit, and the potential enhancement identified was to make it possible for all the charging pumps.	(1), (5), (10), (12)	N

Table F.4-1. Initial List of Candidate Improvements for the CNP SAMA Analysis. (Continued)

SAMA Number	Potential Improvement	Discussion	Source	Qualitative Screening
6	Implement procedure to open the CVCS cross-tie valve to the opposite unit early in the accident response.	Failure of RCP seal cooling was found to be a significant contributor to CDF in the loss of CCW and loss of ESW events. The initiation of charging flow from the opposite unit should provide sufficient RCP seal cooling to prevent RCP seal damage. Basis for Screening: AOPs for ESW system loss or rupture provide directions to quickly implement loss of CCW AOPs if ESW cannot be restored through the use of existing cross-tie connections between headers. Loss of CCW AOP provides directions to quickly implement cross-tie of CVCS to obtain charging flow from opposite unit. Later steps in the AOPs direct the operators to implement cross-tie of the CCW system to obtain CCW flow from the opposite unit to at least one of the available and still operable charging pumps. Therefore, the intent of this SAMA is met with the current procedures.	(22)	B
7	Implement procedure to shed CCW loads to extend the CCW heatup time on loss of ERCW.	Increases time before the loss of CCW (and RCP seal failure) in the loss of ESW (ERCW) sequences. Basis for Screening: AOPs for ESW system loss or rupture provide directions to quickly implement loss of CCW AOPs if ESW cannot be restored. Loss of CCW AOP provides directions to trip all of the RCPs, and then to quickly implement cross-tie of CVCS to obtain charging flow from opposite unit. RCS letdown is then isolated to remove letdown heat exchanger load on the out of service CCW system. Therefore, the intent of this SAMA is met with the current procedures.	(1)	B
8	Implement loss of ESW procedure changes similar to that of loss of CCW to reduce significance of RCP seal LOCAs.	Potentially reduces CDF due to RCP seal LOCAs from loss of ESW. Basis for Screening: AOPs for ESW system loss or rupture provide directions to quickly implement loss of CCW AOPs if ESW cannot be restored. Therefore, the intent of this SAMA is met with the current procedures.	(23)	B
9	Increase charging pump lube oil capacity.	Increases time before charging pump failure due to lube oil overheating in loss of CCW sequences.	(1)	N
10	Eliminate RCP thermal barrier dependence on CCW, such that loss of CCW does not result directly in core damage.	Prevents loss of RCP seal integrity after a loss of CCW. Watts Bar Nuclear Plant IPE identified that an ERCW connection to charging pump seals could be used.	(1), (12)	N
11	Provide additional SW pump.	Potentially decreases CDF due to a loss of SW. Basis for Screening: For an existing plant, the estimated cost of implementation would exceed the bounding benefit (i.e., >>$2,700,000).	(4)	C

Table F.4-1. Initial List of Candidate Improvements for the CNP SAMA Analysis. (Continued)

SAMA Number	Potential Improvement	Discussion	Source	Qualitative Screening
12	Create an independent RCP seal injection system, with dedicated diesel.	Adds redundancy to RCP seal cooling alternatives, potentially reducing CDF from loss of CCW, loss of SW, or SBO.	(5), (10), (12)	N
13	Create an independent RCP seal injection system, without dedicated diesel.	Adds redundancy to RCP seal cooling alternatives, potentially reducing CDF from loss of CCW, loss of SW, or SBO.	(10)	N
14	Use existing hydro test pump for RCP seal injection.	Provides an independent RCP seal injection source, without cost of a new system. Basis for Screening: CNP does not have an existing hydro test pump. Therefore, this item is not applicable and is screened from further consideration.	(6)	A
15	Replace ECCS pump motors with air-cooled motors.	Removes dependency of ECCS pump motor operation on CCW. Basis for Screening: ECCS pump motors are air-cooled. Therefore, the intent of this SAMA is met with the current design.	(9), (12)	B
16	Install improved RCP seals.	Reduces probability of RCP seal LOCA by using RCP seal O-rings constructed of improved materials. Basis for Screening: The RCP number 1 seal design in use at CNP since 1987 has been generally recognized as contributing to a reduction in the frequency of RCP seal failures, through the use of improved O-ring polymer material. Therefore, the intent of this SAMA is met by the current design.	(10), (12)	B
17	Add a third CCW pump.	Reduces probability of loss of CCW leading to RCP seal LOCA.	(12)	N
18	Prevent charging pump discharge flow diversion from relief valves.	Reduces probability of loss of RCP seal cooling for plants where relief valve opening causes a flow diversion large enough to prevent RCP seal injection. Basis for Screening: This SAMA is from Kewaunee Nuclear Power Plant, and is related to a situation where 100% charging flow diversion is possible through the relief valves on the discharge of the charging pumps. At CNP, the relief valves on the discharge side of the centrifugal charging pumps are in the recirculation lines, beyond an orifice that limits the amount of flow diversion to approximately 60 gpm. Therefore, this item is not applicable and is screened from further consideration.	(12)	A

Table F.4-1. Initial List of Candidate Improvements for the CNP SAMA Analysis. (Continued)

SAMA Number	Potential Improvement	Discussion	Source	Qualitative Screening
19	Revise procedures to isolate RCP seal letdown flow on loss of CCW, and provide guidance on loss of injection during RCP seal LOCA.	Potentially reduces CDF from loss of RCP seal cooling. Basis for Screening: AOPs for a loss of CCW provide directions to quickly implement cross-tie of CVCS to obtain charging flow from opposite unit. Later steps in the AOPs then direct the operators to implement cross-tie of the CCW system to obtain CCW flow from the opposite unit to at least one of the available and still operable charging pumps. RCS letdown flows are then isolated to remove heat exchanger load on the out of service CCW system. Therefore, the intent of this SAMA is met with the current procedures.	(12)	B
20	Implement procedures to stagger HPSI pump use after a loss of SW.	Allows time period of high-pressure injection to be extended after a loss of SW. Basis for Screening: Instead of HPSI pumps, charging pumps are considered for this SAMA at CNP. AOPs for ESW system loss or rupture provide directions to quickly implement loss of CCW AOPs if ESW cannot be restored through the use of existing cross-tie connections between headers. Loss of CCW AOP provides directions to quickly implement cross-tie of CVCS to obtain charging flow from opposite unit. AOPs include caution to only run charging pumps without CCW for less than 1-1/2 minutes, except one charging pump may and should be left in service until CVCS cross-tie is complete while ensuring that at least one charging pump remains available and operable for later use. Later steps in the AOPs then direct the operators to implement cross-tie of the CCW system to obtain CCW flow from the opposite unit to at least one of the available and still operable charging pumps. Therefore, the intent of this SAMA is met with the current design and current procedures.	(12)	B
21	Use firewater pumps as a backup seal injection and high pressure makeup.	Reduce RCP seal LOCA frequency and SBO CDF. Basis for Screening: Fire pumps operate with a discharge pressure of approximately 140 psig. This is insufficient to provide RCP seal injection flow or to provide RCS makeup. Therefore, this item is not applicable and is screened from further consideration.	(12)	A

Table F.4-1. Initial List of Candidate Improvements for the CNP SAMA Analysis. (Continued)

SAMA Number	Potential Improvement	Discussion	Source	Qualitative Screening
22	Implement procedure guidance for use of cross-tied CCW or SW pumps.	Potentially reduces the frequency of the loss of either of these. Basis for Screening: 1) The CCW system for each unit is arranged in three flow circuits, two parallel safeguards equipment trains, and one miscellaneous services train which can be served by either of the safeguards trains. AOPs for a loss of CCW provide directions to restore CCW through the use of existing cross-tie connections between each unit's CCW system. Therefore, the intent of this SAMA is met with the current design and current procedures. 2) Both units share ESW. System piping is arranged in two independent headers, each serving certain components in each unit. The two headers are arranged such that a rupture in either header will not jeopardize the safety functions of the system. Two ESW pumps serve each header. AOPs for ESW system loss or rupture provide directions to quickly restore ESW through the use of existing cross-tie connections between headers. Therefore, the intent of this SAMA is met with the current design and current procedures.	(12)	B
23	Implement procedure and operator training enhancements in support system failure sequences, with emphasis on anticipating problems and coping.	Potentially improves success rate of operator actions after support system failures. Basis for Screening: AOPs exist for coping with the loss of support systems, such as a loss of ESW, CCW, and control air, and are used extensively in license operator initial training and license operator continuing training programs. Therefore, the intent of this SAMA is met with the current procedures and the associated operator training.	(1), (12)	B
24	Improve ability to cool RHR heat exchangers.	Reduces probability of loss of decay heat removal. Options considered include 1) performing procedure and hardware modification to allow manual alignment of fire protection system to the CCW system, or 2) installing a CCW header cross-tie. Basis for Screening: 1) The ability to manually align fire protection system sources of water to the CCW system do not currently exist. Therefore, this item is further evaluated. 2) The CCW system for each unit is arranged in three flow circuits, two parallel safeguards equipment trains, and one miscellaneous services train which can be served by either of the safeguards trains. An additional pump is provided as an installed maintenance spare for either unit and is located in a cross-tie header between the Unit 1 and 2 systems. The piping and valve arrangement is such that the maintenance spare can supply water to any one of the four trains, after the electrical controls have been transferred to it from the affected train. Therefore, the intent of this SAMA is met with the current design.	(11), (12), (26)	N(1),B(2)
25	Stage backup fans in switchgear rooms.	Provides alternate ventilation in the event of a loss of switchgear ventilation, preventing potential failure of switchgear from loss of cooling.	(12)	N

Table F.4-1. Initial List of Candidate Improvements for the CNP SAMA Analysis. (Continued)

SAMA Number	Potential Improvement	Discussion	Source	Qualitative Screening
26	Provide redundant train of ventilation to 480V board room.	Potentially improves reliability of 480V HVAC. At Watts Bar Nuclear Plant, only one train of HVAC cools the 480V board room that contains the unit vital inverters, and recovery actions are heavily relied on.	(1), (12)	N
27	Implement procedures for temporary HVAC.	Provides for improved credit to be taken for loss of HVAC sequences. <u>Basis for Screening</u>: 1) The turbine-driven AFW pumps, motor-driven AFW pumps, CCW pumps, ESW pumps, SI pumps, RHR pumps, and CTS pumps, do not depend on HVAC systems to be operable. Therefore, the intent of this SAMA is met for these HVAC systems with the current design and current procedures. 2) No procedure exists for mitigating loss of supply and/or exhaust ventilation for the EDG rooms and EDG control panels. Therefore, this item is further evaluated. (See SAMA Number 28) 3) There are no procedures for abnormal operations of the switchgear ventilation system in the event of an equipment failure for providing alternative ventilation alignments, including use of temporary supply and/or exhaust fans. Therefore, this item is further evaluated. (See SAMA Number 25)	(10), (12)	B(1), N(2,3)
28	Provide backup ventilation for the EDG rooms, should their normal HVAC supply fail.	Provides enhanced ventilation for EDG rooms.	(21), (26)	N
29	Add a switchgear room high temperature alarm.	Improves diagnosis of a loss of switchgear HVAC event. <u>Basis for Screening</u>: There is a common alarm that actuates upon detecting high temperature in either of the switchgear rooms or upon the failure of any of the supply fans to the switchgear rooms. The current annunciator response procedures direct the operator to monitor temperature and to restart supply and exhaust fans. Therefore, the intent of this SAMA is met with the current design.	(12)	B
30	Create ability to switch fan power supply to DC in SBO.	Item was created for a BWR RCIC room, Fitzpatrick. Represents a possible improvement for turbine-driven AFW that requires a fan for operability. Allows continued operation during SBO. <u>Basis for Screening</u>: The turbine-driven AFW pump room does not require any ventilation, and does not require opening of the room doors, for the four-hour coping duration of a SBO. Therefore, the intent of this SAMA is met with the current design.	(12)	B

Table F.4-1. Initial List of Candidate Improvements for the CNP SAMA Analysis. (Continued)

SAMA Number	Potential Improvement	Discussion	Source	Qualitative Screening
31	Delay CTS actuation after large LOCA.	When ice remains in the ice condenser at such plants, containment sprays have little impact on containment performance, yet rapidly drain down the RWST. This improvement potentially lengthens time of RWST availability. Basis for Screening: Significant modifications and new containment recirculation sump water inventory analyses were implemented in 1999 to resolve issues concerning whether sufficient water is made available to the containment recirculation sump from the RWST and from melting of the ice in the ice condenser. These modifications and new analyses ensure that all loss-of-coolant accident break sizes can be successfully mitigated within the design capabilities of the ECCS and containment. Accident analyses confirmed that the selected parameters for ice condenser inventory, RWST inventory, and ECCS operation (including CTS operation) provided the best capability for mitigating all postulated loss-of-coolant accident break sizes. Therefore, the intent of this SAMA is met with the current design.	(1), (5)	B
32	Install CTS throttle valves.	Potentially extends the time during which water remains in the RWST, when full CTS flow is not needed. Basis for Screening: Significant modifications and new containment recirculation sump water inventory analyses were implemented in 1999 to resolve issues concerning whether sufficient water is made available to the containment recirculation sump from the RWST and from melting of the ice in the ice condenser. These modifications and new analyses ensure that all loss-of-coolant accident break sizes can be successfully mitigated within the design capabilities of the ECCS and containment. Accident analyses confirmed that the selected parameters for ice condenser inventory, RWST inventory, and ECCS operation (including CTS operation) provided the best capability for mitigating all postulated loss-of-coolant accident break sizes. Therefore, the intent of this SAMA is met with the current design.	(10), (11), (12)	B
33	Install an independent method of suppression pool cooling.	Potentially decreases frequency of loss of containment heat removal.	(2), (3)	N
34	Develop an enhanced drywell spray system.	Provides a redundant source of water to containment to control containment pressure, when used in conjunction with containment heat removal.	(2), (3), (15), (16)	N
35	Provide a dedicated existing drywell spray system.	Identical to the previous concept, except that one of the existing spray loops would be used instead of developing a new spray system.	(2), (3) [similar PWR CTS option in (4), (5), (10)]	N

Table F.4-1. Initial List of Candidate Improvements for the CNP SAMA Analysis. (Continued)

SAMA Number	Potential Improvement	Discussion	Source	Qualitative Screening
36	Install a containment vent large enough to remove ATWS decay heat.	Assuming injection is available, provides alternative decay heat removal in an ATWS. Basis for Screening: For an existing plant, the estimated cost of implementation (greater than SAMA Number 37 and SAMA Number 38 options) would exceed the bounding benefit (i.e., >>$2,700,000).	(2), (3)	C
37	Install a filtered containment vent to remove decay heat.	Assuming injection is available (non-ATWS sequences), provides alternate decay heat removal with the released fission products being scrubbed. Basis for Screening: For an existing plant, the estimated cost of implementation ($5,700,000, representative of similar nuclear power plants) would exceed the bounding benefit (i.e., >>$2,700,000).	(2), (3) [similar options in (4), (5), (7), (10), (11), (15), (16)]	C
38	Install an unfiltered hardened containment vent.	Provides an alternate decay heat removal method (non-ATWS), which is not filtered. Basis for Screening: For an existing plant, the estimated cost of implementation ($3,100,000, representative of similar nuclear power plants) would exceed the bounding benefit (i.e., >>$2,700,000).	(2), (3), (8), (13)	C
39	Create/enhance hydrogen igniters with independent power supply. (GSI-189)	Reduces hydrogen detonation at lower cost. Use a new, independent power supply, a non-safety grade portable generator, existing station batteries, or existing AC/DC independent power supplies such as the security system diesel generator to provide power to the hydrogen igniters.	(4), (5), (6), (8), (10), (11), (12), (13), (14), (15), (16), (20)	N
40	Create a passive hydrogen ignition system.	Reduces hydrogen detonation potential without requiring electric power.	(2), (6), (15), (16)	N
41	The action to turn on hydrogen igniters fails frequently due to the time needed to remotely turn off the ice condenser air handling units, as committed to during the original installation of the hydrogen igniter system. This commitment will be investigated and removed if justifiable.	Turning on the hydrogen igniters sooner would reduce containment failure probability for some sequences.	(23)	N
42	Create a giant concrete crucible with heat removal potential under the basemat to contain molten debris.	A molten core escaping from the vessel would be contained within the crucible. The water cooling mechanism would cool the molten core, preventing a melt through. Basis for Screening: For an existing plant, the estimated cost of implementation ($90,000,000 to $108,000,000, representative of similar nuclear power plants) would exceed the bounding benefit (i.e., >>$2,700,000).	(2), (3), (15), (16)	C

Table F.4-1. Initial List of Candidate Improvements for the CNP SAMA Analysis. (Continued)

SAMA Number	Potential Improvement	Discussion	Source	Qualitative Screening
43	Create a water-cooled rubble bed on the pedestal.	This rubble bed would contain a molten core dropping onto the pedestal, and would allow the debris to be cooled. Basis for Screening: For an existing plant, the estimated cost of implementation ($18,000,000, representative of similar nuclear power plants) would exceed the bounding benefit (i.e., >>$2,700,000).	(2), (3), (7), (15), (16)	C
44	Provide modification for flooding of the drywell head.	Would help mitigate accidents that result in leakage through the drywell head seal. Basis for Screening: This is a BWR item. PWR containment does not include an equivalent structure or component that this modification could apply to. Therefore, this item is not applicable and is screened from further consideration.	(3), (8)	A
45	Enhance fire protection system and/or standby gas treatment system hardware and procedures.	Improve fission product scrubbing in severe accidents. Basis for Screening: This is a BWR item. In addition, CNP does not have a secondary containment that could include a scrubbing or ventilation filtering system. Therefore, this item is not applicable and is screened from further consideration.	(3)	A
46	Enhance air return fans (ice condenser containment).	Provide an independent power supply for the air return fans, potentially reducing containment failure probability during SBO sequences. Basis for Screening: 10 CFR 50.44 analysis shows these fans are negligible contribution to the containment's ability to handle a hydrogen burn. Therefore, the intent of this SAMA is met with the current design.	(5), (10)	B
47	Create a reactor cavity flooding system.	Enhances debris coolability, reduces core-concrete interaction and provides fission product scrubbing. Basis for Screening: For an existing plant, the estimated cost of implementation ($8,750,000, representative of similar nuclear power plants) would exceed the bounding benefit (i.e., >>$2,700,000).	(4), (5), (8), (10), (11), (12), (14), (15), (16)	C

Table F.4-1. Initial List of Candidate Improvements for the CNP SAMA Analysis. (Continued)

SAMA Number	Potential Improvement	Discussion	Source	Qualitative Screening
48	Create other options for reactor cavity flooding (Part a).	(a) Use water from dead-ended volumes, the condensed blowdown of the RCS, or secondary system by drilling pathways in the reactor vessel support structure to allow drainage from the SG compartments, refueling canal, sumps, etc., to the reactor cavity. Also (for ice condensers), allow drainage of water from melted ice into the reactor cavity. Basis for Screening: Significant modifications and new containment recirculation sump water inventory analyses were implemented in 1999 to resolve issues concerning whether sufficient water is made available to the containment recirculation sump from the RWST and from melting of the ice in the ice condenser. These modifications and new analyses ensure that all loss-of-coolant accident break sizes can be successfully mitigated within the design capabilities of the ECCS and containment. Accident analyses confirmed that the selected parameters for ice condenser inventory, RWST inventory, and ECCS operation (including CTS operation) provided the best capability for mitigating all postulated loss-of-coolant accident break sizes. Because of the design of penetrations between the active containment recirculation sump area and the reactor cavity, the reactor cavity will be flooded and remain flooded during and following injection of coolant sources and melting of the ice condenser. Therefore, the intent of this SAMA is met with the current design.	(6), (8), (12)	B
49	Create other options for reactor cavity flooding (Part b).	(b) Flood cavity via systems such as diesel-driven fire pumps.	(6), (8), (12)	N
50	Provide a core debris control system.	Intended for ice-condenser plants, this prevents the direct core debris attack of the primary containment steel shell by erecting a barrier between the seal table and containment shell. Basis for Screening: For an existing plant, the estimated cost of implementation ($45,000,000, representative of similar nuclear power plants) would exceed the bounding benefit (i.e., >>$2,700,000).	(5), (10)	C
51	Create a COMSORS.	Place enough glass underneath the reactor vessel such that a molten core falling on the glass would melt and combine with the material. Subsequent spreading and heat removal from the vitrified compound would be facilitated, and concrete attack would not occur (such benefits are theorized in the reference). Basis for Screening: For an existing plant, the estimated cost of implementation ($90,000,000, representative of similar nuclear power plants) would exceed the bounding benefit (i.e., >>$2,700,000).	(17)	C

Table F.4-1. Initial List of Candidate Improvements for the CNP SAMA Analysis. (Continued)

SAMA Number	Potential Improvement	Discussion	Source	Qualitative Screening
52	Provide containment inerting capability.	Prevents combustion of hydrogen and carbon monoxide gases. Basis for Screening: For an existing plant, the estimated cost of implementation ($10,900,000, representative of similar nuclear power plants) would exceed the bounding benefit (i.e., >>$2,700,000).	(5), (8), (10), (13)	C
53	Use firewater spray pump for CTS.	Provides for redundant CTS method without high cost.	(6), (8), (11)	N
54	Install a passive CTS system.	Provides CTS benefits at a very high reliability, and without support systems. Basis for Screening: The source of this SAMA is the AP600 Design Certification Review submittal. For an existing plant, the cost of implementation ($20,000,000, representative of similar nuclear power plants) would exceed the bounding benefit (>>$2,700,000).	(7)	C
55	Install secondary containment filtered ventilation.	For plants with a secondary containment, would filter fission products released from the primary containment. Basis for Screening: CNP design incorporates a primary containment with containment isolation and does not include a secondary containment. Therefore, this item is not applicable and is screened from further consideration.	(7)	A
56	Increase containment design pressure.	Reduces chance of containment overpressure failures. Basis for Screening: For an existing plant, the cost of implementation caused by reconstruction of the containment building would exceed the bounding benefit (>>$2,700,000).	(7)	C
57	Increase the depth of the concrete basemat, or use an alternative concrete material to ensure melt through does not occur.	Prevents basemat melt through. Basis for Screening: For an existing plant, the cost of implementation caused by reconstruction of the containment building would exceed the bounding benefit (>>$2,700,000).	(15), (16)	C
58	Provide a reactor vessel exterior cooling system.	Provides potential to cool a molten core before it causes vessel failure, if the lower head can be submerged in water. Basis for Screening: For an existing plant, the cost of implementation ($2,500,000 to $4,700,000, representative of similar nuclear power plants) either nearly equals (at the low end) or would exceed the bounding benefit (>>$2,700,000).	(15), (16)	C

Table F.4-1. Initial List of Candidate Improvements for the CNP SAMA Analysis. (Continued)

SAMA Number	Potential Improvement	Discussion	Source	Qualitative Screening
59	Create another building, maintained at a vacuum to be connected to containment.	In an accident, connecting the new building to containment depressurizes containment and reduces any fission product release. Basis for Screening: For an existing plant, the cost of implementation ($10,000,000 and up, representative of similar nuclear power plants) would exceed the bounding benefit (>>$2,700,000).	(16)	C
60	Add ribbing to the containment shell.	Reduces the chance of buckling of containment under reverse pressure loading. Basis for Screening: For an existing plant, the cost of implementation would exceed the bounding benefit (>>$2,700,000).	(16)	C
61	Train operations crew for response to inadvertent actuation signals.	Improves chances of a successful response to the loss of two 120V AC buses, which causes inadvertent signals. Basis for Screening: Procedures exist detailing response to spurious actuation and loss of CRID buses, and are used extensively in license operator initial training and license operator continuing training programs. Therefore, the intent of this SAMA is met with the current procedures and the associated operator training.	(12)	B
62	Implement procedure for alignment of spare EDG to shutdown board after LOSP and failure of the EDG normally supplying it.	Reduced SBO frequency. Basis for Screening: CNP has no spare EDG for use during an SBO. An additional EDG would be required before benefiting from this SAMA (See SAMA Number 63). Therefore, this item is not applicable and is screened from further consideration.	(1)	A
63	Provide an additional EDG.	Increases onsite emergency AC power reliability and availability (decrease SBO initiating event frequency). Basis for Screening: For an existing plant, the cost of implementation ($8,500,000 to $22,800,000, representative of similar nuclear power plants) would exceed the bounding benefit (>>$2,700,000).	(4), (5), (9), (12), (15), (16)	C

Table F.4-1. Initial List of Candidate Improvements for the CNP SAMA Analysis. (Continued)

SAMA Number	Potential Improvement	Discussion	Source	Qualitative Screening
64	Provide additional DC battery capability.	Ensures longer battery capability during a SBO, reducing frequency of long-term SBO sequences. <u>Basis for Screening</u>: Both units have separate 250V Train AB and Train CD batteries for essential loads capable of supplying all required DC emergency equipment for four hours. Each unit has the capability to manually cross-tie the Train AB and Train CD batteries to supply DC power to opposite train equipment. Unit 1 has an additional 250V DC BOP battery system for non-essential loads, including emergency turbine-generator auxiliaries, capable of operating associated equipment for a minimum of two hours with the possibility of operation up to eight hours with proper load management. It is physically and electrically isolated from other plant battery systems. Both units have a separate 250V N train battery supply for the operation of the turbine driven AFW system and the AMSAC inverter. This N battery is physically and electrically isolated from the other plant batteries. EOPs include specific load shedding recommendations to preserve DC power from all available 250V DC battery sources during extended SBO events, and are used extensively in license operator initial training and license operator continuing training programs. Therefore, the intent of this SAMA is met with the current procedures and the associated operator training.	(4), (5), (12), (15), (16)	B
65	Use fuel cells instead of lead-acid batteries.	Extends DC power availability in a SBO. <u>Basis for Screening</u>: For an existing plant, the cost of implementation caused by replacing all batteries with fuel cells, including structural, electrical, and HVAC changes required, would exceed the bounding benefit (>>$2,700,000).	(15), (16)	C
66	Implement procedure to cross-tie HPCS diesel.	(BWR 5/6). <u>Basis for Screening</u>: This is a BWR item. PWRs do not have a HPCS and associated diesel similar to advanced BWRs. Therefore, this item is not applicable and is screened from further consideration.	(9)	A
67	Improve bus cross-tie ability between a unit's emergency buses.	Improves AC power reliability.	(9), (12)	N
68	Provide alternate battery charging capability.	Improves DC power reliability. Options to consider include installation of a cross-tie between AC buses, or installation of a portable diesel-driven battery charger.	(9), (10), (11), (12)	N

Table F.4-1. Initial List of Candidate Improvements for the CNP SAMA Analysis. (Continued)

SAMA Number	Potential Improvement	Discussion	Source	Qualitative Screening
69	Increase/improve DC bus load shedding.	Improves battery life during SBO. Basis for Screening: Both units have separate 250V Train AB and Train CD batteries for essential loads capable of supplying all required DC emergency equipment for four hours. Unit 1 has an additional 250V DC BOP battery system for non-essential loads, including emergency turbine-generator auxiliaries, capable of operating associated equipment for a minimum of two hours with the possibility of operation up to eight hours with proper load management. Both units have a separate 250V N train battery supply for the operation of the turbine driven AFW system and the AMSAC inverter. EOPs include specific load shedding recommendations to preserve DC power from all available 250V DC battery sources during extended SBO events, and are used extensively in license operator initial training and license operator continuing training programs. Therefore, the intent of this SAMA is met with the current procedures and the associated operator training.	(9), (10), (11), (12)	B
70	Replace batteries.	Improves reliability. Basis for Screening: Both units have separate 250V Train AB and Train CD batteries for essential loads capable of supplying all required DC emergency equipment for four hours. These batteries have a 20 year life with at least 80% capacity at the end of life with a battery temperature of 77°F. The batteries are sized to supply the load profile amperes during LOCA/LOSP and during SBO conditions as shown in their respective sizing calculations at the end of life without assistance from the charging source and with the adequate battery terminal voltage. The 250V N train battery supplies dc power for the operation of the turbine driven AFW system and the AMSAC inverter. The batteries are also sized to supply the load profile amperes shown on their sizing calculations at the end of life without assistance from the charging source and with the adequate battery terminal voltage. Technical Specifications require performance tests and service tests that ensure the 250V Train AB and Train CD batteries and the 250V N train battery remain capable of meeting the capacity requirements at all times. Therefore, the intent of this SAMA is met with the current design and current procedures.	(9)	B
71	Create AC power cross-tie capability across units at a multi-unit site.	Improves AC power reliability. Basis for Screening: Unit 1 is connected to a 345KV switchyard consisting of eleven 345KV circuit breakers. These connect Unit 1 to six 345KV transmission lines and substation transformers number 4 and 5. Unit 2 is connected to a 765KV switchyard consisting of three 765KV circuit breakers. These connect Unit 2 to a 765KV transmission line and to transformer number 4. Transformer number 4 is a 765/345KV auto-transformer that connects the 765KV and 345KV switchyards between the units. Therefore, the intent of this SAMA is met with the current design.	(10), (11), (12)	B

Table F.4-1. Initial List of Candidate Improvements for the CNP SAMA Analysis. (Continued)

SAMA Number	Potential Improvement	Discussion	Source	Qualitative Screening
72	Create a cross-unit tie for EDG fuel oil.	For multi-unit sites, adds EDG fuel oil redundancy.	(12)	N
73	Develop procedures to repair or change out failed 4KV breakers.	Offers a recovery path from a failure of breakers that perform transfer of 4.16KV non-emergency buses from unit station service transformers to system station service transformers, leading to loss of emergency AC power (i.e., in conjunction with failures of the EDGs).	(12), (26)	N
74	Prioritize steps in recovery of offsite power after a SBO.	Reduces human error probability of offsite power recovery. Basis for Screening: AOPs exist for SBO events, and include a high priority for steps calling for restoration of offsite power. These procedures are used extensively in license operator initial training and license operator continuing training programs. Therefore, the intent of this SAMA is met with the current procedures and the associated operator training.	(12)	B
75	Develop a severe weather conditions procedure.	For plants that do not already have one, reduces the likelihood of external events CDF. Basis for Screening: Severe weather procedure exists for general site preparations and placing the plant in a safe condition depending upon severe weather conditions, and provides guidance to mitigate known vulnerabilities of equipment or systems to specific external events, including missiles generated from tornadoes or high winds and cold weather conditions. These procedures are used extensively in license operator initial training and license operator continuing training programs. Therefore, the intent of this SAMA is met with the current procedures and the associated operator training.	(12)	B
76	Implement procedures for replenishing EDG fuel oil.	Allows long-term EDG operation. Basis for Screening: Procedures exist for maintaining long-term operation of the EDGs when necessary, including monitoring and replenishing EDG fuel oil. These procedures are used extensively in license operator initial training and license operator continuing training programs. Therefore, the intent of this SAMA is met with the current procedures and the associated operator training.	(12)	B
77	Install gas turbine generators.	Improves onsite AC power reliability. Basis for Screening: For an existing plant, the estimated cost of implementation ($3,350,000 to $30,000,000, representative of similar nuclear power plants) would exceed the bounding benefit (i.e., >>$2,700,000).	(12)	C

Table F.4-1. Initial List of Candidate Improvements for the CNP SAMA Analysis. (Continued)

SAMA Number	Potential Improvement	Discussion	Source	Qualitative Screening
78	Install tornado protection on gas turbine generator.	If the unit has a gas turbine, the tornado-induced SBO frequency would be reduced. Basis for Screening: CNP does not use gas turbine generators for back-up power source. EDGs are protected from tornadoes. Therefore, this item is not applicable and is screened from further consideration.	(15), (16)	A
79	Create a lake water backup for EDG cooling.	Provides redundant source of EDG cooling.	(12), (26)	N
80	Use firewater as a backup for EDG cooling.	Provides redundancy in EDG support systems.	(12)	N
81	Provide a connection to alternate offsite power source.	Increases offsite power redundancy. Basis for Screening: A 69KV power line provides the alternate offsite power source. Therefore, the intent of this SAMA is met with the current design.	(12), (21)	B
82	Implement underground offsite power lines.	Potentially improves offsite power reliability, particularly during severe weather. Basis for Screening: The distance that would be necessary to bury offsite power lines would be significant since severe weather to which transmission lines are susceptible typically affects a broad area. For an existing plant, the estimated cost of implementation would exceed the bounding benefit (i.e., >>$2,700,000).	(12)	C
83	Replace anchor bolts on EDG oil cooler.	Millstone found a high seismic SBO risk due to failure of the EDG oil cooler anchor bolts. For plants with a similar problem, this would reduce seismic risk. Basis for Screening: The SBO risk resulting from a failure of the EDG oil cooler anchor bolts is not prevalent at CNP. Therefore, this item is not applicable and is screened from further consideration.	(12)	A
84	Develop procedures for use of pressurizer vent valves during SGTR sequences.	Calvert Cliffs Nuclear Power Plant procedures direct the use of pressurizer sprays to reduce RCS pressure after a SGTR. Use of the vent valves provides a backup method.	(12)	N
85	Install a redundant spray system to depressurize the primary system during a SGTR.	Enhances depressurization ability during SGTR.	(15), (16)	N
86	Implement improved SGTR coping abilities.	Install improved instrumentation to detect SGTR, or additional systems to scrub fission product releases. Basis for Screening: For an existing plant, the estimated cost of implementation for any of these suggested modifications to add instrumentation or new systems would exceed the bounding benefit (i.e., >>$2,700,000).	(6), (8), (12), (13), (15), (16)	C

Table F.4-1. Initial List of Candidate Improvements for the CNP SAMA Analysis. (Continued)

SAMA Number	Potential Improvement	Discussion	Source	Qualitative Screening
87	Add other SGTR coping features.	Options considered include 1) adding a highly reliable (closed loop) SG shell-side heat removal system that relies on natural circulation and stored water sources, 2) adding a system which returns the discharge from the SG relief valve back to the primary containment, and 3) increasing the pressure capability on the SG shell side with corresponding increase in the safety valve setpoints. Basis for Screening: For an existing plant, the estimated cost of implementation for any of these suggested modifications would exceed the bounding benefit (i.e., >>$2,700,000).	(6), (7), (16)	C
88	Increase secondary side pressure capacity such that a SGTR would not cause the relief valves to lift.	SGTR sequences would not have a direct release pathway. Basis for Screening: For an existing plant, the estimated cost of implementation would exceed the bounding benefit (i.e., >>$2,700,000).	(7), (16)	C
89	Replace SGs with new design.	Lowers frequency of SGTR. Basis for Screening: For an existing plant, the estimated cost of implementation would exceed the bounding benefit (i.e., >>$2,700,000).	(12)	C
90	Direct SG flooding after a SGTR, prior to core damage.	Provides for improved scrubbing of SGTR releases. Basis for Screening: Severe accident guidelines for response to a SGTR contain guidance to ensure that competing consequences and risks are evaluated between feeding or not feeding both intact SGs and SGs that have ruptured tubes. If secondary release of large amounts of radiation is a concern, then the guidelines encourage evaluation of flooding of the affected SG(s) to the point of covering the tubes. Therefore, the intent of this SAMA is met with the current procedures.	(1), (13), (14)	B
91	Implement a maintenance practice that inspects 100 percent of the tubes in a SG.	Reduces probability of SGTR. Basis for Screening: Current requirements result in inspecting three percent or more of the total tubes depending upon results of previous inspections. The estimated cost of implementation, including the increase in cumulative radiological dose required to perform the additional inspections of up to 97 percent of total tubes, would exceed the bounding benefit (i.e., >>$2,700,000).	(15), (16)	C
92	Revise EOPs to direct that a faulted SG be isolated.	For those plants whose EOPs don't already direct this, reduces consequences of SGTR. Basis for Screening: EOPs for response to a SGTR contain guidance to ensure that a faulted SG is isolated as long as an intact SG remains available. Therefore, the intent of this SAMA is met with the current procedures.	(12)	B

Table F.4-1. Initial List of Candidate Improvements for the CNP SAMA Analysis. (Continued)

SAMA Number	Potential Improvement	Discussion	Source	Qualitative Screening
93	Locate RHR inside of containment.	Prevents ISLOCA from the RHR pathway. <u>Basis for Screening</u>: For an existing plant, the estimated cost of implementation ($28,000,000, representative of similar nuclear power plants) would exceed the bounding benefit (i.e., >>$2,700,000).	(7)	C
94	Install self-actuating CIVs.	For plants that don't have this, it potentially reduces the frequency of isolation failure.	(7)	N
95	Install additional instrumentation for ISLOCA sequences.	Pressure or leak monitoring instruments installed between the first two pressure isolation valves on low-pressure injection lines, RHR suction lines, and HPSI lines potentially decreases ISLOCA frequency.	(4), (5), (10), (12)	N
96	Increase frequency of valve leak testing.	Potentially decreases ISLOCA frequency.	(11)	N
97	Improvement of operator training on ISLOCA coping.	Decreases ISLOCA effects. <u>Basis for Screening</u>: AOPs exist for coping with ISLOCA symptoms, and are used extensively in license operator initial training and license operator continuing training programs. Therefore, the intent of this SAMA is met with the current procedures and the associated operator training.	(11), (12)	B
98	Install relief valves in the CCW system.	Relieves pressure buildup in CCW piping caused by an RCP thermal barrier tube rupture, preventing an ISLOCA. <u>Basis for Screening</u>: Relief valves on the CCW lines downstream from each RCP thermal barrier are designed to relieve excessive pressure that may be caused by overheating. The CCW system is designed to withstand a complete guillotine break in the RCP thermal barrier heat exchanger. Therefore, the intent of this SAMA is met with the current design.	(12)	B
99	Provide leak testing of valves in ISLOCA paths.	At Kewaunee Nuclear Power Plant, four MOVs isolating RHR from the RCS were not leak tested. Potentially reduces ISLOCA frequency. <u>Basis for Screening</u>: At CNP, valves in the ISLOCA paths are tested in accordance with approved procedures. Therefore, the intent of this SAMA is met with the current procedures.	(12)	B
100	Revise EOPs to improve ISLOCA identification.	Salem had a scenario in which an RHR ISLOCA could direct initial leakage back to the PRT, giving indication that the LOCA was inside containment. Procedure enhancement would ensure LOCA outside containment would be observed.	(12)	N

Table F.4-1. Initial List of Candidate Improvements for the CNP SAMA Analysis. (Continued)

SAMA Number	Potential Improvement	Discussion	Source	Qualitative Screening
101	Revise ISLOCA procedure to specifically address the ISLOCA sequence with the frequency that was dominant in Rev. 1 of the PRA.	Potentially reduces ISLOCA CDF.	(23)	N
102	Ensure all ISLOCA releases are scrubbed.	Scrub ISLOCA releases using water, including suggestion to plug drains in the break area so the break point would cover with water. Basis for Screening: For an existing plant, the estimated cost of implementation to plug drains and ensure all vent paths are isolated or scrubbed would exceed the bounding benefit (i.e., >>$2,700,000).	(13), (14)	C
103	Add redundant and diverse limit switch to each CIV.	Enhanced isolation valve position indication, which potentially reduces frequency of containment isolation failure and ISLOCAs.	(15), (16)	N
104	Modify swing direction of doors separating turbine building basement from areas containing safeguards equipment.	For a plant where internal flooding from turbine building to safeguards areas is a concern, this modification prevents flood propagation. Basis for Screening: The current modeling of flooding concerns in the CNP PRA does not indicate a vulnerability to this item. Therefore, the intent of this SAMA is met with the current design.	(12)	B
105	Improve inspection of rubber expansion joints on main condenser.	For a plant where internal flooding due to failure of circulating water expansion joint is a concern, this potentially reduces the frequency of flooding events. Basis for Screening: The current modeling of flooding concerns in the CNP PRA does not indicate a vulnerability to this item. Therefore, the intent of this SAMA is met with the current design.	(12)	B
106	Implement internal flood prevention and mitigation enhancements.	Options considered include 1) use of submersible MOV operators, and 2) back flow prevention in drain lines. Basis for Screening: The current modeling of flooding concerns in the CNP PRA does not indicate a vulnerability to this item. Therefore, the intent of this SAMA is met with the current design.	(12)	B

Table F.4-1. Initial List of Candidate Improvements for the CNP SAMA Analysis. (Continued)

SAMA Number	Potential Improvement	Discussion	Source	Qualitative Screening
107	Implement internal flooding improvements identified at Fort Calhoun Station.	Implement improvements to prevent or mitigate 1) a rupture in the RCP seal cooler of the CCW system, 2) an ISLOCA in a shutdown cooling line, and 3) an AFW flood involving the need to possibly remove a watertight door. For a plant where any of these apply, potentially reduces flooding risk. Basis for Screening: The current modeling of flooding concerns in the CNP PRA does not indicate a vulnerability to this item. Therefore, the intent of this SAMA is met with the current design.	(12)	B
108	Implement a digital FW upgrade.	Could reduce the frequency of trips caused by feedwater transients.	(12)	N
109	Perform surveillances on manual valves used for backup AFW pump suction.	Improves success probability for providing alternate water supply to AFW pumps. Basis for Screening: Procedures exist to perform surveillance of the ESW supply valves to the AFW pumps. Therefore, the intent of this SAMA is met with the current procedures.	(12)	B
110	Install manual isolation valves around AFW turbine driven steam admission valves.	Reduces the dual turbine driven pump maintenance unavailability. Basis for Screening: This item is related to a plant design having two turbine-driven AFW pumps with common steam admission piping and valves. CNP has only one turbine-driven AFW pump per unit, with separate, unit-specific steam supplies. Therefore, this item is not applicable and is screened from further consideration.	(12)	A
111	Install accumulators for turbine-driven AFW pump flow control valves.	Provide control air accumulators for the turbine-driven AFW flow control valves, the motor-driven AFW pressure control valves, and SG PORVs. This eliminates the need for local manual action to align nitrogen bottles for control air during a LOSP. Basis for Screening: Turbine-driven AFW pump flow control valves are electrically operated. Backup accumulators exist for the SG PORVs. Therefore, the intent of this SAMA is met with the current design.	(10)	B
112	Install a new CST (AFWST).	Either replace old tank with a larger one, or install a backup tank. Basis for Screening: Availability of opposite unit CST and cross-tie capability provides at least 24 hour supply. CNP specific analysis shows that each unit's CST has at least a 24 hour supply of water 98 percent of the time. Therefore, the intent of this SAMA is met with the current design.	(12), (15), (16)	B

Table F.4-1. Initial List of Candidate Improvements for the CNP SAMA Analysis. (Continued)

SAMA Number	Potential Improvement	Discussion	Source	Qualitative Screening
113	Provide alternate cooling of steam-driven AFW pump in a SBO.	Options considered include 1) using firewater to cool pump, or 2) making the pump self-cooled. Improves probability of success during a SBO. Basis for Screening: The turbine-driven AFW pump room does not require any direct cooling or ventilation, and does not require opening of the room doors, for the four-hour coping duration of a SBO. Therefore, the intent of this SAMA is met with the current design and associated procedures.	(12)	B
114	Implement procedures for local manual operation of AFW when control power is lost.	Potentially lengthens AFW availability in SBO. Also provides a success path should AFW control power be lost in non-SBO sequences. Basis for Screening: EOPs provide guidance for local manual operation of the turbine-driven AFW pump. Therefore, the intent of this SAMA is met with the current procedures.	(12)	B
115	Provide portable generators to be hooked in to the turbine-driven AFW, after battery depletion.	Extends AFW availability in a SBO (assuming the turbine-driven AFW requires DC power).	(15), (16)	N
116	Add a motor train of AFW to the steam trains.	For PWRs that do not have any motor trains of AFW, this potentially increases reliability in non-SBO sequences. Basis for Screening: The AFW system for each unit includes two motor-driven AFW pumps and trains. Therefore, the intent of this SAMA is met with the current design.	(12)	B
117	Create ability for emergency connections of existing or alternate coolant inventory.	Provides a backup water supply for the coolant makeup systems.	(11), (26)	N
118	Use firewater as a backup for SG inventory.	Creates a backup to main FW and AFW for SG water supply. Basis for Screening: There are two other sources of water inventory available to the AFW pumps. First, there is a cross-tie between the Unit 1 and Unit 2 CSTs that allows sharing of water inventory. Second, each AFW pump has an alternate supply line from the ESW system that can be manually placed into service in the AFW pump rooms. Therefore, the intent of this SAMA is met by having these two, diverse alternate water sources.	(12)	B
119	Procure a portable diesel-driven pump for IC makeup.	Provides backup to the city water supply and diesel-driven firewater pump in providing IC makeup. Basis for Screening: This is a BWR item. PWRs do not have an equivalent system to the IC in BWRs. Therefore, this item is not applicable and is screened from further consideration.	(12)	A

Table F.4-1. Initial List of Candidate Improvements for the CNP SAMA Analysis. (Continued)

SAMA Number	Potential Improvement	Discussion	Source	Qualitative Screening
120	Install an independent diesel for the CST makeup pumps.	Would allow continued inventory in CST during a SBO. Basis for Screening This is a BWR item. PWRs do not have an equivalent system to that used in BWRs to prevent water hammer in the CST makeup line by use of a jockey pump. Therefore, this item is not applicable and is screened from further consideration.	(12)	A
121	Change failure position of condenser makeup valve.	If the condenser makeup valve fails open on loss of air or power, this can result in CST flow diversion to condenser. Allows greater inventory for the AFW pumps. Basis for Screening: This item is from Kewaunee Nuclear Power Plant, where the CST only contains a four-hour supply of water. Although the condenser makeup valve from the CST is a fail-open air-operated valve at CNP, each unit's CST contains a 24-hour supply of water, and there are two other sources of water inventory available to the AFW pumps. First, there is a cross-tie between the Unit 1 and Unit 2 CSTs that allows sharing of water inventory. Second, each AFW pump has an alternate supply line from the ESW system that can be manually placed into service in the AFW pump rooms. Therefore, the intent of this SAMA is met by having a large CST and these two, diverse alternate water sources.	(12)	B
122	Create passive secondary side coolers.	Provide a passive heat removal loop with a condenser and heat sink. Reduces CDF from the loss of FW. Basis for Screening: For an existing plant, the estimated cost of implementation would exceed the bounding benefit (i.e., >>$2,700,000).	(16)	C
123	Provide capability for diesel-driven, low pressure vessel makeup.	Provides extra water source in sequences in which the reactor is depressurized and all other injection is unavailable (e.g., firewater).	(3), (4), (9), (12)	N
124	Provide an additional HPSI pump with independent diesel.	Reduces frequency of core melt from small LOCA sequences, and from SBO sequences.	(5), (15), (16)	N
125	Install independent AC HPSI system.	Allows make up and feed and bleed capabilities during an SBO.	(10)	N
126	Prevent overpressurization of RHR piping by SI system.	Failure of check valve SI-151W fails HPI. A redundant path, parallel to the check valve, would improve reliability.	(26)	N
127	Create the ability to manually align ECCS recirculation.	Provides a backup should automatic or remote operation fail.	(11)	N

Table F.4-1. Initial List of Candidate Improvements for the CNP SAMA Analysis. (Continued)

SAMA Number	Potential Improvement	Discussion	Source	Qualitative Screening
128	Implement an RWST makeup procedure.	Decreases CDF from ISLOCA scenarios, some smaller break LOCA scenarios, and SGTR. Basis for Screening: EOPs provide directions on monitoring RWST inventory and adding water from different sources when necessary. Therefore, the intent of this SAMA is met with the current procedures.	(11), (12)	B
129	Stop low pressure injection pumps earlier in medium or large LOCAs.	Would give more time to perform recirculation swapover. Basis for Screening: With the ice condenser containment, most LOCA sizes will actuate sprays, and because of the high spray flowrate, reducing ECCS flow would not have a significant effect on RWST water management. Therefore, this item is not applicable and is screened from further consideration.	(12)	A
130	Emphasize timely recirculation swapover in operator training.	Reduces human error probability of recirculation failure. Basis for Screening: EOPs exist providing directions for monitoring and conserving water in the containment recirculation sump, including ensuring maximum injection of water from the RWST occurs prior to performing swapover to containment recirculation. These procedures are used extensively in license operator initial training and license operator continuing training programs, and are practiced in the plant simulator. Therefore, the intent of this SAMA is met with the current operator training.	(12)	B
131	Upgrade CVCS to mitigate small LOCAs.	For a plant like the Westinghouse AP600 PWR where CVCS cannot mitigate a small LOCA, an upgrade decreases CDF from small LOCA. Basis for Screening: For an existing plant, the estimated cost of implementation to increase CVCS flow capacity would exceed the bounding benefit (i.e., >>$2,700,000).	(7)	C
132	Install an active HPSI system.	For a plant like the AP600, where an active HPSI system does not exist, would add redundancy in high pressure injection. Basis for Screening: This item is related to plant designs that only have a passive HPSI system. Therefore, this item is not applicable and is screened from further consideration.	(7)	A
133	Change “in-containment” RWST suction from 4 check valves to 2 check and 2 air operated valves.	Remove common mode failure of all four injection paths. Basis for Screening: This item only applies to AP600 plants that have the RWST located inside of containment. Therefore, this item is not applicable and is screened from further consideration.	(7)	A
134	Replace two of the four safety injection pumps with diesel-driven pumps.	Intended for Combustion Engineering System 80+ PWR, which has four trains of SI. This reduces common cause failure probability.	(15), (16)	N

Table F.4-1. Initial List of Candidate Improvements for the CNP SAMA Analysis. (Continued)

SAMA Number	Potential Improvement	Discussion	Source	Qualitative Screening
135	Align LPCI or core spray to CST on loss of suppression pool cooling.	Low pressure ECCS can be maintained in loss of suppression pool cooling scenarios. <u>Basis for Screening</u>: This is a BWR item. PWRs do not have a suppression pool similar to BWRs. Therefore, this item is not applicable and is screened from further consideration.	(9), (12)	A
136	Raise HPCI/RCIC backpressure trip setpoints.	Ensures HPCI/RCIC availability when high suppression pool temperatures exist. <u>Basis for Screening</u>: This is a BWR item. PWRs do not have turbine-driven ECCS pumps that exhaust steam to a suppression pool inside containment similar to BWRs. Therefore, this item is not applicable and is screened from further consideration.	(12)	A
137	Improve the reliability of the automatic depressurization system.	Reduce frequency of high pressure core damage sequences. <u>Basis for Screening</u>: This is a BWR item. PWRs do not implement the same logic for deliberately depressurizing the RCS upon failure of high pressure injection to allow low pressure injection that is used in BWRs. Therefore, this item is not applicable and is screened from further consideration.	(3)	A
138	Disallow automatic vessel depressurization in non-ATWS scenarios.	Improve operator control of plant. <u>Basis for Screening</u>: This is a BWR item. PWRs do not implement the same logic for deliberately depressurizing the RCS upon failure of high pressure injection to allow low pressure injection that is used in BWRs. Therefore, this item is not applicable and is screened from further consideration.	(12)	A
139	Create automatic swapover to implement low pressure pump to HPSI pump piggyback operation during recirculation following RWST depletion.	Removes human error contribution from recirculation failure.	(4), (5), (10), (18)	N
140	Modify EOPs for ability to align EDG power to more air compressors.	For plants that do not have EDG power to all normal and backup air compressors, this change increases reliability of instrument air after a LOSP. <u>Basis for Screening</u>: There are four air compressors (one plant and one control air compressor per unit) that can be supplied with electric power from both normal and emergency sources (including the EDGs) so that a supply of compressed air can be made available in any foreseeable circumstance. EOPs address restoration of control air as soon as possible when necessary. Therefore, the intent of this SAMA is met with the current design and current procedures.	(12)	B
141	Replace old air compressors with more reliable ones.	Improves reliability and increases availability of instrument air compressors.	(12), (26)	N

Table F.4-1. Initial List of Candidate Improvements for the CNP SAMA Analysis. (Continued)

SAMA Number	Potential Improvement	Discussion	Source	Qualitative Screening
142	Implement modifications to the compressed air system (Unit 1 control air compressor) to increase the capacity of the system.	In the IPE, failure of the compressed air system was found to be a significant contributor to CDF. Even though acceptable event tree modeling modifications would lower compressed air contributions and virtually eliminate this vulnerability, evaluate cost-beneficial upgrades to the capacity of the Unit 1 control air compressor. <u>Basis for Screening</u>: Modifications were implemented after the initial IPE modeling to increase the capacity of the Unit 1 and Unit 2 control air compressors. Therefore, the intent of this SAMA is met with the current design.	(22)	B
143	Install nitrogen bottles as backup gas supply for SRVs.	Extends operation of SRVs during SBO and loss of air events (BWRs). <u>Basis for Screening</u>: Backup air supplies are provided for two of the three pressurizer PORVs using compressed air bottles. The SG PORVs are provided with backup nitrogen bottles and equipped with handwheels for manual operation under plant procedures. Therefore, the intent of this SAMA is met with the current design.	(12)	B
144	Install MG set trip breakers in control room.	Allows the operator to trip the MG sets from the control room. Currently, at Watts Bar Nuclear Plant, an ATWS would require an immediate operator action outside the control room to trip the MG sets. Potentially reduces ATWS CDF.	(10)	N
145	Add capability to remove power from the bus powering the control rods.	Decreases time to insert control rods if the reactor trip breakers fail (during a loss of FW ATWS which has rapid pressure excursion).	(12)	N
146	Create cross-connect ability for SLC trains.	Improved reliability for boron injection during ATWS. <u>Basis for Screening</u>: This is a BWR item. Diverse sources of borated water with multiple, diverse paths for delivery of borated water to the RCS exist in a PWR. Therefore, this item is not applicable and is screened from further consideration.	(12)	A
147	Create an alternate boron injection capability (backup to SLC).	Improved reliability for boron injection during ATWS. <u>Basis for Screening</u>: This is a BWR item. Diverse sources of borated water with multiple, diverse paths for delivery of borated water to the RCS exist in a PWR. Therefore, this item is not applicable and is screened from further consideration.	(12)	A
148	Remove or allow override of LPCI injection during ATWS.	This is a BWR item. On failure of HPCI and condensate, the Susquehanna units direct reactor depressurization followed by 5 minutes of automatic LPCI injection. Would allow control of LPCI immediately. <u>Basis for Screening</u>: This is a BWR item. PWRs do not implement the same logic for governing low pressure injection that is used in BWRs. Therefore, this item is not applicable and is screened from further consideration.	(12)	A

Table F.4-1. Initial List of Candidate Improvements for the CNP SAMA Analysis. (Continued)

SAMA Number	Potential Improvement	Discussion	Source	Qualitative Screening
149	Install a system of relief valves that prevents any equipment damage from a pressure spike during an ATWS.	Improves equipment availability after an ATWS.	(15), (16)	N
150	Create a boron injection system to back up the mechanical control rods.	Provides a redundant means to shut down the reactor. Basis for Screening: Diverse sources of borated water with multiple, diverse paths for delivery of borated water to the RCS exist in a PWR as a backup to the mechanical control rods. Therefore, the intent of this SAMA is met with the current design.	(15), (16)	B
151	Provide an additional instrumentation system for ATWS mitigation (e.g., AMSAC).	Improves I&C redundancy and reduces ATWS frequency. Basis for Screening: AMSAC has already been provided to reduce ATWS frequency at CNP. Therefore, the intent of this SAMA is met with the current design.	(15), (16)	B
152	Provide capability for remote operation of secondary side PORVs in SBO.	Manual operation of these valves is required in a SBO scenario. High area temperatures may be encountered in this case (no ventilation in main steam areas), and remote operation could improve success probability. Basis for Screening: The SG PORVs are provided with backup nitrogen bottles and equipped with handwheels for local manual operation under plant procedures. In addition, the SG PORVs have separate, local valve control stations located in areas safe from high area temperatures that can be used with either normal control air or backup nitrogen to remotely operate the valves. Operation of the SG PORVs using the local valve control stations is also described in procedures. Therefore, the intent of this SAMA is met with the current design and current procedures.	(1)	B
153	Create/enhance RCS depressurization ability.	Implement with a new depressurization system, or with existing PORVs, head vents and secondary side valve. RCS depressurization would allow low pressure ECCS injection. Even if core damage occurs, low RCS pressure alleviates some concerns about high pressure melt ejection.	(4), (5), (8), (10), (11), (12), (13), (14), (15), (16)	N
154	Make procedural changes only for the RCS depressurization option.	Reduces RCS pressure to allow low pressure ECCS injection without cost of a new system.	(6), (8), (12)	N
155	Defeat 100 percent load rejection capability.	Eliminates the possibility of a stuck open PORV after a LOSP, since PORV opening wouldn't be needed. Basis for Screening: This item applies to plants that have 100 percent load rejection capability. CNP design is for 50 percent load rejection. Therefore, the intent of this SAMA is met with the current design.	(12)	B

Table F.4-1. Initial List of Candidate Improvements for the CNP SAMA Analysis. (Continued)

SAMA Number	Potential Improvement	Discussion	Source	Qualitative Screening
156	Change CRD flow control valve failure position.	Change failure position to the ‘fail-safest’ position. Basis for Screening: This is a BWR item. PWRs do not include an equivalent system or component that this modification could apply to. Therefore, this item is not applicable and is screened from further consideration.	(12)	A
157	Install secondary side guard pipes up to the MSIVs.	Potentially prevents secondary side depressurization should a steam line break occur upstream of the MSIVs. Also guards against or prevents consequential multiple SGTR following a main steam line break event.	(15), (16)	N
158	Install digital large break LOCA protection.	Upgrade plant instrumentation and logic to improve the capability to identify symptoms/precursors of a large break LOCA (i.e., capability to detect a leak before a break). Basis for Screening: For an existing plant, the estimated cost of implementation would exceed the bounding benefit (i.e., >>$2,700,000).	(16)	C
159	Increase seismic capacity of the plant to a HCLPF of twice the SSE.	Reduces seismic CDF. Basis for Screening: For an existing plant, the estimated cost of implementation would exceed the bounding benefit (i.e., >>$2,700,000).	(16)	C
160	Provide self-cooled ECCS seals.	ECCS pump seals are CCW cooled. Self-cooled seals would remove this dependency.	(19)	N
161	Separate non-vital buses from vital buses.	Some non-vital loads mixed with vital loads on load centers potential cause load shedding difficulties. Basis for Screening: This SAMA would prevent failures of non-vital 600V breakers from impacting the associated 600V vital bus section. Installing new non-vital 600V buses would be extremely costly, and the cost of implementation would be expected to exceed the bounding benefit (>>$2,700,000).	(19)	C
162	Make CCW trains separate.	Current cross-tie capability creates a potential common mode failure mechanism for both trains (and both stations).	(19)	N
163	Make ICW trains separate.	Current cross-tie capability creates a potential common mode failure mechanism for both trains (and both stations).	(19)	N
164	Provide a centrifugal charging pump.	Currently charging pumps are positive displacement pumps. Basis for Screening: CNP has two centrifugal charging pumps for each unit that are used for high pressure injection of borated water during emergency conditions requiring actuation of the ECCS. Therefore, the intent of this SAMA is met with the current design.	(19)	B

Table F.4-1. Initial List of Candidate Improvements for the CNP SAMA Analysis. (Continued)

SAMA Number	Potential Improvement	Discussion	Source	Qualitative Screening
165	Provide a motor-operated AFW pump.	Provides redundancy for plants with only turbine-driven AFW pumps. Basis for Screening: The AFW system for each unit includes two motor-driven AFW pumps and trains. Therefore, the intent of this SAMA is met with the current design.	(19)	B
166	Provide containment isolation design per GDC and SRP.	Potentially enhances containment isolation capability.	(19)	N
167	Improve RHR sump reliability.	Reduces potential for common mode failure of RHR due to debris in sump.	(19)	N
168	Provide auxiliary building vent/seal structure.	Enhances ventilation in auxiliary building.	(19)	N
169	Add charcoal filters on auxiliary building exhaust.	Enhances fission product removal after ISLOCA.	(19)	N
170	Add penetration valve leakage control system.	Enhances capability to detect/control leakage from penetration valves.	(19)	N
171	Enhance screen wash.	Reduces potential for loss of ICW due to clogging of lake water screens.	(19)	N
172	Enhance training for important operator actions.	The Fussell-Vesely importance list was reviewed to identify any significant human errors. Those with a F-V importance of 5E-03 or greater are: 1) HI1-FAILURE-HE, Failure to turn on hydrogen Igniters in large LOCA or in SBO. 2) OLI---13B-EHHE, Conditional failure of execution to cooldown and depressurize given failure of high pressure injection and simultaneous need to switch to recirculation. 3) RRI---CCW-EHHE, Errors of execution cause failure to restore CCW system after a SBO. 4) CCW-CVCS—MHHE, Errors of execution cause failure to initiate CVCS cross-tie. 5) CSR-HIGHDEP-HE, Conditional failure to switch containment spray to recirculation given loss of secondary heat sink and failure of primary feed and bleed. 6) RCC---EXE-EHHE, Errors of execution cause failure to cooldown after station blackout. 7) OA2----E3-MHHE-L, Conditional failure to cooldown and depressurize on a SGTR given overfill of ruptured steam generator. 8) OA1--E3CD-MHHE-M, Errors of execution cause failure to cooldown and depressurize to prevent overfill of ruptured steam generator. 9) RRI---AFW-EHHE, Errors of execution cause failure to restore AFW system after station blackout. 10) EPORVMANOPENHE, Errors of execution cause failure to manually open steam generator PORV given loss of support systems.	(26)	N

Table F.4-1. Initial List of Candidate Improvements for the CNP SAMA Analysis. (Continued)

SAMA Number	Potential Improvement	Discussion	Source	Qualitative Screening
172 Continued	Enhance training for important operator actions.	The Fussell-Vesely importance list was reviewed to identify any significant human errors. Those with a F-V importance of 5E-03 or greater are: 11) BAMV-ESWWESTHE, Failure to switch to standby CCW header. 12) BAMV-ESWEASTHE, Failure to switch to standby CCW header. 13) CCW-----COG-HE, Cognitive failure to recognize loss of CCW. 14) CCW—XTIE-MHHE, Execution errors cause failure to cross-tie CCW system. 15) CCW-REPAIR--HE, Failure to repair or recover CCW system. 16) AFW-OPENDOORHE, Failure to open AFW pump room doors on a loss of room cooling. 17) HPRC-LPR-EXEME, Execution errors cause failure to align high pressure ECCS pump suction to RHR. 18) AFW-CROSSTIEHE, Failure to cross-tie AFW system to opposite unit. 19) AABS-MS-T11DHE, Failure to manually strip loads from safety buses given failure of automatic load shedding. 20) ABBS-MS-T11AHE, Failure to manually strip loads from safety buses given failure of automatic load shedding. 21) RRIA-CSI-PBBHE, Cognitive error to recognize need for ECCS flow following station blackout. HE, Execution errors cause failure to isolate ISLOCA.22) LTS----S1-EHHE, Execution errors cause failure to provide long-term shutdown following ATWS. 23) HPRA-LPR-CSRME, Cognitive error to recognize need to switch to recirculation. 24) CCW-RCP---MHHE, Execution errors cause failure to trip reactor coolant pumps following a loss of cooling water. 25) BBXV-1ESW130HE, Failure to restore ESW header discharge valve following maintenance on standby header. 26) BAXV-1ESW131HE, Failure to restore ESW header discharge valve following maintenance on standby header. 27) OIB-DYNAM-EHHE, Execution errors cause failure to isolate ISLOCA.	(26)	N

Table F.4-1. Initial List of Candidate Improvements for the CNP SAMA Analysis. (Continued)

SAMA Number	Potential Improvement	Discussion	Source	Qualitative Screening
173	Foldout pages are used inconsistently by Unit Supervisors. The possibility of revising the usage of the foldout pages will be investigated to see if diagnosis of red path conditions can be improved.	Potentially reduces CDF related to operator error in red path sequences. Basis for Screening: In the Westinghouse Owners Group Revision 1C EOPs, foldout pages were placed on the opposite side of the EOPs. The foldout pages are available and open for the entire duration of the procedure. During each procedure transition, the operator is directed to review the foldout pages in accordance with site administrative procedure requirements. These procedures are used extensively in license operator initial training and license operator continuing training programs, and are practiced in the plant simulator. Therefore, the intent of this SAMA is met with the current procedures and the associated operator training.	(23)	B
174	A clear definition of the coordination strategy for local recovery actions (e.g., between units during cross-tying operations) could save considerable action time.	Reduces human error related to cross-tie actions. Basis for Screening: AOPs for ESW system loss or rupture and for loss of CCW establish and coordinate requirements between units, including methods to restore ESW and CCW system trains and to use CVCS cross-ties as necessary to preserve RCP seal injection and cooling. Other emergency response procedures provide directions for possible methods to restore core cooling in the event that all ECCS pumps fail (a beyond design basis event) using the CVCS cross-ties as necessary. These procedures are used extensively in license operator initial training and license operator continuing training programs, and are practiced in the plant simulator. Therefore, the intent of this SAMA is met with the current procedures and the associated operator training.	(23)	B
175	Implement operator training on the impact of primary and secondary system heat removal on containment pressure response and the possibility of containment failure preceding core melt. In addition, consider procedural upgrades to minimize the possibility of such situations arising.	Reduces likelihood of core melt into a failed containment. Basis for Screening: EOPs for responding to loss-of-coolant accidents and secondary side breaks address operator actions for monitoring and reducing the pressure rise in containment as a result of inadequate heat removal from the containment. These procedures are used extensively in license operator initial training and license operator continuing training programs, and are practiced in the plant simulator. Therefore, the intent of this SAMA is met with the current procedures and the associated operator training.	(22)	B

Table F.4-1. Initial List of Candidate Improvements for the CNP SAMA Analysis. (Continued)

SAMA Number	Potential Improvement	Discussion	Source	Qualitative Screening
176	Implement operator training on the importance of a wet reactor cavity on potential fission product releases.	This training will emphasize injecting the maximum amount of water possible from the RWST to the containment prior to switchover to recirculation. Basis for Screening: EOPs exist providing directions for monitoring and conserving water in the containment recirculation sump, including ensuring maximum injection of water from the RWST occurs prior to performing swapover to containment recirculation. Maximizing water input to the RCS and containment ensures the reactor cavity remains flooded, either through RCS break flow into the reactor cavity, or flow from the containment into the reactor cavity through penetrations located in the reactor cavity wall. These procedures are used extensively in license operator initial training and license operator continuing training programs, and are practiced in the plant simulator. Therefore, the intent of this SAMA is met with the current design, current procedures and the associated operator training.	(22)	B
177	Add protection to prevent tornado damage to RWST and penetration rooms.	Penetration rooms are tornado protected. Tornado category F2 and higher can generate heavy enough missiles that they could impact and damage the RWST.	(18)	N
178	Man SSF continuously to align coolant makeup system for RCP seal cooling.	At Oconee Nuclear Station a dedicated operator for seals or for the highest value operator action could be considered. Basis for Screening: This is an Oconee Nuclear Station specific item. Therefore, this item is not applicable and is screened from further consideration.	(18)	A
179	Add protection to prevent tornado damage causing failure of power and upper surge tanks.	Consider tornado protection for tanks or switchgear in turbine building. Surge tanks are suction source for emergency FW pumps.	(18)	N
180	Replace reactor vessel with stronger vessel.	Reduces core damage contribution due to vessel failure. Basis for Screening: For an existing plant, the estimated cost of implementation would exceed the bounding benefit (i.e., >>$2,700,000).	(18)	C
181	Improve seismic capacity of walls near 4160/600 VAC transformers.	Failure of these transformers caused by a seismically induced failure of the walls contributed approximately 25% of seismic CDF. Reinforcing the walls potentially eliminates this failure mode. Basis for Screening: Design changes have been implemented to reinforce these walls. Therefore, the intent of this SAMA is met with the current design.	(24), (27)	B

Table F.4-1. Initial List of Candidate Improvements for the CNP SAMA Analysis. (Continued)

SAMA Number	Potential Improvement	Discussion	Source	Qualitative Screening
182	Improve seismic capacity of the EDG fuel oil day tanks.	Seismically induced failure of the EDG fuel oil day tanks contributed approximately 20% of seismic CDF. A modification to prevent seismic impact potentially eliminates this failure mode. Basis for Screening: Design changes have been implemented to prevent seismically induced failures. Therefore, the intent of this SAMA is met with the current design.	(24), (27)	B
183	Reinforce the seismic capacity of the steel structure supporting the auxiliary building.	Seismic failure of the steel structure supporting the auxiliary building would lead to collapse of the building. Reinforcing the building potentially precludes or lessens this failure mode. Basis for Screening: For an existing plant, the estimated cost of implementation to reinforce the auxiliary building to withstand beyond-design-basis earthquake levels would exceed the bounding benefit (i.e., >>$2,700,000).	(24), (27)	C
184	Provide a means to ensure RCP seal cooling so that RCP seal LOCAs are precluded for SBO events.	Options to consider include using the CVCS cross-tie, installation of a new, independently powered pump, or a temporary connection to provide cooling to RCP thermal barriers. Such a strategy would also benefit loss of ESW and loss of CCW events. This item is related to SAMA Numbers 5, 9, 10, 12, 13, 17, 124, 125, 134 and 160.	(25)	N
185	Improve EDG reliability.	Minimizes the probability of a SBO event given a LOSP.	(26), (28)	N
186	Improve circulating water screens and debris removal.	Minimizes the chance of clogging heat exchangers and condensers and initiating transient events. This item is similar to SAMA Number 171.	(28)	N
187	Improve reliability of power supplies.	Reduces reactor trip frequency. This item is similar to SAMA Number 108.	(28)	N
188	Improve switchyard and transformer reliability.	This initiative is to reduce human errors in the switchyard and alarms on plant transformers. This initiative potentially lowers the frequency of transient events initiated by the electrical system.	(28)	N
189	Reduce biofouling of raw water systems.	Improves control of zebra mussels. This item is similar to SAMA Number 171.	(28)	N
190	Improve reliability of main feedwater pumps.	Potentially reduces transient initiating event frequency.	(28)	N
191	Establish a preventive maintenance program for expansion joints, bellows, and boots.	Potentially reduces flooding initiating event frequency and the failure probability of plant components.	(28)	N
192	Improve reliability of AFW pumps and valves.	Potentially reduces occurrence of loss of secondary heat sink.	(28)	N

Table F.4-1. Initial List of Candidate Improvements for the CNP SAMA Analysis. (Continued)

SAMA Number	Potential Improvement	Discussion	Source	Qualitative Screening
193	Eliminate MSIV vulnerabilities.	Reduces the chance that MSIVs will drift off their open seat during low-power operations.	(26), (28)	N
194	Upgrade main turbine controls.	Potentially reduces turbine trip frequency. Basis for Screening: For an existing plant, the estimated cost of implementation would exceed the bounding benefit (i.e., >>$2,700,000).	(28)	C

Source Key

1. Letter from Mr. M. O. Medford, TVA, to NRC Document Control Desk, "Watts Bar Nuclear Plant (WBN) Units 1 and 2 - Generic Letter (GL) 88-20 – Individual Plant Examination (IPE) for Severe Accident Vulnerabilities - Response - (TAC M74488)," dated September 1, 1992.
2. "Cost Estimate for Severe Accident Mitigation Design Alternative, Limerick Generating Station for Philadelphia Electric Company," Bechtel Power Corporation, June 22, 1989.
3. NUREG-1437, "Generic Environmental Impact Statement for License Renewal of Nuclear Plants," Volume 1, Table 5.35, Listing of SAMDAs considered for the Limerick Generating Station, U. S. Nuclear Regulatory Commission, May 1996.
4. NUREG-1437, "Generic Environmental Impact Statement for License Renewal of Nuclear Plants," Volume 1, Table 5.36, Listing of SAMDAs considered for the Comanche Peak Steam Electric Station, U. S. Nuclear Regulatory Commission, May 1996.
5. Letter from Mr. W. J. Museler, TVA, to NRC Document Control Desk, "Watts Bar Nuclear Plant (WBN) Units 1 and 2 - Severe Accident Mitigation Design Alternatives (SAMDA) - (TAC Nos. M77222 and M77223)," dated June 5, 1993.
6. Letter from Mr. D. E. Nunn, TVA, to NRC Document Control Desk, "Watts Bar Nuclear Plant (WBN) Units 1 and 2 - Severe Accident Mitigation Design Alternatives (SAMDA) - Response to Request for Additional Information (RAI) - (TAC Nos. M77222 and M77223)," dated October 7, 1994.
7. Letter from N. J. Liparulo, Westinghouse Electric Corporation, to NRC Document Control Desk, "Submittal of Material Pertinent to the AP600 Design Certification Review," dated December 15, 1992.
8. Brookhaven National Laboratory, Department of Advanced Technology, Technical Report FIN W-6449, "NRC - IPE Workshop Summary Held in Austin Texas; April 7-9, 1997," Appendix F - Industry Presentation Material, Contribution by Swedish Nuclear Power Inspectorate (SKI) and Safety Assessment Consulting (SAC): "Insights from PSAs for European Nuclear Power Plants," presented by Wolfgang Werner, SAC, dated July 17, 1997.
9. Brookhaven National Laboratory, Department of Advanced Technology, Technical Report FIN W-6449, "NRC - IPE Workshop Summary Held in Austin Texas; April 7-9 1997," Appendix D - NRC Presentation Material on Draft NUREG-1560 dated July 17, 1997.
10. NUREG-0498, Supplement 1, "Final Environmental Statement Related to the Operation of Watts Bar Nuclear Plant, Units 1 and 2," U. S. Nuclear Regulatory Commission, April 1995.
11. NUREG/CR-5567, "PWR Dry Containment Issue Characterization," U. S. Nuclear Regulatory Commission, August 1990.
12. NUREG-1560, "Individual Plant Examination Program: Perspectives on Reactor Safety and Plant Performance," Volume 2, U. S. Nuclear Regulatory Commission, December 1997.

Table F.4-1. Initial List of Candidate Improvements for the CNP SAMA Analysis. (Continued)

13. NUREG/CR-5630, “PWR Dry Containment Parametric Studies,” U. S. Nuclear Regulatory Commission, April 1991.
14. NUREG/CR-5575, “Quantitative Analysis of Potential Performance Improvements for the Dry PWR Containment,” U. S. Nuclear Regulatory Commission, August 1990.
15. CESSAR Design Certification, Appendix U, Section 19.15.5, “Use of PRA in the Design Process,” December 31, 1993.
16. NUREG-1462, “Final Safety Evaluation Report Related to the Certification of the System 80+ Design,” U. S. Nuclear Regulatory Commission, August 1994.
17. Forsberg, C. W., E. C. Beahm, and G. W. Parker, “Core-Melt Source Reduction System (COMSORS) to Terminate LWR Core-Melt Accidents,” Second International Conference on Nuclear Engineering (ICONE-2) San Francisco, California, March 21-24, 1993.
18. “Oconee Nuclear Station, Applicant’s Environmental Report, Operating License Renewal Stage: Attachment K, Oconee Nuclear Station Severe Accident Mitigation Alternatives (SAMAs) Analysis,” Revision 0, dated June 1998.
19. “Turkey Point Units 3 & 4 Probabilistic Risk Assessment Individual Plant Examination Submittal Final Report,” Florida Power & Light Co., dated June 1991.
20. NUREG/CR-6427, “Assessment of the DCH Issue for Plants with Ice Condenser Containments,” U. S. Nuclear Regulatory Commission, April 2000.
21. LSB-02-04, “Atomic Safety and Licensing Board (ASLB) Panel Rulings On Duke License Renewal Application,” U. S. Nuclear Regulatory Commission, January 24, 2002.
22. “Donald C. Cook Nuclear Plant Units 1 and 2, Individual Plant Examination Summary Report,” American Electric Power Service Corporation, dated April 1992; Letter from E. E. Fitzpatrick, I&M, to U. S. Nuclear Regulatory Commission Document Control Desk, “Donald C. Cook Nuclear Plant Units 1 and 2 Individual Plant Examination Submittal Response to Generic Letter 88-20,” AEP:NRC:1082E, dated May 1, 1992; and Letter from J. B. Hickman, NRC, to E. E. Fitzpatrick, I&M, “Review of D. C. Cook Individual Plant Examination Submittal – Internal Events (TAC Nos. M74398 and M74399),” dated September 6, 1996.
23. “Donald C. Cook Nuclear Plant Units 1 and 2, Individual Plant Examination Summary Report,” American Electric Power Service Corporation, Revision 1, dated October 1995.
24. “Donald C. Cook Nuclear Plant Units 1 and 2, Individual Plant Examination of External Events Summary Report,” American Electric Power Service Corporation, dated April 1992.
25. PRA-NB-SUM, “Probabilistic Risk Assessment Update Summary Report,” American Electric Power Service Corporation, Revision 0.
26. PRA-NB-SDR, “Donald C. Cook Nuclear Plant Units 1 and 2 Safety Monitor Shutdown Risk Model Development,” American Electric Power Service Corporation, Revision 0.
27. Letter from E. E. Fitzpatrick, I&M, to U. S. Nuclear Regulatory Commission Document Control Desk, “Donald C. Cook Nuclear Plant Units 1 and 2 Individual Plant Examination Submittal Response to Generic Letter 88-20,” AEP:NRC:1082E, dated May 1, 1992; and Letter from J. F. Stang, NRC, to J. R. Sampson, I&M, “Donald C. Cook Nuclear Plant Units 1 and 2 Review of Individual Plant Examination of External Events (TAC Nos. M83609 and M83610),” dated August 5, 1998.
28. CNP Equipment Reliability Steering Committee Top Ten Issues, American Electric Power Service Corporation, 2003.

Table F.4-1. Initial List of Candidate Improvements for the CNP SAMA Analysis. (Continued)

- Criterion A - Not applicable: The SAMA is not applicable at CNP, either because the enhancement is only for BWRs, the Westinghouse AP600 design, or it is a plant specific enhancement that does not apply at CNP.
- Criterion B - Implemented or intent met: The SAMA has already been implemented at CNP or the CNP design meets the intent of the SAMA.
- Criterion C - Too Costly: Either too costly or only feasible for a plant in the design phase.
- Criterion N - Not initially screened

Table F.4-2. Summary of CNP SAMA Candidates Considered in Cost-Benefit Analysis.

SAMA Number	Potential Improvement	Discussion	Percent Reduction in CDF (Bounding)	Percent Reduction in Offsite Person-Rem (Bounding)	Total Benefit (Bounding)	Estimated Cost	Conclusion	Basis for Conclusion
5	Provide hardware connections to allow ESW (SW) to cool charging pump seals.	Reduces effect of loss of CCW by providing a means to maintain the charging pump seal injection after a loss of CCW. Note, at Watts Bar Nuclear Plant, this capability was already there for one charging pump at one unit, and the potential enhancement identified was to make it possible for all the charging pumps.	32.3	15.5	<$603,793	$866,000	Potentially Cost-Beneficial	Estimated cost is greater than bounding total benefit but less than twice the benefit.
9	Increase charging pump lube oil capacity.	Increases time before charging pump failure due to lube oil overheating in loss of CCW sequences.	32.3	15.5	<$603,793	$866,000	Potentially Cost-Beneficial	Estimated cost is greater than bounding total benefit but less than twice the benefit.
10	Eliminate RCP thermal barrier dependence on CCW, such that loss of CCW does not result directly in core damage.	Prevents loss of RCP seal integrity after a loss of CCW. Watts Bar Nuclear Plant IPE identified that an ERCW connection to charging pump seals could be used.	38.0	19.8	<$738,120	$766,000	Potentially Cost-Beneficial	Estimated cost is greater than bounding total benefit but less than twice the benefit.
12	Create an independent RCP seal injection system, with dedicated diesel.	Adds redundancy to RCP seal cooling alternatives, potentially reducing CDF from loss of CCW, loss of SW, or SBO.	60.5	49.2	<$1,463,388	$2,000,000	Potentially Cost-Beneficial	Estimated cost is greater than bounding total benefit but less than twice the benefit.
13	Create an independent RCP seal injection system, without dedicated diesel.	Adds redundancy to RCP seal cooling alternatives, potentially reducing CDF from loss of CCW, loss of SW, or SBO.	27.7	13.4	<$518,195	$1,000,000	Potentially Cost-Beneficial	Estimated cost is greater than bounding total benefit but less than twice the benefit.
17	Add a third CCW pump.	Reduces probability of loss of CCW leading to RCP seal LOCA.	4.2	2.6	<$87,880	>2 x Benefit	Screen out	Cost of implementation would exceed benefit.

Table F.4-2. Summary of CNP SAMA Candidates Considered in Cost-Benefit Analysis. (Continued)

SAMA Number	Potential Improvement	Discussion	Percent Reduction in CDF (Bounding)	Percent Reduction in Offsite Person-Rem (Bounding)	Total Benefit (Bounding)	Estimated Cost	Conclusion	Basis for Conclusion
24	Improve ability to cool RHR heat exchangers.	Reduces probability of loss of decay heat removal. Options considered include performing procedure and hardware modification to allow manual alignment of fire protection system to the CCW system.	0.2	0.6	<$11,437	>2 x Benefit	Screen out	Cost of implementation would exceed benefit.
25	Stage backup fans in switchgear rooms.	Provides alternate ventilation in the event of a loss of switchgear ventilation, preventing potential failure of switchgear from loss of cooling.	1.0	0.9	<$26,581	$40,000	Potentially Cost-Beneficial	Estimated cost is greater than bounding total benefit but less than twice the benefit.
26	Provide redundant train of ventilation to 480V board room.	Potentially improves reliability of 480V HVAC. At Watts Bar Nuclear Plant, only one train of HVAC cools the 480V board room that contains the unit vital inverters, and recovery actions are heavily relied on.	1.0	0.9	<$26,581	$40,000	Potentially Cost-Beneficial	Estimated cost is greater than bounding total benefit but less than twice the benefit.
27	Implement procedures for temporary HVAC.	Provides for improved credit to be taken for loss of HVAC sequences. Items evaluated include backup ventilation for the EDG rooms (See SAMA Number 28) and switchgear rooms (See SAMA Numbers 25 and 26).	1.0-11.0	0.9-11.9	<$26,581 to <$315,689	$40,000 to $252,000	Potentially Cost-Beneficial	Options considered that are potentially cost-beneficial include SAMA Numbers 25, 26, and 28.
28	Provide backup ventilation for the EDG rooms, should their normal HVAC supply fail.	Provides enhanced ventilation for EDG rooms.	11.0	11.9	<$315,689	$252,000	Potentially Cost-Beneficial	Estimated cost is less than bounding total benefit.

Table F.4-2. Summary of CNP SAMA Candidates Considered in Cost-Benefit Analysis. (Continued)

SAMA Number	Potential Improvement	Discussion	Percent Reduction in CDF (Bounding)	Percent Reduction in Offsite Person-Rem (Bounding)	Total Benefit (Bounding)	Estimated Cost	Conclusion	Basis for Conclusion
33	Install an independent method of suppression pool cooling.	Potentially decreases frequency of loss of containment heat removal.	0.2	0.6	<$11,437	>2 x Benefit	Screen out	Cost of implementation would exceed benefit.
34	Develop an enhanced drywell spray system.	Provides a redundant source of water to containment to control containment pressure, when used in conjunction with containment heat removal.	0.0	0.0	Negligible	>2 x Benefit	Screen out	Cost of implementation would exceed benefit.
35	Provide a dedicated existing drywell spray system.	Identical to the previous concept, except that one of the existing spray loops would be used instead of developing a new spray system.	0.0	0.0	Negligible	>2 x Benefit	Screen out	Cost of implementation would exceed benefit.
39	Create/enhance hydrogen igniters with independent power supply. (GSI-189)	Reduces hydrogen detonation at lower cost. Use a new, independent power supply, a non-safety grade portable generator, existing station batteries, or existing AC/DC independent power supplies such as the security system diesel generator to provide power to the hydrogen igniters.	0.0	7.5	<$130,864	$147,000	Potentially Cost-Beneficial	Estimated cost is greater than bounding total benefit but less than twice the benefit.
40	Create a passive hydrogen ignition system.	Reduces hydrogen detonation potential without requiring electric power.	0.0	7.5	<$130,864	$147,000	Potentially Cost-Beneficial	Estimated cost is greater than bounding total benefit but less than twice the benefit.

Table F.4-2. Summary of CNP SAMA Candidates Considered in Cost-Benefit Analysis. (Continued)

SAMA Number	Potential Improvement	Discussion	Percent Reduction in CDF (Bounding)	Percent Reduction in Offsite Person-Rem (Bounding)	Total Benefit (Bounding)	Estimated Cost	Conclusion	Basis for Conclusion
41	The action to turn on hydrogen igniters fails frequently due to the time needed to remotely turn off the ice condenser air handling units, as committed to during the original installation of the hydrogen igniter system. This commitment will be investigated and removed if justifiable.	Turning on the hydrogen igniters sooner would reduce containment failure probability for some sequences.	0.4	0.4	<$9,923	>2 x Benefit	Screen out	Cost of implementation would exceed benefit.
49	Create other options for reactor cavity flooding (Part b).	(b) Flood cavity via systems such as diesel-driven fire pumps.	0.0	47.5 (Estimated)	<$765,463	>2 x Benefit	Screen out	Implementation of this SAMA would not reduce CDF, but would only reduce offsite exposure for sequences where the ECCS or CTS did not already flood the cavity. Therefore, the bounding benefit was estimated by assuming the cavity is flooded for all accident sequences that normally consider a dry cavity. Cost of implementation would exceed benefit.
53	Use firewater spray pump for CTS.	Provides for redundant CTS method without high cost.	0.0	0.0	Negligible	>2 x Benefit	Screen out	Cost of implementation would exceed benefit.
67	Improve bus cross-tie ability between a unit's emergency buses.	Improves AC power reliability.	2.1	4.0	<$87,368	$100,000	Potentially Cost-Beneficial	Estimated cost is greater than bounding total benefit but less than twice the benefit.

Table F.4-2. Summary of CNP SAMA Candidates Considered in Cost-Benefit Analysis. (Continued)

SAMA Number	Potential Improvement	Discussion	Percent Reduction in CDF (Bounding)	Percent Reduction in Offsite Person-Rem (Bounding)	Total Benefit (Bounding)	Estimated Cost	Conclusion	Basis for Conclusion
68	Provide alternate battery charging capability.	Improves DC power reliability. Options to consider include installation of a cross-tie between AC buses, or installation of a portable diesel-driven battery charger.	1.5	2.7	<$59,865	>2 x Benefit	Screen out	Cost of implementation would exceed benefit.
72	Create a cross-unit tie for EDG fuel oil.	For multi-unit sites, adds EDG fuel oil redundancy.	0.0	0.0	Negligible	N/A	Screen out	The EDG failure data from the CNP PRA models were reviewed and no failures of the fuel oil transfer pumps were identified. Implementation of this SAMA would not affect the likelihood of any failure mode failure that has been observed over a significant portion of CNP operation. Therefore, the benefit of implementing this SAMA is judged to be insignificant and no further analysis performed.
73	Develop procedures to repair or change out failed 4KV breakers.	Offers a recovery path from a failure of breakers that perform transfer of 4.16KV non-emergency buses from unit station service transformers to system station service transformers, leading to loss of emergency AC power (i.e., in conjunction with failures of the EDGs).	0.7	2.0	<$20,423	>2 x Benefit	Screen out	Cost of implementation would exceed benefit.
79	Create a lake water backup for EDG cooling.	Provides redundant source of EDG cooling.	1.1	1.9	<$42,811	>2 x Benefit	Screen out	Cost of implementation would exceed benefit.
80	Use firewater as a backup for EDG cooling.	Provides redundancy in EDG support systems.	1.1	1.9	<$42,811	>2 x Benefit	Screen out	Cost of implementation would exceed benefit.

Table F.4-2. Summary of CNP SAMA Candidates Considered in Cost-Benefit Analysis. (Continued)

SAMA Number	Potential Improvement	Discussion	Percent Reduction in CDF (Bounding)	Percent Reduction in Offsite Person-Rem (Bounding)	Total Benefit (Bounding)	Estimated Cost	Conclusion	Basis for Conclusion
84	Develop procedures for use of pressurizer vent valves during SGTR sequences.	Calvert Cliffs Nuclear Power Plant procedures direct the use of pressurizer sprays to reduce RCS pressure after a SGTR. Use of the vent valves provides a backup method.	0.4	0.9	<$19,022	>2 x Benefit	Screen out	Cost of implementation would exceed benefit.
85	Install a redundant spray system to depressurize the primary system during a SGTR.	Enhances depressurization ability during SGTR.	0.4	0.9	<$19,022	>2 x Benefit	Screen out	Cost of implementation would exceed benefit.
94	Install self-actuating CIVs.	For plants that don't have this, it potentially reduces the frequency of isolation failure.	0.0	0.0	Negligible	>2 x Benefit	Screen out	Cost of implementation would exceed benefit.
95	Install additional instrumentation for ISLOCA sequences.	Pressure or leak monitoring instruments installed between the first two pressure isolation valves on low-pressure injection lines, RHR suction lines, and HPSI lines potentially decreases ISLOCA frequency.	0.6	5.8	<$95,885	>2 x Benefit	Screen out	Cost of implementation would exceed benefit.
96	Increase frequency of valve leak testing.	Potentially decreases ISLOCA frequency.	0.6	5.8	<$95,885	>2 x Benefit	Screen out	Cost of implementation would exceed benefit.
100	Revise EOPs to improve ISLOCA identification.	Salem had a scenario in which an RHR ISLOCA could direct initial leakage back to the PRT, giving indication that the LOCA was inside containment. Procedure enhancement would ensure LOCA outside containment would be observed.	0.0	0.0	<$1,054	>2 x Benefit	Screen out	Cost of implementation would exceed benefit.

Table F.4-2. Summary of CNP SAMA Candidates Considered in Cost-Benefit Analysis. (Continued)

SAMA Number	Potential Improvement	Discussion	Percent Reduction in CDF (Bounding)	Percent Reduction in Offsite Person-Rem (Bounding)	Total Benefit (Bounding)	Estimated Cost	Conclusion	Basis for Conclusion
101	Revise ISLOCA procedure to specifically address the ISLOCA sequence with the frequency that was dominant in Rev. 1 of the PRA.	Potentially reduces ISLOCA CDF.	0.4	5.7	<$92,599	$30,000	Potentially Cost-Beneficial	Estimated cost is less than bounding total benefit.
103	Add redundant and diverse limit switch to each CIV.	Enhanced isolation valve position indication, which potentially reduces frequency of containment isolation failure and ISLOCAs.	0.0	0.0	Negligible	>2 x Benefit	Screen out	Cost of implementation would exceed benefit.
108	Implement a digital FW upgrade.	Could reduce the frequency of trips caused by feedwater transients.	4.9	2.9	<$100,022	>2 x Benefit	Screen out	Cost of implementation would exceed benefit.
115	Provide portable generators to be hooked in to the turbine-driven AFW, after battery depletion.	Extends AFW availability in a SBO (assuming the turbine-driven AFW requires DC power).	1.5	2.7	<$59,865	>2 x Benefit	Screen out	Cost of implementation would exceed benefit.
117	Create ability for emergency connections of existing or alternate coolant inventory.	Provides a backup water supply for the coolant makeup systems.	0.2-0.6	0.6-0.7	<$11,437 to <$17,370	>2 x Benefit	Screen out	Options considered for this SAMA include SAMA Numbers 24, 33 and 123. Cost of implementation of each of these bounding cases would exceed benefit.
123	Provide capability for diesel-driven, low pressure vessel makeup.	Provides extra water source in sequences in which the reactor is depressurized and all other injection is unavailable (e.g., firewater).	0.6	0.7	<$17,370	>2 x Benefit	Screen out	Cost of implementation would exceed benefit.

Table F.4-2. Summary of CNP SAMA Candidates Considered in Cost-Benefit Analysis. (Continued)

SAMA Number	Potential Improvement	Discussion	Percent Reduction in CDF (Bounding)	Percent Reduction in Offsite Person-Rem (Bounding)	Total Benefit (Bounding)	Estimated Cost	Conclusion	Basis for Conclusion
124	Provide an additional HPSI pump with independent diesel.	Reduces frequency of core melt from small LOCA sequences, and from SBO sequences.	13.0	9.7	<$299,185	>2 x Benefit	Screen out	Cost of implementation would exceed benefit.
125	Install independent AC HPSI system.	Allows make up and feed and bleed capabilities during an SBO.	13.0	9.7	<$299,185	>2 x Benefit	Screen out	Cost of implementation would exceed benefit.
126	Prevent overpressurization of RHR piping by SI system.	Failure of check valve SI-151W fails HPI. A redundant path, parallel to the check valve, would improve reliability.	0.0	0.0	Negligible	N/A	Screen out	Through consideration of multiple factors not previously evaluated by the CNP PRA model, failure of SI-151E and SI-151W as important contributors to CDF can be eliminated. Therefore, it is concluded that implementation of this SAMA would result in an insignificant benefit and no further evaluation is performed.
127	Create the ability to manually align ECCS recirculation.	Provides a backup should automatic or remote operation fail.	1.5	1.4	<$39,169	>2 x Benefit	Screen out	Cost of implementation would exceed benefit.
134	Replace two of the four safety injection pumps with diesel-driven pumps.	Intended for Combustion Engineering System 80+ PWR, which has four trains of SI. This reduces common cause failure probability.	13.0	9.7	<$299,185	>2 x Benefit	Screen out	Cost of implementation would exceed benefit.
139	Create automatic swapover to implement low pressure pump to HPSI pump piggyback operation during recirculation following RWST depletion.	Removes human error contribution from recirculation failure.	2.7	11.8	<$220,769	>2 x Benefit	Screen out	Cost of implementation would exceed benefit.

Table F.4-2. Summary of CNP SAMA Candidates Considered in Cost-Benefit Analysis. (Continued)

SAMA Number	Potential Improvement	Discussion	Percent Reduction in CDF (Bounding)	Percent Reduction in Offsite Person-Rem (Bounding)	Total Benefit (Bounding)	Estimated Cost	Conclusion	Basis for Conclusion
141	Replace old air compressors with more reliable ones.	Improves reliability and increases availability of instrument air compressors.	1.4	0.9	<$28,591	>2 x Benefit	Screen out	Cost of implementation would exceed benefit.
144	Install MG set trip breakers in control room.	Allows the operator to trip the MG sets from the control room. Currently, at Watts Bar Nuclear Plant, an ATWS would require an immediate operator action outside the control room to trip the MG sets. Potentially reduces ATWS CDF.	1.0	0.2	<$15,130	>2 x Benefit	Screen out	Cost of implementation would exceed benefit.
145	Add capability to remove power from the bus powering the control rods.	Decreases time to insert control rods if the reactor trip breakers fail (during a loss of FW ATWS which has rapid pressure excursion).	1.0	0.2	<$15,130	>2 x Benefit	Screen out	Cost of implementation would exceed benefit.
149	Install a system of relief valves that prevents any equipment damage from a pressure spike during an ATWS.	Improves equipment availability after an ATWS.	11.7	12.2	<$315,931	>2 x Benefit	Screen out	Cost of implementation would exceed benefit.
153	Create/enhance RCS depressurization ability.	Implement with a new depressurization system, or with existing PORVs, head vents and secondary side valve. RCS depressurization would allow low pressure ECCS injection. Even if core damage occurs, low RCS pressure alleviates some concerns about high pressure melt ejection.	11.7	12.2	<$315,931	>2 x Benefit	Screen out	Cost of implementation would exceed benefit.

Table F.4-2. Summary of CNP SAMA Candidates Considered in Cost-Benefit Analysis. (Continued)

SAMA Number	Potential Improvement	Discussion	Percent Reduction in CDF (Bounding)	Percent Reduction in Offsite Person-Rem (Bounding)	Total Benefit (Bounding)	Estimated Cost	Conclusion	Basis for Conclusion
154	Make procedural changes only for the RCS depressurization option.	Reduces RCS pressure to allow low pressure ECCS injection without cost of a new system.	11.7	12.2	<$315,931	>2 x Benefit	Screen out	Cost of implementation would exceed benefit.
157	Install secondary side guard pipes up to the MSIVs.	Potentially prevents secondary side depressurization should a steam line break occur upstream of the MSIVs. Also guards against or prevents consequential multiple SGTR following a main steam line break event.	2.2	4.0	<$86,844	>2 x Benefit	Screen out	Cost of implementation would exceed benefit.
160	Provide self-cooled ECCS seals.	ECCS pump seals are CCW cooled. Self-cooled seals would remove this dependency.	33.1	16.3	<$624,947	$866,000	Potentially Cost-Beneficial	Estimated cost is greater than bounding total benefit but less than twice the benefit.
162	Make CCW trains separate.	Current cross-tie capability creates a potential common mode failure mechanism for both trains (and both stations).	0.0	0.0	<$0	N/A	Screen out	The resulting benefit of this SAMA is negative. Therefore, no further evaluation of this SAMA was performed.
163	Make ICW trains separate.	Current cross-tie capability creates a potential common mode failure mechanism for both trains (and both stations).	0.0	0.0	<$0	N/A	Screen out	The resulting benefit of this SAMA is negative. Therefore, no further evaluation of this SAMA was performed.
166	Provide containment isolation design per GDC and SRP.	Potentially enhances containment isolation capability.	0.0	0.0	Negligible	>2 x Benefit	Screen out	Cost of implementation would exceed benefit.
167	Improve RHR sump reliability.	Reduces potential for common mode failure of RHR due to debris in sump.	0.3	0.5	<$11,802	>2 x Benefit	Screen out	Cost of implementation would exceed benefit.
168	Provide auxiliary building vent/seal structure.	Enhances ventilation in auxiliary building.	0.6	5.8	<$95,885	>2 x Benefit	Screen out	Cost of implementation would exceed benefit.

Table F.4-2. Summary of CNP SAMA Candidates Considered in Cost-Benefit Analysis. (Continued)

SAMA Number	Potential Improvement	Discussion	Percent Reduction in CDF (Bounding)	Percent Reduction in Offsite Person-Rem (Bounding)	Total Benefit (Bounding)	Estimated Cost	Conclusion	Basis for Conclusion
169	Add charcoal filters on auxiliary building exhaust.	Enhances fission product removal after ISLOCA.	0.6	5.8	<$95,885	>2 x Benefit	Screen out	Cost of implementation would exceed benefit.
170	Add penetration valve leakage control system.	Enhances capability to detect/control leakage from penetration valves.	0.0	0.0	Negligible	>2 x Benefit	Screen out	Cost of implementation would exceed benefit.
171	Enhance screen wash.	Reduces potential for loss of ICW due to clogging of lake water screens.	11.1	6.2	<$221,837	>2 x Benefit	Screen out	Cost of implementation would exceed benefit.
172	Enhance training for important operator actions.	The Fussell-Vesely importance list was reviewed to identify any significant human errors. Those with a F-V importance of 5E-03 or greater were evaluated.	0.1-4.8	0.0-2.5	<$919 to <$92,599	$10,000 to $220,000	Potentially Cost-Beneficial	27 operator actions were evaluated using 15 different cases, with 10 cases either bounded by other SAMA candidates or determined to have negligible benefits. The remaining 5 cases were further evaluated. 4 of these cases were found to not be cost-beneficial. However, item 27 was found to be potentially cost-beneficial, with a bounding benefit of $92,599 and an estimated cost of implementation of $30,000. Item 27 is the same as the alternative described in SAMA Number 101.
177	Add protection to prevent tornado damage to RWST and penetration rooms.	Penetration rooms are tornado protected. Tornado category F2 and higher can generate heavy enough missiles that they could impact and damage the RWST.	0.0	0.0	Negligible	N/A	Screen out	The CNP IPEEE shows that tornado-induced core damage is an insignificant contributor to CDF. Therefore, any changes to eliminate or reduce their importance would provide an insignificant benefit and no further evaluation of this SAMA was performed.

Table F.4-2. Summary of CNP SAMA Candidates Considered in Cost-Benefit Analysis. (Continued)

SAMA Number	Potential Improvement	Discussion	Percent Reduction in CDF (Bounding)	Percent Reduction in Offsite Person-Rem (Bounding)	Total Benefit (Bounding)	Estimated Cost	Conclusion	Basis for Conclusion
179	Add protection to prevent tornado damage causing failure of power and upper surge tanks.	Consider tornado protection for tanks or switchgear in turbine building. Surge tanks are suction source for emergency FW pumps.	0.0	0.0	Negligible	N/A	Screen out	The CNP IPEEE shows that tornado-induced core damage is an insignificant contributor to CDF. Therefore, any changes to eliminate or reduce their importance would provide an insignificant benefit and no further evaluation of this SAMA was performed.
184	Provide a means to ensure RCP seal cooling so that RCP seal LOCAs are precluded for SBO events.	Options to consider include using the CVCS cross-tie, installation of a new, independently powered pump, or a temporary connection to provide cooling to RCP thermal barriers. Such a strategy would also benefit loss of ESW and loss of CCW events. This item is related to SAMA Numbers 5, 9, 10, 12, 13, 17, 124, 125, 134 and 160.	27.7-60.5	13.4-49.2	<$518,195 to <$1,463,388	$766,000 to $2,000,000	Potentially Cost-Beneficial	Options considered that are potentially cost-beneficial include SAMA Numbers 5, 9, 10, 12, 13 and 160. For each of these options, estimated cost is greater than bounding total benefit but less than twice the benefit.
185	Improve EDG reliability.	Minimizes the probability of a SBO event given a LOSP.	17.5	18.9	<$500,300	>2 x Benefit	Screen out	Cost of implementation would exceed benefit.
186	Improve circulating water screens and debris removal.	Minimizes the chance of clogging heat exchangers and condensers and initiating transient events. This item is similar to SAMA Number 171.	11.1	6.2	<$221,837	>2 x Benefit	Screen out	Cost of implementation would exceed benefit.

Table F.4-2. Summary of CNP SAMA Candidates Considered in Cost-Benefit Analysis. (Continued)

SAMA Number	Potential Improvement	Discussion	Percent Reduction in CDF (Bounding)	Percent Reduction in Offsite Person-Rem (Bounding)	Total Benefit (Bounding)	Estimated Cost	Conclusion	Basis for Conclusion
187	Improve reliability of power supplies.	Reduces reactor trip frequency. This item is similar to SAMA Number 108.	4.9	2.9	<$100,022	>2 x Benefit	Screen out	The benefit of this SAMA (reduction of reactor trip frequency) would be bounded by the analysis performed for SAMA Number 108. Since the benefit calculated for SAMA Number 108 is small compared to the potential cost of implementation for this SAMA, no further evaluation was performed.
188	Improve switchyard and transformer reliability.	This initiative is to reduce human errors in the switchyard and alarms on plant transformers. This initiative potentially lowers the frequency of transient events initiated by the electrical system.	4.9	2.9	<$100,022	>2 x Benefit	Screen out	The benefit of this SAMA (reduction of reactor trip frequency) would be bounded by the analysis performed for SAMA Number 108. Since the benefit calculated for SAMA Number 108 is small compared to the potential cost of implementation for this SAMA, no further evaluation was performed.
189	Reduce biofouling of raw water systems.	Improves control of zebra mussels. This item is similar to SAMA Number 171.	11.1	6.2	<$221,837	>2 x Benefit	Screen out	Cost of implementation would exceed benefit.
190	Improve reliability of main feedwater pumps.	Potentially reduces transient initiating event frequency.	4.9	2.9	<$100,022	>2 x Benefit	Screen out	The benefit of this SAMA (reduction of reactor trip frequency) would be bounded by the analysis performed for SAMA Number 108. Since the benefit calculated for SAMA Number 108 is small compared to the potential cost of implementation for this SAMA, no further evaluation was performed.

Table F.4-2. Summary of CNP SAMA Candidates Considered in Cost-Benefit Analysis. (Continued)

SAMA Number	Potential Improvement	Discussion	Percent Reduction in CDF (Bounding)	Percent Reduction in Offsite Person-Rem (Bounding)	Total Benefit (Bounding)	Estimated Cost	Conclusion	Basis for Conclusion
191	Establish a preventive maintenance program for expansion joints, bellows, and boots.	Potentially reduces flooding initiating event frequency and the failure probability of plant components.	0.0	0.0	Negligible	N/A	Screen out	Internal flooding events are not currently identified as significant contributors to core damage. Therefore, it is concluded that implementation of this SAMA would result in a negligible benefit, and no further evaluation was performed.
192	Improve reliability of AFW pumps and valves.	Potentially reduces occurrence of loss of secondary heat sink.	0.0	0.0	Negligible	N/A	Screen out	As evidenced by the basic event importance analysis, failure of the AFW system is not an important contributor to overall CDF. Five trains of AFW must fail to cause loss of secondary heat sink. Therefore, implementation of this SAMA is expected to result in negligible benefit, and no further evaluation was performed.
193	Eliminate MSIV vulnerabilities.	Reduces the chance that MSIVs will drift off their open seat during low-power operations.	0.0	0.0	Negligible	N/A	Screen out	The CNP PRA models only one function for the MSIVs, closure after a secondary line break. Since the intent of this SAMA is to improve the reliability of the MSIVs to stay open, there would be no impact on the function modeled in the PRA. Therefore, implementation of this SAMA is expected to result in negligible benefit and no further evaluation was performed.

Table F.6-1. Sensitivity Analysis Results.

SAMA Number	Potential Improvement	Total Benefit (Bounding)	Estimated Cost	Conclusion	Benefit (3 percent Discount Rate Sensitivity) (Bounding)	Basis for Conclusion
5	Provide hardware connections to allow ESW (SW) to cool charging pump seals.	<$603,793	$866,000	Potentially Cost-Beneficial	<$986,213	Estimated cost is greater than bounding total benefit but less than twice the benefit.
9	Increase charging pump lube oil capacity.	<$603,793	$866,000	Potentially Cost-Beneficial	<$986,213	Estimated cost is greater than bounding total benefit but less than twice the benefit.
10	Eliminate RCP thermal barrier dependence on CCW, such that loss of CCW does not result directly in core damage.	<$738,120	$766,000	Potentially Cost-Beneficial	<$1,198,859	Estimated cost is greater than bounding total benefit but less than twice the benefit.
12	Create an independent RCP seal injection system, with dedicated diesel.	<$1,463,388	$2,000,000	Potentially Cost-Beneficial	<$2,311,563	Estimated cost is greater than bounding total benefit but less than twice the benefit.
13	Create an independent RCP seal injection system, without dedicated diesel.	<$518,195	$1,000,000	Potentially Cost-Beneficial	<$846,081	Estimated cost is greater than bounding total benefit but less than twice the benefit.
17	Add a third CCW pump.	<$87,880	>2 x Benefit	Screen out	<$141,110	Cost of implementation would exceed benefit.
24	Improve ability to cool RHR heat exchangers.	<$11,437	>2 x Benefit	Screen out	<$16,866	Cost of implementation would exceed benefit.
25	Stage backup fans in switchgear rooms.	<$26,581	$40,000	Potentially Cost-Beneficial	<$41,566	Estimated cost is greater than bounding total benefit but less than twice the benefit.
26	Provide redundant train of ventilation to 480V board room.	<$26,581	$40,000	Potentially Cost-Beneficial	<$41,566	Estimated cost is greater than bounding total benefit but less than twice the benefit.
27	Implement procedures for temporary HVAC.	<$26,581 to <$315,689	$40,000 to $252,000	Potentially Cost-Beneficial	<$41,566 to <$489,515	Options considered that are potentially cost-beneficial include SAMA Numbers 25 and 28.
28	Provide backup ventilation for the EDG rooms, should their normal HVAC supply fail.	<$315,689	$252,000	Potentially Cost-Beneficial	<$489,515	Estimated cost is less than bounding total benefit.
33	Install an independent method of suppression pool cooling.	<$11,437	>2 x Benefit	Screen out	<$16,866	Cost of implementation would exceed benefit.
34	Develop an enhanced drywell spray system.	Negligible	>2 x Benefit	Screen out	Negligible	Cost of implementation would exceed benefit.

Table F.6-1. Sensitivity Analysis Results. (Continued)

SAMA Number	Potential Improvement	Total Benefit (Bounding)	Estimated Cost	Conclusion	Benefit (3 percent Discount Rate Sensitivity) (Bounding)	Basis for Conclusion
35	Provide a dedicated existing drywell spray system.	Negligible	>2 x Benefit	Screen out	Negligible	Cost of implementation would exceed benefit.
39	Create/enhance hydrogen igniters with independent power supply. (GSI-189)	<$130,864	$147,000	Potentially Cost-Beneficial	<$182,863	Estimated cost is greater than bounding total benefit but less than twice the benefit.
40	Create a passive hydrogen ignition system.	<$130,864	$147,000	Potentially Cost-Beneficial	<$182,863	Estimated cost is greater than bounding total benefit but less than twice the benefit.
41	The action to turn on hydrogen igniters fails frequently due to the time needed to remotely turn off the ice condenser air handling units, as committed to during the original installation of the hydrogen igniter system. This commitment will be investigated and removed if justifiable.	<$9,923	>2 x Benefit	Screen out	<$15,546	Cost of implementation would exceed benefit.
49	Create other options for reactor cavity flooding (Part b).	<$765,463	>2 x Benefit	Screen out	<$1,069,604	Implementation of this SAMA would not reduce CDF, but would only reduce offsite exposure for sequences where the ECCS or CTS did not already flood the cavity. Therefore, the bounding benefit was estimated by assuming the cavity is flooded for all accident sequences that normally consider a dry cavity. Cost of implementation would exceed benefit.
53	Use firewater spray pump for CTS.	Negligible	>2 x Benefit	Screen out	Negligible	Cost of implementation would exceed benefit.
67	Improve bus cross-tie ability between a unit's emergency buses.	<$87,368	$100,000	Potentially Cost-Beneficial	<$131,283	Estimated cost is greater than bounding total benefit but less than twice the benefit.
68	Provide alternate battery charging capability.	<$59,865	>2 x Benefit	Screen out	<$90,375	Cost of implementation would exceed benefit.

Table F.6-1. Sensitivity Analysis Results. (Continued)

SAMA Number	Potential Improvement	Total Benefit (Bounding)	Estimated Cost	Conclusion	Benefit (3 percent Discount Rate Sensitivity) (Bounding)	Basis for Conclusion
72	Create a cross-unit tie for EDG fuel oil.	Negligible	N/A	Screen out	Negligible	The EDG failure data from the CNP PRA models were reviewed and no failures of the fuel oil transfer pumps were identified. Implementation of this SAMA would not affect the likelihood of any failure mode failure that has been observed over a significant portion of CNP operation. Therefore, the benefit of implementing this SAMA is judged to be insignificant and no further analysis performed.
73	Develop procedures to repair or change out failed 4KV breakers.	<$20,423	>2 x Benefit	Screen out	<$30,087	Cost of implementation would exceed benefit.
79	Create a lake water backup for EDG cooling.	<$42,811	>2 x Benefit	Screen out	<$64,864	Cost of implementation would exceed benefit.
80	Use firewater as a backup for EDG cooling.	<$42,811	>2 x Benefit	Screen out	<$64,864	Cost of implementation would exceed benefit.
84	Develop procedures for use of pressurizer vent valves during SGTR sequences.	<$19,022	>2 x Benefit	Screen out	<$28,439	Cost of implementation would exceed benefit.
85	Install a redundant spray system to depressurize the primary system during a SGTR.	<$19,022	>2 x Benefit	Screen out	<$28,439	Cost of implementation would exceed benefit.
94	Install self-actuating CIVs.	Negligible	>2 x Benefit	Screen out	Negligible	Cost of implementation would exceed benefit.
95	Install additional instrumentation for ISLOCA sequences.	<$95,885	>2 x Benefit	Screen out	<$136,640	Cost of implementation would exceed benefit.
96	Increase frequency of valve leak testing.	<$95,885	>2 x Benefit	Screen out	<$136,640	Cost of implementation would exceed benefit.
100	Revise EOPs to improve ISLOCA identification.	<$1,054	>2 x Benefit	Screen out	<$1,473	Cost of implementation would exceed benefit.
101	Revise ISLOCA procedure to specifically address the ISLOCA sequence with the frequency that was dominant in Rev. 1 of the PRA.	<$92,599	$30,000	Potentially Cost-Beneficial	<$131,339	Estimated cost is less than bounding total benefit.

Table F.6-1. Sensitivity Analysis Results. (Continued)

SAMA Number	Potential Improvement	Total Benefit (Bounding)	Estimated Cost	Conclusion	Benefit (3 percent Discount Rate Sensitivity) (Bounding)	Basis for Conclusion
103	Add redundant and diverse limit switch to each CIV.	Negligible	>2 x Benefit	Screen out	Negligible	Cost of implementation would exceed benefit.
108	Implement a digital FW upgrade.	<$100,022	>2 x Benefit	Screen out	<$161,260	Cost of implementation would exceed benefit.
115	Provide portable generators to be hooked in to the turbine-driven AFW, after battery depletion.	<$59,865	>2 x Benefit	Screen out	<$90,375	Cost of implementation would exceed benefit.
117	Create ability for emergency connections of existing or alternate coolant inventory.	<$11,437 to <$17,370	>2 x Benefit	Screen out	<$16,866 to <$27,102	Options considered for this SAMA include SAMA Numbers 24, 33 and 123. Cost of implementation of each of these bounding cases would exceed benefit.
123	Provide capability for diesel-driven, low pressure vessel makeup.	<$17,370	>2 x Benefit	Screen out	<$27,102	Cost of implementation would exceed benefit.
124	Provide an additional HPSI pump with independent diesel.	<$299,185	>2 x Benefit	Screen out	<$475,386	Cost of implementation would exceed benefit.
125	Install independent AC HPSI system.	<$299,185	>2 x Benefit	Screen out	<$475,386	Cost of implementation would exceed benefit.
126	Prevent overpressurization of RHR piping by SI system.	Negligible	N/A	Screen out	Negligible	Through consideration of multiple factors not previously evaluated by the CNP PRA model, failure of SI-151E and SI-151W as important contributors to CDF can be eliminated. Therefore, it is concluded that implementation of this SAMA would result in an insignificant benefit and no further evaluation is performed.
127	Create the ability to manually align ECCS recirculation.	<$39,169	>2 x Benefit	Screen out	<$61,278	Cost of implementation would exceed benefit.
134	Replace two of the four safety injection pumps with diesel-driven pumps.	<$299,185	>2 x Benefit	Screen out	<$475,386	Cost of implementation would exceed benefit.
139	Create automatic swapover to implement low pressure pump to HPSI pump piggyback operation during recirculation following RWST depletion.	<$220,769	>2 x Benefit	Screen out	<$320,523	Cost of implementation would exceed benefit.

Table F.6-1. Sensitivity Analysis Results. (Continued)

SAMA Number	Potential Improvement	Total Benefit (Bounding)	Estimated Cost	Conclusion	Benefit (3 percent Discount Rate Sensitivity) (Bounding)	Basis for Conclusion
141	Replace old air compressors with more reliable ones.	<$28,591	>2 x Benefit	Screen out	<$46,054	Cost of implementation would exceed benefit.
144	Install MG set trip breakers in control room.	<$15,130	>2 x Benefit	Screen out	<$25,742	Cost of implementation would exceed benefit.
145	Add capability to remove power from the bus powering the control rods.	<$15,130	>2 x Benefit	Screen out	<$25,742	Cost of implementation would exceed benefit.
149	Install a system of relief valves that prevents any equipment damage from a pressure spike during an ATWS.	<$315,931	>2 x Benefit	Screen out	<$493,037	Cost of implementation would exceed benefit.
153	Create/enhance RCS depressurization ability.	<$315,931	>2 x Benefit	Screen out	<$493,037	Cost of implementation would exceed benefit.
154	Make procedural changes only for the RCS depressurization option.	<$315,931	>2 x Benefit	Screen out	<$493,037	Cost of implementation would exceed benefit.
157	Install secondary side guard pipes up to the MSIVs.	<$86,844	>2 x Benefit	Screen out	<$130,993	Cost of implementation would exceed benefit.
160	Provide self-cooled ECCS seals.	<$624,947	$866,000	Potentially Cost-Beneficial	<$1,019,310	Estimated cost is greater than bounding total benefit but less than twice the benefit.
162	Make CCW trains separate.	<$0	N/A	Screen out	<$0	The resulting benefit of this SAMA is negative. Therefore, no further evaluation of this SAMA was performed.
163	Make ICW trains separate.	<$0	N/A	Screen out	<$0	The resulting benefit of this SAMA is negative. Therefore, no further evaluation of this SAMA was performed.
166	Provide containment isolation design per GDC and SRP.	Negligible	>2 x Benefit	Screen out	Negligible	Cost of implementation would exceed benefit.
167	Improve RHR sump reliability.	<$11,802	>2 x Benefit	Screen out	<$17,731	Cost of implementation would exceed benefit.
168	Provide auxiliary building vent/seal structure.	<$95,885	>2 x Benefit	Screen out	<$136,640	Cost of implementation would exceed benefit.

Table F.6-1. Sensitivity Analysis Results. (Continued)

SAMA Number	Potential Improvement	Total Benefit (Bounding)	Estimated Cost	Conclusion	Benefit (3 percent Discount Rate Sensitivity) (Bounding)	Basis for Conclusion
169	Add charcoal filters on auxiliary building exhaust.	<$95,885	>2 x Benefit	Screen out	<$136,640	Cost of implementation would exceed benefit.
170	Add penetration valve leakage control system.	Negligible	>2 x Benefit	Screen out	Negligible	Cost of implementation would exceed benefit.
171	Enhance screen wash.	<$221,837	>2 x Benefit	Screen out	<$359,342	Cost of implementation would exceed benefit.
172	Enhance training for important operator actions.	<$919 to <$92,599	$10,000 to $220,000	Potentially Cost-Beneficial	<$1,549 to <$145,605	27 operator actions were evaluated using 15 different cases, with 10 cases either bounded by other SAMA candidates or determined to have negligible benefits. The remaining 5 cases were further evaluated. 4 of these cases were found to not be cost-beneficial. However, item 27 was found to be potentially cost-beneficial, with a bounding benefit of $92,599 ($131,339 using 3 percent discount rate) and an estimated cost of implementation of $30,000. Item 27 is the same as the alternative described in SAMA Number 101.
177	Add protection to prevent tornado damage to RWST and penetration rooms.	Negligible	N/A	Screen out	Negligible	The CNP IPEEE shows that tornado-induced core damage is an insignificant contributor to CDF. Therefore, any changes to eliminate or reduce their importance would provide an insignificant benefit and no further evaluation of this SAMA was performed.
179	Add protection to prevent tornado damage causing failure of power and upper surge tanks.	Negligible	N/A	Screen out	Negligible	The CNP IPEEE shows that tornado-induced core damage is an insignificant contributor to CDF. Therefore, any changes to eliminate or reduce their importance would provide an insignificant benefit and no further evaluation of this SAMA was performed.
184	Provide a means to ensure RCP seal cooling so that RCP seal LOCAs are precluded for SBO events.	<$518,195 to <$1,463,388	$766,000 to $2,000,000	Potentially Cost-Beneficial	<$846,081 to <$2,311,563	Options considered that are potentially cost-beneficial include SAMA Numbers 5, 9, 10, 12, 13 and 160. For each of these options, estimated cost is greater than bounding total benefit but less than twice the benefit.

Table F.6-1. Sensitivity Analysis Results. (Continued)

SAMA Number	Potential Improvement	Total Benefit (Bounding)	Estimated Cost	Conclusion	Benefit (3 percent Discount Rate Sensitivity) (Bounding)	Basis for Conclusion
185	Improve EDG reliability.	<$500,300	>2 x Benefit	Screen out	<$776,141	Cost of implementation would exceed benefit.
186	Improve circulating water screens and debris removal.	<$221,837	>2 x Benefit	Screen out	<$359,342	Cost of implementation would exceed benefit.
187	Improve reliability of power supplies.	<$100,022	>2 x Benefit	Screen out	<$161,260	The benefit of this SAMA (reduction of reactor trip frequency) would be bounded by the analysis performed for SAMA Number 108. Since the benefit calculated for SAMA Number 108 is small compared to the potential cost of implementation for this SAMA, no further evaluation was performed.
188	Improve switchyard and transformer reliability.	<$100,022	>2 x Benefit	Screen out	<$161,260	The benefit of this SAMA (reduction of reactor trip frequency) would be bounded by the analysis performed for SAMA Number 108. Since the benefit calculated for SAMA Number 108 is small compared to the potential cost of implementation for this SAMA, no further evaluation was performed.
189	Reduce biofouling of raw water systems.	<$221,837	>2 x Benefit	Screen out	<$359,342	Cost of implementation would exceed benefit.
190	Improve reliability of main feedwater pumps.	<$100,022	>2 x Benefit	Screen out	<$161,260	The benefit of this SAMA (reduction of reactor trip frequency) would be bounded by the analysis performed for SAMA Number 108. Since the benefit calculated for SAMA Number 108 is small compared to the potential cost of implementation for this SAMA, no further evaluation was performed.
191	Establish a preventive maintenance program for expansion joints, bellows, and boots.	Negligible	N/A	Screen out	Negligible	Internal flooding events are not currently identified as significant contributors to core damage. Therefore, it is concluded that implementation of this SAMA would result in a negligible benefit, and no further evaluation was performed.

Table F.6-1. Sensitivity Analysis Results. (Continued)

SAMA Number	Potential Improvement	Total Benefit (Bounding)	Estimated Cost	Conclusion	Benefit (3 percent Discount Rate Sensitivity) (Bounding)	Basis for Conclusion
192	Improve reliability of AFW pumps and valves.	Negligible	N/A	Screen out	Negligible	As evidenced by the basic event importance analysis, failure of the AFW system is not an important contributor to overall CDF. Five trains of AFW must fail to cause loss of secondary heat sink. Therefore, implementation of this SAMA is expected to result in negligible benefit, and no further evaluation was performed.
193	Eliminate MSIV vulnerabilities.	Negligible	N/A	Screen out	Negligible	The CNP PRA models only one function for the MSIVs, closure after a secondary line break. Since the intent of this SAMA is to improve the reliability of the MSIVs to stay open, there would be no impact on the function modeled in the PRA. Therefore, implementation of this SAMA is expected to result in negligible benefit and no further evaluation was performed.

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